GENERAL MECHANICAL DRAWING

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FOREWORD

This book is the realization of a belief that the teaching of Mechanical Drawing could benefit materially by a psychological approach to the subject, rather than the logical approach that has been used through the years. It is the result of ten years of experimenting in classes at Central High School, Scranton, Pennsylvania.

The broadness of the subject dictates that complete presentation is impractical for the level for which the book has been written; however, all important fundamentals have been included that are of value at this level.

The arrangement is such that it takes full advantage of the pupil's initial enthusiasm for and interest in the subject and holds this interest and enthusiasm throughout the course from the first project, which deals with scale, through blueprint reading, to the last project, which deals with the development of a practical roof ventilator.

Projects were selected because of their relationship to life experiences within the scope and understanding and within the skills of the pupils, as well as their adaptability to the development of the use of instruments and the teaching of consumer knowledge.

The fixity of aim of the old approach—that of developing skills and techniques, maintaining standards of neatness and knowledge, and promoting feelings of interest in drawing—did not suffer. Actually the value of the results achieved is increased greatly by the completion of the more complex problems offered and by the application of methods of teaching to these problems.

The arrangement of the course is such that information is presented to the pupil when he is ready to assimilate it. This readiness is set up and assimilation is hastened by the introduction of directed learning of the thought-provoking type.

Where possible, instruction progresses from the very familiar to the unfamiliar of like type. For example, in the earliest manipulations of crayon or pencil, most boys and girls—when asked to draw a house—drew a crude, but more or less theoretically accurate, front elevation of the ordinary gabled house. This fact, coupled with the appreciation gained from actual experience that the ordinary individual had considerable difficulty in conceiving an elevational view of any small object, where more than one side can be seen at one time, suggested the use of the house as the medium for the early presentation of orthographic projection.

There is no problem of lack of interest or motivation when the tasks selected are those that a boy has been waiting all of his cognizant life to do. In the later projects of each chapter, the pupil should be allowed to follow projects of his own choice. Sufficient integrated projects have been included in each chapter to challenge each pupil in regard to achievement. Both through choice and through freedom of expression, in the later projects of each chapter the initiative of the student is encouraged. No pupil is expected to complete all projects of any chapter, with the exception of Chapter I. The course schedule should be such that each pupil begins each chapter at the same time.

In recent years educators have become aware of the fact that, to be worthy of a place in the curriculum, Mechanical Drawing must do more than train skills which may be used later in a vocational way.

It is my contention that this new approach enables one to present a course which can be of such nature that, first, it presents a good exploratory course for the vocational student; second, it is a desirable general mechanical drawing course for those who will continue with the more specialized technical subjects; and last, but far from least, it can make a valuable contribution to the general education of the approximately sixty per cent or more of our boys in secondary schools who will not learn a trade or will not go on to institutions of higher learning.

WILLIAM JERVIS

Scranton, Pa.

GENERAL AIMS:

To present a general mechanical drawing course by using a psychological, rather than the usual logical, approach.

To present interesting problems that are of practical value.

To present new information to the pupil when he is ready to assimilate it.

To present to the pupil projects that are worthy of his consideration.

To give to the pupil, upon completion of the projects, that satisfaction which comes with having completed something worth while.

CONTENTS

CHAPTER I

SCALE OF DRAWINGS

Specific Aims:

To present the first principles of blueprint reading.

To introduce and develop the use of scale.

To teach the pupil to make an intelligent selection of scale in original drawings.

Project 1—Room 29

There is an old Chinese saying that "one picture is worth more than ten thousand words." The meaning behind these few words may be readily appreciated if one were assigned the task of writing the information shown on a small area of one of our road-maps or describing accurately any room in his or her home. Regardless of the length of the composition, invariably it would be non-inclusive in scope.

In the practice of mechanical drawing, maps and house plans or plans of any definite layout continue to be drawn because they are the best of the known means of setting down the information that they portray. It is revealing, after one has made a study of these types of representation, to see the amount of information that they are able to convey. In Fig. 1 is shown a floor plan of Room 29, which has been drawn to the scale of $\frac{1}{8}$ in. = 1 ft. This scale equality tells us that every $\frac{1}{8}$ inch on the floor plan represents 1 foot of actual distance in the room itself. With little inspection it becomes quite apparent that *this floor plan is little more than a map of Room 29.*

The set of graduations on the *architect's scale* that is marked in the margin by the number 16 is to be used for making measurements while working on Projects 1 and 2. This is the same set of graduations that is found on the ordinary foot ruler. There are 12 equal distances, each 1 inch in length, and each inch is divided into 16 equal divisions. By the use of these graduations, distances may be measured accurately to the nearest sixteenth of an inch.

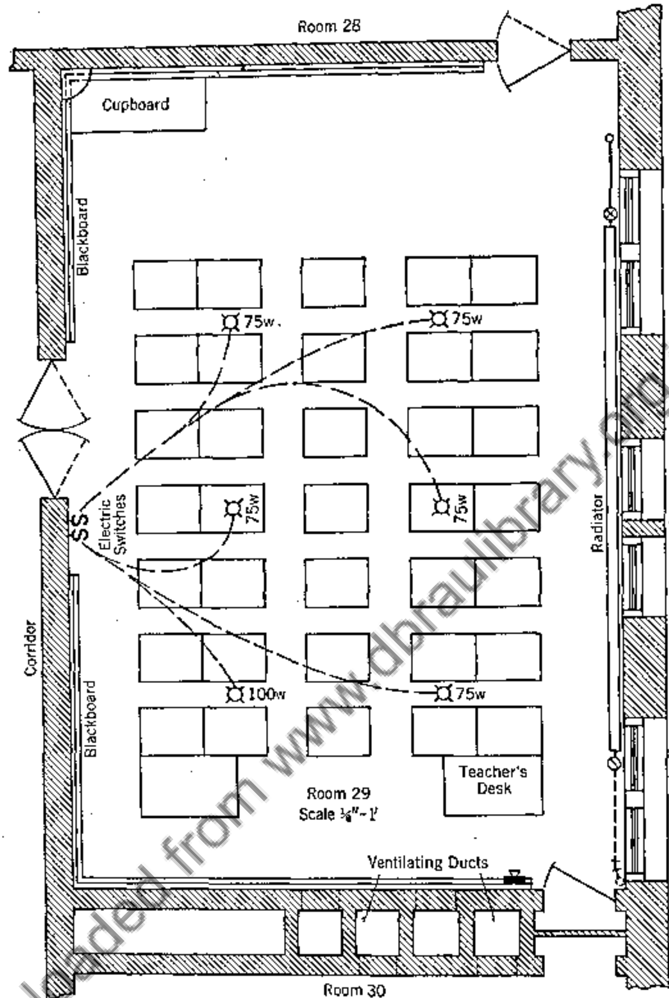


Fig. 1.—Floor Plan of Room 29.

QUESTIONS

The following twenty questions are to be answered by referring to the floor plan of Room 29 in Fig. 1. Distances are to be measured with the set of graduations marked by the number 16.

1. What is the width of the room?
2. What is the length of the room?
3. What is the distance from the front wall to the nearest pupil's desk?
4. What is the distance from the rear wall to the nearest pupil's desk?
5. What are the widths of the outer aisles at the sides of the room?
6. What are the widths of the inner aisles?

7. How many outside windows are there in the room?
8. How many closets are accessible from Room 29?
9. What are the width and the length of the cupboard that is located in the rear of the room?
10. What is the size of the teacher's desk near the windows?
11. What is the length of the radiator?
12. How many electric ceiling outlets are in the room?
13. What is the total wattage of electric lights in the room?
14. How many linear feet of blackboards are located on the walls?
15. What symbol is used to represent a telephone?
16. What symbol is used to represent an electric switch?
17. What is the total thickness of the exterior wall?
18. For the purpose of conducting an examination the pupils' desks are to be arranged in single rows rather than two together, as they are now shown. No desk can be within 2 ft of any wall, and all aisles are to have the same width. What is the largest possible width for each aisle?
19. It has been decided to cover the floor with plain brown linoleum which is to be purchased in rolls that are 6 ft in width. How many feet would you buy? The most economical length is wanted. *Use a diagram to show the layout of the strips.*
20. The room is to be cleared out *entirely*, and tables that are 3 ft wide and 5 ft long (3'-0"×5'-0") are to be placed in the room. No table is to be within 3 ft of any wall, and the tables must be at least 2 ft apart. How many of these tables may be placed in the room?

Project 2—Flying Distances within the United States

In Fig. 2 is shown a map of the United States that is drawn to scale. The accompanying legend will enable you to identify the cities whose locations have been noted on the map.

QUESTIONS

If the straight-line flying distance from Salt Lake City to New York City is 1980 miles, determine each of the following straight-line distances from the map in Fig. 2:

1. Denver to New York City
2. El Paso to Philadelphia
3. San Francisco to New Orleans
4. Atlanta to San Francisco
5. St. Louis to Seattle
6. Salt Lake City to New Orleans
7. Kansas City to Los Angeles
8. San Francisco to Denver to New York City
9. Tampa to New York City to Chicago
10. Tampa to New York City to Seattle to Los Angeles to Tampa

1. Seattle, Wash.
2. Chicago, Ill.
3. New York City, N. Y.
4. Philadelphia, Pa.
5. San Francisco, Cal.
6. Salt Lake City, Utah.
7. Denver, Colo.
8. Kansas City, Kans.
9. St. Louis, Mo.
10. Atlanta, Ga.
11. Los Angeles, Cal.
12. El Paso, Texas
13. New Orleans, La.
14. Tampa, Fla.

Fig. 2.—Map of the United States.

Project 3—Applications of Scale

With a mere scanning of newspapers, periodicals, or technical publications, it is possible to find outline drawings or pictorial views of our modern automobiles that look exactly like the actual vehicles except for the fact that the representations are only from 1 to 20 in. long. Houses that are about 20 ft wide and 30 ft long may be represented by floor plans which occupy areas that are only 4 in. wide and 6 in. long. With a more extensive search, one may find floor plans of larger houses on even smaller areas.

In the pursuit of history courses, maps of the United States are referred to frequently. These maps always have the same shape, regardless of the fact that they range in length from 6 in., or less, to 5 ft. The effect of using different scales is indicated in Fig. 3.

In the case of the 6-in. map, 6 inches probably was very little short of the length of the page of the textbook in which the map was found. No doubt each house plan occupied as much area as was

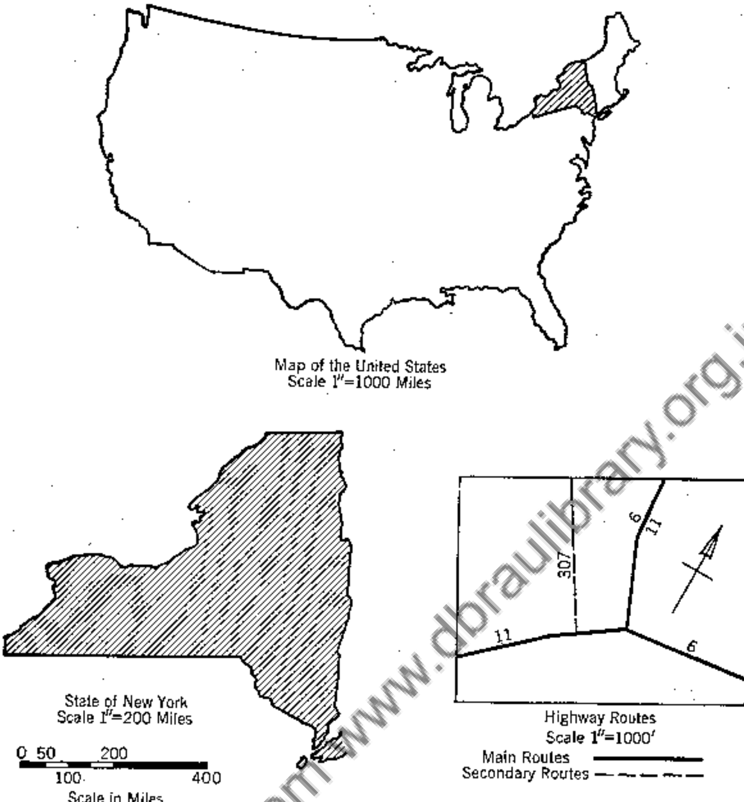


Fig. 3.—Comparative Areas to Different Scales.

available for its presentation. The 1-in. drawing of the automobile may have been part of an advertisement that was one column in width; while the 20-in. illustration may have graced the top of a full-page ad.

It might begin to appear at this time as if the space available for the drawing had something to do with the size of the drawing. Furthermore, *drawings can be made to any desired size.*

QUESTIONS

1. Which of the actual airplanes represented in Fig. 4 is the larger?
2. What observations influenced your answer to Question 1?
3. Which of the two cubes represented in Fig. 5 contains the greater volume?

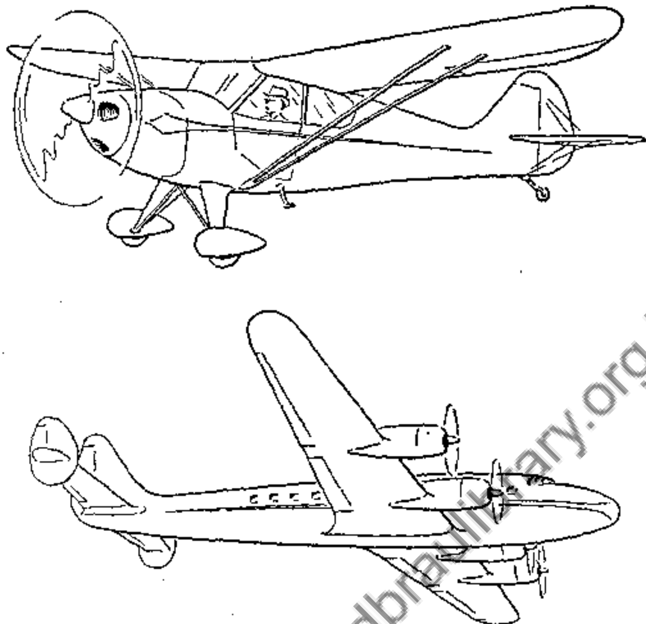


Fig. 4.—Two Airplanes.

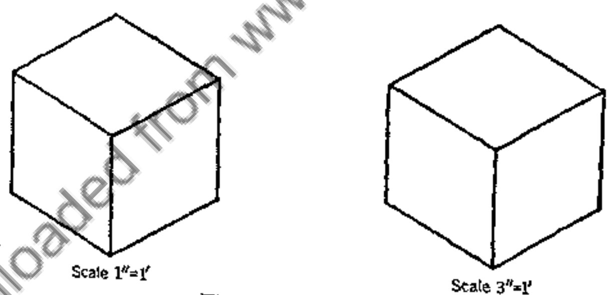


Fig. 5.—Two Cubes.

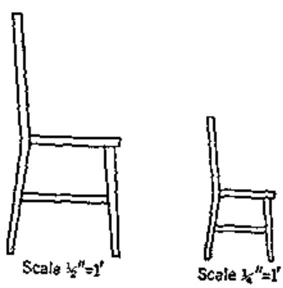


Fig. 6.—Two Chairs

4. Upon what information was your answer to Question 3 based?
5. What is the volume of the cube drawn to the scale of 1 in.=1 ft?
6. What is the volume of the cube drawn to the scale of 3 in.=1 ft?
7. Which of the two chairs shown in Fig. 6 is the larger?
8. Is there much difference in the size of the two chairs?
9. What is the height of the chair drawn to the scale of $\frac{1}{2}$ in.=1 ft?
10. What is the height of the chair drawn to the scale of $\frac{1}{4}$ in.=1 ft?

Project 4—Selection of Scale

Let us assume that the job of drawing a map of the United States has been assigned to you. The map is to be drawn on a piece of paper, the size of which is 24 in.×36 in. Obviously, the country cannot be drawn in its true size; for the United States is about 1,800 miles wide and 2,800 miles long. How would the problem of selecting the proper scale be approached? Obviously, the map should be placed on the sheet as shown at the left in Fig. 7, rather than as shown at the right.

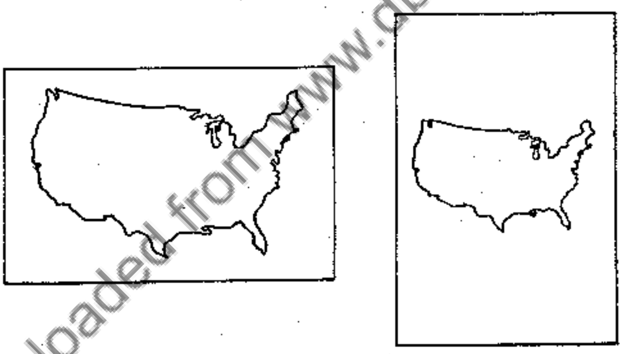


Fig. 7.—Position of Map on Sheet.

In considering a scale to suit the width, we must determine how many miles each inch must represent in order that 1,800 miles can be represented by a distance not greater than 24 in. Since $\frac{1,800}{24}=75$, each inch must represent *at least* 75 miles in order that 1,800 miles can be represented within the width of the paper.

In considering a scale to suit the length, we must determine how many miles each inch must represent in order that 2,800 miles can be represented by a distance not greater than 36 in. Since

$\frac{2,800}{36}=77.8$ (a little less than 78), each inch must represent *at least* 78 miles in order that 2,800 miles can be represented within the length of the paper.

A particular map has but one scale equality. In this case, by making 1 in. equal to a number of miles which is not less than 78, it is assured that the map will fit on the 24″×36″ sheet. If the scale of 1 in.=80 miles is used, the map will fit on the paper with small margins on all sides.

Once the scale has been determined, it remains to select a starting point and to draw the various related areas and distances, much as one would put together a jig-saw puzzle. When the scale of 1 in.=80 miles is used, the distance on the map, in inches, corresponding to any actual distance, in miles, may be computed by dividing the actual distance by 80. A few examples follow:

ACTUAL DISTANCE	LENGTH ON MAP
160 miles	2 inches
400 miles	5 inches
30 miles	$\frac{3}{8}$ inch
70 miles	$\frac{7}{8}$ inch
135 miles	$1\frac{11}{16}$ inches

QUESTIONS

Supply the missing values in the following lists and select suitable scales for the given conditions.

A. Scale: 1 in.=80 miles

ACTUAL DISTANCE	LENGTH ON MAP
1. 240 miles	?
2. 500 miles	?
3. 60 miles	?
4. 25 miles	?
5. 255 miles	?
6. ?	$1\frac{1}{2}$ in.
7. ?	$\frac{5}{8}$ in.
8. ?	$6\frac{3}{4}$ in.
9. ?	$\frac{11}{16}$ in.
10. ?	$\frac{3}{32}$ in.

B. Scale: 1 in.=150 miles

	ACTUAL DISTANCE	LENGTH ON MAP
11.	?	3 in.
12.	?	$2\frac{1}{2}$ in.
13.	?	$\frac{3}{4}$ in.
14.	?	1 ft 6 in.
15.	?	3 ft $5\frac{1}{2}$ in.

C. On a certain map, drawn to the scale of 1 in.=50 ft, points 1, 2, 3, 4, 5, 6, and 7 are located. From the information furnished, the missing values in the following tabulation are to be supplied. It is suggested that the values be expressed in decimal form.

	ACTUAL DISTANCE	LENGTH ON MAP
16. 1 to 2	125 ft	?
17. 2 to 3	73 ft	?
18. 3 to 4	?	3.3 in.
19. 4 to 5	?	19.25 in.
20. 1 to 7	208 ft	?
21. 6 to 4	350 ft	?
22. 5 to 6	733 ft	?
23. 1 to 4	319 ft	?
24. 3 to 7	?	3.47 in.
25. 5 to 7	?	8.33 in.

D. What scales would be used to draw the map of the United States, its width being 1,800 miles and its length being 2,800 miles, on pieces of paper of the following sizes? The scales are to be expressed as 1 inch being equal to a multiple of fifty miles, as 1 in.=250 miles or 1 in.=700 miles.

26.	7 in.× 9 in.
27.	$6\frac{1}{2}$ in.×12 in.
28.	$8\frac{1}{2}$ in.× $8\frac{1}{2}$ in.
29.	20 in.×42 in.
30.	$2\frac{1}{2}$ in.× 4 in.

E. What scales would be used to draw the map of a pond, its width being 175 ft and its length being 300 ft, on pieces of paper of the following sizes? The scales are to be expressed as 1 inch being equal to a multiple of 10 ft, as 1 in.= 40 ft or 1 in.=110 ft.

31.	$8\frac{1}{2}$ in.×11 in.
32.	5 in.×12 in.
33.	6 in.× 9 in.
34.	15 in.×20 in.
35.	10 in.×16 in.

WORKSHEET NO. 1

The answers to the following questions, which are identified by numbers within parentheses, are to be written on another sheet of paper.

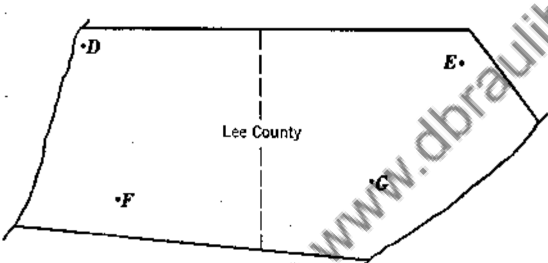
What distances would the following lines represent, if drawn to the scale of $\frac{1}{2}$ in.=1 ft?

Line A ______________________ represents (1)

Line B ______________________ represents (2)

Line C ______________________ represents (3)

On the map shown in Fig. 8, the scale of which is 1 in.=5 miles, what are the actual distances (not the lengths on the map) between the points listed to the right of the map?



D to E (4)

F to E (5)

D to G (6)

E to G (7)

D to F (8)

Fig. 8.—Outline Map of Lee County.

On a map, drawn to the scale of 1 in.=160 ft, points 1, 2, 3, 4, 5, and 6 are located. Supply the missing values in the following table, which refers to that map.

	ACTUAL DISTANCE	LENGTH ON MAP
1 to 2	250 ft	(9)
2 to 3	180 ft	(10)
3 to 4	(11)	3 in.
4 to 5	(12)	$\frac{5}{8}$ in.
5 to 6	110 ft	(13)
6 to 1	75 ft	(14)
1 to 4	(15)	$6\frac{7}{8}$ in.
2 to 6	(16)	$5\frac{3}{64}$ in.

It is desired to make a map of a pond, the width of which is 324 ft and the length of which is 596 ft. This map is to be drawn on a sheet of paper, the size of which is 12 in.×18 in. What scale should be used? The scale equality must be expressed as 1 inch being equal to a multiple of 10 ft. Answer (17)

A map of the same pond is to be drawn on a piece of paper the size of which is 4 in.×7 in. What scale should be used for this drawing? Answer (18)

It is desired to make a map of this same pond to the scale of 1 in.=50 ft. What is the minimum size of the sheet of paper that can be used? The size of the paper must be expressed in whole numbers of inches. Answer (19)

It is desired to make a map of the United States, its width being 1,800 miles and its length being 2,800 miles, to the scale of 1 in.=300 miles. Select the best size of paper from the following: 5 in.×10 in.; 24 in.×32 in.; 10 in.×20 in.; 18 in.×24 in. Answer (20)

Fig. 9.—Famous Newspapers and Famous Headlines.

CHAPTER II

STYLES OF LETTERING

Specific Aims:

To acquaint the pupil with lettering in general.

To teach a simple alphabet to the pupil.

To develop the ability to make a legible alphabet fairly rapidly.

No mechanical drawing plate was ever completed that did not have some form of lettering on it. Lettering may have appeared in the form of notes, dimensions, identifying numbers, or titles. Examples of lettering may vary considerably as to style and form, as shown in Fig. 9. However, letters that are in common use may be

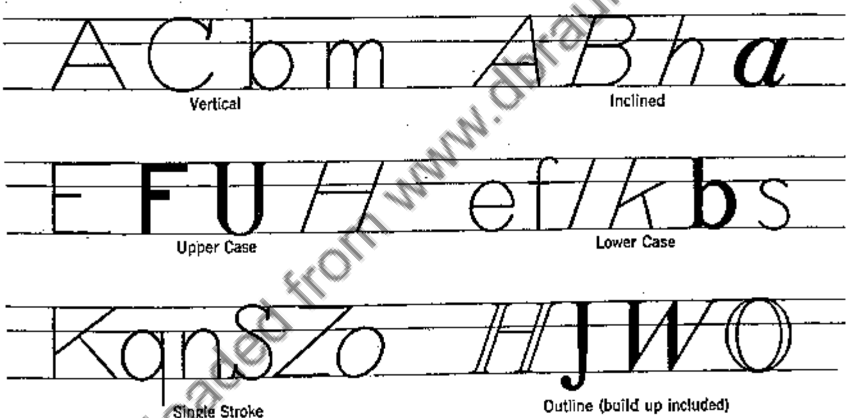


Fig. 10.—Typical Letters.

easily classified. They may be: (1) either vertical or inclined; (2) upper case (also called higher case) or lower case; (3) single stroke or outline (including built up). Typical letters of the various classes are shown in Fig. 10.

In the art of lettering one finds many alphabets; however, regardless of the great number of alphabets, there are very few in common use that are not either gothic or roman in style. A few letters of each of these styles are shown in Fig. 11.

The more simple of the two, the gothic, is preferred for ordinary simple lettering and is in general use for engineering drawing. Roman style alphabets are often used for titles, lettering on commercial maps, and in other places where one desires to be more

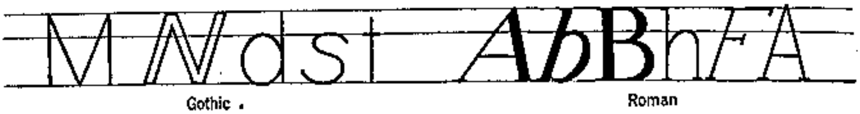


Fig. 11.—Gothic and Roman Letters.

elegant in the presentation. Architects use roman alphabets much more than do engineers. The most popular alphabets for notations on architectural drawings are single-stroke roman alphabets, with vertical alphabets usually taking preference over inclined alphabets.

Project 5—Upper-Case Letters

In Fig. 12 are shown three single-stroke alphabets; *i.e.*, vertical roman and vertical and inclined gothic. The small arrows and the numbers should be followed closely in making the various letters and numbers. These numbers and arrows signify the order and direction in which the strokes are executed to make each letter. It is of the utmost importance that you follow the order and direction of stroke in the performance of each letter at all times. If this practice is strictly adhered to, the quality of your lettering will improve immensely.

The number beneath each vertical gothic letter indicates the number of small units that the letter consumes in width. The height of each space, or the distance from the top guide line to the bottom guide line, is considered as being equal to six small units. These same numbers apply to the inclined gothic letters, where each number indicates the length of the horizontal side of the parallelogram in which the letter is located.

The same order and direction of strokes for each letter applies to all three alphabets.

QUESTIONS

1. What is the widest letter?
2. What letter requires the greatest number of strokes?

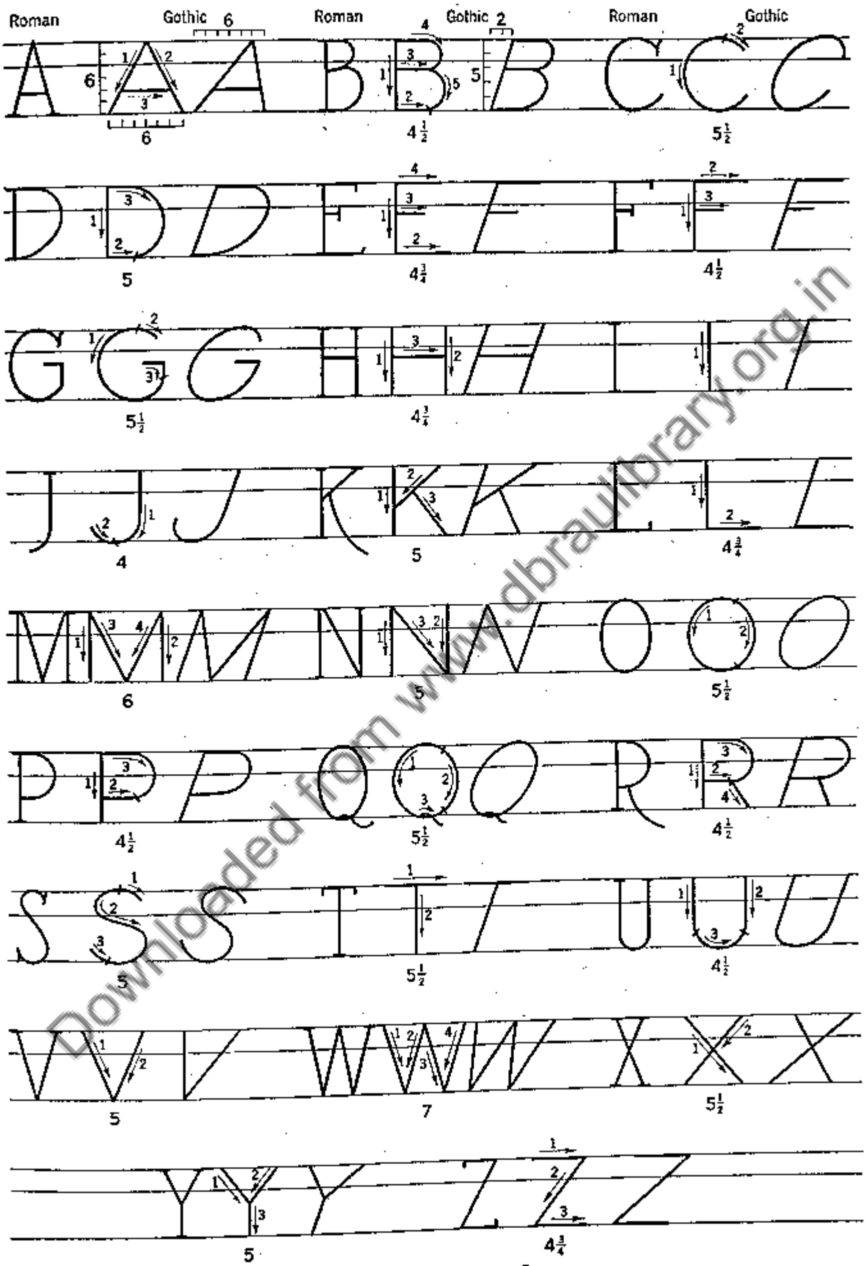


Fig. 12.—Upper-Case Letters.

3. What letters use only vertical lines or combinations of horizontal and vertical lines?
4. What letters have at least one vertical line?
5. What letters make use of inclined straight lines?
6. Is the letter "O" circular in shape?
7. What letters are closely related to the letter "O"?
8. What letters may be considered as being related to the letter "B"?
9. The general directions of strokes are either from ________ to ________ or from ________ to ________.
10. In general, the top portions of the letters are ________ than the bottom portions.

Project 6—Practice Lettering of Upper-Case Letters

The pupil will complete the requirements of all Practice Lettering Projects on sheets of ruled foolscap paper. The pupil's attention is called to the fact that it will be necessary to draw guide lines in addition to those already on the paper.

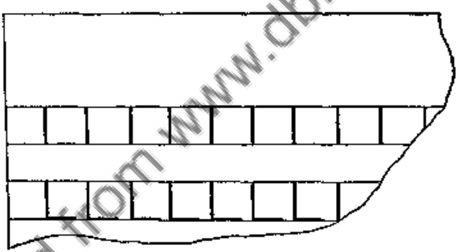


Fig. 13.—Guide for Project 6.

Three guide lines should be used for all lettering. The waist line is to be located at a distance above the bottom guide line equal to two-thirds of the height of the space.

At no time during this course will the pupil be asked to make letters that are more than $\frac{3}{8}$ in. in height.

As the requirement for Project 6, the pupil will make one complete line of each of the following upper-case letters:

I L H T F E A V N M W Z X K Y

The letters will be of the vertical gothic alphabet. The height of the space will be $\frac{3}{8}$ in. Parts of lines for the letters I and L are shown in Fig. 13.

Project 7—Practice Lettering of Upper-Case Letters

On a sheet of ruled foolscap paper, the pupil will letter one line of each of the following upper-case letters.

O Q C G J U D P R B S

The letters are to be of the vertical single-stroke gothic alphabet. The height of the space will be $\frac{3}{8}$ in.

Project 8—Lower-Case Letters

Lower-case letters are used for notes or extended statements. They are preferred for this usage for two reasons: (1) They can be executed much faster than upper-case letters; (2) they can be read more easily and quickly because of the many contacts with printed form which is generally done in lower-case letters.

Where lower-case letters are used, upper-case letters are also employed to observe the rules of capitalization, as in Fig. 14.

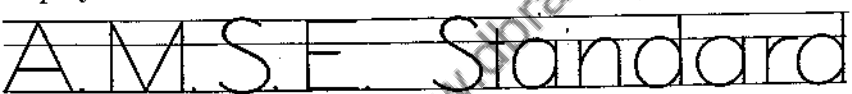


Fig. 14.—Capitalization.

The majority of the lower-case letters are two-thirds of the full space in height; however, some are the full space in height and some extend one-third of the space beneath the lower guide line.

QUESTIONS

1. What letters are closely related to the letter "o," as "a"?
2. What letters are you able to make that will include the letter "r," as "n"?
3. What stroke occurs most often in making the vertical gothic alphabet?
4. How many lower-case letters are a full space or more from top to bottom?
5. It is suggested that the pupil make a copy of each different stroke that he must be able to make in order to form any lower-case letter of the vertical single-stroke gothic alphabet.

Project 9—Practice Lettering of Lower-Case Letters

On a sheet of ruled foolscap paper, the pupil will letter one line of each of the following lower-case letters (see Fig. 15):

l i t v y j w x z k n h m r u f o a b d q p c e g s

The letters are to be of the vertical single-stroke gothic alphabet. The height of the space will be $\frac{3}{16}$ in.

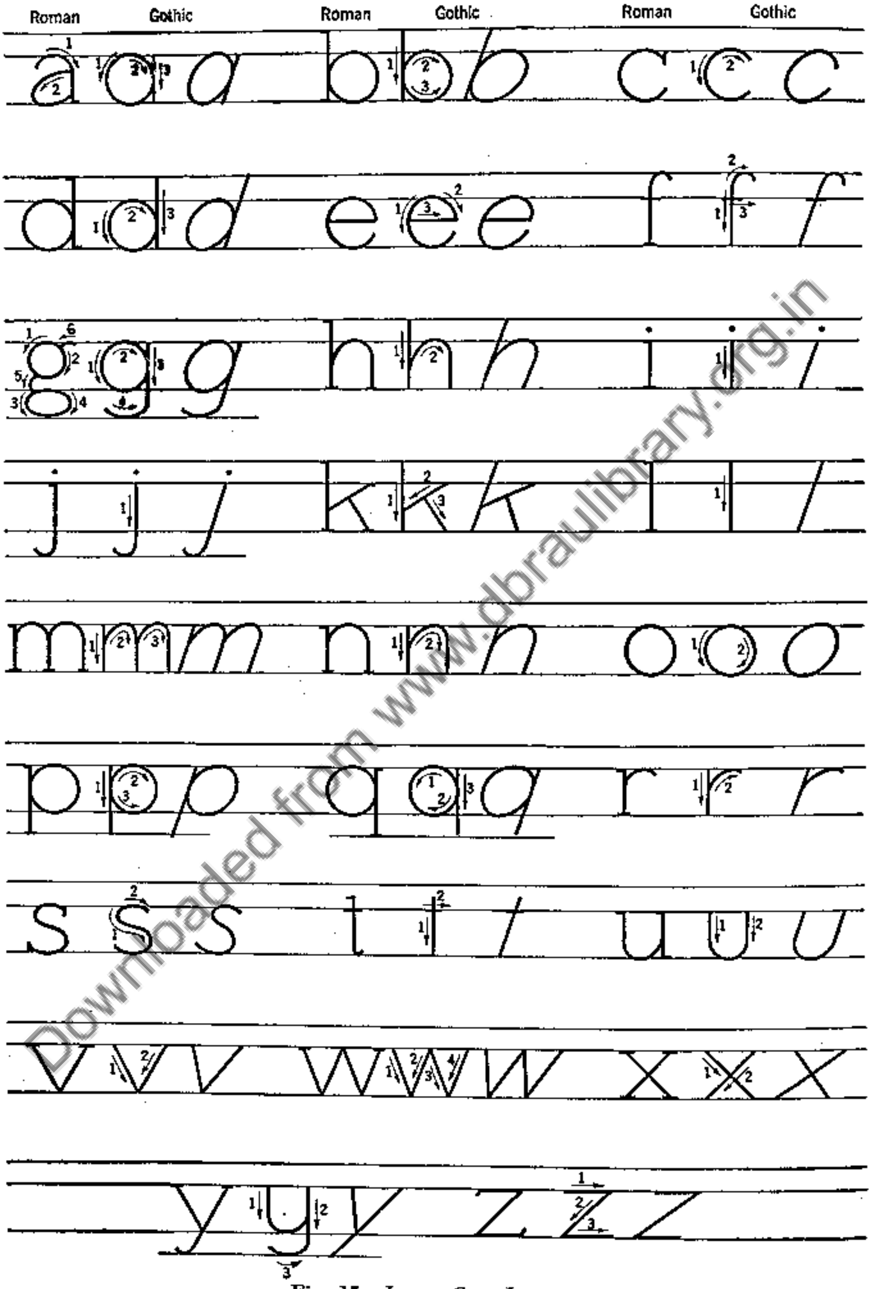


Fig. 15.—Lower-Case Letters.

Project 10—Spacing

Every effort is made to maintain uniform size and slope of letters; on the other hand, *the distance between letters should not be uniform.* In Fig. 16 is shown the effect of making the distance between letters uniform.

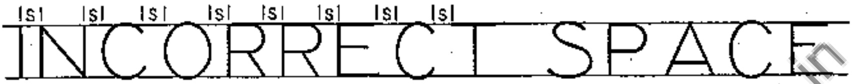


Fig. 16.—Incorrect Spacing.

There is no definite rule for the spacing of letters in words; however, good spacing may be maintained by the exercise of good judgment, as indicated in Fig. 17. It is necessary to keep the open areas between letters as nearly equal as possible in order to produce a well balanced arrangement.

Fig. 17.—Correct Spacing.

As a requirement for this project, the pupil is to letter the following three paragraphs on a sheet of ruled foolscap paper. The height of space will be $\frac{3}{16}$ in.

> For all lettering a set of three guide lines should be used. The third guide line is placed at the upper third point between the bottom and top guide lines. These guide lines do much to insure uniformity of size and slope of your letters.
>
> It is important that uniformity of slope be maintained regardless of what alphabet is used. The slope of the presented inclined alphabet is two horizontal in five vertical. This slope may be altered to meet individual preference or ease of execution.
>
> Anyone, after diligent deliberate practice, can learn to letter well.

Project 11—Figures

Sample figures for the three types of alphabets here considered are shown in Fig. 18.

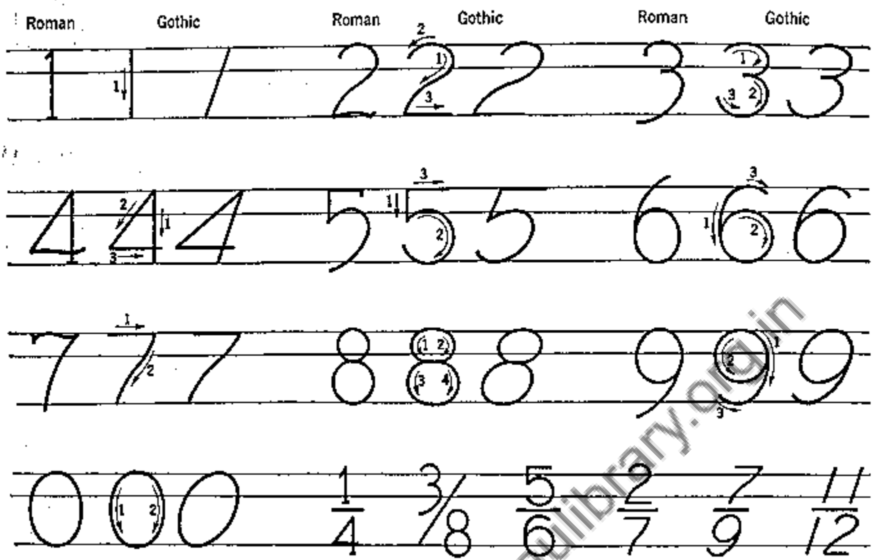


Fig. 18.—Figures and Fractions.

It is to be noted that the fractions extend both above and below the guide lines that mark the top and the bottom of the space.

On a sheet of ruled foolscap paper, the pupil is to make one line of each of the following figures and fractions. The height of the space is to be $\frac{3}{8}$ in.

1 4 7 6 9 8 3 2 5 $\frac{1}{2}$ $\frac{3}{4}$ $\frac{5}{6}$ $\frac{7}{8}$ $\frac{9}{10}$

Project 12—Practice Lettering of Fractions and Numbers

On a sheet of ruled foolscap paper, the pupil is to make one line of each of the following fractions and numbers. The height of the space is to be $\frac{3}{16}$ in.

$\frac{29}{64}$ $5\frac{5}{8}$ $6\frac{9}{32}$ $7\frac{1}{4}$ $9\frac{3}{8}$ $\frac{11}{24}$ $\frac{13}{16}$

6098	8652	3470	4175	3095	6699	8383	52325
.735	.875	.25	.934	.46	57.89	9.6	23.75

Project 13—Practice Lettering of Sentences and Paragraphs

A description of the block shown in Fig. 19 is to be lettered on the usual foolscap sheet. The height of the space is to be $\frac{3}{16}$ in.

Upper-case letters are to be used when rules of capitalization demand; otherwise, lower-case letters will be used throughout the description.

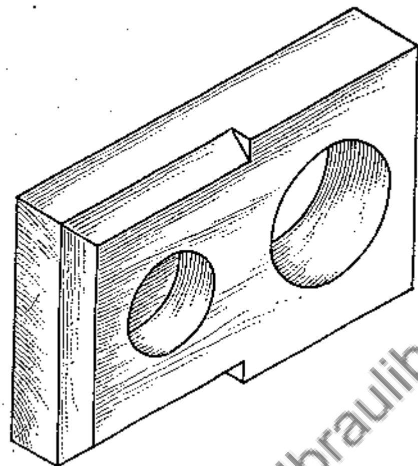


Fig. 19.—Block for Project 13.

When the description has been finished, it is suggested that the pupil read the description to some other pupil, who has not worked on this project, in order to test the thoroughness of the description. Thorough technical description by written word is difficult to achieve.

Project 14—Title for a Map

Design a title to be placed on a map of Kalamazoo, Michigan, prepared by David Richards, Consulting Engineer, for the National Planning Commission. The map was completed during the month

Fig. 20.—Extended and Compressed Lettering.

of August of the present year. It is drawn to the scale of 1 in. = 200 ft. All of the foregoing information is to appear in the title.

Where available space permits or dictates, letters may be extended or compressed, as shown in Fig. 20.

Project 15—Bill of Material for Soap-Box Racer

A young friend has asked your advice as to what material he must have in order to be able to build a soap-box racer. List the material which you think he will need to complete the racer.

Name of Part	Number Required	Type of Material	Size of Material	Approx. Cost
Axle	2	Steel	$\frac{3}{8}'' \times 3'$	20¢
Steering column	1	Wood	$2'' \times 2'' \times 20''$	10¢

Fig. 21.—Bill of Material.

Place the information in tabular form, as in Fig. 21. Use a piece of drafting paper, size 6 in.×9 in., on which to lay out this bill of material.

CHAPTER III

FLOOR PLANS

Specific Aims:

To teach the use of the "architect's scale."

To enable the pupil to draw and to read floor plans.

To make the pupil conscious of room layout.

To enable the pupil to make original simple floor plans.

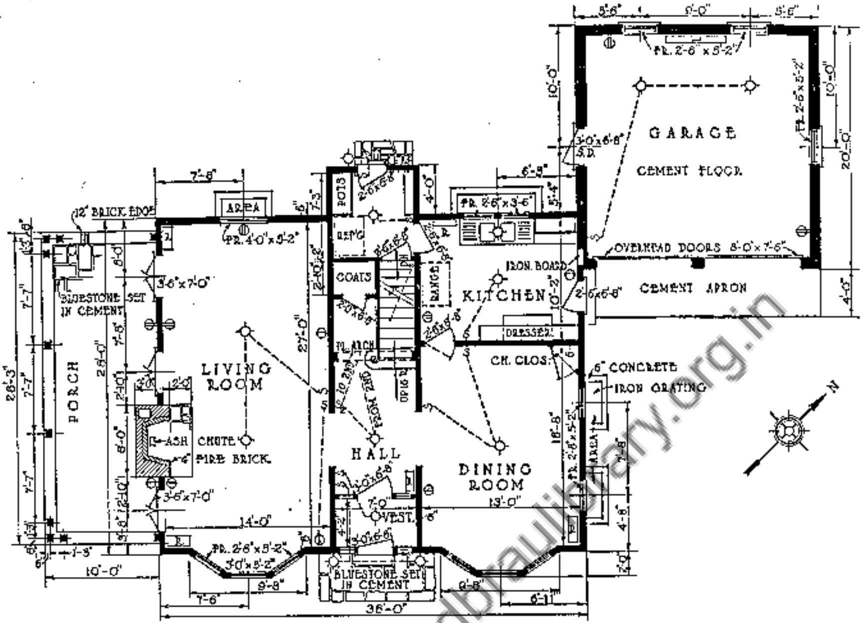
Project 16—Use of the Architect's Scale

Thus far only one set of graduations on the architect's scale has been used. This set of graduations was the one that was marked by the number 16 in the margin. This set did not present anything that was new to us; however, the same cannot be said of the other sets of graduations to be found on this measuring instrument.

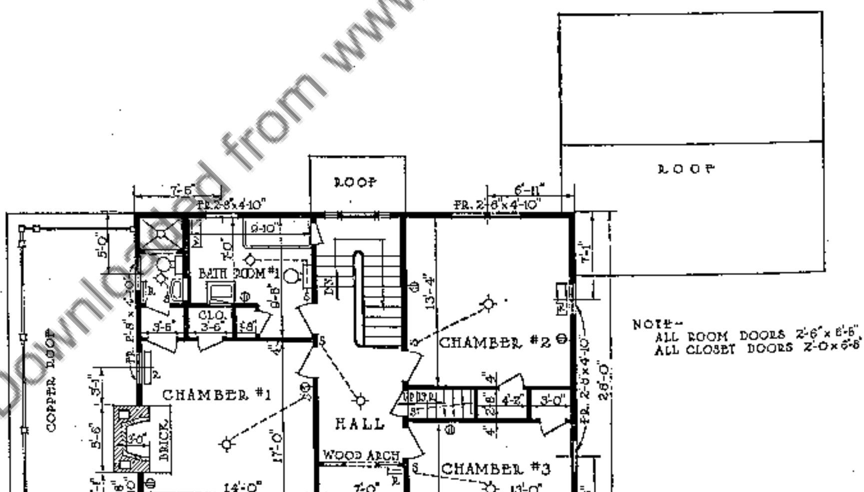
Among the numbers and the fractions marked near the ends of the scale, there is the fraction $\frac{1}{4}$. A short distance in from this fraction there is a "0" mark. Toward the left from this zero mark, $\frac{1}{4}$-in. intervals have been set off. Every other of these quarter-inch marks has been numbered. As the fraction $\frac{1}{4}$ in the margin implies, this set of graduations may be utilized when using the scale equality of $\frac{1}{4}$ in. = 1 ft, where each $\frac{1}{4}$-in. interval represents 1 ft. It should be needless to say that the distance on the "architect's scale" from 4 to 0 represents 4 ft to the scale of $\frac{1}{4}$ in. = 1 ft; likewise, the distance from 6 to 0 represents 6 ft to the scale of $\frac{1}{4}$ in. = 1 ft.

The $\frac{1}{4}$-in. interval to the right of the "0" mark has been divided into twelve equal spaces. Since the scale equality for which this set of graduations has been designed is $\frac{1}{4}$ in. = 1 ft, the $\frac{1}{4}$-in. interval represents 1 ft; and therefore one-twelfth of this interval will represent $\frac{1}{12}$ ft or 1 in. See Fig. 23. Using this set of graduations, one may measure directly to the nearest inch.

The set of graduations marked by the fraction $\frac{1}{2}$ in the margin is the set to be used when working with the scale of $\frac{1}{2}$ in. = 1 ft. When using this scale one may represent distances to the nearest



FIRST FLOOR PLAN
SCALE: 1/4"=1'-0"



SECOND FLOOR PLAN
SCALE: 1/4"=1'-0"

Fig. 22.—Floor Plans.

half inch. See Fig. 24. The division of the first ½-in. interval into 24 equal spaces makes this possible.

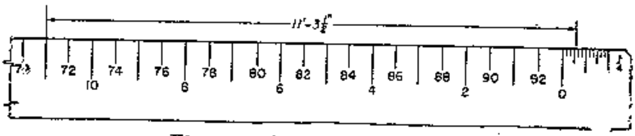


Fig. 23.—Quarter-Inch Scale.

The numbers and fractions marked near the ends of the architect's scale indicate the scale equalities to which the various sets of graduations apply. Every number or fraction, with the exception of the number 16, indicates the set of graduations that is to be used when, *and only when,* that number of inches or fraction of an inch is equal to 1 ft in the scale equality.

As the requirement for Project 16, the pupil is to place the answers to the following questions on a sheet of foolscap paper. The questions are to be completed in numerical order. For parts A and D, a vertical line is to be drawn ¼ in. from the left edge of the paper, and the required horizontal lines are to be drawn from that vertical line to the right.

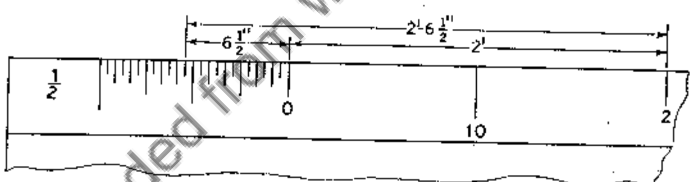


Fig. 24.—Half-Inch Scale.

QUESTIONS

A. Using the scale of ¼ in. = 1 ft, draw horizontal lines that will represent the following distances:

1. 9 in.
2. 17 ft 0 in.
3. 13 ft 5 in.
4. 20 ft 6 in.
5. 11 ft 7½ in.

B. Determine the distance represented by the smallest space on the architect's scale when using the following scales:

6. ⅜ in. = 1 ft
7. ¾ in. = 1 ft
8. ⅛ in. = 1 ft
9. 1½ in. = 1 ft
10. 3 in. = 1 ft

C. Using the most convenient set of graduations on the architect's scale, measure and record the following distances on the floor plan of Room 29 shown in Fig. 1:

11. The distance from the rear of the last desk in the first row at the left to the front of the first desk in that row.
12. The width of the opening in the wall at the entrance to the room.
13. The thickness of the wall between Room 29 and the hall.
14. The width of the room.
15. The length of the room.

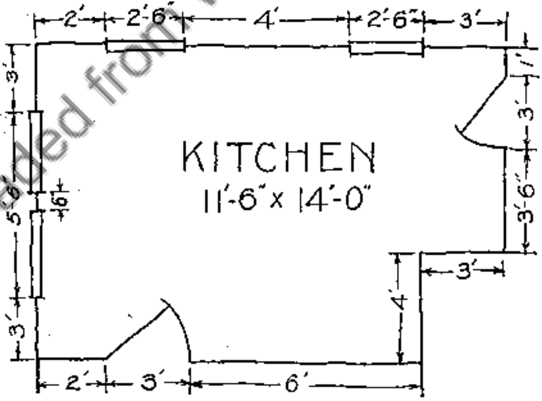
D. Draw horizontal lines that will represent the distance 2 ft 5 in. to the following scales:

16. $\frac{3}{4}$ in.=1 ft
17. $\frac{1}{2}$ in.=1 ft
18. $1\frac{1}{2}$ in.=1 ft
19. $\frac{3}{16}$ in.=1 ft
20. 3 in.=1 ft

E. Make a drawing of a rectangle, the size of which is 8 in.×$12\frac{1}{2}$ in., to the scale of 3 in.=1 ft.

Project 17—Kitchen Floor Plan

Before the pupil can begin the drawing of the kitchen floor plan, it is necessary for him to submit a freehand sketch of the floor plan of the kitchen in his home. This sketch will show the size of the



List of Furnishings

Refrigerator	2'-0"×3'-0"
Table	3'-0"×3'-6"
Stove	2'-0"×2'-9"
Cupboard	1'-4"×3'-6"
Sink	1'-8"×2'-4"
Radiator	9"×1'-3"

Fig. 25.—Freehand Sketch of Kitchen Floor Plan with List of Furnishings.

kitchen and the width and location of all window and door openings. It will be accompanied by a list of the kitchen furnishings, which will show the floor space that each furnishing occupies. A typical sketch and list of furnishings are shown in Fig. 25.

A suggested list of steps for the completion of Project 17 follows. It is advisable that the pupil complete them in the order in which they are listed.

1. Take enough measurements at home to make the required sketch of the kitchen and list of furnishings.
2. Make the sketch. A freehand sketch is desired. Submit the sketch to the teacher for approval. See Fig. 26 for suggestions on freehand sketching.
3. Study thoroughly the following explanations that discuss the "Mechanics of Drawing." *Know this information.*
4. Lay out a sheet of drawing paper, the size of which is 12 in.×18 in., according to the instructions for sheet layout. See Figs. 34, 35 and 36.
5. Select a scale equality for the drawing. The scale equality selected must be one for which there is a set of graduations on the architect's scale.
6. Become familiar with the symbols that are used in architectural plan views. See Fig. 39.
7. Complete the drawing of the walls, doors, and windows. *Exterior walls of frame houses will be 8 in. thick and interior walls will be made 6 in. thick.*
8. Make a study of the information given about kitchen arrangement.
9. Rearrange the furnishings in the kitchen in an attempt to improve the kitchen arrangement.
10. Letter the name, KITCHEN, and the size of the room, as 11′-6″×14′-0″, somewhere near the center of the floor plan. Use upper-case letters for the word KITCHEN. *The size of the room is expressed as the most general distances across the room measured between the insides of the walls.*

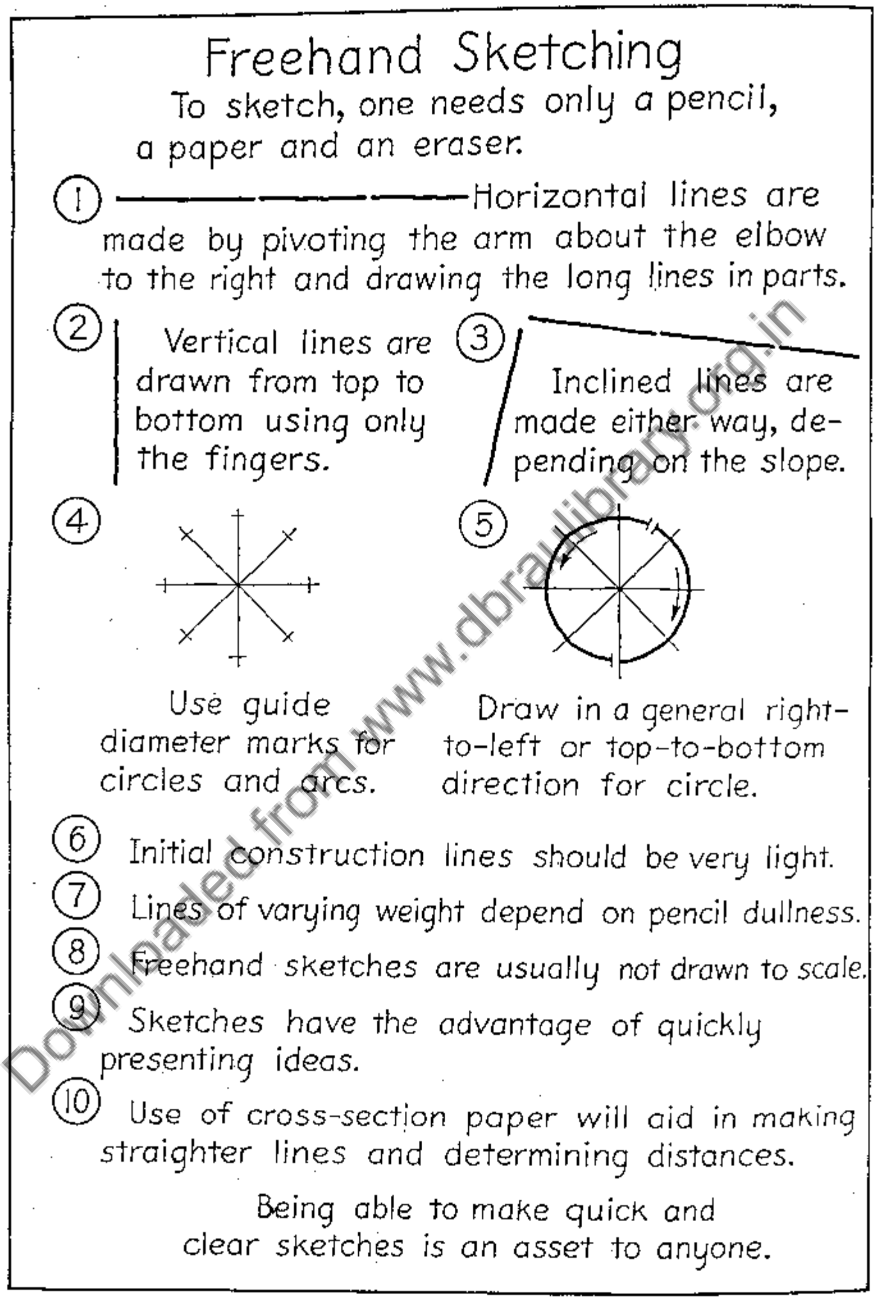


Fig. 26.—Suggestions on Freehand Sketching.

11. Letter the names on the various furnishings in the kitchen. Use lower-case letters, with the exception that the first letter of each name will be an upper-case letter. *All lettering must be placed so as to be read either from the bottom or from the right-hand side of the sheet.*
12. Fill in the title block. See Fig. 37. It is important to include the scale of the drawing in all title blocks. This holds true even when full-size drawings are made.

IMPORTANT

Keep your pencils well sharpened at all times. The lead should be shaped to a point, as in Fig. 27. Use the sand-paper pad often

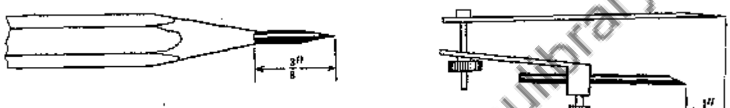


Fig. 27.—Lead Points.

in order to keep the lead well sharpened. Use a chisel point on the lead of the compasses, as indicated in Fig. 27.

MECHANICS OF DRAWING

In mechanical drawing, objects are represented by combinations of horizontal, vertical, and inclined lines, circles and arcs, and irregular curves.

As is to be expected, some of the simple drawings require the use of only horizontal and vertical lines, while the more complicated drawings require the use of all the types of lines just mentioned. Hence, it is necessary to know what the different types of lines are and how they are made.

A horizontal line is a straight line running in the same direction as the horizon (the line between the earth and the sky). Since lines running in the same direction are parallel lines, it may be said that a horizontal line is a line parallel to the horizon. The line along the top of the blackboard is a horizontal line.

A horizontal line is always made by holding the head of the T square firmly against the left* edge of the drawing board and

* If a pupil is left-handed, the word "right" should be substituted for "left."

drawing a line from left to right along the top edge of the T square. See Fig. 28. Any number of horizontal lines may be made by sliding the T square up and down the board to a new position each time.

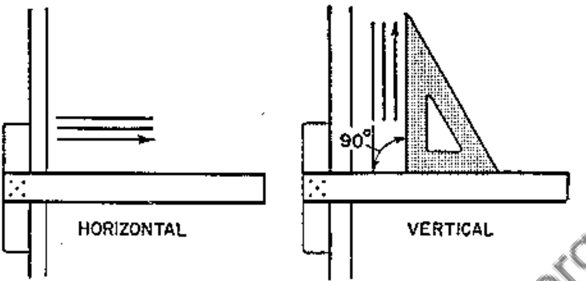


Fig. 28.—Arrangements for Drawing Horizontal and Vertical Lines.

A vertical line may be described as a line made by a string hanging from the ceiling or the path of a stone dropped out of a window. It is a straight line and is perpendicular to a horizontal line. To draw a vertical line the T square is held firmly against the left edge of the board and one of the triangles is then placed against the top edge of the T square with one side of the triangle vertical and

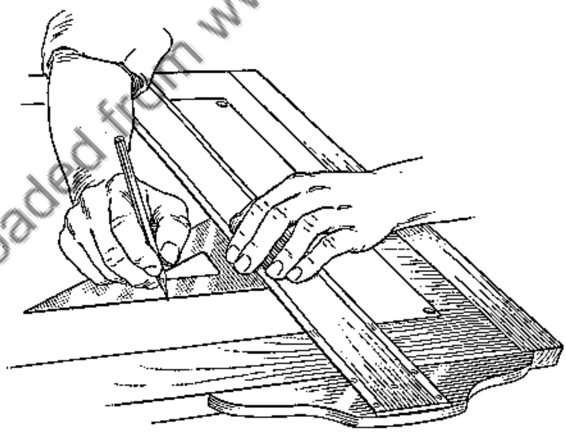


Fig. 29.—Position for Drawing a Vertical Line.

that side nearer the head of the T square. See Figs. 28 and 29. All vertical lines are drawn in the upward direction.

Inclined lines are any straight lines that are neither vertical nor horizontal. Some lines of special inclinations may be drawn by holding the T square and one triangle in the positions shown in Fig. 29 for drawing a vertical line but drawing the line along the inclined side of the triangle. Also, the longest side of either triangle may be placed along the top edge of the T square and inclined lines may be drawn by using one of the shorter sides as a guide.

An inclined line may be drawn by using the T square or any edge of either triangle as a straightedge, and drawing a line connecting any two points that are not directly above one another or in horizontal alinement with each other.

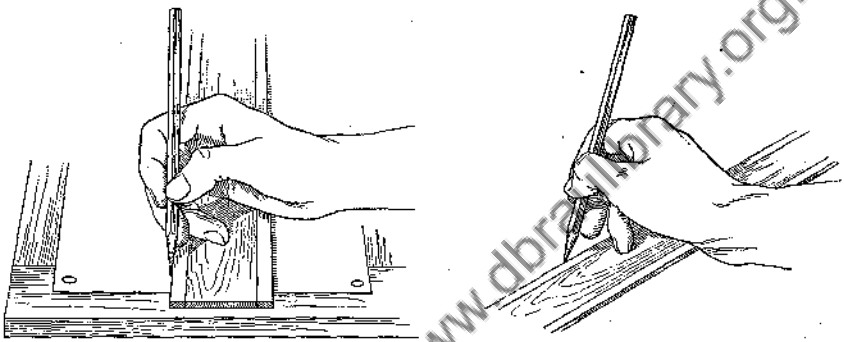


Fig. 30.—Correct Positions in Holding Pencil for Drawing Lines.

IMPORTANT

It is most important that you learn the correct use of the pencil for drawing lines. It should be held in such a manner that it will always be in a plane perpendicular to the drawing surface and inclined with its top toward the direction in which the line is being drawn.

If the proper position and proper direction are maintained, the hand that is holding the pencil will always be above the triangle or T square that is being used as a guide in drawing the line.

In drawing lines, place no pressure on the pencil point, but merely drag the pencil along the guiding edge. Make light lines. *Drawings are not meant to be engravings.*

CIRCLES AND IRREGULAR CURVES

A circle is easily recognized by most people. What is a circle? It is the path of a point revolving around another point, which is stationary, the points being the same distance apart at all times.

Circles are made with the aid of a compass, as indicated in Fig. 31. The distance between the stationary and revolving points

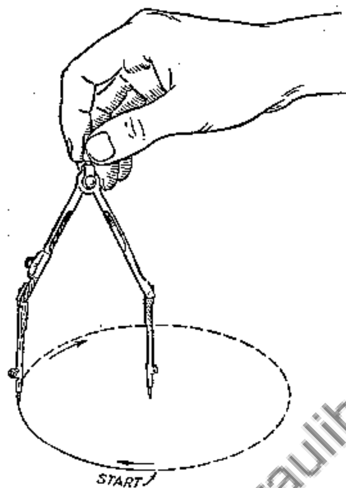


Fig. 31.—Position of Compass Legs for Drawing Large Circle.

determines the size of the circle. This distance is known as the radius and is usually denoted by the upper-case letter *R*.

The distance across the circle, measured through the center, is known as the diameter. The diameter is usually denoted by the upper-case letter *D*. The diameter is always equal in length to twice the radius, or

$$D = 2R$$

An arc is a curved line which is a part of a circle. Several arcs are shown in Fig. 32. A circle may be referred to as "a circle whose

Fig. 32.—Concentric Arcs.

radius is 2 inches." Similarly, an arc may be referred to as "an arc whose radius is $1\frac{1}{4}$ inches." The radius of an arc is the radius of the circle of which the arc is a part.

An irregular curve is any curved line which is not a circle or part of a circle. Celluloid guides (French curves) are obtainable to assist you in drawing irregular curves. Irregular curves are shown in Fig. 33, and a French curve is shown in the various positions in which it would be placed to draw these irregular curves.

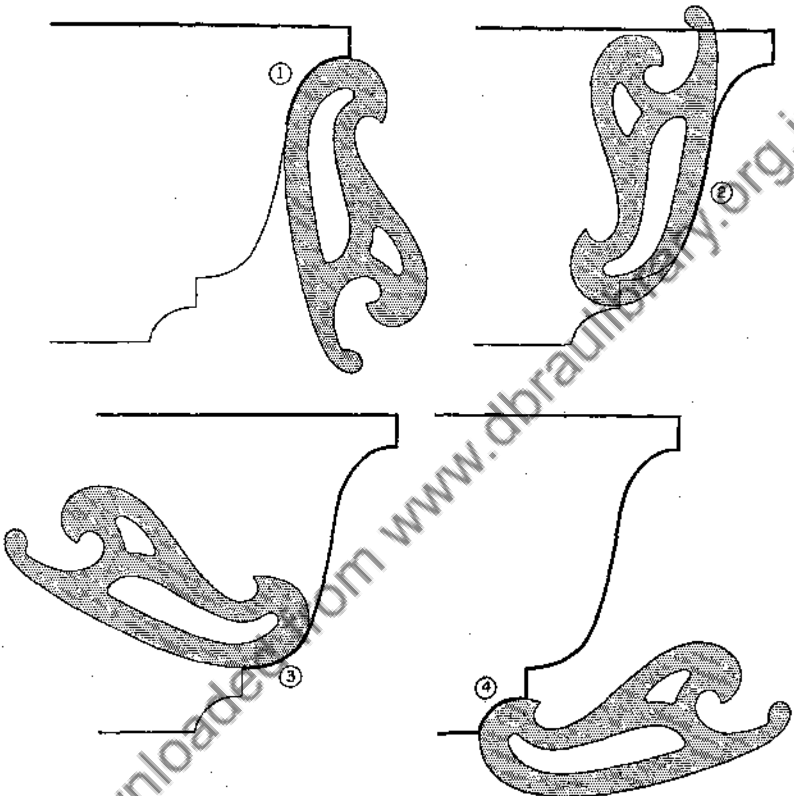


Fig. 33.—Irregular Curves.

GENERAL LAYOUT OF THE SHEET

It is suggested that the pupil follow with complete thoroughness the steps listed here in their numerical order.

1. Measure 17 in. near the bottom of the sheet by making two short vertical marks, as in Fig. 34.
2. Mark a point $\frac{3}{8}$-in. from the right-hand mark and a point 1 in. from the left-hand mark. Use short vertical marks.

3. Lay the scale vertically near the left edge of the paper and make two short horizontal marks 11 in. apart.
4. From the top mark, measure down $\frac{3}{8}$ in. and make another short horizontal mark.

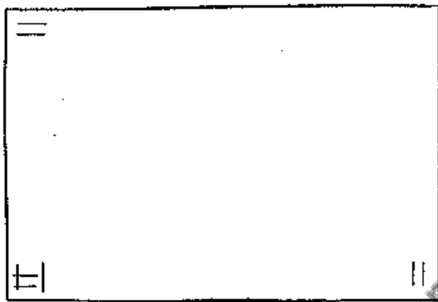


Fig. 34.

5. From the bottom mark, measure up $\frac{3}{8}$ in. and make a mark.
6. With the T square draw horizontal lines through the four horizontal marks.
7. Draw vertical lines through the four vertical marks. At this time, check your layout with Fig. 35.

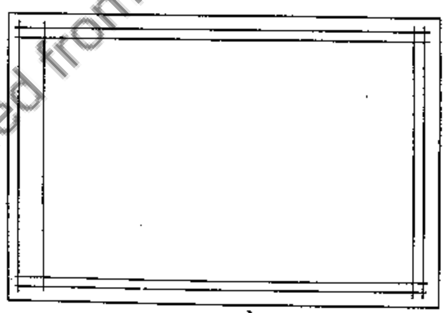


Fig. 35.

8. Erase the portions of the lines that are not needed. Use Fig. 36 as a guide.
9. Reserve a strip, that is $\frac{3}{4}$ in. in height, along *either* the longer side or the shorter side of the working space. This strip is to contain the title block. See Fig. 36. The title

block is usually placed along the longer side. The size of the working space, after space for the title block has been reserved along the longer side, is $9\frac{1}{2}$ in. $\times$ $15\frac{5}{8}$ in.

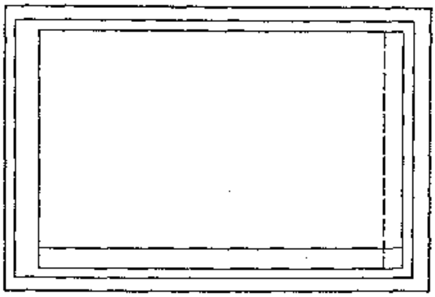


Fig. 36.

TITLE BLOCK LAYOUT

The positions of the guide lines in the title block, as shown in Fig. 37, may be found by measuring from the top or bottom of the

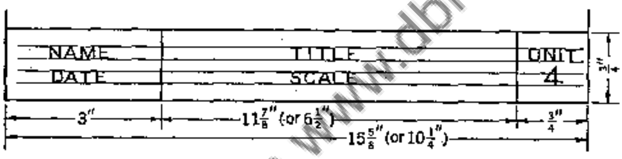


Fig. 37.—Title Block Layout.

title block the following series of distances in the order given here: $\frac{3}{16}$ in., $\frac{1}{8}$ in., $\frac{1}{8}$ in., and $\frac{1}{8}$ in.

All lettering in the title block will be of the single-stroke, vertical, gothic, upper-case alphabet.

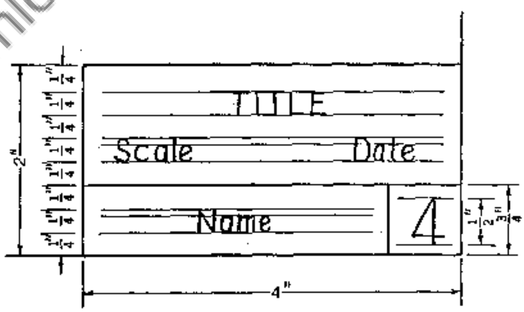


Fig. 38.—Title Block Layout.

The title block in Fig. 38 may be used in preference to the title block previously presented.

Title blocks other than those presented may be designed so that they include information personally desired.

SIZES OF FINISHED PLATES

It is to be noted that the finished plates, when trimmed, will be 11 in.×17 in. This size will fold neatly to the usual letterhead size of 8½ in.×11 in. In drafting offices a movement is fast gaining favor to make drawings in sizes that will fold neatly to this common letterhead size. Sizes which conform to this practice are:

8½″×11″	17″×33″
11″ ×17″	22″×25½″
17″ ×22″	

In instances where a layout other than 11 in.×17 in. is used, the distances 17 in. and 11 in. in steps 1 and 3, respectively, would be changed to fit the over-all dimensions for the particular size to be used. All other steps and dimensions remain the same. In the title block layout, change the size of the middle space only. For large sheets it is recommended that the title block in Fig. 38 be used.

DERIVATION OF SYMBOLS

Symbols used on floor plans are nothing more than conventionalized views of what they represent. One of these symbols is

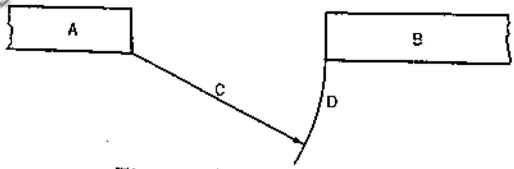
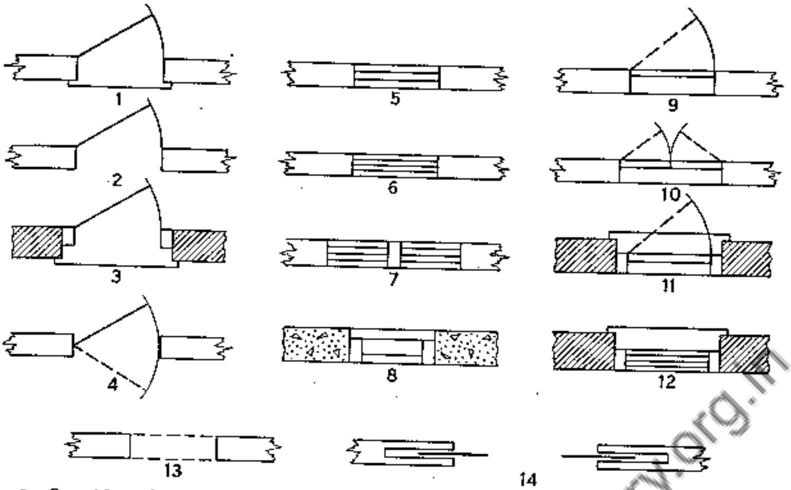


Fig. 39.—Symbol for Door.

shown in Fig. 39. It is a simple drawing showing that part of the house as seen from above. Only enough lines are used to clearly identify the part. In Fig. 39 the portions *A* and *B* are parts of the wall of the room. Notice that no attempt has been made to include the door casing or any of the parts of the door jamb. The line *C*



1. Outside door in frame wall (wood).
2. Inside door in frame wall.
3. Outside door in masonry wall (stone or brick).
4. Double swing door.
5. Single sash window in frame wall.
6. Double hung window in frame wall.
7. Mullion window in frame wall.
8. Single sash window in basement wall (concrete).
9. Single casement window in frame wall.
10. Double casement window in frame wall.
11. Single casement in brick wall.
12. Double hung window in masonry wall.
13. Cased opening or arch.
14. Double sliding door.

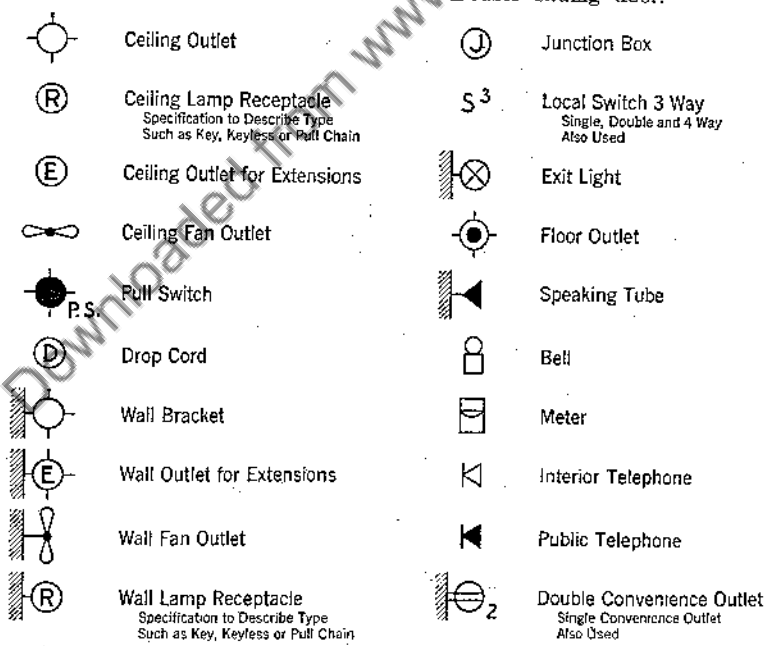


Fig. 40.—Symbols for Openings in Walls and Electrical Appliances.

represents the door itself in a partially opened position; while the arc *D* shows the path of the edge of the door and hence the amount of floor space it commands for usage.

Fig. 39 has been repeated as symbol 2 in Fig. 40, except for a change in the direction in which the door opens.

Symbol 1 in Fig. 40 differs from symbol 2 in that a few lines have been added. The following questions suggest themselves:

1. What do the added lines in symbol 1 represent?
2. In symbol 4, what does the dashed line represent?
3. Why are there two horizontal lines within symbol 5 and three within symbol 6?
4. What do the small rectangles, definitely located by an X in Fig. 41, represent in symbols 3, 8, 11 and 12?

It is suggested that, in a case where it is necessary for the pupil to use a symbol which is not included in Fig. 40, the pupil design his own symbol, using those shown in Fig. 40 as a basis for the de-

Fig. 41.

sign. In the case of the kitchen furnishings, it is suggested a rectangle be used to show the floor space required by each furnishing and that the name of the furnishing be placed in or near the rectangle. This practice has been followed in Fig. 42.

KITCHEN ARRANGEMENT

In recent years much work has been done on the planning of kitchens. People have accepted the idea that meals, like operations in any good factory, should have a line of march—an assembly line from raw materials to finished product. As the current-day efficiency expert would tell you, this assembly line should be so designed as to eliminate unnecessary steps and undue stretching.

The kitchen is the workshop of the housewife. Many varied tasks are performed in the kitchen. Upon the arrival of food in the home, she must be concerned with its cleaning and refrigeration and storage. It is next handled when being prepared, cooked, and served;

and last, but not least, come the dishwashing and the replacing of food and utensils until the cycle of meal preparation begins again.

In the following list are given some of the usual furnishings of a kitchen with remarks regarding each, including possible and recommended locations:

Refrigerator: Should be situated near the delivery entrance and handy to a preparation counter.

Sink: Should be placed near the refrigerator for necessary cleaning of foods before storage, and should have sufficient storage space near-by for glasses, dishes, soaps, and cleaners.

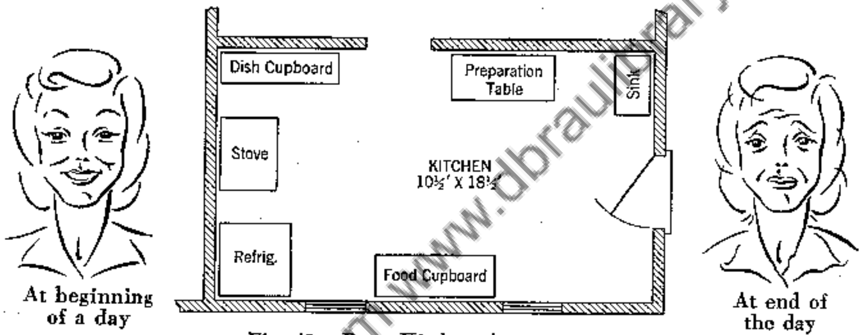


Fig. 42.—Poor Kitchen Arrangement.

Range: Should be located with preparation and serving counters near-by, and should not be too close to the refrigerator.

Counter or auxiliary table: Should be to the left of the refrigerator (since 90 per cent of the refrigerators have hinges on the right side), should be near the range, and should be near the cupboards containing the serving dishes.

Cupboards: Should be near the serving counter for serving dishes; possibly above the refrigerator for groceries used infrequently; near the sink for storage of glass, dishes, and cleaners; and near the preparation counter for food stuffs.

Drawers, shelves and bins: Should be below the preparation counters for storage of flour, sugar, spices, and utensils used in preparation.

In general, it may be said that cupboards and counters should be built where they will be available for ingredients and equipment to be used at the spot. Also, repetition of small items in different work centers is well worth the small added expense for the number of steps saved.

It is suggested that the pupil be permitted to omit or add to the list of furnishings in his kitchen in order to achieve better arrangement, if possible.

Project 18—First Floor Plan

In housing, it has always been man against the elements. The discovery of fire and the comfortable feeling conveyed by the heat prompted man to have walls around his fire in order that he would be more comfortable. Sometimes the walls were those of a cave or crude walls of mud or sod or skin; nevertheless, he eventually has evolved the relation of the fire and the walls into many excellently constructed and fine appearing homes.

The first house naturally consisted of one room having a place provided for a fire, or—as we may say—a fireplace. The rooms must

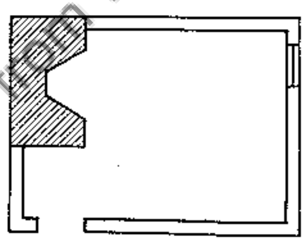


Fig. 43.—Plan of Early One-Room House.

have varied in size and shape, with the fire located in the center in each case. After it was seen that a place for the fire could be constructed near the wall, such an arrangement was probably adopted to afford more freedom of movement about the room.

In the beginning, openings for doors and windows were probably very few. A probable plan of an early one-room house is shown in Fig. 43. The fireplace was probably massive because of the crude craftsmanship and material available at the time of building.

Before long in man's development he felt the need for another room. This need was met in two ways. One was to build a room

Fig. 44.—Two-Story House.

above the original room, as shown in Fig. 44. The single chimney served for a fireplace in each room; and the upper room was reached first by a ladder and later by a staircase, usually located alongside the chimney. Sometimes, rather than add a room above, a room was added to the end, as indicated in Fig. 45. Again, one chimney served both fireplaces.

It was possible to provide four rooms by having two rooms added alongside of or above the original rooms, with the large chimney taking care of all four fireplaces.

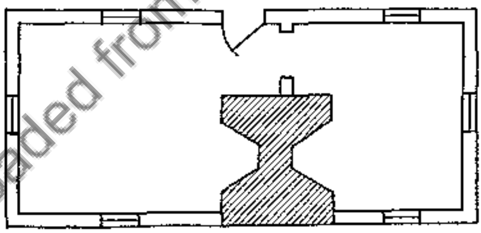


Fig. 45.—Two Rooms on One Floor.

Later constructions provided for even more rooms. One means was to extend the rear roof down to the height of the ceiling of the first floor and to tuck rooms under it—usually three of them. This gave somewhat of a lean-to effect to the appearance of the house, as shown in Fig. 46. The house here represented contained seven rooms, five of which had fireplaces served by one large chimney.

The most general larger house was, in reality, two houses in one with a long hall running between them. This arrangement made it necessary to have two chimneys arranged in such a way that a fireplace could be had in each of eight large rooms. The stairway in the typical early floor plan shown in Fig. 47 is presumably of the open type. Such a stairway location made possible a widening of the hall at the front entrance.

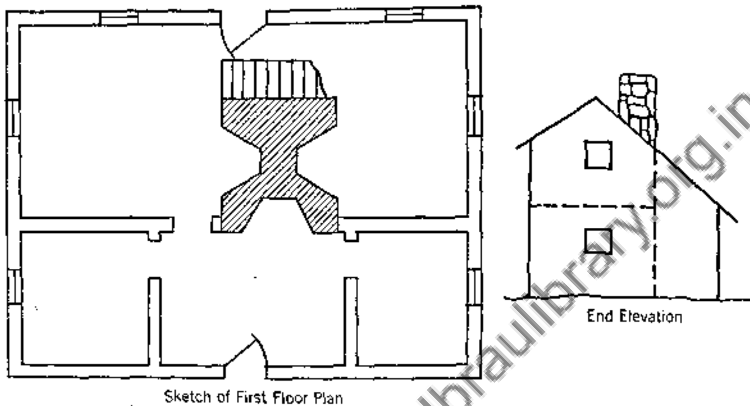


Fig. 46.—House with Several Rooms.

By using brick and stone masonry, it was found that chimneys could be made as part of the walls; hence, with this type of construction it was not necessary to build a large center chimney. Typical plans of early houses of this type are shown in Fig. 48,

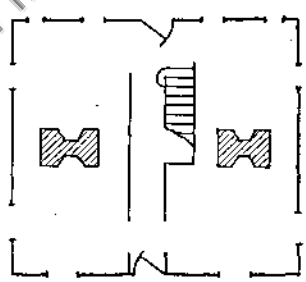


Fig. 47.—House with Interior Chimneys.

The types of plans thus far shown would include a majority of the early English Colonial homes, with the exception of the southern mansions, which were usually built of brick or stone and had wings. Many well-known southern mansions, which are famous

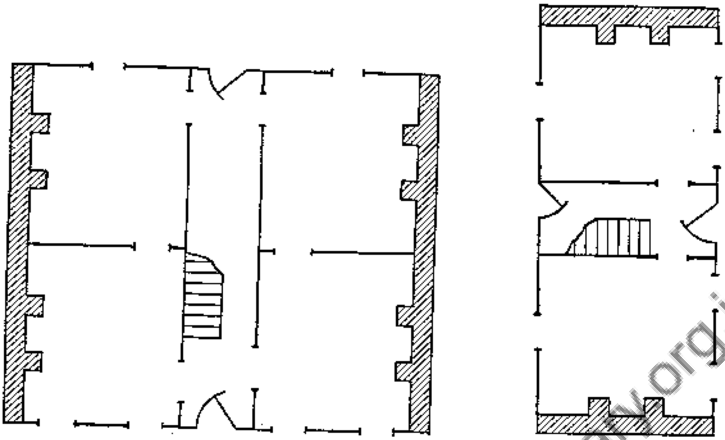


Fig. 48.—Chimneys Made as Parts of Walls.

in history, are of this type. Examples of this type may be found in history textbooks and reference books. The main portion of the building was used by the family, while the wings were used for the preparation of foods and for storage. In some cases, slave quarters were also located in the wings. The larger center chimney in Fig. 49 is of unusual design. How many fireplaces are included in the first floor plan of this home?

In Fig. 50 is shown the plan of the main floor of Independence Hall.

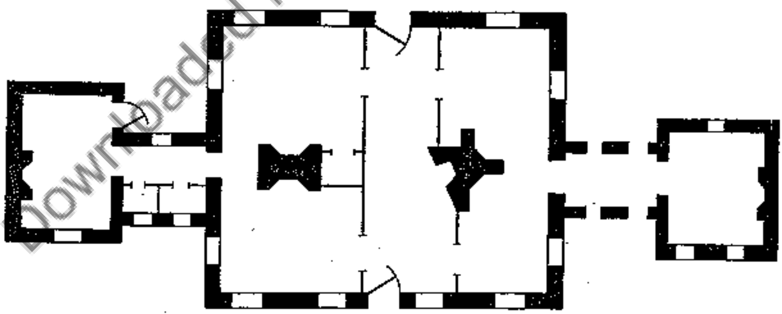


Fig. 49.—Chimneys of Unusual Design.

Modern heating facilities make it no longer necessary to plan a house around a chimney or chimneys; nevertheless, many of our modern house plans have much in common with those previously mentioned in this unit. One of the more modern trends in house

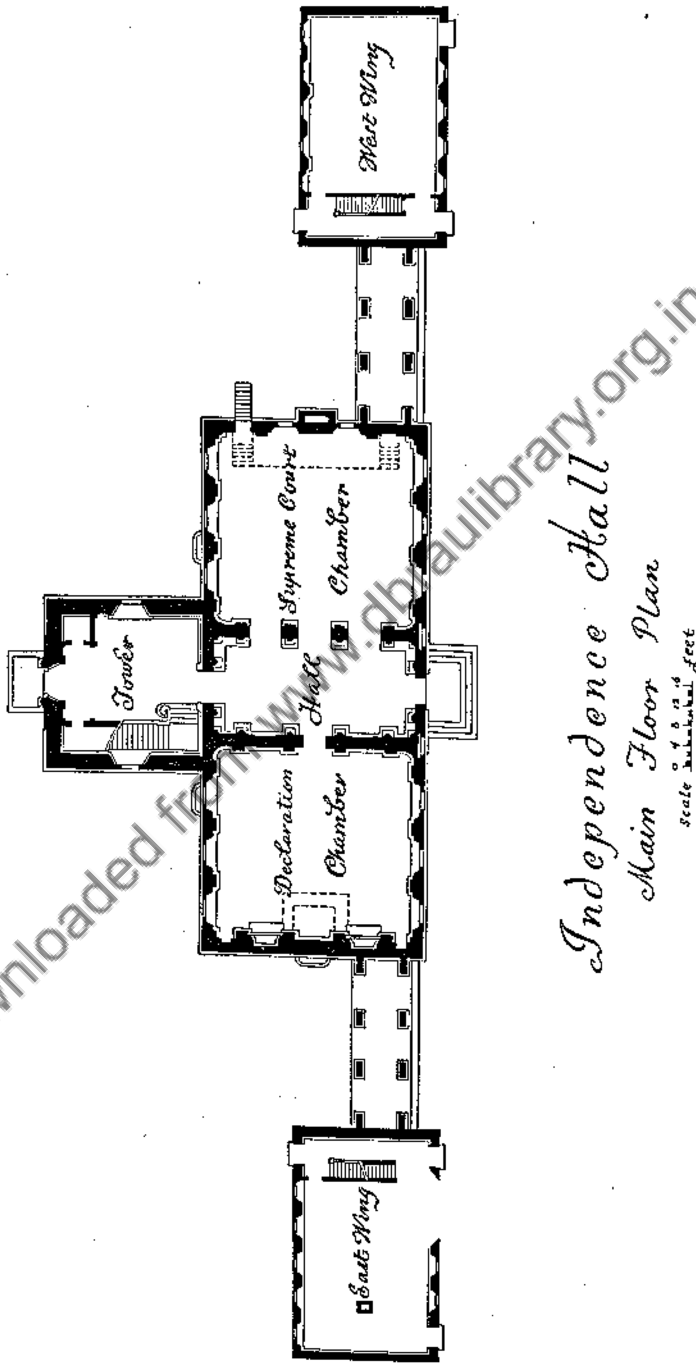


Fig. 50.—Main Floor of Independence Hall.

planning locates the heating and air-conditioning units and other service units in the center of the house, and outlets lead from them to the various rooms which are of course located around the smaller service room. However, as a general rule, the rooms in our houses of today are more irregular in shape and their relative positions are more varied than were those of earlier days. A study of the first floor plans of the homes in any block will find few if any repetitions

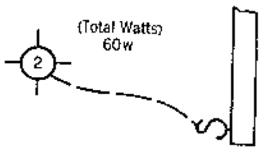


Fig. 51.—Symbols for Electric Outlets.

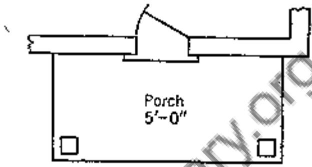


Fig. 52.—Simple Porch.

(with few exceptions); nevertheless, you will find many of those plans related to the earlier floor plans.

The title of the drawing required for Project 18 is "First Floor Plan of My Home." It will be quite similar to the drawing required in Project 17, but this project will include the entire first floor, rather than one room as was the case in the last project.

This first floor plan will include all rooms, halls, closets, porches, and portions of stairways leading up or down from the first floor. No furnishings will be included.

Fig. 53.—Porch with Railing.

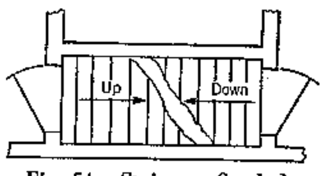


Fig. 54.—Stairway Symbol.

The usual symbols will be used to show the windows, doors, and other details. Electric outlets in the ceiling, walls, and floor will be shown. Broken lines will be used to connect the electrical outlets with the switches that control them, as shown in Fig. 51. The broken lines should be drawn as irregular curves; they *do not represent the paths of the wires*, but merely indicate which switch controls each outlet.

Of course, the walls of the house are denoted by double lines; but the porch symbol makes use of a single line located at the outside floor limits. The porch shown in Fig. 52 is 5 ft wide and has a square column in each of the outermost corners.

The porch symbol shown in Fig. 53 represents a porch that is 6 ft wide with a railing around it and steps leading from it.

To most people, drawing a symbol to represent stairways—especially when one leading to the second floor and another leading to the basement are in the same stairwell—would be a rather perplexing problem. However, this or any other combination of stairways can be represented quite clearly by showing a portion of each stairway involved. In Fig. 54 is a symbol showing the most general arrangement of stairways within a house.

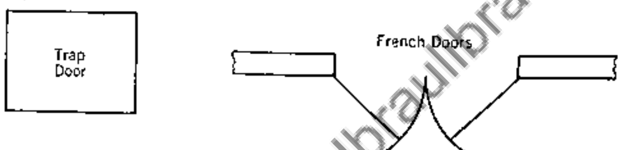


Fig. 55.—Special Symbols.

It may be necessary, in drawing complete floor plans of some homes, to show locations of parts or appliances for which symbols have not been given. When this situation arises, show by outline the space required and place a short notation in or alongside of the outline, telling what it represents, as in Fig. 55.

The only dimensions which will be shown in the first floor plan for Project 18 will be the sizes of each room and the widths of the hallways and porches. These will be shown in the manner in which the kitchen size was shown in Project 17. The name of the room or the word hallway or porch is to be shown above the size, lower-case letters being used except for the first one of each word.

Guide lines should be used for all lettering, and extreme care should be taken to make all letters of the correct form. *Good lettering is essential to a good drawing.*

IMPORTANT

Save the approved drawing of the first floor plan of your home. It can be used as a source for information needed in later projects.

WORKSHEET NO. 2

A. Answer the following questions by referring to the kitchen floor plan shown in Fig. 56.

1. What is the width of the kitchen?
2. What is the length of the kitchen?
3 to 10. List in numerical order what each of the numbered symbols represents.

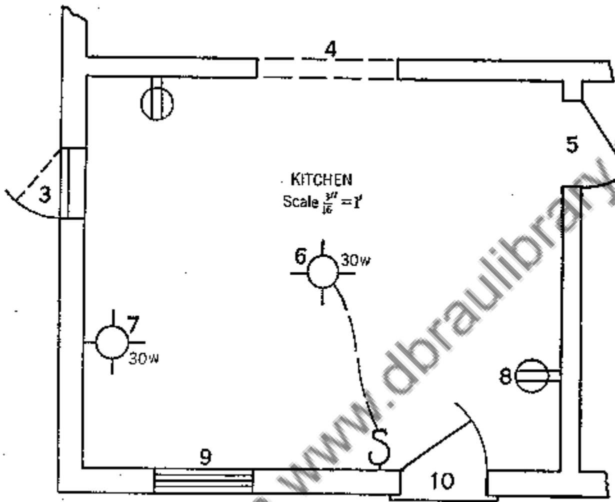


Fig. 56.—Kitchen Floor Plan.

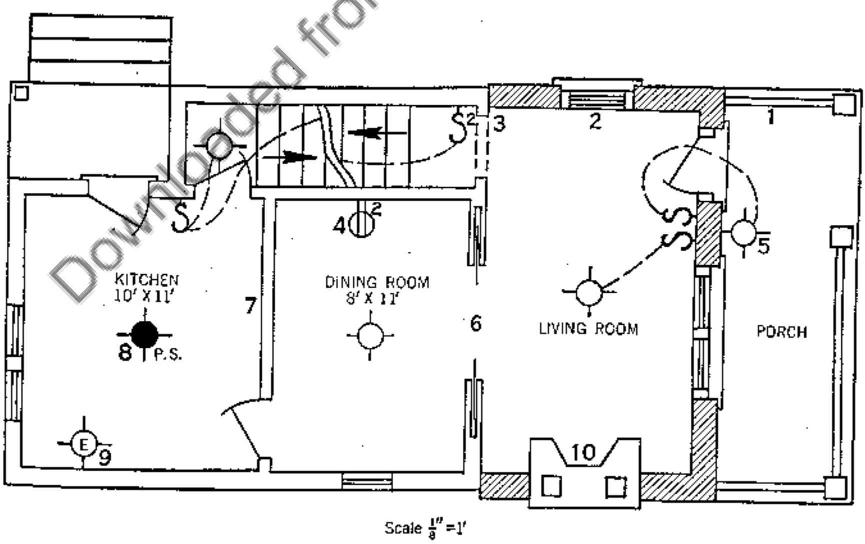


Fig. 57.—First Floor Plan.

B. Answer the following questions by referring to the first floor plan shown in Fig. 57.

11 to 20. List in numerical order what each of the numbered symbols represents.
21. How many windows are located in this first floor plan?
22. What is the width of the front porch?
23. What is the width of the living room?
24. What is the length of the living room?
25. What has been omitted in the symbols indicating the stairways?

Project 19—Kitchen Floor Plan to Simple Specifications

Make a floor plan of a kitchen, size 8′-6″×14′-3″, to the scale of ¾ in.=1 ft. The kitchen is to be rectangular in shape.

The kitchen is to have two exterior walls, two interior walls, two windows, two doors, an electric ceiling outlet controlled by a switch, and any other details it is necessary to add to make the plan that of a complete kitchen.

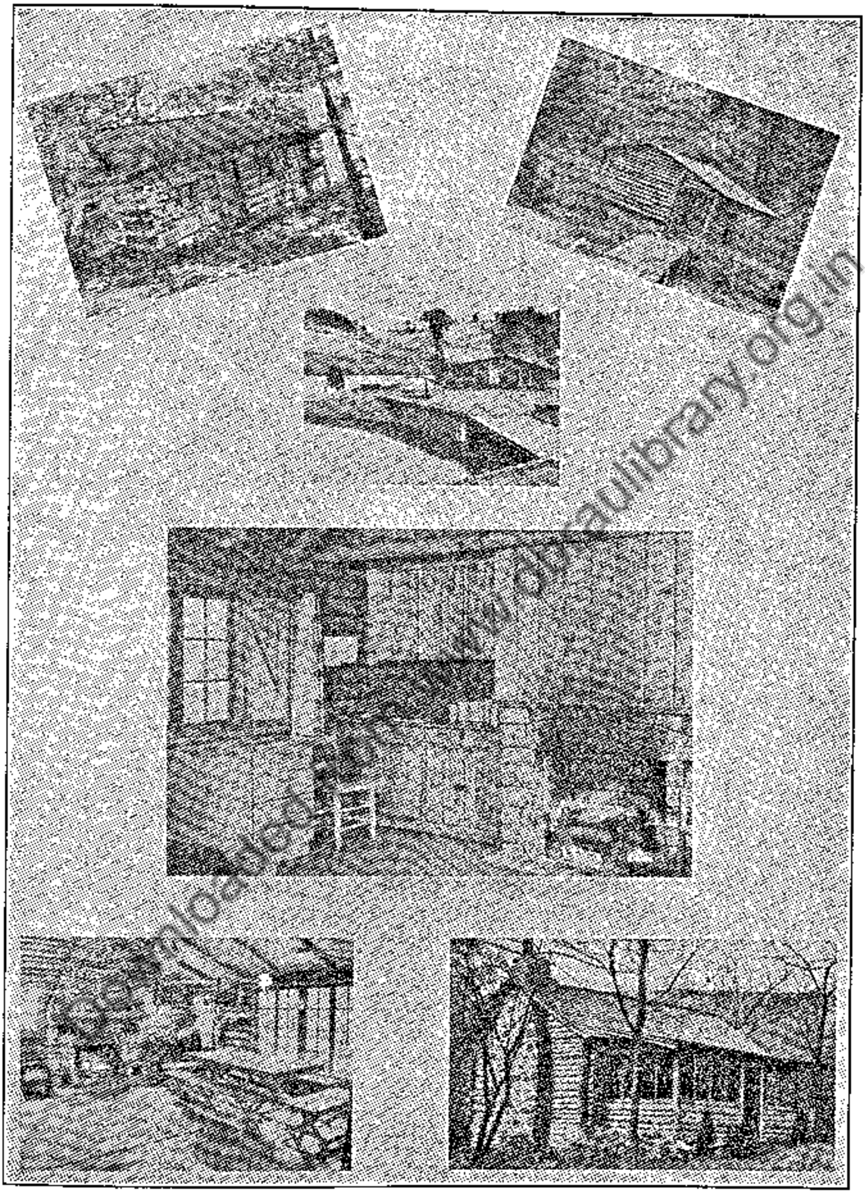
Place the following furnishings in the kitchen:

NAME OF FURNISHING	FLOOR AREA REQUIRED
Stove	2′-0″×3′-0″
Refrigerator	2′-8″×2′-10″
Sink	2′-0″×4′-0″
2 Tables	2′-0″×2′-6″ each
2 Cupboards	1′-8″×2′-6″ each

Project 20—First Floor Plan to Simple Specifications

Draw a rectangle that is 7 in. wide and 12 in. long. This rectangle is to represent the outside of the walls on the first floor of a house, which is drawn to the scale of ⅜ in.=1 ft. Make a complete floor plan that will meet the following conditions:

This first floor contains three rooms, with a stairway leading to the second floor. The house is equipped with electric lights and switches controlling the lights. It is possible to locate windows on all four sides of the house. The house is to have a small front porch, with steps leading from the side of the porch to the ground level.



(Courtesy of Better Homes and Gardens)

Fig. 58.—Cabins.

Project 21—Cabin Floor Plan

Make an original floor plan of a cabin that is to be located in the mountains or on the shore of a body of water and is to be used for vacationing purposes. Several cabins are shown in Fig. 58.

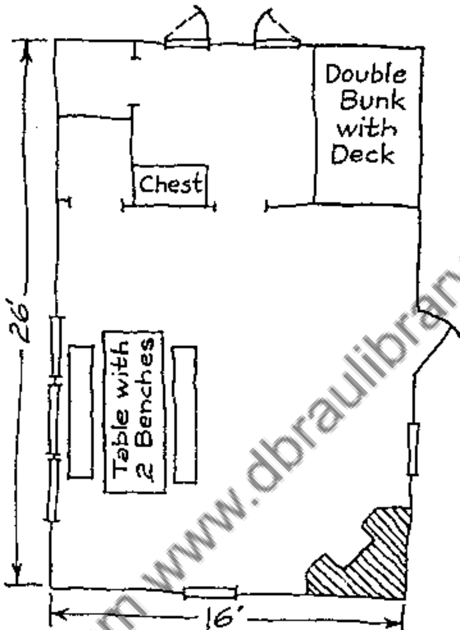


Fig. 59.—Rough Floor Plan of Cabin.

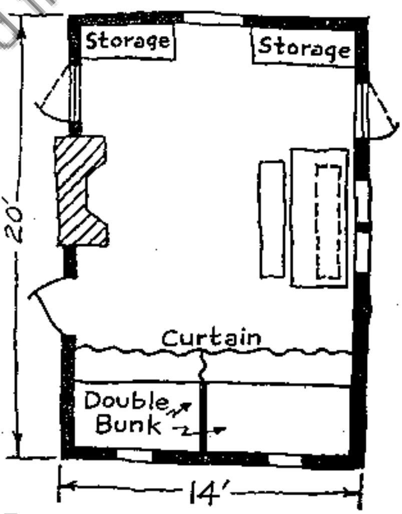


Fig. 60.—Rough Floor Plan of Cabin.

The cabin must be not less than 12 ft×20 ft and not more than 16 ft×30 ft in over-all dimensions.

It must contain a fireplace.

It must have sufficient furnishings to accommodate four people. Sleeping quarters are to be included.

The cabin may contain either one room or two rooms.

It may be assumed that the cooking can be done outside of the cabin.

Before beginning the scale drawing of the floor plan of the cabin, submit a "rough sketch" to the teacher for approval. Two sample "rough sketches" are shown in Figs. 59 and 60.

Project 22—Floor Plan of One-Room Clubhouse

Make a complete floor plan for a one-room clubhouse that will accommodate six to eight fellows in their leisure time. Furnishings are to be placed on the floor plan.

Project 23—Layout for a Filling Station

Make a plan for a filling station. The station is to be located on a corner lot which is 50 ft×50 ft. On the plan locate three gas pumps, a greasing platform, and an office with rest rooms.

Project 24—Kennel Floor Plan

Make a floor plan for a kennel that is to be built in and around a one-story building 17 ft×18 ft in size. The kennel is to have six stalls. Each stall is to be at least 5 ft square. Individual runways are to be placed outside of the building, with an opening to each from some one of the stalls. A stove should be located in the kennel.

Project 25—Floor Plan of Athletic Clubhouse

Make a floor plan of an athletic clubhouse to be located conveniently with respect to the football field. On the floor plan include a shower room and a dressing room for both the home team and the visiting team. Also, include a dressing room for the coaches, a first-aid room, and a room that is accessible from the home dressing room and in which equipment may be kept safely.

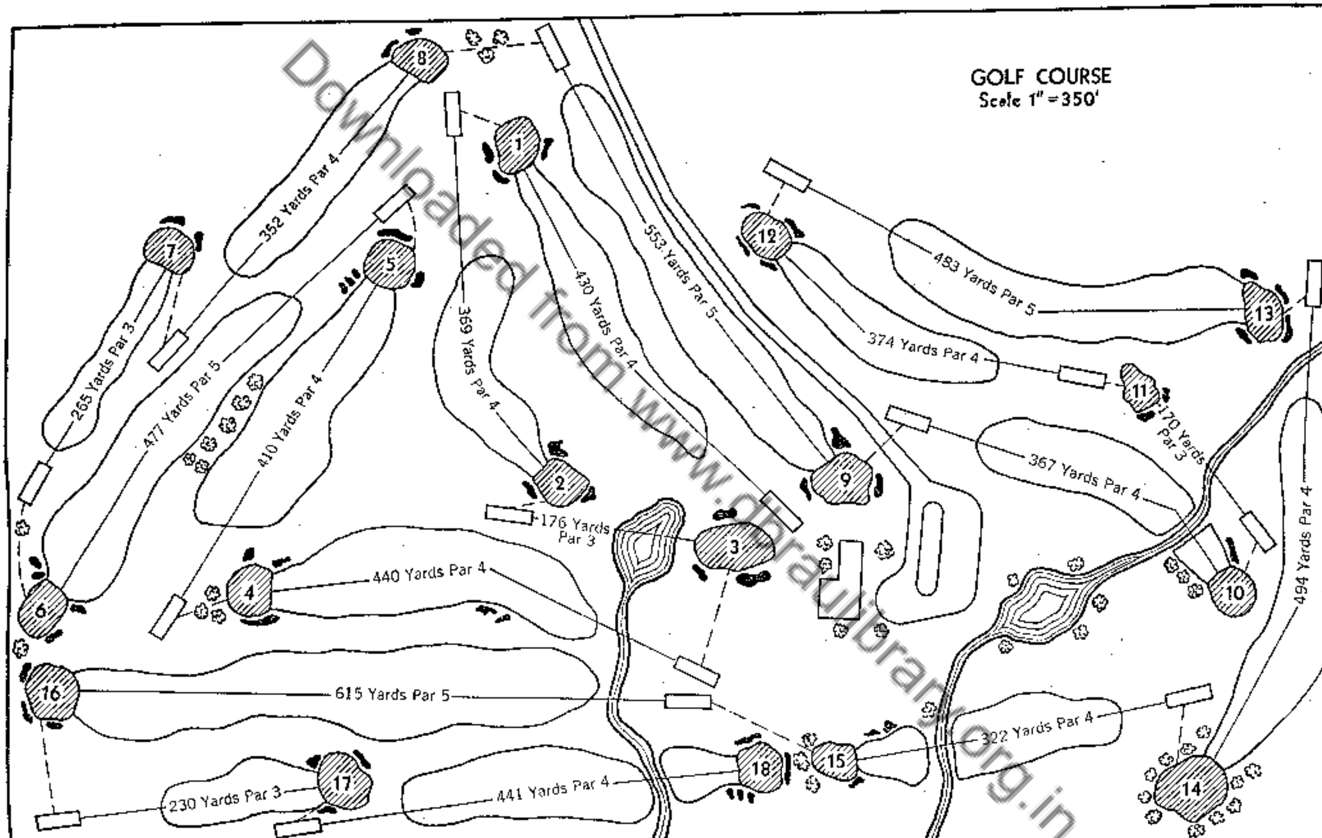


Fig. 61.—Map of a Golf Course.

CHAPTER IV

MAPS OR TOPOGRAPHIC DRAWINGS

Specific Aims:

To teach the use of the "engineer's scale."

To teach the use of the protractor.

To give a concept of surveying practice.

To enable the pupil to make maps from survey notes.

To enable the pupil to make maps of existing plots from his own measurements.

To give an appreciation of contour maps and their uses.

Project 26—Use of the Engineer's Scale

Up to this time, the triangularly shaped wooden scale that has been used was the architect's scale; for most of the work in this project, the engineer's scale will be used.

On the engineer's scale the inches are divided into 10, 20, 30, 40, 50, and 60 equal parts.

The sets of graduations on the architect's scale have been designed so that feet and inches can be measured directly. The sets of graduations on the engineer's scale make it easy to lay out decimal distances, or comparatively long distances, such as, .9 mile, 3.67 ft,

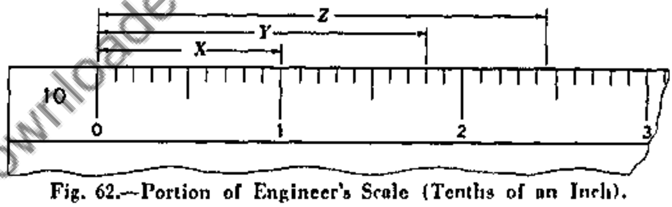


Fig. 62.—Portion of Engineer's Scale (Tenths of an Inch).

and 1620 ft. Each pupil should be able to recognize and become familiar with the uses of each of these measuring instruments.

The set of graduations marked by a "10" in the margin has each inch divided into ten equal parts, as indicated in Fig. 62.

If the scale of 1 in. = 10 ft is used, the distance X represents 10 ft and the distance Z represents 24.5 ft. This same set of graduations may be used for measuring distances represented to many other scale equalities. The following table lists a few of the other scale equalities that make use of this same set of graduations, and shows the distances represented by X, Y, and Z when each of the scale equalities listed is used.

	Distances		
Scales	X	Y	Z
1 in. = 100 ft	100	180	245
1 in. = 1000 ft	1000	1800	2450
1 in. = 1 ft	1	1.8	2.45

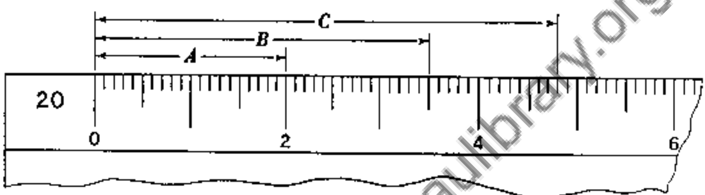


Fig. 63.—Portion of Engineer's Scale (Twentieths of an Inch).

QUESTIONS

A. Answer the following questions about the set of graduations shown in Fig. 63, which was copied from an engineer's scale.

1. The inch was divided into how many equal parts?

2 to 10. Supply the information necessary to fill in the following table. Identifying numbers are placed before each of the blank spaces.

	Distances		
Scale	A	B	C
1 in. = 20 ft	(2) ________	(3) ________	(4) ________
1 in. = 2,000 ft	(5) ________	(6) ________	(7) ________
1 in. = 2 miles	(8) ________	(9) ________	(10) ________

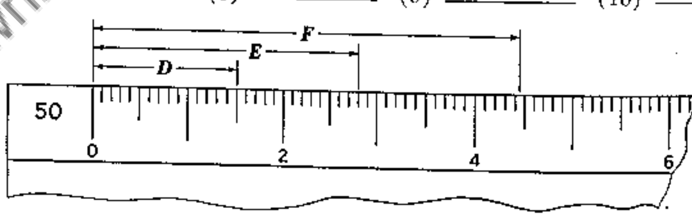


Fig. 64.—Portion of Engineer's Scale (Fiftieths of an Inch).

B. Answer the following questions by referring to the set of graduations of the engineer's scale represented in Fig. 64. On the actual scale each inch is divided into 50 parts, as indicated by the number 50 at the left end.

11 to 19. Supply the information necessary to fill in the following table.

SCALE	DISTANCES D	E	F
1 in.=50 ft	(11) ________	(12) ________	(13) ________
1 in.=500 ft	(14) ________	(15) ________	(16) ________
1 in.=5 miles	(17) ________	(18) ________	(19) ________

20. Could this set of graduations be used to lay out distances to the scale of 1 in.=5 rods?

In answering parts C to F, inclusive, draw all lines as horizontal lines starting from a vertical line which you are to locate near the left edge of the paper. In answering parts C and D the architect's scale is to be used.

C. Using the scale of $\frac{1}{2}$ in.=1 ft, draw lines equal to:

(21) 3 ft 2 in. (22) 6 ft $7\frac{1}{2}$ in. (23) 11 ft $5\frac{3}{4}$ in. (24) 8.6 in.

25. Explain how you were able to draw the line required for question 24 by use of the architect's scale.

D. Using the scale of $1\frac{1}{2}$ in.=1 ft, draw lines equal to:

(26) 11 in. (27) 2 ft $8\frac{3}{4}$ in. (28) 4 ft $\frac{13}{16}$ in. (29) 20.35 in.

E. Using the scale of 1 in.=50 ft, draw lines equal to:

(30) 55 ft (31) 267 ft (32) 209 ft (33) $165\frac{1}{2}$ ft

F. Using the scale of 1 in.=5 ft, draw lines equal to:

(34) 7 ft. (35) 12.9 ft (36) 18.35 ft (37) 10 ft $8\frac{1}{2}$ in

G. Drawings are to be made to the following scales. Which of the wooden triangular scales, the architect's or the engineer's, would you use in each of the three cases? Why?

(38) 1 in.=6 ft (39) 3 in.=1 ft (40) 1 in.=1 ft

Project 27—Use of the Protractor

The triangles in an ordinary set of drawing equipment are: (1) a 30-60 degree triangle shown in Fig. 65 and (2) a 45-degree triangle shown in Fig. 66. These triangles are both right triangles, since each contains a right angle (a right angle is formed when a horizontal line intersects a vertical line).

In the 45-degree triangle, you will find that both acute angles (angles less than right angles) are 45° angles; also, the sides opposite these angles are equal.

In the 30-60 degree triangle, the smaller of the acute angles is 30° and the larger is 60°. An interesting fact regarding triangles of this type is that the hypotenuse (*AB* in Fig. 65) is always double the shortest side (*AC*).

Degrees are units of circular measurement, just as feet are units of measurement of length. The number of degrees in a circle (or a complete revolution) is 360. It follows that in one-half of a circle there are 180 degrees; likewise, in one-fourth of a circle there are 90 degrees. A right angle contains 90 degrees.

Using one or the other of the types of triangles usually available, we are able to draw angles of 30°, 45°, 60°, and 90°. Since

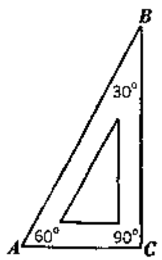


Fig. 65.—30-60 Degree Triangle.

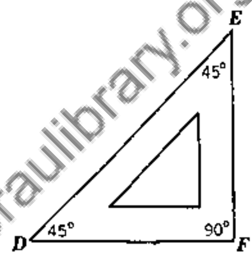


Fig. 66.—45-Degree Triangle.

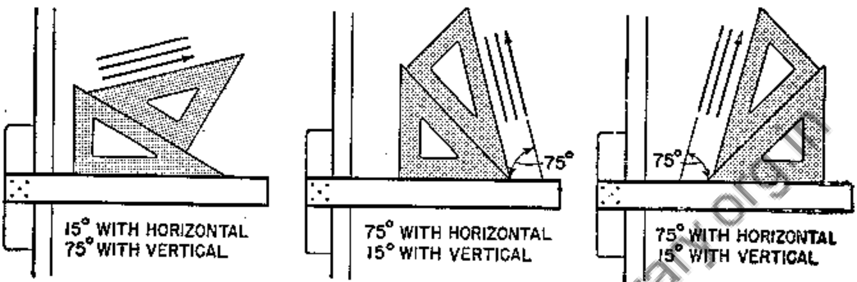
degrees are units of circular measurement, it should not seem strange that we are able to add and subtract them in the same way in which it is possible to add or subtract the length of one board to or from that of another board.

By using the two triangles in combination, it is possible to draw angles of 15° and 75°. There are many ways in which this can be done; three are shown in Fig. 67.

In the diagram at the left the lines make an angle of 15° with the horizontal and an angle of 75° with the vertical. In each of the other diagrams the lines make an angle of 75° with the horizontal and an angle of 15° with the vertical.

Of course it is sometimes necessary to lay off angles other than those angles that it is possible to make by using one triangle or the two triangles in combination. For example, it may be necessary to draw an angle of 67° or an angle of 53°. Neither of these angles can be drawn with the aid of the triangles, but such angles can be drawn by using the protractor.

A protractor is nothing more than a semicircle that is divided into equal divisions. If 180 equal divisions are used, it follows that each division would be equal to 1 degree. What part of a degree does the smallest division on your protractor represent?



NOTE: ONE TRIANGLE IS 45°, THE OTHER IS 30°-60°.
FOR OTHER ANGLES USE A PROTRACTOR

Fig. 67.—Use of T Square and Triangles.

There are two units of circular measurement which are less than a degree. The names of these units will suggest time units. They are the "minute" and the "second." They are not the same units as the units used in the measure of time. In circular measurement, the following table holds true.

	Accepted Notation
60 seconds = 1 minute	$60'' = 1'$
60 minutes = 1 degree	$60' = 1°$
360 degrees = 1 revolution or circle	$360° = 1$ rev.

QUESTIONS

A. How many degrees are there in the following parts of a circle?

(1) $\frac{1}{2}$ (2) $\frac{1}{6}$ (3) $\frac{1}{8}$ (4) $\frac{1}{12}$ (5) $\frac{1}{5}$
(6) $\frac{1}{3}$ (7) 2 (8) $2\frac{1}{2}$ revolutions
(9) $3\frac{5}{8}$ revolutions (10) $\frac{5}{16}$ revolution

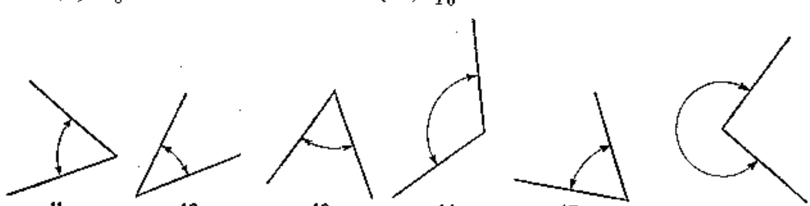


Fig. 68.

B. Measure the angles in Fig. 68 with a protractor and record the number of degrees in each angle.

C. Construct angles equal to each of the following:

(17) 47°

(18) 32°45′

(19) $64\frac{1}{2}$°

(20) One-third of the angle shown in Fig. 69.

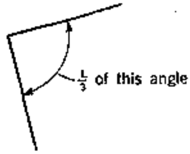


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Fig. 69.

Project 28—Map of a Pond

With some purpose in mind, possibly to locate the edge of a pond, the position of a road that has already been built or is to be built, or the limits of a property, a survey is to be made.

A survey corps, consisting of four or five men, has been sent into the field to the site where the survey is to be made. Upon

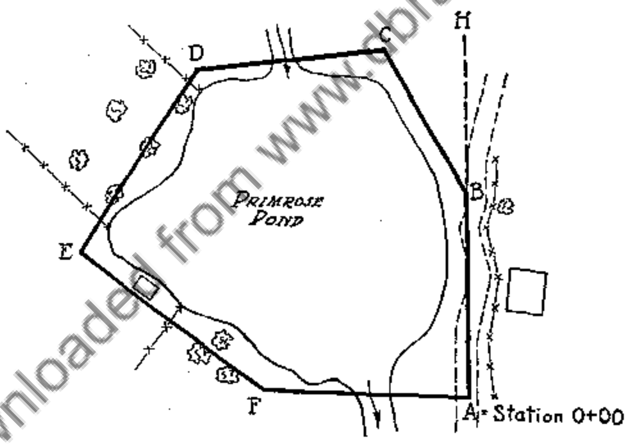


Fig. 70.—Map of a Road.

arrival, the transit (an instrument which may be used for measuring horizontal or vertical angles) is set up at the point from which it is desired that the survey be started. This starting point is known as "Station 0+00."

The transit having been set up at station 0+00 (point *A* in Fig. 70), the corps proceeds with the survey. The transit is pointed in the direction in which the survey is to proceed, and a side of the traverse is measured ahead (presumably to point *B* in Fig. 70).

Perpendicular offsets are measured from points on this survey line (line AB) to the right and to the left in order to locate trees, roads, ponds, and houses or other detail near the survey line.

The transit is then set up at point B, as in Fig. 71, and the angle HBC, the side BC, and station distances and perpendicular offsets to topographic features near line BC are measured. This same procedure is repeated for each angle and side until the purpose of the survey has been accomplished.

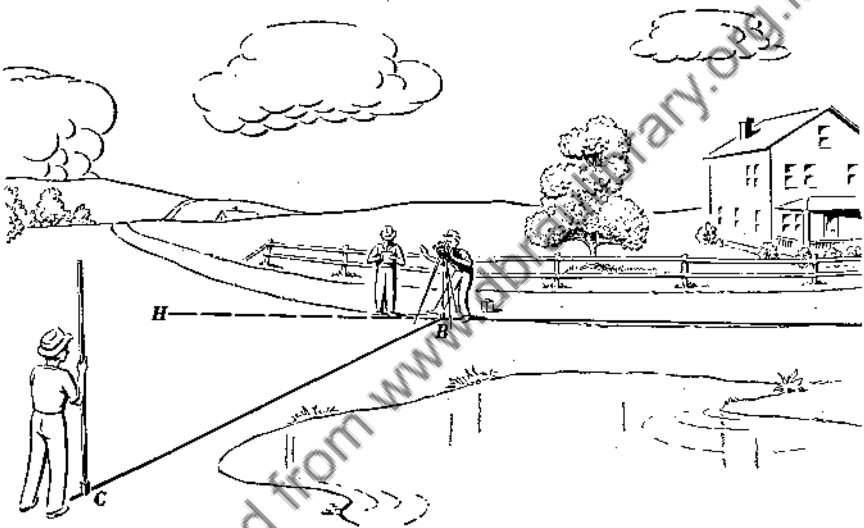


Fig. 71.—Measuring an Angle with a Transit.

The requirements for Project 28 will consist of making a map from field notes, which are typical of those that might be submitted by any survey party. The field notes will include:

(1) a traverse (a system of related lines);

(2) a system of stationing by means of which points on the survey line are located;

(3) perpendicular offsets to topographic features.

Sample field notes are shown in Fig. 72. While at first glance field notes may seem involved, an ample study of the following example and discussion should provide for a thorough understanding.

MAKING THE MAP

The entire traverse is to be plotted with the stations located before an attempt is made to plot any topographic features.

Stations are 100 ft apart (measured along the survey line) and are numbered in consecutive order.

Any point on the survey line may be definitely designated by writing the number of the last station plus the number of feet from that station to the point. For instance, a point 55 ft beyond station 7 would be designated as "Station 7+55." The stationing for a point 32.5 ft beyond station 325 would be "325+32.5."

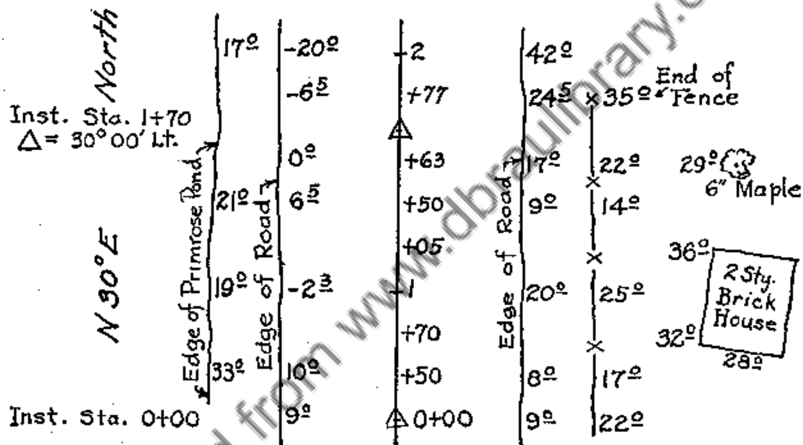


Fig. 72.—Surveyor's Field Notes.

The distance between these two stations would be 32,532.5 minus 755 or 31,777.5 ft. The distance between any two points on the survey line may be determined by subtracting the stationing of the nearer point from the stationing of the more distant point. For determination of these distances, the plus sign may be disregarded and the stationing may be considered as if it were an ordinary number. For instance, station 2+35 is considered as being 235 ft ahead of station 0+00.

It is suggested that the pupil complete Worksheet 3 at this time.

In the field notes, and on the map, each even station (one without a plus distance, as 5+00 or 327+00) is marked by using a short line which is perpendicular to and crosses the survey line, as shown in Fig. 73.

The location of a point where the transit was set up is shown by a triangle drawn around the point.

Points, from which offsets have been measured to topographic features, are shown by recording the distance from the last even station with a plus mark preceding the value, as "+50", "+70", and "+05."

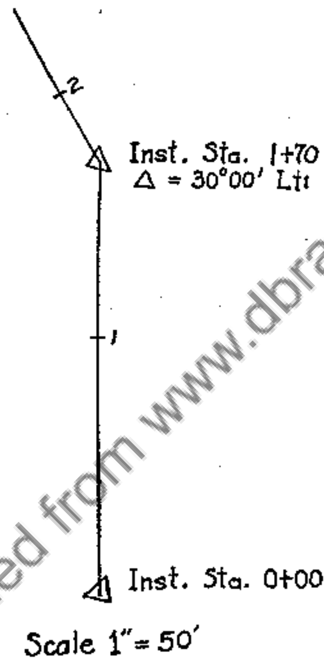


Fig. 73.—Stations on Survey Line.

To both the right and the left of the survey line, notations such as "9$\underline{0}$" and "6$\underline{5}$", are to be found. They are located near topographic features, such as edges of roads, fences, trees, and houses. The values expressed in the notation are the lengths of perpendiculars measured from the indicated points on the survey line to the topographic features. The first of these notations shows that the edge of the road is "nine and no-tenths feet" to the right of station 1+50; while the "6$\underline{5}$" signifies that the other edge of the road is "six and five-tenths feet" to the left of the survey line at this place.

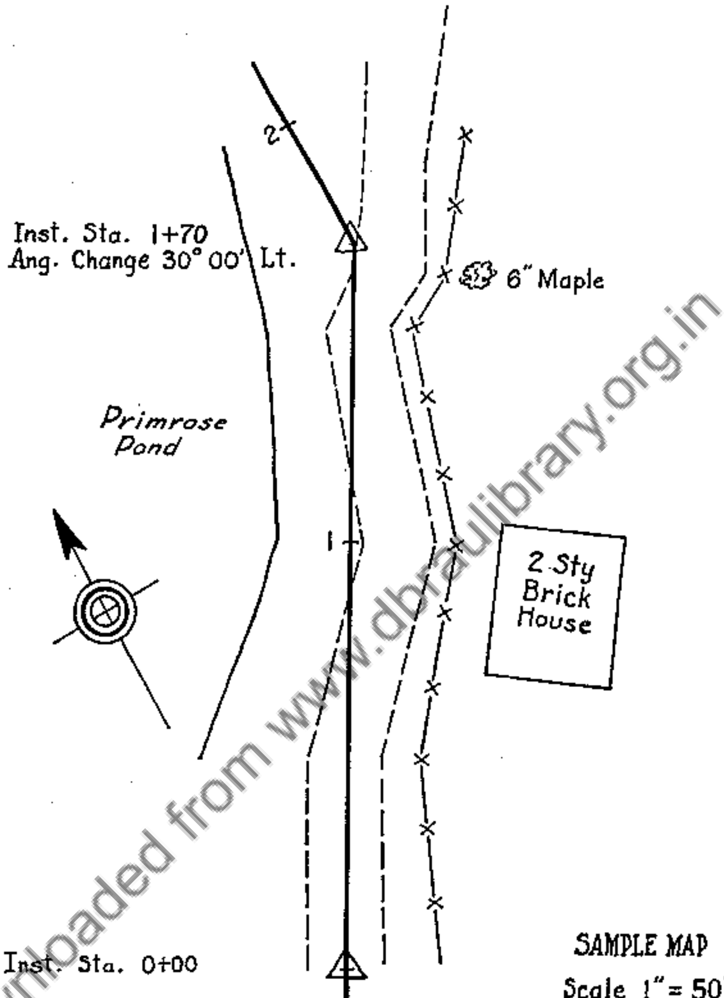


Fig. 74.—Map Plotted from Field Notes in Fig. 72.

At station 1+63, a tree is located 29 ft to the right of the survey line.

At station 1+77, there is a negative offset "−6$\underline{5}$." The negative sign indicates that this offset, shown in the field notes to the left of the survey line, is to be measured to the right. At this station both edges of the road are on the right of the survey line; one edge is 6.5 ft away, and the other is 24.5 ft away.

At station 1+05, a corner of the house is 36 ft to the right.

Offsets are always measured from and perpendicular to the survey line. When an offset is taken at a station at the intersection of two survey lines, it is measured perpendicular to the rear survey line.

Stations at the intersections of survey lines are known as "P.I. stations," that is, stations at the points of intersection.

Check the map shown in Fig. 74, which has been plotted from the field notes given in Fig. 72.

Every map should have an arrow symbol indicating the northerly direction. The position of this arrow may be determined by referring to the observed bearing of any of the survey lines. You will find the observed bearings written vertically between line data (see Fig. 72). These bearings are also used as a check against large errors in recording the angular changes between survey lines.

WORKSHEET NO. 3

A. In each of the following cases, record the distance from the station in the first column to the station in the second column.

	Station	to	Station
(1)	0+00		2+53
(2)	3+00		3+72
(3)	9+11		9+87
(4)	8+27		10+56
(5)	363+12		372+37
(6)	9+62.2		11+00
(7)	15+98.3		26+12.2
(8)	120+01.23		53+73.57

B. Using the information given in the rough sketch in Fig. 75, plot the system of lines accurately to the scale of 1 in.=100 ft.

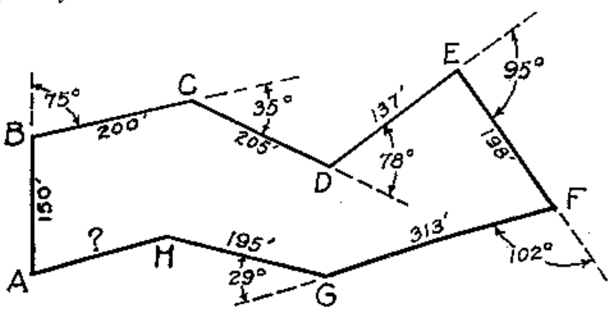


Fig. 75.—Dimensions of Field

C. In Fig. 76 are shown the 16 principal points of a compass. Record the angles between the following points of the compass:

(9) North and east
(10) North and northwest
(11) South and northeast
(12) NNE and ENE
(13) NNW and S

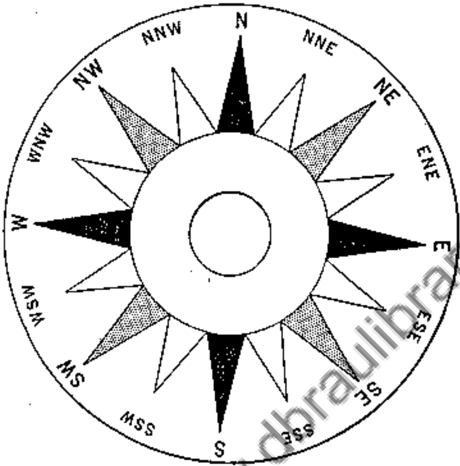


Fig. 76.—Principal Points of the Compass.

D. In surveying practice, bearings are observed on all survey lines in order to check on possible errors in the reading of the angular changes. However, the point system shown in Fig. 76 is not used—a more practical degree method is preferred. See Fig. 77. Point *A* is at N 45° E; *B* is at S 30° E; *C* is at S 82° W; and *D* is at N 15° W.

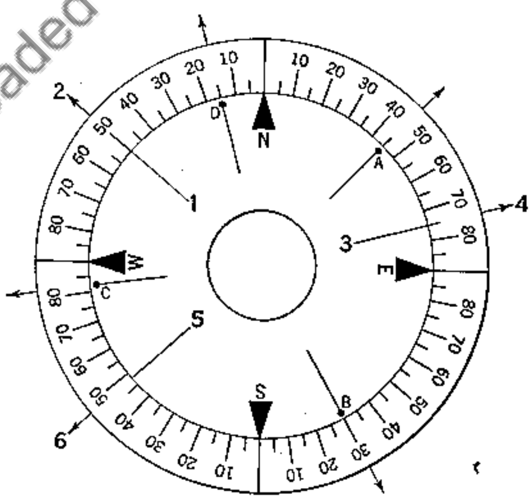


Fig. 77.—Bearings.

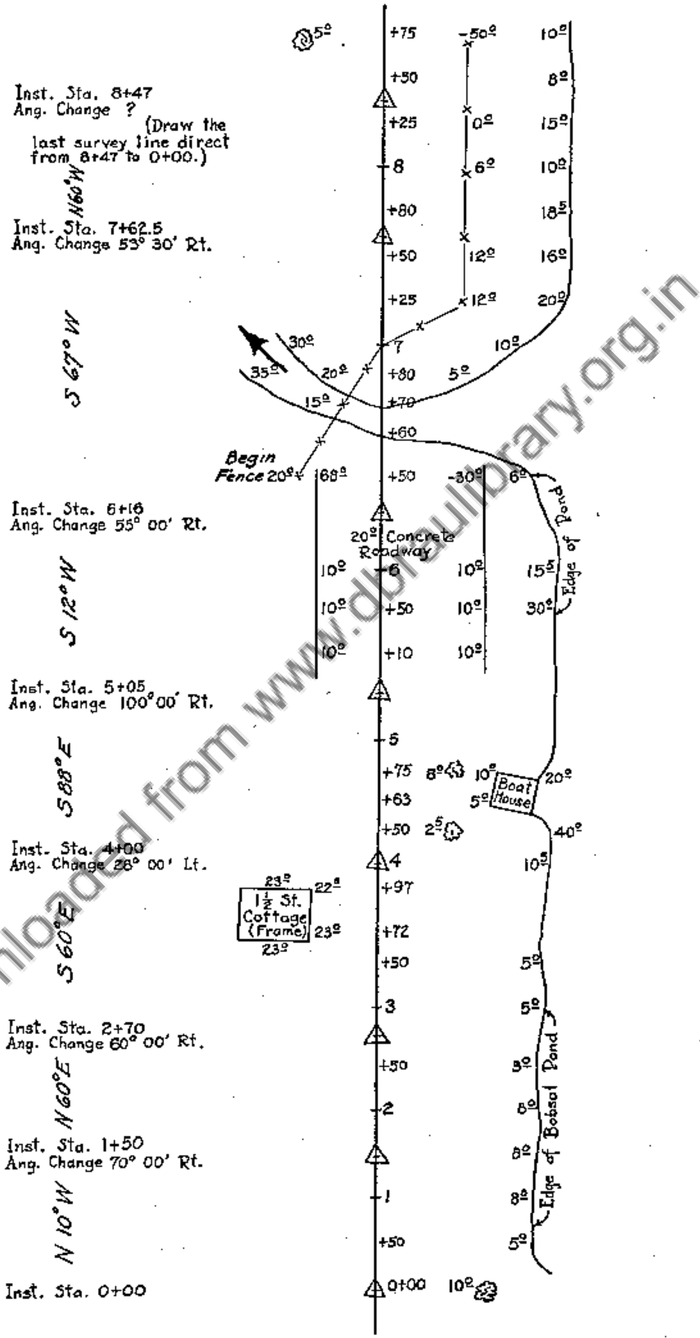


Fig. 78.—Field Notes for Map of Pond.

List the bearings of the following lines:

(14) Line 1–2
(15) Line 3–4
(16) Line 5–6

E. What is the angle formed by each of the following pairs of lines, the bearings of which are as follows? (Hint: In each case make a sketch.)

(17) S 25° W and S 37° W
(18) N 73° E and S 22° E
(19) S 13° W and N 11° E
(20) N 52° W and S 39° E

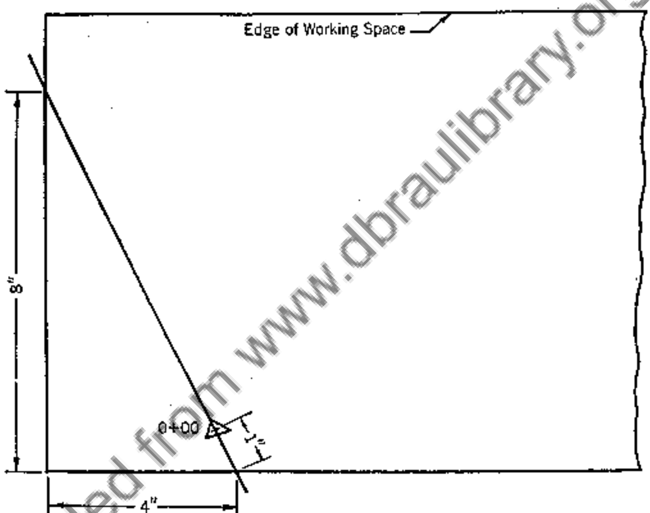


Fig. 79.—Location of Starting Point of Survey.

MAP FOR PROJECT 28

The drawing required for Project 28 is a map of a pond from the survey notes shown in Fig. 78.

The drawing in Fig. 79 gives the information for determining where to begin and for establishing the direction of the first of the survey lines. This information is provided in order that the map will fit within the working space of the regular sheet layout.

The map will be drawn to the scale of 1 in. = 30 ft.

Record on your map, near each intersection of survey lines, the P.I. station and the angular change at that point. Make the height of the space for the lettering equal to $\frac{1}{8}$ inch.

When the traverse is completed, record near station 0+00—using similar lettering—the equality of the traverse as of that point. The equality will be arranged as follows:

0+00 Ahead=9+? Back

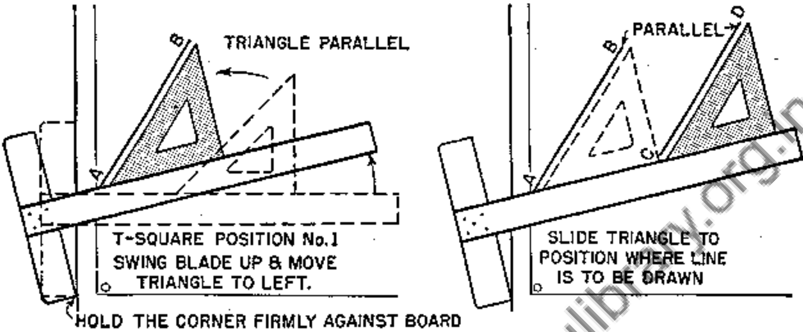


Fig. 80.—Arrangement for Drawing Parallel Inclined Lines.

DRAWING PARALLEL AND PERPENDICULAR LINES

While making the map of the pond, it will be necessary to draw lines through given points parallel to existing lines. Fig. 80 suggests a method for drawing such lines. Place the triangle and the T square in the positions shown with the edge of the triangle coinciding with the existing line *AB*. Move the triangle along the edge of the T square to the position where you desire to draw the line *CD* parallel to the existing line *AB*.

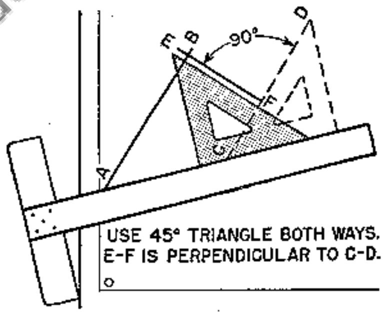


Fig. 81.—Arrangement for Drawing Perpendicular Lines.

Quite often it will be necessary to draw lines through given points that are perpendicular to existing lines. Fig. 81 shows the arrangements for drawing such lines. To draw lines perpendicular to the parallel lines *AB* and *CD*, first place the triangle and the T square so that the hypotenuse of the triangle coincides with either *AB* or *CD*. Then turn the triangle so that the side which was not in contact with the edge of the T square is now held against the T square. Draw the line *EF* along the hypotenuse of the triangle. The line *EF* is perpendicular to lines *AB* and *CD*.

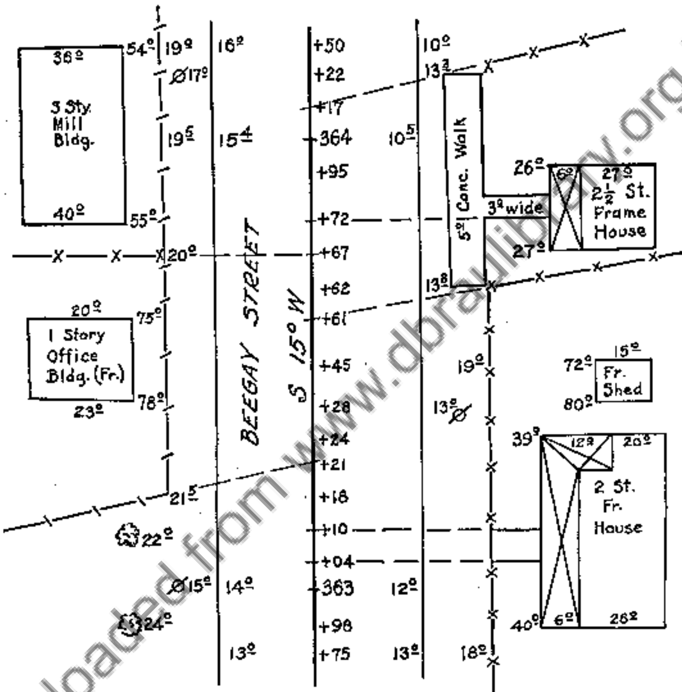


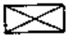
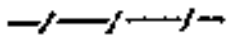
Fig. 82.—Field Notes for Street.

Project 29—Map of a Street

In this project typical survey notes of a portion of a city or village street are provided, as in Fig. 82. These notes are only a small part of a large survey. They include only those notes taken on a part of a single straight survey line.

Extensions of various detail lines have been used to simplify the notes. These extensions show where the detail lines, if extended, would intersect the survey line and are a means of definitely locating the positions of these lines of detail.

New symbols in use are:

ø telephone pole
 porch
 iron fence

Place the survey line on the vertical center line of the working space with station 362+75 located ½ in. above the top of the title block. Use the scale of 1 in. = 20 ft.

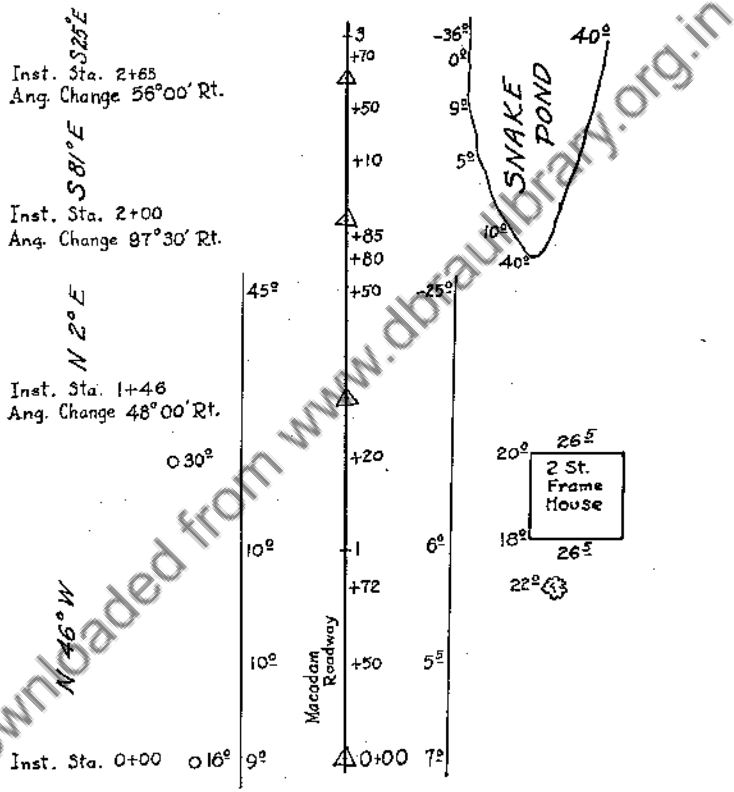


Fig. 83.—Field Notes in Vicinity of Snake Pond.

Project 30—Map in Vicinity of Snake Pond

Plot the survey notes shown in Fig. 83 on a sheet of paper, size 8½ in. × 11 in. Locate station 0+00 by measuring 3 in. from the left edge and 1 in. from the bottom of the working space. The first line of the traverse is a vertical line through station 0+00. Use the scale of 1 in. = 30 ft. This is not a closed traverse.

Project 31—Layout of a Road Around a Pond

Project 31 reverses the procedure that was followed in projects 28, 29, and 30. From the map shown in Fig. 84, a set of survey notes is to be made. A survey line is to be located which will be the center line of a proposed road around the pond. The road is to start at station 0+00, as located on the map, and is to end at point *B*.

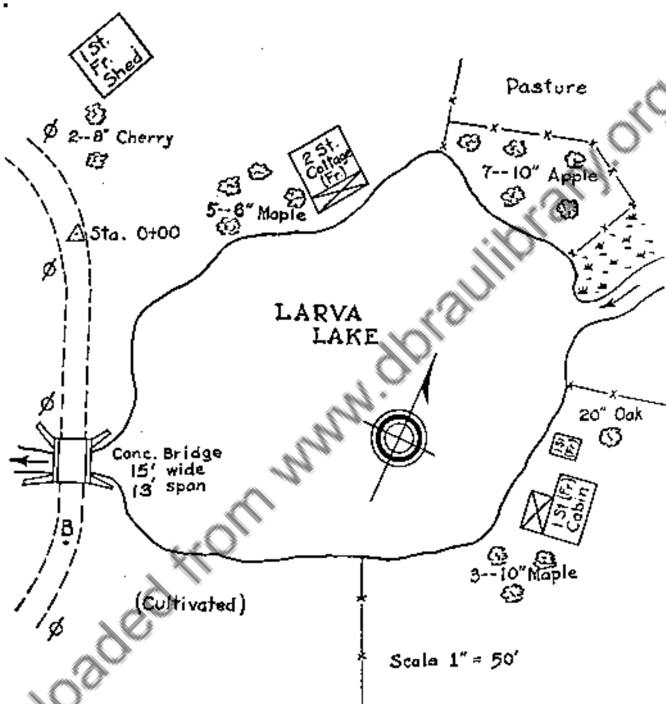


Fig. 84.—Map of Larva Lake.

In the field notes, any topographic feature that might be within 50 ft of the survey line is to be located. The edge of the lake is to be located, regardless of how far from the survey line it may be. The center line of the road is not to be within 25 ft of any building. The road is to be 18 ft in width. If necessary, trees may be removed when building the road. A small bridge will be built over the inlet to the lake wherever the road may cross that inlet.

Make a pencil tracing of the map in Fig. 84. On the tracing locate a survey line that will meet the conditions of Project 31.

Measure the perpendicular offsets from this survey line to the topographic features. On plain tablet paper, make a set of field notes for the survey line you have placed on the tracing.

Project 32—Map of the Lot on Which Your Home Is Located

This chapter thus far has dealt only with maps made from survey notes such as may have been taken by a trained survey corps. Simple measurements may be taken by the pupil and the information may be recorded in the form of field notes. From these field notes, the pupils will be able to make accurate maps of small land areas. The requirements for Project 32 are that the pupil take such measurements as are necessary to enable him to prepare field notes from which he is to make a map of the lot on which his home is located.

The traverse lines may be located along the edge of a walk, along a fence line, along the side of the house, or in any of many possible positions. If possible, it is suggested that the pupil use a long measuring tape; however, if none is available, a 6-ft rule or even a yardstick will suffice.

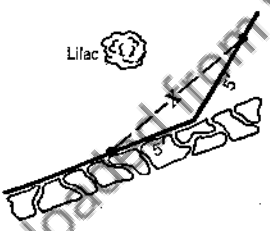


Fig. 85.—Measurement of Angle Without Transit.

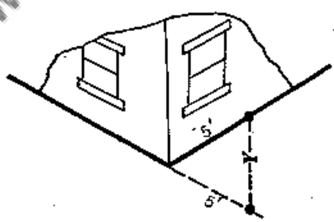


Fig. 86.—Measurement of Angle Without Transit.

Of course, no transit will be available for use in measuring the angles; but there are other ways of accurately determining the angles between two intersecting lines. In Figs. 85 and 86 are shown two ways of doing it. If it is not possible to measure the distance X in Fig. 85, the method indicated in Fig. 86 should be used.

The actual number of degrees in the angular change is to be determined only after the positions of the lines have been plotted on the map. It will be necessary to show the outline of the foundation walls of the house and porch.

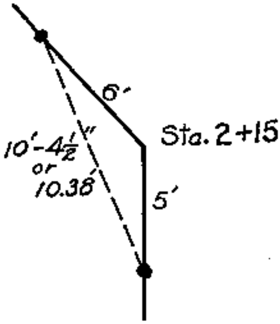


Fig. 87.—Sketch for Laying out an Angle

In the field notes, the usual statements as to angular change are to be replaced by sketches showing the necessary information for laying out each intersection, as shown in Fig. 87.

Submit your field notes to the teacher for approval before beginning the drawing of the map.

Project 33—Map of a Small Park

Make a map of a small park that may be located in the vicinity of your school or home. Locate trees, shrubbery, and benches, as well as any structures.

Project 34—Map of an Athletic Field

Make a map of your school athletic field. Locate fences, playing areas, and structures. Include the baseball diamond, football field, and track.

Project 35—Map of a Roadstand

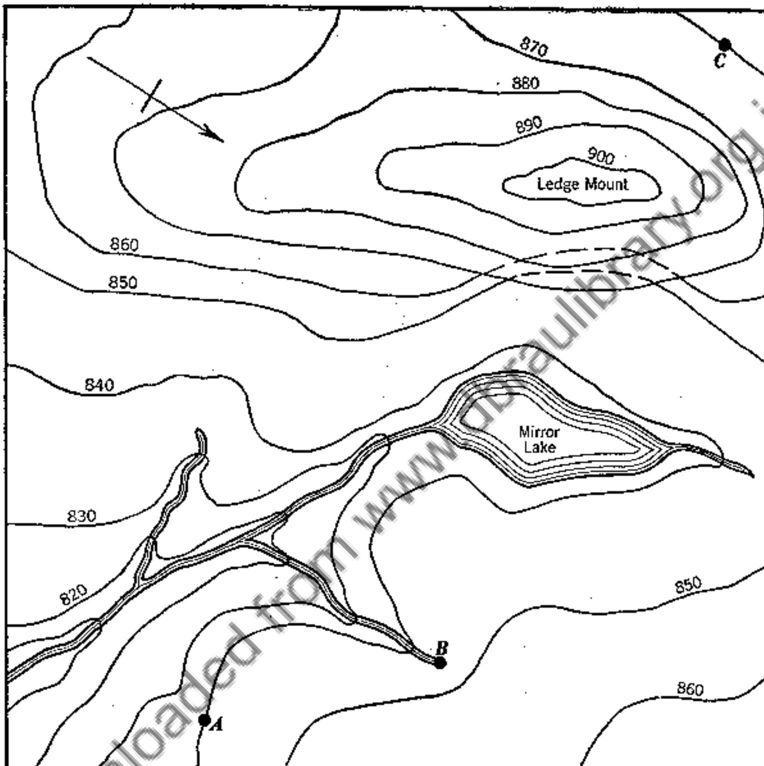
Make a map of a roadstand that sells refreshments and is located on a highway. Assume that there is a grove located to the rear of the roadstand. Plan and draw a picnic-area arrangement in the grove.

Project 36—Contour Map of Mirror Lake

In all surveying practice, all measurements of length are horizontal or are subsequently reduced to horizontal distances. This is necessary because in plan views (maps may be so classed) we are only able to show *relative horizontal sizes and distances.* However, there are maps that show also the form of the surface of the ground. These so-called "contour maps" enable you to find the elevations of points or areas.

Contour maps differ from the maps that we have studied thus far only insofar as they (in addition to the usual details) have contour lines on them. *A contour line passes through points of the same elevation.* Thus, every point on a certain contour line is at the elevation noted on that line.

On the map in Fig. 88 contour lines have been placed at intervals of 10 ft, *i.e.*, at elevations of 900 ft above sea level, 890 ft, etc.



Scale 1″=500′

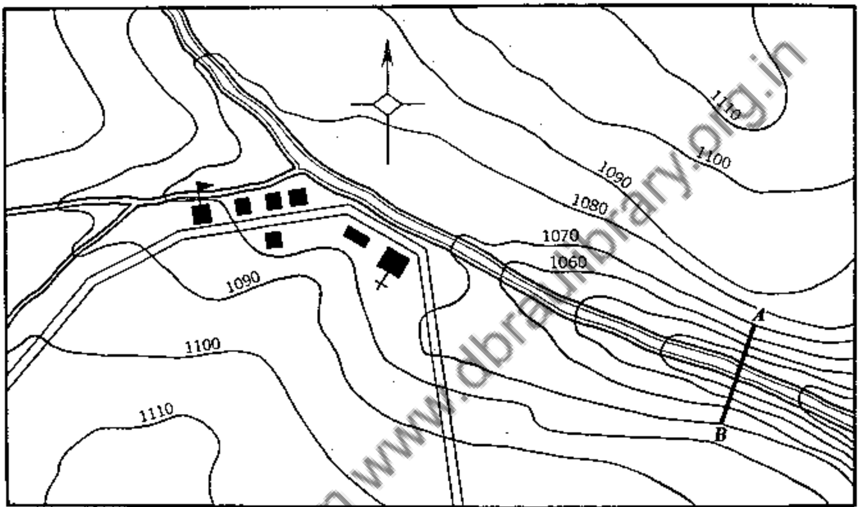
Fig. 88.—Map of Mirror Lake and Vicinity.

QUESTIONS

Refer to Fig. 88 and answer the following questions:

1. What is the elevation of point *A*?
2. What is the elevation of point *B*?
3. What is the elevation of point *C*?
4. Mirror Lake was so named because of the reflections seen on the lake from a near-by overhanging ledge. About how far would you say the edge of the ledge is from the nearest edge of Mirror Lake?

5. Approximately how high is the edge of this ledge above the surface of Mirror Lake?
6. Estimate the elevation at the summit of Ledge Mount.
7. If you were going to climb Ledge Mount, what would be the general direction of your ascent? Why?
8. Explain the peculiar, yet usual, shape of the contour lines in the vicinity of the streams.



OWASCO CREEK near CAMPTOWN
Showing Proposed Dam Location
Scale 1"=400'

Fig. 89.—Location of Proposed Dam.

Project 37—Contour Map of Owasco Creek

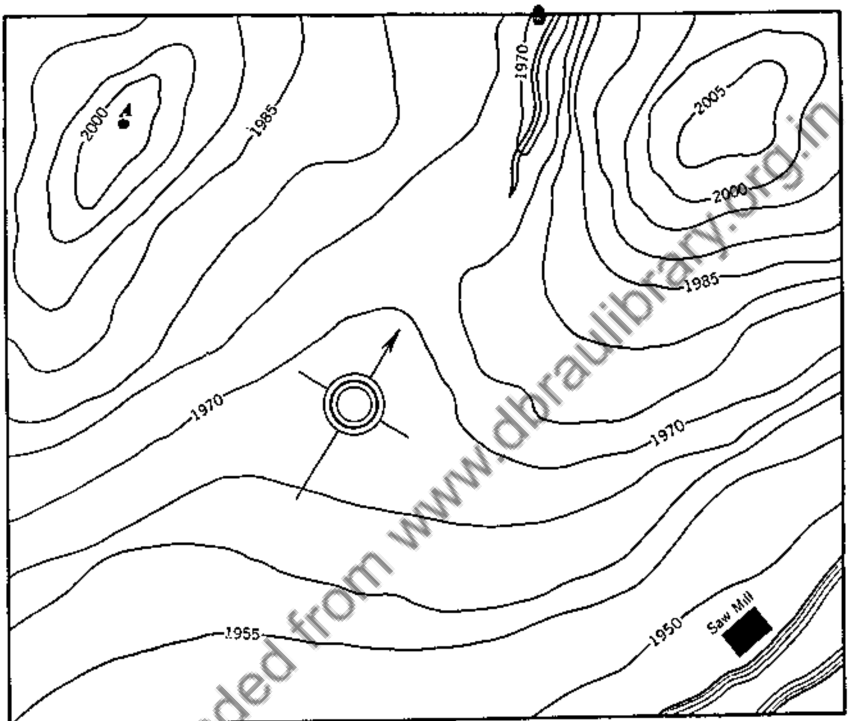
In Fig. 89 is shown a contour map prepared for the purpose of locating a dam on Owasco Creek.

QUESTIONS

Answer the following questions by referring to the contour map of Owasco creek.

1. What is the elevation of the top of the proposed dam?
2. Approximately what would you say was the height of the proposed dam?
3. Why do the old settlers of Camptown strenuously object to any increase in the proposed height of the dam?
4. When the dam is built will it necessitate the relocation of any of the structures or any section of the road? If so, where?

5. What section of the road has the greatest grade?
6. As one walks along the main street of Camptown toward Owasco Creek from the west, does he go uphill or downhill?
7. In time of flood, how high would you expect Owasco Creek to rise before Camptown was inundated?



Scale 1″=200′

Fig. 90.—Contour Map for Project 38.

Project 38—Sawmill Road

Make a pencil tracing of Fig. 90.

On the tracing, lay out the center line of a road from point *A* to the sawmill located on the river. Since trucks will be used to haul the logs to the sawmill, the road is not to rise or fall more than 10 ft in any 100 ft of its length and the grades should be much flatter, if possible. Also, the radii of curves should be as large as feasible.

The company operating the mill is to be known as the Twin Peak Lumber Company. Is this name appropriate?

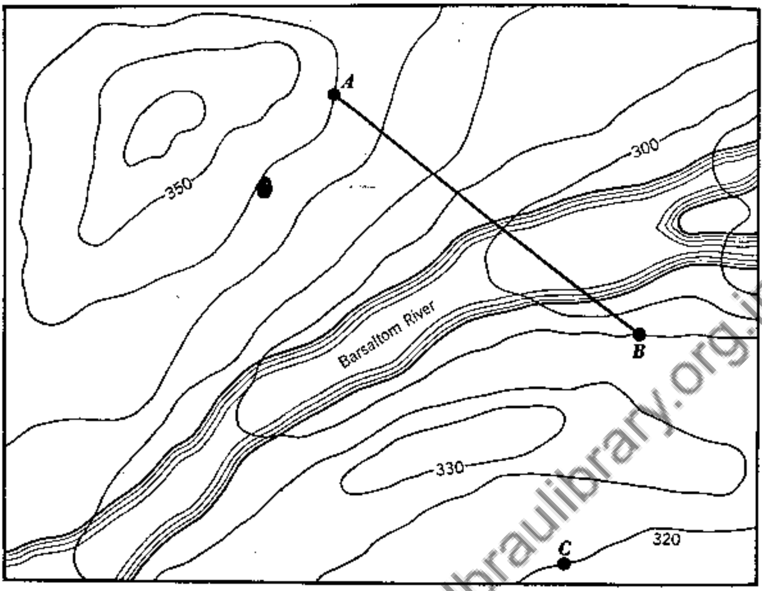


Fig. 91.—Contour Map for Project 39.

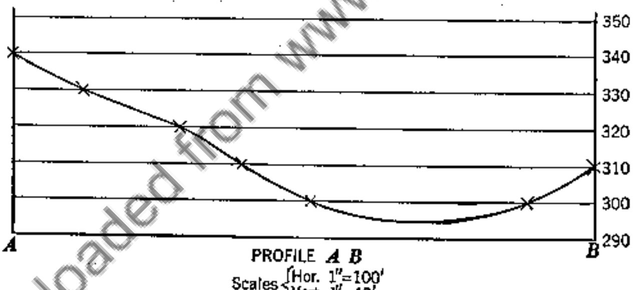


Fig. 92.—Profile.

Project 39—Profile Across Barsaltom River

In Fig. 91 is shown a map, and in Fig. 92 is a profile (which is the outline of the surface of the ground) along the line *AB*. Draw the profile of the ground along a straight line from point *A* in Fig. 91 to point *C*.

Note that two different scales are generally used in drawing a profile. The vertical scale is made larger than the horizontal scale in order that differences in elevation will be more pronounced. Profiles are employed extensively in engineering.

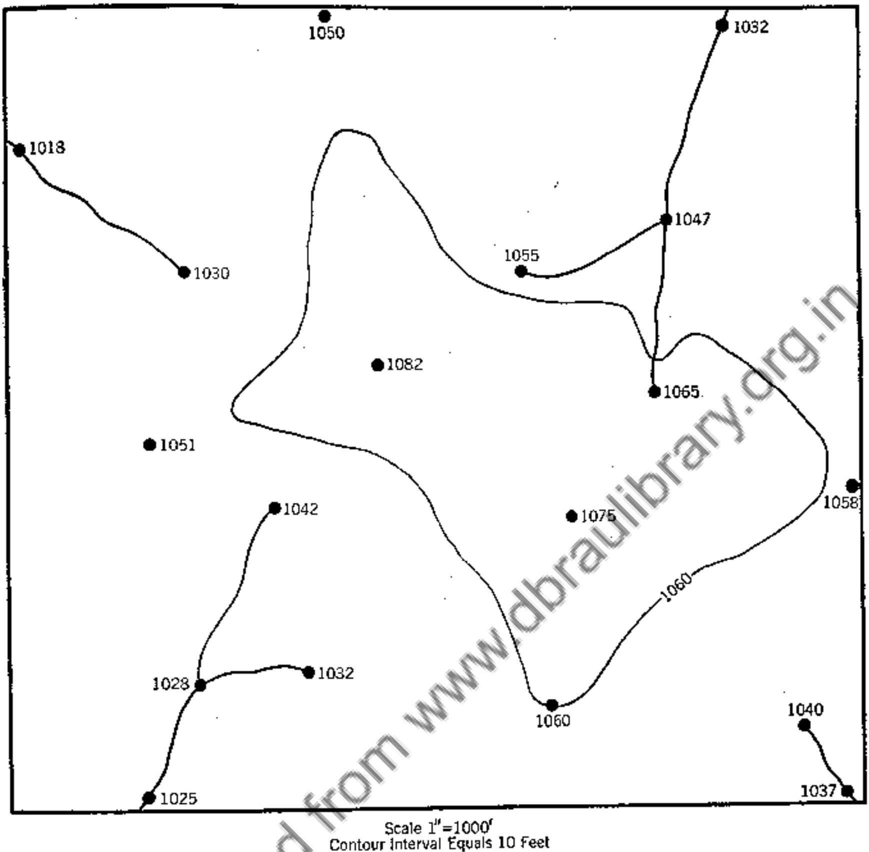
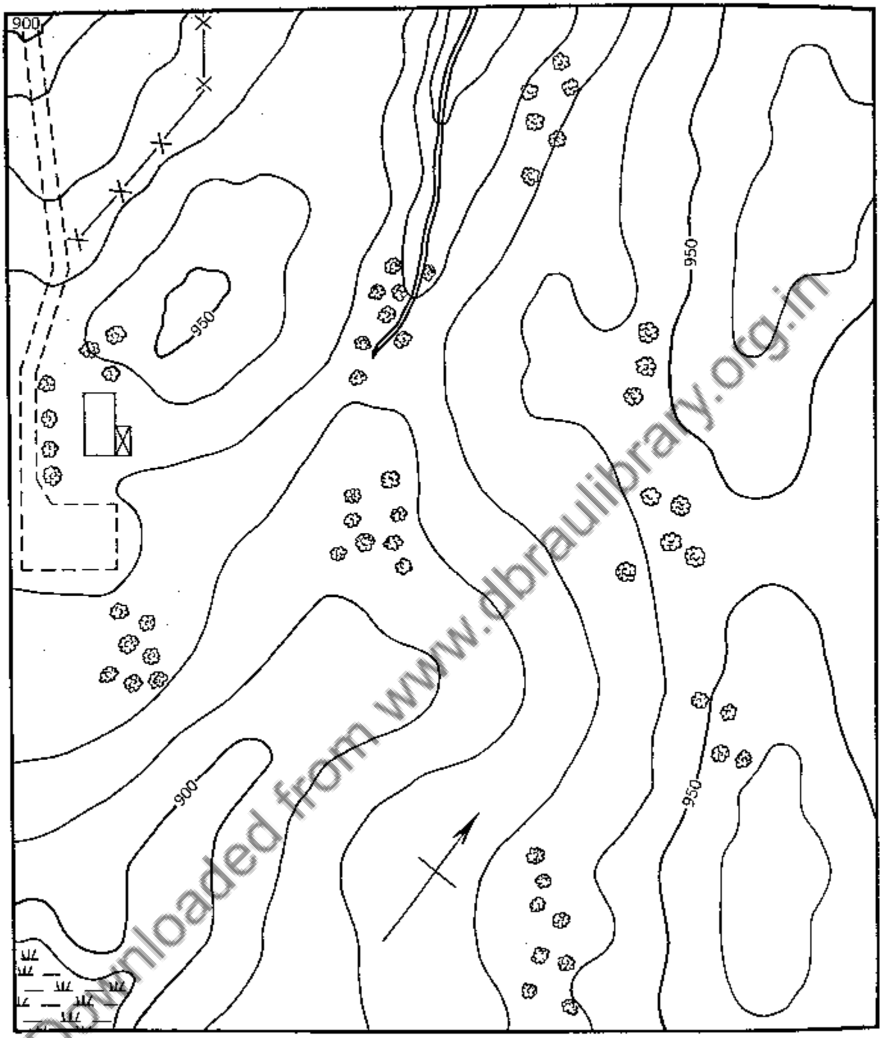


Fig. 93.—Contour Map for Project 40.

Project 40—Placing Contours on a Map

Fig. 93 is a map showing the locations and elevations of streams and summits. Make a pencil tracing of Fig. 93. From the information given, draw the contour lines on the tracing of the map. Use a contour interval of 10 ft. Assume that there is no abrupt change of slope between any of the elevations given. The 1060 contour has been placed on the map.

It is advisable for the pupil to study Figs. 88 and 89 very carefully before he begins to locate and draw the contour lines for Project 40. He should note especially the forms of the contour lines in those illustrations as they approach the streams and cross them.

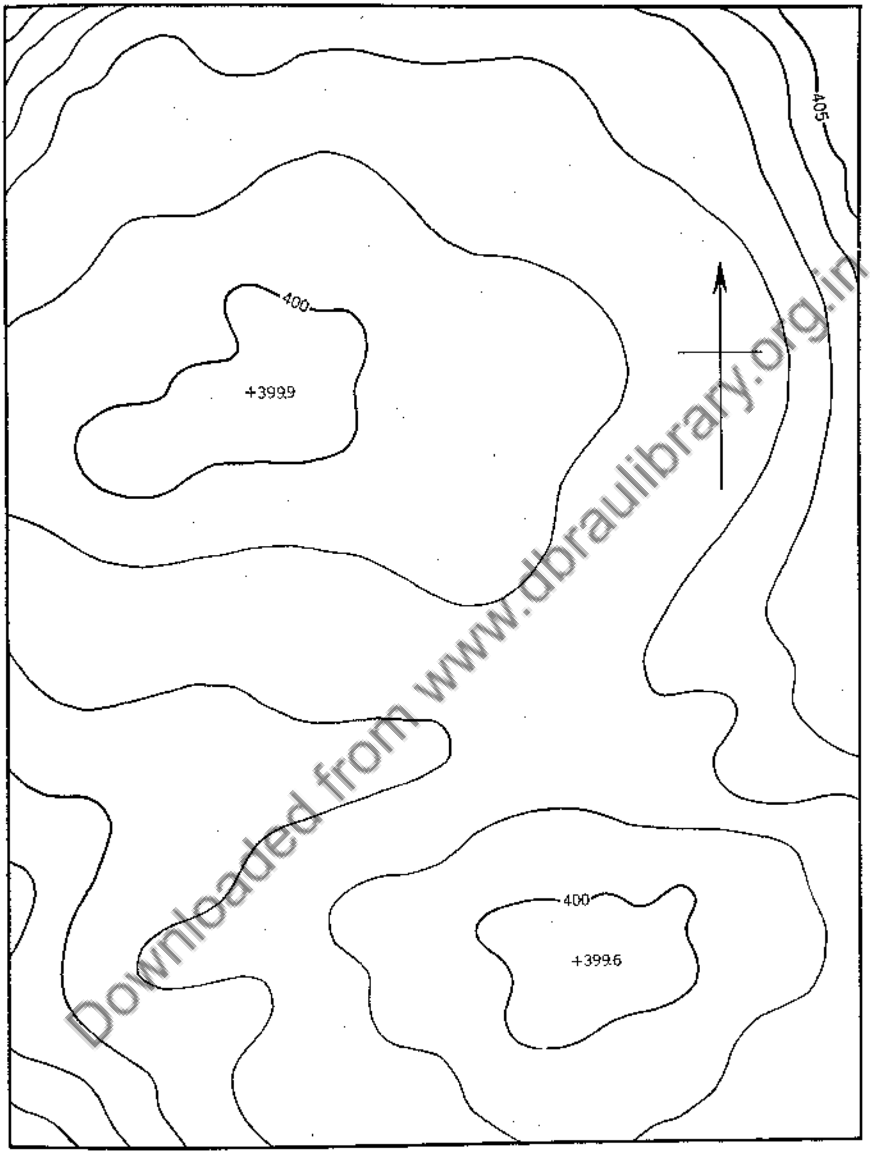


Scale 1"=200'
Contour Interval Equals 10 Feet

Fig. 94.—Contour Map of Area for Proposed Golf Course.

Project 41—Layout of Golf Course

Make a pencil tracing of Fig. 94. On the tracing, lay out the first three holes for a golf course. Reserve the high spot near the existing structure for the eighteenth green. The length of a hole must not be more than 500 yards nor less than 150 yards.



Scale 1″=100′
Contour Interval Equals 1 Foot

Fig. 95.—Contour Map of Area for Proposed Baseball Field.

Project 42—Layout of Baseball Field

Make a pencil tracing of the contour map in Fig. 95. On this tracing, select a good position for a baseball field and lay out the field on the tracing. Fig. 96 gives sufficient sizes from which a regulation field can be laid out. In selecting the position of the field, take into consideration the position of the afternoon sun in relation to the various players.

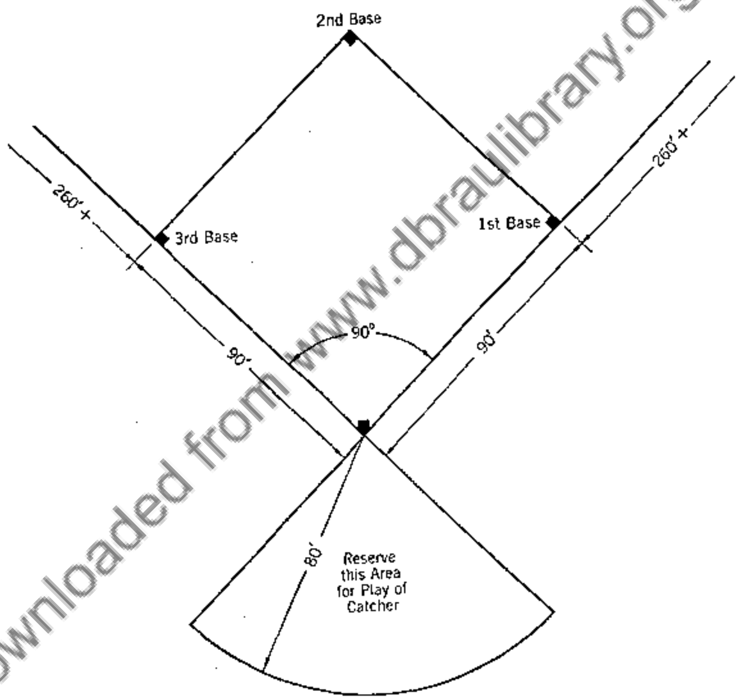


Fig. 96.—Baseball Field.

CHAPTER V

GRAPHS

Specific Aims:

To teach interpretation of graphs.

To present the types of graphs in common use.

To develop the pupil so that he is able to make graphs.

To show where the various types of graphs may be used to the best advantage.

Pictures make a more vivid and lasting impression on the mind than do words, especially when the words tell of or compare large numbers or percentages. It is difficult to get the significant facts

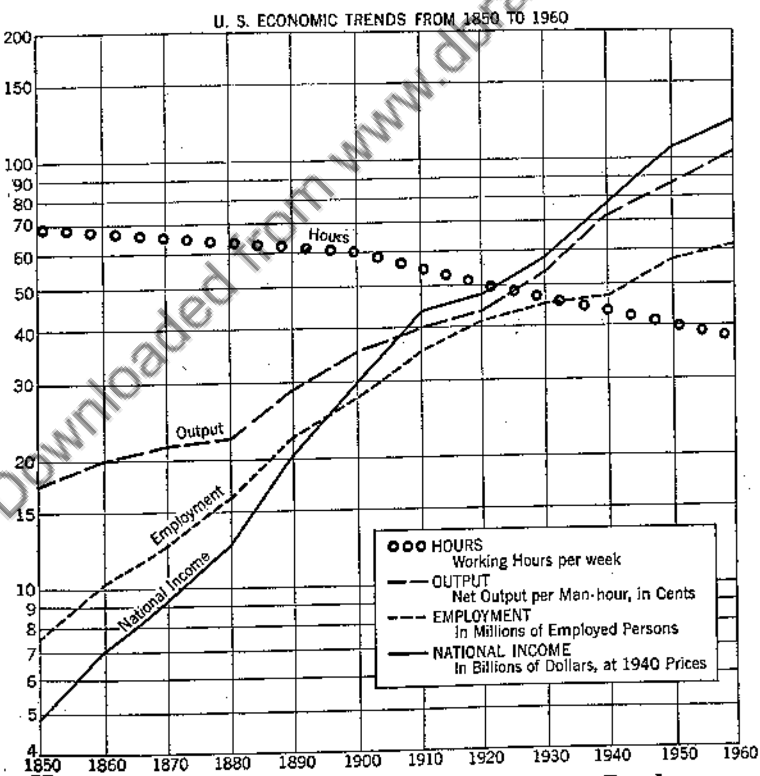


Fig. 97.—Graph of Past and Predicted Economic Trends.

from a table of figures without a considerable amount of concentrated effort. Graphs are used in order that this may be done quickly and vividly. A graph is a pictorial means of presenting facts and figures in comparison for quick apprehension.

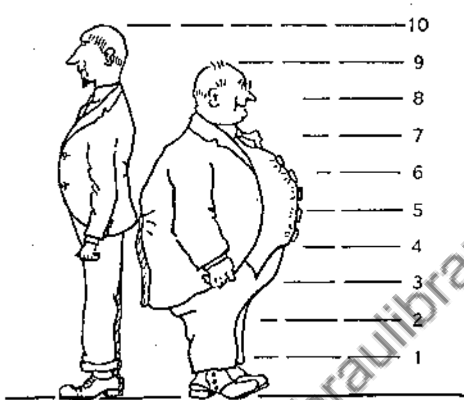


Fig. 98.—Comparative Heights of Two Men.

Project 43—Interpretation of Bar Graphs

Mr. Sothin and Mr. Fatso, two business men, had a friendly argument as to who was the taller and how much taller he was. After some discussion, in which the entire office force took part, the argument was settled to the satisfaction of all when Mr. Sothin and Mr. Fatso stood back to back, as illustrated in Fig. 98, in the age-old manner of determining comparative heights of individuals.

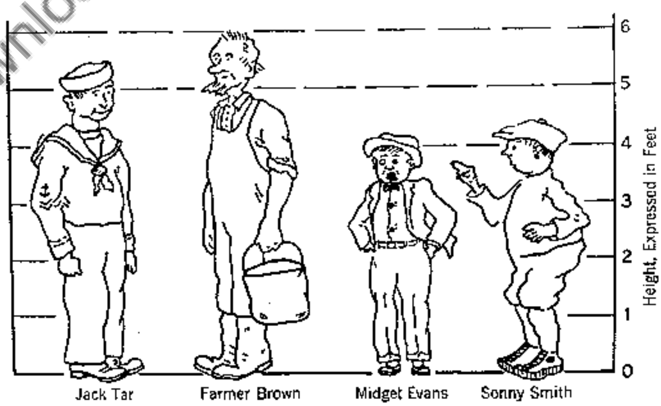


Fig. 99.—Comparative Heights of Four People.

It was decided that Mr. Fatso was only nine-tenths as tall as Mr. Sothin.

In Fig. 99 four characters are sketched as they appeared on the sidewalk of a small town. The following questions are based on this illustration.

QUESTIONS

Refer to Fig. 99 and answer the following questions:

1. What is the name of the tallest person?
2. What is the name of the smallest person?
3. List the names of the persons according to height (the tallest first). It will be sufficient to write only the last names.
4. Were you able to answer the first three questions at the first glance at the illustration?
5. How tall is Farmer Brown? Express his height in feet and inches.
6. How tall is Jack Tar?
7. How tall is Evans?
8. How tall is Smith?
9. Would it have been easier to answer questions 5 to 8, inclusive, if smaller intervals (as perhaps inches) had been marked within the foot intervals on the vertical scale?
10. Can you think of any way in which the illustration could be improved to show better the actual and comparative heights of these individuals?

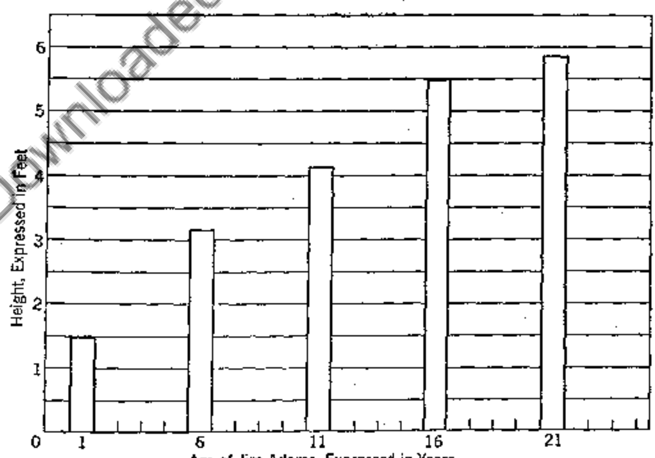


Fig. 100.—Simple Bar Graph.

SIMPLE BAR GRAPH

Dr. Adams was interested in keeping a record of the height of his son as he grew from childhood into boyhood and then manhood. He did not attempt to make sketches (to scale) of the boy at the various ages; but what he did was to measure the boy's height at regular intervals and draw bars representing the heights to scale, as indicated in Fig. 100. Here, the number below each bar represents Jim's age when the corresponding height was measured.

QUESTIONS

Answer the following questions by referring to Fig. 100.

11. During what 5-year period between recordings did Jim have the greatest increase in height?
12. During what 5-year period did he have the least increase?
13. From the information shown in the illustration, what would you say his height was when he was $8\frac{1}{2}$ years old?
14. What was his height apt to have been when he was 18 years old?
15. Between the ages of 16 and 21, his increase in height was what per cent of his height at the age of 21?

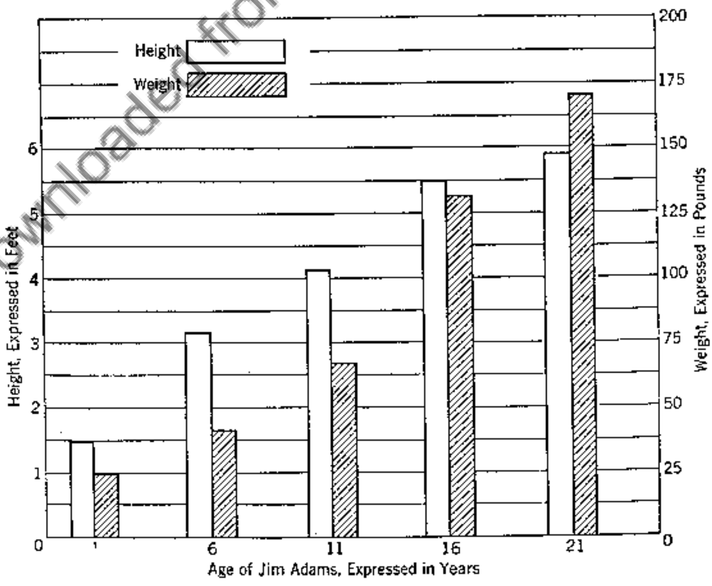


Fig. 101.—Dual Bar Graph.

DUAL BAR GRAPH

The graph used by Doctor Adams in making a chart of his son's heights is a good example of a bar graph. The chart not only was a record of the son's height during specific years of his life but also presented a clear picture of the changes and comparative heights along the span of years from 1 to 21.

Bar graphs not only are applicable to the heights of individuals but have many, many other uses. Also you will find many that differ somewhat from the simple bar graph that Dr. Adams made.

Had he so desired, Dr. Adams could have used a dual bar graph like that shown in Fig. 101 to keep a record of both the height and the weight of his son on a single chart.

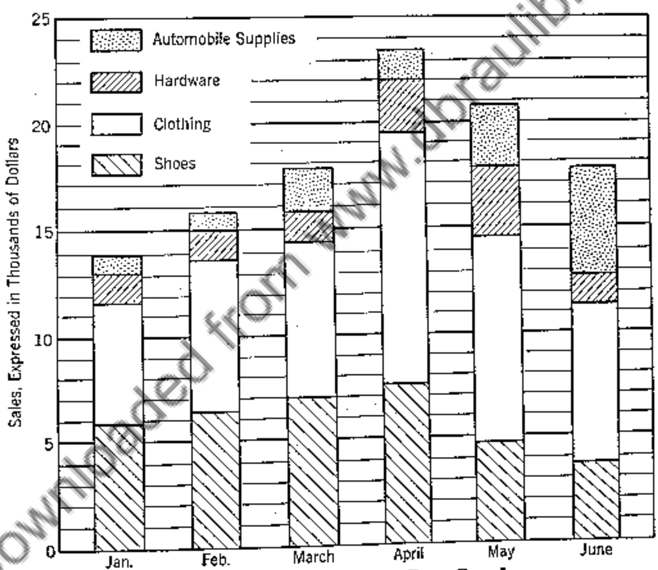


Fig. 102.—Distribution Bar Graph.

DISTRIBUTION BAR GRAPH

Mr. Fatso used the bar graph in Fig. 102 in a slightly different way. He desired to keep a record whereby he could make a clear comparison of the total sales in his general store each month through the year. In making his bars he used definite markings to show the amount of sales of each of the four departments in his store.

This *distribution bar graph* not only shows the total sales but also shows the actual amount of sales in each department as close as accurate reading of the vertical graduations permits.

QUESTIONS

Using the information given in Fig. 102, answer the following questions:

16. In what month did the store have the greatest shoe sales? What was the total amount of shoe sales for that month?
17. In what month did the store have the greatest hardware sales? How much?
18. What was the amount of sales of automobile supplies for the month of March?
19. What was the total amount of sales for the first half of the year?
20. What per cent of the total sales for the month of May was the amount of sales in the shoe department?

HORIZONTAL BAR GRAPH

In the discussion of bar graphs thus far, we have only considered vertical bar graphs. There are horizontal bar graphs, and you will find them in common use also; sometimes they are referred to as rectangular graphs.

Everything that has been said or implied in regard to vertical bar graphs is also true of horizontal bar graphs. For every use to which a vertical bar graph has been put, a horizontal bar graph could have been used instead. The reason is simple. To make a horizontal bar graph of a vertical bar graph necessitates only the changing of the positions of the sets of graduations used for drawing the bars. The vertical markings become the horizontal markings, and the horizontal markings become the vertical markings.

Taxpayers should be interested in the cost of government. Fig. 103 presents *horizontal bar graphs* which deal with the cost of government in Italy, Germany, and the United States for the year of 1936. This was a year during which many countries were preparing for World War II. The receipts are for 1935.

A bar representing population has been drawn to scale in each case. It should be needless to say that these population bars are not drawn to the "Billions of Dollars" scale.

QUESTIONS

Refer to Fig. 103 and answer the following questions:

21. Did any of the countries balance its budget for 1935? In other words, did it receive as much as it expended?
22. What country, would you say, made the greatest increase in its national debt during 1936?
23. One of the chief sources of revenue (receipts) is taxes. What people, would you say, paid the greatest amount of taxes per person?
24. What per cent of the total expenditures did Germany allocate to defense? What per cent did the United States allocate?
25. What country expended the greatest number of dollars per person?

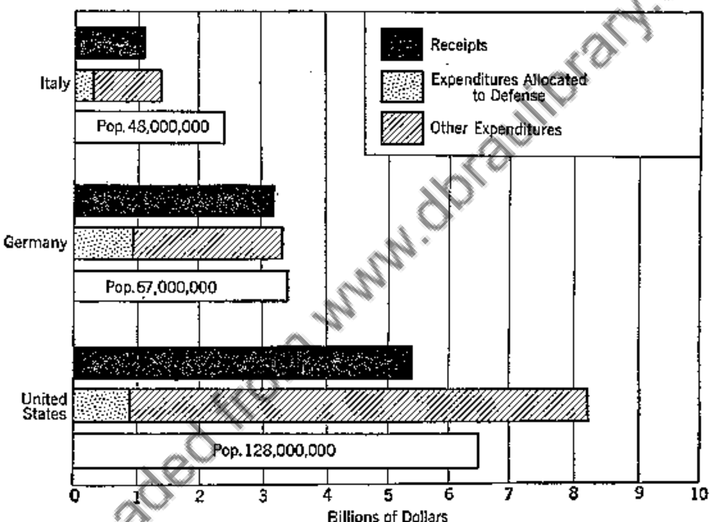


Fig. 103.—Horizontal Bar Graph.

SPECIAL APPLICATIONS OF BAR GRAPHING

In Fig. 104 is shown a special type of bar graph in which a continuous line is used instead of separate bars.

QUESTIONS

Answer the following questions which are based on Fig. 104:

26. Why is this graph considered a special application of bar graphing?
27. What is the total amount of sales for the month of January, 1946?
28. What month in this 2-year period shows the greatest sales?

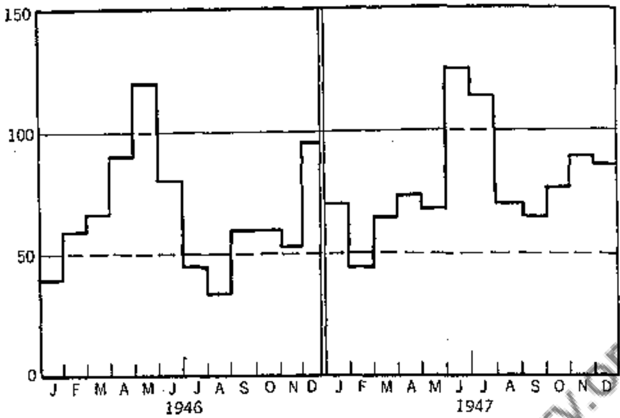


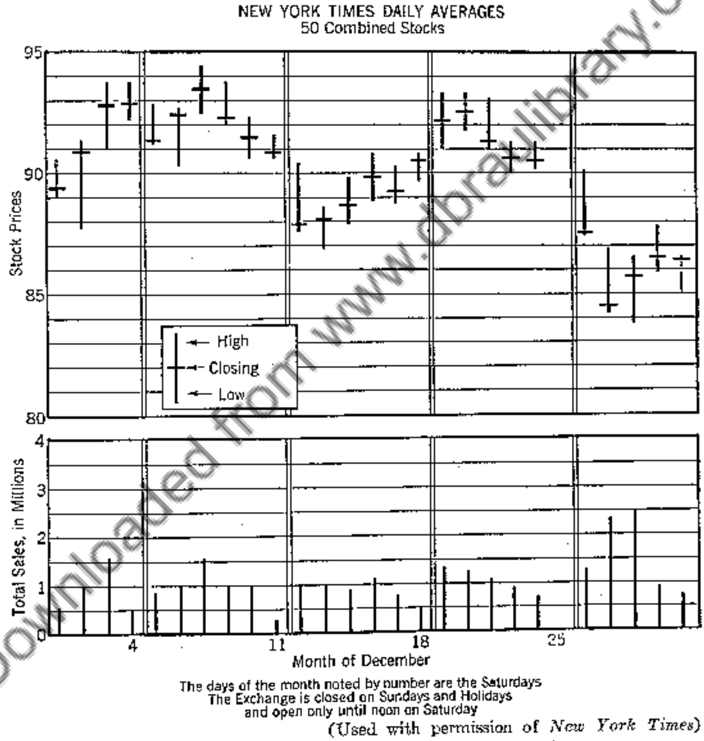
Fig. 104.—Step Graph.

29. In 1946, what month had the greatest amount of sales?
30. Considering the 2-year period, what month shows the greatest increase in amount of sales over the previous month?
31. What month shows the greatest decrease in amount of sales when compared to the previous month?
32. What month in 1947 shows the greatest increase over the corresponding month in 1946?
33. Why is the double line used?
34. In certain places the horizontal lines are shown as dashed lines. Why?
35. Do you approve of drawing the horizontal lines as shown, or would you recommend drawing them as straight uninterrupted lines?

In the New York Stock Exchange there is a daily exchange of ownership of stock of various companies that is listed as transferable in that exchange. The usual procedure is that Broker A (a dealer in stocks) offers to buy 100 shares of "General Motors preferred" at $113.00 per share. Broker B has been instructed by one or more of his clients to sell 300 shares of their stock, "General Motors preferred," at $113.00 per share. The sale (or exchange) is made, and the price of this stock is set at 113 by this exchange. A little later in the day, Broker B has an opportunity to sell the remaining 200 shares at $113.50 per share. Now this stock's price as listed rises to 113½. If later in the day an exchange of this stock is made at the price of $110.00 per share, the listed stock price would drop to 110.

In the *New York Times*, a graph is given which shows the average prices of fifty representative stocks. The average stock prices shown are: (1) the average of the lowest price obtained for each of these fifty stocks that day; (2) the average of the highest prices obtained; and (3) the average of the prices obtained in the last sale of each of the fifty stocks each day. These averages are, respectively, the averages of the low, high, and closing prices.

In addition to the stock prices, the daily totals of sales on the New York Stock Exchange are also shown on the graph. In Fig. 105 is a reproduction of one of these graphs.



(Used with permission of *New York Times*)

Fig. 105.—Graph of Stock Prices and Sales.

QUESTIONS

Refer to Fig. 105 and answer the following questions:

36. What day of the week consistently shows the lowest total sales? Why?
37. What two days of the month had total sales considerably higher than any other day of the month?

38. Are sales, as a general rule, greatest on any certain day each week?
39. What was the amount of the total sales for December 29?
40. What was the average high price for December 22?
41. What was the average low price for the third of the month?
42. What was the average closing price on the sixteenth?
43. Would you say that the majority of the investors made or lost money during December? On what do you base your conclusion?

Project 44—Graph of Ice Cream Sales

Using the simple bar, make a graph of the following listed sales of an ice-cream store for a period of one year.

January	$125	May	$411	September	$385
February	128	June	592	October	215
March	138	July	606	November	132
April	173	August	612	December	88

Project 45—Graph of Comparative Heights

Make a dual vertical bar graph comparing the height of Jim Adams with that of his brother, Sam. Sam is 5 ft 2 in. tall, while Jim is 6 ft 0 in. tall.

Project 46—Graph of Weekly Temperature

Make a dual bar graph that will show the maximum temperature and the minimum temperature for a period of one week. This information may be obtained from your local weather bureau or in your daily newspaper.

Project 47—Graph of Appliance Sales

A salesman in an electrical-appliance store would like to make a graph that will show the number of sales and the amount of his sales each month for three months. What type of graph would you advise?

Month	Number of Sales	Amount of Sales
October	201	$2210.75
November	187	$3198.03
December	446	$5917.28

Make a graph showing the desired information.

Project 48—Attendance Chart

Make a chart, using a bar graph, that will show the attendance in the drawing class for one week.

Project 49—Sports Preference Chart

Two different boys clubs were visited, and each boy was polled as to his preference in the line of sports.

The preferences in the Willing Worker Club were:

Football	6	Baseball	5
Basketball	3	Tennis	2

The preferences in the Eveready Club were:

Football	5	Baseball	6
Basketball	4	Tennis	1

Make two distribution bars so that one can readily compare the preferences in these two clubs.

Project 50—How You Spend Your Time

For two days determine the amount of time you spend each day engaged as follows:

(1) at school (4) eating
(2) at play (5) sleeping
(3) at work (6) otherwise

Make a chart, using horizontal distribution bars, that will compare how both days were spent.

Project 51—Interpretation of Circle Graphs

Johnny Fatso's mother baked a very good apple pie. The family, consisting of Johnny, sister Mary, brother Frank, grandmother, mother, and father, shared the pie at dinner. The illustration in Fig. 106 shows how the pie was divided.

Actually Johnny received a very little less than one-fifth of the pie; while sister Mary received one-tenth.

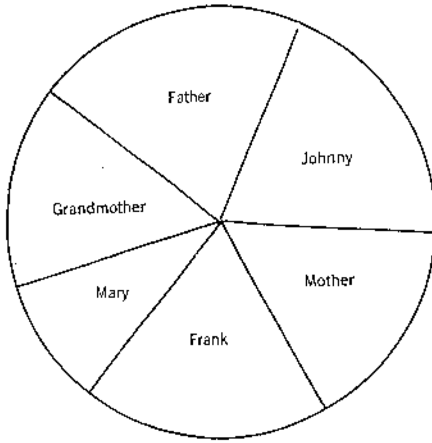


Fig. 106.—Simple Circle Graph.

QUESTIONS

Referring to Fig. 106, answer the following questions:

1. What fractional part of the pie was given to grandmother?
2. How much of the pie did father receive?
3. In the illustration, use your protractor to measure the number of degrees in the portion allotted to father. How many degrees are there in this portion?
4. What per cent of the total circle is the portion allotted to father?
5. Do you agree that it would be a much more intelligent illustration if it had marked on it the per cent that each portion was of the whole?

Mr. Fatso, in addition to the distribution bar graph shown in Fig. 102, each month makes a circle graph (or a pie graph, as it is also called) to show the per cent of his total sales contributed by each of his four departments. He believes that the information is shown more clearly on the circle graph than in the case of the bar distribution graph.

The graph shown in Fig. 107 is based on the following information.

DEPARTMENT	SALES
Clothing	$12,024.37
Shoes	7,498.79
Hardware	2,507.98
Automobile Supplies	1,502.11
Total	$23,533.25

By using round numbers Mr. Fatso determined that the sales in the clothing department were approximately 51 per cent of the total sales; shoes, 32 per cent; hardware, 11 per cent; and automobile supplies, 6 per cent.

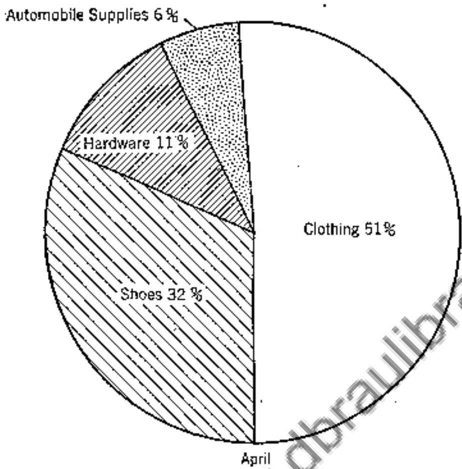


Fig. 107.—Circle Graph.

Next, he determined that 51 per cent of a circle would be a sector made by an angle of $183\frac{1}{2}°$; 32 per cent, 115°; 11 per cent, $39\frac{1}{2}°$; and 6 per cent, 22°. Using a protractor, he divided a circle into four sectors of those sizes and marked them accordingly.

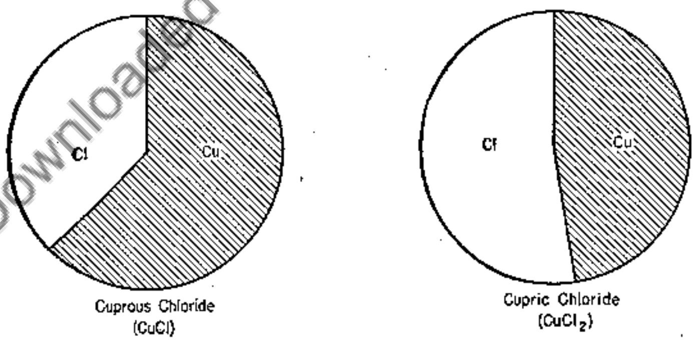


Fig. 108.—Comparative Circle Graphs.

The circle graphs in Fig. 108 show the per cents, by weight, of copper (*Cu*) and chlorine (*Cl*) in the two substances known as cuprous chloride and cupric chloride.

Project 52—Allowance Distribution Graph

A certain student receives an allowance of $10.00 each month. In the month of June, he spent $1.60 for carfare, $4.05 for lunches, $1.50 for shows and amusements, and $1.05 for candy and ice cream. He saved what was left. Use a circle graph to show what he did with his allowance for that month.

Project 53—Athletic Association Expenditure Graph

In a certain high school the athletic association, during the last school year, spent the following amounts on various sports:

Football	$1202.37	Swimming	$123.15
Basketball	345.20	Baseball	257.92
Track	142.32	Tennis	37.50

By means of a circle graph show the distribution of expenditures for that year.

Project 54—Chart showing Relative Expenditures of Governments

Using three different circles, show the relation of the expenditures allocated to defense to the total expenditures of (1) the United States, (2) Germany, and (3) Italy for the year of 1936. Secure your data from the horizontal bar graph in Fig. 103.

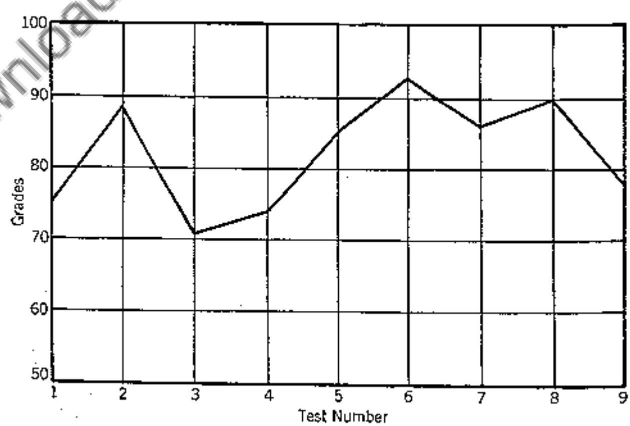


Fig. 109.—Simple Straight-Line Graph.

Project 55—Interpretation of Line Graphs

STRAIGHT-LINE GRAPHS

Jim Adams made a graph of the grades he made in tests given in his Algebra class during the first half of the school year. This graph is shown in Fig. 109.

QUESTIONS

Answer the following questions by referring to Fig. 109.

1. What grade did he make in the first test?
2. What grade did he make in the seventh test?
3. When do you suppose he did the most and the best studying?
4. During which quarter of the year did he do the best work?
5. By observing the graph alone, what would you say was an approximate average of his nine test grades?

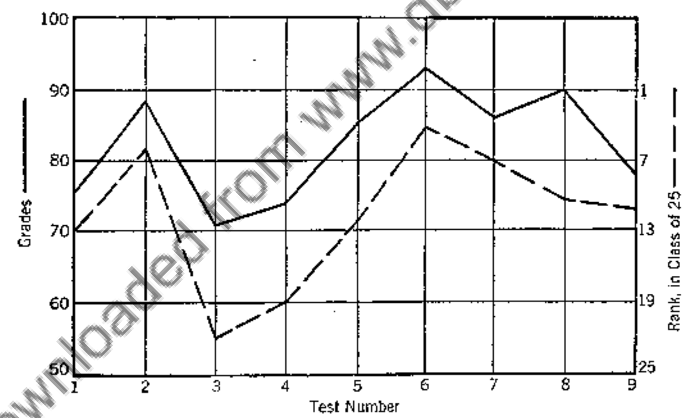


Fig. 110.—Comparative Straight-Line Graph.

Jim's teacher not only made known to the pupils their test grades but also gave them their rank in each test; for instance, they were told whether they had the highest grade in the class (rank 1) or the lowest mark in the class of 25 (rank 25). To the graph shown in Fig. 109 Jim added a dashed, or broken-line, graph that would show where he ranked in the class of 25 in each of the nine tests. The graph with the dashed line is shown in Fig. 110.

QUESTIONS

The following questions refer to Fig. 110.

6. What was Jim's rank in the eighth test?
7. What was his rank in the fifth test?
8. In what test did he rank lowest?
9. In what test did he rank highest?
10. By observing the graph alone, would you say that Jim, considering the nine tests, ranked in the first, second, third, or last quarter of the class?

After Jim graduated from the grammar grades, his father presented him with a new rifle and an ample supply of small paper targets. Jim kept a record of the shots he fired and the hits he scored each day. The graph in Fig. 111 shows his record for the first ten days.

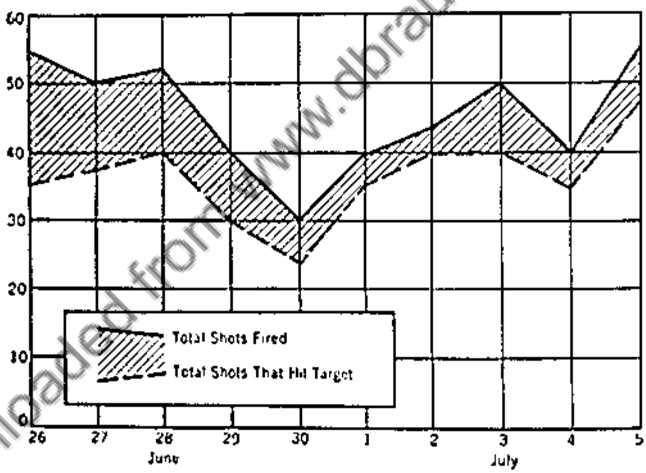


Fig. 111.—Comparative Straight-Line Graph.

QUESTIONS

Referring to Fig. 111, answer the following questions:

11. Did Jim's marksmanship improve on each successive day?
12. What were his four poorest days (as far as accuracy was concerned)?
13. On which day did he score the greatest number of hits?
14. On which day did he have the best percentage of hits?
15. Do you believe that Jim, with practice, will become an expert marksman? Explain your answer.

In Fig. 104 is presented a graph that shows comparative monthly sales, over a 2-year period, of the R. and J. Realty Company. It consists of several horizontal and vertical lines and shows what would have been the outline of the tops of many bars placed one against the other. While perhaps not the usual method of presentation, this graph could be classified as a straight-line graph.

CURVES

A graph is often constructed by drawing a continuous curved line through a number of established points, just as straight lines were drawn in preceding cases. Such a curved-line graph is shown in Fig. 112.

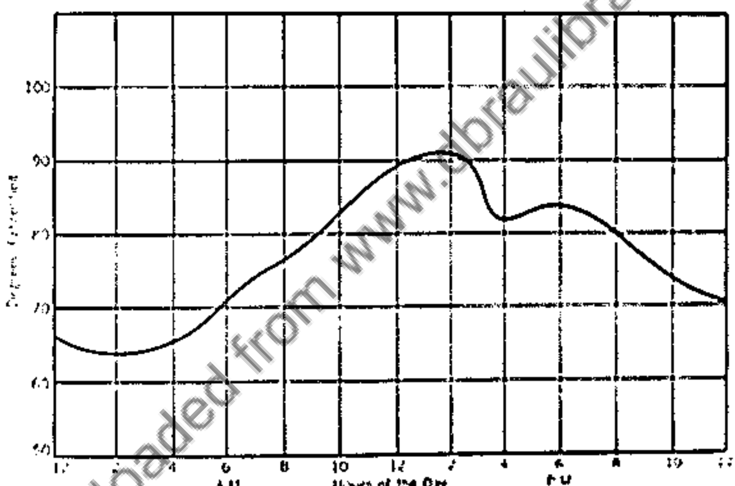


Fig. 112.—Curved-Line Graph.

QUESTIONS

Answer the following questions by referring to Fig. 112.

16. What was the temperature at noon?
17. What was the temperature at 7 A.M.?
18. What was the temperature at 8:30 P.M.?
19. What would you say was the average temperature for the day?
20. During the daylight hours there was a slight shower. At what time of day did it rain?

The graph in Fig. 113 was made by the B. and S. Water Company. It shows the contents of the Clearwater reservoir over the period of the first ten days of July, along with a cumulative rainfall curve for the same period.

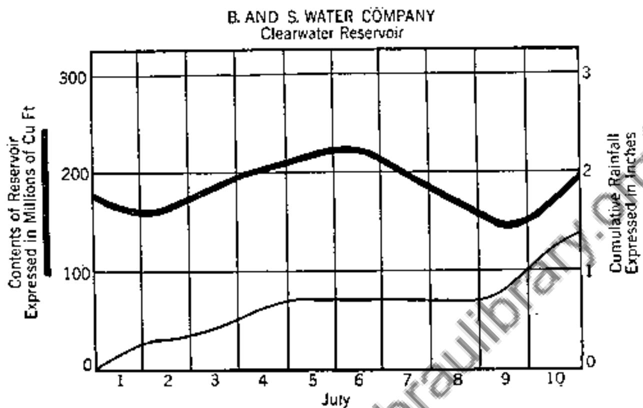


Fig. 113.—Curved-Line Graph.

QUESTIONS

By referring to Fig. 113, answer the following questions:

21. On what day was the reservoir at its lowest height?
22. How many inches of rain fell on the day on which the reservoir was at its lowest height?
23. Does it seem unusual that, although rain fell early on a certain day, the reservoir reached its lowest point about noon of that same day?
24. Can you account for the reservoir being as low as it was at that time?
25. Did the contents of the reservoir increase (the height of the water rise) before, during, or after periods of rainfall?
26. On what day did the most rain fall?
27. How much rain fell on that day?
28. Which of these ten days would you expect had the fairest weather?

SPECIAL APPLICATION OF LINE GRAPHING

In Fig. 114 is shown a progress chart of the Hale-Yarvard football game, showing the plays leading up to the first Hale score.

The background upon which the graph is plotted is a drawing of a football field, with the 10-yard lines and the goal that each

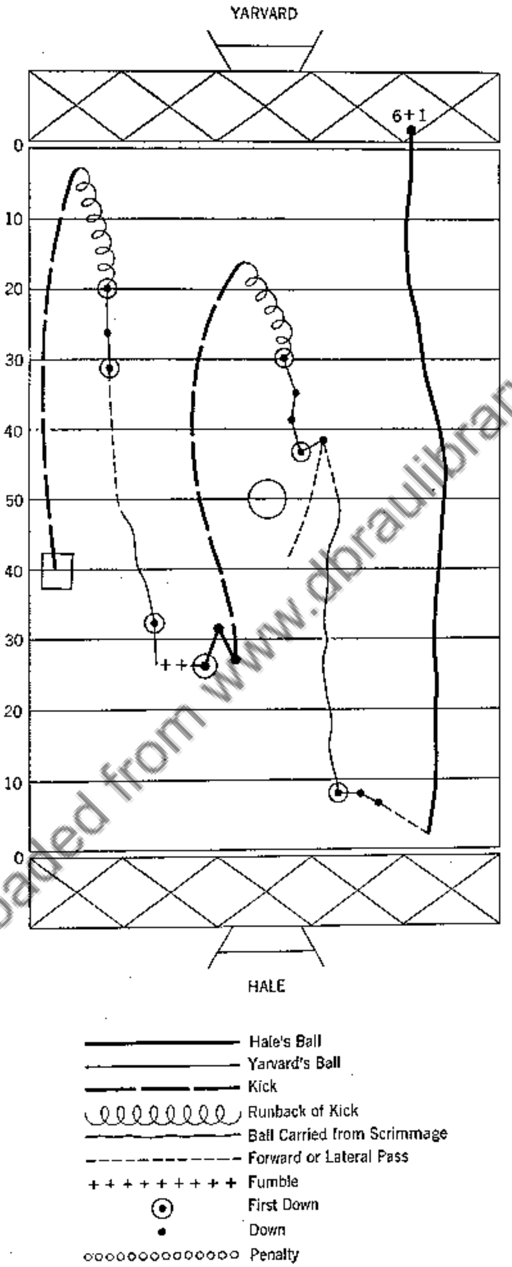


Fig. 114.—Progress Chart of Football Game.

team is defending so marked. A legend explaining the various curved lines is shown below the graph.

The graph tells the following story of the game.

Hale kicked off to Yarvard's 3-yard line, and Yarvard returned the ball to its own 20-yard line. First down, Yarvard. On the first down Yarvard gained 6 yards by carrying the ball. On second down Yarvard carried the ball 5 more yards for a first down on its own 31-yard line. On the next play Yarvard completed a forward pass to a receiver on Hale's 48-yard line, and he ran to the Hale 32-yard line for another first down. Yarvard carried the ball through the line for 6 yards, but fumbled and Hale recovered on its own. . . . (continue with the story the graph tells).

QUESTIONS

Refer to Fig. 114 and answer the following questions:

29. How many yards did Hale lose in trying to run the ball on its second attempt?
30. On what yard line did Yarvard have an incompleted forward pass?

Project 56—Graph of Gasoline Prices

Make a line graph of the prices of a gallon of gasoline, representing the information given below. The price often was lowered beyond the usual seasonal trend by so-called "gas wars."

MONTH	PRICE	MONTH	PRICE
January	19¢	July	16¢
February	19	August	17
March	20	September	16
April	18	October	19
May	15	November	20
June	14	December	20

Project 57—Graph of Accidents Due to Fireworks

In "Our Town" a record was kept, each year, of the number of accidents resulting from the use of fireworks. In 1935 a city ordinance forbade the use of fireworks. In 1938 a state law was enacted, prohibiting the sale or use of fireworks without a permit. Make a line graph of the information that follows. Show the years in chronological order.

YEAR	NUMBER OF ACCIDENTS
1934	12
1933	10
1930	9
1931	8
1932	6
1935	3
1937	2
1936	1
1938	0
1939	0

Project 58—Cumulative Line Graph of Car Sales

A motor-car agency wanted to make a cumulative line graph of the number of cars sold in 1938. It was aiming to reach a total number of sales for the year amounting to 350. Make the type of graph it wanted from its sales for the year, which are listed below.

MONTH	SALES	MONTH	SALES	MONTH	SALES
Jan.	15	May	42	Sept.	26
Feb.	19	June	39	Oct.	21
Mar.	30	July	39	Nov.	27
April	37	Aug.	33	Dec.	31

Did the agency reach its quota?

Project 59—Progress Chart of Football Plays Leading to a Score

In a football game between East High and West High the only score of the game was made early in the second half. Following are the plays leading up to the score. Make a line graph similar to that made for the Hale-Yarvard game in Fig. 114. It is suggested that you use two pencils of different colors to distinguish between East's and West's possession of the ball.

SECOND HALF

East kicked to West's 10-yard line, and West ran the kick back 13 yards. West completed a pass to its own 30-yard line. On the next play the West fullback cracked the center of the East line and carried the ball forward for about 5 yards before fumbling. East recovered the ball on West's 38-yard line. On the first play East completed a forward pass in the end zone for the only touchdown of the game. The attempt for the extra point was missed.

Project 60—Charting a Football Game

Lay out four sheets upon which football plays may be plotted. Take these sheets with you to your school's next football game. Keep a record of the game. Use a new sheet for each quarter.

Project 61—Interpretation of Pictographs

Pictographs differ from bar, circle and line graphs in that they make use of simple pictorial representations to help the graph to more clearly tell its story. Two representations of a battleship, that indicate the comparative tonnages of European navies, are used in the pictograph shown as Fig. 115.

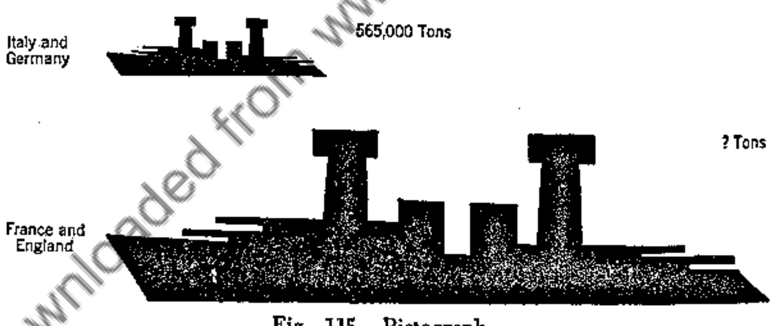


Fig. 115.—Pictograph.

QUESTIONS

To answer the following questions, refer to Fig. 115.

1. How many times as large as the first ship is the second ship?
2. Is the graph considering merchant marine or fighting fleet?
3. Do you approve of the selection of symbol for the graph?
4. Suggest other symbols which may have been used in this graph.

If the symbols are intelligently selected, a pictograph can present the situation to the mind very forcibly. There is one objection to the type of pictograph used in Fig. 115. How many times as large as the first ship is the second ship? The large ship was intended to represent a tonnage of 1,742,000 tons. This is just a little more than three times the tonnage of Italy and Germany combined, which is given as 565,000 tons. The area of the second ship is about ten times that of the first ship, while it actually represents a tonnage which is a little more than three times that represented by the first ship.

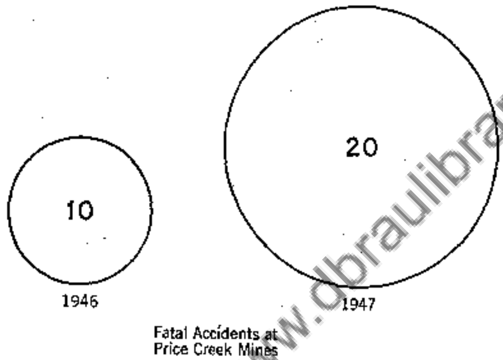


Fig. 116.—Pictograph.

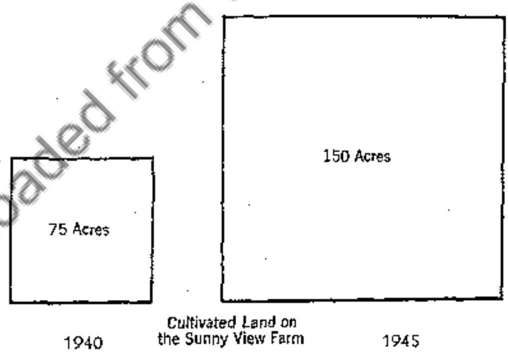


Fig. 117.—Pictograph.

Graphs which use symbols that are drawn to scale in two dimensions are likely to be very misleading because of the ratio of the areas involved. When such symbols are used, the actual quantities should be marked in or adjacent to the respective areas. The graphs shown in Figs. 116 and 117 are other examples of this type, where the ratio of the areas is misleading.

Not many years ago a new method of presenting facts came out of Central Europe. In the meantime it has become very popular and it is now very widely used. This method of preparing pictographs *by using isotypes* presents facts easily, rapidly, and correctly by the use of pictures alone.

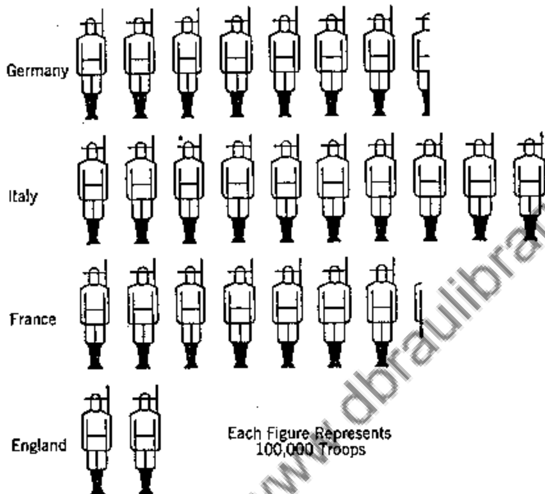


Fig. 118.—Pictograph Using Isotypes.

Instead of comparing the strength of the Italian and English armies by using only two soldiers, a large one representing the 1,000,000 Italian soldiers and a small one representing the 200,000 English soldiers, two rows of small soldiers are used, as in Fig. 118. One row contains ten soldiers and the other contains two soldiers, and a caption reading "Each figure represents 100,000 men" has been included.

Where it is necessary to present a quantity that involves a fractional part of the number each isotype represents, only a portion of the isotype is shown for the fractional part. It was necessary to put this procedure into practice to represent the standing armies of Germany and France in Fig. 118.

The isotype should be representative, but very simple. Very little detail should be shown—merely that necessary for positive identification. A field hat, a blackout where puttees would be, and a vertical line—suggesting a rifle—drawn upward from the right shoulder unmistakably identify the isotype used in Fig. 118 as that of a soldier.

QUESTIONS

The following questions are to be answered by referring to Fig. 118.

5. How many troops did Italy have?
6. How many troops did England have?
7. How many troops did Germany have?
8. How many troops did France have?
9. By how much would the troops of Italy outnumber the combined troops of England and France?
10. Remake the graph shown in Fig. 115 so that it is of the same type as the graph shown in Fig. 118. For a symbol, use a simple silhouette of a battleship. Let each symbol represent 500,000 tons. Use freehand sketching in making the graph.

An isotype must be simple in design, and yet capable of telling the tale that the graph has to convey. Three isotypes are shown in Fig. 119. Human figures will have heads without faces; and arms without hands.

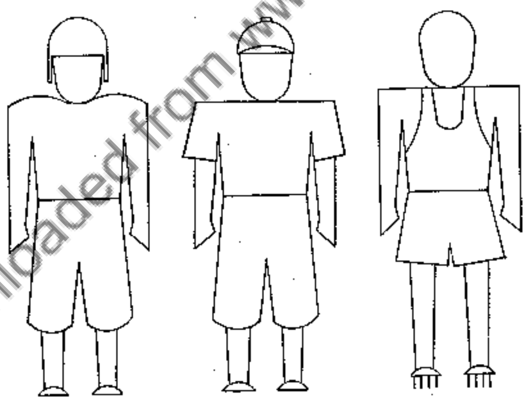


Fig. 119.—Isotypes.

In Fig. 120 are shown two isotypes which are clearly identified by the type of head covering; one represents a football player, and the other represents a baseball player.

To show the isotypes as complete figures, rather than merely as heads, use is made of distinguishing differences in the various sport outfits.

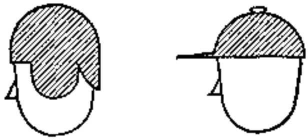


Fig. 120.—Isotypes.

Isotype pictures are always objective and, by all means, practical. They should be the very simplest symbols drawn with the fewest possible lines and with a complete absence of any uninformative, decorative detail. Much information may be conveyed by a simple figure drawn in different poses or positions. The symbols shown in Fig. 121, which were evolved from the same simple figure, adequately represent what they were intended to represent.

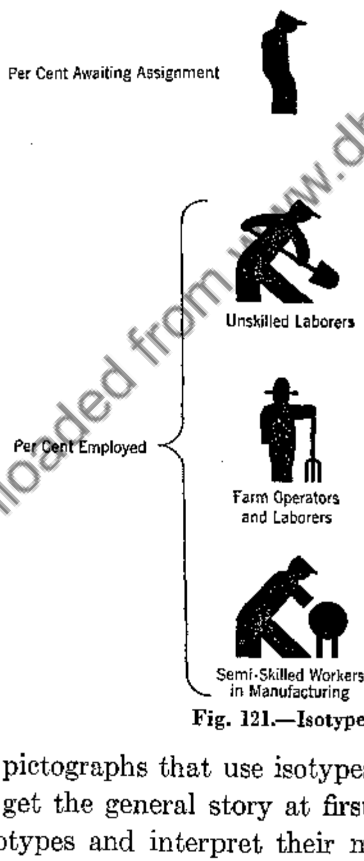


Fig. 121.—Isotypes.

When pictographs that use isotypes are presented, one should be able to get the general story at first glance. It is far easier to identify isotypes and interpret their messages than to make the original composition. The method is so easily comprehended that it may be readily applied and understood, regardless of age or education. Pictographs have no equal in the rapidity and directness with which they are able to convey facts.

Even though the idea of pictographs was conceived a relatively short time ago, it is already in extensive use, especially in the United States; and already the need of standardization has been felt. Each person who has made a graph or chart has modified the practice somewhat. As a result the need has been felt for a "Dictionary of Symbols," which will give a definite figure to be used to represent a Frenchman, a Hindu, a farmer, or whatever symbol you or anyone else may desire to use. When this is done, it will be a simple task for you to make a very comprehensive pictograph by using standard isotypes.

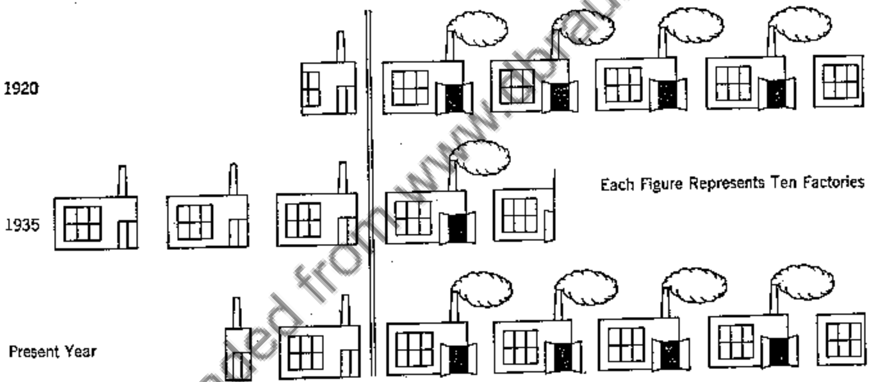


Fig. 122.—Pictograph of Factories in a Town.

QUESTIONS

A. The following questions refer to Fig. 122. The isotypes to the left of the double line represent idle factories, while those to the right represent factories in operation.

11. Were there more factories in the town in 1920 than in 1935?
12. In which of the three years shown were there the greatest number of factories?
13. How many factories were idle in 1935?
14. Would you say that the percentage of unemployment was greater in 1935 than in the present year? Explain your answer.
15. Do you approve of the symbols used? How do they differ? Why?

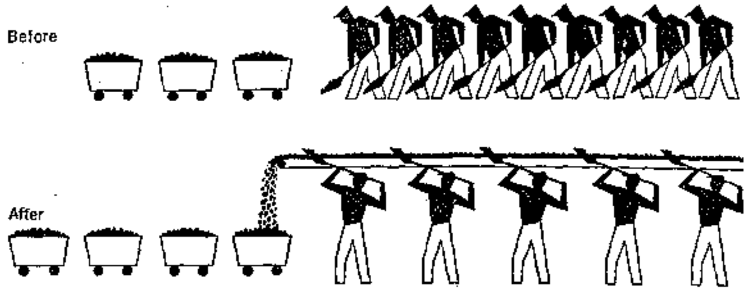


Fig. 123.—Pictograph of Workers in a Mine.

B. The pictograph in Fig. 123 shows a comparison of output, as well as the number of workers employed, in a certain mine before and after mechanical loading methods were installed. The following questions are based on Fig. 123.

16. Have you any way of finding the actual number of men employed in the mine when hand loading methods were used?
17. What is the ratio of the number of men employed when hand loading was necessary to the number employed after mechanical loading methods were installed?
18. What was the output before mechanical loading was possible? Can you give an answer in tons? Why?
19. If you had the original statistics, could you, by slightly altering the graph, make it possible to read the approximate tonnages produced both before and after the mechanical equipment was installed?
20. Would you advise installation of mechanical loading equipment? Explain your answer.

Project 62—"Ain't" Chart

Six-year-old Mary had the habit of saying "ain't." Her mother made a chart on which she placed filled-in black circles. The diameter of each circle corresponded in size to the number of times Mary said "ain't" that day.

Mary's mother thought that this was an excellent way to emphasize increase or decrease in the habit. Do you? Why?

Make a chart, similar to that prepared by Mary's mother, showing the following information:

Day	Number of Mistakes	Day	Number of Mistakes
Monday	6	Thursday	5
Tuesday	7	Friday	3
Wednesday	9	Saturday	1

Project 63—Sports Participation Pictograph

Make a pictograph that will clearly show the number of boys participating in the various sports in your high school. Design your own isotypes.

Project 64—Pictograph Comparing Menageries

Make a pictograph that will compare the menageries of the Dingaling Sons circus and the 1001 Ranch circus. Following is a list of the animals in each menagerie.

	CIRCUS	
ANIMAL	*1001 Ranch*	*Dingaling Sons*
Lions	3	8
Tigers	5	7
Zebras	2	3
Snakes	8	0
Monkeys	6	12

Project 65—Pictograph of Ice-Cream Sales

Make a pictograph from the information given in project 44 for the period of six months from April to September, inclusive.

Project 66—Summary of Graphs

Bar graphs are substantial. Being presented as bars to scale, one can determine relative sizes quickly. Along with their many other uses, they may be well adapted to comparing several conditions at any one time.

Circle graphs should be used to show the percentages that the relative parts are of the whole. From them the comparative sizes of the various parts may also be determined.

Line graphs should be used for progress charts, for instance, where the data being considered extends over a period of time. Broken-line graphs should be used where there are abrupt changes. Smooth-line graphs or curves (as they are also called) should be used where the changes are gradual. Values may be read at any interval along a curve.

Graphs using figures that are drawn to scale in two dimensions (as those shown in the beginning of the discussion on pictographs) may be easily misunderstood; however, they may be used to advantage where you desire to emphasize increases or decreases.

Pictographs, although not so easily made as the other types, are more easily understood. When the isotypes are well designed, they can excellently present any information.

In general, it is much better to present facts and figures by graphs than by long columns of numbers.

QUESTIONS

1. Why are graphs in common use in newspapers and magazines?
2. Would you advise the use of color in making graphs?
3. What advantage, if any, is derived from using graph paper on which to construct the graphs?
4. To what use would you limit the circle graph?
5. What type of graph permits readings to be taken at any point along the graph?
6. What type or types of graphs would you say have the most general use?
7. What would you consider the first step in making a graph?
8. What would you consider the last step in making a graph?
9. Explain the following statement: "There is more to a graph than what appears on the surface."

CHAPTER VI

RELATED VIEWS OR ORTHOGRAPHIC PROJECTION

Specific Aims:

To present the theory of shape description by using large objects which are usually viewed by the pupil so that he sees only one side at a time.

To enable the student to understand the drawings that are necessary in house construction.

To give an understanding of the different types of roofs.

To teach orthographic projection as applied to surfaces inclined to the planes of projection.

To develop an appreciation of the reasons for architectural styles.

To give information regarding the actual construction of a frame house.

To apply the theory of related views to objects smaller than a house.

To show the uses of center lines and line symbols.

To present a recommended order for drawing procedure.

To practice the interpretation of related views.

Project 67—Elevations and Roof Plans of Simple Models of Houses

In the practice of *mechanical drawing,* the shape of an object, whether large or small, is accurately described by showing two or more related views of the object. These views are drawn by projecting lines from points on the object perpendicular to planes that are parallel to its principal faces, as indicated in Fig. 124.

In drawing the floor plan of your home you unknowingly followed such a practice; however, in that case, only one view was shown.

Perhaps you can now better appreciate the fact that floor plans are no more than maps, taken at different levels in the house, which show relative *horizontal* sizes and positions of areas and distances.

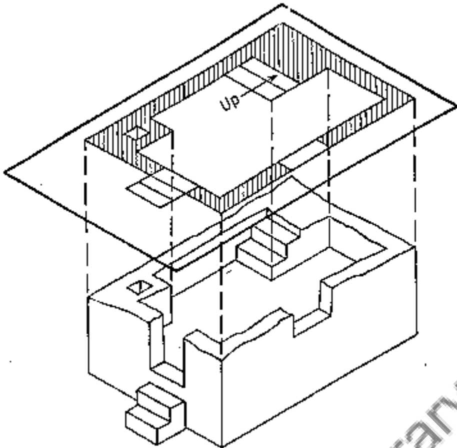


Fig. 124.—Related Views.

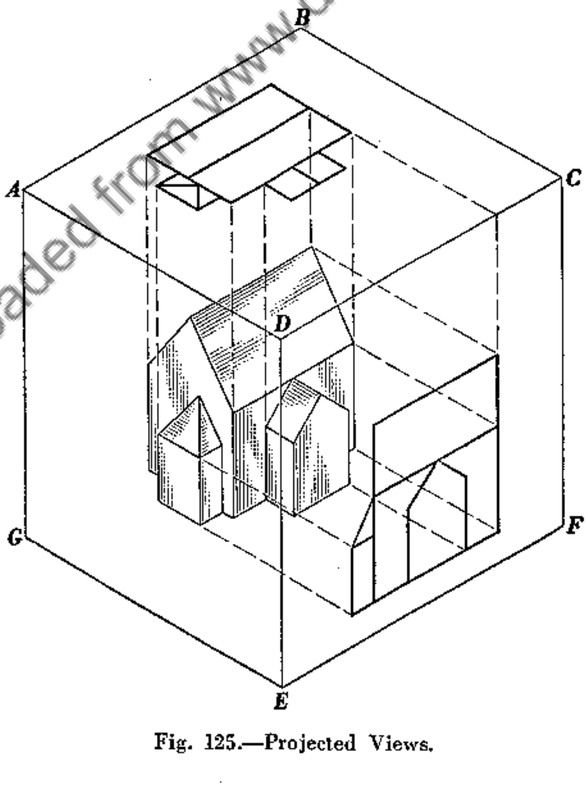


Fig. 125.—Projected Views.

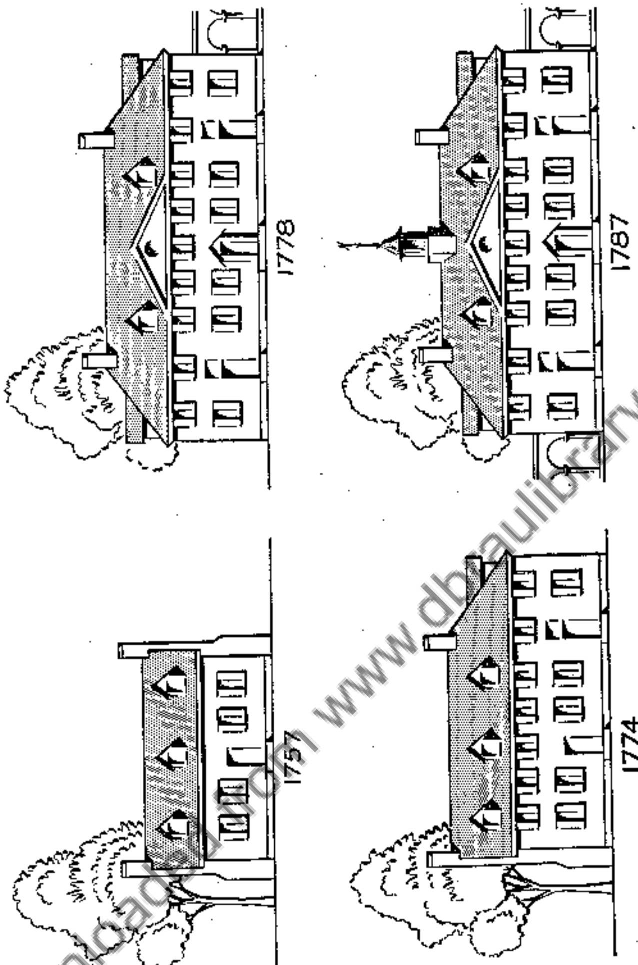


Fig. 126.—Front Elevations of Mount Vernon.

Without the use of the arrows and notations—as "Up" and "Down" —on the steps, there is no way of knowing whether the steps go up or down.

The principal faces of most objects are perpendicular to each other; consequently, the planes on which the views are projected are generally at right angles to one another. In Fig. 125, this method of projection is shown in regard to a block that is quite similar in shape to some houses. The view shown on plane *CDEF* is an elevational view.

The mansion at Mount Vernon pictured in Fig. 126 is an example of a house which, through a series of additions and alterations, has changed from a residence of simple type to one that is much more elaborate. Represented here is a series of elevations showing the changes and the dates when they were made. These are elevations of the front of the mansion. The mansion at Mount Vernon differs from most historical buildings in that the view of the house most publicized is the rear elevation of the house—the view that shows the portico which overlooks the Potomac.

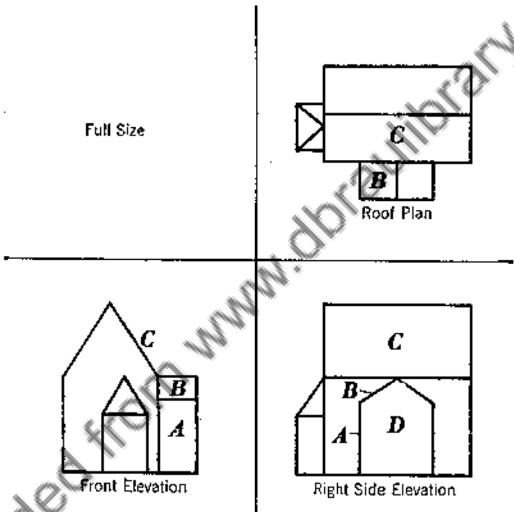


Fig. 127.—Views for Worksheet No. 4.

WORKSHEET NO. 4

Elevations differ from plans in so far as they show relative *vertical* sizes and positions. You might well think of them as vertical plans. They are *flat views* of the front or sides of the house, *and singly they in no way attempt to show depth;* however, when considered jointly with other related elevations, they are capable of thoroughly describing the shape of the exterior of the house. In Fig. 127 are shown three complete views of the block used in Fig. 125. The views have been marked with their proper names. Certain of the surfaces have been marked with letters—references to these surfaces are made in the following questions.

Refer to Fig. 127 and answer the following questions:

1. What is the width of the front of the block?
2. What is the width of the side of the block?

3. What is the width of the inclined surface *C*?
4. What is the vertical height of the block?
5. In the right side elevation, how far is the surface *A* from the nearest vertical edge of the block?
6. How wide is surface *A*?
7. How tall is surface *A*?
8. What is the width of surface *B*?
9. What is the length of surface *B*?
10. How many square inches are there on surface *D*?

RELATIVE POSITIONS OF VIEWS

The three related views shown in Fig. 127 were obtained by projecting lines from the block perpendicular to the following three planes in Fig. 125: *ABCD, CDEF,* and *ADEG*. These planes are parallel to the principal faces of the block and are perpendicular to each other. The views without the block are shown in Fig. 128.

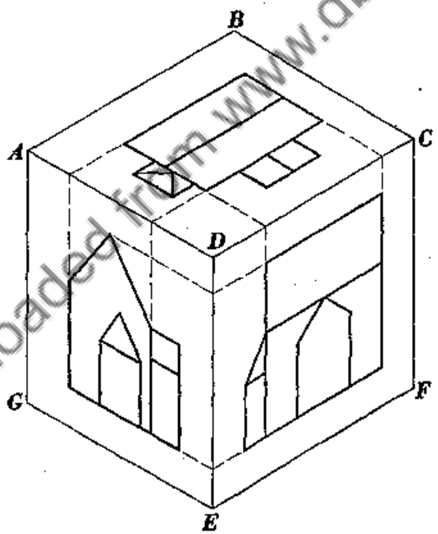


Fig. 128.—Views of Block in Fig. 125.

In the actual drawing in Fig. 127, all three views are shown as being on the one plane—the plane of the paper. The placing of the views in that position is achieved by swinging the planes into one common plane, as shown in Figs. 129 and 130.

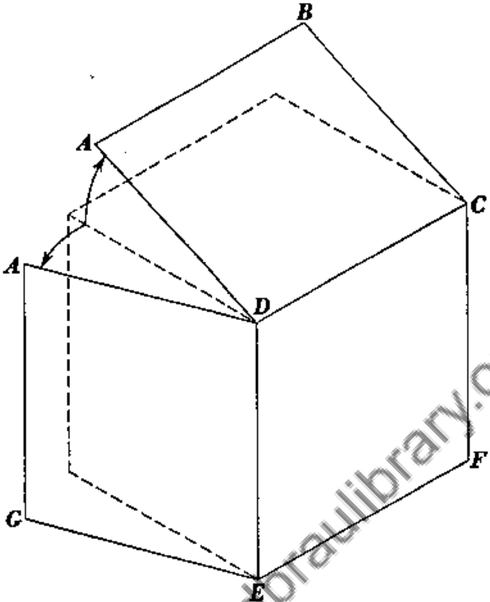


Fig. 129.—Swinging of Planes.

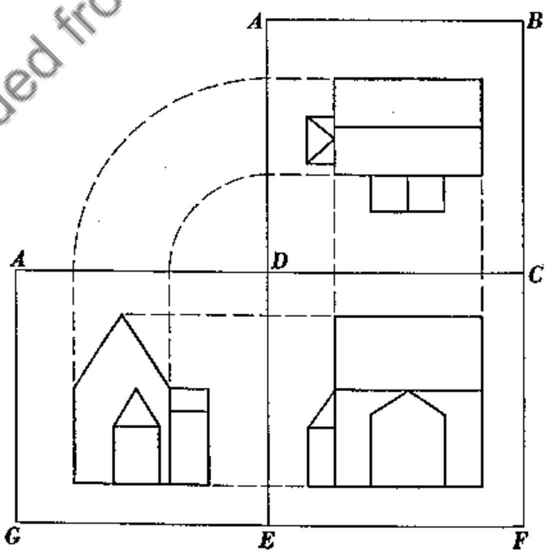


Fig. 130.—Swinging of Planes into Plane of Paper.

The locations of the views are to be noted. The front and side elevations are directly opposite one another. The right side elevation is always placed to the right of the front elevation; likewise, the left side elevation would be placed to the left. *This practice of so arranging the views should be strictly adhered to, for it permits the projection of points and lines between views.*

Points in one elevation are directly opposite corresponding points in the other elevations. In Fig. 131, for example, each point in the right side elevation is directly opposite the corresponding point in the front elevation, and vice versa.

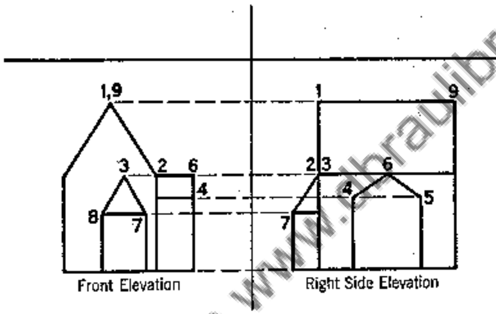


Fig. 131.—Projection Between Front and Side Elevations.

QUESTIONS

Referring to Fig. 131, answer the following questions:

11. Why are points 2 and 3 located at the same place in the right side elevation?
12. Where would you mark point 8 in the right side elevation?
13. Where would you mark point 5 in the front elevation?

The roof plan (top view) may be located above any of the elevations. In this case, it was located above the right side elevation. *Points in the right side elevation are directly beneath the corresponding points in the roof plan,* as shown in Fig. 132.

The roof plan has as much in common with the views not located beneath it as with the view located directly beneath. Projection also can easily be made from the roof plan to the view not

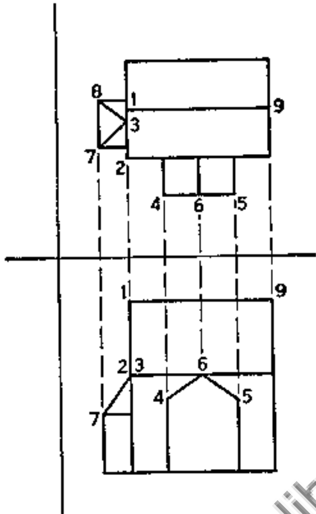


Fig. 132.—Projection from Roof Plan to Elevation Beneath.

beneath it. Either of two methods may be used. Both are in common usage.

The methods are shown in Figs. 133 and 134. In the first case, the projection lines are drawn to the line which bisects the angle between the lines AD and A_1D.

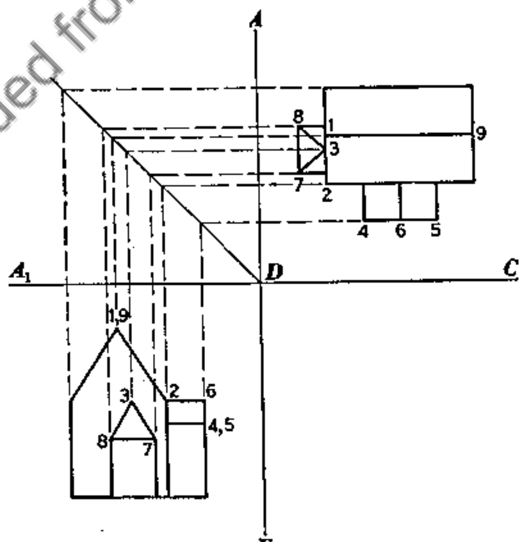


Fig. 133.—Method of Locating Projections.

In the second method, concentric arcs, the centers of which are the point D, are used to carry the projection from the line AD to the line A_1D.

The distance from line DC to the top view is equal to the distance from line DE to the front elevation. This condition must exist if projection between these two views is to be used.

When two related views are drawn, no further scaling is necessary to draw the third related view. It may be drawn through the use of projection alone; for, as you may see, *measurements of height are common to the elevations, measurements of length are common to the top view and the elevation located beneath, and measurements of width are common to the top view and the elevation that is not located directly beneath.*

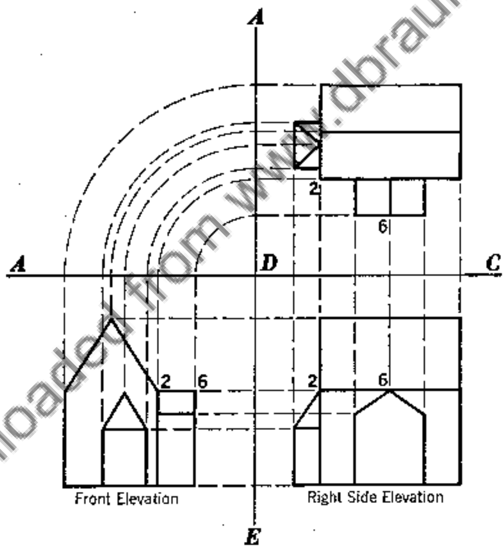


Fig. 134.—Method of Locating Projections.

QUESTIONS

The following questions are based on Fig. 134

14. How could you locate point 2 in drawing the right side elevation, if only the top view and the front elevation were given?
15. How could you locate point 6 in the front elevation, if only the top view and the right side elevation were given?

WORKSHEET NO. 5

Make a pencil tracing of the elevations and the roof plan shown in Fig. 135. Place your answers on the tracing. Do not write on this sheet.

The dashed lines show the positions of hidden lines that help in the description of the block. They are lines that cannot be seen because a portion of the block is in front of them.

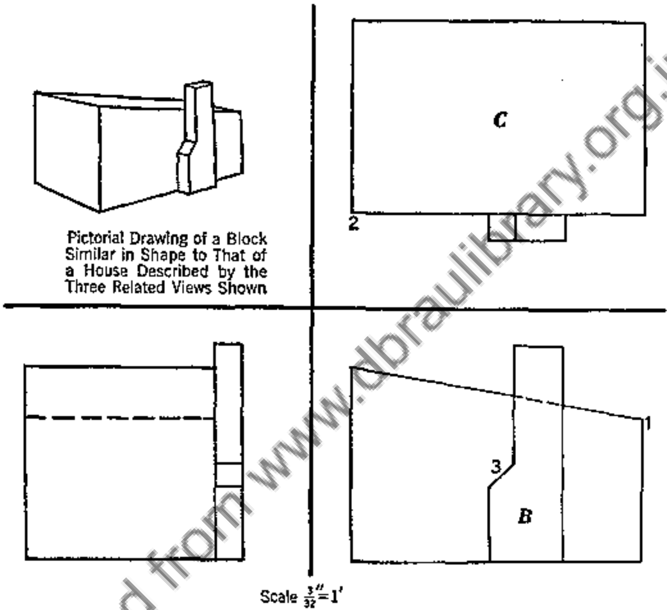


Fig. 135.—Projections for Worksheet No. 5.

1. Draw projection lines from point 1 to the corresponding points in the other views.
2. Draw projection lines from point 2 to the corresponding points in the other views.
3. Draw projection lines from the ends of the line marked by the number 3 to the ends of that line in the other two views.
4. Where does line 3 appear in its true length? Why?
5. Place the letter *A* on all surfaces that are not shown in true size in the various views. (HINT: These will be surfaces that have one or more of the boundary lines not shown to true size.)
6. What is the area of surface *B*?
7. What is the area of surface *C*?
8. What is the volume of the block with the chimney not included?

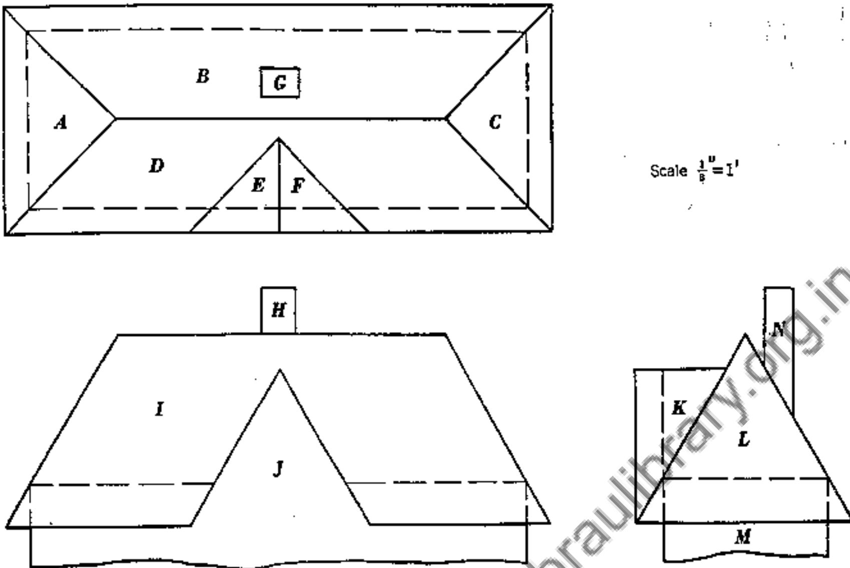


Fig. 136.—Drawings for Worksheet No. 6.

WORKSHEET NO. 6

The following questions are based on the drawing shown in Fig. 136.

1. What is the length of the roof?
2. What is the height of the roof?
3. How far does the chimney extend above the top of the roof?
4. Record all letters in all views that are located on inclined surfaces.
5. Record all letters in all views that are located on vertical surfaces.
6. Record all letters in all views that are located on horizontal surfaces.
7. List three surfaces that are lettered in more than one view. Give the letters in each case.
8. How far is the surface *H* located back from the outside of the front wall of the house?
9. From the information given in the views shown, what would you expect the outside dimensions of the cellar wall to be?
10. How many square feet are there in the true size of the surface marked by the letter *K*?

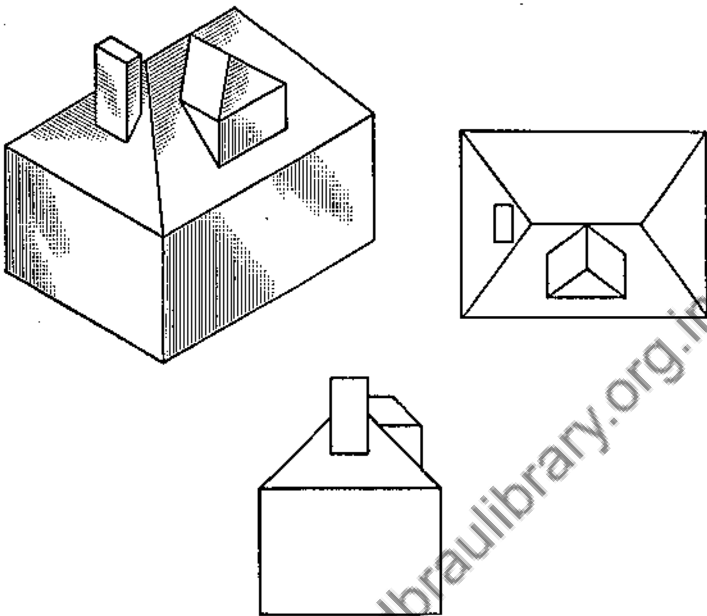


Fig. 137.—Drawings for Worksheet No. 7.

WORKSHEET NO. 7

Make pencil tracings of the elevations and plans in Figs. 137 and 138 in the same relative positions in which they are shown. Make the required drawings on the tracing. *Do not write on this sheet.*

A. Draw the third view of the block that is shown in Fig. 137. The top view and one elevation are given. Use projection to draw the third view.

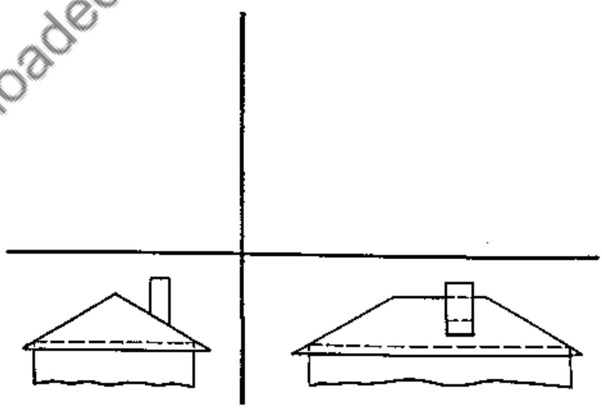


Fig. 138.—Drawings for Worksheet No. 7.

B. By projecting from the two views given in Fig. 138, draw the top view of the simple house model that is described.

WORKSHEET NO. 8

In Figs. 139, 140, and 141 are descriptions of three blocks, which are similar in shape to some houses. The views have been drawn to the scale of 1 in.=20 ft.

List the answers to the following questions. Keep the answers in numerical order.

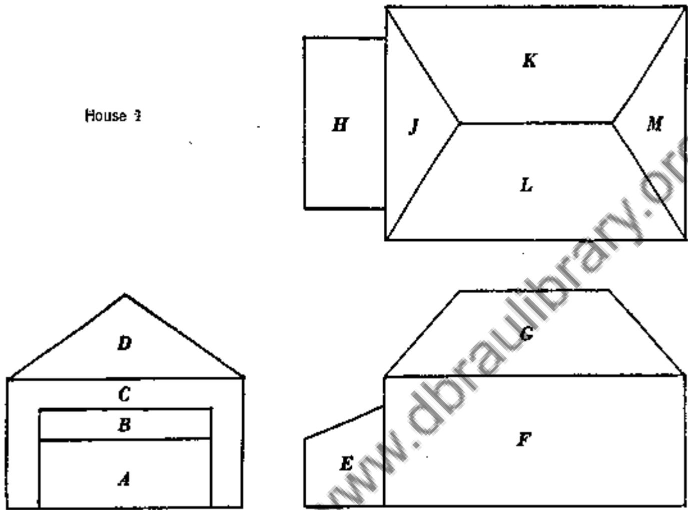


Fig. 139.—Drawings for Worksheet No. 8.

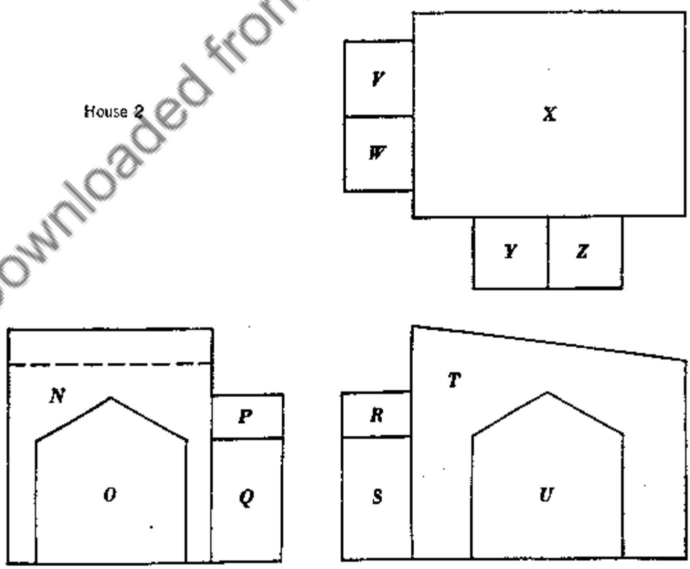


Fig. 140.—Drawings for Worksheet No. 8.

1 to 8. In Figs. 139, 140, and 141, several surfaces have been marked in two different views, such as the surface marked by the letters *D* and *J*. List eight other surfaces that have been marked double. Give both letters or both numbers, as the case may be.

9 to 13. Compute the number of square feet in each of the following surfaces. You will have six answers.

9. Surface E
10. Surface 2
11. Surface 8
12. Surface N
13. Surface 5

14. How many vertical surfaces are there on the house in Fig. 140?

15. How many inclined surfaces are there on the house in Fig. 141?

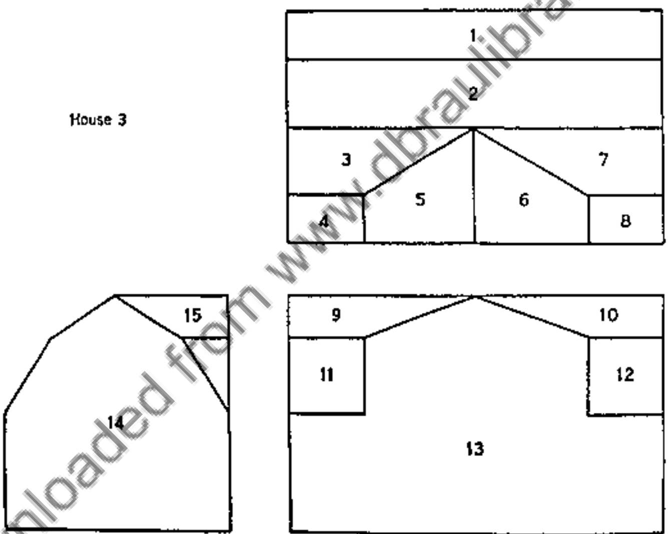


Fig. 141.—Drawings for Worksheet No. 8.

Project 68—Related Views of House Model No. 1

Draw a front elevation, a side elevation, and a roof plan of House Model No. 1, shown in Fig. 142. Estimate the dimensions that have not been given.

Project 69—Related Views of House Model No. 2

Draw a front elevation, a side elevation, and a roof plan of House Model No. 2, shown in Fig. 143. This model has a gabled

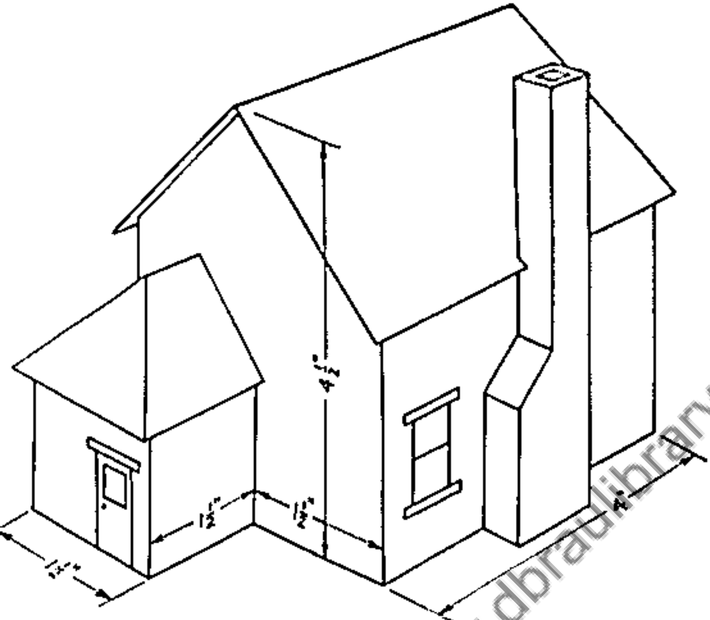


Fig. 142.—Picture of House for Project 68.

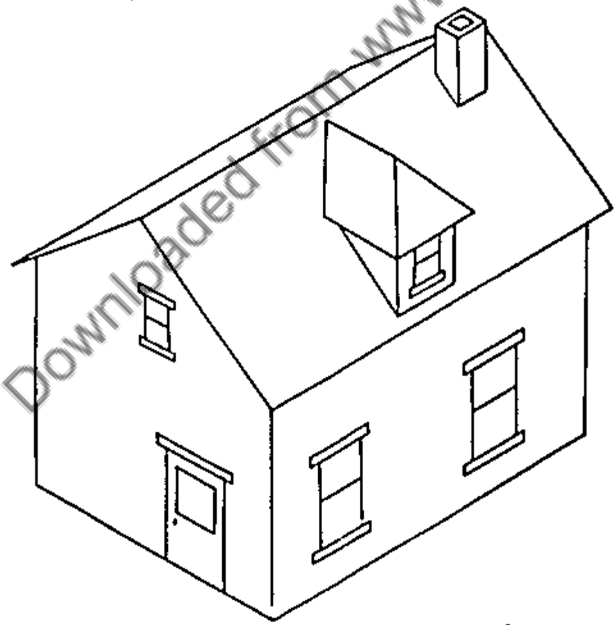


Fig. 143.—Picture of House for Project 69.

roof with a dormer that has a hipped roof. The dimensions of the house model on the drawing are to be as follows:

Length	....	4 in.
Width	....	3 in.
Height	....	$3\frac{3}{4}$ in.

Estimate the dimensions that are not given.

Project 70—Related Views of House Model No. 3

Draw sufficient related views to describe the house model shown in **Fig. 144**. The dimensions of the house model on the drawing are to be as follows:

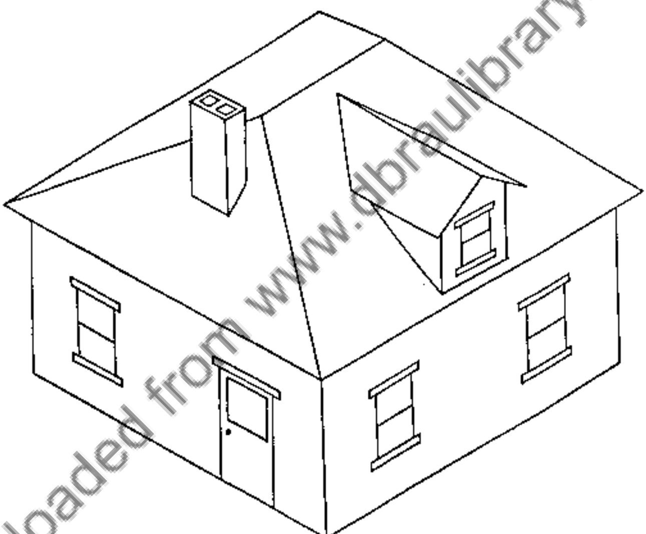


Fig. 144.—Picture of House for Project 70.

Length	....	$3\frac{1}{2}$ in.
Width	....	$3\frac{1}{2}$ in.
Height	....	3 in.

Estimate the dimensions that are not given.

Project 71—Related Views of House Model No. 4

Draw sufficient related views to describe the shape of the house model shown in Fig. 145. The dimensions of the house model on the drawing are to be as follows:

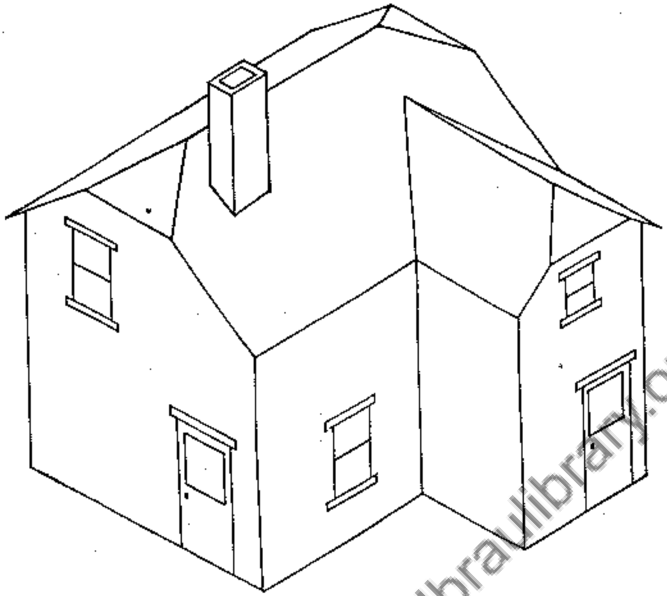


Fig. 145.—Picture of House for Project 71.

Length .... $3\frac{1}{2}$ in.
Width .... $2\frac{3}{4}$ in.
Height .... $3\frac{3}{4}$ in.

Estimate the dimensions that are not given.

WORKSHEET NO. 9

The following questions are to be answered by referring to Fig. 146.

1. How many flue openings are in the chimney and what are their sizes?
2. How far does the roof over the rear entrance extend out from the main building?
3. How wide is the roof over the rear entrance?
4. What is the height of the cellar?
5. What is the difference between the ceiling height of the first floor and the ceiling height of the second floor?
6. How many feet of rain gutter are shown in the front elevation and the right side elevation?
7. How many feet of pipe leading from the gutters to the ground are shown in these elevations?
8. The top portion of window A is shown in the side elevation. State where the tops of windows B and C are located in the front elevation.

9. What is the total area, shown in these two elevations, that is covered with siding?
10. What is the total of the roof areas that are shown in the front and right side elevations?
11. From the three views shown, what information are you able to obtain regarding the detail on the rear elevation of the house?
12. Is sufficient information given to draw the rear elevation and show accurate details?

Project 72—Elevations and Roof Plan of Houses

In each of the house models of the previous projects, three views were used to describe the exterior of the models. Three views adequately described the exteriors of these simple models. This would not be true if there were considerable detail in the rear of the house, or on the side opposite that for which the side elevation was shown.

In describing the exterior of an ordinary house there is considerable detail to show on all sides of the house. In order to show all the details clearly and completely, four—rather than two—elevations are drawn.

A set of blueprints for an ordinary house will include at least eight principal views, with added views showing wall sections and other details. The eight principal views will include:

PLANS	ELEVATIONS
1. Basement	5. Front
2. First Floor	6. Right Side
3. Second Floor	7. Left Side
4. Roof	8. Rear

The elevations and the roof plan shown in Fig. 146 are like those which might appear in a typical set of blueprints to be used for building a house.

The drawing requirement for this project will be three related views of the house in which you live. The three required views will be:

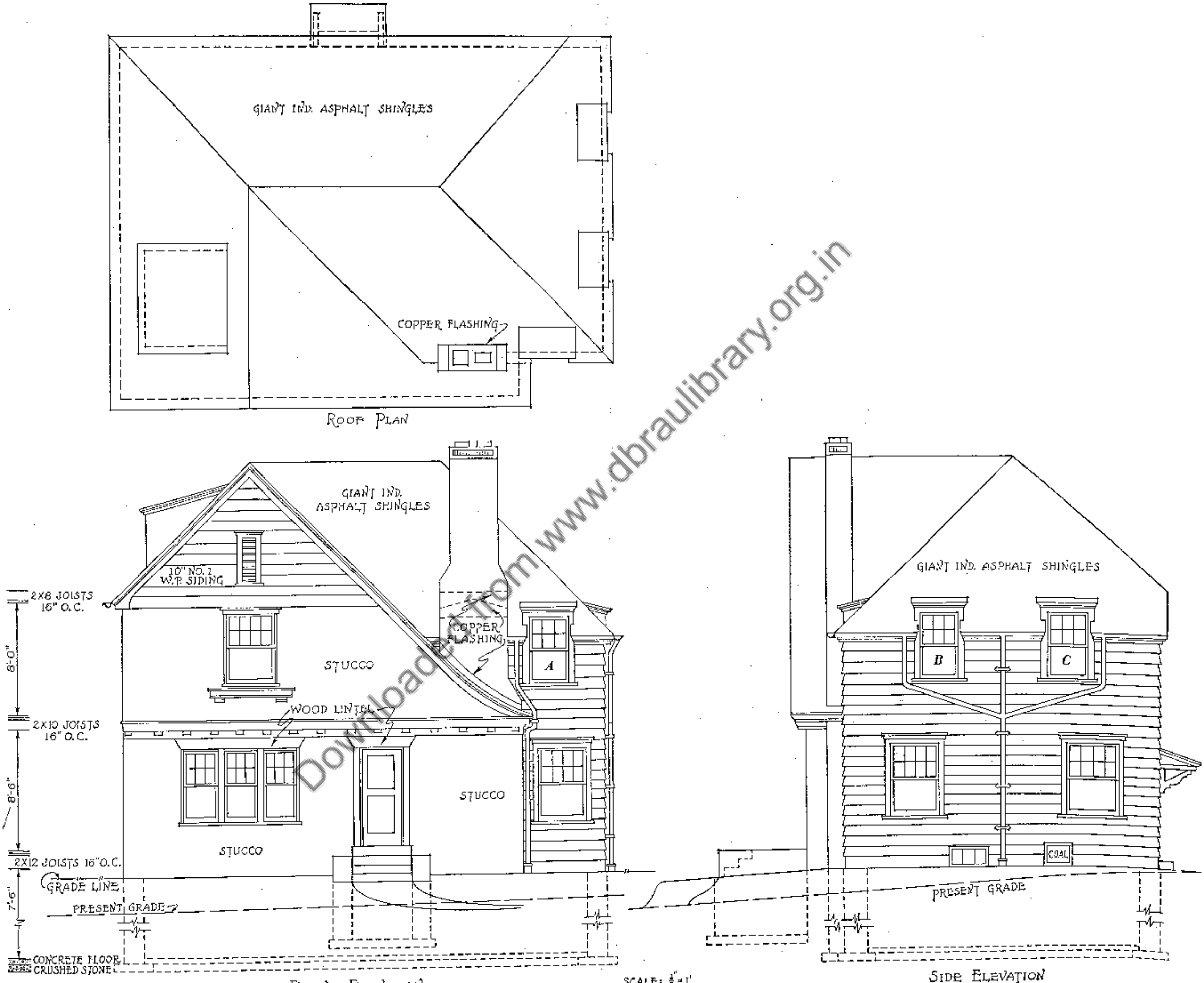


Fig. 146.—Views of House for Worksheet No. 9.

(1) Front elevation

(2) Side elevation—you may draw either the right side or the left side, but you should place whichever side is chosen directly opposite, and on its corresponding side of, the front elevation.

(3) Roof plan—this view may be placed directly above either the front elevation or the side elevation, but make sure that corresponding points are directly above one another.

IMPORTANT

In your drawing it is not necessary to show any dimensions. It is also recommended that you show only the principal details in the simplest manner possible. It will be considered adequate if the position of each window is shown by a rectangle only; however, the appearance of your plate is helped materially if some of the actual detail is added.

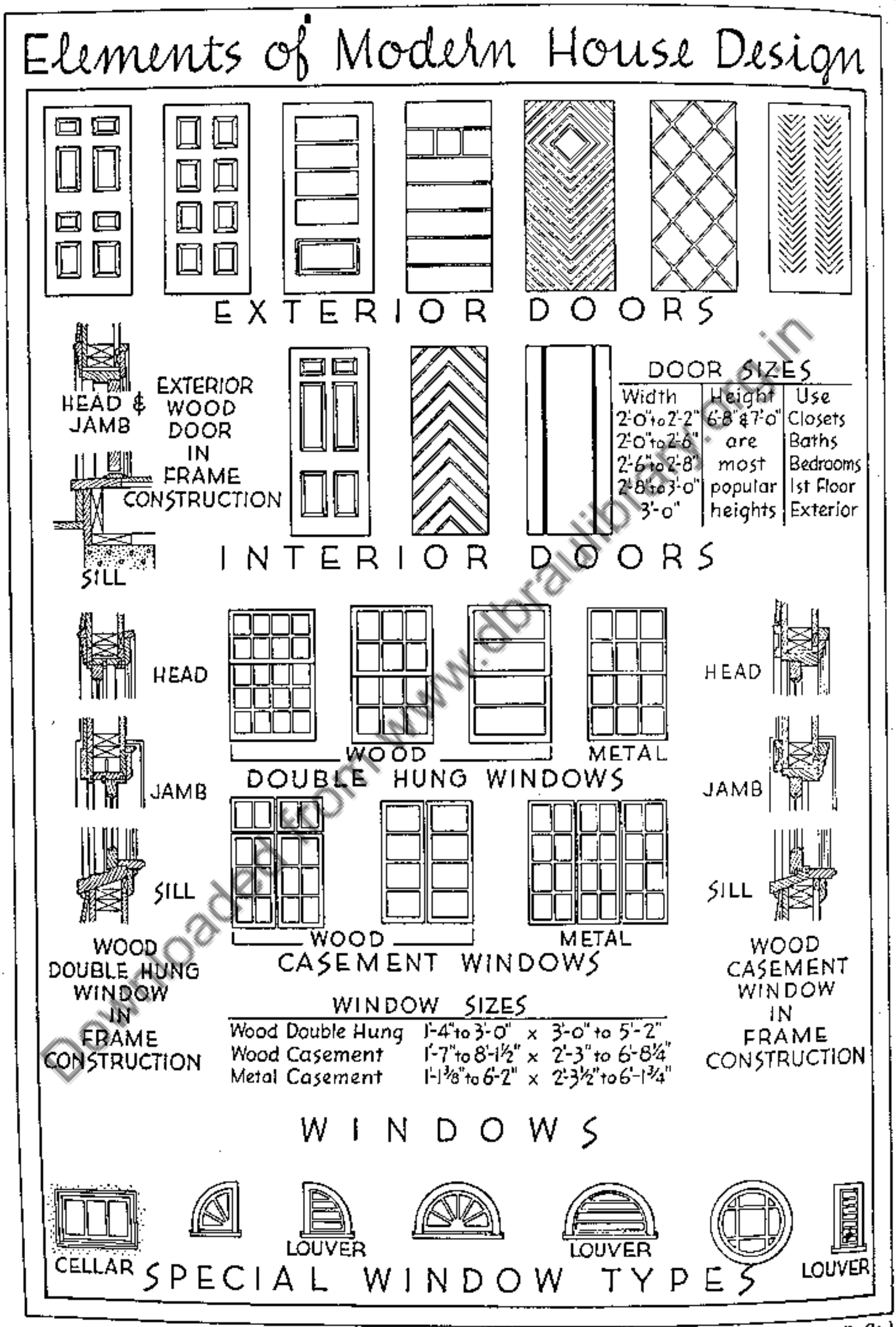
SUGGESTIONS REGARDING SCALE

Building plans of ordinary houses are usually drawn to the scale of $\frac{1}{4}$ in.=1 ft; however, this scale is not suitable for use in the drawing for this project. Since this plate will be drawn of the usual size (11″×17″), it will be necessary to select some smaller fraction of an inch (one that is shown in the margin of the architect's scale) as being equal to 1 foot for the plate for this project.

While making the drawings required for this project, much use can be made of the first floor plan, which was completed for Project 18. It will be necessary to make some measurements at home —*measurements of height,* as ceiling, door, and window heights. To determine the height of the house it is suggested that the ceiling heights be measured and their sum be increased by estimated thicknesses of floors and the attic height. The thickness of a floor, which includes the ceiling construction, floor joist, sub-floor, and flooring, is usually very little more than 1 ft.

Locations of windows in the upper floors may be estimated after those on the first floor have been located.

The pupil is to estimate the height of the chimney and the amount of overhang of the eaves.



(Courtesy of Eberhardt Faber Pencil Co.)

Fig. 147.—Elevations of Architectural Details.

SYMBOLS IN ELEVATIONS

As far as elevations are concerned, little need be said about symbols. Details are shown as they appear, as indicated in Fig. 147. If they are so small or involved that they cannot be shown clearly to the scale being used, detail drawings of the area involved are made to a much larger scale so that the information can be clearly shown, as indicated in Fig. 148.

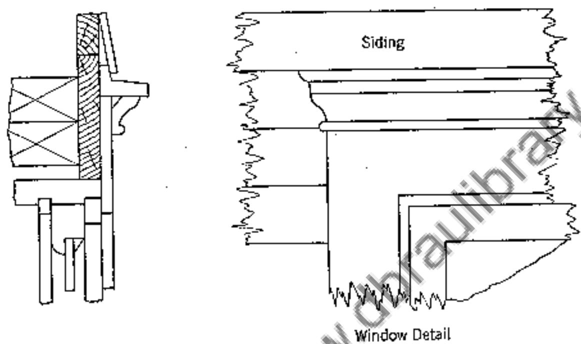


Fig. 148.—Detail Drawing.

Information is often conveyed by way of notes shown in the outline of the areas involved. Many examples of this may be seen in Fig. 146; for instance, there are notes about the roof covering, stucco, and siding.

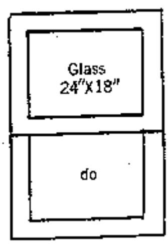


Fig. 149.—Detail of Window Sash.

Sometimes the sizes of the glass are marked on the window panes. Where the same size is used in more than one sash, the notation "do" (meaning ditto) is used, as shown in Fig. 149.

Project 73—Types of Roofs

From the houses drawn in class and with some casual observations of buildings, large and small, it should become quite apparent that roofs differ one from another. Not only are there differences in regard to type of roof, but roofs of the same type have variations in size and in slope. A diagram of a simple roof is shown in Fig. 150.

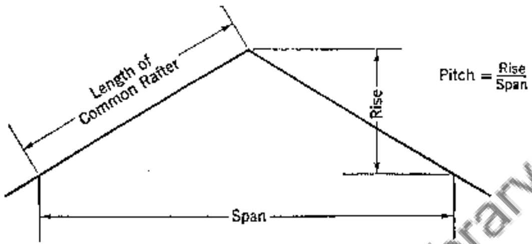


Fig. 150.—Pitch of Roof.

The pitch of the roof is the ratio of the rise to the span. The slope is the ratio of the rise to one-half of the span.

Roofs are of four general types. These four types are as follows:

(1) flat
(2) pitched
(3) ogee
(4) dome

Roofs are called flat when they are almost level, although a slight slope is always necessary in order that water will drain from the roof. Examples of this type of roof may be seen by observing the roofs of some of the higher office buildings, lower structures that cover a large ground area, and probably some of the garages in your own neighborhood. A flat roof is one of the easiest roofs to construct; nevertheless, this roof is not in the most general use for house construction.

The most common of the four types listed, as far as houses are concerned, is the pitched roof. Roofs that have noticeably inclined surfaces are called pitched roofs. Pitched roofs may be made up of one, two, four, or more inclined surfaces. There are many different forms of pitched roofs, and distinguishing names have been given to roofs which are included in this type.

A roof with a single inclined surface, as that in Fig. 151, may be known as *a single-pitch roof, a shed roof,* or *a lean-to*. This form is in general use for small structures. It is in much use for small farm buildings, as wood sheds, chicken houses, and spring houses. In the city it is often used for garages and many smaller structures.

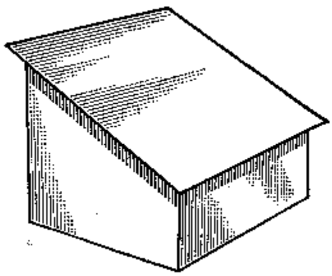


Fig. 151.—Single-Pitch Roof.

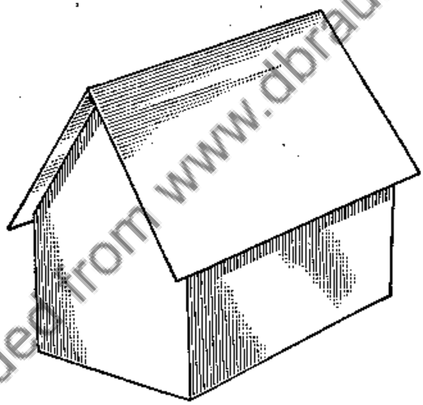


Fig. 152.—Gabled Roof.

Double-pitched, or *gabled, roofs* (see Fig. 152) are in very common use for houses. In all probability this is the kind of house roof you have been drawing since the first set of crayons was placed at your disposal. Little need be said of this form of a pitched roof.

Fig. 153 shows a roof with gables on all four sides. The line *EF* is known as a *valley,* while the line *EG* is known as a *ridge.*

A *hipped roof* is shown in Fig. 154; *AO, BO,* and *PC* are *hips.* Another hip, which could be called *PD,* cannot be seen. The line *OP* represents the *ridge.* In a hipped roof, separate inclined surfaces

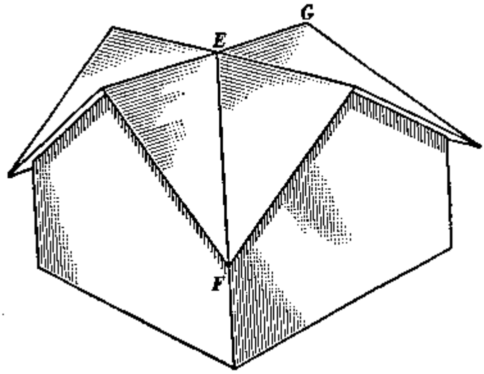


Fig. 153.—Gable with Valleys.

slope to the four sides of the house. Their intersections form the hips and the ridge. Often dormers (roof additions which enable you to place vertical windows above the main roof) are added to the roof to provide light and ventilation to the attic story, which in many cases is used for living quarters. A gabled dormer has been drawn on the inclined surface *BOPC*.

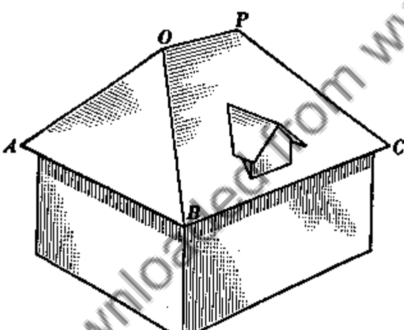


Fig. 154.—House with Hipped Roof and Dormer.

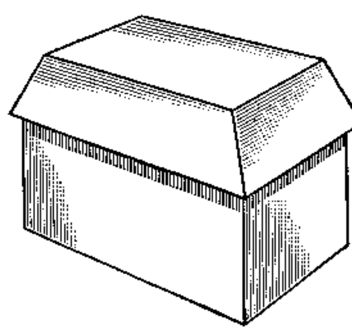


Fig. 155.—Decked Roof.

A *decked roof* is shown in Fig. 155. The example shown is nothing more than a hipped roof that ends in a flat roof before it reaches the ridge. It would still be considered a decked roof it it were a gabled roof that was interrupted by the flat roof.

Of quite similar shape to the roof in Fig. 155 is the one shown in Fig. 156. This is a *mansard roof*. The steeper portions of this roof are concave lines, rather than straight lines, and the more or less flat roof has been arranged so that it slopes very slightly from the center toward all four sides. All mansard roofs to be seen today are of old construction. There is very little new construction of this type. In general, a mansard roof has quite a number of dormers located on every side inasmuch as the top story is as usable (ample ceiling height) as the other stories. It is the function of these dormers to provide light and ventilation for this top story.

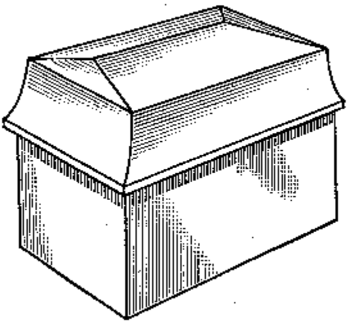


Fig. 156.—Mansard Roof.

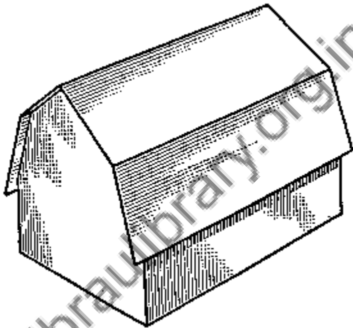


Fig. 157.—Gambrel Roof.

Fig. 157 probably reminds you of a barn. This is an example of a *gambrel roof*. The roof slopes toward two opposite sides of the structure, and there is a double slope in each direction. It gives added cubic content to the attic story without the high steep gable and still the top of the roof is sufficiently inclined for the quick removal of water and snow. While this form of roof is in common use on barns, many houses have roofs of this form with dormers added.

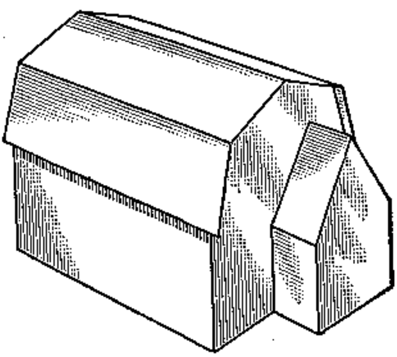


Fig. 158.—Form of House with Gambrel Roof.

The illustration in Fig. 158 shows the general form of a present-day house, the main roof of which is of the gambrel type.

Fig. 159 shows a line sketch of a *hipped and valley roof*. This type of roof is quite similar to the gable and valley type of roof shown in Fig. 153.

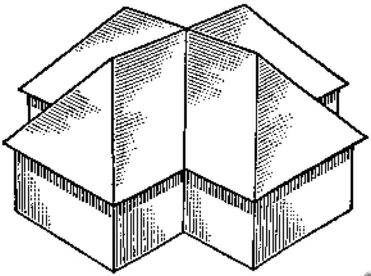
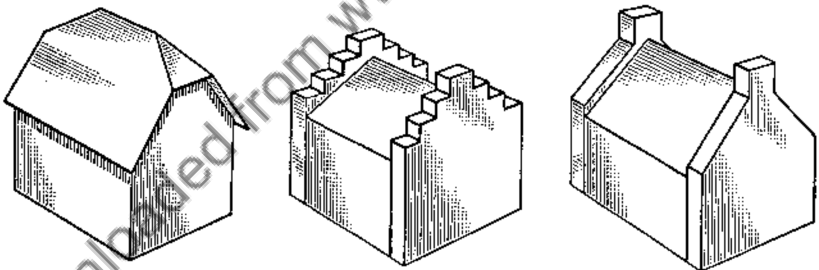


Fig. 159.—Hipped and Valley Roof.

Several types have evolved from the simple gable roof, some of which are the bobbed gable, crow-step gable, and walled gable shown in Fig. 160. The last two mentioned are usually found in houses or buildings of brick construction, while the first is used to make a gabled house appear smaller in height.



Bobbed Gable Crow-Step Gable Walled Gable

Fig. 160.—Gabled Roofs.

Some of the houses built a few decades ago have additions, usually housing a small room, that projects above the main roof. Some of these additions are circular in shape and are covered by *conical roofs*, as shown in Fig. 161. Often these additions were shaped as regular polygons of six or eight sides. When this was the case, they were usually covered by a *pyramidal roof*, as in Fig. 162. A four-sided pyramidal roof, similar to a hipped roof, has four hips that meet at a point rather than a ridge.

Sometimes the side of the roof of a tower or other small structure is made up of curved lines—usually a reverse curve or one that is part concave and part convex. This type is known as an *"ogee" roof* or *double curved roof.* When such a roof is placed on a circular tower, it is called a *bell roof,* because of its resemblance in shape to a bell.

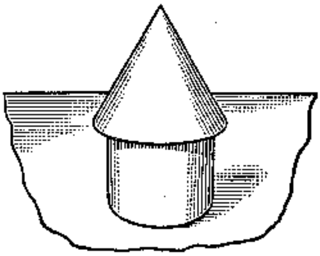


Fig. 161.—Conical Roof.

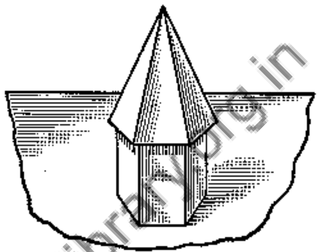


Fig. 162.—Pyramidal Roof.

A dome is a type of roof that is used frequently to add dignity to the appearance of an important building. In shape a dome is generally a portion of the surface of a sphere. The roof covering used on domes is usually sheet metal.

Before beginning the drawing requirements for Project 73, the pupil should complete Worksheets 10 and 11.

DRAWING REQUIREMENT FOR PROJECT 73

Draw three related views of the roofs of four different houses, which do not include your home. Make the views similar to those shown on Worksheets 10 and 11. Of these four houses, one must have a hipped roof; one, a gabled roof; one, a gambrel roof; and the last, a roof of some other type (flat roofs excluded) or a combination of two or more types. At least one of the roofs must have at least one dormer. With each set of views, name the type of roof and give the location of the house of which the roof is a part.

The usual layout will be used, with the working space divided into four equal rectangles. One quarter of the working space is to be used for each set of views. If necessary, a different scale may be selected for each roof in order that the views may be placed in their correct relative positions within the allotted spaces.

It will be necessary to estimate the dimensions of the roofs.

WORKSHEET NO. 10

Answer the following set of five questions in regard to each of the roofs shown in Figs. 163, 164, and 165. All views are drawn to the scale of 1 in.=20 ft.

1. Identify the type and form of each roof.
2. Give the rise of each roof.
3. Give the span of each roof.
4. Give the length of the common rafter of each roof.
5. Give the pitch of each roof.

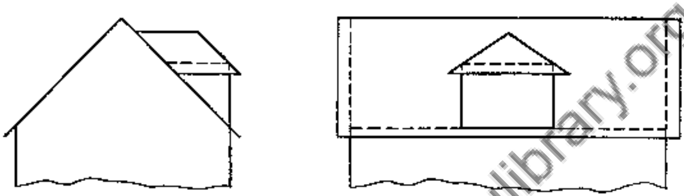


Fig. 163.—Roof for Worksheet No. 10.

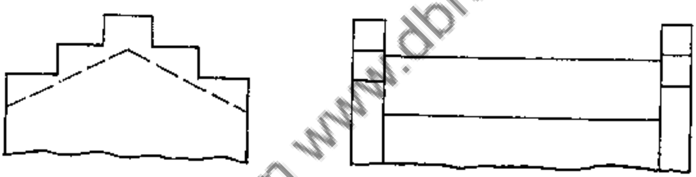


Fig. 164.—Roof for Worksheet No. 10.

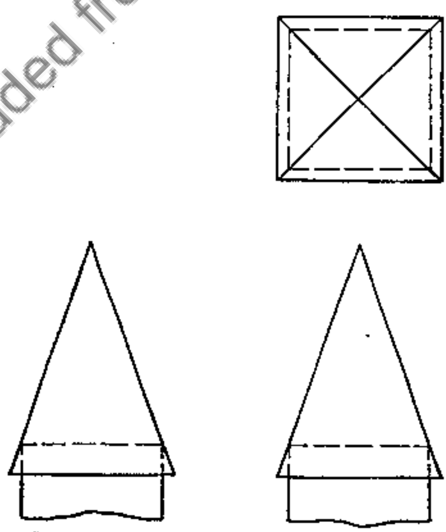


Fig. 165.—Roof for Worksheet No. 10.

WORKSHEET NO. 11

Make a pencil tracing of the drawings shown in Figs. 166 and 167. Perform the required work on the tracing. *Do not write on this sheet.*

A. Complete the three views of a hipped hoof with a gabled dormer shown in Fig. 166. Place a chimney on the roof.

B. Complete the three views of a gambrel roof with a gabled addition shown in Fig. 167. There is no chimney.

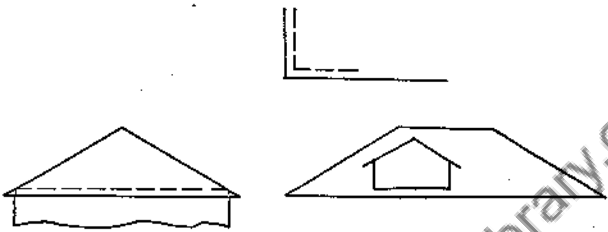


Fig. 166.—Hipped Roof for Worksheet No. 11.

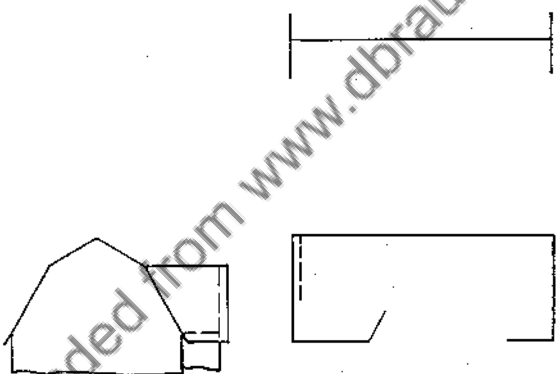


Fig. 167.—Gambrel Roof for Worksheet No. 11.

Project 74—Front Elevation from Floor Plans and Photograph

Secure from a newspaper or magazine a photograph of a house which has floor plans accompanying the photograph. From the information shown in the photograph and the floor plans, draw a front elevation of the house.

Project 75—Cabin Elevations and Roof Plan

Draw a front elevation, a side elevation, and a roof plan to accompany the cabin floor plan that was drawn as Project 21.

Project 76—Elevations and Roof Plan for Playhouse

Draw a front elevation, a left side elevation, and a roof plan for a playhouse, the floor plan of which is shown in Fig. 168.

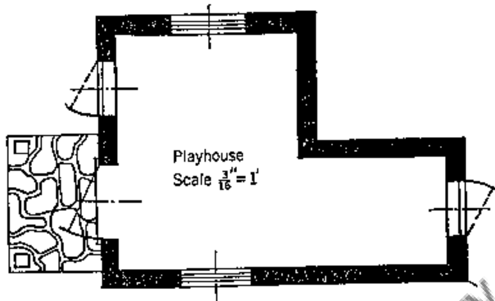


Fig. 168.—Floor Plan of Playhouse.

Project 77—Elevations and Roof Plans in Modern Style of Architecture

Draw a front elevation, a side elevation, and a roof plan of a structure built in the modern style of architecture.

Project 78—Garage Elevations and Roof Plan

Draw a front elevation, a side elevation, and a roof plan for a one-car garage.

Fig. 169.—House of the Seven Gables (Five Gables Are Visible).

Project 79—Frame House Construction

There is not a house built today that is not in some way related to others built before it. This may also be said of the early American homes. One such home is shown in Fig. 169. Architecture in America had its beginning when the various colonists built homes from the materials they found available and quite naturally built them similar either to the houses in the country from which they came or to those of the native Indians. The first log cabins in America—a type that we are inclined to consider originally American—were built by the Swedish colonists after a type of log construction that was a recognized building feature in their native land. The construction of log cabins was a good idea. Anyone can see the advantages of it. It made use of the trees cut in clearing the ground and provided a somewhat permanent structure. It has been used in one variation or another, from the early days down to the present, wherever man has thrust himself into the forests.

Spain's early efforts in this new country were toward the establishment of missions and forts usually located one day's march apart. In plan they were combinations of buildings located around a yard called a patio. The work was done by Indian converts, and naturally was of native Indian adobe construction. The walls were 3 ft in thickness and held up heavy pole rafters which supported a thatched roof. However, shortly afterward, tile from Spain was used to replace the roof covering and also to cover the crude earth floors. Needless to say, houses are being built today along practically these same lines. While they are being built chiefly in California and in the South, you may find in other regions houses of this style with necessary changes for differences in climate.

When the French under Champlain settled in the region of Quebec, they built the types of houses that they had used in Normandy. These houses were so suited to this part of the country that the French Canadians have continued to build them to this day. The houses were usually made of stone, were a story and a half in height, and had high steep roofs which sometimes covered two or more attic stories, as shown in Fig. 170. Light and ventilation for these attic stories were provided by small dormers, which were made smaller as they were located higher on the roof. Because of the intense cold of the winters, the windows were small and few in number. The eaves projected and wooden shutters were placed on the windows to give added protection against the weather.

New York City in its infancy, as today, had the highest building in the colonies. The early Dutch settlers at New Amsterdam built houses mostly of stone and brick. Some of these houses were four or five stories high, there usually being a shop on the first floor and living quarters above. None of these original New York houses are standing today.

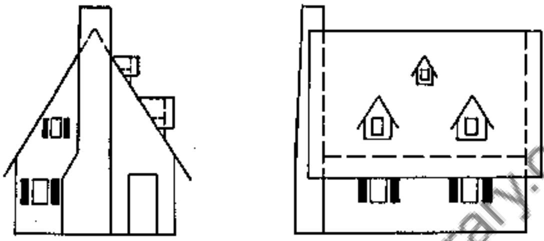


Fig. 170.—French Colonial Style.

The Dutch developed extensively two types of houses. They were those with crow-step gables and those with gambrel type roofs. These types of roofs are illustrated in Fig. 171.

In the gambrel type, the roof was extended and supported by slender columns so as to become the roof of a porch, which generally was not very wide. See circle A in Fig. 172.

An improvement over this type of porch roof was made in houses built of Dutch colonial design. See circle B in Fig. 172.

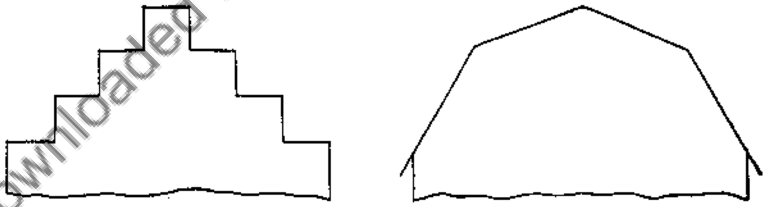


Fig. 171.—Dutch Colonial Roof.

The homes of the English colonists were built similar to types in England. John Smith's adventurers, some of whom were gentlemen's sons, used their indentured white and slave labor to build homes modeled after the English mansions. They were centers of hospitality—large houses, with imposing entrances and spacious gardens. Wings were built for servant quarters, kitchens, and storerooms. Mt. Vernon, the home of George Washington, as it now stands is an example of this type. Mt. Vernon had its evolution from a more simple design to its present form, starting with a plan similar to the first floor plan in Fig. 48 with two chimneys.

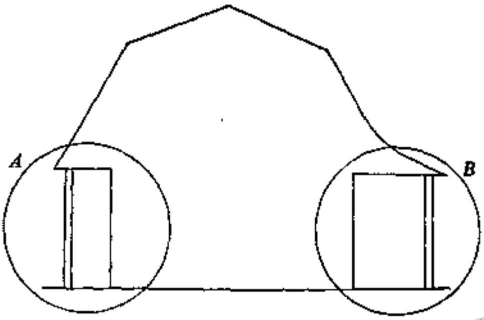
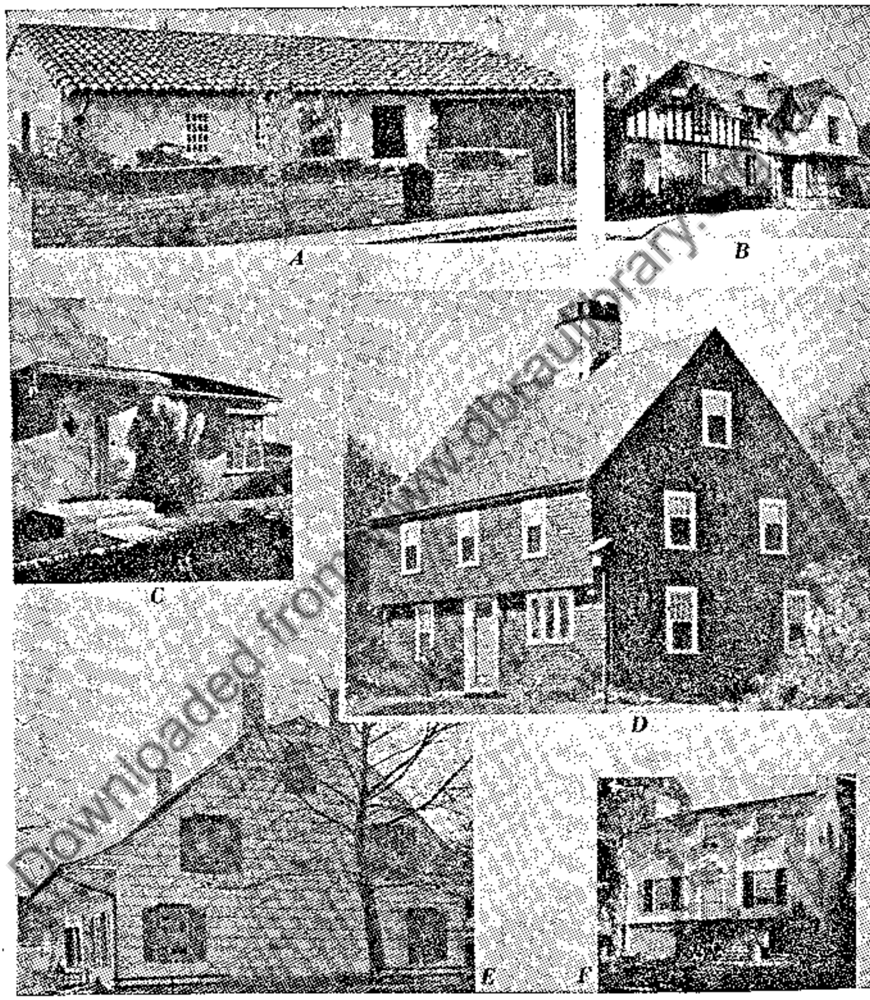


Fig. 172.—Porches with Dutch Colonial Design.

New England may be said to be the home of the frame house in America. Here the colonists copied the smaller houses of England. Lack of lime or the stone from which to derive lime caused the elimination in the building line of anything that required mortar. Hence, they did not build stone houses, as most of the colonists did, but built their houses of hewn timbers after a method called "half-timber construction" which had been in use in England for years. Sometimes this method has been called Gothic or medieval —but, regardless of what it is called, it has been solid enough to remain standing through three centuries.

Fig. 173.—Home of Paul Revere.

These people not only introduced the type of construction which was familiar to them but quite naturally built houses that had most of the features of the English cottages. A distinct characteristic of their houses was the overhanging second story. Sometimes this story overhung all the way around; sometimes, only on the ends or on any combination of sides and ends. When both the gable and second story overhung, they called it a double overhang.



(Courtesy of Better Homes and Gardens)

Fig. 174.—Houses for Worksheet No. 12.

The "Home of Paul Revere," shown in Fig. 173, still stands today in an excellent state of preservation at its original site in the city of Boston, Mass. This house has a second story overhang and a large end chimney, only a small portion of which can be seen in the photograph.

In Connecticut they reduced this overhang until at last it became nothing more than a molding around the house. They, on the other hand, developed the entrance doorway. These doorways were elaborate when compared with the rest of the exterior of the house. Their purpose was to breathe hospitality to anyone except the witches, and crosses were placed in the panels of most of the doors to keep them out.

The early frame houses had high-pitched gabled roofs. Later hipped roofs were to be seen as often as roofs with gabled ends. The many gabled houses, such as "The House of Seven Gables," are distinctly a New England type. Houses with gambrel roofs, now commonly thought of as Dutch Colonial, were also to be found in some parts of New England. Regardless of the fact that the houses of New England had high roofs, they appeared to hug the ground because of the low ceiling height used.

WORKSHEET NO. 12

Classify each of the six houses shown in Fig. 174 in regard to architectural style. In each case, list the architectural features that were the reasons for the particular classification.

WORKSHEET NO. 13

1. Draw freehand a front elevation and a side elevation of a home in your town that has some of the architectural features of the English Colonial homes.
2. Draw freehand a front elevation and a side elevation of a home that has some of the architectural features of the Spanish Colonial homes.
3. Draw freehand elevations of a structure built in the Modern style of architecture.

HALF-TIMBER CONSTRUCTION

The frame houses built by the early New England settlers were very sturdy. They were fashioned after one of three types of "half-timber construction" used in England at the times of the departures of the settlers. These types were known as "Post and Pan," "Transom Framed," and "Intertie Framed."

In Fig. 175 is shown a picture of the house in which William Shakespeare was born. Tradition sets the date of his birth as April 23, 1564. In all probability the house was built many years before that time. It is an example of a type of house standing in England when her colonists came to America.

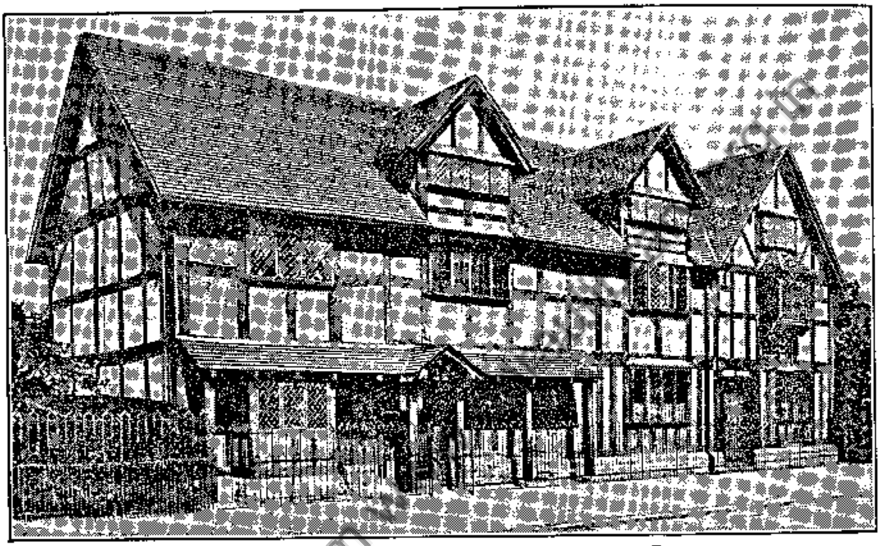
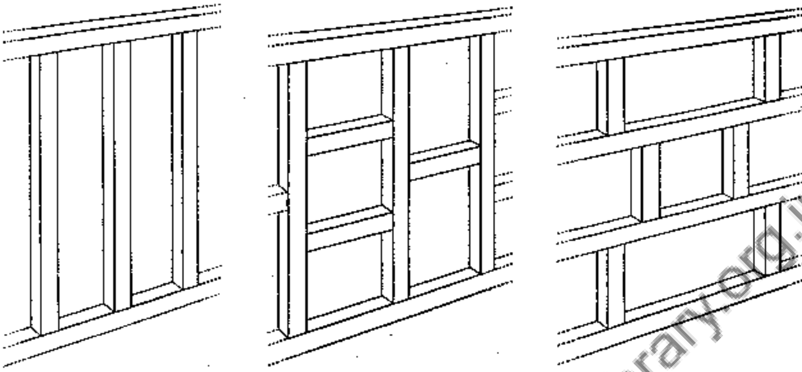


Fig. 175.—House in Which Shakespeare Was Born.

The "Post and Pan" style was the earliest used in England and consisted of upright posts placed between the horizontal ground sill and the head beam which supported the roof. These posts were fixed from 4 to 9 in. apart, and the spaces between them were filled with clay or interwoven twigs and crude mortar.

Later builders, with more confidence, set their upright posts further apart and held them together with horizontal timbers called transoms. This was the beginning of the transom framed houses, the walls of which consisted of vertical and horizontal timbers forming large square or rectangular openings. Some of these openings were used for doors and windows, while the others were filled with twigs and crude mortar.

Intertie framework was very little different from the transom style. The one difference was that it consisted of strong uninterrupted horizontal timbers rather than vertical timbers. Vertical posts framed between these heavy horizontal beams formed the usual squares and rectangles. In order to strengthen the framework, diagonal braces were often added at the corners of the houses.



Post and Pan Transom Framed Intertie Framed

Fig. 176.—Types of Half-Timber Construction.

In all three types, beams spanned the upper story; and, at their centers, upright posts were placed to support cross-beams. These cross-beams were fastened at the ends to the slanting beams (rafters) of the roof. This construction is illustrated in Fig. 177.

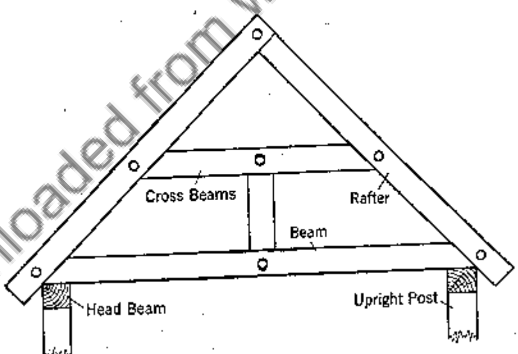


Fig. 177.—Half-Timber Roof Truss.

With an abundant supply of timber available, it was not long before the colonists fastened split logs to both the outside and the inside of the framing. After doing this, they no longer found it necessary to use the crude mortar with sticks to fill the openings in the framing.

In later years, with saw mills turning out lumber to any desired size and with nails replacing wooden pins as a means of fastening members in place, the builder found it quicker and more economical to build his framework of lumber of a smaller size.

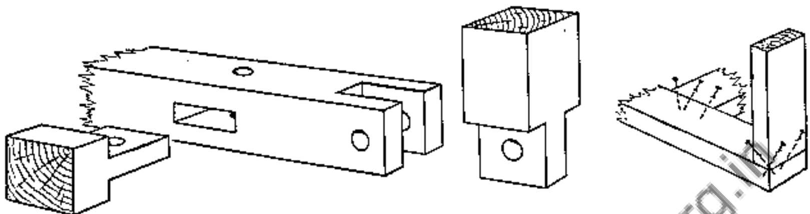
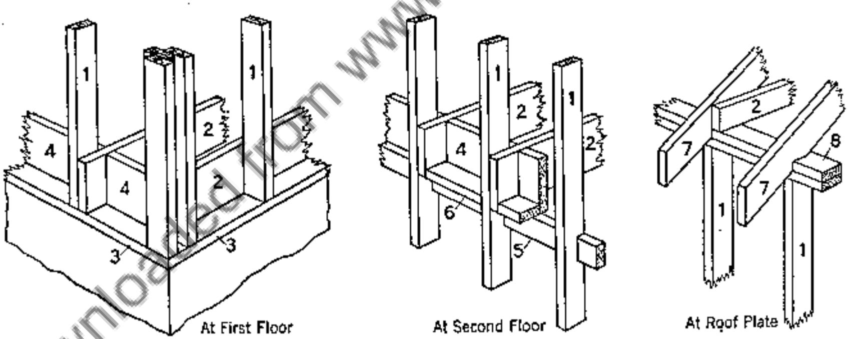


Fig. 178.—Joinery—Past Versus Present.

When spikes came into use, it was no longer necessary to make the old mortise-and-tenon joints, which were required when members were fastened together with the help of a wooden pin. Now it is possible to nail the various members together without being skilled in the art of joinery. The old and new methods of making connections are shown in Fig. 178.



1. studs
2. joists
3. sill
4. header
5. false girt or ribbon
6. fire stop
7. rafter
8. roof plate

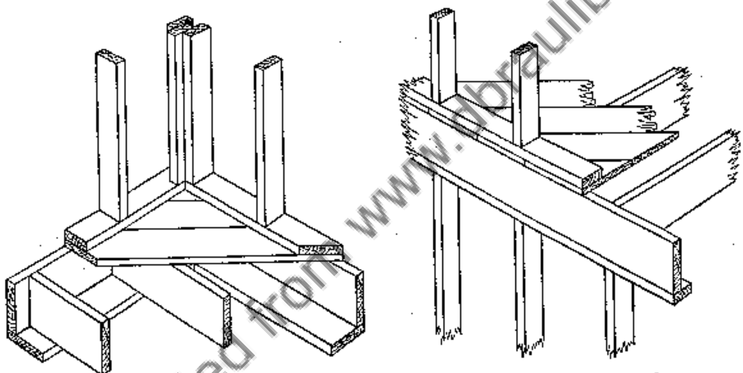
Fig. 179.—Balloon Type Framing.

HOUSE FRAMING

Framing for walls today differs very little from that used in the transom framed house of yore. We still have our upright posts, but they differ in size. We now use 2 x 4's for studs in place of the earlier upright posts. These studs are usually placed 16 in. apart, center to center. (For small one-story structures, such as garages, this spacing is often increased to 24 in. center to center.) These studs rest on the sill (size 2 in. x 10 in.), which is placed on the foundation.

The type of framing most generally used today is called the *balloon type* and is illustrated in Fig. 179. In this type the studs run continuously from the sill to the roof plate. The roof plate consists of two 2 x 4's running horizontally over the tops of the studs and supports the rafters (2 in. x 6 in.) and sometimes the attic joists (2 in. x 4 in. or 2 in. x 8 in.).

The lower ends of the studs (2 in. x 4 in.) and the first-floor joists (2 in. x 10 in.) rest on the sill (2 in. x 10 in.) and are nailed together.



At First Floor At Any Other Floor

Fig. 180.—Platform Type Framing.

The second-floor joists (2 in. x 10 in.) rest on a "ribbon," or false girt (usually 1 in. x 6 in.), which is notched into the studs on the inside at the proper height. The joists are spiked to the sides of the studs.

Another type of framing, in less general use, is the *platform type*. In this type, as shown in Fig. 180, *the studs rest on a platform,* which consists of floor beams, headers, and sub-flooring. This platform rests on the foundation wall. A small plate (2 in. x 4 in.) is placed between the platform and the studs. (A better understanding of both types of framing may be obtained by supplementing the reading of this section of this unit with a careful study of models constructed of balsa wood.)

When a house is platform-framed, each floor being a platform, the studs run between platforms and the usual plates are placed at the bottoms of the studs and at their tops. This arrangement permits the use of shorter studding, and it is claimed that this type has unusual strength and rigidity in spite of the interruptions in its vertical members. As may be expected, corner bracing is used in this type of framing.

A roof plate detail similar to that shown for a balloon-framed house may be used with a platform-framed house.

In both balloon framing and platform framing, openings are provided for windows and doors by using headers and trimmers. Window headers are placed between studs to give the required vertical location and height. Window headers are 2 in. x 4 in. in cross-section. In the case of openings for wide windows or doors, two 2 x 4's are used for each header. Trimmers are vertical 2 x 4's placed between headers to give the required horizontal location and width. There should be at least as many trimmers at the sides of an opening (counting both sides collectively) as there are studs cut by the header above.

In balloon type framing, several smaller lengths of both 2 x 10's and 2 x 4's are used. The 2 x 10's are headers which are framed between the floor joists on the inside of the studs. In the case of a bearing partition, these headers are placed between the joists on both sides of the studs forming a frame upon which the ends of the sub-flooring are nailed. While they aid considerably as bracing, lending much to the strength and rigidity of a building, they also serve as a support for the ends of the sub-floor.

If it were not for the 2 x 4's which are placed between the studs, there would be a natural flue between the floors and walls, through which flames would draw readily in case of fire. These 2 x 4's are quite appropriately called "*fire stops*," and are usually placed adjacent to the second-floor system. When placed in this position, they quite effectively close the natural flues. Quite often, additional fire stops are placed midway between floors.

The sub-floor is usually made up of lumber the size of which is 1 in x 6 in. It is laid diagonally across the joists. When well nailed, it serves as additional bracing.

An inconspicuous factor in framing, the importance of which is often underestimated, is *bridging*. This consists of small braces, about $1\frac{1}{8}$ in. x 3 in., extending crosswise from the top of one floor joist to the bottom of the adjacent joists. This row of braces is generally found in the center of the floor span. Where the span is greater than 16 ft, rows of braces should be placed not more than 8 ft apart. Proper bridging will tend to keep the joists in alinement and will distribute to all the floor joists any weight applied directly over one or two of them. In other words, it tends to tie the floor into one solid structural unit.

So far no mention has been made of the sheathing, which is nothing more than the boards (1 in. x 12 in.) that are nailed diagonally to the outside of the studs. It should be well nailed, for it then serves very effectively as bracing. The sheathing makes the surface upon which the siding is nailed. Building paper is placed on the outside of the sheathing before the siding is placed. Building paper, in addition to being placed between the sheathing and the siding, is also placed on top of the sub-floor before the finish flooring is laid.

NOMINAL COMMERCIAL SIZE	MINIMUM ALLOWABLE SIZE
2 x 4	$1\frac{5}{8}$ x $3\frac{5}{8}$
2 x 6	$1\frac{5}{8}$ x $5\frac{5}{8}$
2 x 8	$1\frac{5}{8}$ x $7\frac{1}{2}$
2 x 10	$1\frac{5}{8}$ x $9\frac{1}{2}$
2 x 12	$1\frac{5}{8}$ x $11\frac{1}{2}$
3 x 4	$2\frac{5}{8}$ x $3\frac{5}{8}$
3 x 6	$2\frac{5}{8}$ x $5\frac{5}{8}$
3 x 8	$2\frac{5}{8}$ x $7\frac{1}{2}$
3 x 10	$2\frac{5}{8}$ x $9\frac{1}{2}$
3 x 12	$2\frac{5}{8}$ x $11\frac{1}{2}$

In this discussion sizes of members have been referred to as 2 x 4, 2 x 10, and other whole number sizes. This is common parlance, and these sizes are known as the nominal commercial sizes. If one were to measure some of these members, he would find that they were not 2 in. x 4 in. or 2 in. x 10 in., because there is an allowable minimum actual size and the boards usually are more nearly that size than the nominal size.

The list on page 151 shows the minimum actual sizes of some of the larger members.

QUESTIONS

1. What people are accredited with having built the first log cabins in America?
2. Of what did the early efforts of Spanish pioneers toward building in this country consist? Describe.
3. What type of houses did the French build at Quebec?
4. Describe two types of early Dutch Colonial houses.
5. What section of the United States is said to be the home of the frame house in America?
6. What type of house did the followers of John Smith eventually build?
7. What type of construction was used in building the houses in New England?
8. List at least three characteristics of the early New England frame houses.
9. What were the three types of "half-timber construction" used in England before the departure of the colonists? In a few words tell the differences between the three types.
10. What is a stud? What is the maximum allowable distance from center line to center line of adjacent studs.
11. What is a rafter?
12. In the ordinary frame house what are the usual sizes of first-floor and second-floor joists, attic joists, rafters, roof plates, sills, false girts, and studs?
13. How does a "platform framed" house differ from a "balloon framed" house? Answer in detail.
14. What are trimmers? What size are they? Where are they placed?
15. In the framing for a window, where are headers placed and how many should be used?
16. In framing for the first floor, where are the headers placed?
17. What is a fire stop? Where are fire stops placed? Why?
18. What is bridging? What is its function?
19. What is sheathing? What is its function?
20. Where should building paper be used?
21. How does a rafter differ from a joist?

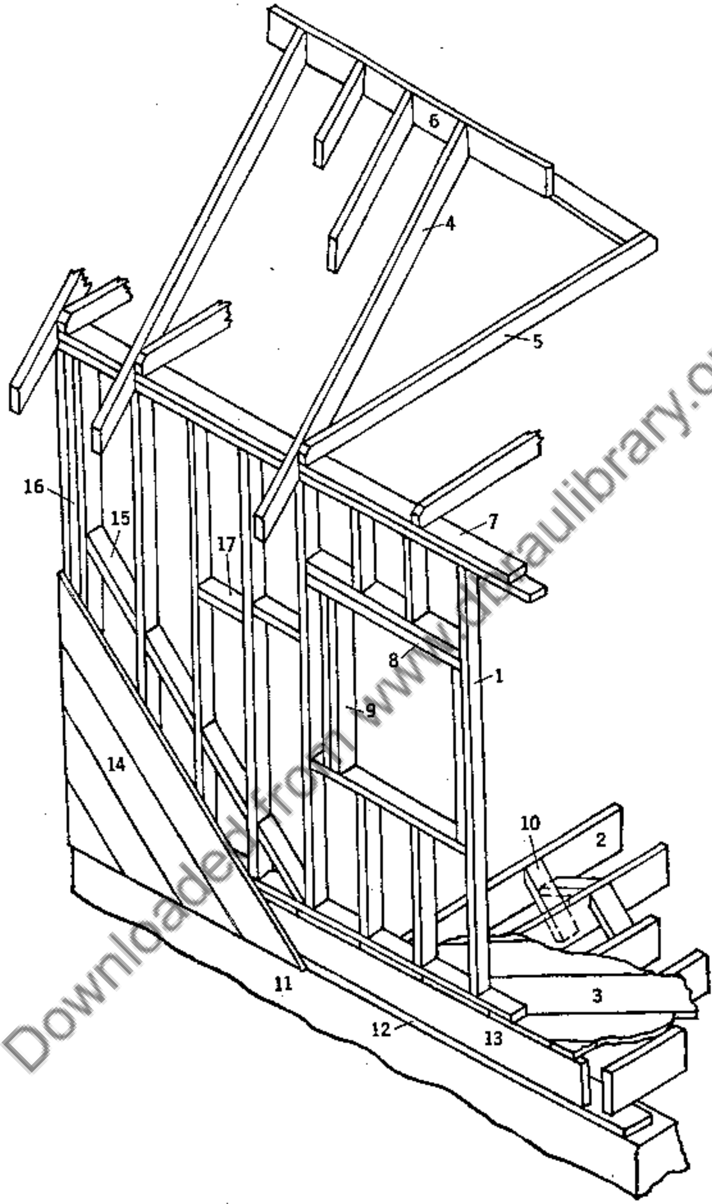


Fig. 181.—Drawing for Worksheet No. 14.

22. What material is most used for roof covering in your locality? Why? Name other roof coverings.

23. Find the location of a frame building under construction at this time. Make daily reports on the progress of the building.

WORKSHEET NO. 14

On a separate sheet of paper, match the number identifying each member in Fig. 181 with the number identifying each member in the following list:

1. ceiling joist	5. floor joist	9. fire stop	13. roof plate
2. trimmer	6. rafter	10. corner brace	14. sub-flooring
3. sill	7. joist header	11. bridging	15. ridge
4. stud	8. corner post	12. sheathing	16. header

17. concrete or masonry wall

DRAWING REQUIREMENTS FOR PROJECT 79

Make a front elevation and a side elevation (to the scale of $\frac{3}{4}$ in. = 1 ft) of the framing details for the corner of the house which is accurately described by the elevations shown in Fig. 182.

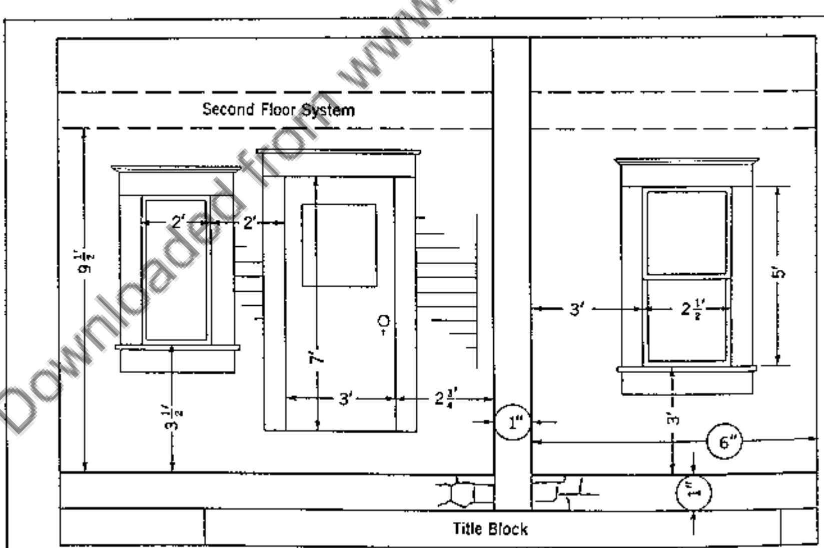


Fig. 182.—Corner of a House.

The *name,* as stud and joist, and the *size,* as 2 x 4 and 2 x 6, of one of each type of member is to be placed on each of the elevations. The width and the height of each framed opening are to be shown within the opening. Framing details for a window are shown in Fig. 183. The width of openings for double hung windows should be 7 in. greater than the width of the sash. This will allow sufficient space for the frame and the necessary sash weights. All heights and the widths of all other openings will be 5 in. greater than the size of the sashes or doors.

For locating the elevations in the working space, the pupil should use the dimensions shown in circles in Fig. 182. These dimensions are full size.

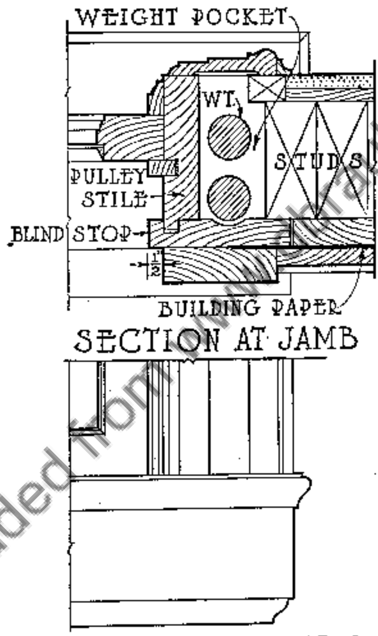


Fig. 183.—Framing Details for Window.

Project 80—Framing Details for Garage

Draw a front elevation and a side elevation of framing details for the one-car garage you drew for Project 78.

Project 81—Framing Details for Playhouse

Draw a front elevation and a side elevation of framing details for the playhouse of Project 76.

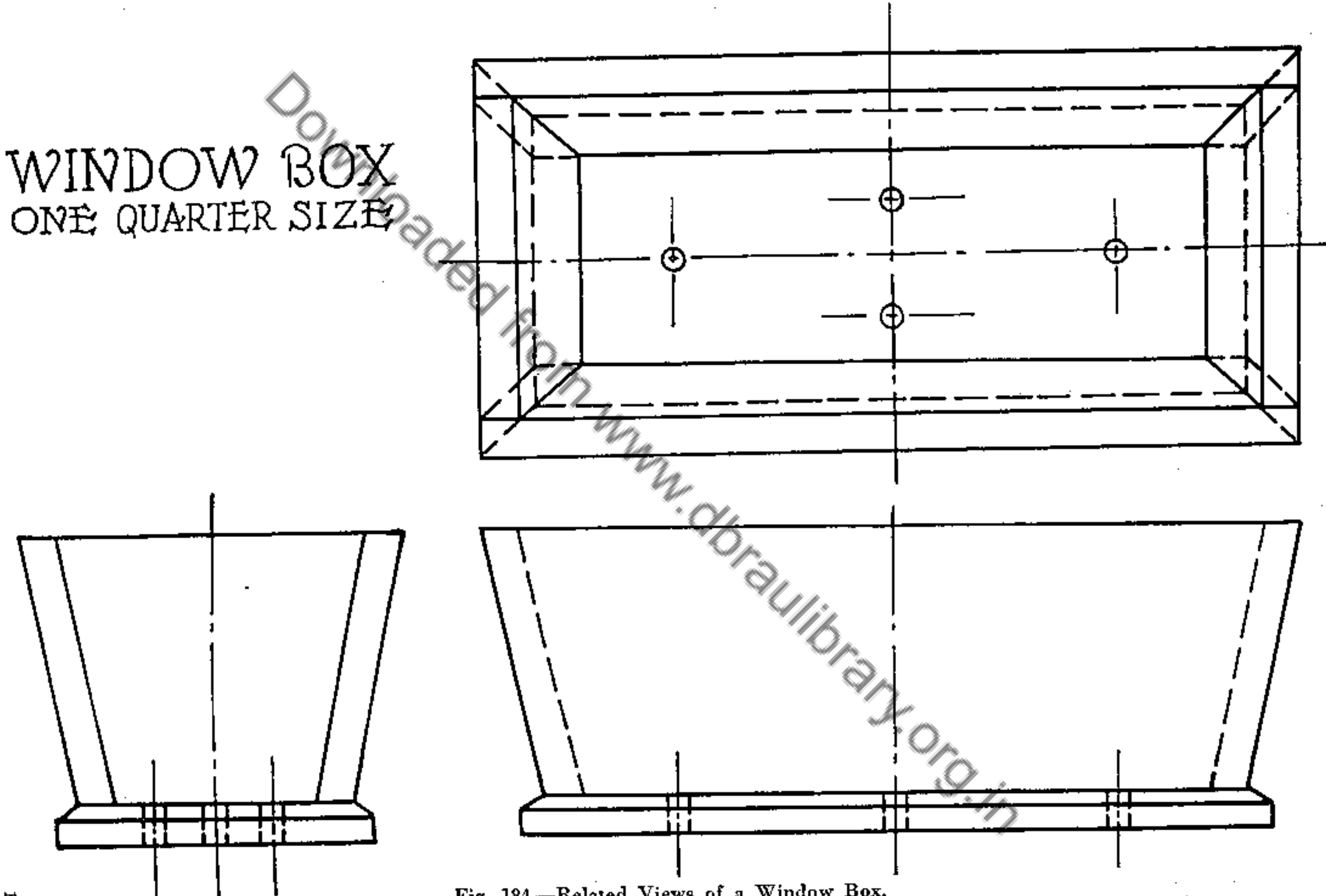


Fig. 184.—Related Views of a Window Box.

Project 82—Lumber Order for Cabin

Make a list of the length of each size of lumber that it will be necessary to have to build the cabin you drew for Project 75.

Project 83—Interpretation of Related Views of a Window Box

In Fig. 184 are shown three orthographic views of a window box. The scale to which these views have been drawn is *quarter size*. When the scale is *quarter size*, 3 inches on the drawing will represent a distance of 1 foot on the actual window box.

QUESTIONS

Refer to Fig. 184 and answer the following questions:

1. What is the greatest width of the window box?
2. What is the greatest length of the box?
3. What is the width of the base of the box?
4. What is the length of the base of the box?
5. What is the length of the opening in the top of the box?
6. What is the width of the opening in the top of the box?
7. What is the height of the outside of the box?
8. What is the height of the inside of the box?
9. How many drainage holes are there in the bottom of the box?
10. What is the shortest distance (measured on the inside of the box) from the front of the box to the nearest drainage hole?
11. Explain why, when looking at the front or the side view, only three drainage holes are apparent.
12. How many cubic inches of dirt would be required to completely fill the window box?

Project 84—Orthographic Views of Objects Smaller than Houses

Orthographic projection is in universal use as a means of graphically describing objects. It is a method that enables one to show the exact shape of an object by a system of related views, generally taken at right angles to one another. Project 83 is an example of this method in practice.

Orthographic views may be considered as being drawn on planes that are parallel to the main surfaces of the object and generally at right angles to each other. The actual views may be obtained by drawing perpendiculars to the planes from the object. These perpendiculars are shown as dashed lines in Fig. 185.

In actual practice it is impossible to have the conditions as illustrated in Fig. 185. Nevertheless, with slight use of some imagination and very little reasoning power, one should be able to visualize the more simple views quite easily.

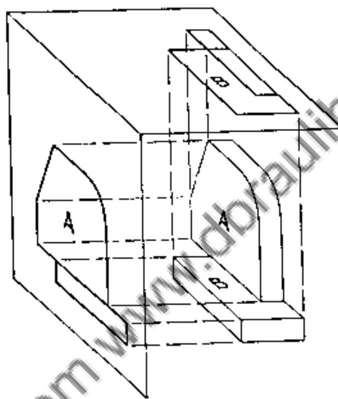


Fig. 185.—Perpendiculars from Object to Planes of Projection.

In describing an object by showing orthographic views, *three views usually* are shown. In Fig. 186, three views of each object are shown. However, two views often are sufficient to thoroughly describe the object, and *sometimes more than three views* are necessary to do the same job. In flat sheet-metal work, one view is sufficient. Cylindrical objects often require but two views; where this is the case, if the third were drawn it would merely be a duplication of one of the other two.

The three views most generally shown are: (1) a top (or plan) view, (2) a front view, and (3) a side view. There is a definite arrangement to be maintained in the placing of these views on the drawing sheet.

The top view, or that view drawn as the object would appear from above, is placed directly above the front view; the right side

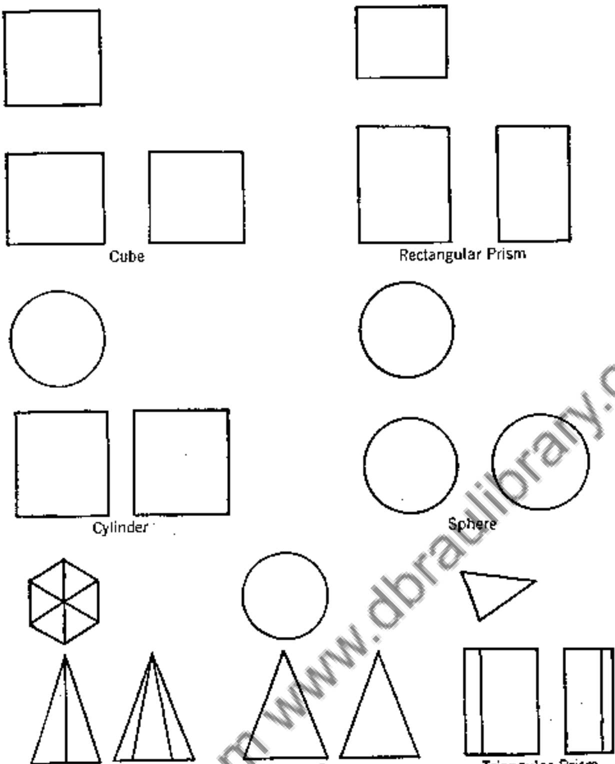


Fig. 186.—Orthographic Views of Common Geometric Shapes.

view is placed to the right of and facing the front view; and, similarly, the left side view—if used—is placed to the left of the front view. The usual arrangement of views is shown in Fig. 187.

When space limitations require, the side views may be placed across from the top view, as in Fig. 188.

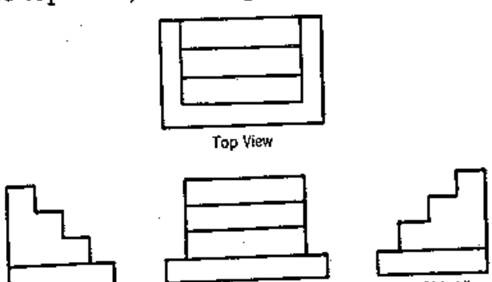


Fig. 187.—Usual Arrangement of Views.

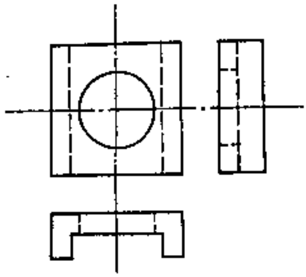


Fig. 188.—Flower Pot Holder.

It is possible to draw six principal views of an object: (1) front, (2) top, (3) right side, (4) left side, (5) rear, and (6) bottom. A bottom view or a rear view of an object can be used to advantage when a considerable amount of the detail to be shown is on those faces. The bottom view, when shown, is placed beneath the front view; while the rear view is placed laterally in line with the front and side views.

For objects where two side views can be used to better advantage than one, these views need not be complete views of the entire object if together they describe the shape of the object, as in Fig. 189.

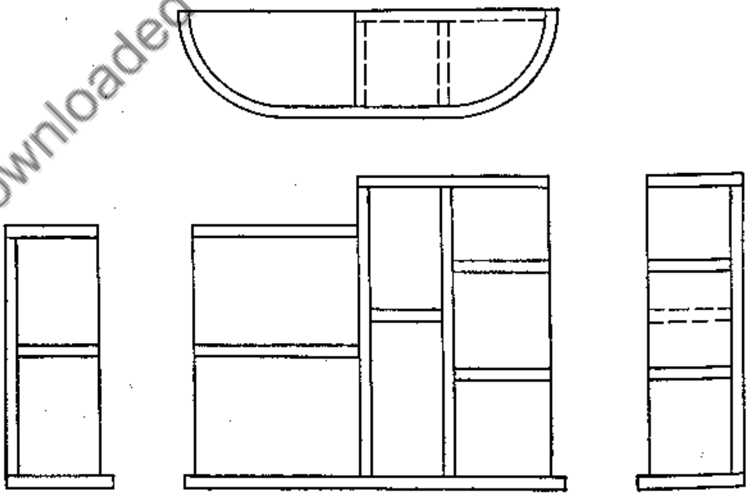
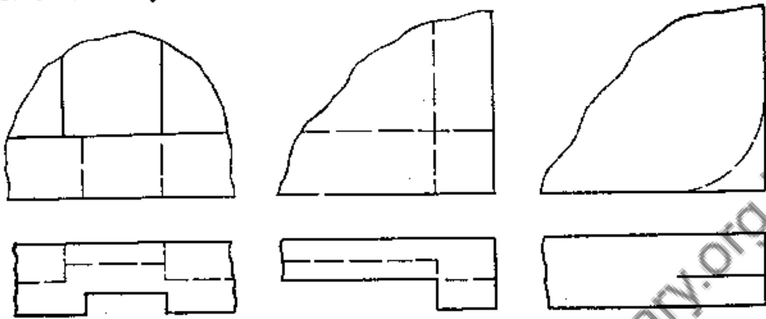


Fig. 189.—Four Views of End Table.

Only those views of an object should be drawn which are absolutely necessary to portray clearly the shape of the object; but one should make sure that sufficient information is given to thoroughly describe the object.



(*a*) (*b*) (*c*)

Fig. 190.—Dashed Lines.

In Project 83 and in figures in this project, use has been made of *dashed lines.* These dashed lines are universally used to represent *hidden lines.* These *hidden lines* are *lines located somewhere back of the surfaces being considered* and add considerably to the shape description.

A dashed line should always begin with a dash in contact with the line from which it starts, except when that dash will form a continuation of a full line as in Fig. 190 (*a*). Dashes should touch

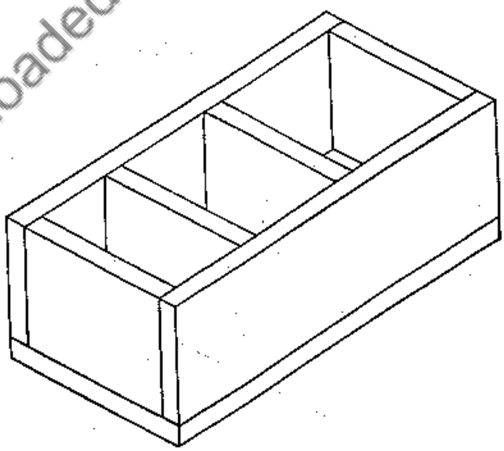


Fig. 191.—Nail Box (Quarter Size).

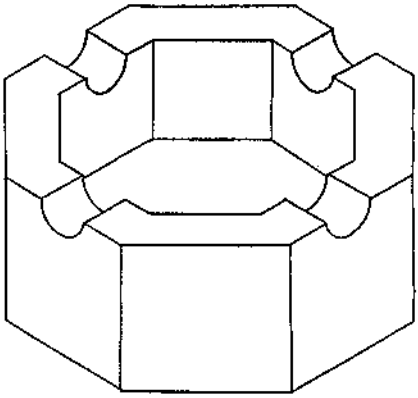


Fig. 192.—Ash Tray (Half Size).

at intersections, as in Fig. 190 (*b*). Tangent arcs should start with dashes at tangent points, as in Fig. 190 (*c*).

The requirements for Project 84 are that each pupil complete the following worksheets. Do not forget to show both full lines and dashed lines. Dashed lines should be made lighter than full lines.

Make pencil tracings of the views given in Figs. 194, 195, and 196. Perform the required work on the tracings.

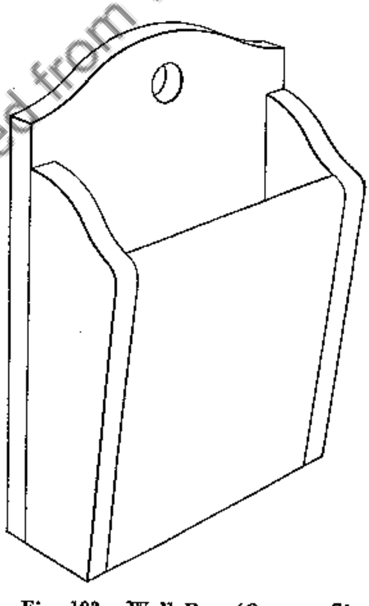


Fig. 193.—Wall Box (Quarter Size).

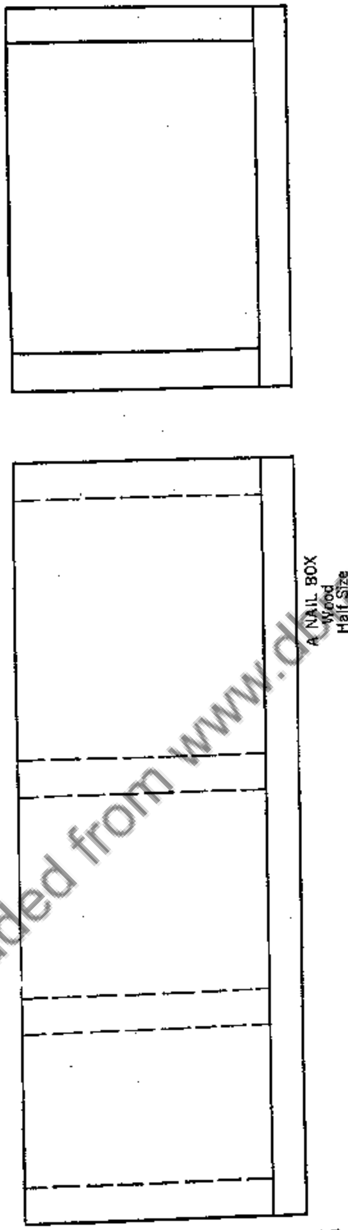


Fig. 194.—Nail Box for Worksheet No. 15.

WORKSHEET NO. 15

In Fig. 194 are shown two complete orthographic views, namely, the front and right side views, of a nail box. The box is pictured in Fig. 191.

Draw, in proper arrangement, the top view of the nail box.

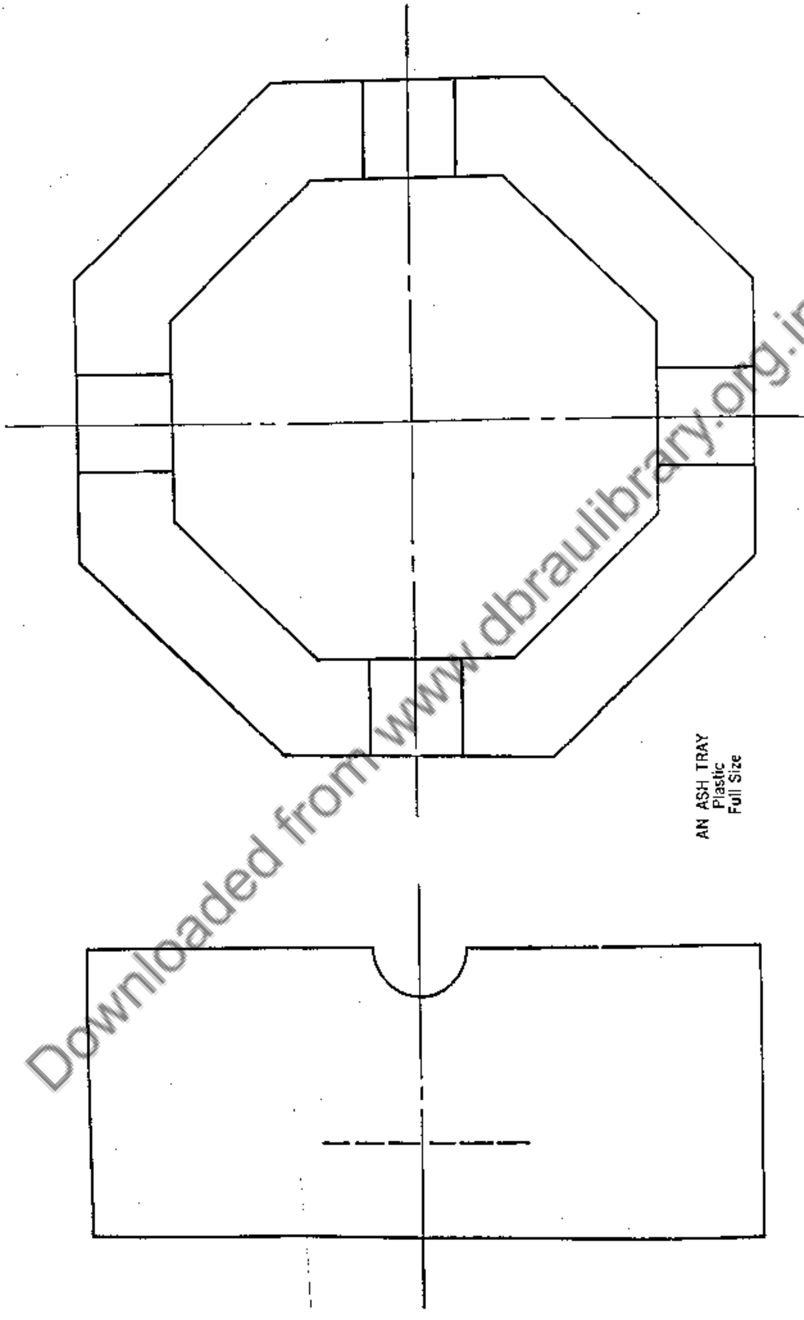


Fig. 195.—Ash Tray for Worksheet No. 16.

WORKSHEET NO. 16

In Fig. 195 are shown a complete top view and a partially completed left side view of an ash tray. Complete the left side view. When completed, these two views are sufficient to describe the ash tray. A pictorial drawing of the ash tray is shown in Fig. 192.

The four semi-circular grooves cut in the top surface have the same dimensions.

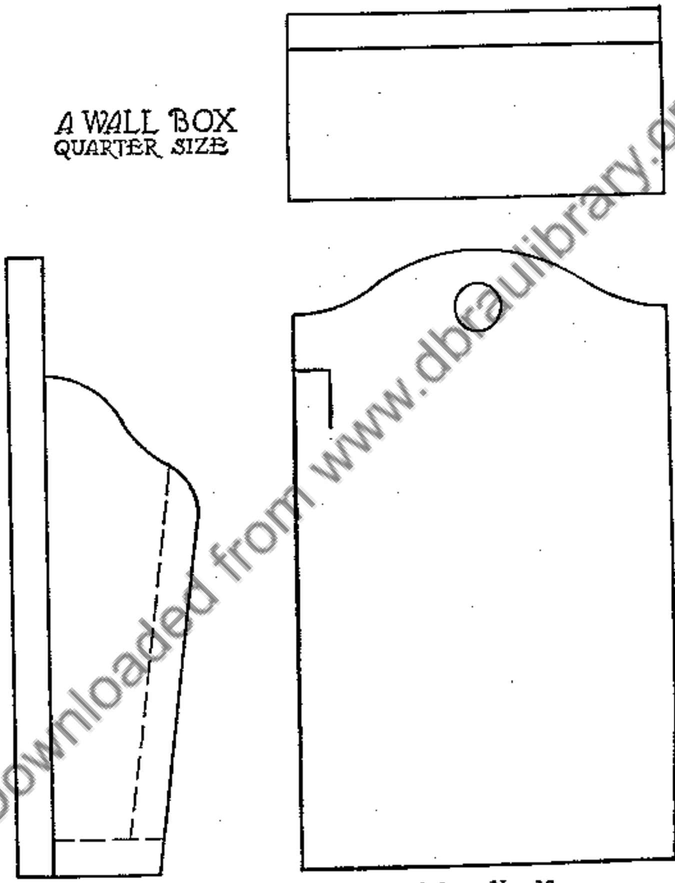


Fig. 196.—Wall Box for Worksheet No. 17.

WORKSHEET NO. 17

Complete all three views of the wall box, for which partly completed views are shown in Fig. 196. A pictorial drawing of a wall box of this type is shown in Fig. 193.

Project 85—Three Related Views of a Bench

Draw the top, front, and left side orthographic views of the bench shown in Fig. 197. Use the scale of 3 in. = 1 ft. Include the main center lines.

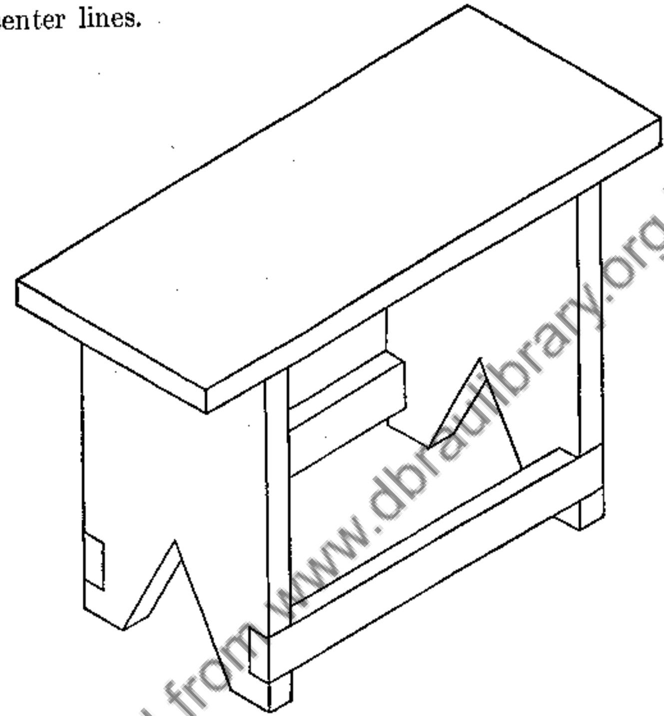


Fig. 197.—Bench for Project 85.

DIMENSIONS OF THE BENCH

All material is 1 in. thick, with the exception of the horizontal braces which are $\frac{3}{4}$ in. in thickness.

The top of the bench is a rectangle, which is 9 in. wide and 1 ft 10 in. long.

The supports, which are arranged in a vertical position with the outer edges 3 in. from the edge of the top, are 9″ × 14″. Notches are cut in their sides to permit the placing of horizontal braces, which are 1′-4″ × 2″ × $\frac{3}{4}$″. The bottom of each brace is to be 1 in. above the bottoms of the supports. The triangles cut out of the bottoms of the supports are isosceles triangles. These triangles have altitudes of 5 in. and bases of 5 in.

LINE SYMBOLS

Common line symbols used on drawings are shown in Fig. 198.

The outline of a part should be the outstanding feature. In pencil drawings, which will not be traced in ink later, it is advisable to go over *the outlines of the parts* with pencil, when the drawing is completed, in order to make the outlines stand out.

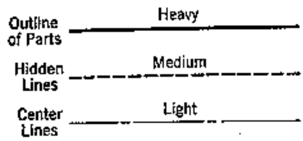


Fig. 198.—Line Symbols.

Make hidden lines with short dashes of medium weight. Be sure to keep the distances between the dashes much less than the length of the dashes.

For a center line, draw a light broken line, made up of long (1 in.) and very short ($\frac{1}{32}$ in.) dashes alternately spaced.

USE OF CENTER LINES

Center lines are used for a number of purposes:

1. To locate centers of circles and arcs, as in Fig. 199.

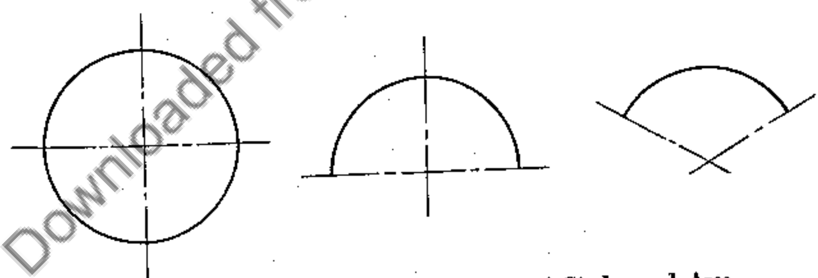


Fig. 199.—Center Lines to Locate Centers of Circles and Arcs.

2. To show limits of arcs, as in Fig. 200.

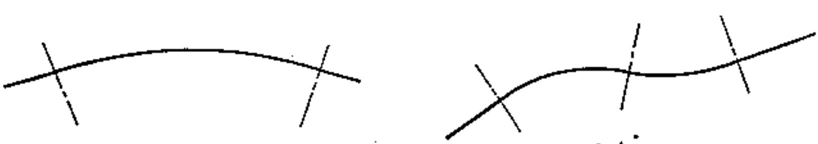


Fig. 200.—Center Lines to Show Limits of Arcs.

3. As a center line of a symmetrical view or of a symmetrical part of a view, as in Fig. 201.

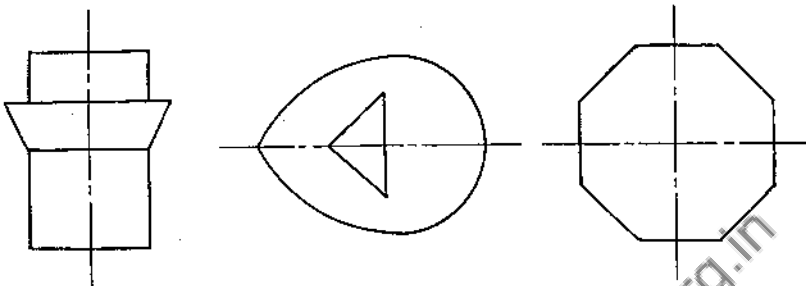


Fig. 201.—Center Lines of Symmetrical Views or Parts.

4. As a center line of a circular hole or a semi-circular groove, as in Fig. 202.

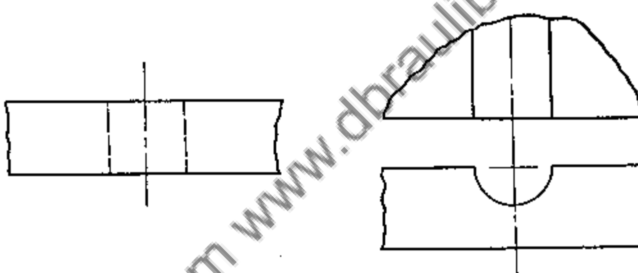


Fig. 202.—Center Lines of Circular or Semi-Circular Grooves or Holes.

A center line is not always straight. In Fig. 203, for example, a circular center line is passed through the centers of the holes.

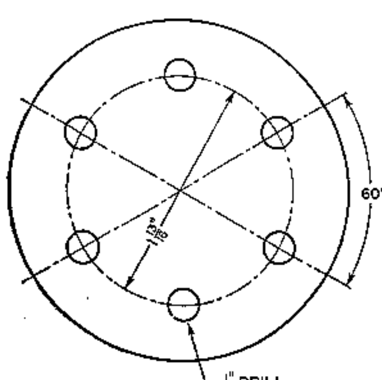


Fig. 203.—Circular Center Line.

EXTENSION LINES

Light full lines, called extension lines, are used to show the limits of dimensions. Center lines are often extended and used as extension lines, as shown in Fig. 204.

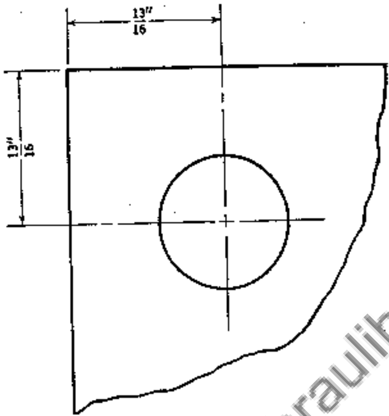


Fig. 204.—Center Line Used as Extension Line.

DRAWING PROCEDURE

It is imperative that the following steps be completed in their numerical order while making drawings.

1. Lay off the sheet according to the sheet layout directions you have been using since Unit 4.
2. Choose a scale that permits showing the views (and dimensions if required) without crowding.
3. Draw the main center lines for each view, and "box in" the views by drawing the principal outlines.
4. Draw center lines for all circles and arcs.
5. Draw all circles and arcs.
6. Complete the drawing of all outline of parts.
7. Draw the hidden lines.
8. Check for any lines that have not been drawn as yet.
9. Erase excess portions of lines.
10. Trace all outline of parts with pencil.

* 11. Draw all extension and dimension lines.

* 12. Draw guide lines for dimensions and notes.

* 13. Letter the dimensions and notes.

† 14. Draw all section lines required.

15. Fill in the title block.

16. Check the drawing very carefully.

* Steps 11, 12, and 13 concern drawings on which dimensions are shown; such drawings will be required in later units.

† Step 14 concerns only drawings which include sectional views; such drawings are also required in later units.

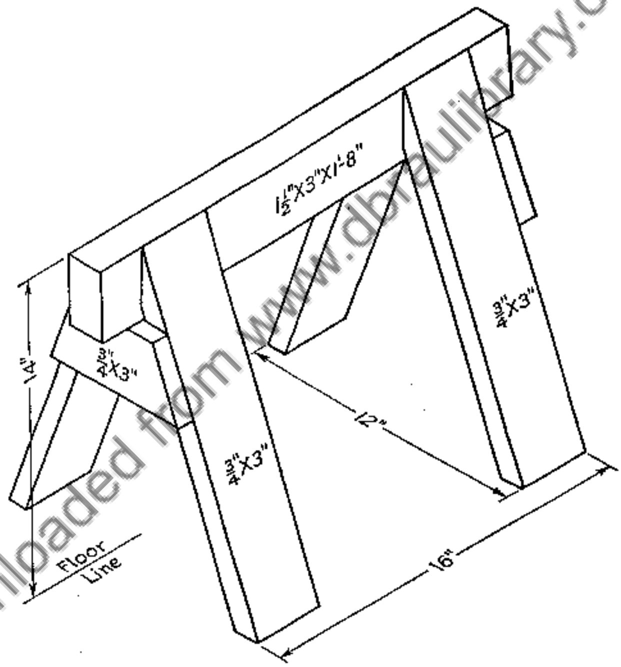


Fig. 205.—Sawhorse for Project 86.

Project 86—Two Orthographic Views of a Sawhorse

Draw two orthographic views that will describe the shape of the small sawhorse shown in Fig. 205.

Project 87—Three Views of an Original Birdhouse

Draw three orthographic views of an original birdhouse.

Project 88—Views of Desk

Make a drawing consisting of three related orthographic views of the desk at which you work while in the drawing room.

Project 89—Views of Stool

Make a drawing consisting of two related orthographic views of the stool that has been provided for your use in the drawing room.

Project 90—Views of Furnishings

Submit freehand sketches of related orthographic views of one or more of the furnishings in your home. Select, with the approval of the teacher, a set of views of a furnishing and draw the views to an appropriate scale.

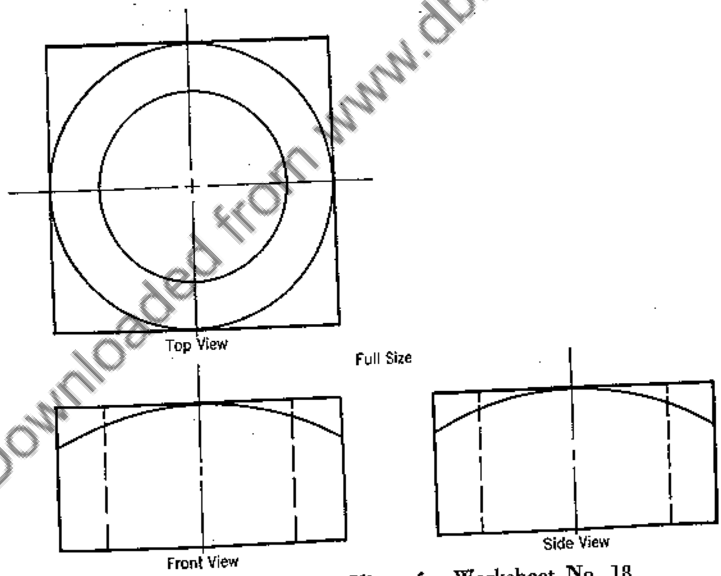


Fig. 206.—Orthographic Views for Worksheet No. 18.

WORKSHEET NO. 18

The purpose of this worksheet is to test your ability to interpret orthographic views.

A. The following questions are based on Fig. 206.

1. What is the approximate area of the vertical surface on any one of the sides?
2. What is the area of the upmost flat surface?
3. Are three views necessary to describe the shape of this object?
4. Write a description of the shape of the object that these three orthographic views describe.

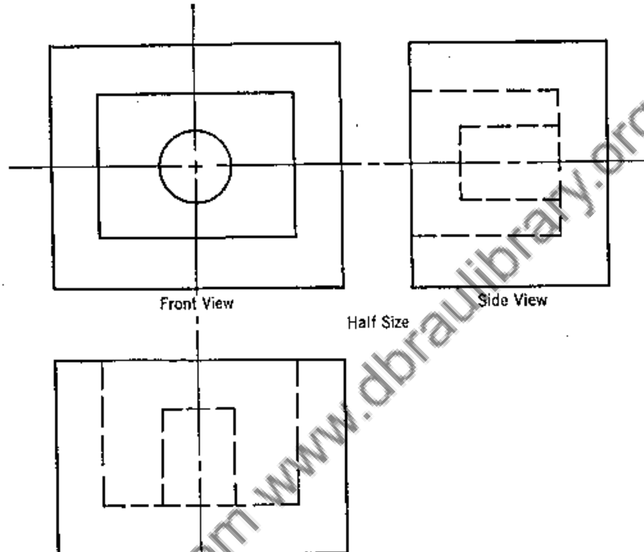


Fig. 207.—Orthographic Views for Worksheet No. 18.

B. Refer to Fig. 207 and answer the following questions.

5. Write a description of the object that these three orthographic views describe.
6. What is its total surface area?
7. How much material is required to make the object? Express your answer in cubic inches.

C. Referring to Fig. 208, answer the following questions.

8. List the pairs of letters that mark surfaces which appear in more than one view.
9. What is the volume of that part of the object which in shape is a rectangular prism?
10. What is the volume of the part that is a triangular prism?
11. What is the volume of the part that is a triangular pyramid?

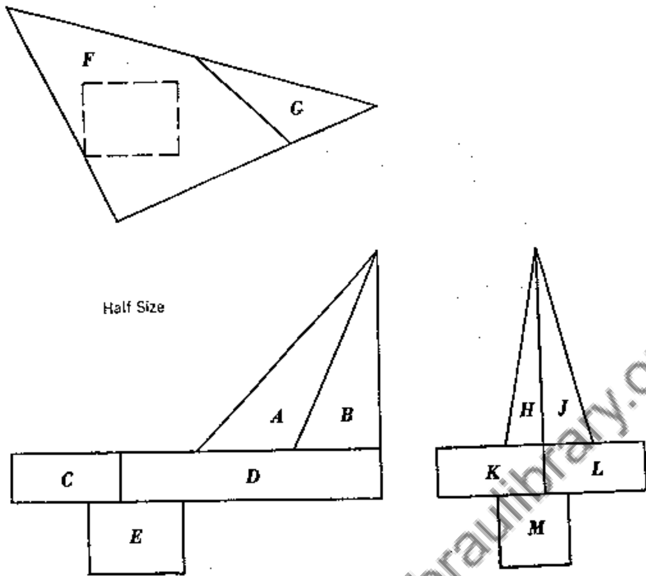


Fig. 208.—Orthographic Views for Worksheet No. 18.

CHAPTER VII

WORKING DRAWINGS

Specific Aims:

To enable the pupil to take measurements of objects.

To facilitate the drawing of related views by making it possible for the pupil to handle the object being described.

To teach thread forms and their presentation.

To show how and why dimensions are placed on drawings.

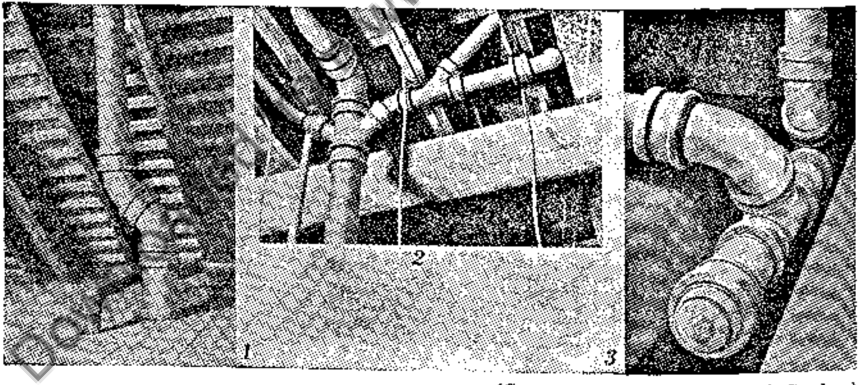
To present auxiliary projection.

To show drawings of related parts as detail drawings.

To definitely describe the shape and size of mechanical parts by the use of working drawings.

Project 91—Drawings of Pipe Fittings

Common plumbing fixtures are shown in Fig. 209. It is recommended that 1½-in. cast-iron steam fittings be used for models in determining dimensions for this project.



(*Courtesy of Better Homes and Gardens*)

(1) Offset of pipe in order not to weaken attic joist by otherwise necessary cutting.
(2) No cutting of floor-joists due to plumbing; in fact, joists have been doubled to prevent floor sag due to heavy bathroom fixtures.
(3) Readily accessible cleanout.

Fig. 209.—Approved Plumbing.

The task assigned is to describe by the use of *only* two orthographic views either an "Ell" or a "Tee." The pupil will be required

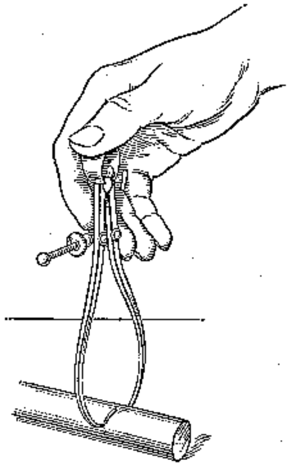


Fig. 210.—Measuring Outside Diameter.

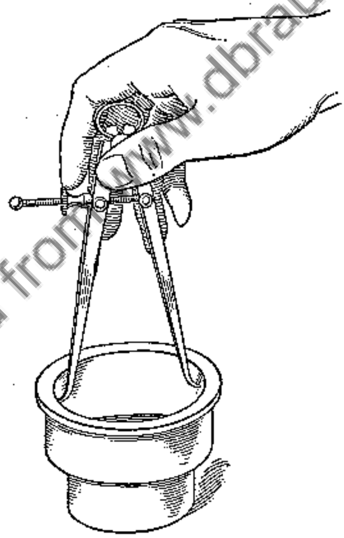


Fig. 211.—Measuring the Inside Diameter.

to take the measurements for the drawings directly from the objects, which will be furnished to him. In this course, sufficient accuracy can be attained in taking the measurements by using the triangular scale, the inside calipers, and the outside calipers.

The sketches in Figs. 210, 211, and 212 illustrate the use of the calipers. In Fig. 210 the outside calipers are being used to take the diameter of a round bar. In Fig. 211 the inside calipers are being used to take an inside diameter. In Fig. 212, the outside calipers are being used to take the thickness of the side wall. Because of the fact that there is a flange on the end of the object, it was necessary to place a block of measurable thickness against the side wall when the measurement was being taken. This enables one to remove the calipers without disturbing the position of the ends. The thickness of the side wall is found by subtracting the thickness of the block from the distance between the ends of the calipers.

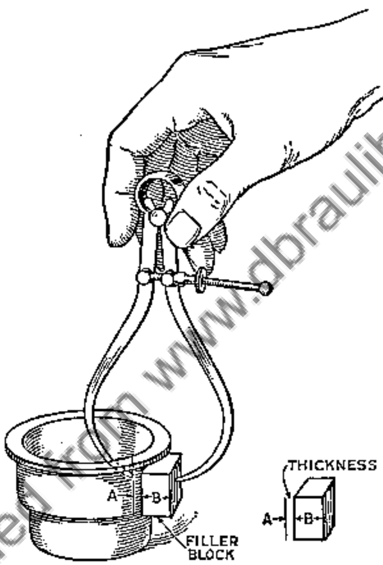


Fig. 212.—Measuring Object with a Flange.

THREAD FORMS

Threads are used for many purposes: for fastenings, for adjustments, and for transmitting power or motion. Because of the many and varied purposes, many different forms of threads are now in use.

For fastenings the U. S. Standard, or American Standard, thread is in most common use, and in this country *is the form understood when no other is specified*. See the examples of a portion of this thread form shown in section in Fig. 213. It is a variation of

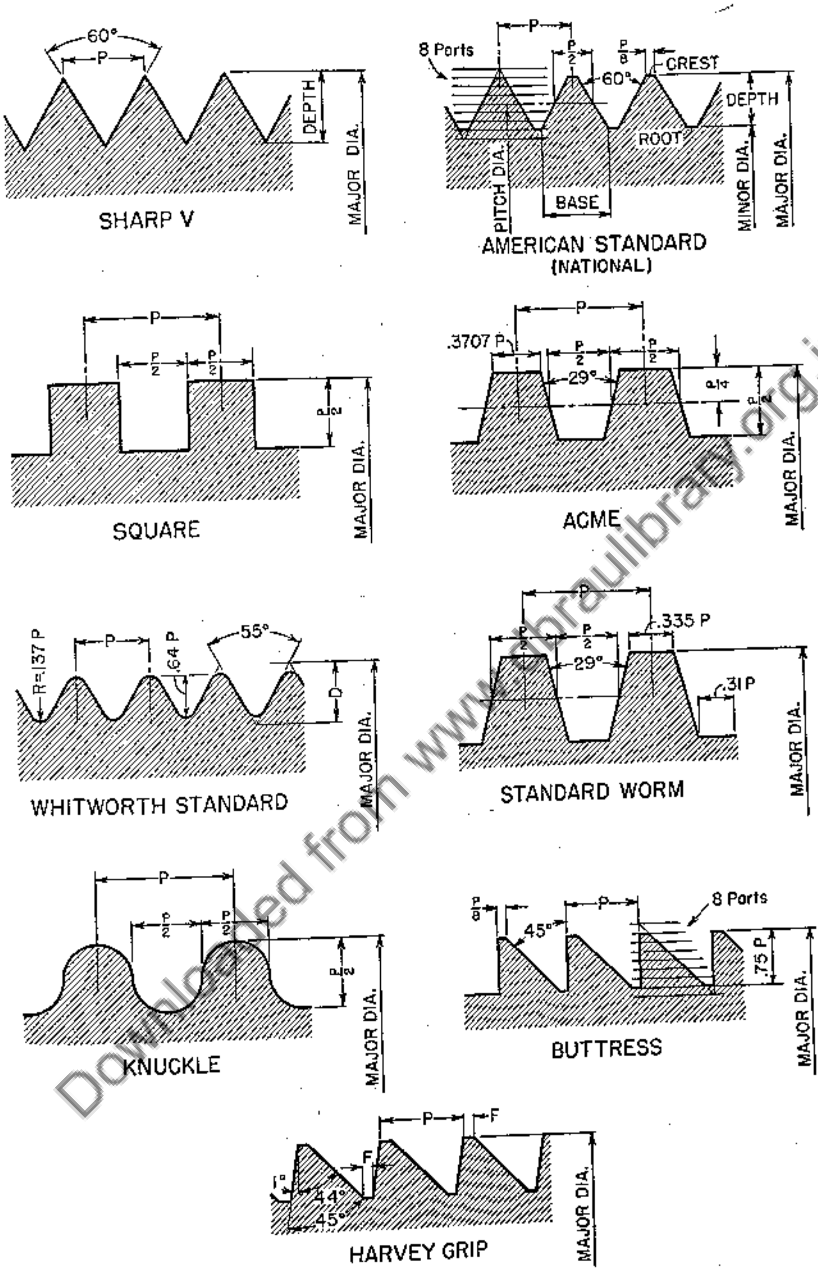


Fig. 213.—Standard Thread Profiles.

the "V" shape at 60 degrees, with the top of the thread flattened to one-eighth of its height (making the thread less apt to be injured) and the root of the thread filled in to one-eighth of the height (increasing the strength of the bolt). In actual drawing, these flats need not be shown.

The sharp "V" thread at 60 degrees is still in use, but its use should be limited to adjustment screws, where its increased holding power is of value.

The square thread is preferred over the 60-degree types for transmission of power or motion. Several modifications of the square thread are also in use for transmission of power or motion. Three are: the *Acme*, or 29-degree, thread; the *Worm* thread; and the *Buttress* thread. The Buttress thread is used where power is being transmitted only in one direction.

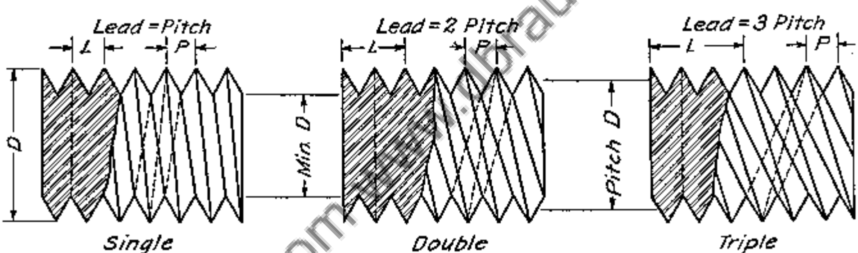


Fig. 214.—Pitch and Lead of Screw Threads.

The *Knuckle* thread is used for heavy rough work and can be cast in a mold. This thread may also be seen on an electric light bulb. For this purpose it is rolled into shape by using sheet metal.

In the thread forms just mentioned, which are dimensioned in Fig. 213, the letter *P* denotes the pitch. The *pitch* is the distance (measured parallel to the axis of the cylinder) from a point on one tooth of the thread to the corresponding point on the next tooth.

Another term with which you should be familiar is the *lead*. The lead of a thread is the distance, in the direction of the axis of the rod, that the thread advances in one revolution. The relation between the pitch and the lead is shown in Fig. 214.

A simple thread, as the name implies, is one thread running continuously around the cylinder. In the case of a single thread, the lead is equal to the pitch. *All threads are understood to be single threads, unless otherwise noted.*

A double thread has two threads running continuously around the cylinder. For a double thread, the lead is equal to twice the pitch.

A triple thread has three threads running continuously around the cylinder. The lead is equal to three times the pitch for a triple thread.

Threads may be right-handed or left-handed. A right-handed thread advances away from the body when turned in a clockwise direction. *All threads, unless marked "L.H." (left-handed), are understood to be right-handed.*

In absolutely accurate representations, the threads are shown with the lines at the top or ridge of the thread and those at the bottom or root of the thread in a helical shape, as indicated in Fig. 215

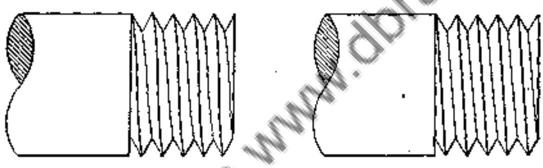


Fig. 215.—Representation of Screw Thread.

at the left. This is a rather laborious undertaking and is used only in the case of cylinders that have very large diameters.

For ordinary conditions, the helix is conventionalized into a straight line, as at the right in Fig. 215. While this practice is not realistic, it has the general appearance and requires much less time to execute.

A thread is dimensioned by noting the name of the thread form and the number of threads per inch. Knowing the number of threads per inch, one can determine the *pitch* of the thread.

If not otherwise noted, it is assumed that the thread is a right-handed, American Standard, single thread. In Fig. 216 is illustrated the procedure for drawing a screw thread.

It is to be noted that, if the cylinder on which the thread is cut is revolved clockwise, the right-handed thread will advance away

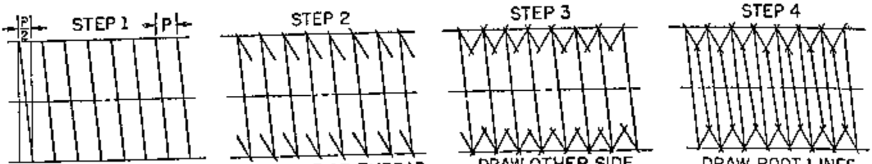


Fig. 216.—Progressive Stages in Drawing a Screw Thread.

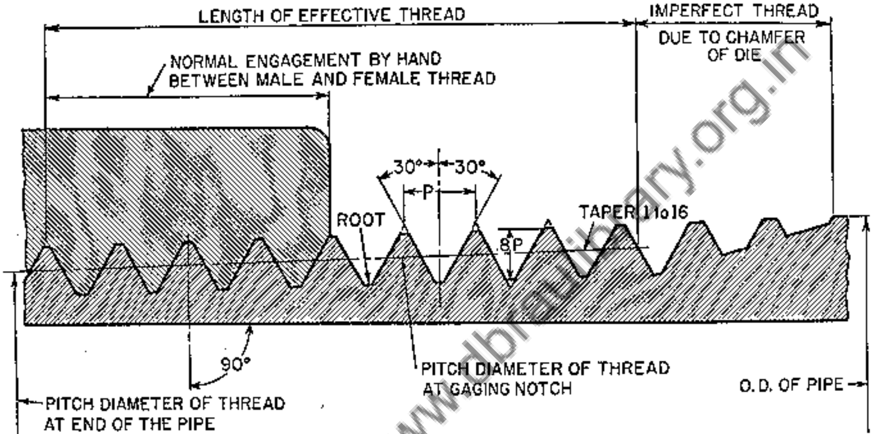


Fig. 217.—Tapering Pipe Threads.

from the body, while a left-handed thread will advance toward the body.

American Standard threads are used in pipe fittings and pipes. Most of the pipes and fittings have tapering pipe threads, as shown in Fig. 217. There are a few exceptions for special uses. The tapering of the threads fixes the distance for which a pipe will enter a fitting, and also ensures a tight joint. The taper used is 1 in 16, which amounts to $\frac{3}{4}$ in. per ft. An examination of threaded pipe will show that a perfect thread form does not continue as far as threading was attempted.

IMPORTANT

It is optional in your drawings for Project 91 whether or not you show the many small arcs that may vary in degree of curvature without affecting in any way the use or general over-all size of that particular fitting. Some of these small arcs have been marked for your information by arrows in the sketch in Fig. 218.

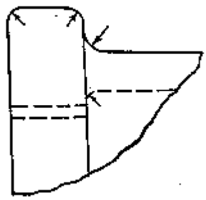


Fig. 218.—Small Arcs.

Select your views so that two views adequately describe the object. Make the drawing to double size.

WORKSHEET NO. 19

Refer to Fig. 219 and list your answers to the following questions on a sheet of paper approximately 8½ in. × 11 in. All four forms are shown half size.

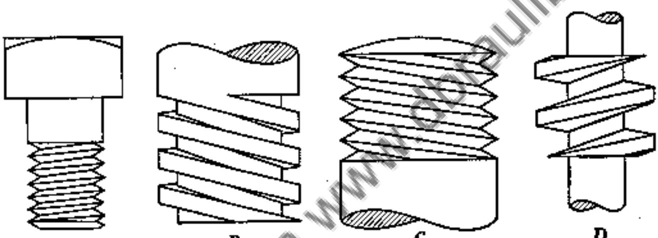


Fig. 219.—Thread Forms for Worksheet No. 19.

Thread Form	A	B	C	D
Pitch	(1)	(7)	(13)	(19)
Lead	(2)	(8)	(14)	(20)
Diameter of bolt or shaft	(3)	(9)	(15)	(21)
Type of thread form	(4)	(10)	(16)	(22)
Single, double, or triple thread	(5)	(11)	(17)	(23)
Right- or left-handed thread	(6)	(12)	(18)	(24)

Project 92—Dimensions

Orthographic projection, with its many related views, provides a most suitable means of shape description; furthermore, when the views are drawn to a known scale, the size of the object and its various details may also be determined. If such is the case—and it is—why do we use dimensions as the means of size description? The reasons follow:

(1) Dimensions show size quickly. They eliminate scaling in size determination. One may see by a glance at the dimension what the distance between two points is.

(2) They eliminate the small errors that are often made in scaling.

(3) Dimensions are adaptable. They may be placed on drawings that are not drawn to any definite scale (as drawings using more than one scale and freehand sketches) as well as scale drawings.

(4) They may be readily understood by persons who have little or no knowledge of the use of scale.

Drawings should be dimensioned in such a way that the object or any part of the object can be made *without scaling* the drawing. Drawings should be *clearly* dimensioned and *completely* dimensioned. Dimensions should not be duplicated on various views or a single view, except where they will add to the clearness of the drawing. At no time should dimensions be shown which are not necessary for the production of the object.

DIMENSION LINES, EXTENSION LINES AND LEADERS

In Fig. 220 is an orthographic view dimensioned. Lines marked A are dimension lines. Lines marked B are extension lines. Leaders have been used to designate definitely which lines have been marked.

Dimension lines should be fine full lines (of the same weight as center lines) so as to contrast with the heavier lines of the drawing, and are placed outside of the views whenever possible. The dimension lines are broken to insert the dimensions. If the dimension is a fraction or a mixed number, the line between the numerator and denominator of the fraction is placed as a continuation of the dimension line.

Arrowheads are placed at the ends of dimension lines. The width of an arrowhead is approximately one-third of its length, the length being about $\frac{1}{8}$ in.

Extension lines are also fine full lines. They indicate the distance measured when the dimension is placed outside the drawing. These lines start about $\frac{1}{16}$ in. away from the outline and extend about $\frac{1}{8}$ in. beyond the dimension line, which is located about $\frac{1}{4}$ in. from the outline. If more than one row of dimensions is needed, the extension lines continue unbroken until they are $\frac{1}{8}$ in. beyond the last dimension line to which they pertain.

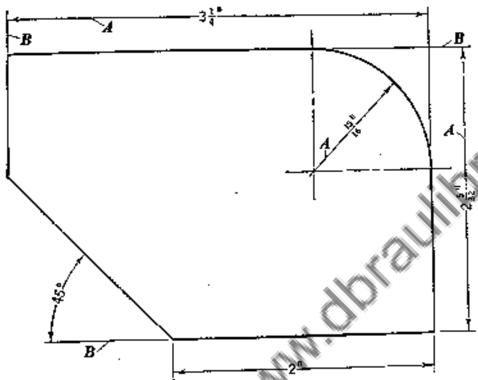


Fig. 220.—Dimension Lines, Extension Lines, and Leaders.

Leaders consist of fine, full, straight lines, and should never be curved nor made freehand.

RULES FOR DIMENSIONING

1. All dimensions should be placed so that they may be read from the bottom or the right-hand side of the drawing. Check this rule with the example in Fig. 220.

2. Dimensions are to be placed so as to read in the direction of the dimension line, as in Fig. 221.

3. Dimension lines should not be placed at inclinations included in the shaded area of Fig. 222, unless unavoidable. This area extends 45° from the center line.

4. Where there are several parallel dimension lines, the dimensions should be staggered to avoid confusion, as in Fig. 223.

5. Dimensions should be arranged in such a manner that they may be measured from a base line, center line, or surface that can be readily established.

6. Over-all dimensions should be placed outside of all sub-dimensions, as in Fig. 224.

7. Where space is limited, the arrowheads should be reversed and any of the methods shown in Fig. 225 may be used.

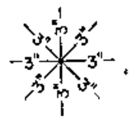


Fig. 221.—
Positions of Dimensions.

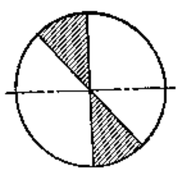


Fig. 222.—
Undesirable Inclinations of Dimension Lines.

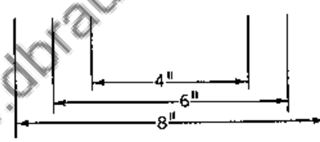


Fig. 223.—Staggering of Dimensions.

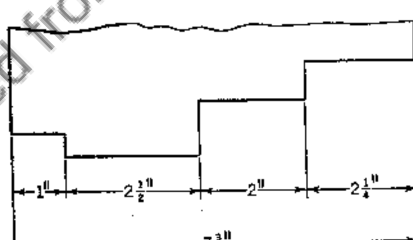


Fig. 224.—Over-All Dimensions and Sub-Dimensions.

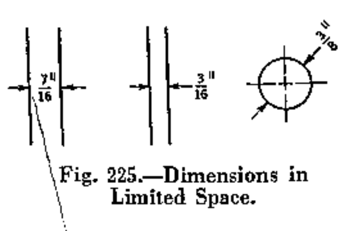


Fig. 225.—Dimensions in Limited Space.

8. In dimensioning angles, an arc should be drawn which will be broken to permit the dimension to be read from a horizontal position. Notice the angle dimensioned in Fig. 220.

DIMENSIONING CIRCLES AND CURVES

9. Circles are dimensioned by showing their diameters. When it is not obvious from the drawing that the dimension is a diameter, it should be followed by the abbreviation "D", as in Fig. 226.

Fig. 226.—Dimensioning of Diameter.

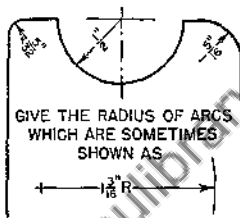


Fig. 227.—Dimensioning of Arcs.

10. Arcs are dimensioned by showing their radii. The dimension line used to show a radius has an arrowhead on one end only. The other end of the dimension line starts at the center of the circle of which the arc is a part. If center lines have not been used to mark the center, then a small cross or a small circle may be used. See examples in Fig. 227.

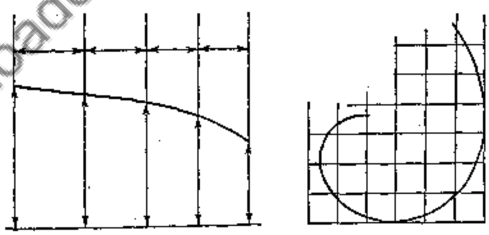


Fig. 228.—Dimensioning of Irregular Curve.

11. A curved line, especially an irregular curve, may be dimensioned by the use of offsets or location on a grid, as in Fig. 228.

12. Always locate circular parts from center to center—never to the edges. See Figs. 229 and 230.

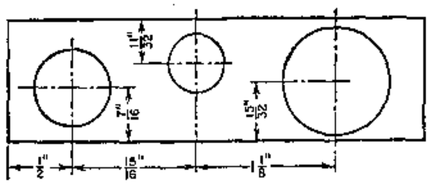


Fig. 229.—Location of Centers of Circles.

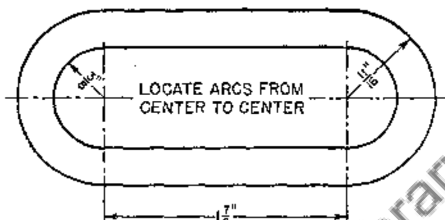


Fig. 230.—Location of Centers of Arcs.

DIMENSIONING HOLES

13. Holes may be dimensioned in much the same manner as circles, diameters being used. On occasion it is desirable to show more information than merely the diameter. Holes which are to be drilled, reamed, or punched should have the diameter—given preferably on a leader—followed by the word indicating the operation and by any other information desired. See Figs. 231 and 232.

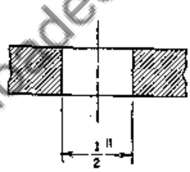


Fig. 231.—Diameter of Hole.

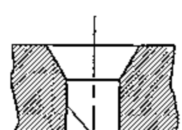


Fig. 232.—Directions for Operations.

DIMENSIONS WITH TOLERANCES

14. Accurate dimensions which are to be established with a limit gage or a micrometer (tools with which very accurate measurements may be made) should be expressed in decimals to at least three decimal places and the drawing should show the limits allowed, as in Figs. 233 and 234.

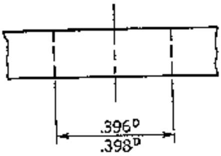


Fig. 233.—Tolerance.

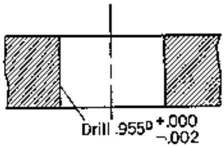


Fig. 234.—Tolerance.

CHANGING OF DIMENSIONS

15. On a drawing, if a dimension is to be changed, the changed figures should be underlined or otherwise marked, as in Fig. 235. It is customary to tabulate these changes on the drawing and refer to them by letters or symbols placed after the altered dimensions.

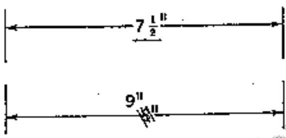


Fig. 235.—Change in Dimension.

FINISHED SURFACES

16. A surface to be machined or "finished" from unfinished material, such as a casting or a forging, should be marked by a 60° "V", the bottom of the "V" touching the surface to be finished. A code figure or letter may be placed in the "V" to indicate the quality of the finish. The meaning of the code should be indicated by notes or a table on the drawing. See Fig. 236.

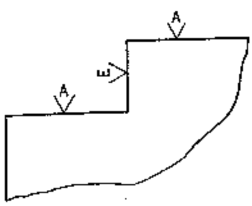


Fig. 236.—Finished Surfaces.

THREADS

17. In dimensioning threads it is sufficient to show either the root or the ridge diameter with a note telling the type of thread form, whether it is a single, double, or triple thread, whether it is a

right- or left-handed thread, and the number of threads per inch. See Figs. 237 and 238.

18. Threads are often dimensioned by notes, such as the following:

$\frac{3}{4}$-10-NC-2 $\frac{1}{4}$-20-NF-3

The first number is the diameter. The second is the number of threads per inch. The letters stand for the series used. National Coarse (NC) or National Fine (NF) will be shown here. The last number represents the screw-thread fit.

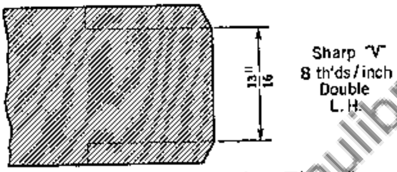


Fig. 237.—Dimensioning Thread.

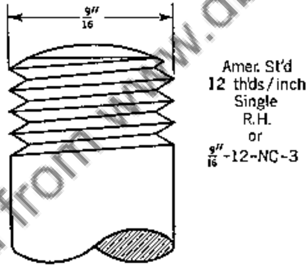


Fig. 238.—Dimensioning Thread.

American Standards recognize four classifications of fit. They are class 1, a reasonable amount of play; class 2, work of usual quality; class 3, a better grade such as used in automobile work; and class 4, a high grade of precision work such as in aircraft construction.

USE OF NOTES

19. The clearness and completeness of drawings may often be improved by the use of notes. These notes may specify a series of tool operations or explain an involved detail. Notes should read horizontally.

Some of the more common machine-shop operations, which are quite often found in notes on working drawings, are listed below.

Arc-Weld—To make use of the electric arc process to weld metals.

Bore—To enlarge a hole, making one of greater diameter, by using a boring tool as in a lathe.

Broach—To change the shape or size of a hole by pushing or pulling a tool with serrated edges through the hole.

Chamfer—To bevel an external edge, as in Fig. 239.

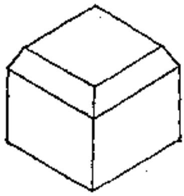


Fig. 239.—Chamfer.

Core—To make a solid form of a sand mixture that is the shape and size of the hollow part of a casting. This solid form is baked and placed in the mold before the casting is poured. After the casting cools, the core is easily removed by breaking it, and the casting is left hollow.

Counterbore—To enlarge a hole to a desired depth, as in Fig. 240.

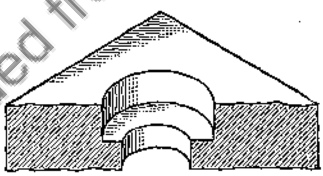


Fig. 240.—Counterbore.

Countersink—To enlarge the end of a hole in such a way as to fit the shape of the conical head of a screw, as in Fig. 241.

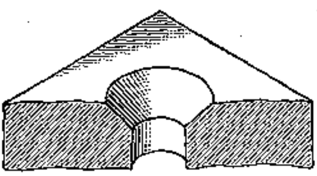


Fig. 241.—Countersink.

Drill—To make a hole with a drill.

Forge—To shape hot metal by hammering either by hand or by machine.

Grind—To finish a surface by using an abrasive wheel.

Mill—To machine by using rotating cutters on a milling machine.

Plane—To machine work on a planer.

Punch—To force a tool through the material.

Ream—To rotate a special tool in a punched or drilled hole to finish the edges to a desired diameter.

Rivet—To fasten by upsetting the headless end of a pin in order to use it as a permanent fastening.

Shear—To cut metal between two blades.

Spot-Face—To finish a round spot on a rough surface, usually to provide a good seat for a fastening.

Spot-Weld—To weld in spots by fusion caused by the heat of resistance to an electric current.

Sweat—To join two pieces of metal together by clamping them together with solder between them and then applying heat.

Tap—To cut threads in a hole.

Temper—To change the physical properties of steel by using a heat-treatment process.

Turn—To machine on a lathe.

Upset—To increase the diameter at the end of a bar by a forging process.

Weld—To fuse two pieces of metal by heating them.

Study these rules for dimensioning thoroughly and then complete Worksheet No. 20. Satisfactory completion of this worksheet is the only requirement for Project 92.

WORKSHEET NO. 20

Make pencil tracings of the drawings and place the dimensions on the tracings.

A. Place dimensions on the orthographic views in Fig. 242. These views were drawn to full size.

B. In Fig. 243 is a drawing of a gasket, made to quarter size. Place dimensions on the drawing.

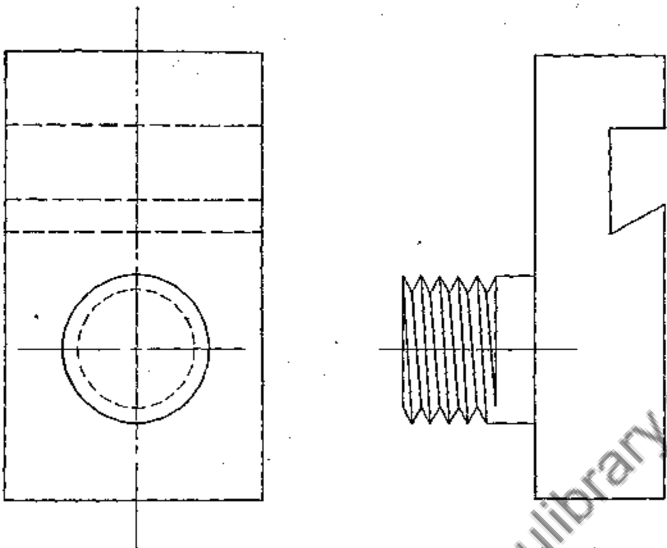


Fig. 242.—Orthographic Views for Worksheet No. 20.

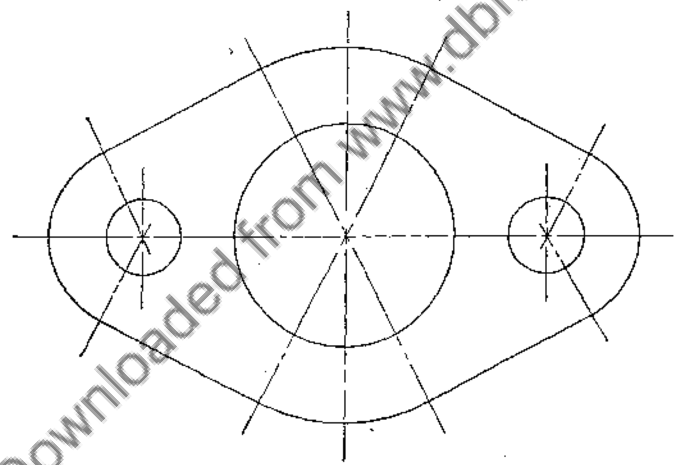


Fig. 243.—Gasket for Worksheet No. 20.

Project 93—Auxiliary Views

Working drawings describe both the shape and the size of an object so that the finished drawing may be understood universally by persons mechanically trained. Thus far only orthographic views, which are projections on planes that are at right angles to one another, have been considered. The fact is to be noted that *a* *surface is shown in its true shape and size when it is projected to a plane that is parallel to the surface.*

With most objects there are few, if any, surfaces that are not parallel to some one of the three reference planes used for orthographic projection. However, occasions arise when one or more of the principal surfaces are not parallel to the usual reference planes and therefore cannot be shown in true shape or size in the usual orthographic views. To meet these situations, auxiliary views are drawn.

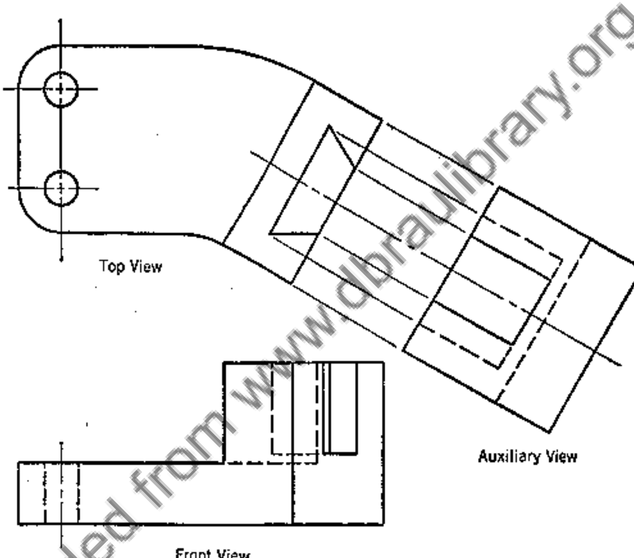


Fig. 244.—Use of Auxiliary View.

An auxiliary view is a view found by projecting from an inclined surface to an auxiliary plane that is parallel to the inclined surface, as in Fig. 244.

Draw top and side orthographic views and an auxiliary view that will describe the block shown in Fig. 245. Dimension the drawing. Make the views to double size.

WORKSHEET NO. 21

Use tracing paper. Do not write on this sheet.

A. In Fig. 246 are given three orthographic views of a truncated hexagonal prism, and an auxiliary view that shows the true shape and size of the inclined top surface.

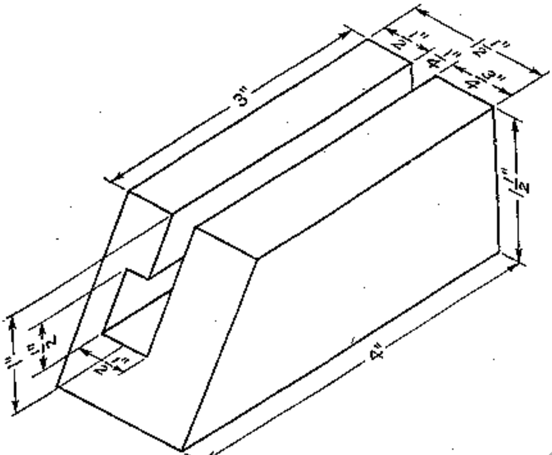


Fig. 245.—Block for Project 93.

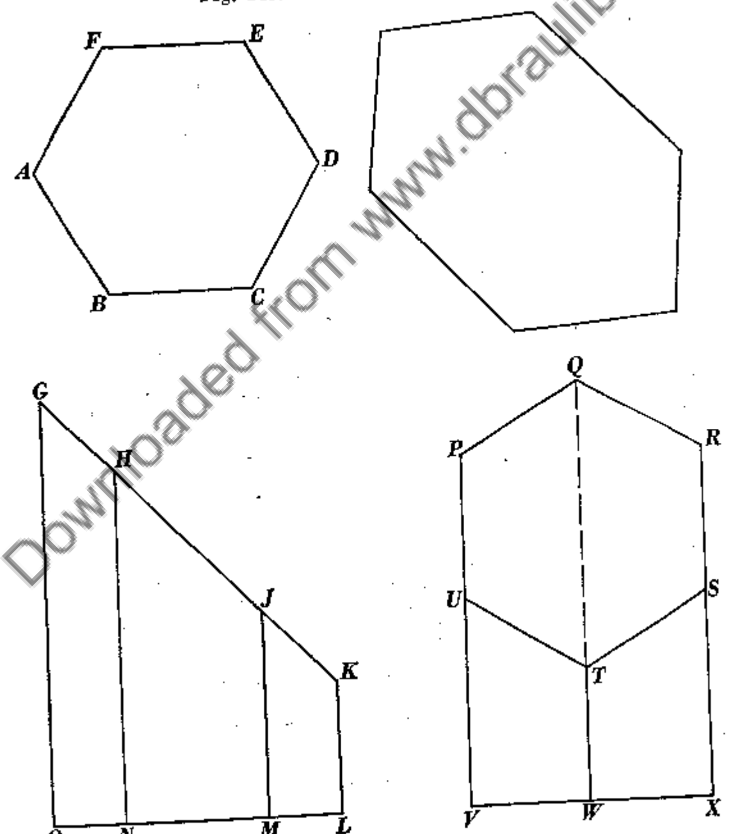


Fig. 246.—Truncated Prism for Worksheet No. 21.

1. In which of the three orthographic views may the true length of the auxiliary view be found? Give the letters marking the lines or distances.
2. Where may the true width of the auxiliary view be found? Give the letters marking the lines or distances.
3. Are you able to see the top surface in true shape in any of the three orthographic views?

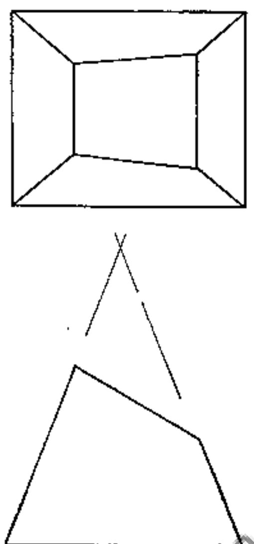


Fig. 247.—Truncated Pyramid for Worksheet No. 21.

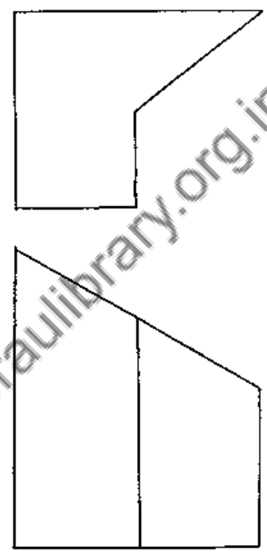


Fig. 248.—Truncated Block for Worksheet No. 21.

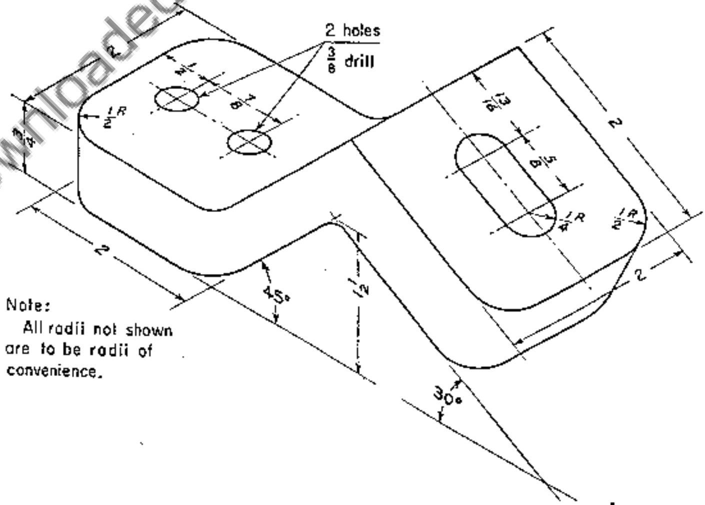


Fig. 249.—Angular Brace.

4. Give the true length of each of the following lines: AF, RS, UV, GK, UT, TW.

B. Draw an auxiliary view for each of the objects represented in Figs. 247 and 248 which will show the true size and shape of its inclined top surface. Make a pencil tracing of the views as given. Make the required drawings on the tracing paper.

Project 94—Angular Brace

Make a working drawing of the angular brace shown by a freehand sketch in Fig. 249. Show enough views, orthographic and auxiliary, to describe the true shapes and sizes of all surfaces.

Project 95—Sections

When the interior of an object is such that it cannot be shown clearly in the regular orthographic views, *sectional views,* or *sections,* should be drawn.

A sectional view shows the outline of the object and its parts as it appears along a definite cutting plane. The location of the cutting plane is definitely marked on one of the accompanying orthographic views.

Sectional views are little more than altered orthographic views and take the same relative positions as the orthographic views which they may have replaced. Because of the fact that they are located in the same relative positions, projection may be utilized, as in drawing the regular orthographic views.

In drawing the sectional view, the portion of the object in front of the cutting plane is supposedly removed and a view of what is left is drawn. A sectional view is shown in Fig. 250.

In sectional views *hidden lines are not drawn* unless (as in an occasional instance) they are necessary for adequate shape description.

The areas through which the cutting plane was passed are "cross-hatched" or, as it is also called, "section-lined."

The section lining is to be made by drawing light full lines that are parallel and uniformly spaced, the spacing depending on the size of the area to be cross-hatched. These lines preferably should be drawn at an angle of 45 degrees with the outline.

The cutting plane, as *A-A* in Fig. 250, is clearly marked and the corresponding section is so labeled.

The location of the cutting plane is indicated by drawing a very heavy broken line consisting of a long (1 in.) dash and two short ($\frac{1}{32}$ in.) dashes repeated in that order for the desired length, as in Fig. 250.

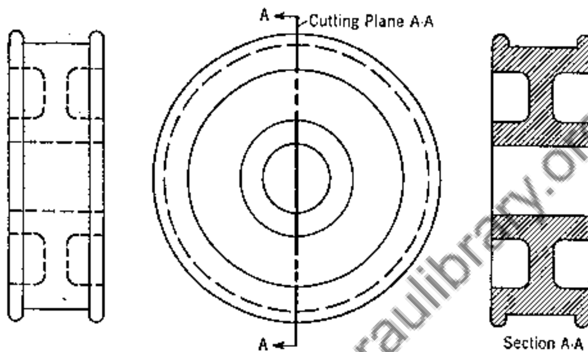


Fig. 250.—Sectional View of Pulley.

The two most simple and most used sections are the "full section" and the "half section." When the cutting plane extends entirely across the object, a full section is obtained. Section *A-A* in Fig. 250 is a full section.

A half-sectional view may be used in describing a symmetrical object, as in Fig. 251. It can serve the double purpose of showing

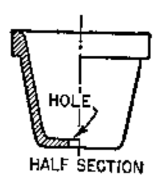


Fig. 251.—Half-Sectional View of Flower Pot.

one half of the view in section and the other half as an ordinary orthographic view. The cutting plane, for a half-sectional view, will extend only half way into the object. In Fig. 252, it is assumed that one quarter of the object is removed.

You will note that the swivel joint shown in Fig. 252 is made up of more than one piece. It is to be noted how the various pieces

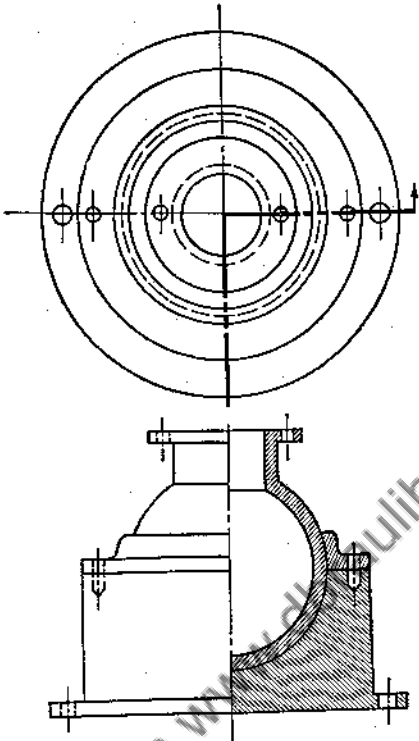


Fig. 252.—Part Sectional View of Swivel Joint.

have been cross-hatched. Adjacent parts are cross-hatched in different directions. No two parts of an object, adjacent or otherwise, should be cross-hatched both at the same angle and in the same direction—the angle or the direction, or both, should vary. Different spacings of section lines may also be used as a means of identifying the different parts.

Symbols, a number of which are shown in Fig. 253, may be used in section-lining to indicate the various materials of construction or to identify or place emphasis on the location of a certain part. When in doubt as to the proper symbol to use for any material, it is permissible to show simple cross-hatching with the name of the material near the middle of the area, as shown in the last symbol of Fig. 253.

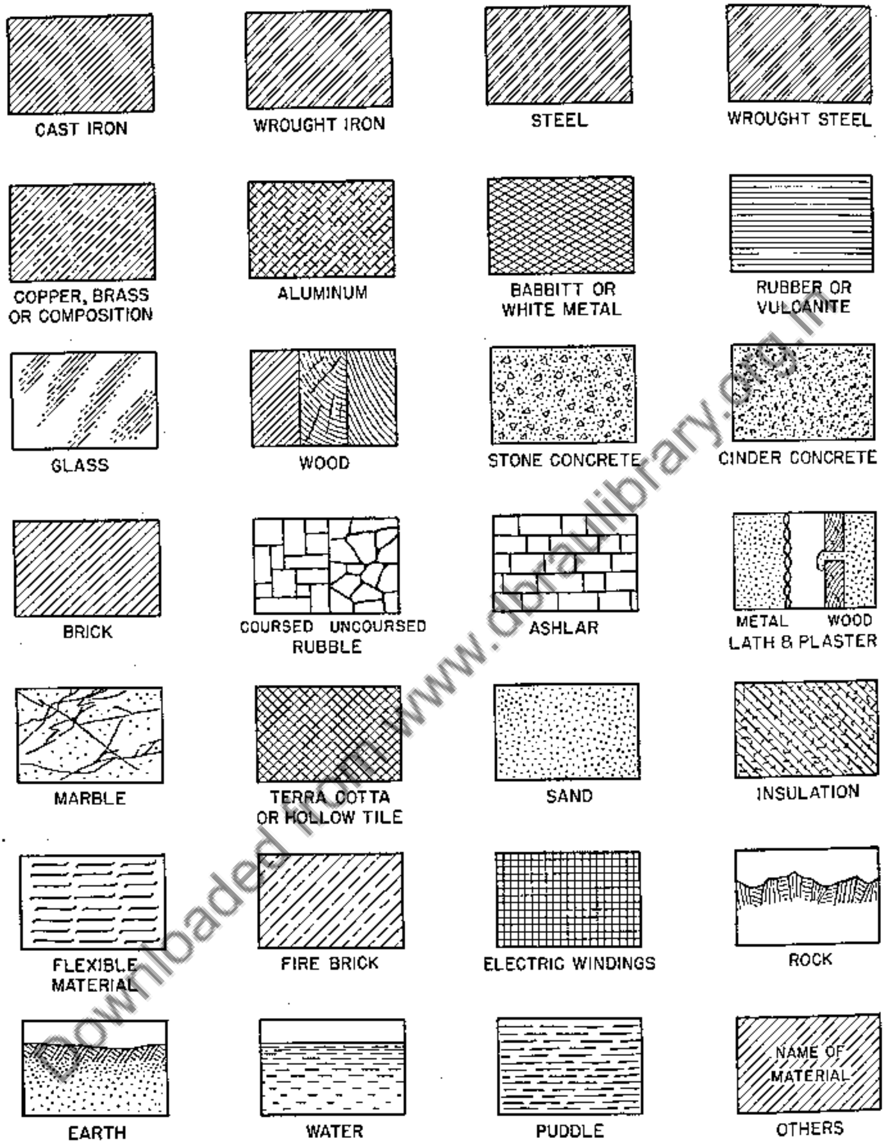


Fig. 253.—Standard Sections.

It is not necessary that the cutting section consist of one continuous plane; the section may be bent or offset if in that way the detail can be better shown. Views taken along the irregular cutting sections *C-C* and *D-D* are shown in Fig. 254. The reference letters

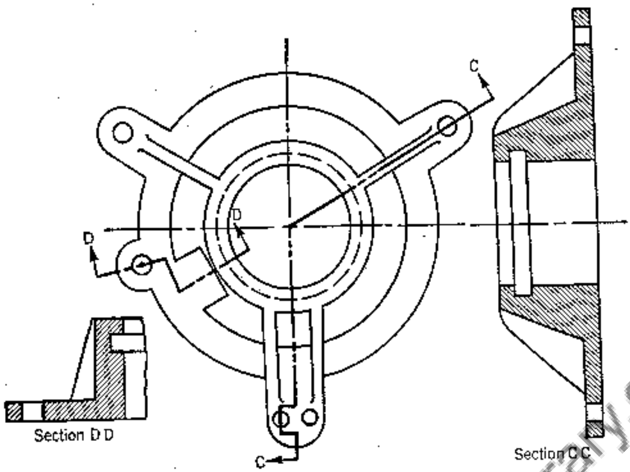


Fig. 254.—Offset Section.

should be repeated at points of change of direction in the cutting section, unless the parts are very short and the changes are frequent. Section *D-D* is an *offset* cutting section.

It has just been stated that "the areas through which the cutting plane was passed are cross-hatched." There are a few exceptions to this statement. These exceptions follow:

1. When the cutting plane passes through a web, a rib, or a similar element, the section lining is omitted from that portion. This exception is applied to the web in the top of section *C-C* in Fig. 254.
2. Shafts, bolts, nuts, rods, rivets, keys, pins, and similar parts whose axes lie in the cutting plane should not be sectioned. See Fig. 255.

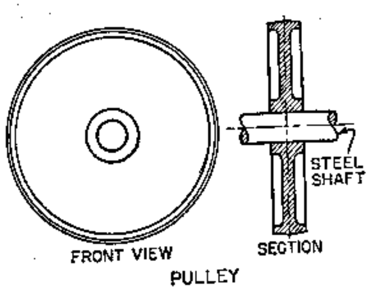


Fig. 255.—Section Through Shaft.

3. When the true projection of a piece may be misleading, a spoke, arm, rib, or similar part should be rotated until it is parallel to the plane of the section for projection, as in Fig. 256.

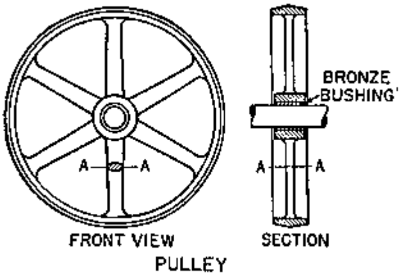


Fig. 256.—Section Through Spoke.

SPECIAL SECTIONS

Revolved Sections: A revolved section shows the shape of the cross-section of the entire object, as in Fig. 257, or the cross-section of some portion of the object, as in Fig. 256.

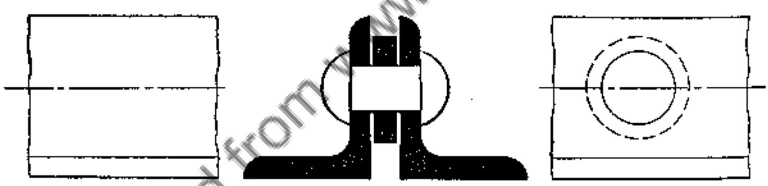


Fig. 257.—Revolved Section.

Detail Sections: A detail section is drawn the same as any other section, but it is placed to one side and often is drawn to a larger scale than the view on which its position is indicated. Section *D-D* in Fig. 254 is a detail section.

Broken-Out Sections: A broken-out section is used where a sectional view of only a small portion of the object is desired. Such

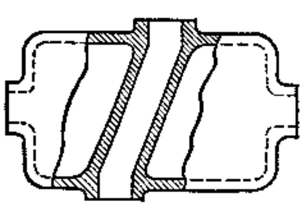


Fig. 258.—Broken-out Section.

a section is shown in Fig. 258. Cutting planes are not used with broken-out sections.

Phantom Sections: A phantom section is an addition to an ordinary outside view. The outside view is shown as usual, and hidden lines and section lining made with dashed lines are added, as in Fig. 259.

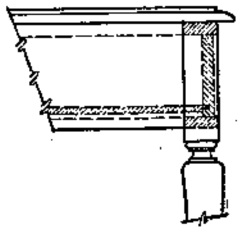
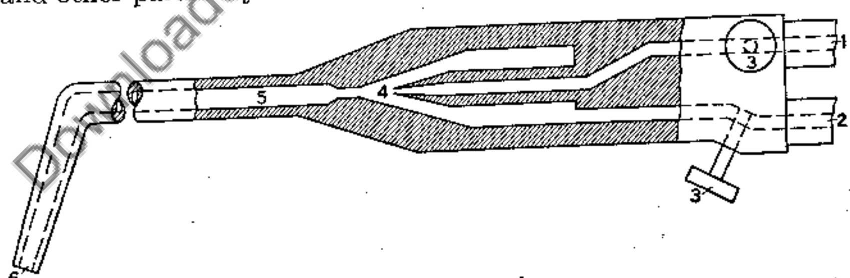


Fig. 259.—Phantom Section.

Thin Sections: Sections which are too thin for line sectioning may be shown solid, as in Fig. 260. Structural shapes (which would

Fig. 260.—Thin Section.

include I-beams, channels, rails, etc.), sheet metal, packing, gaskets, and other parts may be handled in this manner. Where two or more



(1) Oxygen supplied from a high pressure tank
(2) Acetylene (this may be supplied at low pressure)
(3) Control valves
(4) Mixture of gases begins at this point; oxygen escaping at high velocity creates suction on acetylene supply
(5) Size of opening increased to permit expansion of gases which aids mixing
(6) Burning of mixture at tip provides necessary heat for welding

Fig. 261.—Sectional View Showing Injector Principle as Used in a Welding Torch.

thicknesses which are actually in contact are shown, a space should be left between them.

In Fig. 261 is shown a sectional view of part of a welding torch. This sectional view shows the way in which the gases are mixed in the torch. The oxygen (1) rushes through a jet to mix with the acetylene (2), and the oxy-acetylene mixture (4) is forced through the torch (5) for combustion at the tip (6).

DRAWING REQUIREMENT FOR PROJECT 95

Draw a full sectional view of the "ell" and a half-sectional view of the "tee" that were used as models in Project 91. Make the drawings to double size.

In Figs. 262 and 263 are shown sketches (not drawn to scale) which locate the cutting planes for the sectional views required for this project.

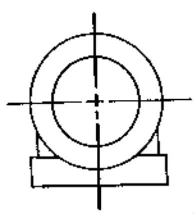


Fig. 262.—Cutting Plane for Project 95.

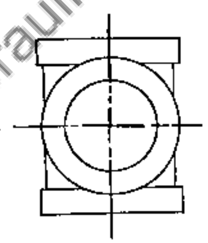


Fig. 263.—Cutting Planes for Project 95.

WORKSHEET NO. 22

Do not write on this sheet.

A. Two of the sets of views shown in Fig. 264 are correct. List the letters that mark those sectional views that are correct.

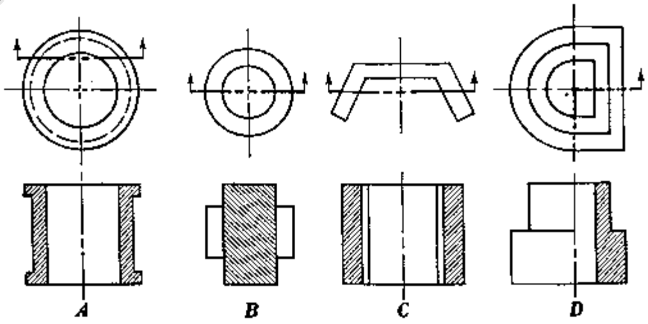


Fig. 264.—Sectional Views for Worksheet No. 22.

B. At the left in Fig. 265 are given two orthographic projections of an object. Record the letter that marks the correct representation of the section along the cutting plane shown in the given view.

C. In Fig. 266 are given three sets of orthographic views upon which cutting planes have been located. Make freehand sketches of the indicated sectional views.

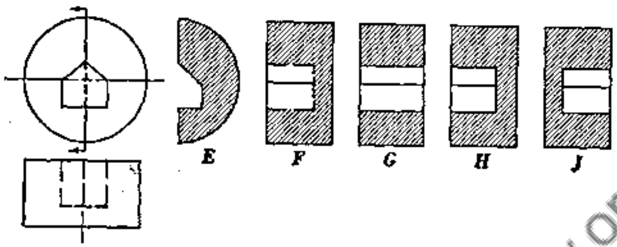


Fig. 265.—Views for Worksheet No. 22.

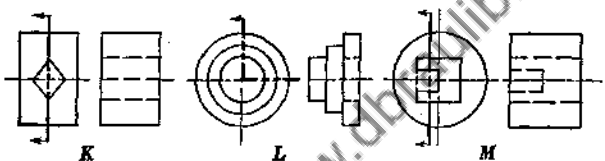


Fig. 266.—Views for Worksheet No. 22.

Project 96—Piston Head

Use a half-sectional view and an orthographic view to describe a piston head of a gasoline (automobile) engine.

Project 97—Heating Your Home

The fuels used in our central heating units in the home (usually furnaces) vary considerably. The choice of fuel depends on the proximity of an adequate supply (which is an important factor in the cost of fuel), personal preferences, and the standards of living we are able to maintain. Some of the fuels in general use are coal (both anthracite and bituminous), coke, oil, gas, and wood.

When burned in a furnace these fuels generate heat, raising the temperature of the water or air which surrounds the combustion chamber (the fire box). The hot air or hot water or steam is then conducted to the rooms, where heat is given up to bring the rooms to the desired temperatures.

When water is used in the boiler, the heating system may be either a hot-water heating system or a steam heating system, the name depending on whether hot water or steam is the circulating medium used. When air is the medium used, in some cases the pipes (or ducts, as they are often called) are omitted.

Furnaces may be referred to as being of one of the following three types: (1) steam, (2) hot water, and (3) hot air.

DRAWING REQUIREMENT FOR PROJECT 97

Select a furnace of one of the three types mentioned. It is advisable to select the furnace in your home or one in the home of a friend or a relative. You are to draw one or more sectional views of the furnace that will clearly show the path of the draft air through the furnace. The sectional view or views must have an accompanying orthographic view upon which your cutting planes (if any) will be located. In your description, you may use any type of sectional view that was mentioned in Project 95.

Before beginning the drawing, submit to the teacher answers to *the one* of the following sets of reference questions that pertains to the type of furnace you have selected.

REFERENCE QUESTIONS

Steam Heating System

1. What is the value of asbestos covering for pipes?
2. What is the function of an air vent?
3. What guards against excessive steam pressure in the system?
4. How would you test the height of the water in the furnace if the water column were broken?
5. What would happen if you "flooded" the system by forgeting to turn off the water when adding water to the supply in the furnace?
6. There are single-pipe and two-pipe steam systems. Explain the difference.
7. What is the cause of "hammering" and "pounding" in steam systems?
8. Steam heating systems may be better utilized than hot-air and hot-water systems—and are generally used—in apartment houses, in larger residences and buildings, and also in heating groups of houses from central heating plants. Why?
9. Explain the following statement: "It is chiefly the heat of vaporization that is utilized in the radiator, not the temperature of the steam."

10. Make freehand orthographic sketches of that portion of the furnace that contains the water and steam. Your attention is called to the fact that, in most cases, this portion will be very irregular in shape.

Hot-Water System

1. State an advantage and a disadvantage of hot-water heating.
2. In steam heating, a "water column" shows the height of the water in the boiler. There is no "water column" on a hot-water furnace. Why?
3. Where is the overflow pipe located?
4. What is the function of the expansion tank?
5. There are always two pipes leading from each radiator. Why?
6. What is the function of the air vents on the radiators?
7. How does a hot-water radiator valve differ from a steam radiator valve?
8. In hot-water heating, there are high-pressure systems and low-pressure systems. How do they differ?
9. Which would you say had the greater initial cost—a steam heating system or a hot-water heating system? Why?
10. Make freehand orthographic sketches of that portion of your furnace that contains the water. Your attention is called to the fact that, in most cases, this portion will be very irregular in shape.

Hot-Air System

1. State an advantage and a disadvantage of hot-air heating.
2. Locate the cold-air inlet to the furnace. Why is it near the bottom of the furnace?
3. What is the function of the "humidifier"?
4. What is a "pipeless" hot-air furnace?
5. It is recommended that a hot-air furnace have an inlet for cold air from the outside of the house. When is this advisable, and when would you consider other sources of supply from inside the house?
6. Some hot-air systems have pipes that convey the cold air from the rooms back to the furnace for reheating. State an advantage and a disadvantage of this arrangement.
7. Some furnaces use both hot air and hot water as a medium for transferring heat. How do you suppose this is accomplished?
8. Make freehand orthographic sketches showing the shape of the fire box and attachments within the furnace leading to the chimney.

Project 98—Carburetion

Explain the principle of carburetion by means of a sectional view or sectional views and a short explanation. Use any type or types of sectional views. Your school library will provide a source of information on the subject.

Project 99—Duplication of Drawings

If, when more than one copy of an original drawing is needed, it were necessary for the copies to be made in the same manner as the original, it certainly would be a slow, laborious and expensive procedure. Fortunately it is not necessary that copies be made in this manner.

When it is desired that copies be made, with present-day methods available, one may select the method to be used that will best satisfy the requirements of the occasion. Since copies are relatively inexpensive to make, in field and shop practice original drawings are used for no more than a source of copies and an ultimate reference.

The methods of duplicating in most general use today are:

(1) Blueprinting
(2) Van Dyke printing
(3) Ozalid printing
(4) Photostating
(5) Mimeographing
(6) Hectographing

Blueprinting: This method of copying drawings is the one most commonly used. In general it is the cheapest and one of the quickest. Before reproductions can be made by this method, it is necessary that the drawings be made or traced on transparent paper with opaque lines. The more transparent the paper and the more opaque the lines, the clearer the reproduction will be. These tracings may be made on tracing paper or specially prepared tracing cloth. The choice of paper or cloth and ink or pencil should depend on the desired life and usage of the tracing. India-ink tracings on tracing cloth are by far the most durable.

In making a blueprint, a tracing is placed over special surface-sensitized blueprint paper and the two are exposed to artificial light, or even sunlight, for a short time. The opaque lines do not permit the passage of light through certain parts of the tracings. Where light penetrates the tracing, it affects the chemically active surface of the blueprint paper in such a way that when washed with water those areas become blue. White lines are found where the opaque lines did not permit light to strike the surface.

Blueprints are not absolutely accurate reproductions, because of the stretching of the paper in the necessary washing processes. Even though, in most cases, a chemical fixing bath is given during the washing process, blueprints will fade somewhat when exposed to light for long periods of time.

Van Dyke Printing: This method of reproducing drawings differs from the blueprinting method only in that there is an added step. A transparent-lined negative copy is made from the original tracing. Finished copies made on blueprint paper from this negative appear with blue lines on a white background.

This method is being slowly placed in the discard by the more modern methods which give copies with white backgrounds directly from original tracings.

Ozalid Printing: This process uses a specially prepared paper which, after being exposed to light in a manner similar to that in blueprinting, is developed in fumes of ammonia. By this method it is possible to make a black-line print on a white background. No wet wash is used in the process; hence, it has the advantage over the two previously discussed methods in that, since there is little stretching of the paper, you are able to obtain more accurate copies. It can be used in every instance where blueprinting may be used and is rapidly coming into popular use.

Photostating: "Photostating" consists of nothing more than duplicating by taking photographs. Cost limits the use of this method, since the developing paper is quite an expensive item when the drawing is large or a large number of copies are desired. Photostat prints may be obtained as negatives (white lines where black lines were on the original drawing) or positives.

It is not necessary to prepare tracings to make photostatic copies.

Mimeographing: Originally, to duplicate by the use of a mimeographing machine, it was necessary to cut a stencil (draw, write, or type on a special waxed gauze sheet). However, through the development of the *photochemical stencil,* it is now possible to have direct duplication by using the mimeograph.

The size of drawings which may be duplicated by using the usual mimeographing machine is limited to $8\frac{1}{2}$ in. × 13 in. Mimeograph prints, in general, consist of black lines on a white background.

Hectographing: To duplicate by hectographing, it is necessary to reproduce the drawing on a master sheet by using a special hectograph ink. Hectograph carbon paper is also available for use. This prepared reproduction is then pressed smoothly in contact with a gelatinous layer for a few minutes. After this reproduction is removed, good copies are made by placing hectographing paper in contact with the gelatinous layer.

Modern developments have presented a direct method of hectographing which eliminates the use of the gelatinous layer and is to be highly recommended. By using hectograph carbon paper of good quality, a negative master copy is written, drawn, or typed. To make each copy, this master is brought into contact with paper that has been slightly dampened with a methyl-alcohol solution.

As in the case of mimeographing, the size of the drawing for practical duplication by hectographing is somewhat limited. As many as 200 copies, or slightly more, can be obtained from one master sheet on a hectographing machine.

QUESTIONS

1. Determine what kinds of duplicating machines are in use in your school, and obtain samples of duplications made by these machines. What are their limitations in regard to size, number of copies, etc?
2. At what commercial firms in your town or vicinity may you have duplications made?
3. What methods for duplication are available?
4. How much would it cost to have 50 copies made of a drawing, size 8 in. × 12 in., by each of the various methods that are commercially available?
5. How much would it cost to have 20 copies made of a drawing, size 15 in. × 24 in.?
6. Make estimates of the costs asked for in Questions 4 and 5, and record them in order to compare them with the actual costs when received.

MAKING TRACINGS

In several of the modern methods of duplicating, the first step is the making of a tracing. Previously in this course you have made many tracings which were suitable for duplicating usage.

Tracings, for duplicating purposes, may be made on any transparent paper or prepared tracing cloth by using either pencil or India ink. As you have already seen by personal experience, making pencil tracings presents no new problem. However, when making ink tracings, there are several "Do's" and "Don'ts" which, coupled with diligent practice will enable one to make very presentable ink tracings.

INKING

In inking, the ruling pen receives much use; it is used for all straight lines. Small arcs and circles are inked with the bow pen, while larger arcs and circles are inked by using the large compass. In using the large compass, the ends of the legs should be set so that they are perpendicular to the surface of the drawing. Lettering is done with the aid of an ordinary penholder and a pen point of personal choice. It is suggested that the point be changed to suit the type of lettering that is being performed.

When using the ruling pen it should be held, as shown in Fig. 267, so that it is slightly inclined but in a plane perpendicular to

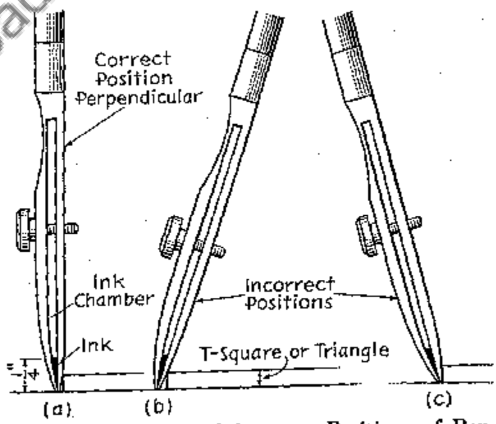


Fig. 267.—Correct and Incorrect Positions of Pen.

the surface of the paper; and it should be moved at a uniform rate of speed without undue delay at the beginning or the end of the line.

Keep your instruments clean at all times. Lint or an accumulation of small particles of dust can very easily cause unsightly blots or ragged lines on your drawing. Good and poor lines are shown in Fig. 268.

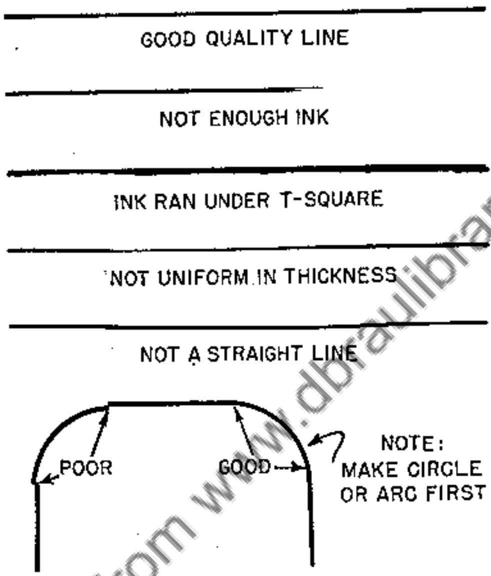


Fig. 268.—Line Technique.

Observe all general rules of cleanliness and neatness, and your drawings and tracings will reflect the care and precision with which they were executed.

Don't forget the old saying, "They will never ask you how long it took you; they will ask you *who did it.*"

Constant practice will develop speed.

For practical purposes the following order of inking is recommended.

(1) Solid circles
(2) Solid arcs
(3) Dashed circles
(4) Dashed arcs

(5) Straight solid lines
  (a) Horizontal
  (b) Vertical
  (c) Inclined
(6) Straight dashed lines
  (a) Horizontal
  (b) Vertical
  (c) Inclined
(7) Center lines and centers of arcs
(8) Extension lines and dimension lines
(9) Arrowheads
(10) Dimension numerals
(11) Notes and titles
(12) Border
(13) Check carefully

TRACING REQUIREMENT

A. Ink the pencil lines of the drawings of the pipe fittings completed for Project 91.

B. Make an ink tracing (on tracing paper) of the drawing made in A.

C. Make an ink tracing (on tracing paper) of any drawing other than those used or made in class. Obtain your drawing from a magazine, a newspaper, or some other source.

Project 100—Detail Drawings of a Faucet

Thus far the projects have dealt with drawings that would clearly and completely describe the shape, or both the shape and size, of single objects. In this project an object that is made up of more than one part will be dealt with.

In the preparation of a detail drawing, each part of the object is considered as if it were a single object in itself.

The object to be described in this project is a $1\frac{1}{2}''$ threaded bibb faucet. It is a type of faucet that is to be found in any home. In drawing the views to describe the parts of the faucet, it is recommended that one part be completely described before proceeding to the next.

At least two related views will be required of each of the parts to be described. In most cases, more than two views will be necessary for adequate description. It is suggested that sectional views be used where they will aid in the description.

These drawings, which are known as *detail drawings,* will treat each part separately and will show the following information:

1. *Shape description* by means of orthographic views, including the use of sectional views where they will add to the description; each part is to be considered independent of all other parts.
2. *Size description* by clear and complete dimensions, with notes added wherever necessary.
3. The surfaces to be finished and the kind of a finish required.
4. Any shop operations which may be required.
5. The allowed limits of accuracy in the case of precise work.
6. The material from which the piece is to be made.
7. The number of pieces of each kind required in one complete assembled unit.

SUGGESTED VIEWS FOR DESCRIPTION OF PARTS

For this project it is suggested that the pupil complete the following views of the following parts. It is not imperative that this suggestion be adopted; other combinations are thorough and acceptable.

Cap—bottom and half-sectional views
Handle—top, side, and full sectional views
Stem—top, front, and bottom views
Body—top view, two side views, and full sectional view.

Those parts needed for one complete assembly, other than the parts just suggested, will be considered as being of standard sizes; and the listing of their identifying names, the materials from which they are made, the sizes, and any other special individual notes in the "Bill of Materials" will be deemed as being sufficient identification. A sample "Bill of Materials" is shown in Fig. 269.

BILL OF MATERIALS FOR FAUCET					
Name of Part	No.	Material	Size	Type of Threads	Miscellaneous
Button cap bolt	..	Brass	$\frac{3}{16}$" D $\frac{1}{2}$" long	U. S. St'd	
Body	1	Brass		See detail drawing.	

Fig. 269.—Bill of Materials.

It is to be noted that in Project 91 some of the small arcs were not dimensioned. In each case, where an arc was not dimensioned, the radius of that arc could have been varied slightly to conform with facility of manufacture without hindering in any way the use for which the object was designed. Arcs of that nature need not be dimensioned in this project or any of the projects that follow.

CONVENTIONS USED FOR THREAD REPRESENTATIONS

Where threads are to be shown on cylinders that are less than 1 in. in diameter, the thread outlines should be omitted and use should be made of some one of the regular thread conventions shown in Fig. 270 or Fig. 271 or one of the simplified conventions shown in Fig. 272.

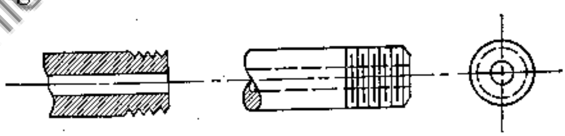


Fig. 270.—External Threads.

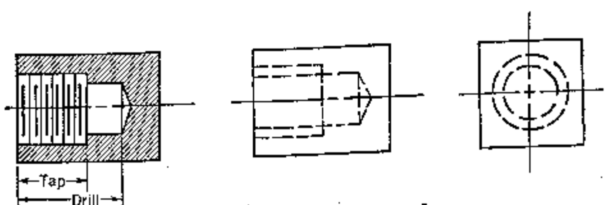


Fig. 271.—Internal Threads.

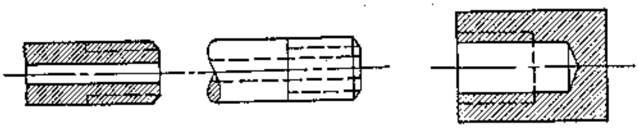


Fig. 272.—Simplified Conventions.

In drawing these thread representations, one should make use of the following facts:

(1) The pitch may be approximated.

(2) The lines at the base (or root, as it is called) of the thread are made heavy for effect.

(3) No inclined lines are used.

WORKSHEET NO. 23

Make the required drawings on a separate sheet.

A. Using thread conventions, make copies of the drawings shown in Fig. 273.

B. Using thread conventions, make a full sectional drawing of part No. 3 of the pipe fitting (a union) shown in Fig. 274.

C. What are the lengths of the drills and the taps in the drawings in Fig. 275?

Project 101—Detail Drawings of a Steam Valve

From a new or discarded steam valve, make detail drawings of the various parts. With your views include a bill of materials.

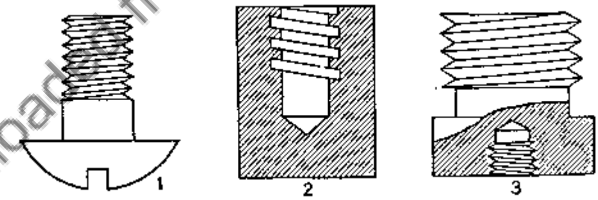


Fig. 273.—Thread Conventions for Worksheet No. 23.

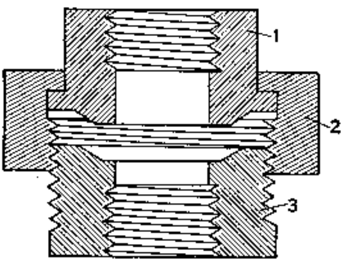


Fig. 274.—Pipe Fitting for Worksheet No. 23.

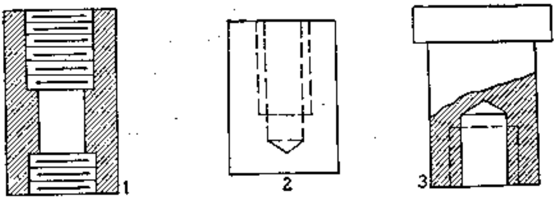


Fig. 275.—Drills and Taps for Worksheet No. 23.

Project 102—Connecting Rod

By means of a bill of materials and related views, describe all parts that are included in a connecting-rod assembly.

CHAPTER VIII

ASSEMBLY DRAWINGS

Specific Aims:

To show the relation of detail drawings to assembly drawings.

To acquaint the pupil with the different types of assembly drawings.

To have the pupil make assembly drawings.

Assembly drawings are drawings of objects with all parts assembled. They show the relative positions of the various parts. Assembly drawings may be made for different uses and, hence, may vary in the purpose for which they are intended. In some cases only one view of the assembled object is shown, while in other instances two, three, or more views are shown. In Fig. 276 is shown an assembly drawing for a model airplane.

The *design drawing,* used in the case of a new design and consisting of more than one assembly view, is a preliminary drawing on which the designing is worked out accurately from the freehand and mechanical sketches and calculations that always precede an original design. The design drawing is made to full size, if possible.

An *assembly drawing,* usually consisting of one view, is often drawn to a smaller scale than the design drawing in order that it will fit on a standard sheet. If the detail drawings are used as the source of information for making this *assembly drawing,* it furnishes an excellent check on the accuracy of the detail drawings. Reference numbers are generally used to mark the different parts. These reference numbers may be used to tie up the assembly drawing with the detail drawings and as a means of definite reference in the case of a bill of materials or any other note that one might want to show. An assembly drawing should not be overloaded with detail, especially hidden detail (here, as in the case of all sectional drawing, unnecessary hidden detail should be omitted). When dimensions are placed on assembly drawings, they will, in general, include no more than the over-all dimensions, distances from center

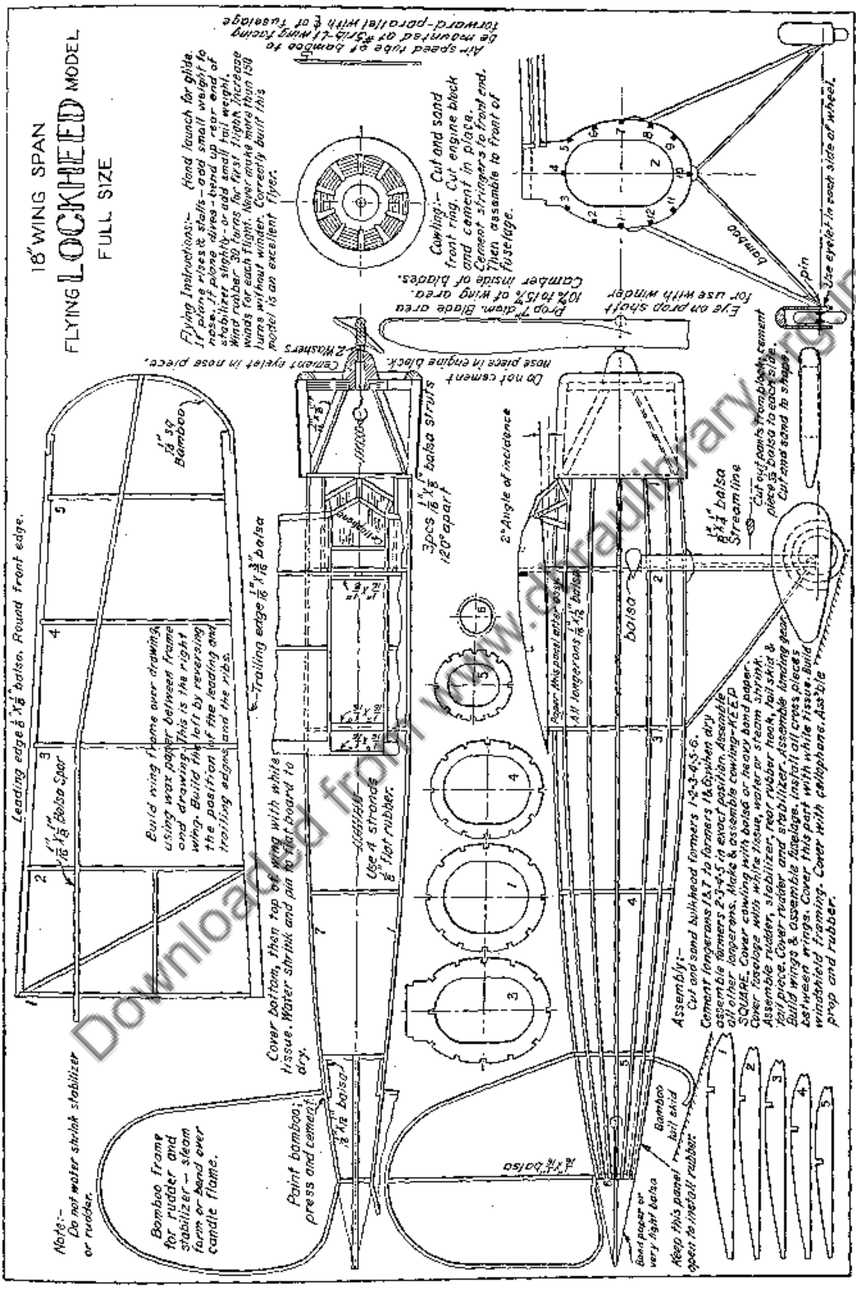
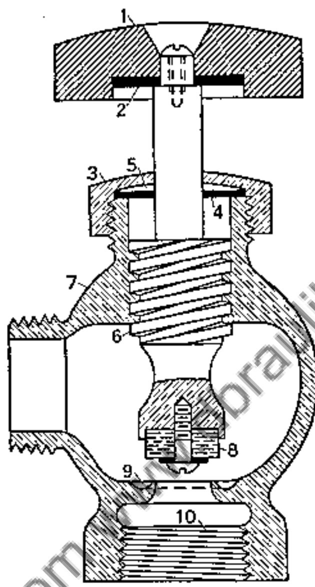


Fig. 276.—Assembly Drawing of Model Airplane.

to center of the various parts, or sufficient information to indicate the location and relation of one part to another in order that the machine may be put together by reference to the assembly drawing alone.

An assembly drawing of a steam valve is shown in Fig. 277.



1—Non-breakable handle of heat-resistant composition
2—Square piece of flat metal fitting over square portion of stem to securely lock the handle
3—Metal cap
4—Metal washer
5—Space available for packing
6—Stem with square right-handed double thread
7—Body
8—Disc of high quality rubber composition
9—Groove about seat insuring a tight fit with even a worn washer
10—Right-handed thread

Fig. 277.—Assembly Drawing of Steam Valve.

Project 103—Assembled Parts of a Union

The three parts which make up a union are shown in Fig. 278. Show these three parts assembled as they would appear in a sectional view of the union. The sectional view is to be taken along the longitudinal axis of the union. Make the drawing to triple size.

SPECIAL TYPES OF ASSEMBLY DRAWINGS

An *assembly working drawing* is an assembly drawing that not only shows the relations of the parts but describes fully the

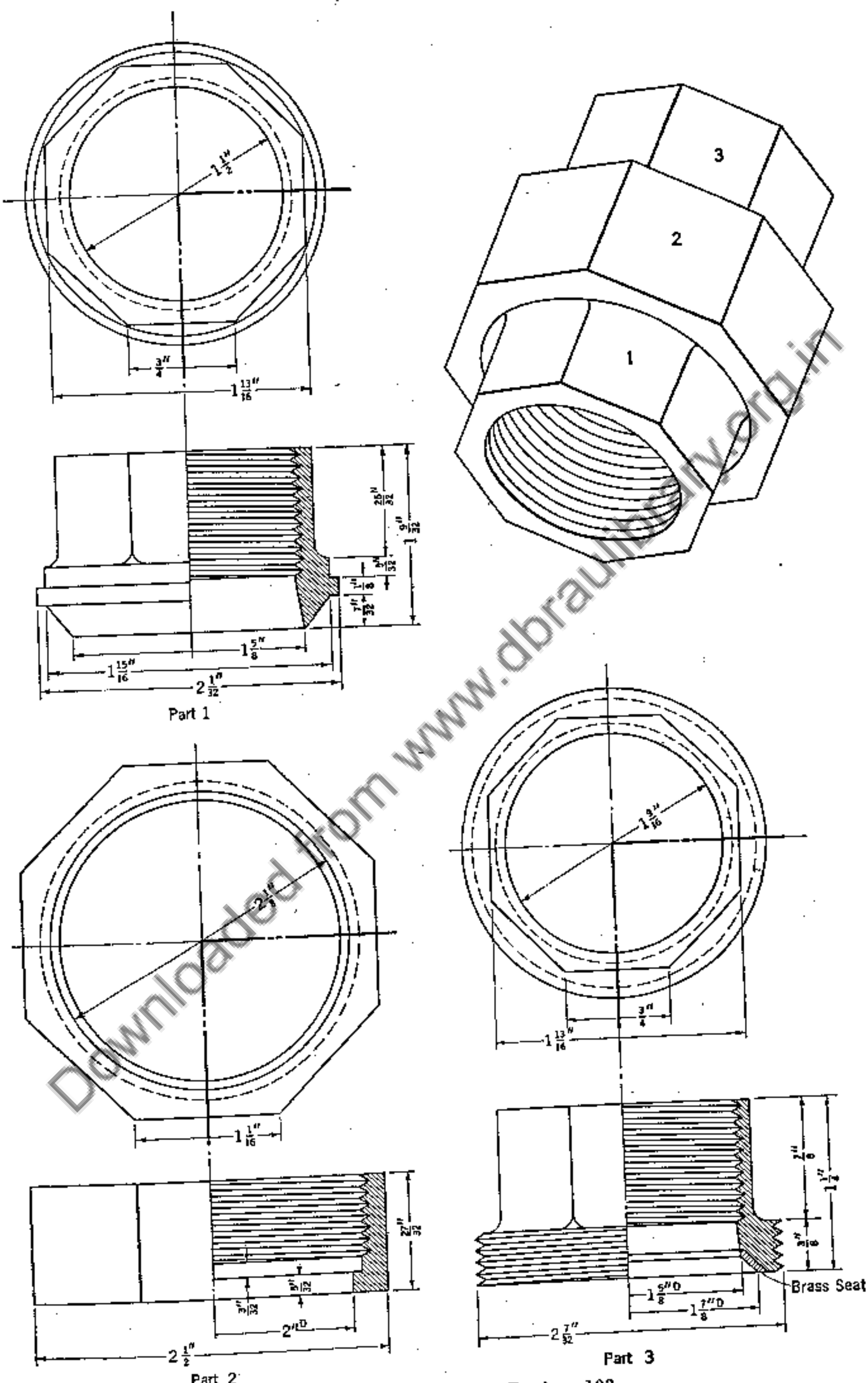


Fig. 278.—Union for Project 103.

shape and size of each part. Needless to say, when this type of drawing is shown, it is necessary to use more than one view. This type is adaptable to the more simple machines.

A *unit assembly drawing* is a drawing of a related group of parts taken from a more complicated machine. An example of this type is shown in Fig. 279; it is a simplified drawing of the differential* joint in an automobile. Gear 1 transmits power from the driveshaft to gear 2, which is fixed to sleeve 3. This sleeve is mounted on the rear axle but is free to rotate about it. Gear 4 is free to rotate in either direction and meshes with two gears 5, which are attached to the rear axle.

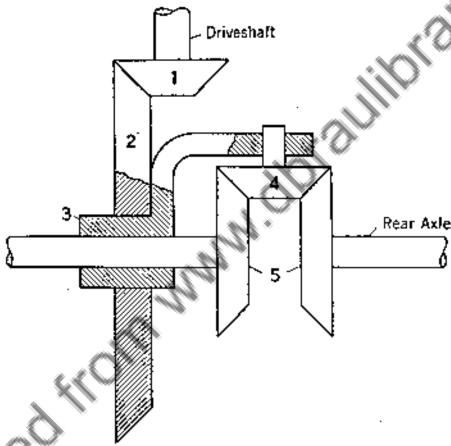


Fig. 279.—Unit Assembly Drawing of a Differential.

When both rear wheels are turning at the same rate, gear 4 does not rotate about its own axis. On curves, when one wheel must turn faster than the other, then gear 4 rotates, allowing one of the gears attached to the rear axle to rotate faster than the other. This prevents the sliding of the wheels on curves.

Diagrammatic drawings show diagrams of piping, wiring, heating, etc. Although not commonly thought of as assembly drawings, they are classified as such. An example of diagrammatic plumbing

* It is suggested that a wooden model of a differential and a transmission be placed in the classroom.

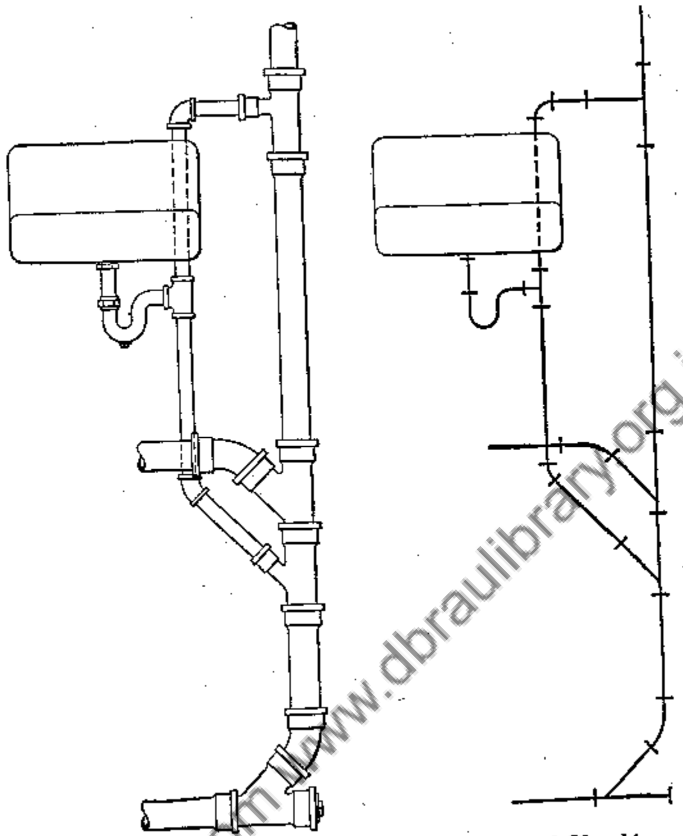


Fig. 280.—Realistic and Symbolic Representation of Plumbing.

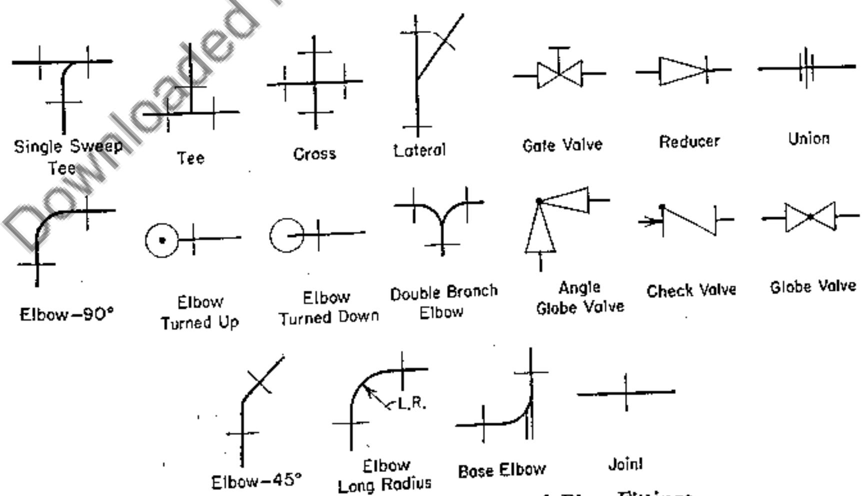


Fig. 281.—Conventional Symbols of Pipe Fittings.

is shown in Fig. 280. The meanings of various plumbing symbols are shown in Fig. 281.

Diagrams may be shown in plan views or elevations or both in related orthographic positions.

Wiring diagrams show the locations of units along electrical circuits. In Fig. 282 is shown a wiring diagram for an electrical outlet that may be operated from any one of the three switches in the circuit. Radio wiring diagrams are a common example of this kind of drawing.

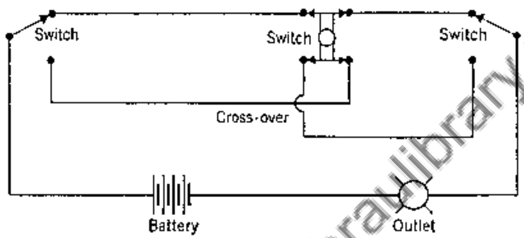


Fig. 282.—Wiring Diagram.

Project 104—Assembly Drawing of a Faucet

In Project 100 the detail drawings that were drawn described each part of a faucet; but they in no way attempted to show the relative positions of the parts when the faucet was assembled.

As the drawing requirement for Project 104, make an assembly drawing of the faucet. The assembly drawing is to show no dimensions, and the parts are to be arranged as if the faucet were open. Only one view is required.

Project 105—Electrolier with Switches

Make a freehand sketch showing the necessary wiring for an electrolier of three outlets, with a key switch controlling each of the outlets and a wall switch controlling the entire electrolier.

Make a simple schematic wiring diagram for this hook-up.

Project 106—Bell and Buzzer Hook-up

Make a wiring diagram to be followed in installing a bell for one door of a house and a buzzer for another. Use only one transformer.

Project 107—Garage Ceiling Outlet

Make a wiring diagram to be followed for the installation of a ceiling outlet in a garage which is located at least 20 feet away from a house. Either of two switches, one located in the house and one located in the garage, may be used to control the outlet. Wires may be placed either above or below the ground and will go from the house to the garage.

Make a freehand sketch (in section) that will show the paths of the proposed wires and the locations of the switches and the outlet.

Project 108—Plumbing in the Basement of Your Home

Make a diagrammatic drawing of the plumbing in the basement of your home. Use related plan and elevational views. The necessary symbols are shown in Figs. 280 and 281.

Project 109—Hot-Water Tank

Make a plumbing diagram that may be used for installation of a hot-water tank. Provide for an arrangement whereby the tank can be drained directly into the sewer.

Project 110—Transmission of an Automobile

By the use of an assembly drawing and a short explanation (see Fig. 279), describe the operation of a transmission of an automobile. Use your school library to obtain your information.

Project 111—Steam Valve

Make an assembly drawing of a steam valve. Show the principal dimensions.

Project 112—Piston Assembly

Draw a unit assembly view that will show how the piston head, the wrist pin, and the connecting-rod are assembled. It will be sufficient to show the upper half of the connecting-rod.

CHAPTER IX

PICTORIAL DRAWINGS

Specific Aims:

To show the value of a pictorial drawing.

To teach an appreciation of the limitations of perspective drawings in mechanical description.

To give an understanding of isometric drawings.

To teach the pupil to make isometric drawings.

To show the relationship of isometric, oblique, and cabinet drawings.

To present a method for construction of mechanical perspective drawings.

Pictorial drawings are of several types, but all types serve the purpose of representing objects approximately as they appear to the eye. A bird's-eye view of the second floor of a house is shown in Fig. 283.

Project 113—Isometric Drawing of a Block

In Fig. 284 is shown a mechanical perspective drawing (a drawing that presents the object somewhat as seen by the eye) of a bookend. By reference to the drawing, answer the following questions to the best of your ability.

QUESTIONS

Assume that the total height of the bookend in Fig. 284 is 5 in.

1. Does the drawing give you a clear impression as to what the actual bookend will look like?
2. What is the width of the bookend?
3. Is the width of the bookend the same at the top as at its base?
4. Measure the lengths of the lines *AB*, *GH*, *CD*, and *EF*. Are these lines equal in length?
5. On the object, lines *AB*, *IJ*, and *CD* are parallel. Do they have this relationship on the drawing?

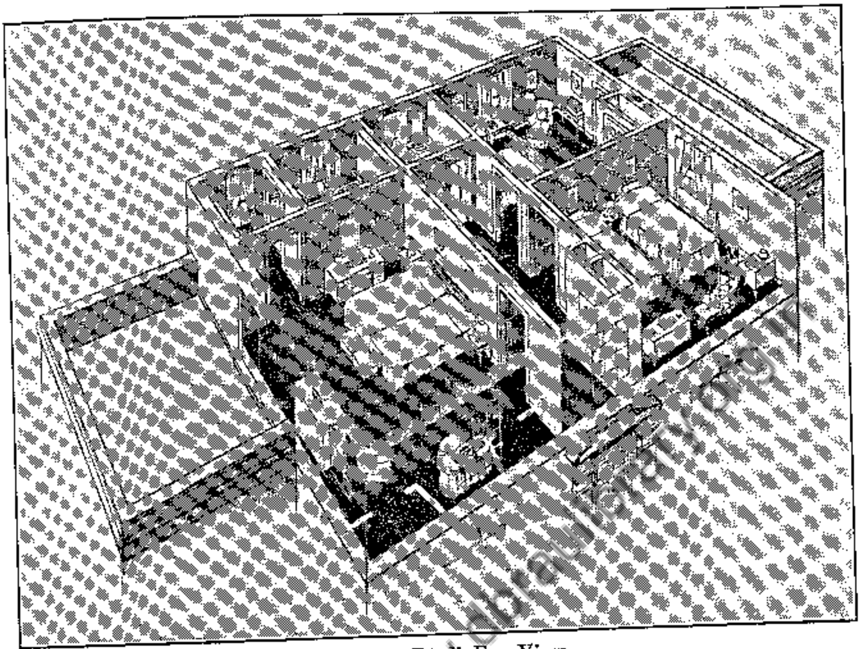


Fig. 283.—Bird's-Eye View.

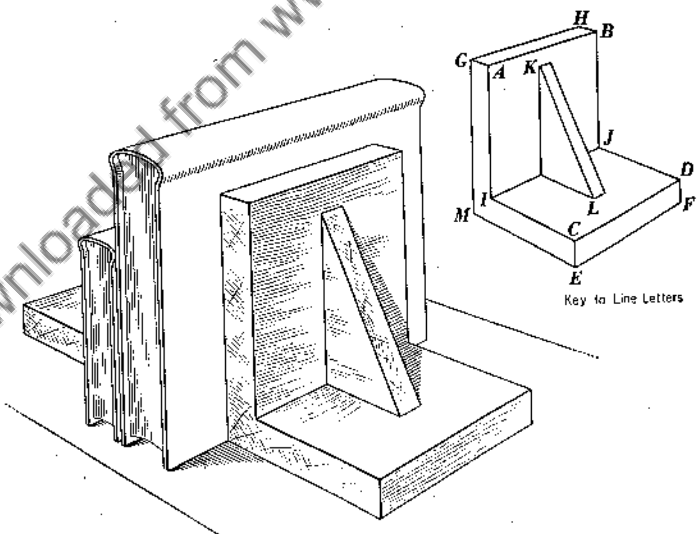


Fig. 284.—Angular Perspective Drawing of a Bookend.

6. On the object, lines *AI* and *BJ* are equal. How do they compare in length on the drawing?
7. On the bookend how many surfaces are rectangular in shape? In the drawing are they shown as rectangles?
8. Estimate the number of degrees in angle *AIC*. Is the angle drawn in true size?
9. Estimate the number of degrees in the angle *MEF*. Is this angle drawn in true size?
10. What is the length of line *KL*?

Check your answers to the preceding questions with the information given in the working drawings of that bookend which are shown in Fig. 285.

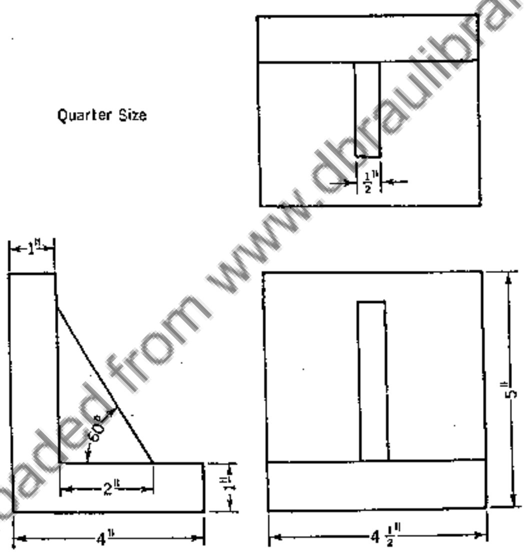


Fig. 285.—Working Drawings of Bookend.

SUMMARY

The mechanical perspective drawing adequately presented a picture to your mind's eye as to the likeness of the bookend, but showed very little information that would help in producing an accurately-sized copy of the bookend.

The working drawings give you an account of the size and shape of the bookend. Would the working drawings explain the shape and the size of the bookend to an untrained individual?

There are pictorial drawings which are so designed that accurate models may be made from the drawing, and yet the drawing presents the object in such a way that its detail may be conceived by even an untrained individual. One of the most common types of pictorial drawings of this class is the *isometric drawing*. In Fig. 286 is shown an isometric drawing. Compare it with the angular perspective drawing shown in Fig. 284.

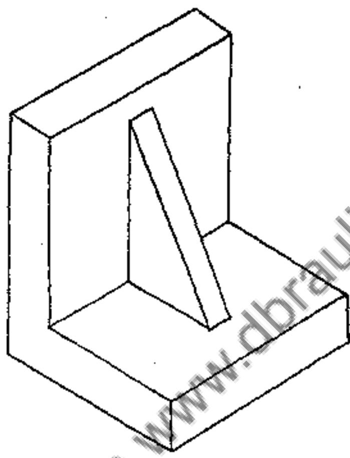


Fig. 286.—Isometric Drawing of Bookend.

QUESTIONS

By referring to the isometric drawing in Fig. 286, answer the ten questions regarding the bookend given on pages 224 and 226.

HOW TO MAKE AN ISOMETRIC DRAWING

The word "isometric" means "equal-measure." In making an isometric drawing, each line is measured equal to its actual length or a scaled equivalent of its actual length. This is quite contrary to the practice in making perspective drawings, where the optical perception desired is gained by foreshortening lines. Because of the omission of this practice of foreshortening in making isometric drawings, an isometric drawing gives the impression that the object was drawn with its rear corner raised and tilted forward. The fact that many of the lines in an isometric drawing are shown in true length permits their use when scaling of distances is desired.

Lines that are parallel to any of the three isometric axes are called *isometric lines* and are shown in their true lengths. These isometric axes are comparable to the lines at the nearest vertical edge, as shown in Fig. 287.

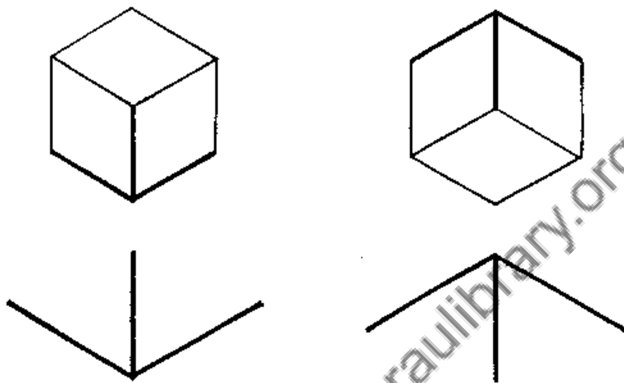


Fig. 287.—Isometric Axes.

The positions of the three isometric axes are always definitely located. As shown in Fig. 288, one is vertical, and the others make angles of 30° with the horizontal—one to the left and one to the right.

Any line that is *not parallel* to some one of these isometric axes is a *non-isometric line* and is not shown in its true length.

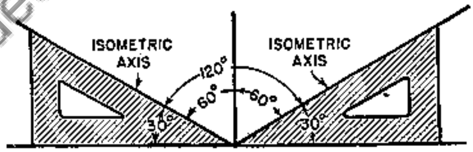


Fig. 288.—Positions of Isometric Axes.

WORKSHEET NO. 24

A. The isometric drawing of a shoe-shining box is shown in Fig. 289.

1. List the letters of the lines that are isometric lines.
2. List the letters of the lines that are non-isometric lines.

B. Draw three orthographic views, namely, a top view, a front view, and a side view, of the shoe-shining box. Omit all hidden detail. Determine your dimensions by scaling true lengths from the isometric drawing.

NON-ISOMETRIC LINES

A non-isometric line is located by determining the positions of the points at the ends of the line. No use of angles can be made in this determination because of the fact that no angles in an isometric drawing are shown in their true size. *All angles are distorted.*

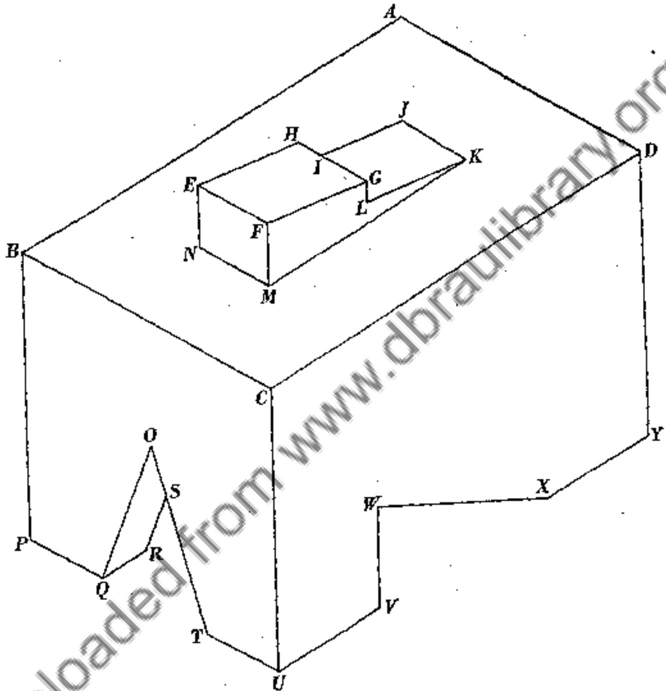


Fig. 289.—Isometric Drawing of Shoe-Shining Box.

The positions of the points at the ends of a non-isometric line are determined by drawing lines of measurable length, such as *X* and *Y* in Fig. 290, which are parallel to one isometric axis and intersect another isometric axis. On the object or on orthographic views of the object, these lines—to be parallel to an isometric axis—must be either horizontal or vertical. Being parallel to an isometric axis, these lines are isometric lines and will be shown to their true lengths. Points *A* and *C* were previously located at the ends of the isometric lines AB and BC. The intersection of the lines X and Y will be the location of the point D.

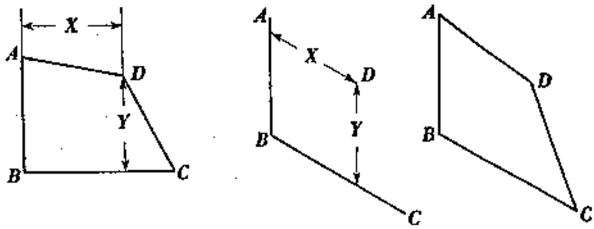


Fig. 290.—Non-Isometric Lines.

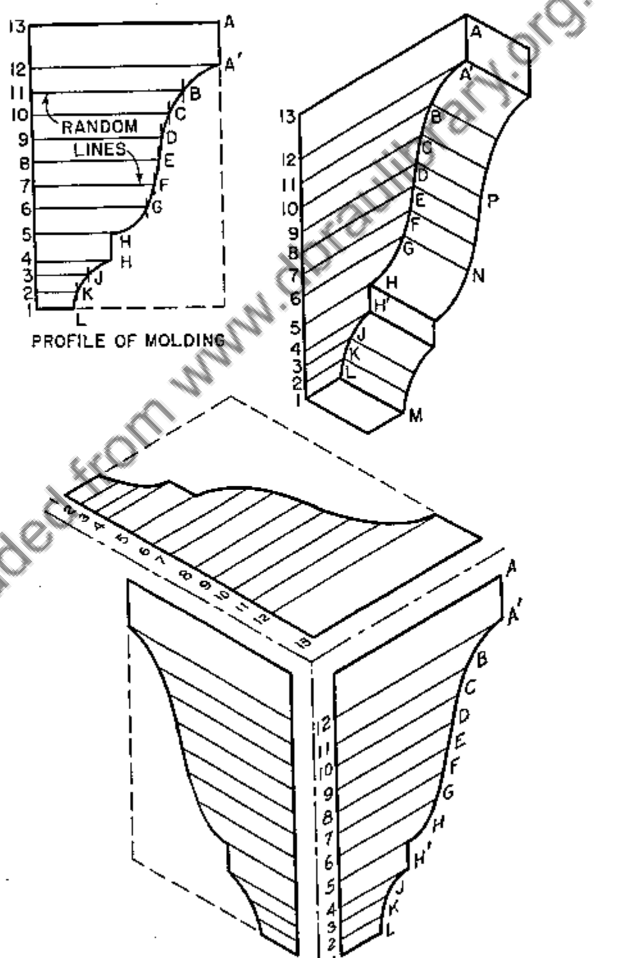


Fig. 291.—Isometric Projection of a Molding.

Since the points at the end of a straight line determine the position and length of the line, the isometric line is then accurately located.

The position of *any curved line* may be determined in a similar manner. It is necessary to locate several points along the line and

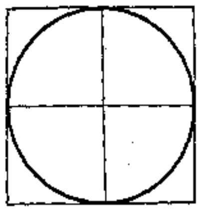


Fig. 292.—Center of Circle.

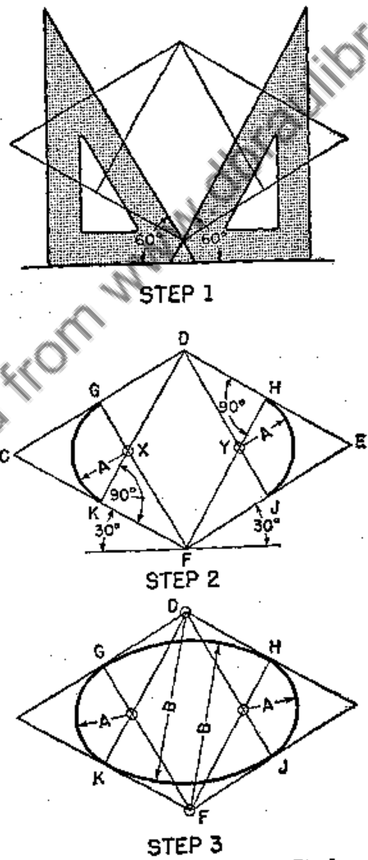


Fig. 293.—Construction of Circle on Isometric Drawing.

then to connect them with a smooth curve. See the example in Fig. 291.

ISOMETRIC CIRCLES

There is a special construction for isometric circles, semicircles, and quarter-circles. The following method will meet any case.

In the practice of geometry, if you were given a circle with a diameter of 2 in., you could very easily draw a square in which the circle would be inscribed; and, if you were to draw perpendicular bisectors to the sides of the square, they would intersect at the center of the circle, as shown in Fig. 292.

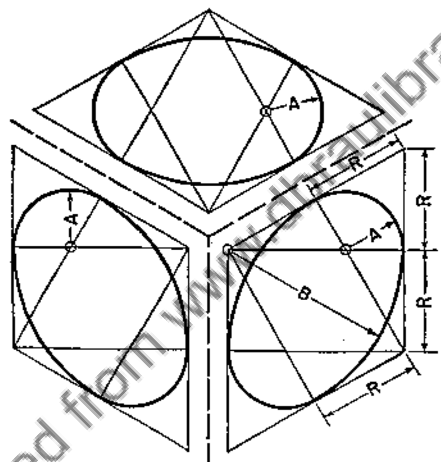


Fig. 294.—Isometric Circles in Three Planes.

Isometrically we can very easily reproduce the square and the perpendicular bisectors. In so doing you will find that the perpendicular bisectors no longer meet at a common point but have four different intersections, as shown in Fig. 293 at *D*, *X*, *F*, and *Y*. Each of these points of intersection is used as a center for drawing an arc. The four arcs required are those shown in Fig. 293 with radii *A* and *B*.

As shown in Fig. 294, there are three possible arrangements of the isometric square, the correct one depending on where the square is located on the object; in other words, parallel to which principal face.

In order to represent a semicircle or a quarter-circle in an isometric drawing, it is necessary first to draw that portion of the isometric square which will enclose the part of the isometric circle that one desires to draw. Step (1) in Fig. 295 shows this first step.

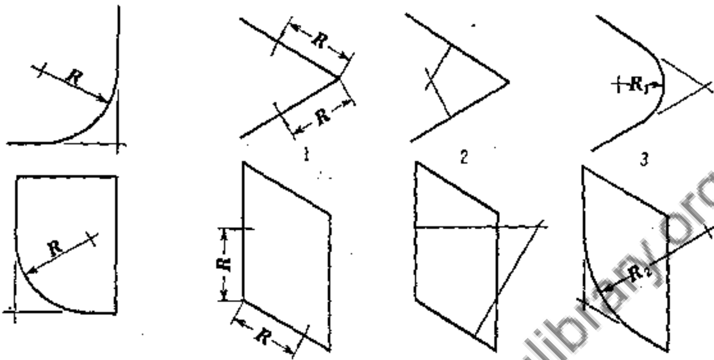


Fig. 295.—Isometric Arcs.

Next, distances equal to the true radius of the isometric circle are measured from the corner of the isometric square. These distances have been indicated by the letter R in step (1). Perpendiculars to the sides of the isometric square are drawn through the points which are at distance R from the corner, as shown in step (2). These perpendiculars are actually the perpendicular bisectors of the sides of the isometric square.

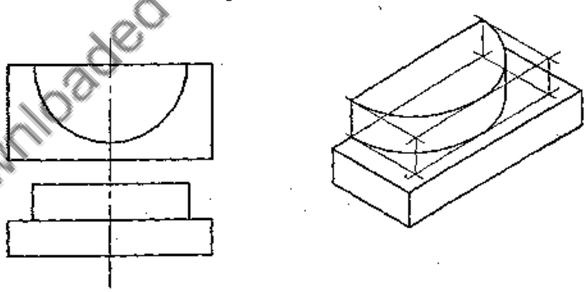


Fig. 296.—Boxing-in.

To round any corner, find the intersection of the two perpendiculars and use that point as a center for swinging an arc, the radius of which is the perpendicular distance from that point to the side of the isometric square, as R_1 or R_2 in step (3).

As a step in the construction of lines—other than straight lines—in an isometric drawing, you will find it advisable to first "box-in," as in Fig. 296. These construction lines are erased before the drawing is considered complete.

DRAWING REQUIREMENT FOR PROJECT 113

As a drawing requirement for Project 113, make an isometric drawing of the block described in Fig. 297.

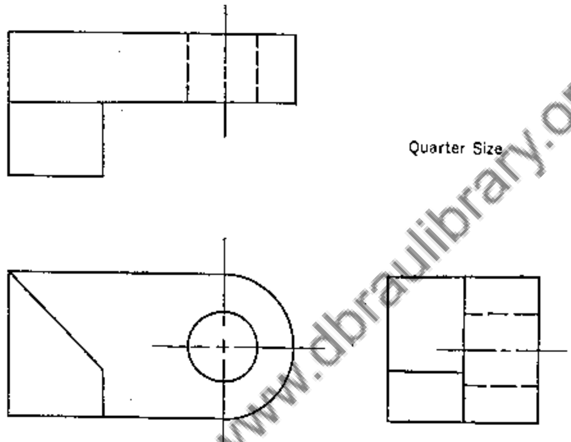


Fig. 297.—Block for Project 113.

Project 114—Isometric Drawing of Combined Letters

On a drawing plate, the finished size of which is to be $8\frac{1}{2}$ in.× 11 in., make an isometric drawing of the "combined letters and period" shown in Fig. 298. This sketch is drawn to half size. Your drawing should be made to full size.

Project 115—Isometric Drawing of Framing Details

Make an isometric drawing of the framing details of that corner of the house which was definitely described by the elevations of Project 79. The size of the finished plate will be 11 in.×17 in. The title block is to be placed across the shorter dimension of the working space.

The scale of the drawing will be $\frac{3}{4}$ in.=1 ft. You are to show as much of the framing detail as will fit within the limits of your working space.

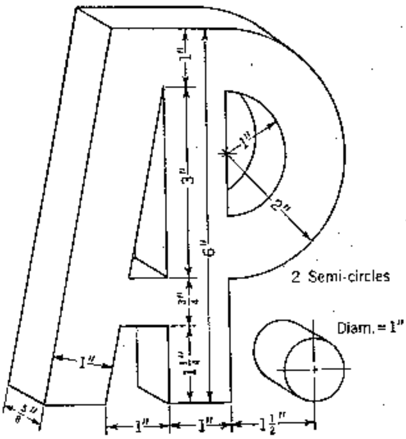


Fig. 298.—Combined Letters for Project 114.

Project 116—Isometric Drawing of Collapsible Shelf

Make an isometric drawing, to the scale of 3 in. = 1 ft, of the collapsible shelf described in Fig. 299. All material is $1\frac{1}{2}$ in. thick.

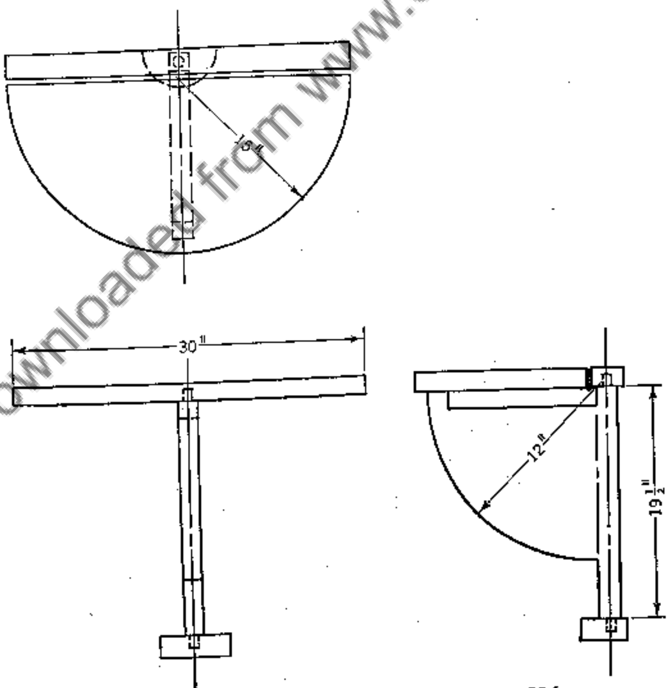


Fig. 299.—Collapsible Shelf for Project 116.

Project 117—Isometric Drawing of a Cabin

Make an isometric drawing of the cabin drawn for Project 82.

Project 118—Oblique and Cabinet Drawings

Isometric, oblique, and cabinet drawings have much in common. They are all types of pictorial drawings. Their differences and similarities are noted in the table shown in Fig. 300.

In both the oblique drawing and the cabinet drawing you are able to present one surface in true shape. This may be well appreciated when complicated round objects are being drawn.

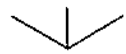
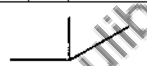
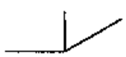
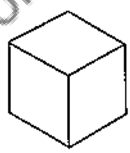
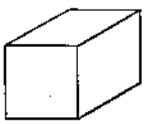
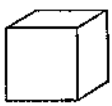
TYPE	ISOMETRIC	OBLIQUE	CABINET
Axes			
Number of Axes	3	3	3
Vertical Axes	1	1	1
Angular Axes	2 at 30°	1 At Any Angle	1 At Any Angle
Horizontal Axes	0	1	1
Axes in Direction of Which Lines Have True Length	All Three	All Three	Horizontal Vertical True Lengths to Half Size Along Angular Axis
Illustration (Model is Cube, each Side of Which Equals ⅜ in.)			

Fig. 300.—Comparison of Isometric, Oblique, and Cabinet Drawings.

The cabinet drawing does not seem so unusual as the oblique drawing. The reason for this is that by showing one-half of the true length along the angular axis the drawing more nearly approaches a perspective drawing (a drawing that shows the object as seen by the eye).

It is more difficult to draw detail on the shortened inclined side of a cabinet drawing than on the inclined side of an oblique drawing because distances along the inclined axis of a cabinet drawing are shown to one-half of their true lengths.

Two drawings will be required for this project. First, on a plate $8\frac{1}{2}$ in. × 11 in. in size, make an oblique drawing of the block described in Fig. 297. Second, on a plate 11 in.×17 in. in size, make a cabinet drawing of the desk at which you work while in the drawing room.

Project 119—Oblique Drawing of Combined Letters

Make an oblique drawing of the "combined letters and period" shown in Fig. 298.

Project 120—Exploded View of a Faucet Stem Assembly

Industry has made use of pictorial drawings which show the various parts of an object arranged in relative positions and sequence for assembly of the parts. Presentations of this type are known as "exploded views." In Fig. 301 is shown an exploded view of a pencil sharpener.

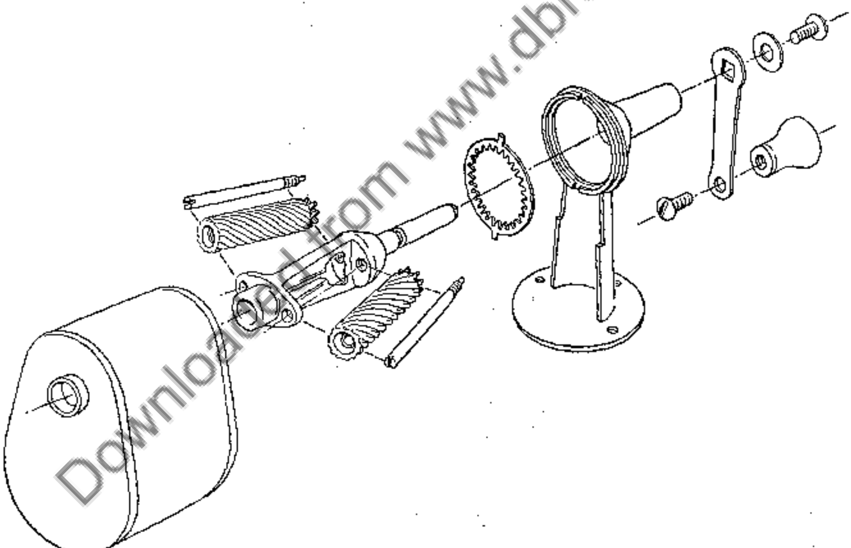


Fig. 301.—Exploded View of Pencil Sharpener.

As the drawing requirement for Project 120, make an exploded view of the stem assembly of the faucet for which detail drawings were prepared in Project 100. All parts of the faucet, except the body and the handle, are to be included in this exploded view.

Project 121—Exploded View of a Connecting-Rod

As the drawing requirement for Project 121, make an exploded view of a connecting-rod. Include all the parts that are necessary to make one complete connecting-rod.

Project 122—Perspective Drawings

Perspective has been adequately defined in dictionaries as "the art of presenting objects on a plane surface as they appear to the eye." The perspective drawings that have been seen by anyone who may read this are countless in number. Principles of perspective may be recognized in practically all paintings, newspaper and magazine illustrations, scenic cartoons, and other drawings.

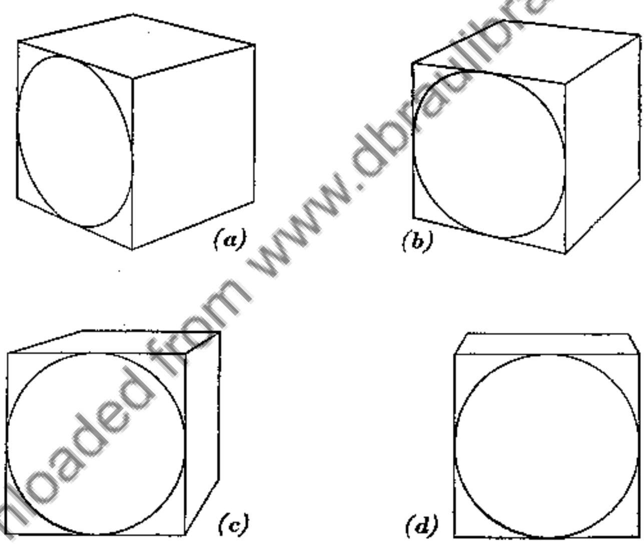


Fig. 302.—Angular Perspective and Parallel Perspective.

There are two types of perspective drawings: (1) *angular perspective*, or two-point perspective, as shown in Fig. 302 (*a*) and (*b*), in which the object is located so that none of its principal surfaces are parallel to the plane of the picture; (2) *parallel perspective*, or one-point perspective, as in (*c*) and (*d*), in which one of the principal faces of the object is parallel to the picture plane. In each case is shown a perspective drawing of a cube with a circle inscribed on one of its faces.

HOW TO MAKE AN ANGULAR PERSPECTIVE DRAWING

It has been decided to make an angular perspective drawing of a cube, one side of which is 4 in., that is located 2 in. below and 1 ft in front of your eye. The procedure is illustrated in Fig. 303.

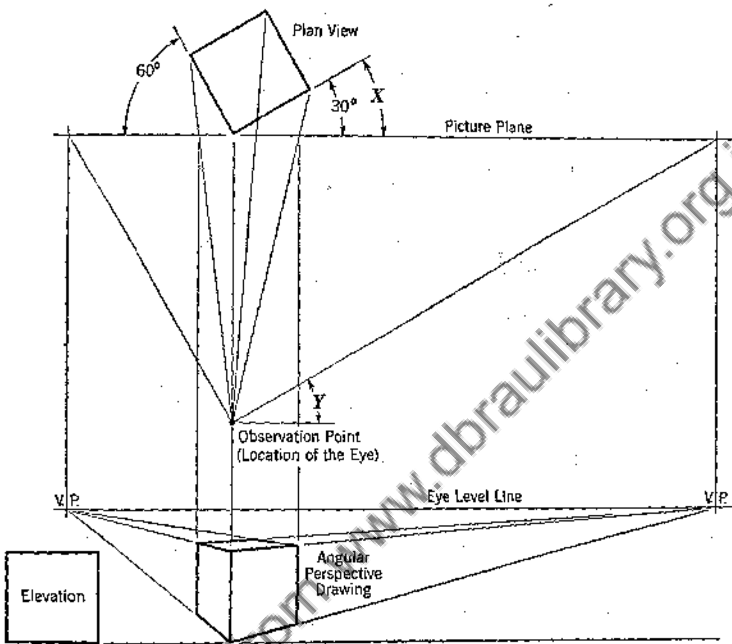


Fig. 303.—Layout for Angular Perspective.

A. Near the top of the sheet, make a plan view—to scale is desirable—of the locations of the object, the eye, and the picture plane. The picture plane, represented in Fig. 303 by the marked line, is an imaginary vertical plane passing through the nearest point or points of the object.

B. Near the bottom of the sheet, draw an elevation of the object on a base line which is parallel to the line that represents the picture plane. Locate the elevation near the edge of the paper.

C. In proper position with relation to the elevation of the object, draw another parallel line at the level of the eyes across the paper above or below the elevational view of the object, as the case may be. This line is known as "the eye level line."

D. From the observation point draw sight rays to the corners or principal points on the object.

E. Determine the location of the vanishing points by drawing lines parallel to the principal faces of the object from the observation point to the picture plane. Thus, *angle Y equals angle X*. Drop a perpendicular from each point of intersection with the picture plane to the eye level line, locating the vanishing points on the eye level line.

F. Locate the nearest edge of the object by projecting down from the plan view and across from the elevation view.

Now, with the vanishing points and the nearest edge located, work out the completion of the drawing by applying the following principles of perspective.

All parallel lines receding to the right or the left of the object appear to converge and meet at the vanishing point to the corresponding side of the object.

Each point in the perspective drawing is directly beneath the intersection of its sight ray with the picture plane.

When the points at the ends of a straight line are located, the position of the line is definitely located.

ANGULAR PERSPECTIVE AND ISOMETRIC DRAWING

While a perspective drawing is ideal in presenting an object to an untrained individual, since the drawing presents the object as it appears to the eye, such a drawing is not of much use when one wants to scale distances from the drawing. The effect of the perspective is achieved by the foreshortening and converging of lines; because of this foreshortening and convergency, it is not possible to scale distances from a perspective drawing. An isometric drawing—another form of pictorial representation—appears somewhat distorted, presenting the object as if it were raised in the rear and tilted forward. However, this type has the advantage of permitting the scaling of most distances directly from the drawing. Let us consider the angular perspective drawing and the isometric drawing of a cube which are shown in Fig. 304. A comparison of the drawings is as follows:

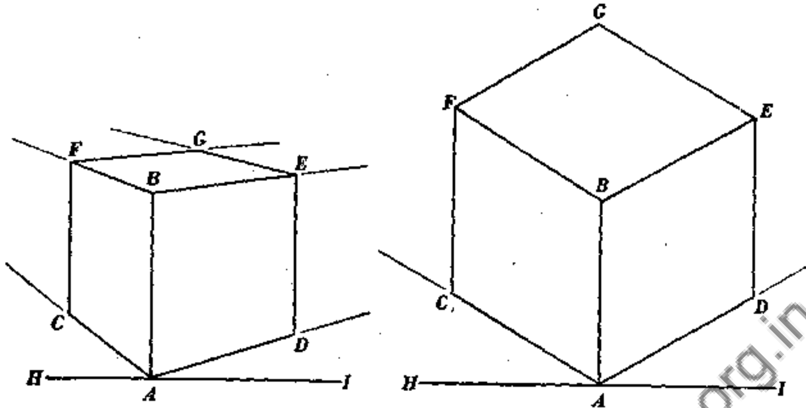


Fig. 304. Comparison of Perspective and Isometric Drawings.

PERSPECTIVE DRAWING

1. A simple examination of lines *AD* and *BE*, which are parallel on the object, will show that they are converging on the drawing.

2. Although lines *AD*, *BE*, *AB*, and *ED* represent equal edges of the cube, no two of these lines are of the same length on the perspective drawing. The same is true of lines *AC*, *AB*, *CF*, and *BF*.

3. Lines *AB*, *AD*, *AC*, *AE*, *AF*, *ED*, *AG*, *EF*, and *FG* are all equal, and each of them is parallel to at least one other on the object; but in the drawing no two of them are equal and, with the exception of the vertical lines, they are not parallel one to the other.

4. The angles *DAI* and *CAH* are not fixed angles but depend on the relative positions of the object and the eye. The sizes of these angles will probably vary with each perspective drawing that is made.

ISOMETRIC DRAWING

1. All lines which were parallel on the object are parallel on the drawing, as lines *AC*, *BF*, and *EG*.

2. All sides of the cube are of equal length in the drawing, as lines *AB*, *AC*, *AD*, *BE*, *CF*, *DE*, *EG*, and *FG*.

3. The angles *DAI* and *CAH* are fixed angles. In all cases, they are angles of 30 degrees.

PARALLEL PERSPECTIVE DRAWING

Parallel perspective is nothing more than a special case of angular perspective in which one of the principal faces is parallel to the plane of the picture (picture plane). An example of parallel perspective is shown in Fig. 305. This type is especially adapted to objects having circles or other curved lines in a vertical plane, for these curves when represented on a face parallel to the picture plane will then be shown in their true shapes. The procedure in parallel perspective is illustrated in Fig. 306.

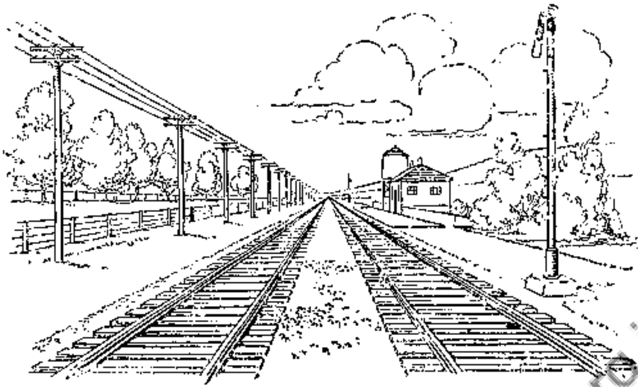


Fig. 305.—Vanishing Point in Parallel Perspective.

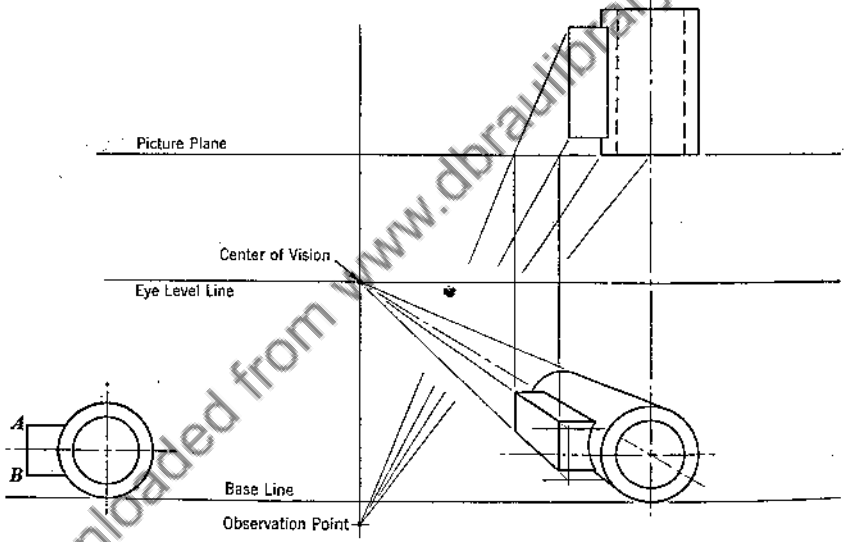


Fig. 306.—Layout for Parallel Perspective.

Steps A, B, C and D are the same as those for making an angular perspective drawing.

E. Determine the location of the center of vision by intersecting the eye level line with a perpendicular drawn from the observation point.

F. Project to the base line from the plan view and across from the elevation view, drawing the face that is located on the picture plane to true shape and size (use scale if necessary).

G. Using the principles of perspective employed in angular perspective drawing and stated after Step F in the procedure for making an angular perspective drawing, complete the drawing.

The position of a line (such as line *AB* in Fig. 306), which is located back of the picture plane in the plan layout, is determined in

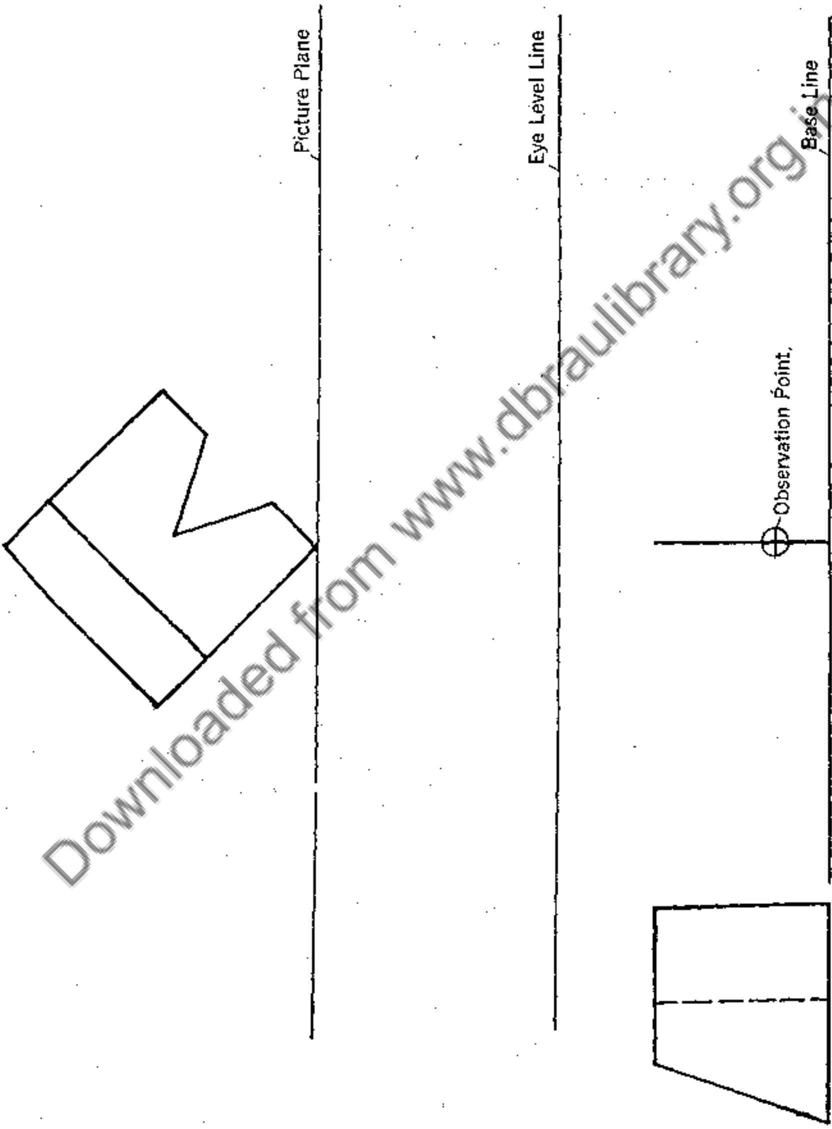


FIG. 307.—Angular Perspective for Project 122.

the finished drawing by first determining the position and size of the line as if it were located on the picture plane in the plan layout.

DRAWING REQUIREMENT FOR PROJECT 122

Make a complete mechanical angular perspective drawing of the block in Fig. 307 on the nearest edge, which is already located. *Do not write on this sheet.* Make a pencil tracing and complete the drawing on the tracing.

QUESTIONS

Answer the following questions regarding the perspective drawing you made. Place the answers in numerical order in the lower right-hand corner of the tracing.

A. The observation point is (1) inches above and (2) inches in front of the nearest corner of the block.

B. The observation point must always be located in this position with respect to the object. (3) (Answer yes or no.)

C. In this case, the two front faces of the object make angles of (4) and (5) with the picture plane.

D. At what other angles might these principal faces intersect the picture plane? (6).

E. The line that all the sight rays intersect represents the (7).

F. The point where the sight rays intersect represents the (8) point.

Project 123—Perspective Drawing of Holding Block

Make an angular perspective drawing of the holding block shown in Fig. 297.

Project 124—Perspective Drawing of Cabin

Make either a mechanical angular or parallel perspective drawing of the exterior of the cabin you drew in the earlier projects.

CHAPTER X

DEVELOPMENTS

Specific Aims:

To introduce developments to the pupil.

To teach the pupil to make developments.

A development is a flat pattern which, when cut, may be folded, bent, or rolled into shape to make the object of which it is the development. For example, each section of the fuselage of the airplane shown in Fig. 308 may be formed from a development.

(Courtesy of American Air Lines)

Fig. 308.

Project 125—Development of Business Envelope

In early school days sheets of paper were cut and folded to make paper boxes. A little later in life, sheets of newspaper were folded so that they would imitate a "military hat," the type of hat a youngster wears in uniform with a wooden sword. Many are the pupils who have been amused by the smooth sailing of folded paper airplanes. All of these ventures made use of developments.

In the development of the box shown in Fig. 309, tabs have been added to the sides of the box. Each tab is to be pasted to the

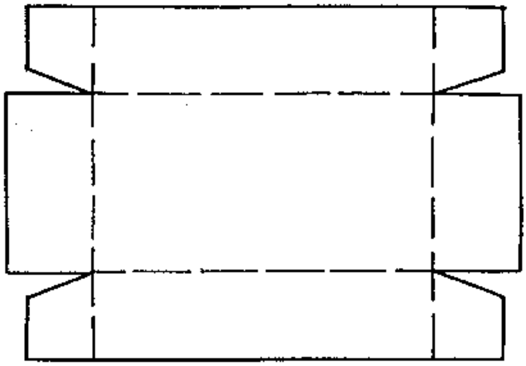


Fig. 309.—Development of a Rectangular Box.

adjacent side of the box to keep the box in shape. The development is to be cut on the solid line and folded on the dashed lines.

The development of the triangular-shaped box shown in Fig. 310 makes use of another means of fastening the tabs.

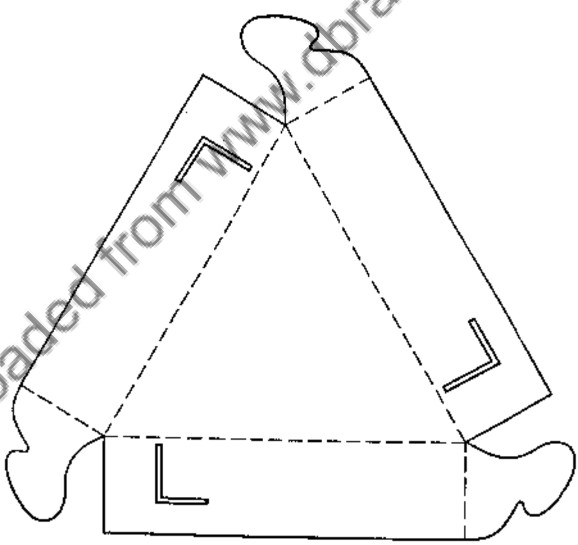


Fig. 310.—Development of a Triangular Box.

Envelopes are cut from developments that are designed in the same manner as the box developments shown in Figs. 309 and 310. Bring an envelope from home and draw the development for the envelope. After the development has been checked by the teacher, cut it out and fold it to make the envelope.

Project 126—Development of Worm Box

Make a development for all surfaces of the worm box shown in Fig. 311. The hinges may be omitted from the development.

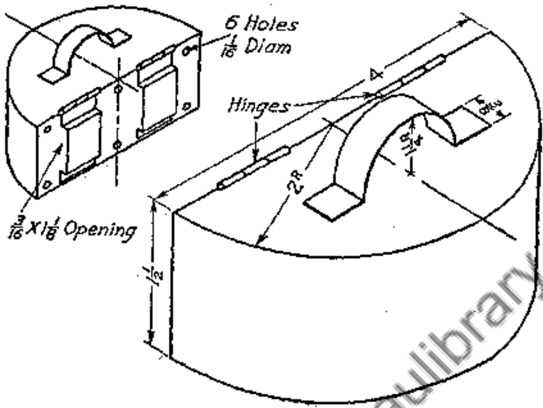


Fig. 311.—Worm Box.

Project 127—Cookie Cutter

Design a star-shaped cookie cutter.
Make a development of the cookie cutter.

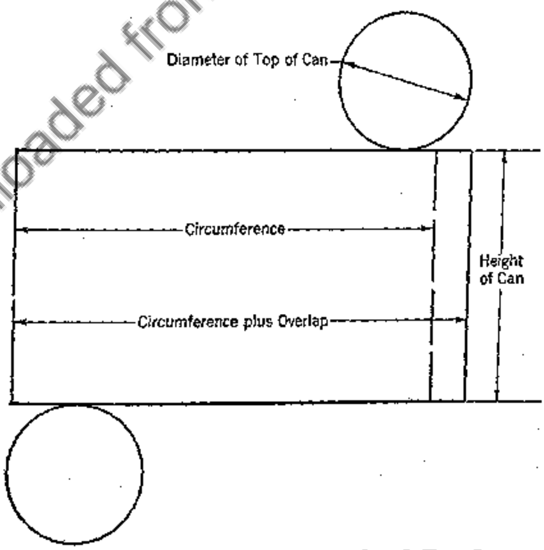


Fig. 312.—Development of Cylindrical Tin Can.

Project 128—Development of Gutter and Drain Pipe

It has been stated that a development is a flat pattern which, when cut, could be folded, bent, or *rolled* into shape to make the object. When rectangular-shaped sheets of paper are rolled, they clearly demonstrate that the development of a cylinder is a rectangle. The development of an ordinary tin can that could be used for the commercial packing of vegetables is shown in Fig. 312.

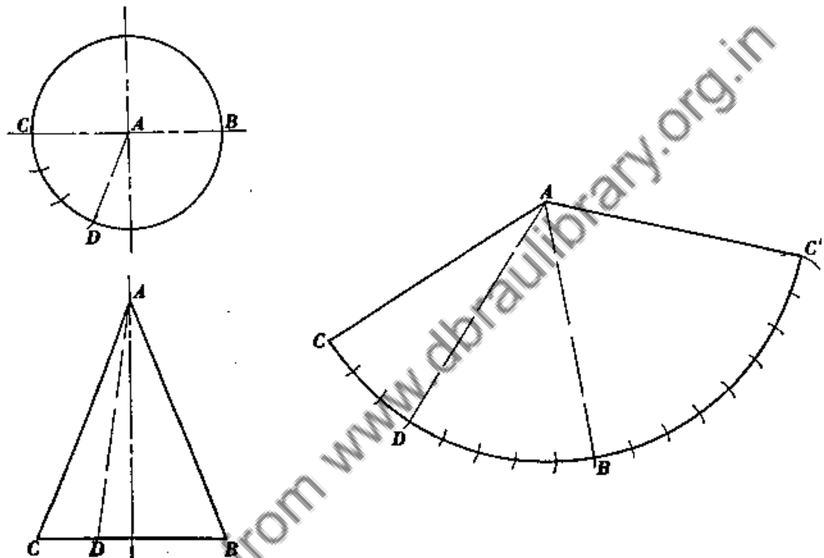


Fig. 313.—Development of Cone.

In Fig. 313 is shown the development of a right cone. The length of the curved line CC' is equal to the circumference of the base. The length of the line AB or AC or any other straight line from point A to line BC is equal to the length of the side of the cone. The lines on the side of the cone are shown only in true size at positions AB and AC in the elevation view.

In Fig. 314 is shown the development of a truncated cone. The true lengths of the lines 5–5′ and 7–7′ are found in the elevation view by projecting their indicated lengths to the line 1–1′ or line 9–9′ at the side of the cone.

As a drawing requirement for Project 128, draw developments that may be used when cutting sheet metal for the portions of the rain gutter and drain pipe shown pictorially in Fig. 315.

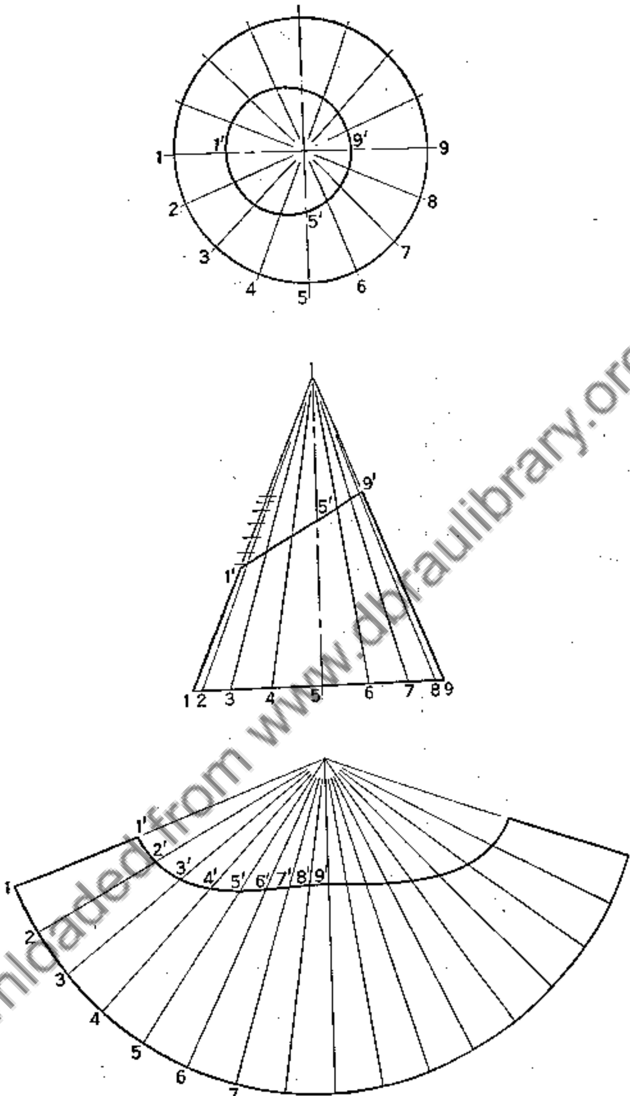


Fig. 314.—Development of Truncated Cone.

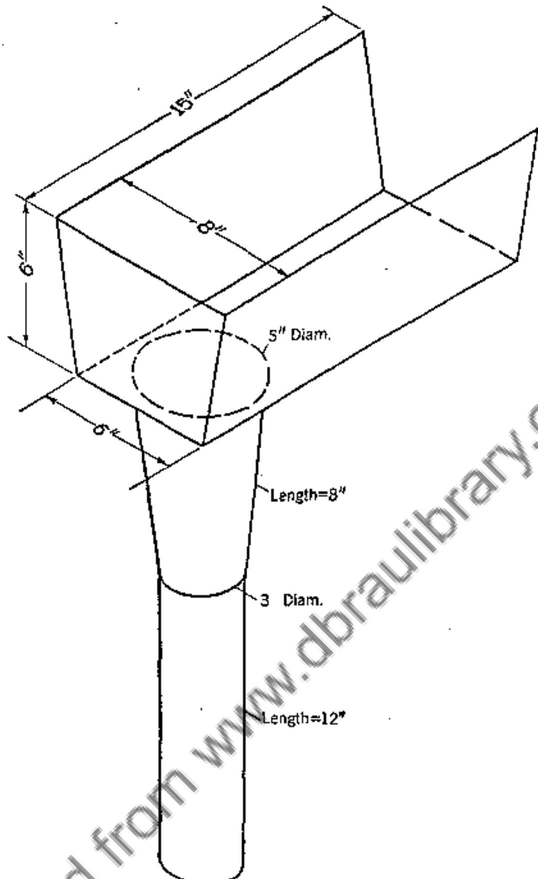


Fig. 315.—Rain Gutter and Drain Pipe for Project 128.

Project 129—Development of Funnel

Draw the development of the funnel described in Fig. 316.

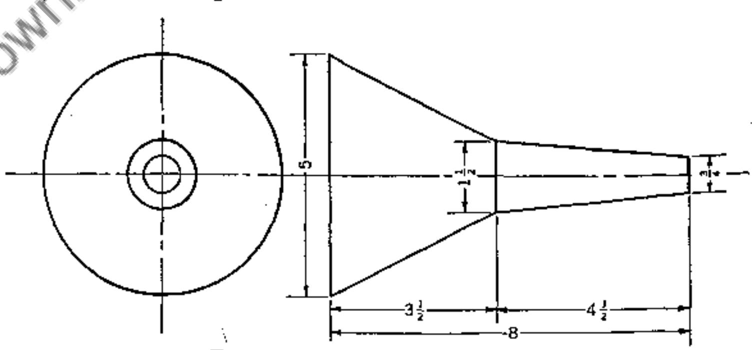


Fig. 316.—Funnel for Project 129.

Project 130—Development of Sugar Scoop

Draw the development of the sugar scoop described in Fig. 317.

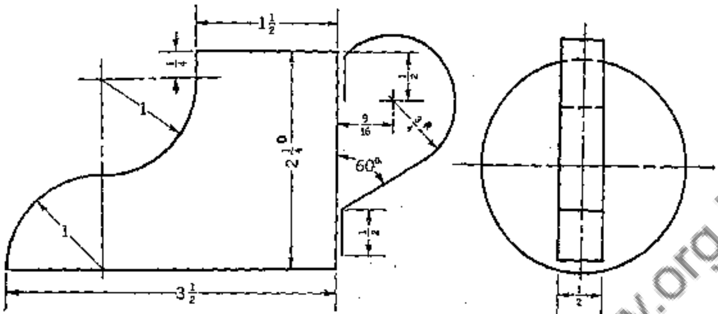


Fig. 317.—Sugar Scoop for Project 130.

WORKSHEET NO. 25

A. List the names of the geometrical solids the surface developments of which are shown in Figs. 318, 319, 320, and 321.

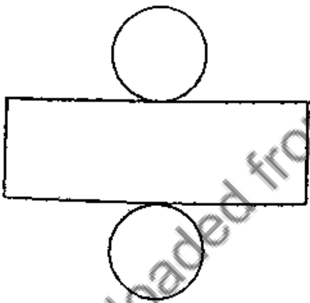


Fig. 318.

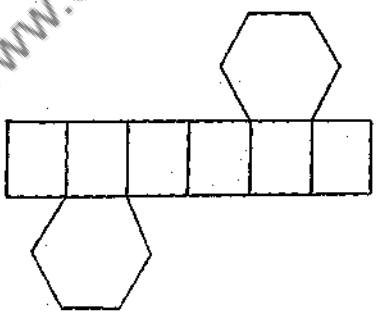


Fig. 319.

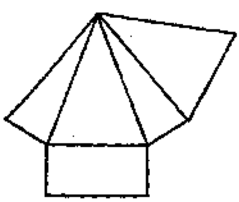


Fig. 320.

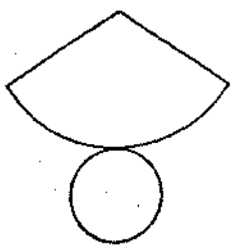


Fig. 321.

B. Draw the developments of the objects described by the orthographic views shown in Figs. 322 and 323.

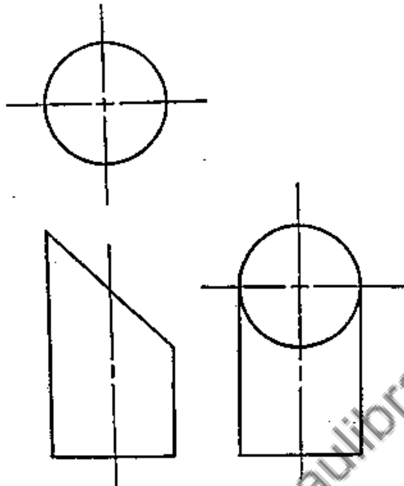


Fig. 322.

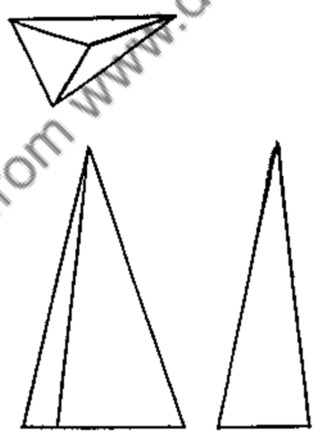


Fig. 323.

Project 131—Development of a Paper Pail

Grocery stores have used paper pails for the customer to carry oysters from the stores to the homes. These pails would not permit the liquid, which came as part of the purchase, to leak out.

These paper pails are made from flat pieces of cardboard, cut in such a way that all open edges are level with the top of the pail.

In Fig. 324 is shown an isometric drawing of such a pail. Draw the development. The pail drawn has no flaps to fold over the top. Attach four flaps to your development so that they will fold over the top of the pail. Provide some means of fastening for the two topmost flaps.

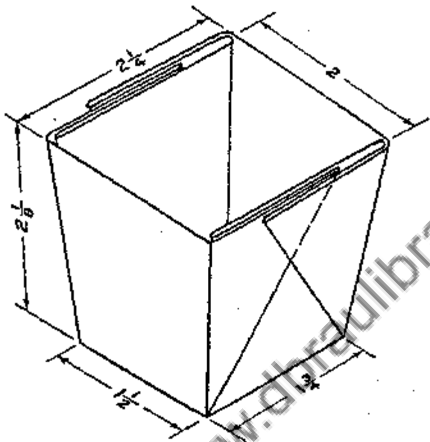


Fig. 324.—Paper Pail.

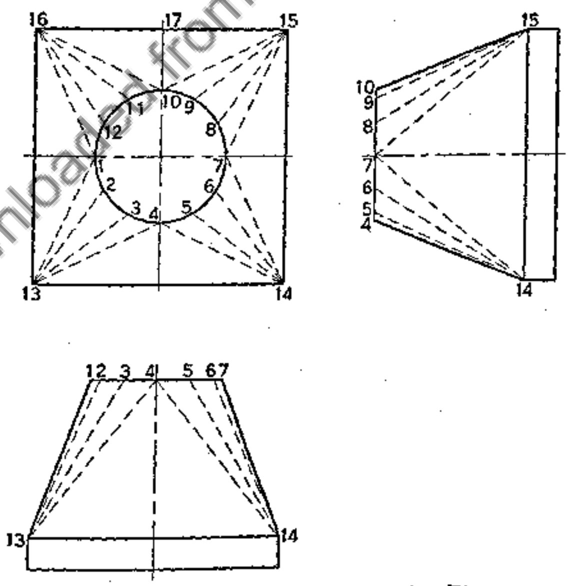


Fig. 325.—Related Views of Transition Piece.

Project 132—Development of a Ventilator

Often it is necessary to make developments of objects which are so shaped that none of the methods treated thus far can be used successfully. If such is the case, one can use the method of development by triangulation. This method consists of finding the true lengths of the sides of many triangles which, when placed together, will make the development. Where curvature changes rapidly, it is advisable to use narrow triangles. Why?

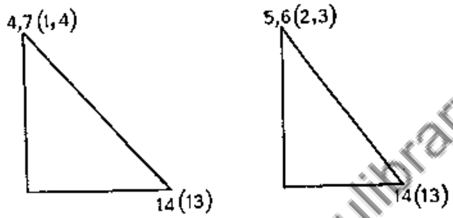


Fig. 326.—True Lengths of Lines on Transition Piece.

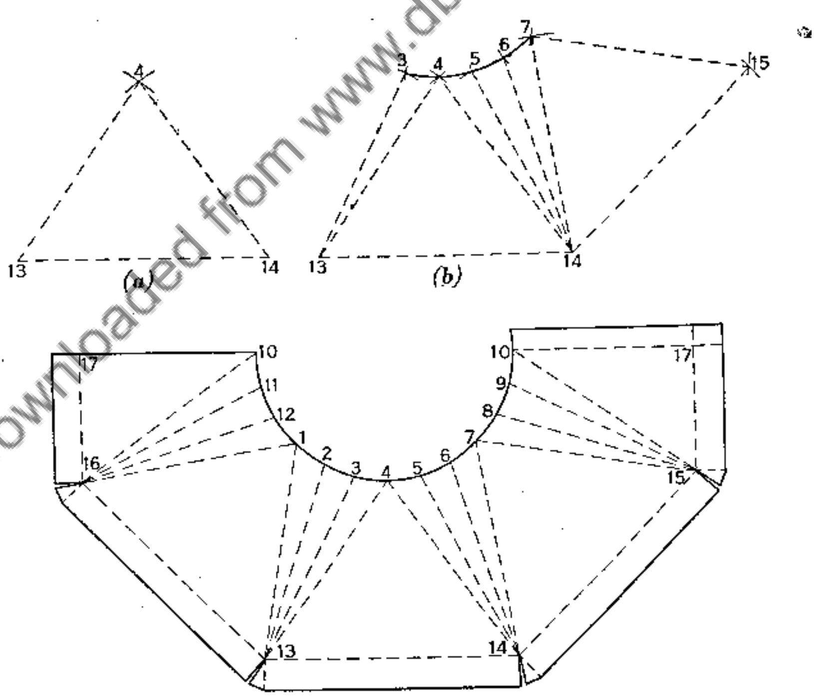


Fig. 327.—Stages in Development of Transition Piece.

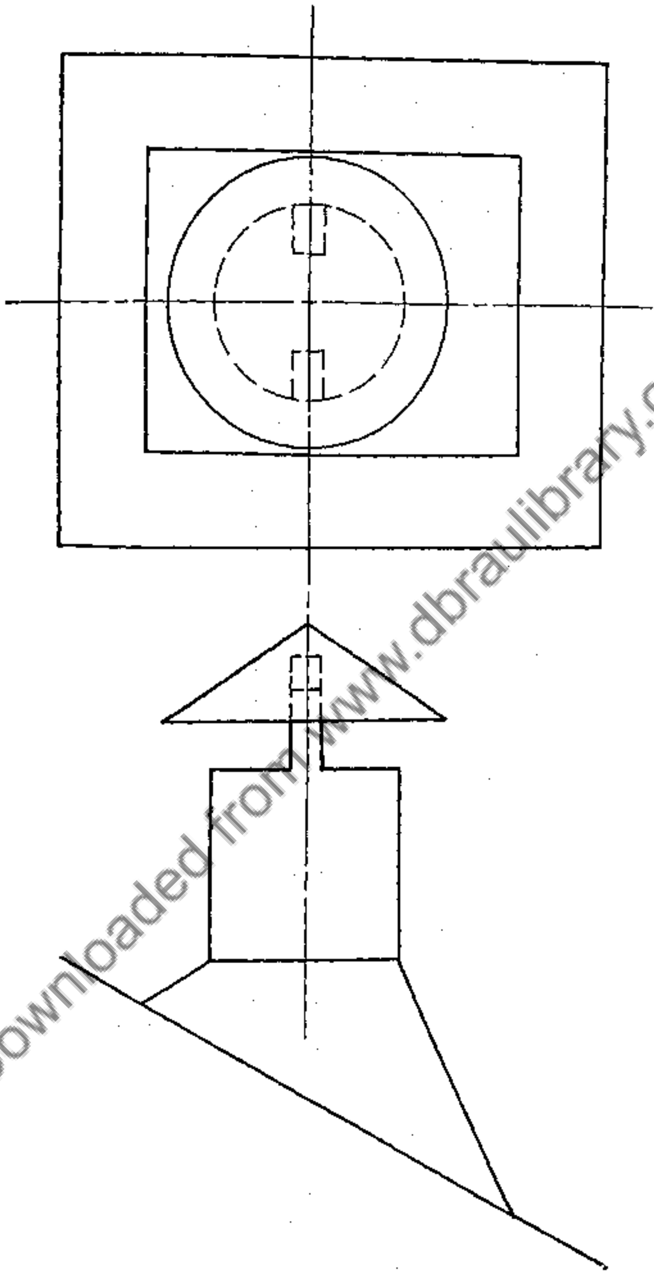


Fig. 328.—Ventilator for Project 132.

Three related views of a transition piece are shown in Fig. 325. This piece has been designed to make the change from an opening 8 in. square to a round opening with a diameter of 4 in. The dashed lines in the views are the construction lines that are necessary for the drawing of the development.

The true length of a line is determined by using the horizontal and vertical projections of the line as the sides of a right triangle and then measuring the hypotenuse (which is equal to the true length), as shown in Fig. 326.

Progressive stages in the drawing of the development are shown in Fig. 327.

As a drawing requirement for Project 132, make the necessary developments for cutting from sheet metal the ventilator shown in Fig. 328.

CHAPTER XI

GEOMETRY IN MECHANICAL DRAWING

Specific Aims:

To provide a means of testing the pupil's knowledge of those parts of Geometry used in Mechanical Drawing.

To present needed geometrical information in a concise manner for pupil reference.

Project 133—Geometrical Inventory

It is desirable, though not absolutely necessary, that a pupil study Geometry before beginning a course in Mechanical Drawing. Much information regarding geometry is absorbed during the pursuit of earlier arithmetical courses.

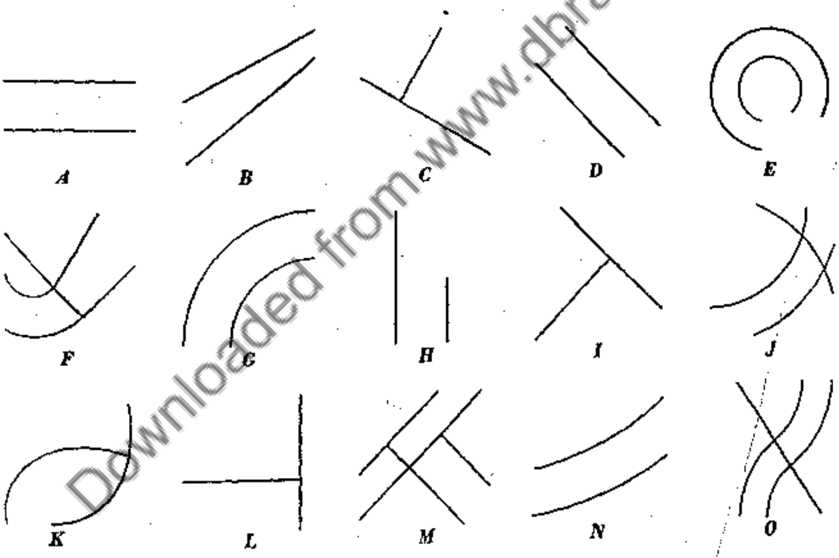


Fig. 329.

QUESTIONS

A. In Fig. 329 are shown several sets of lines. Each set is identifiable by the letter located beneath it. In answering the questions, make a list of the letters of the sets involved.

1. What sets contain parallel lines?
2. What sets contain perpendicular lines?
3. What sets contain a regular curve (an arc of a circle)?
4. What sets contain an irregular curve?
5. Which of the sets show concentric arcs?

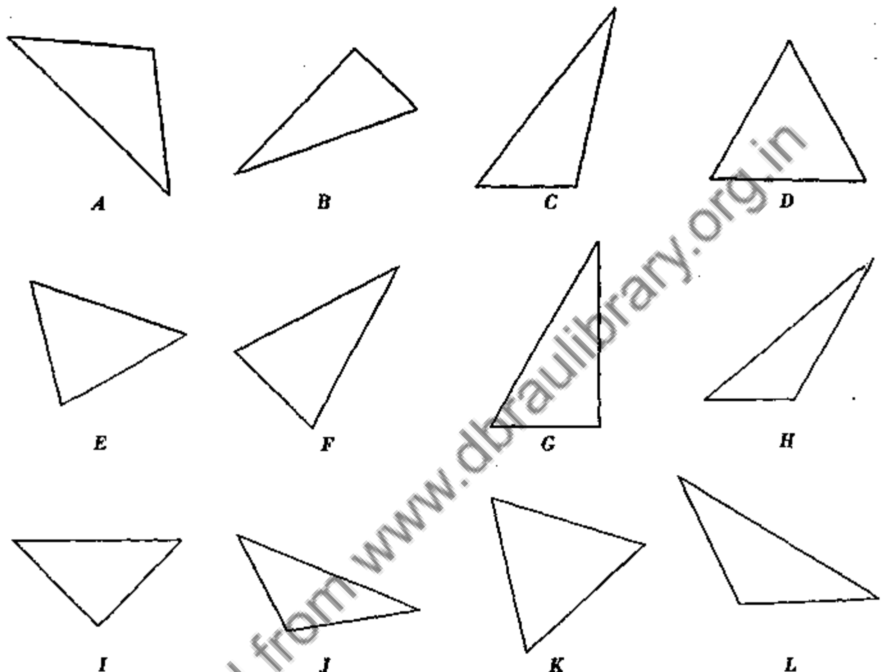


Fig. 330.

B. Of the triangles shown in Fig. 330, list those that have the following characteristics:

6. Which contain a right angle?
7. Which contain an obtuse angle?
8. Which contain three acute angles?
9. Which are isosceles?
10. Which are equilateral?
11. Which are right triangles?

C. Of the geometrical figures in Fig. 331, list those that may be described as follows:

12. Which are quadrilaterals?
13. Which are hexagons?
14. Which are pentagons?
15. Which are regular figures (all sides equal)?

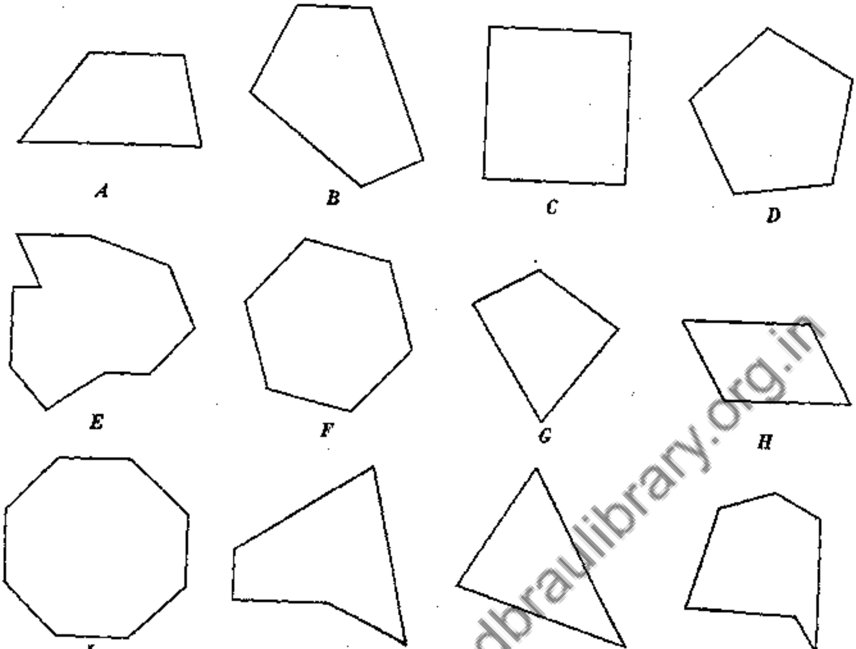


Fig. 331.

D. In Fig. 332 are shown a square and a rhombus, each side of which is equal to 1 in. Answer the following questions and explain your answers.

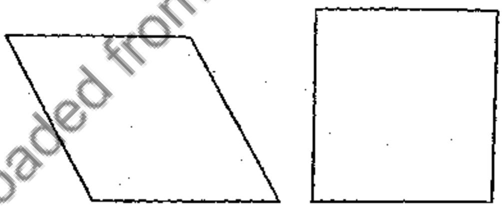


Fig. 332.

16. Which has the larger area?
17. Which has the greater perimeter?

E. In Fig. 333 are shown a parallelogram and a trapezoid. The altitudes are equal, and the larger sides of the parallelogram are equal to the lower base of the trapezoid.

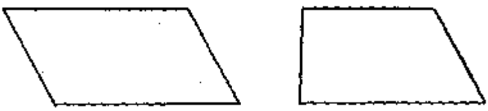


Fig. 333.

18. Which has the larger area? Why?
19. How many sets of parallel lines are contained in the two figures?

F. In Fig. 334 are shown a regular hexagon and a regular pentagon inscribed in circles of equal diameter.

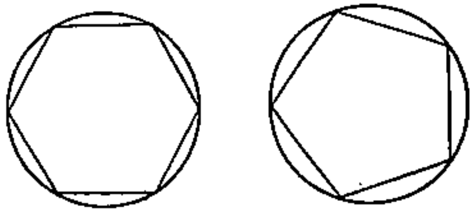


Fig. 334.

20. Which figure has the larger area? Why?
21. Which has the larger perimeter? On what facts did you base your decision?

G. Given a circle whose diameter is 1 in. and an ellipse whose major axis is equal to 1 in. Which has the larger area? Explain your answer.

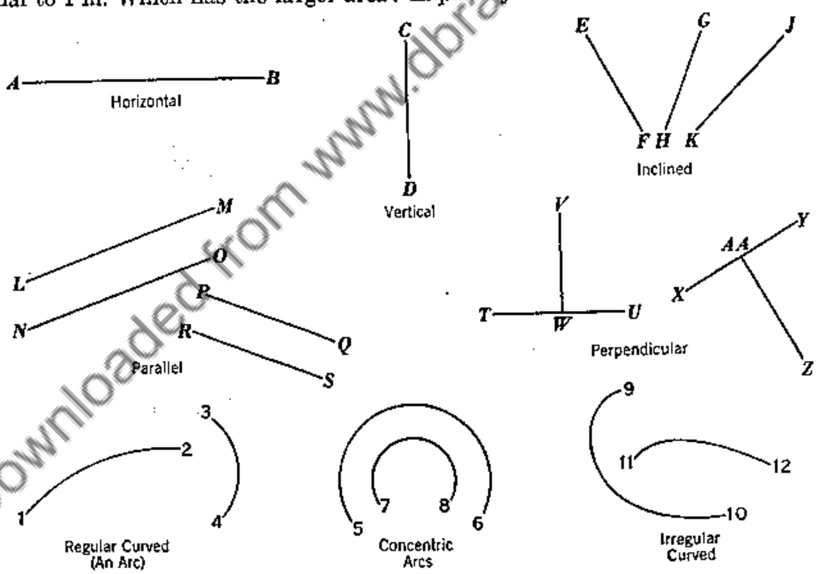


Fig. 335.—Types of Lines.

Project 134—Geometrical Relations and Figures

The following information should serve to acquaint or reacquaint the pupil with the more common geometric figures and some of their characteristics.

Several types of lines are shown in Fig. 335.

As indicated in Fig. 336, angles are of three general classes, namely, acute angles, obtuse angles, and right angles.

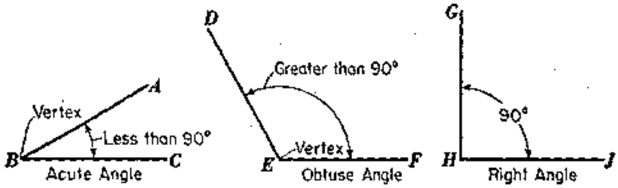


Fig. 336.—Types of Angles.

TRIANGLES

A triangle is a three-sided figure. Various types of triangles are pictured in Fig. 337.

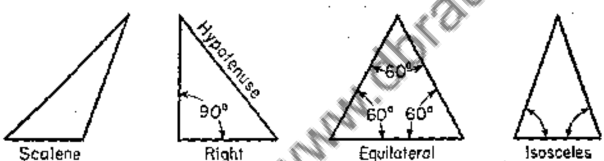


Fig. 337.—Types of Triangles.

The area of a triangle is equal to one-half of its base multiplied by its altitude. Area of a triangle $= \frac{1}{2}bh$.

In each of the triangles shown in Fig. 338, the base b is the line AB; and the altitudes have been marked by the letter h.

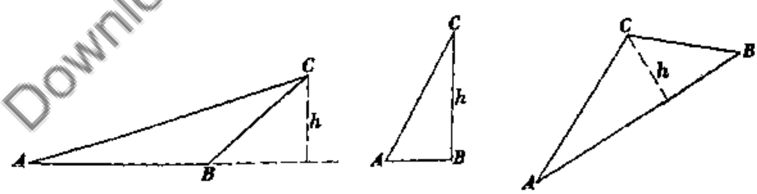
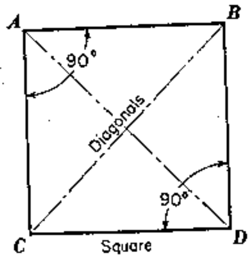


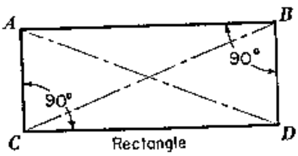
Fig. 338.—Base and Altitude of Triangle.

QUADRILATERALS

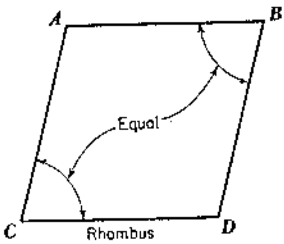
A quadrilateral is a four-sided figure. Various types of quadrilaterals are shown in Fig. 339.



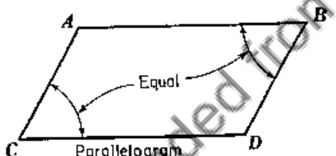
Square: Area equals base times altitude.
The four sides are equal.
The four angles are equal.
All the angles are right angles.



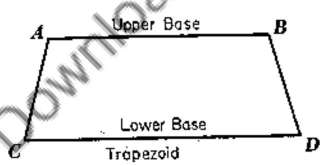
Rectangle: Area equals base times altitude.
Opposite sides are equal
All angles are right angles.



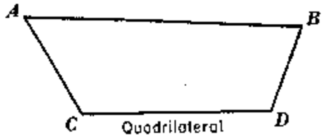
Rhombus: Area equals base times altitude.
The four sides are equal.
Opposite angles are equal.
No angles are right angles.



Parallelogram: Area equals base times altitude.
Opposite sides are equal.
Opposite angles are equal.
No angles are right angles.



Trapezoid: Area equals $\frac{1}{2}$ (base+top) times altitude.
Two sides are parallel.



Irregular quadrilaterals: Area equals ?

Fig. 339.—Types of Quadrilaterals.

POLYGONS

A polygon is a many-sided figure. Triangles and quadrilaterals are polygons. Some of the other more common polygons are known by special names, as follows:

5-sided—pentagon
6-sided—hexagon
8-sided—octagon
10-sided—decagon

Irregular and regular polygons are shown in Fig. 340.

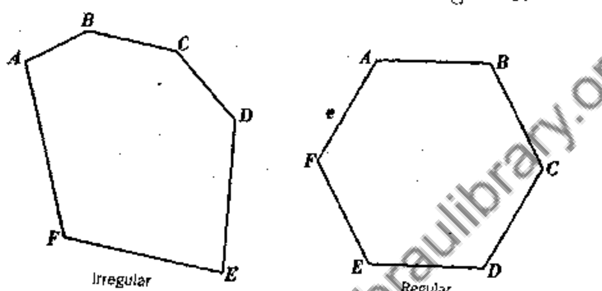


Fig. 340.—Irregular and Regular Polygons.

CIRCLES

Several circles and parts of circles are shown in Fig. 341.

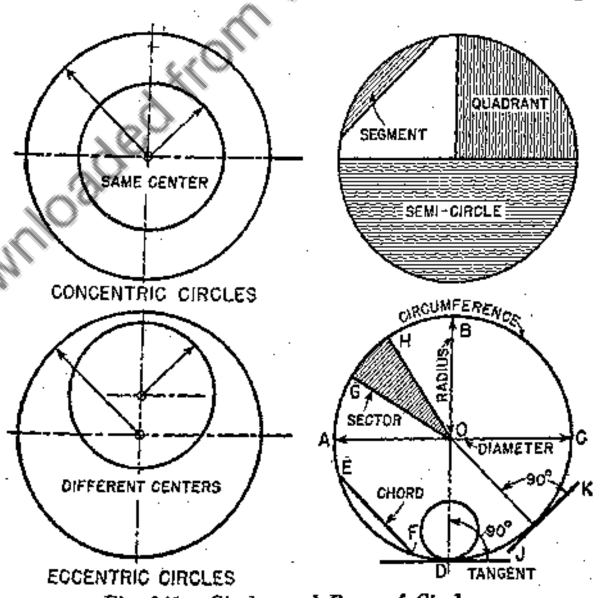


Fig. 341.—Circles and Parts of Circles.

Area equals π (3.1416) times the radius squared.

Circumference equals π times the diameter.

Diameter equals twice the radius.

A circle contains 360 degrees (360°).

ELLIPSES

An ellipse is shown in Fig. 342. Its important properties follow:

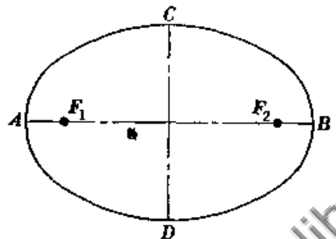


Fig. 342.—Ellipse.

Major axis equals AB.

Minor axis equals CD.

F_1 and F_2 are the foci (plural of focus).

The distance from point C (or D) to either F_1 or F_2 is equal to one-half of the length of the major axis.

$$\text{Area} = \pi\left(\frac{AB}{2}\right)\left(\frac{CD}{2}\right)$$

Project 135—Geometrical Constructions

A geometric construction is one that may be produced by using only a straight edge and a compass.

CONSTRUCTION NO. I—TO BISECT ANY LINE (DIVIDE IT INTO TWO EQUAL PARTS)

The procedure is illustrated in Fig. 343, where AB is the given line. The steps are as follows:

1. Set the compass at a radius which is obviously greater than one-half the length of the given line AB.
2. Using points A and B as centers, draw the arcs as shown in the illustration.

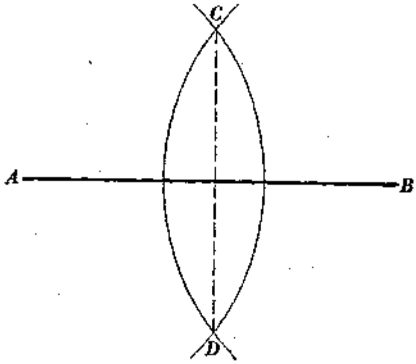


Fig. 343.—Bisecting a Line.

3. Through the intersections—points *C* and *D*—of the two arcs just drawn, draw the line *CD*. The line *CD* divides the line *AB* into two equal parts. (Incidentally, the line *CD* will also be perpendicular to the line *AB*.)

SUGGESTED CONSTRUCTION

1. Find the mid-points of lines equal in length to the two given below.
M————————————————————————N
R——————————S
2. Draw a perpendicular to one of these lines at either end.

CONSTRUCTION NO. II—TO BISECT ANY ANGLE

The procedure is shown in Fig. 344, where *ABC* is the given angle.

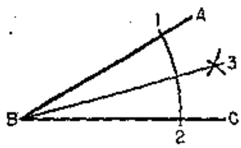


Fig. 344.—Bisecting an Angle.

1. Using the vertex *B* of the angle as a center, draw an arc that will intersect the sides of the angle, as at points 1 and 2.
2. With the points 1 and 2 as centers and a radius that can be somewhat less than the distance from 1 to *B*, draw two arcs that will intersect one another at some point, as 3.

3. Through points B and 3, draw line $B3$. This line divides the angle ABC in half.

SUGGESTED CONSTRUCTION

Bisect a 60° angle. Check your work by comparing the final angle with the smallest angle on your 30–60 triangle.

CONSTRUCTION NO. III—TO COPY AN ANGLE

This construction is shown in Fig. 345, where BAC is the given angle.

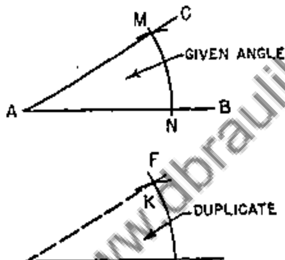


Fig. 345.—Duplicating an Angle.

1. With point A as a center, draw an arc that will intersect the sides of the angle to be copied. The points of intersection have been marked M and N.
2. Using as a center a point D on the line DG, on which the angle is to be copied, draw an arc of the same radius as arc MN. This arc will intersect line DG at some point, as E.
3. Set the compass at a radius equal to the distance from M to N. With this radius and point E as a center, draw the small intersecting arc which determines the location of point K.
4. Draw the straight line DK. Angle GDK is equal to angle ABC.

SUGGESTED CONSTRUCTION

Copy any two of the five angles of the polygon given in Fig. 346.

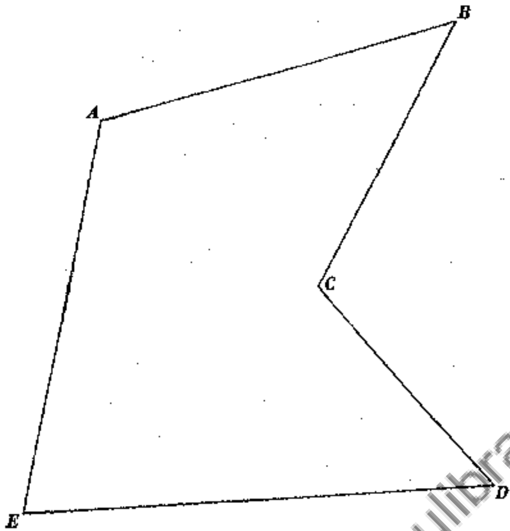


Fig. 346.

CONSTRUCTION NO. IV—TO DIVIDE A LINE INTO A NUMBER OF EQUAL PARTS

The construction in this case is shown in Fig. 347, where it is required to divide line AB into seven equal parts.

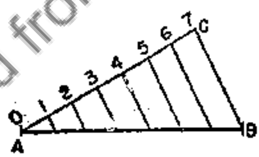


Fig. 347.—Dividing Line into Equal Parts.

1. At any acute angle to line AB, draw line AC.
2. Using the compass, lay off seven lines of equal length along line AC from point A.
3. Connect point B with point 7.
4. Draw lines parallel to line $B7$ through points 1, 2, 3, 4, 5, and 6 to intersect the given line AB. The intersections of these parallel lines with line AB divide the given line into seven equal parts.

QUESTIONS

1. Point 7 in Fig. 347 is nearly above point *B*. Why do you think it is advisable to have it in that region?
2. How may Construction III be used in the construction shown in Fig. 347?
3. Why is this construction not applicable to a curved line?
4. Divide a line equal in length to line *MN* following Construction I into nine equal parts.

CONSTRUCTION NO. V—TO DIVIDE AN ARC INTO EQUAL PARTS

The procedure is illustrated in Fig. 348, where it is desired to divide arc *CD* into three equal parts.

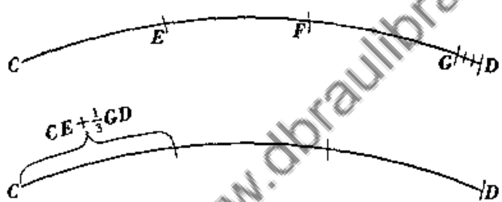


Fig. 348.—Dividing Arc into Equal Parts.

1. Lay off arc *CE*, your estimate of one-third of the length of arc *CD*.
2. Measure along arc *CD* three lines each of which is equal in length to arc *CE*. In this way you may determine how much of an error you made in your estimating. In this case, the error is $\frac{1}{3}$ *GD*.
3. Correct your original estimate by this error.
4. Lay off three of the corrected estimates. The arc should then be accurately divided into three equal parts.

QUESTIONS

1. What might happen to necessitate a corrected estimate of $CE - \frac{1}{3}\ GD$?
2. On some occasions it is necessary to correct the estimate two or more times. Why?

SUGGESTED CONSTRUCTION

Divide a circle into five equal parts.

CONSTRUCTION NO. VI—TO DETERMINE THE LENGTH OF AN ARC

This construction is shown in Fig. 349, where it is required to determine the length of the arc EF on line EK.

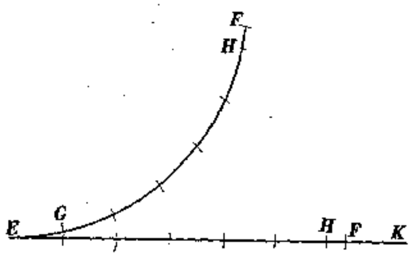


Fig. 349.—Determining Length of an Arc.

1. Using a small arc, as arc EG, determine by actual trial the number of times it can be laid off on arc EF (six in this case). Make note of the remaining portion HF.
2. On line EK measure six lengths equal to the distance from E to G. In addition lay off the distance from H to F.
3. The length of the arc may be determined by measuring the distance from E to F on line EK. When this method is carefully carried out, the determined length very closely approximates the true length of the arc.

QUESTIONS

1. Is it necessary that line EK be a horizontal line?
2. Is it necessary that the line EK start at the end of the arc to be measured? If not, where might the line be placed?
3. Would the determined length be more or less accurate if a longer arc were used than the length EG that was used? Explain the reason for your answer.

SUGGESTED CONSTRUCTION

Draw a circle the radius of which is 2 in. Draw a central angle of 60°. Determine the length, in inches, of the arc that this angle intercepts on the circumference of the circle.

Check this length with the true length of the arc, which you can find mathematically from the fact that the length of this arc equals $\frac{1}{6}$ (3.1416) (4).

CONSTRUCTION NO. VII—TO CONSTRUCT A TRIANGLE WITH THREE SIDES GIVEN

The three sides are the lines *a*, *b*, and *c* in Fig. 350, and the required triangle is constructed as follows:

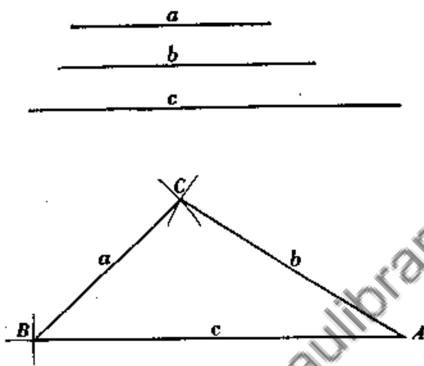


Fig. 350.—Constructing Triangle with Three Sides Given.

1. Lay out one of the sides, as side *c*.
2. From *A* and *B*, the ends of side *c*, swing arcs equal in length to sides *b* and *a*, respectively; and mark point *C* where the arcs intersect.
3. To form the triangle, connect points *A* and *C* and also connect *B* and *C*.

Note: The letters used in marking the sides and vertexes of the triangles in Fig. 350 are those in common usage for marking triangles.

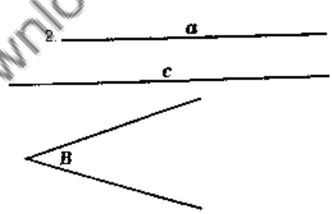


Fig. 351.

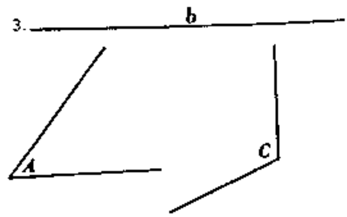


Fig. 352.

SUGGESTED CONSTRUCTION

1. Construct a triangle with three sides equal, respectively, to $1\frac{3}{4}$, $2\frac{1}{2}$ and $2\frac{3}{4}$ in.
2. Construct a triangle with sides *a* and *c* and angle *B* shown in Fig. 351.
3. Construct a triangle with side *b* and angles *A* and *C* shown in Fig. 352.

CONSTRUCTION NO. VIII—TO TRANSFER A POLYGON BY TRIANGULATION

In this case, it is required to redraw the polygon *ABCDE*, Fig. 353. The procedure is as follows:

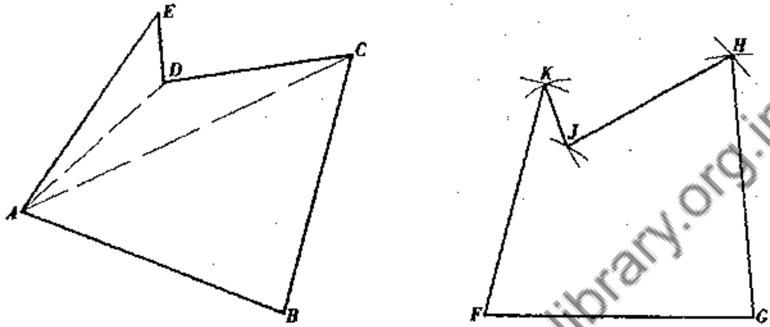


Fig. 353.—Transferring Polygon by Triangulation.

1. Divide the polygon *ABCDE* into triangles, as triangles *ABC*, *ACD*, and *ADE*.
2. Draw line *FG* equal to side *AB*, and determine the position of point *H* by the method of constructing a triangle with three sides given, *i.e.*, lines *AB*, *BC*, and *AC*.
3. Determine the position of point *J* from points *F* and *H* by the same method.
4. Determine the position of point *K* from points *F* and *J* by the same method.
5. Connect points *G* and *H*, *H* and *J*, *J* and *K*, and *K* and *F*, forming polygon *FGHJK*, which has the same size and the same shape as polygon *ABCDE*.

SUGGESTED CONSTRUCTION

Construct a polygon *ABCDE* from the following given information:

Lengths of Sides		Sizes of Angles	
AB	3 in.	*B*	90°
BC	2 in.	*C*	60°
CD	2 in.	*D*	30°
DE	$\frac{3}{4}$ in.		

CONSTRUCTION NO. IX—TO CONSTRUCT A REGULAR HEXAGON

The procedure in this case is shown in Fig. 354.

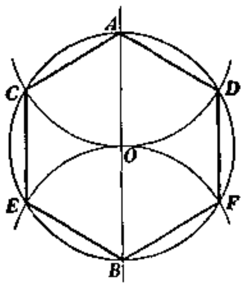


Fig. 354.—Constructing Regular Hexagon.

1. Draw a circle the diameter of which is equal to the distance *AB* across corners of the hexagon.
2. With a radius equal to the radius *OA* of the circle and the points *A* and *B* as centers, draw arcs that will intersect the circumference of the circle at points *C*, *D*, *E*, and *F*.
3. Connect points *A*, *C*, *E*, *B*, *F*, *D*, and *A* to form the regular hexagon.

QUESTIONS

1. How many times the length of a side of the hexagon is the distance across corners?
2. What is the relation (comparative size) of the circumference of a circle to the perimeter of a regular hexagon inscribed in that circle?

CONSTRUCTION NO. X—TO CONSTRUCT A REGULAR HEXAGON ON A GIVEN SIDE

The construction is shown in Fig. 355, where line *AB* is the given side of a regular hexagon.

1. On the side *AB*, construct the equilateral triangle *AOB*. Point *O* will be the center of a circle through the desired points of the regular hexagon.

2. With O as a center and a radius equal to AB, draw a circle. This circle will pass not only through points A and B but also through the other points of the regular hexagon.
3. From point B mark on the circle consecutive lengths of arc equal to the length of arc AB, as BC, CD, DE, EF, and FA. The end of the last arc should coincide with the original position of point A.
4. Connect the points in alphabetical order to form the regular hexagon.

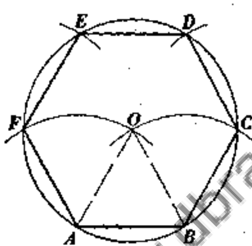


Fig. 355.—Constructing Regular Hexagon on Given Side.

QUESTIONS

1. If the sum of the angles in a triangle is equal to 180°, what is the size of angle AOB in Fig. 355?
2. What is the size of angle FAB?

CONSTRUCTION XI—TO CONSTRUCT A REGULAR OCTAGON

In Fig. 356 is shown the method of constructing a regular octagon, the distance across the flats of which is to be 2 inches.

1. Draw a square, each side of which is 2 in. in length.
2. Draw the diagonals of the square.
3. With a radius equal to one-half of the length of a diagonal and with points A, B, C, and D, respectively, as centers, swing arcs to intersect the sides of the square at points such as E, F, G, and H.
4. Connect these points to form the regular octagon.

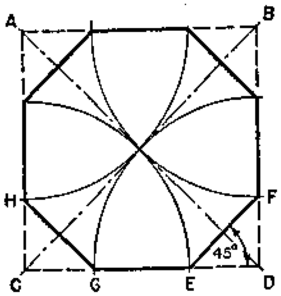


Fig. 356.—Constructing Regular Octagon.

QUESTIONS

1. What is the length of a side of this octagon?
2. Does the length of a side bear any simple relation to the distance across flats, as $\frac{1}{4}$, $\frac{1}{3}$, or $\frac{1}{2}$?
3. How would you construct a regular octagon, if you were given the distance across corners?

SUGGESTED CONSTRUCTION

Construct a regular octagon for each of the following conditions:

1. Distance across flats equals $1\frac{3}{4}$ in.
2. Distance across flats equals 3 in.
3. Distance across corners equals 3 in.
4. Length of a side equals 2.828 in.

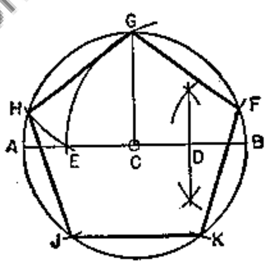


Fig. 357.—Constructing Regular Pentagon.

CONSTRUCTION NO. XII—TO CONSTRUCT A REGULAR PENTAGON

The construction in this case is illustrated in Fig. 357.

1. Draw a circle with the horizontal diameter AB and the vertical radius CG.
2. Bisect the radius CB. Call the mid-point D.

3. With the distance from D to G as a radius and point D as a center, draw arc GE to determine the position of point E on line AC.
4. With the distance from E to G as a radius and point G as a center, draw arc EH to determine the position of point H on the circumference of the circle. The arc GH is equal to one-fifth of the circumference.
5. With a radius equal to the distance from G to H, locate the successive points J, K, and F on the circumference of the circle.
6. Connect the points G, H, J, K, and F, to form the regular pentagon.

SUGGESTED CONSTRUCTION

1. Construct a regular pentagon within a circle whose diameter is 4 in.
2. Draw a five-pointed star within a circle, the diameter of which is to be 3 in.

CONSTRUCTION NO. XIII—TO CONSTRUCT A REGULAR POLYGON OF ANY NUMBER OF SIDES

The following method of construction is applicable to a regular polygon of any number of sides. The construction of a regular pentagon is shown in Fig. 358.

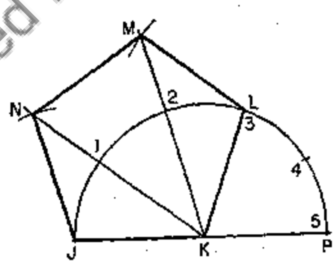


Fig. 358.—Constructing Regular Polygon.

1. Draw a semicircle, the radius of which is equal to the length of a side of the polygon.
2. Divide the semicircle into as many equal parts as the polygon has sides. (In this case it will be five.)

3. Draw radii through the dividing points and extend them beyond the semicircle.
4. The line *JK* is a side of the pentagon; also, the line *KL* is a side of the pentagon.
5. With point *J* as a center and a radius equal in length to a side of the polygon, swing an arc beyond the semicircle to intersect dividing line 1, thus finding the location of point *N*.
6. In a similar manner, with the newly found point as a center, establish the position of point *M*.
7. Connect points *J* and *K*, *K* and *L*, *L* and *M*, *M* and *N*, and *N* and *J*, to form the regular pentagon.

SUGGESTED CONSTRUCTIONS

1. Using a method like that just described for a pentagon, construct a regular polygon with seven sides.
2. Construct a regular nine-sided figure.

QUESTIONS

1. Could the method of Constructon XIII be used for the construction of a square?
2. Could it be used for an equilateral triangle?
3. If the construction in each of these cases is possible, is it advisable? Give your reason.

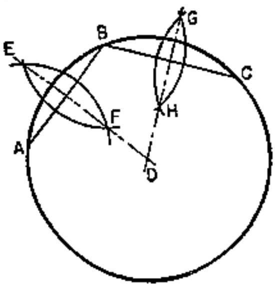


Fig. 359.—Drawing Arc Through Three Given Points.

CONSTRUCTION NO. XIV—TO DRAW A CIRCLE (OR ARC) THROUGH THREE GIVEN POINTS

In Fig. 359, the three given points are *A*, *B*, and *C*.

1. Connect the three points with the two lines *AB* and *BC*.

2. Construct perpendicular bisectors to the lines *AB* and *BC*, extending the bisectors to intersect at a point *D*.
3. Point *D* is the center of a circle which will pass through the three points. The radius of the circle is the distance from point *D* to any of the three given points. Draw the circle.

SUGGESTED CONSTRUCTION

1. Construct a triangle the sides of which are equal to 2 in., $2\frac{1}{2}$ in., and 3 in. Draw a circle that passes through the points of the triangle.
2. Draw a circle that passes through the points of an equilateral triangle, one side of which is 2 in.

CONSTRUCTION NO. XV—TO INSCRIBE A CIRCLE IN A TRIANGLE

This construction is illustrated in Fig. 360, where *ABC* is the given triangle.

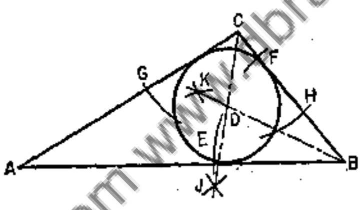


Fig. 360.—Inscribing Circle in Triangle.

1. Bisect two angles of the triangle, in this case, angles *ABC* and *ACB*.
2. These two bisectors will meet at the point *D*, which is the center of the circle to be inscribed. The radius of the circle is the shortest distance from point *D* to a side of the triangle.

QUESTIONS

1. Would the point *D* in Fig. 360 be located more accurately by constructing the bisectors of the three angles of the given triangle?
2. Would an inscribed circle be concentric with a circumscribed circle?

SUGGESTED CONSTRUCTION

1. Inscribe a circle in a triangle whose sides are 2 in., $2\frac{1}{2}$ in., and 3 in.
2. Inscribe a circle in an isosceles triangle whose sides are $2\frac{1}{2}$ in., $2\frac{1}{2}$ in., and 4 in.

CONSTRUCTION NO. XVI—TO DRAW A TANGENT TO A CIRCLE AT A GIVEN POINT

In Fig. 361 is illustrated the method of drawing a tangent to the given circle at the point *A*.

Fig. 361.—Drawing Tangent to Circle.

1. Draw a radial line from point *A* to point *O*, the center of the circle.
2. Construct the line *BC* perpendicular to line *AO* at point *A*. The line *BC* is tangent to the circle at point *A*.

SUGGESTED CONSTRUCTION

1. Draw a triangle, the sides of which are equal to 1 in., 2 in., and 3 in. Draw a circle that will pass through the three points of the triangle. Draw tangents to the circle at the three points of the triangle.
2. Extend the tangents until they intersect, thus forming another triangle. Is there any similarity between the two triangles?

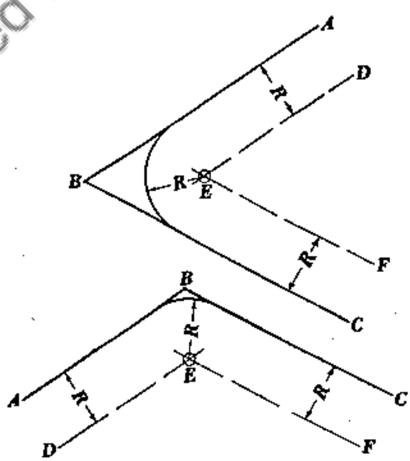


Fig. 362.—Rounding a Corner.

CONSTRUCTION NO. XVII—TO ROUND CORNERS

In Fig. 362 is shown the procedure for rounding a corner, where the lines *AB* and *BC* intersect at any angle and the radius of the arc is *R*.

1. Draw lines *DE* and *EF* parallel to lines *AB* and *BC* and at a distance *R* from the given lines.
2. The intersection of lines *DE* and *EF* is the center of a circle of which the arc connecting lines *AB* and *BC* is a part. The radius of the circle is equal to *R*.

In case the given lines intersect at right angles, the construction is as shown in Fig. 363.

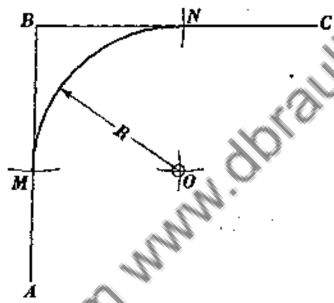


Fig. 363.—Rounding a Right-Angled Corner.

1. From the point *B*, swing an arc of radius *R* to intersect lines *AB* and *BC* at points *M* and *N*.
2. From points *M* and *N* swing arcs of radius *R*, which will intersect at point *O*. Point *O* is the center for drawing the arc *MN*.

CONSTRUCTION NO. XVIII—TO DRAW A COMPOUND CURVE

In Fig. 364 is illustrated the procedure for connecting lines *AB* and *CD* with a compound curve, the change in curvature occurring at point *E*.

1. Draw a straight line, as *FG*, which connects lines *AB* and *CD* and passes through point *E*.

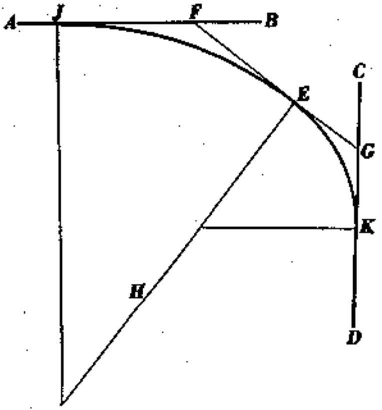


Fig. 364.—Drawing Compound Curve.

2. Draw line EH perpendicular to line FG at point E.
3. On line AB, lay off FJ equal in length to FE.
4. Draw a line, perpendicular to line AB, from point J to line EH. The intersection of this line with line EH is the center for drawing arc JE.
5. Draw arc JE.
6. On line CD, lay off GK equal in length to EG.
7. Draw a line, perpendicular to line CD, from point K to line EH. The intersection of this with line EH is the center for drawing arc EK.
8. Draw arc EK, completing the compound curve.

In any curve—whether a single arc, a part of a compound curve, or a part of a reverse curve—the distances similar to FE and FJ in Fig. 364 must always be equal to each other.

In a compound curve or a reverse curve the centers used to swing the arcs are always located on a perpendicular to the tangent at the intersection of the arcs; in Fig. 364 both centers are *on line* EH, which is perpendicular to the tangent FG at the intersection E of the arcs.

CONSTRUCTION NO. XIX—TO DRAW A REVERSE CURVE

In Fig. 365 is shown the construction for connecting lines AB and CD with a reverse curve, the change in curvature occurring at point *E*. The steps in this construction are exactly the same as those given for the compound curve in Fig. 364.

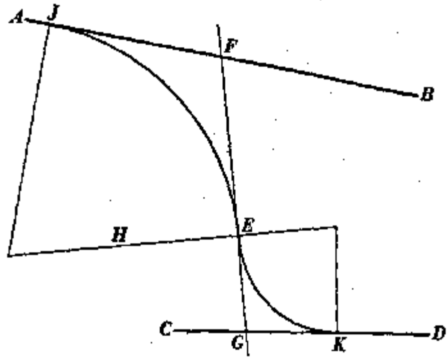


Fig. 365.—Drawing Reverse Curve.

CONSTRUCTION NO. XX—TO DRAW AN ELLIPSE

In Fig. 366 is illustrated a method of constructing an ellipse, called the concentric-circle method.

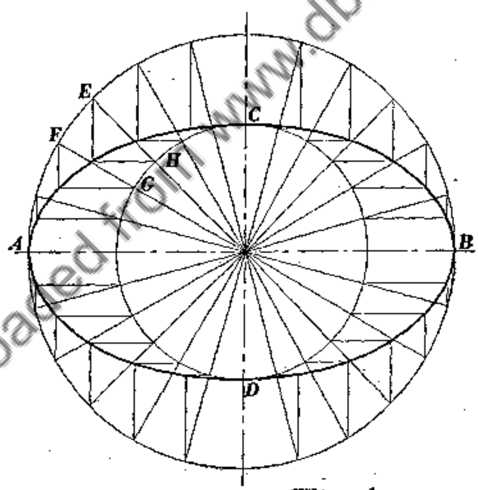


Fig. 366.—Drawing Ellipse by Concentric-Circle Method.

1. Draw two concentric circles, one having a diameter equal to the length of the minor axis of the ellipse and the other having a diameter equal in length to the major axis.
2. Draw radial lines that will divide the circles into an even number of equal parts.

3. Through each point in which the radial lines intersect the smaller circle, draw a horizontal line.
4. Through each point in which the radial lines intersect the larger circle, draw a vertical line. The intersections of the vertical lines with the horizontal lines determine the positions of points on the ellipse.
5. Draw the ellipse by connecting these points with a smooth curve.

In Fig. 367 is illustrated an approximate method of constructing an ellipse, known as the four-center method.

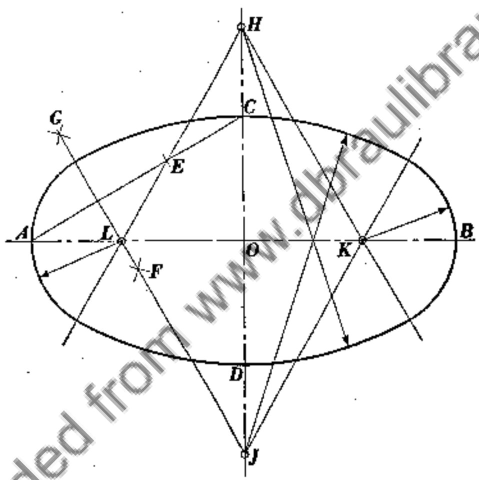


Fig. 367.—Drawing Ellipse by Four-Center Method.

1. Draw the major axis AB and the minor axis CD in their correct relative positions.
2. Draw line AC.
3. On line AC, lay off line AE, which is equal to CO.
4. Construct a perpendicular bisector to line AE. This bisector intersects line AB at point L and intersects line CD (prolonged) at point J.
5. With L and J, respectively, as centers, draw arcs through points A and C.

6. Steps similar to steps 2 to 4, inclusive, in which line *BD* is used instead of line *AC*, will establish points *H* and *K*.
7. With *H* and *K* as centers, draw arcs through points *B* and *D*, thus completing the ellipse.

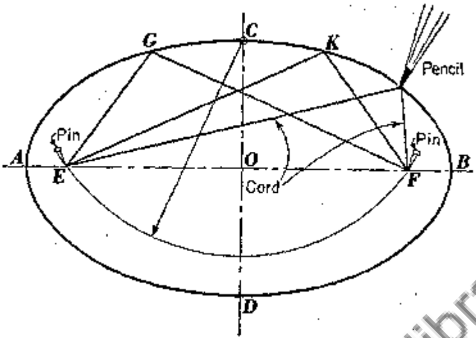


Fig. 368.—Drawing Ellipse by Pin-and-String Method.

In Fig. 368 is shown a third method of constructing an ellipse, known as the pin-and-string method. This method is especially applicable to the drawing of a relatively large ellipse. It may be used to good advantage in laying out elliptical flower beds, pools, etc.

1. Lay out the minor and major axes.
2. Determine the positions of the foci *E* and *F*. The foci are always located on the major axis. The distance from point *C* to either *E* or *F* is equal to one-half the length of the major axis.
3. Fix the ends of a string, equal in length to the major axis, at points *E* and *F*.
4. Stretch the string taut, and with a marker draw the curve that the string will determine. Keep the string taut at all times. Positions of the marker are designated by the letters *B*, *A*, *G*, *C*, and *K*, and by the pencil.

CONSTRUCTION NO. XXI—TO DRAW A HELIX

A helix is the path of a point that is revolving uniformly around an axis, while it is moving at a uniform rate in the direction parallel to the axis; for instance, the path of a point on the thread of a light bulb when it is being turned into its socket is a helix. The construction in Fig. 369 shows the path of a point that is on the outside of a cylinder $1\frac{1}{2}$ in. in diameter and moves upward 2 in. during each revolution of the cylinder.

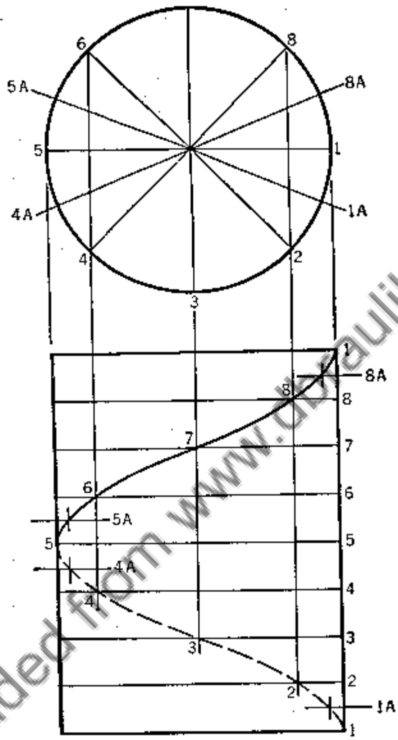


Fig. 369.—Drawing Helix.

1. Draw a circle that is $1\frac{1}{2}$ in. in diameter.
2. Divide the circle into an even number of parts. (Eight was used in this case.) Number the dividing lines in a clockwise direction.
3. Immediately beneath the circle, draw a rectangle $1\frac{1}{2}$ in. wide and 2 in. high, on which you will be able to plot the lateral and forward progress of the point.
4. Divide the height of the rectangle into a number of equal parts which is the same as the number used for dividing

the circle in Step 2. Draw horizontal lines through the dividing points, and number the lines in numerical order from the bottom upward.

Each dividing point on the circle will determine the lateral position of a point on the helix at some eighth of a revolution; while the corresponding horizontal line will indicate the forward progress at that same eighth of a revolution.

5. Intersect each numbered horizontal line with a perpendicular from the corresponding point on the circle above. These intersections determine positions on the helical path of the point.
6. Connect these intersections with a smooth curve. This curve is a helix.

QUESTIONS

1. Why were points 4A and 5A used?
2. What fraction of a revolution was made between positons 1 and 1A?
3. Would the helix be more accurately shown if the circle and the rectangle were each divided into four parts? Sixteen parts? Twenty parts?
4. Could the helix be constructed if the circle and the rectangle were each divided into the same *odd* number of parts?
5. Is it necessary that each be divided into the same number of parts?
6. What advantage is derived from dividing the circle and the rectangle into an even number of parts?
7. Where have you seen or used practical applications of the helix?

SUGGESTED CONSTRUCTIONS

1. Show the path of a point located on the edge of a cylinder 2 in. in diameter (2-in. cylinder) that moves forward 3 in. during each revolution. Draw the path of the point for the duration of two revolutions.
2. Show the path of a point, for one revolution only, that is located on the outside of a 6-in. cylinder which moves forward 3 in. per revolution. Divide your circle into 24 equal parts.

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