MECHANICAL DRAWING
FOR
INDUSTRIAL AND HIGH SCHOOLS

LEEDS

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MECHANICAL DRAWING

FOR

INDUSTRIAL AND HIGH SCHOOLS

BY

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PREFACE

THIRD EDITION

It is seven years since this work was first published, and the author feels very grateful for the generous manner in which it has been received.

In the preface of the first edition we emphasized the need of teaching Mechanical Drawing by a method which should develop the student's creative faculties. We desire strongly to reaffirm this position, as these years of added experience have strengthened our belief in the vital importance of stimulating the student's imagination.

We have added considerable new subject matter and have presented certain fundamentals in much clearer form than in the previous edition.

In presenting the subject of Isometric Projection, the illustration Fig. 18 is original with us, as we have never before seen the relationship between Mechanical and Isometric shown in this simple fashion.

We have taken out the lessons on Gearing and Intersections and Developments, under the belief that most High School students gain little of real value from these subjects as they are generally taught. We believe that these subjects can be handled to much better advantage in a Technical School or College.

We are attempting to place certain theories before teachers of Mechanical Drawing by means of a "Letter" placed at the beginning of the text. This plan is due to the desire on our part to make clear our aims to those who use this work as a text or reference book.

We have tried to correct all the errors in the previous editions and shall be grateful to those who may call our attention to any mistakes discovered in this one.

Charles C. Leeds.

May 15, 1915.

A LETTER TO DRAWING TEACHERS

To help the boys of secondary schools to a realization that Mechanical Drawing is a Language, to assist them in learning to read and write this Language and to stimulate and strengthen their imagination, these are the primary aims of this book.

These boys should be taught that mechanical drawings are used in a large portion of the commercial enterprises to which they will look for employment when their school days are over, and that a clear knowledge of this subject has considerable value in the business world.

The fact that so many boys are obliged to leave school as soon as the law permits, makes it all the more imperative that, while they are still in school, they shall be given instruction that will prepare them for their future as wage earners.

Those boys who are able to continue their studies should be benefited as well, from the fact that, if they can acquire the fundamentals of mechanical drawing while in a secondary school, they may take more advanced work when entering a Technical School or College.

We have tried to lay out this work in such manner as to lead the student along by easy steps, taking him from one basic principle to the next as he is able to grasp the subject.

The instruction should be individual as far as possible, for much better results can be obtained by this method than by trying to carry a group of students along, all on the same lesson, regardless of their varying ability.

The use of models in teaching the elements of mechanical drawing should be discouraged, as the practice tends to prevent the development of the creative imagination. This faculty of forming mental pictures of various forms of construction is very essential to all who would use mechanical drawings to the best advantage.

Models are valuable when teaching free-hand sketching, as they give an added interest to the work by making it seem more like the conditions under which commercial work is done.

Where the teacher has difficulty in making the student understand the shape of an object from a mechanical drawing, it is preferable to show an isometric or perspective sketch of the object as an aid, rather than a model, as this will help the student more clearly to see the distinction between these two methods, mechanical and perspective, and will also help to develop his imagination.

One of the serious handicaps carried by a large element of the entering classes in Technical Schools is the *lack* of *imagination.* The development of this faculty is absolutely essential if a man is to use to the fullest extent his powers for *creative work.*

Contrary to general belief this faculty is as necessary to the successful business man as to the artist and writer. It is therefore the hope of the author that this book may be of value as an aid in developing the boy's imagination and, to the same extent, his reasoning powers.

To give force to the theory we have advanced in regard to the value of developing the imagination, the author begs leave to quote the following from a great modern psychologist:

A LETTER TO DRAWING TEACHERS—Continued.

"There is an identity of nature between the constructive imagination of the mechanic and that of the artist: the difference is only in the end, the means and the conditions. . . . Taken as a whole, its psychological mechanism is the same as that of any other creative work."

In preparing the text matter we have treated the subjects rather briefly in most cases, with the thought in mind that we may count on the teacher's giving more elaborate explanation of the principles involved where it is necessary.

In closing we wish to recommend *very strongly* that the teacher, when giving aid to the student on his drawings, use the "Induction Method." That is, do not give a direct answer to the student's appeal for help, but try to help him, by suggestion, to see for himself the solution of his difficulty.

This method requires patience and resourcefulness on the part of the teacher, but it also has the desired advantage of stimulating the student's reasoning powers.

THE AUTHOR.

LESSON No. 1.

MECHANICAL DRAWING.—A Mechanical Drawing is an instrument used to convey exact information from one person to another. Generally speaking it is a graphic illustration of some mechanism or form of construction used in the commercial life around us.

A mechanical drawing represents the written form of a *Language* that is a commercial necessity. This language may be described as a "pictorial" one, as it is by means of a drawing, showing one or more views of an object, that we furnish the necessary information as to the shape and size of this object.

Mechanical drawings are in constant use in some form in the business world with which our lives are brought into daily contact, consequently this is a modern language that we should know something of if we wish to make the most of our opportunities when we take up commercial work.

To be able clearly to understand mechanical drawings, we must learn to read and write this language after the manner in use in commercial life. This means that we must become familiar with the principles upon which the subject is founded.

Mechanical drawings, as the name indicates, are made mechanically, that is, with instruments, as distinguished from drawings made freehand.

The instruments included in a simple set vary greatly, but in the main consist of a pencil compass, a pair of dividers, a ruling pen, and a compass pen. The instruments mentioned are those that are actually necessary, but more elaborate sets should be obtained where one's means will permit, as the expenditure is justifiable on account of the greater convenience and ease in making good drawings.

In addition to the instruments mentioned, each student needs a T-square, scale, 45-degree triangle, 30-60 degree triangle, drawing pencils, an eraser and thumb tacks.

Plain pear-wood T-squares are satisfactory and inexpensive. One with a 24-inch blade is long enough for this work.

A flat 12-inch scale graduated in 16ths on one edge and 32ds on the other is most suitable for our purpose, as the fractions used on most mechanical drawings are multiples of these numbers. A scale with white edges and dark graduation lines is highly desirable, as the use of this type is least tiresome for the eyes.

Triangles of some transparent material, such as celluloid, are most satisfactory, though many draftsmen use triangles made of pear or cherry wood. A 7-inch 45° triangle (° degree sign) and a 9-inch 30°–60° triangle will be found large enough for our purpose.

The hardness of the lead in drawing pencils is usually indicated by a number before the letter H, as 2H, 3H, 4H, etc.; the higher the number the harder the lead in the pencil.

For the students of secondary schools, 4H pencils will be found quite satisfactory when making their mechanical drawings, as this grade of pencil will hold a point for a reasonable length of time and will also make a fairly dark line. For freehand work, such as lettering, putting on dimensions and sketching, nothing harder than 2H should be used.

One of the best erasers is the Emerald No. 111, though the Ruby No. 112 is just as good.

The common manila drawing papers are very satisfactory and are inexpensive. These papers are used more than any others in commercial drafting rooms. Paper 11 inches by 15 inches in size will be found large enough for all lessons.

The drawing board should be made of soft wood; white pine or yellow poplar are preferable where they can be obtained, as it is easier to push in and pull out the thumb tacks which hold the drawing paper. For all this work a board 18 inches by 24 inches is amply large.

Small thumb tacks are much to be preferred to large ones, as they hold the paper as well and are more easily pushed into or drawn from the board.

PENCIL.—Having selected the drawing pencil most suitable for our purpose (4H) let us prepare it for use. First we cut away the

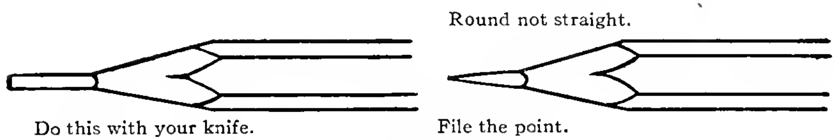
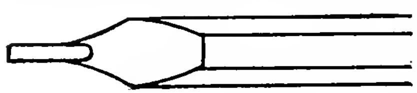


Fig. 1.

wood as shown in the illustration, Fig. 1, then the lead is sharpened by rubbing it over a strip of sandpaper mounted on a piece of wood, or on a smooth, single cut file.

About 1 inch from the end of the pencil, beginning on one of the six corners, cut away the wood in a clean manner so as to bare about $\frac{3}{8}$ inch of the lead; then sharpen by sliding the lead over the surface of the file or sandpaper, turning the pencil as it is moved along, so as to produce a round point.



The other end of the 4H pencil should be sharpened to a flat point. To produce this point enter the knife about 1 inch from the end of the pencil on one of the flat sides (not corner), and cut away the wood in the manner shown in the illustration, Fig. 2, baring about $\frac{3}{8}$ inch of the lead.

Fig. 2.

To sharpen the lead, slide it back and forth along the file, forming a chisel-like point.

The round point is used in setting off dimensions and for lining in all the finished lines of the drawing, while the flat point is used mainly for light, thin construction lines, center lines, etc.

The 2H pencil should be sharpened at one end only, in a fashion similar to the round point of the drawing pencil, though not so sharp a point is needed as on the latter.

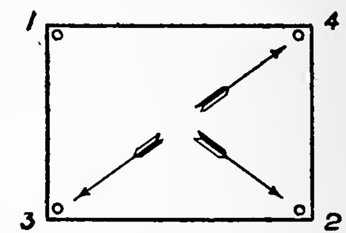


Fig. 3.

PAPER.—Drawing paper should be fastened to the board as smoothly as possible, for it is very difficult to do satisfactory work on paper which does not lie flat on the board.

Use small thumb tacks to fasten down the paper, placing them in the order shown in the illustration, Fig. 3. Push the tacks well down, so that the heads bind the paper closely; this will also enable the T-square to be slipped over them easily without knocking small chips out of the edge of the blade.

DRAWING BOARD. — T-SQUARE. — TRIANGLES. — The Drawing Board should be somewhat larger than the paper used, and the surface upon which the paper is mounted should be smooth and flat. As the left-hand edge of the board is the one against which we place the T-square head, this edge must be perfectly straight, as well as smooth and free from bumps or high spots.

The upper edge of the T-square blade and the inside edge of the head should be perfectly straight, and be smoothly and accurately finished. These two surfaces are set at a right angle with each other; in other words, they form an angle of 90°.

When using these tools the head of the square is held against the left-hand edge of the board and the upper edge of the blade used as a ruling edge for *all* horizontal lines. For vertical lines, hold square as mentioned above, also hold one of the triangles as shown in the illustration, Fig. 4, and use the left-hand edge of the triangle for a ruling edge, always drawing the pencil *away* from square blade when ruling a line.

To rule lines properly, lean the top of the pencil slightly away from the ruling edge so that the pencil point will slide along in the corner formed by the ruling edge and the surface of the paper.

MEASUREMENTS.—The student must become familiar with the scale used in making measurements, as this part of the work is of the greatest importance in making accurate drawings.

The simplest plan to follow in laying off a given length is, first to rule a light, thin line (generally termed a construction line) in the proper position, then place the edge of the scale just against the line; now mark small pencil points on the line, *directly* opposite the graduations in the scale which indicate the desired length. Now using the square or triangle as a ruling edge, make the line heavy between the two points and the result is the finished line of the proper length.

Lay out ten horizontal lines just $6\frac{1}{2}$ inches long, ten vertical lines $5\frac{3}{4}$ inches long, and ten 45° lines $4\frac{1}{8}$ inches long. These lines may be any suitable distance apart.

FIG. 4.

LESSON No. 2.

DRAWING TO MEASUREMENTS.—We will use the T-square, one triangle, the scale and the pencil for this lesson, and the student should keep in mind the fact that the main purpose of our present lesson is to increase his knowledge of these tools and his skill in using them, with special emphasis laid on the use of the scale.

When laying off measurements for the following figures, great care must be used to get the sizes exact, as the student should not be satisfied with any work but the very best he can produce.

Lay out an 8-inch square, that is, a figure whose four sides are each 8 inches long. A good plan to follow is to draw in the sides with light, thin lines first, then when the proper sizes are measured off, to run over the lines again, making the outline of the square heavy. Also lay out a 4-inch and a 2-inch square on the same sheet of paper.

Draw a light line diagonally across each square, that is, a line from far corner to far corner, or the *longest* straight line that can be drawn inside of each square. On this diagonal line lay off points or measurements as follows: for the 8-inch square these points should be $\frac{1}{4}$ inch apart, starting at one corner and letting the last measurement come what it will, on the 4-inch square make the points $\frac{3}{16}$ inch apart and on the 2-inch square $\frac{1}{8}$ inch between points. Now using the T-square and 45° triangle, with the triangle as the ruling edge, draw light lines through these points in each square, these lines to be at right angles to the diagonal line.

When drawing in these lines care must be taken to see that they cut the center of the point, and the finished result should be three figures similar to that shown in Fig. 5.

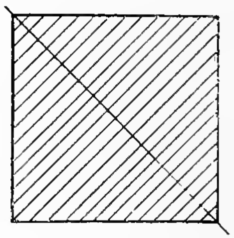


FIG. 5.

It is rather preferable that the student should finish completely one square at a time.

One feature of the work that we desire to emphasize is that the student should study the instruction sheets of each lesson very carefully; he should try to learn the purpose of the lesson and its important points *before* attempting to make the drawing.

LESSON No. 3.

COMPASS POINTS.—Our first duty is to prepare the compass points for use. If possible use compasses that have a needle point similar to that shown in Fig. 6. The end with the shoulder should be used, as by its use large center holes are eliminated.

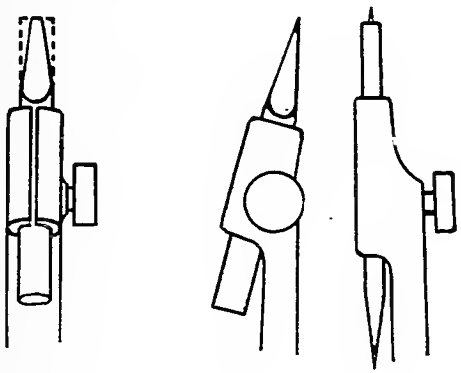


Fig. 6.

Set the lead pencil $\frac{1}{4}$ to $\frac{3}{8}$ inch out from the end of the compass leg; now with the file produce a flat point somewhat like a chisel point (except that it is dressed off on both sides); this flat pencil point should be set at right angles to the needle point and about even with the shoulder of the latter.

After adjusting the lead properly, file off the corners of the flat point as shown in Fig. 6, and the result should be a fairly narrow flat pencil point, which is slightly shorter than the needle point.

The preparation of the compass points is of considerable importance and should be done carefully if accurate work is expected.

Taking the compass in the right hand and the scale in the left, as shown in the illustration, Fig. 7, set the compass points to a measurement or radius of $\frac{1}{2}$ inch, then holding compass as shown

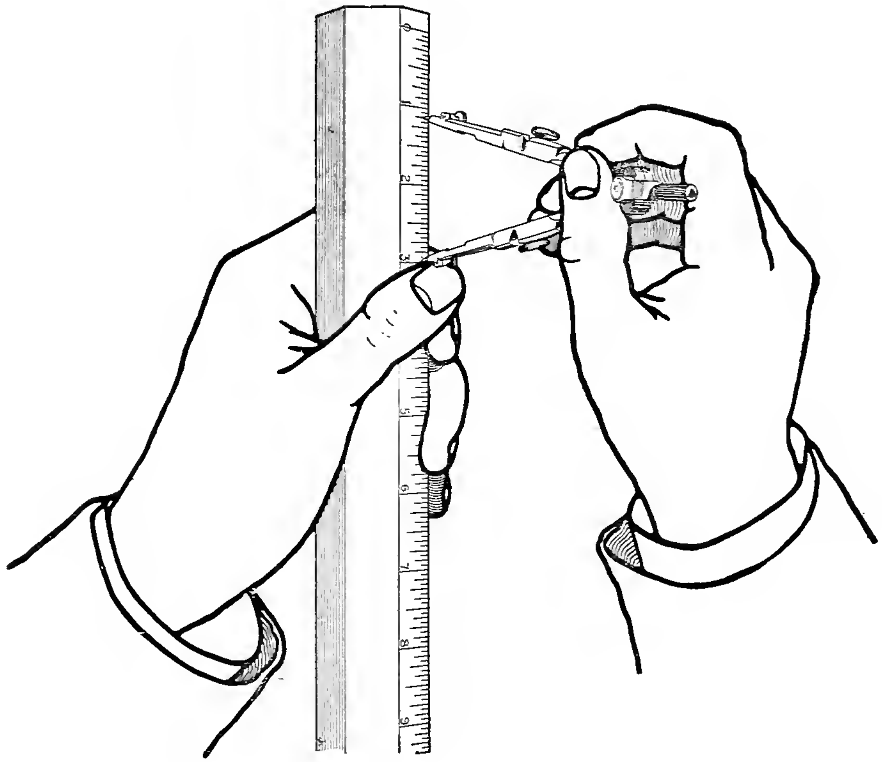


Fig. 7.

in Fig. 8, throw in a 1-inch circle. Test for accuracy by measuring the finished circle with the scale.

Cover the drawing paper with circles, beginning with the 1-inch circle described, making each circle a little larger than the previous one. Set the compass points very carefully to the dimensions on the scale before making each circle, then use the scale to measure the finished work.

The purpose of this lesson is to familiarize the student with the use of the compass, with special emphasis laid on its preparation for use and the setting to measurements from the scale.

The student should not underestimate the value of properly prepared drawing pencil and compass pencil points, and he should make it a rule always to keep them in good order. Neat, accurate drawings are a necessity and properly kept tools are a great aid in their production.

Fig. 8.

LESSON No. 4.

ROUNDED CORNERS.—FILLETS.—In the construction of machinery of various types it is a common practice to round some of the corners of the castings and of many other parts that make up the machines. Where the round corner is formed at the junction of two surfaces, as shown in Fig. 9, it is termed a fillet.

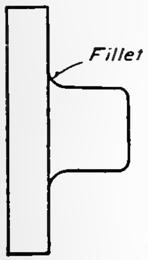


Fig. 9.

The surfaces joined by these round corners may form any angle; consequently we should select a method of throwing in radii, or rounding the corners, which will apply to *all* corners.

The method suggested, for lack of a better name, we have given the title "trial method," as it is by trial that we locate the position of the compass needle.

When finding the center of the radius, place the compass in such a position that the lead point rests directly upon one of the corner lines, then rest the needle point *lightly* on the paper in the position which the eye indicates as the center. Now balance the compass *lightly* on the needle point and swing the lead point around to the other corner line; if this point comes directly on the line, the needle position is correct and the radius may be thrown in. If the position is not quite right, swing the lead point back to the original line, balance on this, and shift the needle point the amount judged to be necessary. By this method, and with a little practice, the student should become quite proficient in locating the radius center without loss of time.

For the purpose of demonstrating the value of the above method of throwing in radii, it is desired that the student shall make a drawing of the following figures:

Using light, thin construction lines, lay out a 4-inch square, an equilateral triangle with 5-inch sides, and a rhombus with 5-inch sides. The smaller angle between the sides of the latter is to be 45°. These figures should be arranged so that all three may be placed on the same sheet of drawing paper.

Having laid out these figures in *light, thin* lines, set the compass to a ½-inch radius and, after finding the center *by trial*, round the corners of each. Remember that when finding the compass needle position it must be set in such a manner that the lead comes just on the construction line and blends with it.

Make these round corner lines fairly heavy when throwing them in, then line in the rest of the figure, making the whole outline of the same thickness.

The trial method of finding radius centers is advantageous from the fact that it applies equally well to all angle corners, and tends to promote speed in production.

LESSON No. 5.

CONSTRUCTION CIRCLES.—Certain figures are of such shape that they are of considerable value as aids in constructing the drawings of other figures. The circle is used for this purpose constantly, as it is a great help when it is desired to lay out quickly and accurately such figures as the square, the hexagon, etc.

Both shopmen and draftsmen make use of the circle as an aid to lay out these figures. Their methods of use differ, mainly because these two departments use different tools for laying out their work. Usually the shopman will inscribe the figure desired inside the circle, while the draftsman will circumscribe it outside of the circle.

When the figure is inscribed within the circle, the diameter of the circle is equal to the diameter of the figure across corners, or its *greatest* diameter. When the figure circumscribes the circle, the diameter of the circle is equal to the diameter across flats, or the *short* diameter of the figure.

It is desired that the student shall draw the following figures, using both of the above mentioned methods:

Inscribe a square within a $2\frac{13}{16}$-inch circle and a hexagon within a $2\frac{5}{16}$-inch circle.

Draw two 2-inch circles, circumscribe one with a square and the other with a hexagon figure. All of these construction circles should be formed of light lines.

When inscribing the square within the $2\frac{13}{16}$-inch circle, use the T-square and one triangle to draw two light construction lines across the circle. These lines must be placed at right angles to each other and the point where they intersect must be the center of the circle.

The four points formed by these two lines crossing the circle are the corners of the square; connect these points with firm, clear lines and the square is complete.

To inscribe the hexagon in the $2\frac{5}{16}$-inch circle, set the dividers to the radius of the circle and with this step off six points around the circle. If this is done carefully the circumference will be divided into six equal parts, as the radius of the circle equals the chord of one-sixth of the circumference. Connect these six points with firm, clear lines and the hexagon is complete.

To circumscribe one of the 2-inch circles with a square, use the T-square and the 45° triangle (the latter to be the ruling edge) to draw in the lines which form the sides of the square. These lines must blend with the circle, that is, each line should touch the circle at one point only and the finished result should be a square of firm, clear lines, with a faint-lined construction circle just touching each of the four sides.

The circumscribed hexagon figure should be laid out in the same manner as the square, with the exception that the student should use the 30°–60° triangle as a ruling edge for drawing in the sides.

The principles of construction used in this lesson are constantly applied in commercial work and they are well worth the student's earnest attention.

LESSON No. 6.

NUTS.—This lesson is an application of the principles of construction given in our previous lesson, that is, the use of the circle as an aid to lay out these figures.

The method to be followed is that of the draftsman, and the student is expected to make a full-size drawing of the two nuts shown.

The large circle shown in the top view in each case is used as a construction circle; it is also customary to show this circle as a means of indicating that the corners of the nuts are chamfered, or rounded off.

HEXAGON NUT.—Lay off the center lines first, so that the positions of the views are fixed at the beginning. Arrange the positions of the views of the two nuts upon the paper so that their appearance is pleasing, as taste in such matters is of considerable value.

Lay out the top view before the others, as from this we may project the edge and side views.

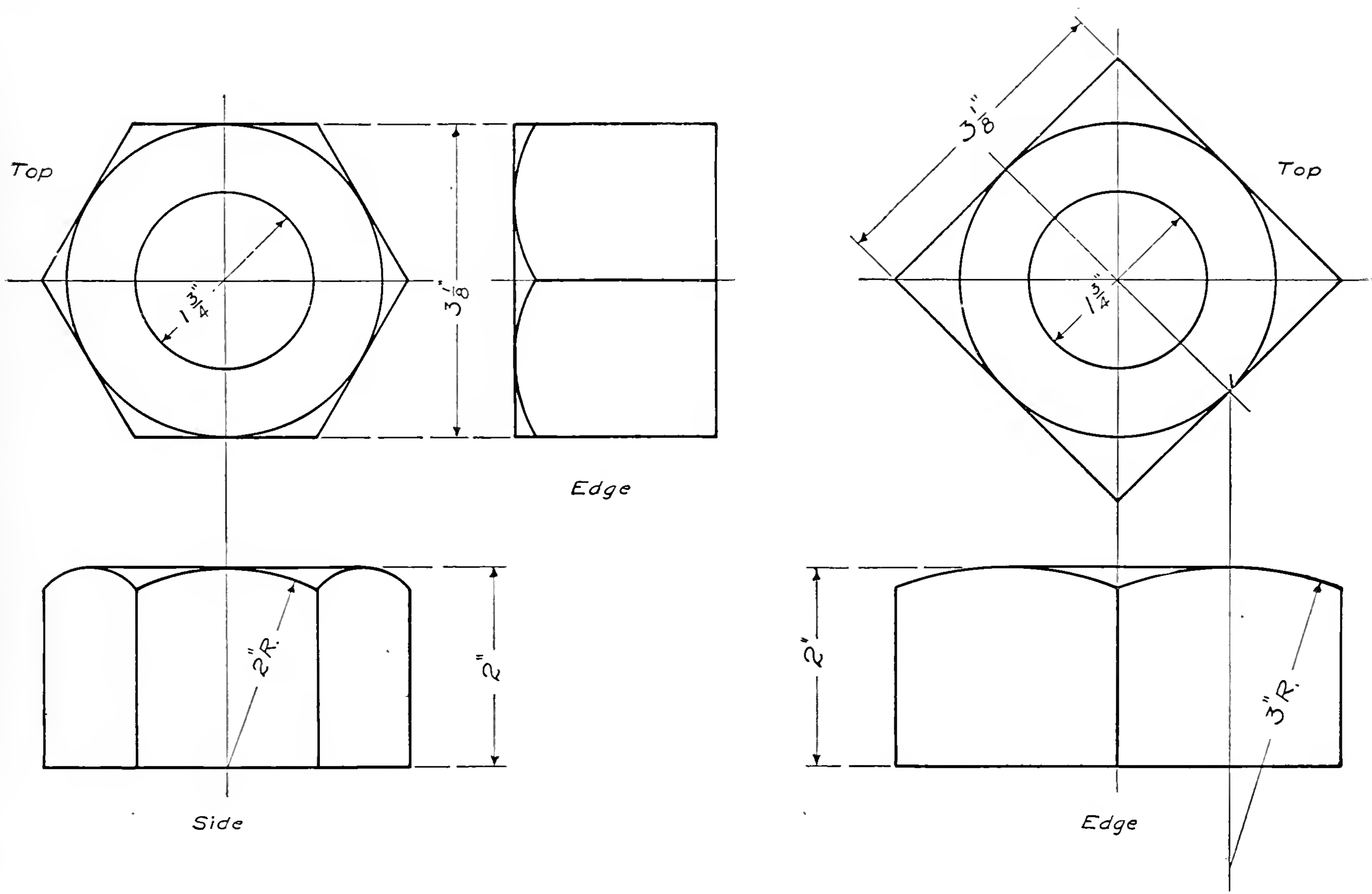
Set the compass correctly and throw in the construction circle representing the diameter across flats. Then, with T-square and 30°–60° triangle, rule in the hexagon outline.

Next, project light construction lines (lines any length) from the sides and corners of the top view to assist in drawing the side and edge views. After measuring the height of nut and throwing in the radii, line in the part of these construction lines that is needed and erase the balance. Finish the outlines of all three views neatly and put in the dimension lines and the dimensions.

SQUARE NUT.—The same method of procedure is followed for the square nut as that just described for the hexagon nut, except that we use the 45° triangle for a ruling edge when outlining the top view.

Lay out the top view first and make use of it as an aid in constructing the edge view. This is a fundamental principle, which is to be followed as a general rule with pieces of such shape that we can make use of this advantage.

In certain respects there is something lacking as regards the correctness of these views of the nuts illustrated, but the student may ignore this with the understanding that the main purpose of this lesson was to make an application of the principle of construction featured in our previous lesson.



NUTS

CLASS Industrial

NAME John W. Roberts DATE Feb.-6-15.

SCALE Full Size DWG. NO. C-1000

LESSON No. 7.

LETTERING.—The average student does not fully appreciate the value of being able to letter well, and while he is seldom pleased with his lettering, he usually does not like to devote the necessary time to practice. A great many young draftsmen reach the point where they are able to make a neat, workmanlike drawing, the appearance of which they will spoil when they letter and dimension it.

In making a study of the types of letters illustrated, take especial notice of the oval, which is the basis of most of the lower-case letters, and observe the proportions of this type; note also the slope of both types.

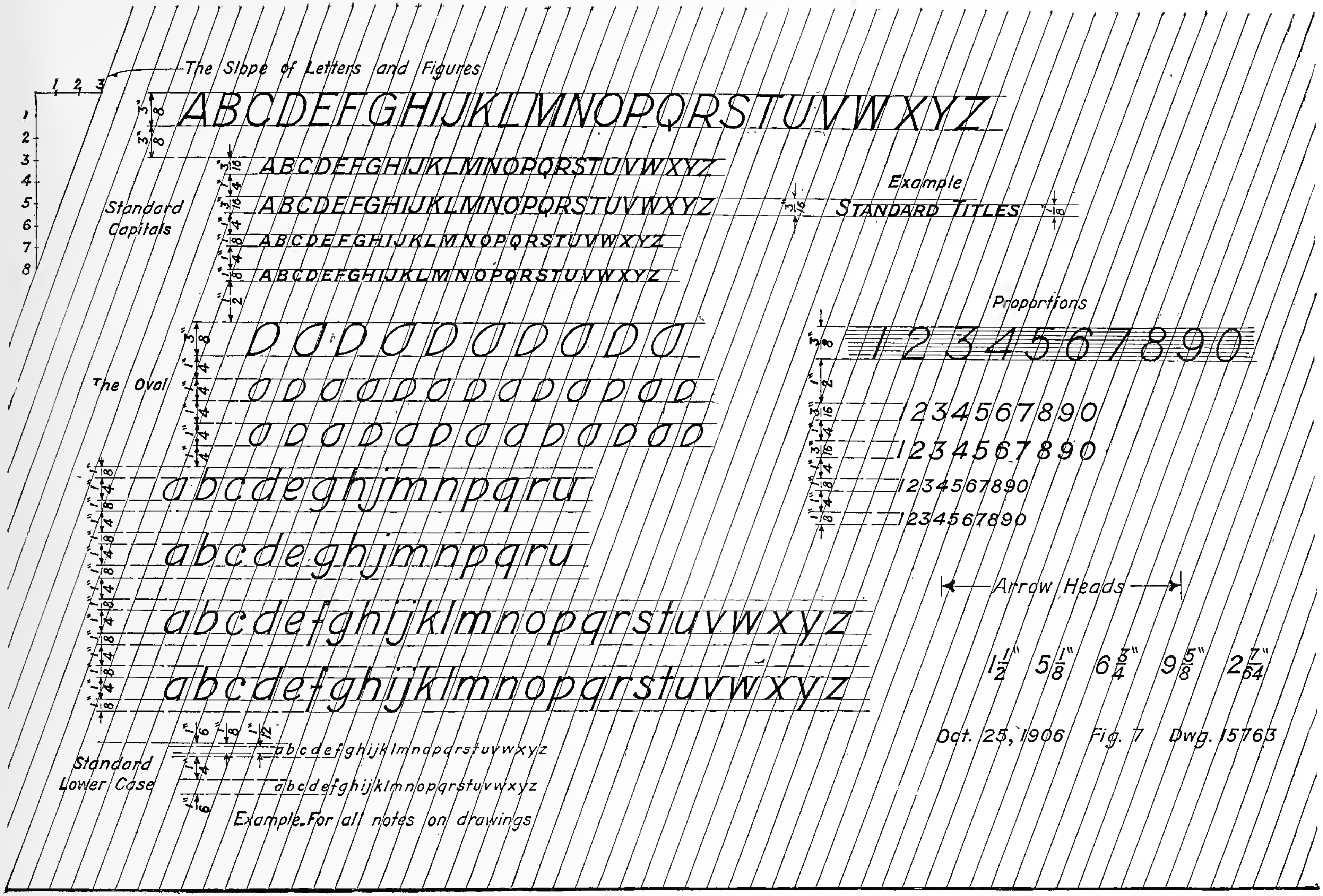
The capitals are used mainly for titles and headings, while the lower-case letters are used for all notes shown on drawings and for all other purposes, except for titles and headings.

As an aid in learning to letter, it is well to use guide lines as shown in the illustration. The student will find the slope guide lines a great help also in making letters of uniform appearance.

FIGURES.—What has been written in regard to lettering applies equally well to figures.

It is of great importance that the student should learn to make his figures so well that no one should have any trouble in reading them easily and quickly. Mistakes in the shops are very frequently caused by poorly written figures on drawings, and these mistakes are often very costly. The value of using great care at all times in placing the dimensions on drawings is thus clearly shown.

THE LESSON.—Make a neat pencil copy of the illustration, using care with both letters and figures; note carefully the proportions of both. Leave off figures showing spacing of guide lines, as these were intended merely as an aid to the student in laying out his lesson sheet.



LETTERING - FIGURES

CLASS Industrial

NAME John W. Roberts DATE Nov. 12, 06

SCALE Full Size DWG. NO. C-1001

LESSON No. 8.

MACHINE BOLT.—Make a full-size three-view mechanical drawing of the $1\frac{1}{2}$-inch machine bolt shown in the illustration, Drawing C-1002. View (*a*) represents the end of the bolt head as seen from the position of (*a*). View (*b*) is a side view of the bolt and hexagon nut. View (*c*) is an end view of the threaded end of the bolt and of the hexagon nut as seen from the position of (*c*). The positions of the views are given in relation to the edges of the paper.

THE DRAWING.—Lay off the center lines first, so that the positions of the views are fixed at the beginning; do not let them "happen" as regards location.

In drawing view (*a*), lay out the $2\frac{1}{4}$-inch construction circle, and then with the T square and 45° triangle, draw in the outline of the head.

View (*c*) is drawn in the same manner, that is, first the $2\frac{3}{8}$-inch construction circle, then, using the T square and the 30°–60° triangle draw the outline of the hexagon nut, and finally throw in the $1\frac{1}{2}$-inch circle to represent the end of the bolt.

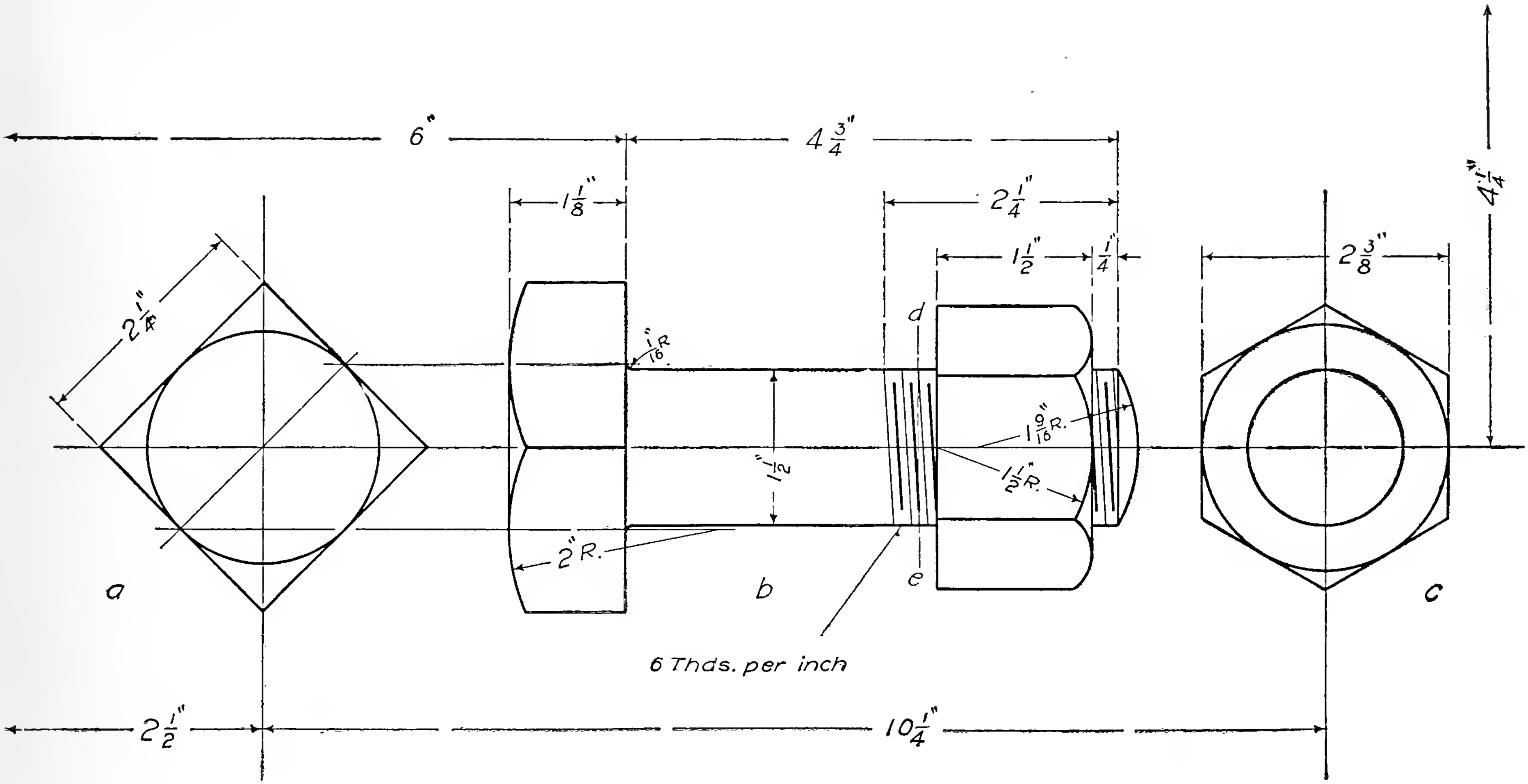
Having drawn views (*a*) and (*c*), now lay off the lengthwise dimensions of view (*b*), and draw vertical construction lines through these points (lines any length). With the T square, project the horizontal lines of the bolt from the end views, these lines to be light construction lines, until their true length is known. Now swing in the various radii, make them as heavy as the final outline is to be, and line in the bolt and nut completely, so that the whole outline stands out clearly and distinctly.

SCREW THREADS.—The threaded end of the bolt is indicated by alternate light and heavy lines, the heavy lines being shorter than the light ones. This is a conventional method of indicating screw threads, and it has the merit of being easily understood and is inexpensive.

While it is not essential that the space between the light lines should be just the same as the pitch of the thread, or that the lines should be sloped at exactly the correct angle, it is of considerable importance that the threaded surface as a whole should look approximately correct.

When the slope is correct for a single-thread screw, a line drawn at right angles to the center line of the screw should touch the end of one of the thread lines at one side and pass midway between that line and the next at the opposite side, as indicated by the light dash line *d–e*. In other words, the slope equals half of the pitch of the thread.

Place the dimensions just as shown in the illustration, and make the figures carefully, so that there can be no doubt as to their meaning. The dimensions which refer to the position of the different views should be left off, as they were intended to aid the student in locating the views, and have no other value.



MACHINE BOLT

CLASS Industrial

NAME John W. Roberts DATE Feb. 20_06.

SCALE Full Size DWG. NO. C-1002

LESSON No. 9.

HIDDEN SURFACES.—Until the present time we have been using lines which could be seen on the surface, or which represented the surface of the figures that we have used as subjects for our drawing lessons.

In mechanical drawing it is constantly necessary to show by some means, surfaces or details of parts that are hidden from view behind the surface shown by solid lines.

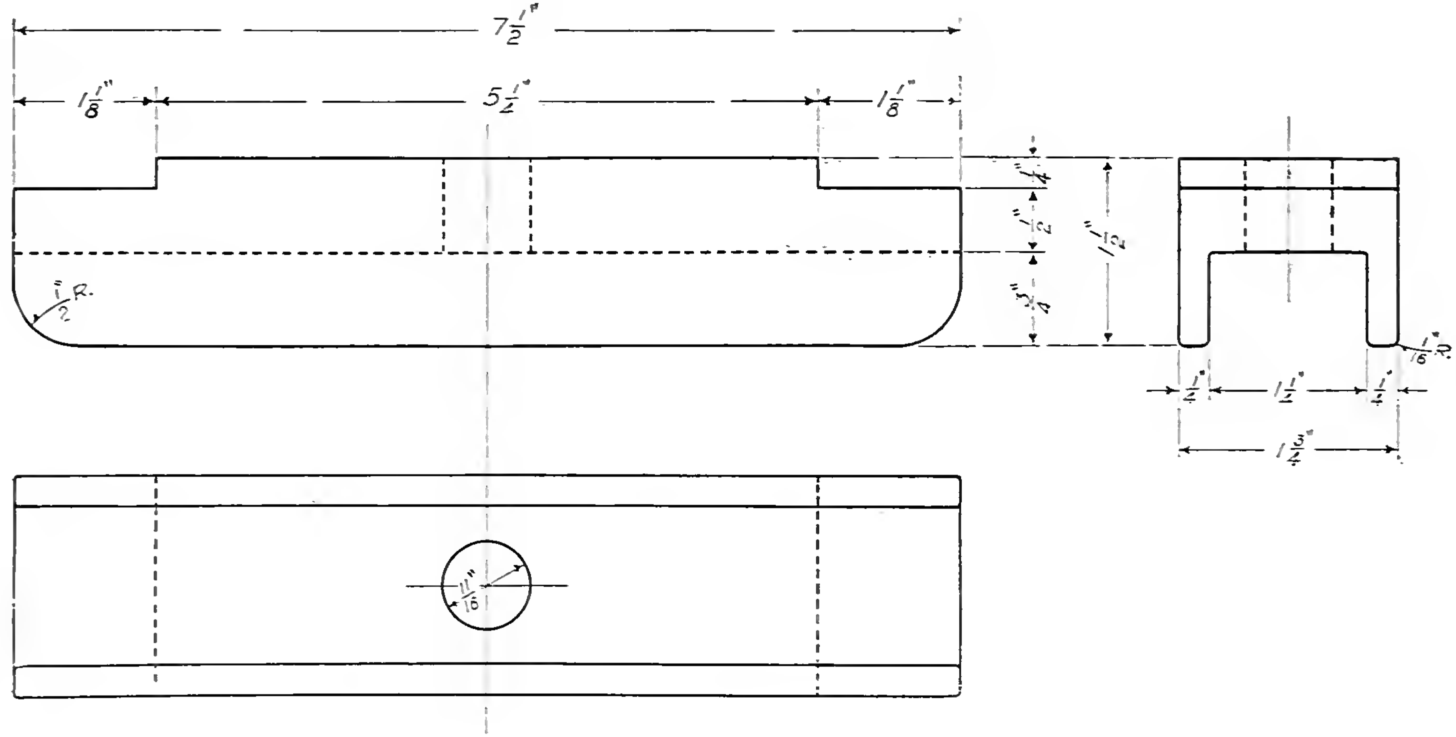
Unless these surfaces could be indicated by some simple method, it would often be necessary to make additional drawings, or at least, additional views to show clearly the shape of the figure illustrated.

The method commonly used to indicate these hidden surfaces is to draw them in, in the proper positions, but to use lines formed of short dashes. These dash lines or "hidden lines," as they are generally called, have a distinctly different appearance from the solid outlines of the rest of the drawing, and their meaning should be readily understood.

THE LESSON.—Make a full-size three-view pencil drawing of the clamp shown on Drawing C–1003. Finish the drawing in a neat, attractive manner, using care to see that no dimensions are left off.

These three views represent the side, the end, and the bottom of the clamp. The shape of the clamp or what it is used for is of no importance in our present lesson, as our purpose in using this piece is merely to illustrate the hidden surface lines.

These hidden surface lines are the essential feature of this lesson, and as this type of line is in constant use on mechanical drawings, it is highly desirable that the student shall have a clear understanding of the subject.



CLAMP

CLASS Industrial

NAME John W. Roberts DATE Oct. 6_06.

SCALE Full Size DWG. No. C_1003

LESSON No. 10.

SECTIONING.—When making drawings it is often necessary to show at least one view of the piece or pieces illustrated, with part cut away, or "in section," as it is generally termed.

The advantage of this plan is that it helps to show the shape of the piece more clearly, and often the dimensions can be placed to better advantage on a sectional view.

As an aid in indicating that a piece is in section, the surface cut is covered with light lines called "section lines." These lines are drawn with the aid of a 45° triangle as a ruling edge, the triangle being held against the T-square blade and moved for each line.

In this course of lessons we will use the type of sectioning shown on Drawing C–1004, for *all metals*, the only variation being that the lines should be spaced close together for small pieces and farther apart for large ones.

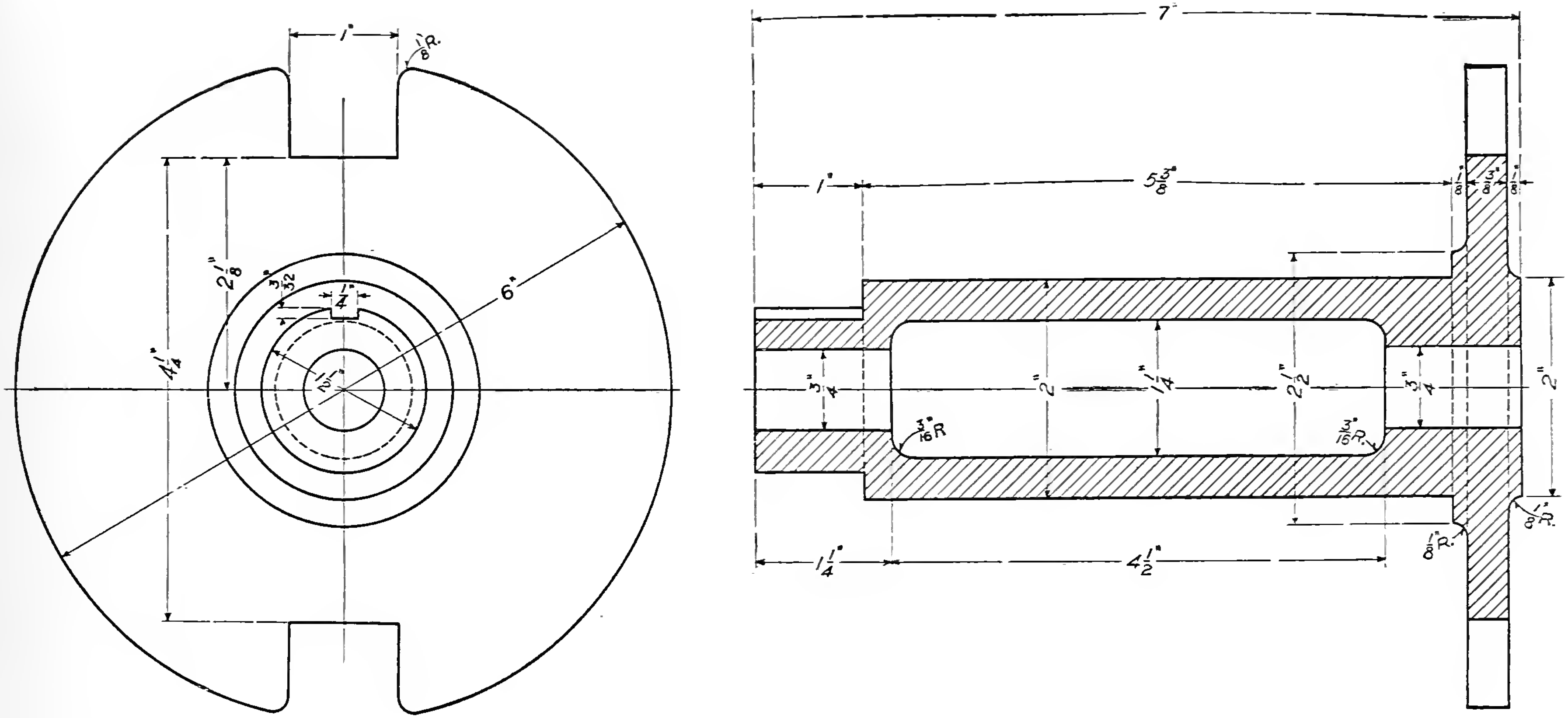
In commercial work it is an economic advantage to follow this method of sectioning, and to indicate by other means than the section lines the kind of metals to be used for the machine parts shown on drawings.

Where two or more pieces assembled together are shown in section, the different parts are shown more clearly by sloping the section lines in opposite directions where the parts join.

Where no special section is indicated, it is usually understood that the cut is made along the center line of the view from which the sectional view is projected. In this lesson the section is taken on the vertical center line of the end view.

THE LESSON.—The important feature of this lesson is the principle of showing a piece in section.

Make a two-view pencil drawing of the hollow sleeve illustrated. Use care to finish the drawing neatly, putting into practice the various fundamentals given in previous lessons.



SLEEVE

CLASS *Industrial*

NAME *John W. Roberts* DATE *Oct. 24-06.*

SCALE *Full Size* DWG. NO. *C-1004*

LESSON No. 11.

ORTHOGRAPHIC PROJECTION.—The natural impulse of most boys when attempting to make a freehand drawing of an object, is to try to represent the object as it appears to their eye. In other words, they make a *one plane* drawing which shows two or three faces or sides of an object in the one view, similar to the way the Vee Block is shown in Fig. 10.

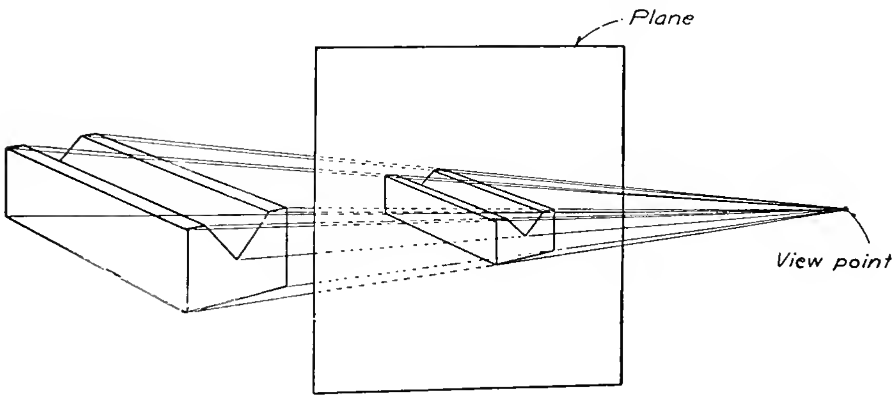


FIG. 10.

Drawings made after the fashion of Fig. 10 are known as perspective drawings, and while this type of drawing has its place in commercial work, the method is not suitable for use by manufacturers of various forms of mechanical construction.

Fig. 10 represents the object as seen from *one* viewpoint only.

A mechanical drawing represents an object as seen from several different viewpoints, as many as are necessary to get a clear idea of the shape of the object.

Instead of one view showing several faces of an object, a mechanical drawing shows a view for each face desired, and these views are arranged in relation to each other according to certain laws of projection, in the manner shown by Fig. 11.

Mechanical drawings are suitable for the purposes of manufacturers, because they not only convey a correct idea of the *shape* of an object, but they also carry information as to the *size* by means of dimensions, or measurements written on the various views.

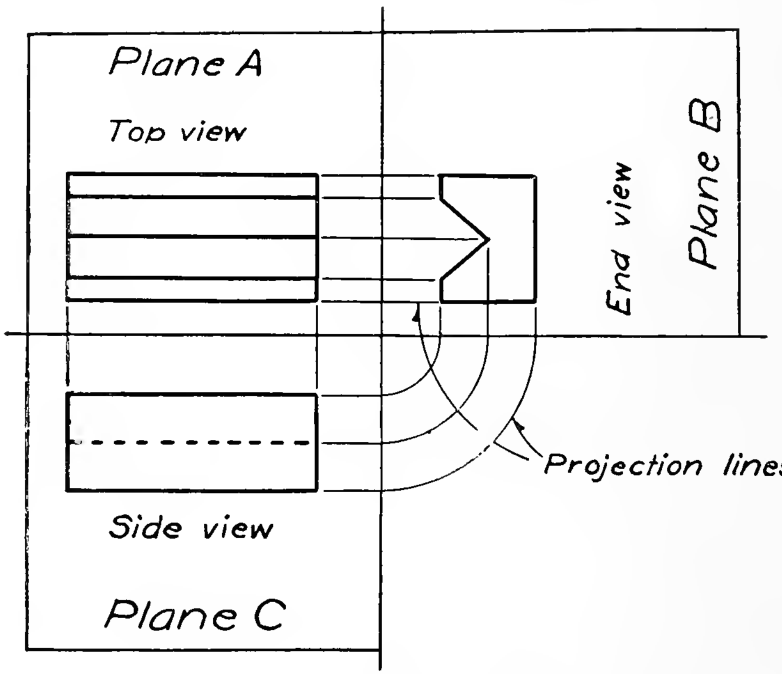


FIG. 11.

To be able to read a mechanical drawing, that is, to obtain a clear idea of the shape and the size of an object, one must develop the faculty of forming a mental picture of it from a study of the different views shown on the drawing. He must have sufficient imagination to be able to clothe the lines of the drawing with a shape.

One cannot get a clear understanding of an object from looking at a single view of a mechanical drawing, but must study all the views, looking from one to the other and trying to see the relation between them until he gradually grasps their message.

A knowledge of Orthographic Projection, or the laws by which mechanical drawings are made, is absolutely necessary if the student is to read a drawing readily and to the best advantage.

Theoretically an object is always seen through a geometrical plane in both perspective and mechanical drawing.

As a geometrical plane is a rather difficult feature for the beginner in this work to understand, we shall use a sheet of glass to represent this plane. The sheet of glass is not altogether correct as an illustration of a geometrical plane, but it will answer our purpose for lack of a better substitute.

In a perspective drawing, as shown in Fig. 10, the projection lines or rays from the viewpoint may form *any angle* with the plane. This must of necessity be so, as the object is seen from a single viewpoint.

According to the laws of Orthographic Projection, by which mechanical drawings are made, the projection lines or rays are *always* at *right angles* to the plane, that is, perpendicular to the plane.

This is one of the vital distinctions between the two methods that the student must always keep in mind if he would obtain a clear grasp of the subject.

A perspective drawing is frequently termed a "one-plane drawing," from the fact that the object is viewed through a single plane, while when making a mechanical drawing, theoretically we use a plane for each view.

To illustrate, when laying out the first view of a mechanical drawing (say the top view), the plane is *between* our eye and the object, and parallel to the face shown. Under the theory of the subject this view is projected toward us onto the plane. The end and side views are projected onto planes which parallel and lie near these faces. Then these last two planes are swung up on a level, or in the same plane, with the plane carrying the top view.

By this arrangement we are enabled to look at three sides of an object at the same time.

Suppose the student to be looking down directly on the top of a box, one side and one end of which are hinged to the top; if this side and end are swung up on a level with the top or in the same plane, then we would have an illustration of the theory of the revolution of the geometrical planes.

From the foregoing the student should note that in mechanical drawing the *relation* between the views is fixed definitely, that while the *arrangement* of the views on the drawing paper is a matter of taste, the relative positions of the views to each other cannot be changed.

To make this more clear, Fig. 12 shows three different arrangements of the views of an object, but the relative positions of the views to each other are not changed at all.

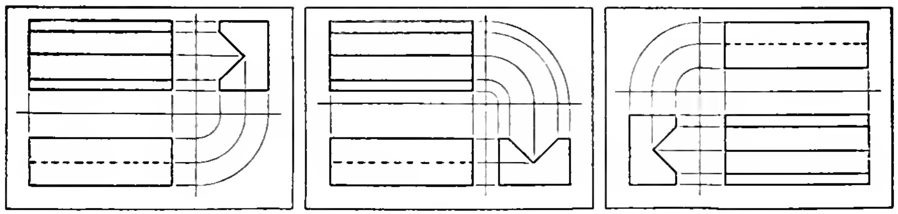


FIG. 12.

The student should make every effort to get a clear understanding of this lesson, as it is of *fundamental importance* in a study of mechanical drawing.

LESSON No. 12.

SHAFT SUPPORT.—Our present lesson is an application of the principles given in our previous lesson. In this lesson the student is given an opportunity to make use of his recently acquired knowledge of projection.

The student will find his work very much simplified if he keeps in mind the positions of the planes of projection, and further if he will remember that the projection lines are always at right angles to these planes.

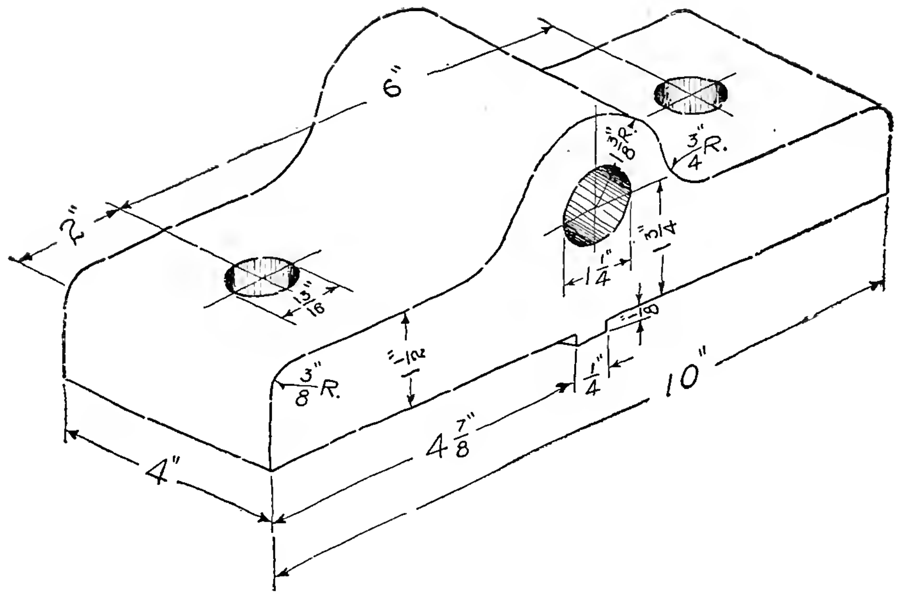
When making the mechanical drawing, the student should try to imagine just what each surface will look like by itself in the form of a view. He will also be obliged to do some thinking, to decide how he will indicate the various surfaces and edges and the type of lines to use for the purpose.

THE DRAWING.—On Drawing C–1005 is shown a perspective sketch of a shaft support from which the student is expected to make a three-view mechanical drawing.

The three views should consist of the top, the side, and one end, say the three surfaces seen in the illustration.

For the first view, choose the surface which seems to you most likely to be an aid in projecting the other views. In this case the side view showing the end of the feather key and the hole for the shaft is possibly the best view to begin with.

Arrange these views neatly on the drawing paper, finish each view carefully and see that no dimensions are left off, so that the final result shall be a drawing which leaves little room for criticism.



CLASS *Industrial*

SHAFT SUPPORT

NAME John W. Roberts DATE Feb. 12. 15.

SCALE

DWG. No. C-1005

LESSON No. 13.

TOOL REST.—This lesson is identical in character with Lesson No. 12; the purpose is the same—to give the student an opportunity to strengthen his hold on the subject of projection.

Another point which the student should consider seriously is the faculty of mental picturing. He should try to develop his imagination by every means within reason, as this faculty is a very important factor in the makeup of the successful business man.

The *ability* to *form* a *mental image* of an object from studying the views of a mechanical drawing is *the* valuable feature of reading such drawings, as one who lacks this ability cannot use the drawing intelligently.

The usual operation is reversed in our present lesson, and in certain other lessons, as we look at the picture and from this make our mechanical drawing.

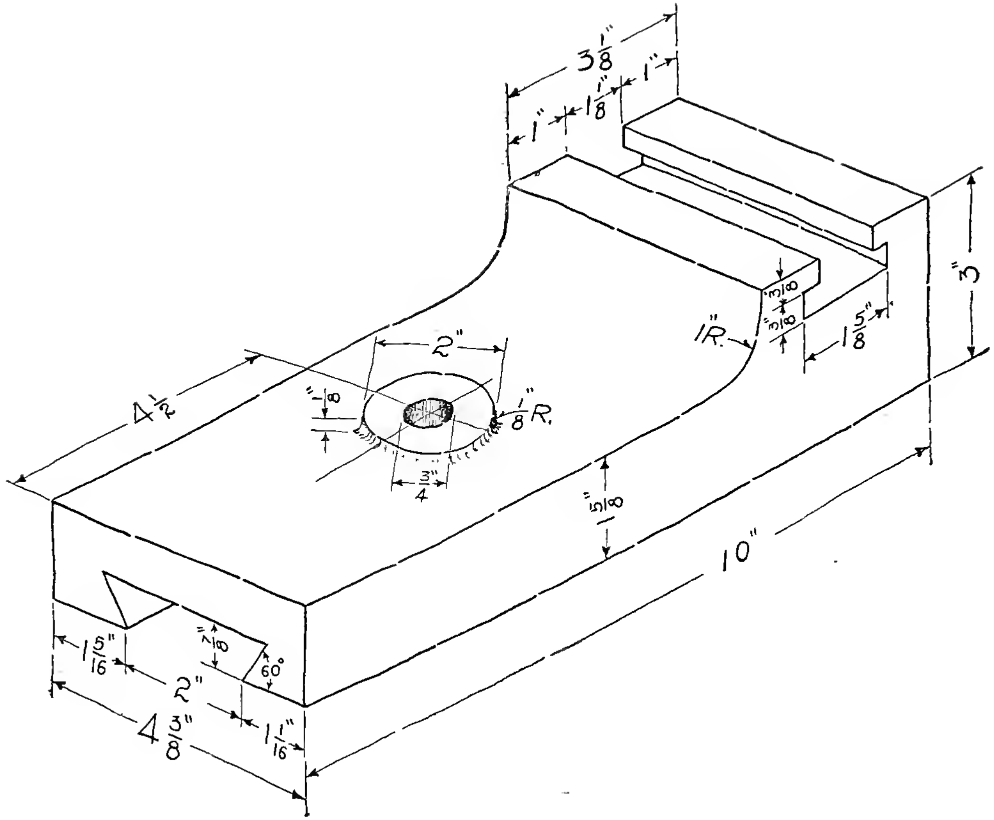
This mode of presenting the subject is adopted because of its value in helping the student to see with greater clearness the difference between the two methods of presentation, but it is also used for the reason that it is an easy step for the student from a known method to an unknown one.

THE DRAWING.—The subject of our lesson is the perspective sketch of a tool rest shown on Drawing C–1006. From this illustration the student is expected to make a three-view mechanical drawing of the tool rest.

Let these three views represent the top, one side, and one end. There is little choice as to which view to make first; either view will do, though the top view cannot be finished until the dovetail is drawn in on the end view and then projected to the top view.

It should be understood that the dovetail groove in the bottom of the tool rest runs through from end to end, and that the bolt hole on top is run through the thickness of metal.

See that no dimensions are left off of the finished drawing and that the final result is a neat, attractive piece of work.



CLASS *Industrial*

TOOL REST

NAME *John W. Roberts* DATE *Feb-18-15.*

SCALE

DWG. No. C-1006

LESSON No. 14.

UNFINISHED VIEWS.—In this lesson we continue our study of the subject of projection. We test the student's knowledge of the subject by a method that differs in the mode of presentation from the two previous lessons, but the principles of projection are the same in all cases.

With one view of an object finished completely and the other two views partially, the student will find it necessary to make use of his imagination if he is to complete the unfinished views in a satisfactory manner.

The student should study each problem carefully, as it is highly desirable that he shall be able to prove the correctness of his finished work.

Certain of the lines left off of the unfinished views are hidden surface lines, others are solid lines, consequently the student will indicate his grasp of the subject by the way in which he finishes these views.

THE DRAWING.—A number of pieces of various shapes are shown in Drawing C–1007, some of the views of each piece being incomplete. The student is expected to lay out a full-size pencil copy of this drawing with all the views properly completed.

It is suggested that the student make use of projection planes as illustrated in Fig. 1, for by means of this aid the problems will be greatly simplified and there is less likelihood of the views being finished incorrectly.

Do this work neatly, showing all the necessary hidden surface lines and placing on all dimensions as shown, but keep clearly in mind the thought that the important feature is to use this work as an aid in obtaining a thorough grasp of the principles of projection.

In Fig. 1, view C is complete; finish A and B.
In Fig. 2, view B is complete; finish A and C.
In Fig. 3, view C is complete; finish A and B.
In Fig. 4, view C is complete; finish A and B.

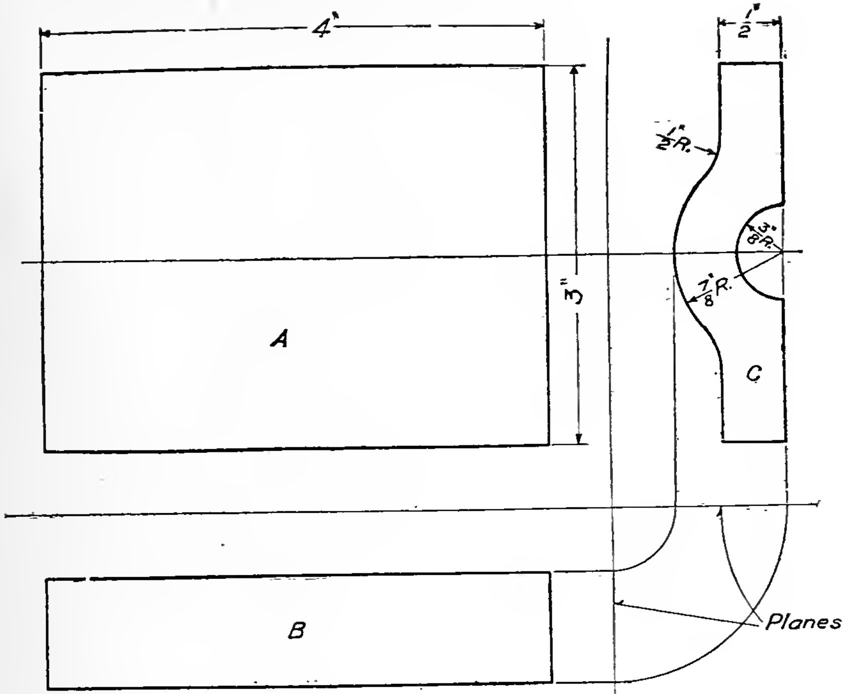


Fig. 1

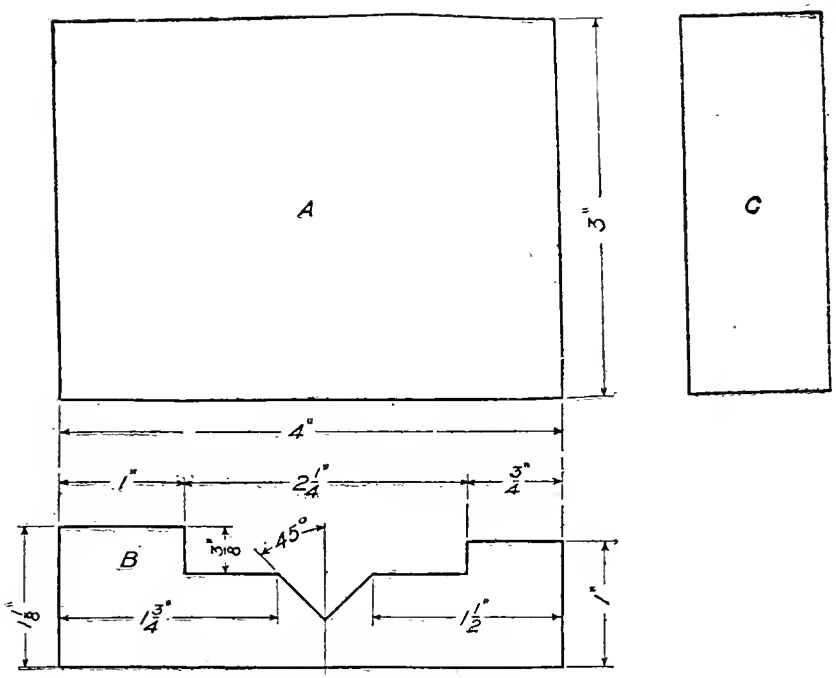


Fig. 2

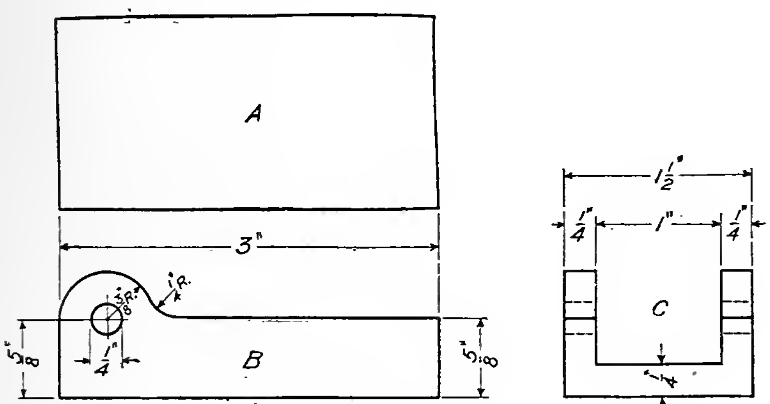


Fig. 3

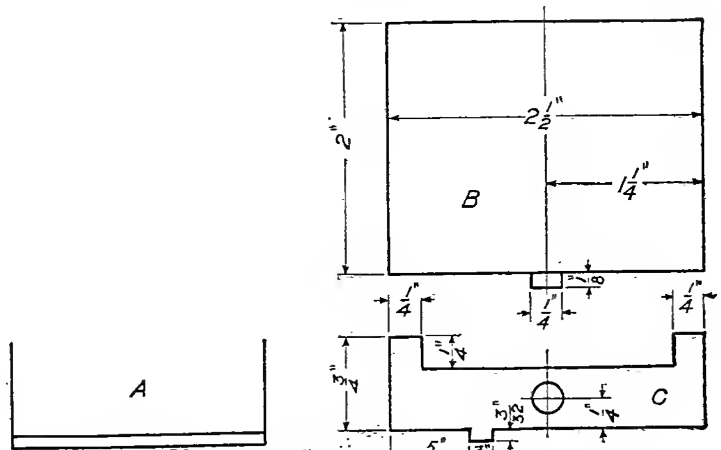


Fig. 4

PROBLEMS IN PROJECTION

CLASS *Industrial*

NAME *John W. Roberts* DATE *Sept. 22-07.*

SCALE *Full Size* DWG. NO. *C-1007*

LESSON No. 15.

SKETCHING.—Whatever course in mechanical drawing the student may pursue, he will sooner or later desire to know something about sketching, or, at least, he will feel the need of it.

A knowledge of sketching is exceedingly useful to men of most of the trades, and the lessons on this subject have been planned with the belief that they may assist the students to use their pencils more freely and easily in making simple mechanical drawings free-hand.

METHOD.—The method that we shall follow, we shall call the "Short-stroke Method," from the fact that as we draw a line in any direction, it is not made by a single stroke of the pencil, but by a series of short strokes. There should be the smallest possible opening between the ends of these short lines, and it would be better still if the ends were to just touch without overlapping.

The object of using these short strokes is to enable the student to correct an error in direction at any point along the line. The result is that the general direction of the line is straight, and though there may be slight errors along the line, they in nowise cause any doubt as to its meaning.

PENCILS.—For sketching, a pencil equalling an H or HB in hardness will give very satisfactory results, though a 2H Koh-i-noor will last much better. The latter, however, is just a little too hard except when used on Manilla paper.

Learn to hold the pencil easily and naturally between the first and second fingers and the thumb, in a manner very similar to that used in writing.

Do not turn the paper to suit the direction in which a line is to be drawn, but fasten it down to the drawing board and try to develop that freedom of movement of fingers, wrist, and arm which will enable one to draw a line in any direction with equal ease.

In drawing straight lines as indicated on the illustration, the student will soon discover that they are made in certain directions by a movement of the wrist mainly. In other directions it is mostly a movement of the fingers which gives the best results.

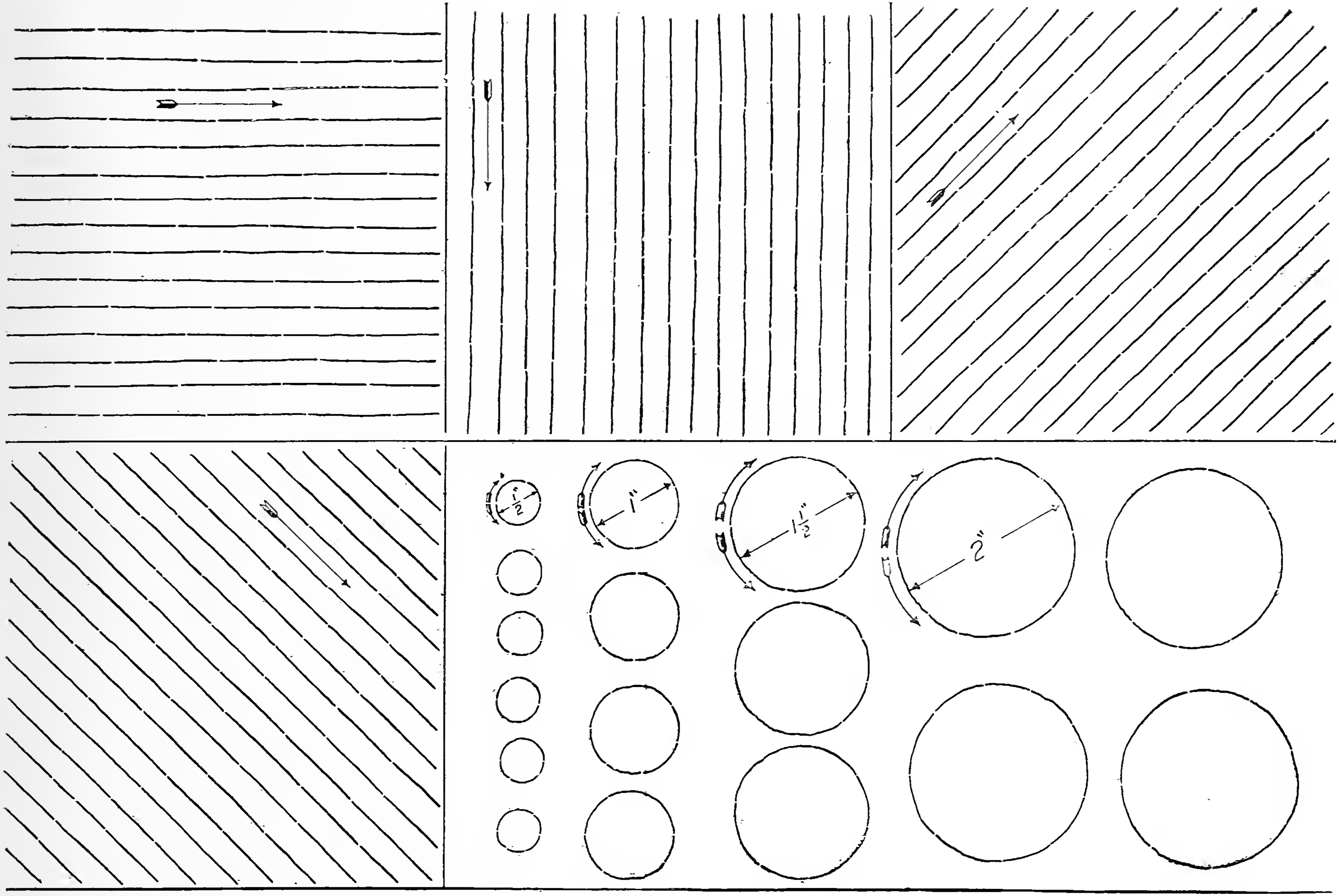
It is quite difficult to make neat circles free-hand, but by putting into practice the following suggestions, the student should obtain satisfactory results.

The student should sit upright while drawing, so that he may the better get a clear view of his work as a whole. By having the head well up over the work, the eyes can direct the movements of the pencil better, and they are in a better position to see if the desired shape is growing under the pencil, than if held close to the work. Start at a point on the left side, as indicated by the arrows, and with short strokes form the upper half of the circle. Then, starting at the same point, form the lower half in the same manner.

THE LESSON.—Fasten the drawing paper smoothly to the board and divide it into sections, as shown in the illustration.

The straight lines should be drawn about $\frac{1}{4}$ inch apart and in the directions indicated by the arrows.

Draw the circles to the sizes shown, without using a rule; try to see how nearly correct you can make them by the eye.



SKETCHING

CLASS Industrial

NAME John W. Roberts DATE Mar. 20_06.

SCALE Full Size DWG. No. C-1008

LESSON No. 16.

PROPORTIONS.—It is a very valuable acquirement, when sketching, to be able to make the details of a drawing of the proper proportions in relation to each other.

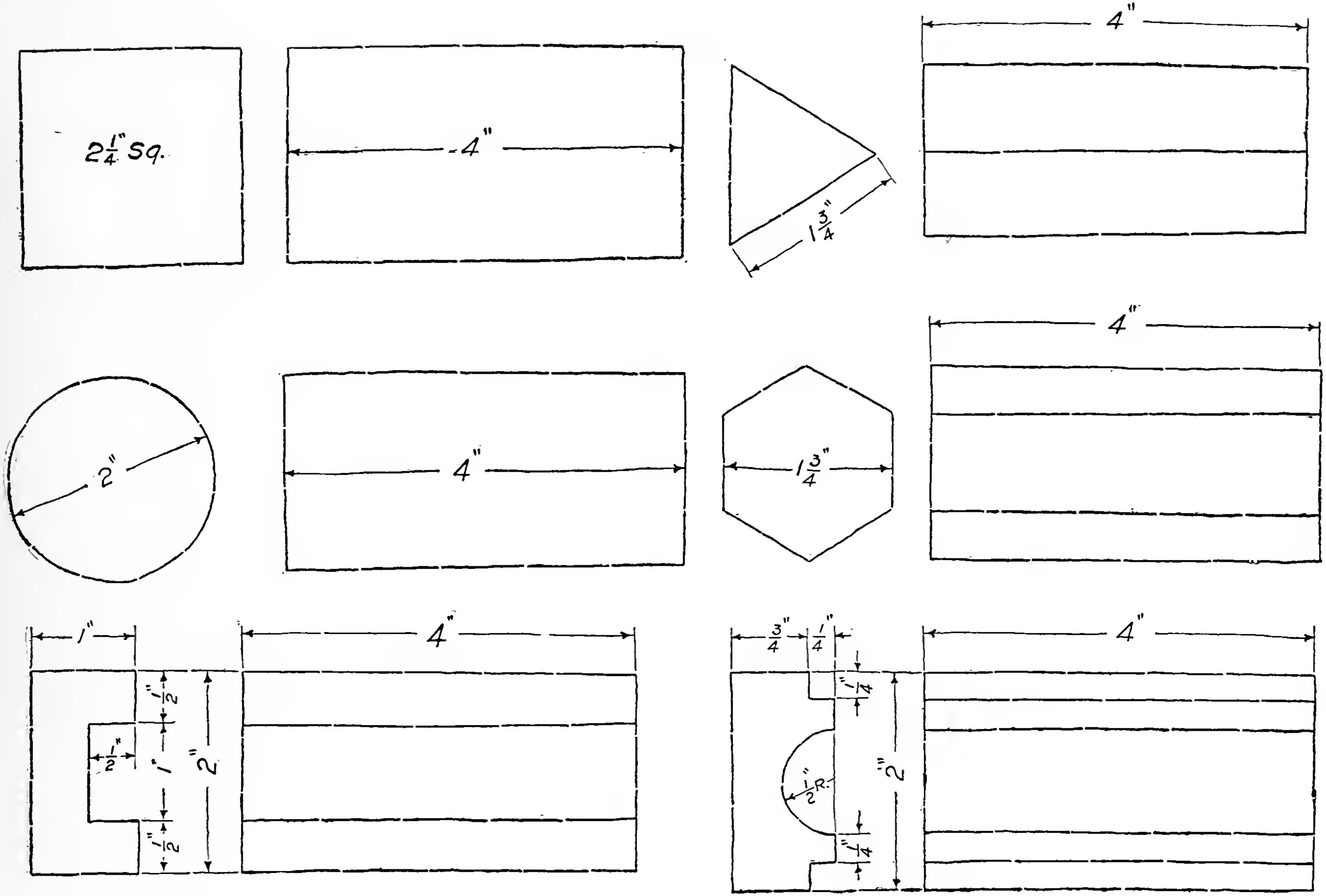
The scale of a sketch is of little importance, provided it is large enough to show clearly the piece or pieces we desire to illustrate. But that which is of importance is that each piece, or detail of the piece, should be drawn to the same scale.

To obtain this result it is quite necessary that the student should train his faculty of observation so as to have a sense of measurement, and so that, without the aid of a rule, he may be able to draw a sketch approximately to a given size.

The student will be helped to develop this faculty if, in sketching, he practises drawing to a certain scale or to given dimensions.

LESSON.—Make a neat free-hand full-size drawing of the figures shown in the illustration. Draw each figure to the dimensions given, as nearly as possible, without using a rule.

Observe that two views are shown of each piece, and try to see the relation between the views.



SKETCHING

CLASS Industrial

NAME John W. Roberts DATE Mar. 20-06.

SCALE Full Size DWG. No. C-1009

LESSON No. 17.

REFERENCE MATTER.—The information given on Drawing C–1010 is a type of reference matter which will be of value to the student when laying out many of the future lessons.

In commercial work it is the custom to give no detail dimensions for bolts and nuts on what are known as "assembly drawings." The diameter of nuts and the diameter and length of bolts are usually given so that these items may be ordered. The dimensions necessary for drawing these details of a mechanical drawing are found in "Data Books," which are made up of a series of reference sheets.

In certain future lessons are shown nuts and bolts, the sizes of which are given, but the student will be obliged to use the information given on this reference sheet to obtain the dimensions necessary to make the drawings of these details.

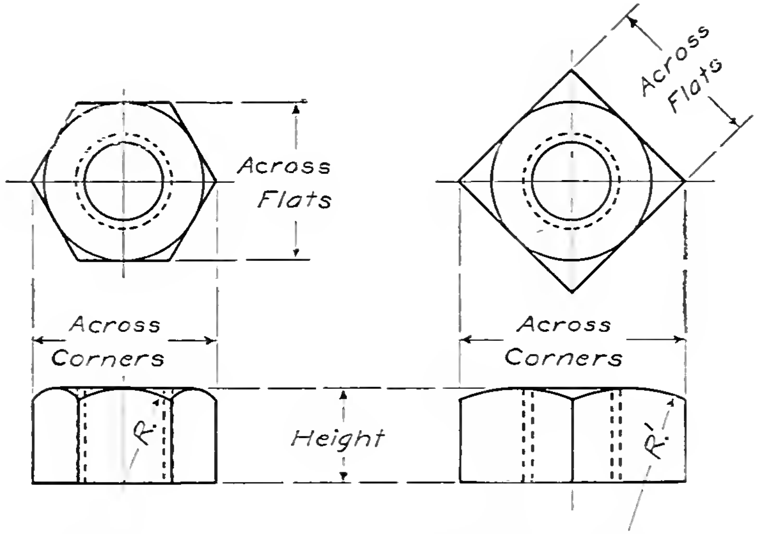
Conventional methods of indicating screw threads are also given on this reference sheet. The methods shown are among the simplest in use and for this reason are very desirable.

Frequently we have objects to make drawings of, which are of such shape that we can illustrate them to the best advantage by "breaking" out part of the object.

The main advantage gained as a rule is that this permits us to draw the object to a large scale on a smaller sheet of paper than we would otherwise be enabled to do.

It is always understood that the portion broken out is identical with that on each side of the "break."

The student is expected to lay out a pencil copy of this reference sheet, the teacher deciding the question as to sizes of nuts, bolts, etc.



U.S. STD. FOR NUTS & BOLT HEADS

Dia. Across Flats = $1\frac{1}{2}$ X Bolt dia. + $\frac{1}{8}''$

" " Corners (Hex.) = Dia. Across Flats X 1.156

" " " (Sq.) = " " " X 1.414

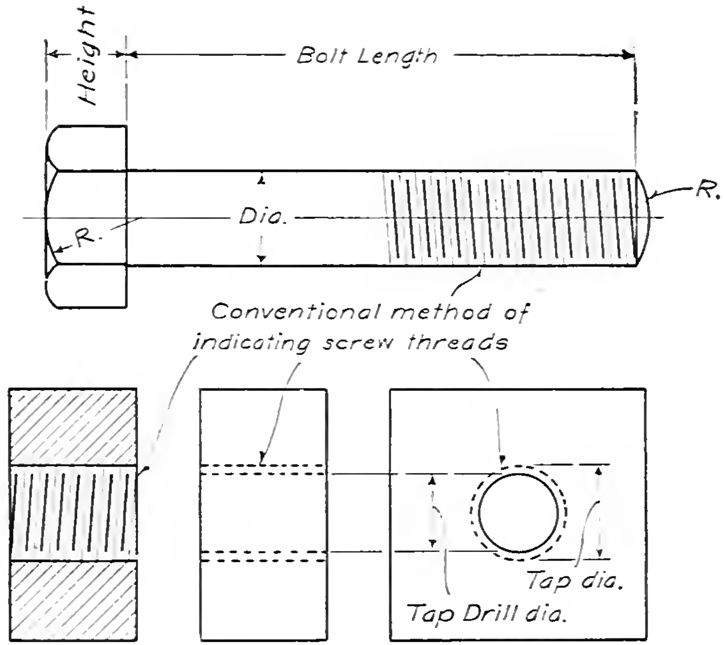
Height of Nut = Bolt dia.

" " Bolt Head = $\frac{1}{2}$ of Dia. Across Flats

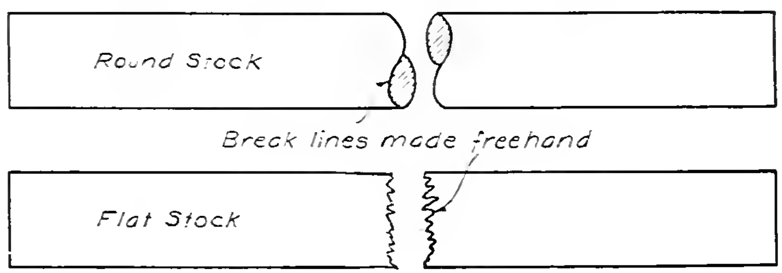
Not U.S. Std.

Radius R = Bolt dia.

" R' = $1\frac{1}{2}$ X Bolt dia.



Methods of showing a "Break" in material



CLASS Industrial

NAME John W. Roberts DATE Mar_16_15.

REFERENCE MATTER

SCALE

DWG. No. C.1010

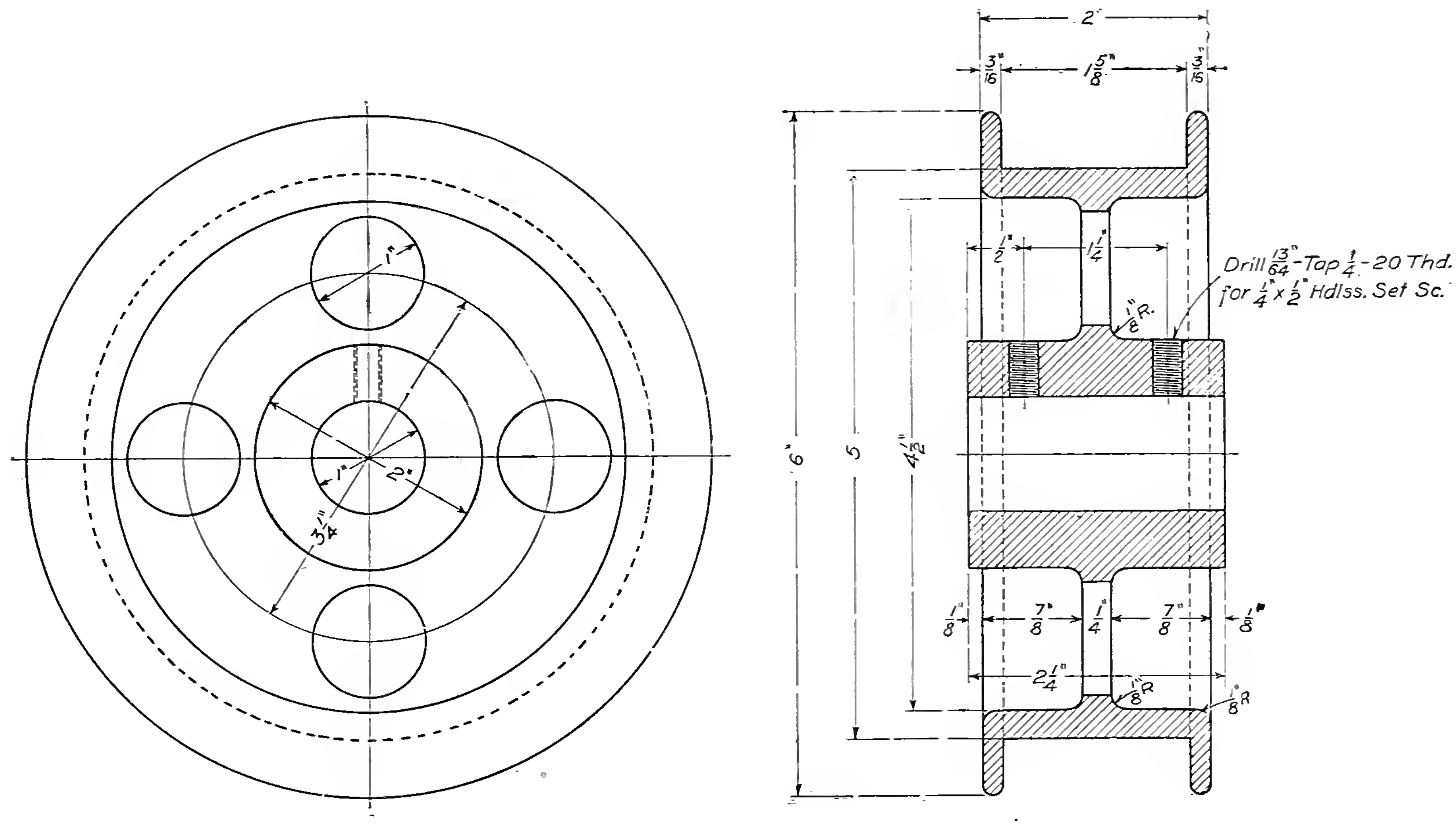
LESSON No. 18.

FLANGED PULLEY.—The figures on Drawing C–1011 represent a side view and a true sectional view of a Flanged Pulley.

The conventional method of indicating screw threads is used in the holes for the set screws; note that the threads appear to be left hand. These threads are in reality right hand, and it is desired that the student shall reason out for himself just why it is correct to show the threads in this manner.

This lesson is intended to give the student a clearer conception of the subject of sectioning; to help him to make a mental picture of what the pulley looks like when cut in half along the vertical center line. Make a free-hand sketch of the pulley, copying carefully all dimensions and necessary information. From this sketch make a full-size pencil drawing of the pulley, placing all dimensions just as shown on the illustration.

When dimensioning a drawing, bear in mind that your drawing is to be used as an instrument to furnish exact information to some one in the shop, and unless you do your work carefully and accurately, costly mistakes may be the result.



FLANGED PULLEY

CLASS Industrial

NAME John W. Roberts DATE Oct. 16 - 05.

SCALE Full Size DWG. No. C-1011

LESSON No. 19.

PROJECTION.—In all of our previous lessons which dealt with the subject of projection, we have considered problems in which the planes were parallel to the surface projected.

The major portion of the drawings made in commercial drafting rooms are made after this fashion, at the same time there are many pieces of such shape that it is necessary to use planes which are placed at some other angle to the object than the conventional one.

It naturally follows that the student should be able to place a plane in any position in relation to an object, so that he may project a certain surface in such manner as to obtain the desired view.

While the plane may form any angle with the surfaces of the object, when the view is projected the projection lines must form right angles with the plane just as when the plane is placed in the conventional manner.

The piece used in the illustration is not of a type to need a special angle plane, but this simple shape will serve very well to demonstrate the principle involved.

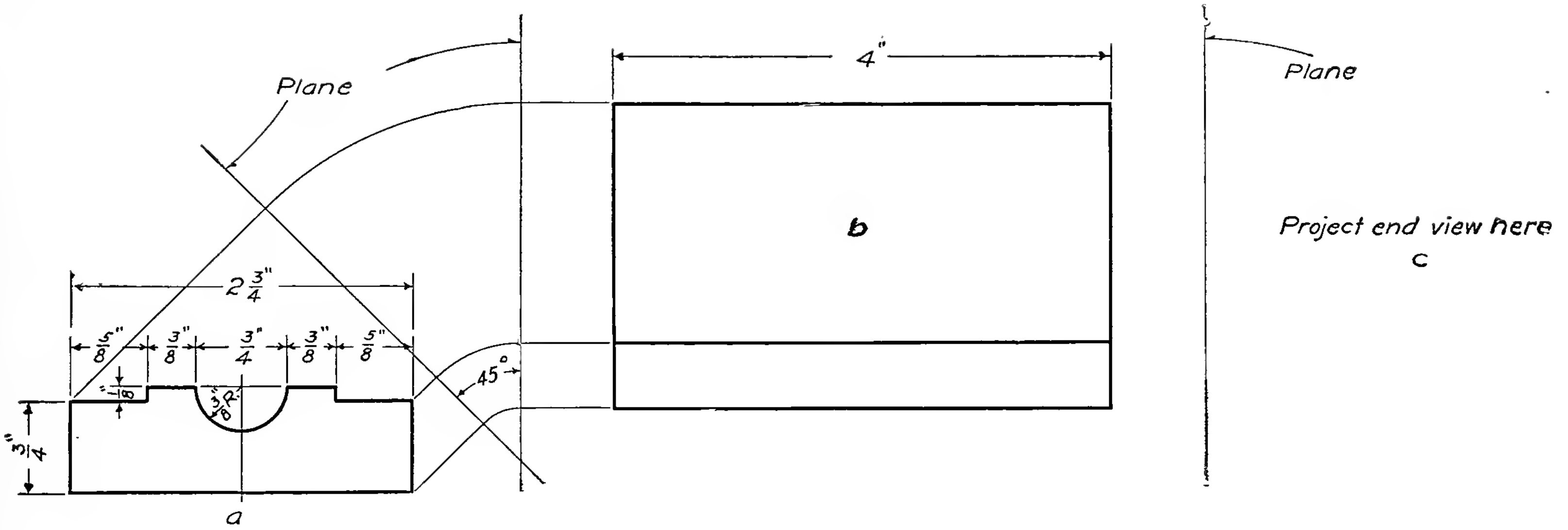
THE DRAWING.—On Drawing C–1012 is shown a partially finished problem in projection. View (*a*) is an end view of a rectangular block with all the dimensions shown; view (*b*) is a partially finished, foreshortened top and edge view, showing the length of the block.

View (*a*) is projected upon a plane which is set at an angle of 45°; this plane is then raised to a vertical position and swung around one-fourth turn or 90°, so as to show view (*b*).

View (*c*) should be an end view of the block tilted at an angle of 45°.

Lay out the three views full-size, finishing them completely and placing them in the positions indicated on the drawing.

The student should note that the plane between view (*b*) and view (*c*) is parallel with the end of the block.



CLASS *Industrial*

PROJECTION

NAME *John W. Roberts* DATE *Oct. 10-07.*

SCALE *Full Size* DWG. NO. *C-1012*

LESSON No. 20.

GEOMETRICAL PROBLEMS.—Before taking up the following problems in geometrical construction, the student should see that the points of his pencil and compass are in first-class order, as it is necessary that this work shall be done carefully and accurately.

The main object of this lesson is to familiarize the student with certain geometrical terms and their meaning, all of which are used frequently in mechanical drawing. This is especially necessary for those students who have not studied plane geometry.

When laying out these problems the student is expected to use the following tools *only*: pencil, both triangles, scale, and large compass.

Fig. 1. Bisect (or divide in half) a straight line.

Fig. 2. Bisect a given arc.

Fig. 3. Bisect a given angle.

Fig. 4. Divide a line $2\frac{33}{64}$ inches long into 11 *equal parts.*

Fig. 5. Divide the *space* between two lines into 13 *equal parts,* the lines to be two inches apart.

Fig. 6. Circumscribe a circle *about* a given triangle. Inscribe a circle *within* the same triangle.

Fig. 7. Through a given point draw a line tangent to a given circle, the point being on the circumference of the circle.

Problems 1, 2, and 3 are of such character that the student should be able to solve them without help.

Fig. 4. To divide a given line into an equal number of parts, draw a construction line, at any angle and of any length, from one end of the line which is to be divided, then using the scale, lay off on the construction line the number of parts desired. Now with one triangle as a ruling edge, and the other as a base, set the ruling edge in line with the last point on the construction line and the end of the line to be divided and connect these two points.

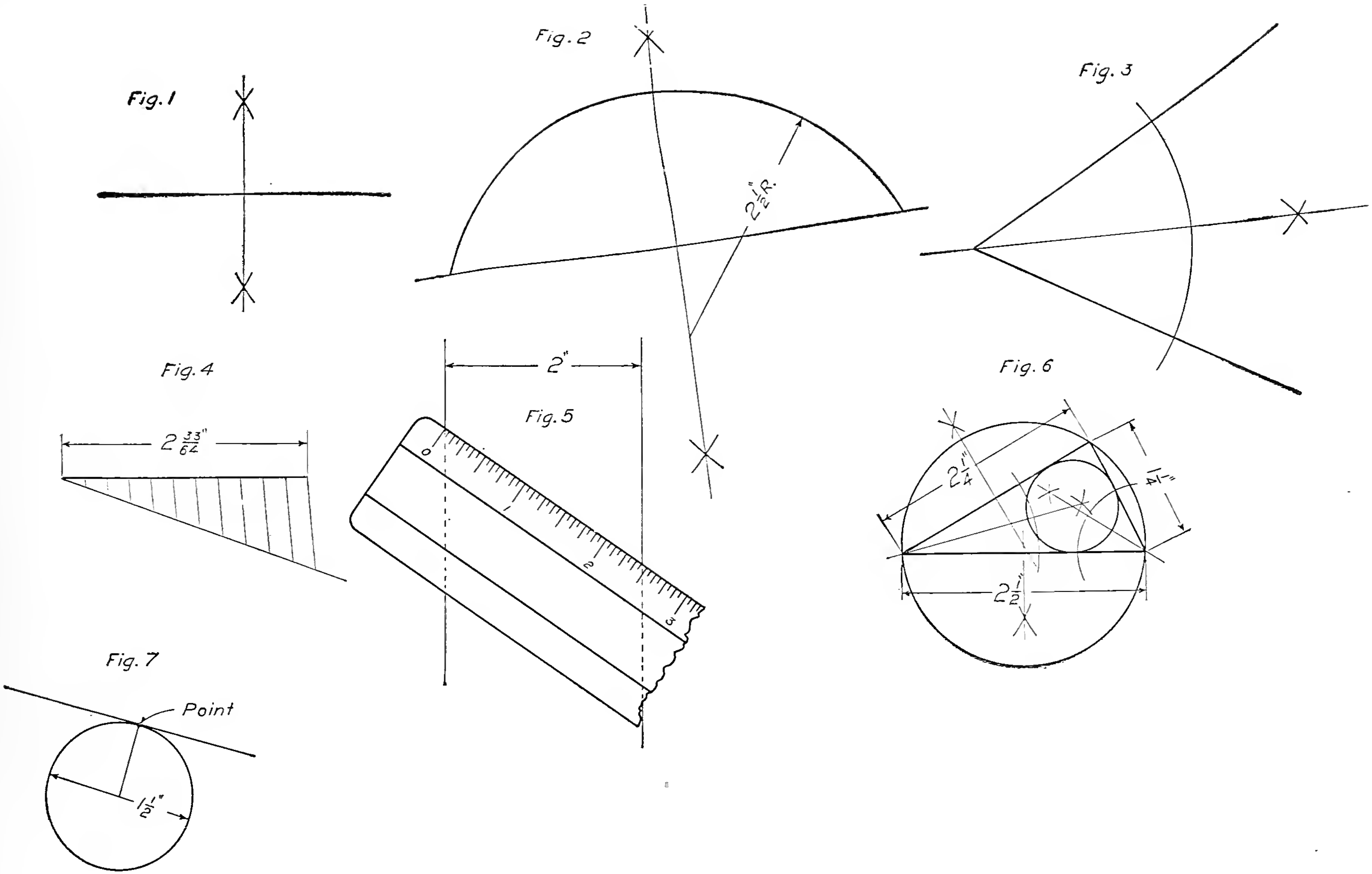
All the other points may be projected from the construction line to the original line in like manner, keeping the ruling edge parallel with the end line.

Fig. 5 is an adaptation of the construction described for Fig. 4. The scale is tilted to an angle which will bring the number of divisions desired between the lines, then the points are set off opposite the graduations representing the unit of division.

Fig. 6 is a combination of Figs. 1 and 3 and should be within the comprehension of the student.

The student should not have much trouble with Fig. 7, especially if he will observe that the point of tangency is located where the radius of the circle intersects the tangent line, when these two lines are at right angles to each other.

The ability to *make* this drawing is of itself of little value, but if the student fully grasps the principles involved in these problems and applies them to later work, this lesson will be of considerable value.



GEOMETRICAL PROBLEMS

CLASS Industrial

NAME John W. Roberts DATE Nov. 20_06.

SCALE Full Size DWG. NO. C-1013

LESSON No. 21.

THE ELLIPSE.—Make a neat pencil drawing of an ellipse by the three methods indicated, and of the elliptical curve shown on Drawing C–1014.

When drawing the ellipse, make the major or long axis $3\frac{1}{2}$ inches, and the minor or short axis 2 inches in each case.

For Fig. 1, lay off the major and minor axes to the lengths given above; take a straight edge made of any suitable material, as card-board or wood, and, on one edge, mark off the points AB equal to half the minor axis; from A, mark off point C equal to half the major axis. Place the straight edge so that the point B comes on the major axis and point C on the minor axis; now, with the pencil, mark a point on the drawing paper at A. Shift the straight edge and repeat (keeping B and C on the major and minor axes respectively), placing a sufficient number of points on the paper to enable you to trace a curve through them easily.

The method illustrated in Fig. 2 is of such a nature that the student should be able to solve the problem without assistance.

Fig. 3 is known as the "Three-radii Method."

Construct the rectangle ADCEB. Draw the diagonal AC. Through D, draw DF at right angles to AC. Then, F is the center for arc GCH, and J is the center for arc KAL.

Make OM=OC. Describe the semicircle AM.

Make OP=CN. With center F, describe arc RPS. Make AQ=ON. Then, with J as center and radius JQ, describe arc intersecting arc RPS at T. T is the center for the tangent arc LG.

To construct the curve shown at Fig. 4, divide the base lines of the curve into the same number of equal parts (any number) and connect these division points by straight lines. The combined outer surfaces of these lines form the desired curve.

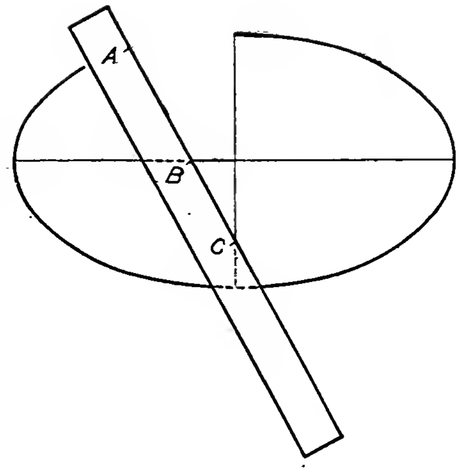


Fig. 1

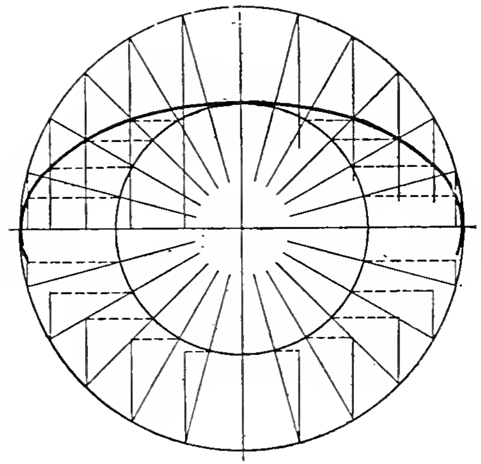


Fig. 2

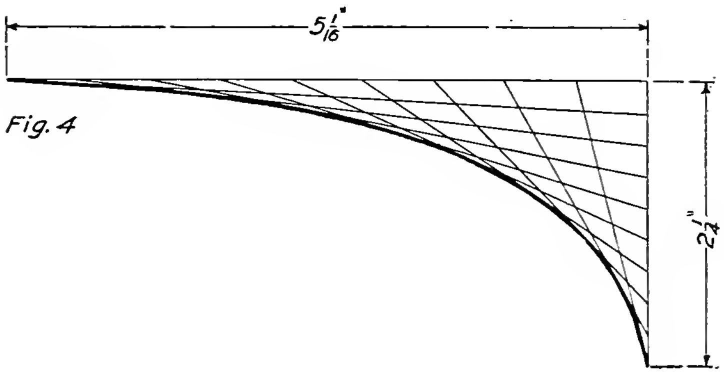


Fig. 4

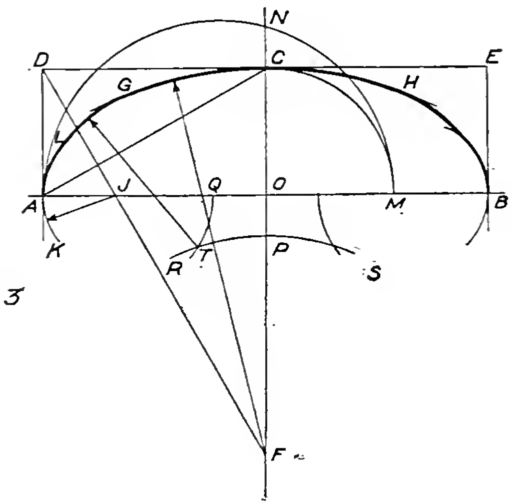


Fig. 3

THE ELLIPSE

CLASS *Industrial*

NAME **John W. Roberts** DATE Dec. 18-06. SCALE Full Size DWG. No. C-1014

LESSON No. 22.

METHOD OF HOLDING PEN.—In learning to trace, one of the first problems which confronts the students is how to hold the instruments.

In general, the ruling pen and the pen point of the compass should be held in such a manner as to bring the points of both jaws on the paper at the same time, as shown at (*b*) of the illustration, Fig. 13.

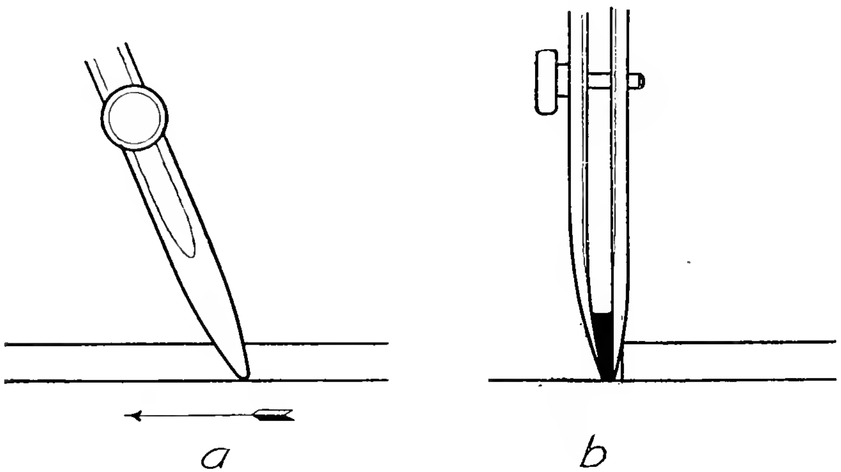


Fig. 13.

Do not lean the pen either toward the ruling edge or away from it, but hold it in a vertical plane, thus obtaining clean even lines free from a ragged edge.

While the pen should not be leaned toward or away from the ruling edge, it will be found that the ink will flow more freely if the pen is leaned slightly *in the direction in which the line is being ruled*, as shown at (*a*).

When using the pen compass for large circles, the legs may be bent at the joints, so as to meet these conditions.

TRACING CLOTH.—The student will find one side of the tracing cloth with a glazed or calendered surface, while the other side has a dull finish. If the glossy side is used, it will be necessary to dust the surface with powdered chalk or talcum powder, as the ink will not flow freely otherwise. In a great many drafting rooms the dull side of the cloth is used from preference, as it takes ink very well without powder of any kind, though the powder makes the ink flow more freely.

CARE OF PENS.—A common mistake of most beginners is to fill the pen with too much ink, with the result that, before they realize it, there is a big blot on their work. This is not necessarily caused by the pen being filled too full, but it is frequently the cause. It is better to fill the pen oftener and to use less ink at one time.

Another very good habit to acquire is to wipe out the pen each time fresh ink is to be put in, as the ink flows more freely from a clean pen than from a dirty one.

TRACING MACHINE BOLT.—When beginning a tracing tack the cloth down carefully over the pencil drawing, then dust the surface with powder, using care to wipe off what is left after rubbing the tracing cloth with a clean linen rag, then begin by adjusting the compass pen to the width of line desired for an outline. In deciding on the width of line, the student should bear in mind that to get blue-prints with clear white lines, it is necessary that the lines of the tracing be fairly heavy; not the fine "pretty" lines that beginners are so prone to use.

The illustration, Fig. 14, shows the various steps in making a tracing: First, throw in all the circles and radii; then, beginning at the top, rule in all the horizontal outlines; next, starting at the

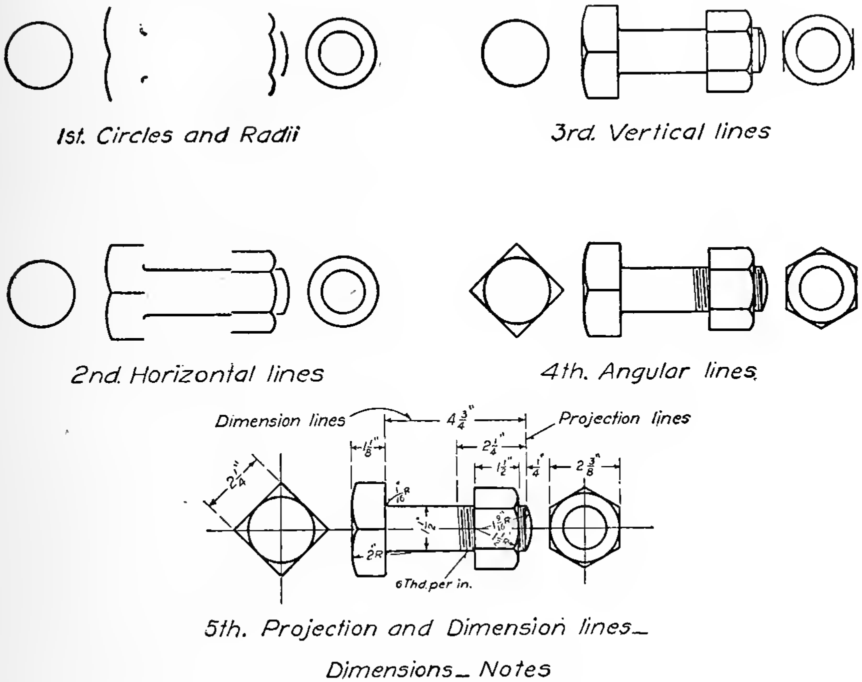


FIG. 14.

left side, rule in all the vertical outlines; and, finally, rule in the angular outlines.

Now, adjusting the pen to a much finer line, rule in the projection lines; these lines for drawings of small figures should be composed of dashes $\frac{1}{4}$ to $\frac{3}{8}$ inch long, and for large figures $\frac{1}{2}$ to $\frac{3}{4}$ inch long. Do not let the projection lines touch the figure, but leave a slight opening between the end of the line and the figure.

Next, rule in the dimension lines; these lines for drawings of small figures should be solid except for the opening left for the dimension, but on drawings of large figures they may be broken lines of long dashes—the length to suit the size of the drawing.

Now, place the arrow heads on the dimension lines and put in the dimensions, using care to make the figures clearly.

FINISHED DRAWING.—In the finished drawing there should be a marked contrast between the weight of the outlines of the figure, and of the center, projection, and dimension lines; the latter should be decidedly lighter than the outlines. When these various lines are drawn to the proper proportions and are well arranged, the figure seems to stand out by itself and is much more easily understood.

When the drawing is completed, print the title on neatly and carefully, as the looks of a good drawing will be spoiled if the printing is done in a careless, slipshod manner.

Use a Gillott's No. 303 pen point for lettering and dimensioning the drawing.

LESSON No. 23.

HAND WHEEL.—In our previous lessons on sectioning we have dealt with true sections, while, in the present lesson, the sectional view shown of the Hand Wheel is what is called a "conventional section." In other words, it is not a true section, but a special one which is used because it illustrates the shape of the piece more clearly for the pattern maker and machinist. The draftsman can lay it out more easily and quickly as well—an economy that should be considered.

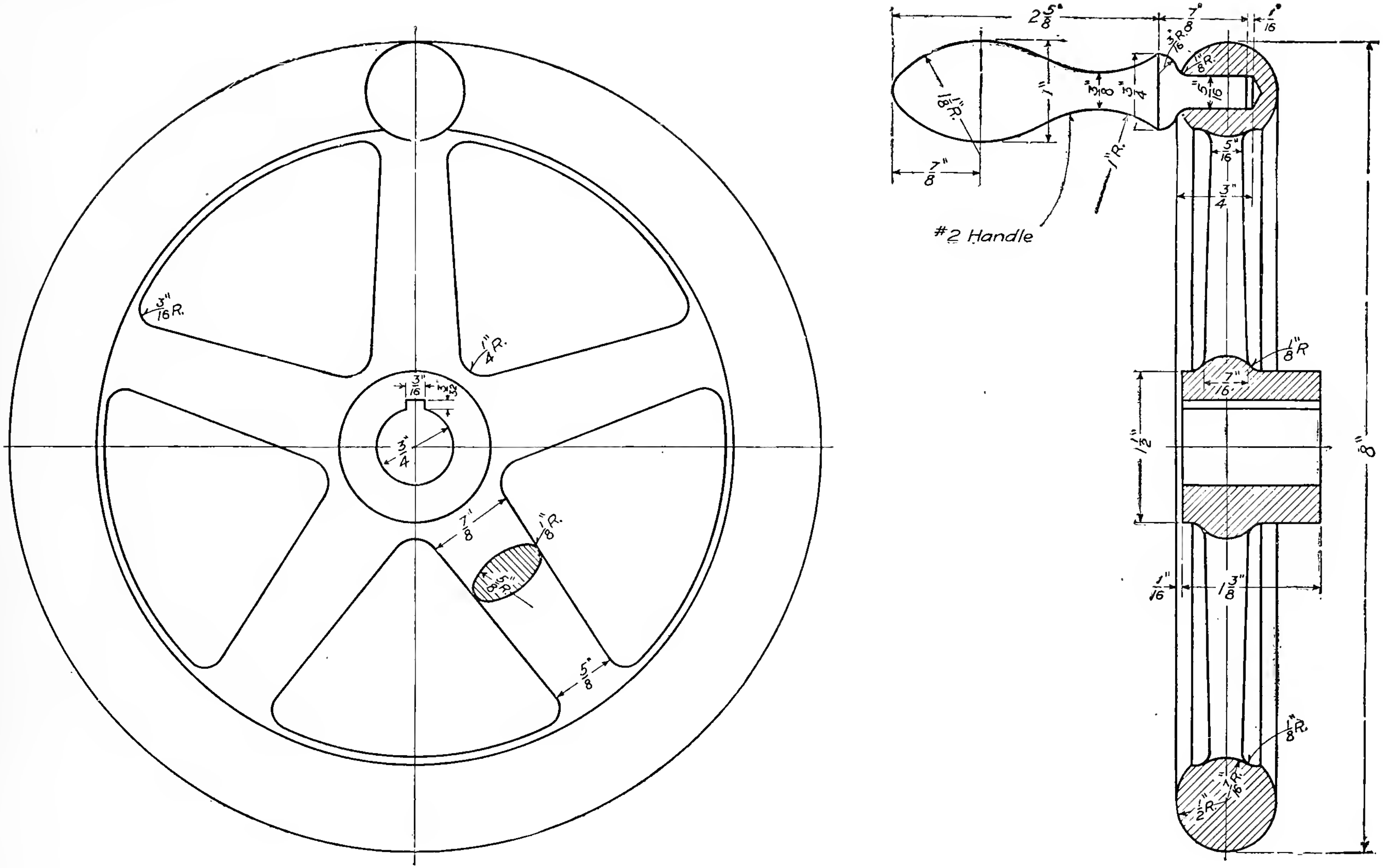
As an illustration of the convenience of special sections, note the conventional section of the arm of the hand wheel; without this section it would be pretty hard to give the pattern maker a clear idea as to the shape of the arm.

This conventional method of sectioning is used constantly on drawings of such pieces as wheels, pulleys, and gears with arms.

LESSON.—Make a full-size pencil drawing of the Hand Wheel.

Place all dimensions just as shown, with the exception of those that refer to the handle; these dimensions should be left off, as they were intended merely as an aid to the student. Mark this part "No. 2 Handle." When the pencil drawing is complete, make a tracing of it. Try to do this work neatly; make the lines of the tracing clear and distinct, keeping in mind the instructions given in Lesson No. 22.

When drawing the ball of the handle, *do not* try to make the two radii ($1\frac{1}{8}$ and 1 inch) touch, as they should be joined with a tangent *straight* line. The student should bear in mind that where radii swinging in opposite directions are to be joined, a straight line should be used for this purpose, otherwise the line appears to have a corner or uneven place. Where the radii are small, as at the stem of the handle, the rule may be overlooked.



8" HAND WHEEL

CLASS *Industrial*

NAME *John W. Roberts.* DATE

SCALE *Full Size* DWG. NO. C-1015

LESSON No. 24.

DRAWING TO SCALE.—In all of our previous lessons, the pieces illustrated have been drawn full size; in our present lesson we shall take up the subject of drawing objects smaller than full size, or "drawing to scale," as it is generally termed.

In most modern commercial drafting rooms, the drawings are made on paper of certain sizes. These standard sizes (usually three or four) are adopted to suit the needs of the manufacturer, and each of the machine parts built is shown on one of these standard-size sheets.

Small parts may be drawn full size, but large ones must, of necessity, be drawn to a smaller scale, as $\frac{1}{2}$ size, $\frac{1}{4}$ size, and $\frac{1}{8}$ size.

These are the scales usually adopted by manufacturers of machinery. The piece is drawn to the scale necessary for clearness and best suited to one of the standard-size sheets, while the dimensions are placed in the same manner as if the piece were drawn full size. In other words, the dimensions must show the sizes to which the piece is to be finished in the shop.

In drawing to a given scale, that scale becomes our unit of measurement. As an illustration, take our present lesson, in which the student is expected to make a half-size drawing of the Lathe Face Plate.

As $\frac{1}{2}$ inch is our unit of measurement, $\frac{1}{2}$ inch equals 1 inch, but instead of dividing each dimension by two, read it thus: "$1\frac{3}{4}$ halves for $1\frac{3}{4}$ inches, 5 halves for 5 inches, $\frac{5}{8}$ halves for $\frac{5}{8}$ inch, etc."

If the student will carefully study the illustration in Fig. 19, he will observe that the divisions can be made on the scale by simply training the eye to perform this operation.

As an aid in readily locating a dimension on the scale, look for the nearest large graduation; the full-size dimension on Fig. 19 is $5\frac{23}{32}$ inches, a thirty-second less than $5\frac{3}{4}$ inches, which figure can be found at once. To find $5\frac{23}{32}$ inches half size, look for $5\frac{3}{4}$ inches half size and point back toward zero one-half of the space between graduations. To locate $5\frac{23}{32}$ inches quarter size, look for $5\frac{3}{4}$ inches quarter size and point back toward zero one-fourth of the space between graduations. $5\frac{23}{32}$ inches one-eighth size is located in the same manner.

By this method it is necessary for the student to keep but one dimension in mind when making a division, and when he learns to read his scale properly, he is much less liable to make mistakes than if he were to make his divisions in the usual way.

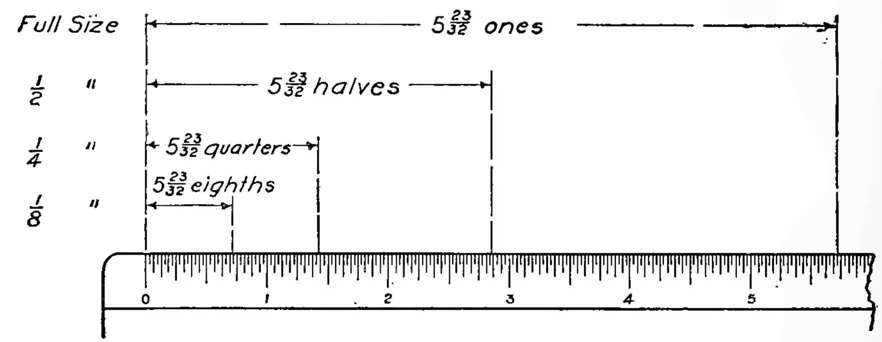


FIG. 15.

To get a radius for half-size circles, set the compasses to the dimension quarter size. For example, to draw the end view of the hub 4-inch diameter half size, take a radius of 4-inch diameter quarter size.

LESSON.—From the illustration, make a half-size pencil drawing of the Lathe Face Plate.

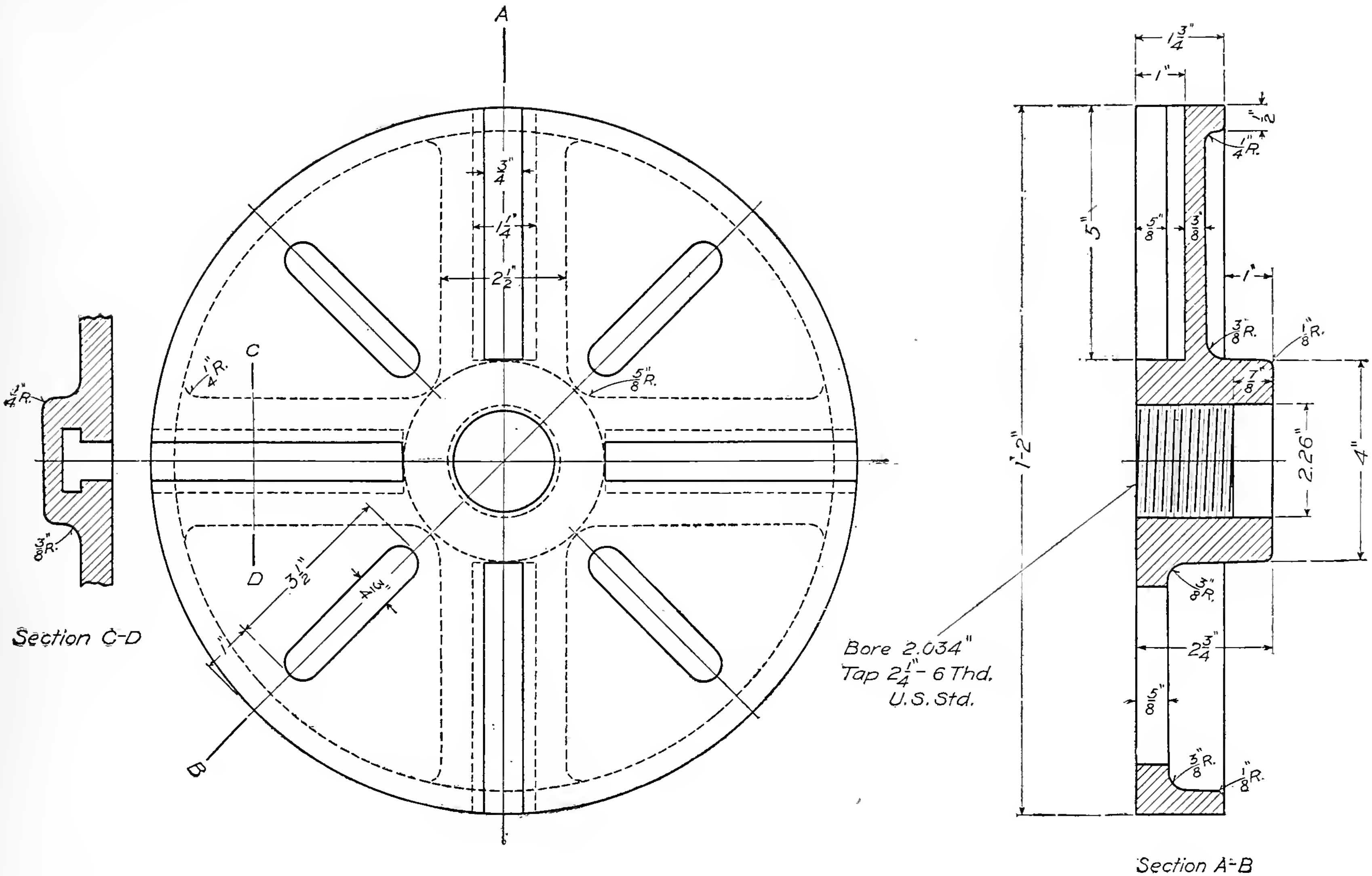
Section AB is cut along the line AB, and is a conventional method of showing a true section along this line.

Section CD is necessary to give the pattern maker a clear idea of the shape of the metal back of the T slot.

Where dimensions are given in decimals, draw that part to the nearest sixty-fourth.

Study the illustration carefully, so as to get a clear idea of the meaning of each line. Do not simply copy; try to make a *mental picture* of the shape of the piece.

Use the edge of your scale, which is graduated in sixteenths, and work from dimensions given.



LATHE FACE PLATE

CLASS Industrial

NAME John W. Roberts DATE Oct. 20-06.

SCALE ½ Size DWG. NO. C-1016

LESSON No. 25.

ASSEMBLY DRAWINGS.—It is a common practice in most drafting rooms to make drawings which show the various parts of some mechanism fastened together. These drawings are termed "assembly drawings," and they are of decided value to the men in the shop who erect or assemble the machines.

The most important feature of this lesson is this new type of drawing, which is brought to the student's attention now for the first time.

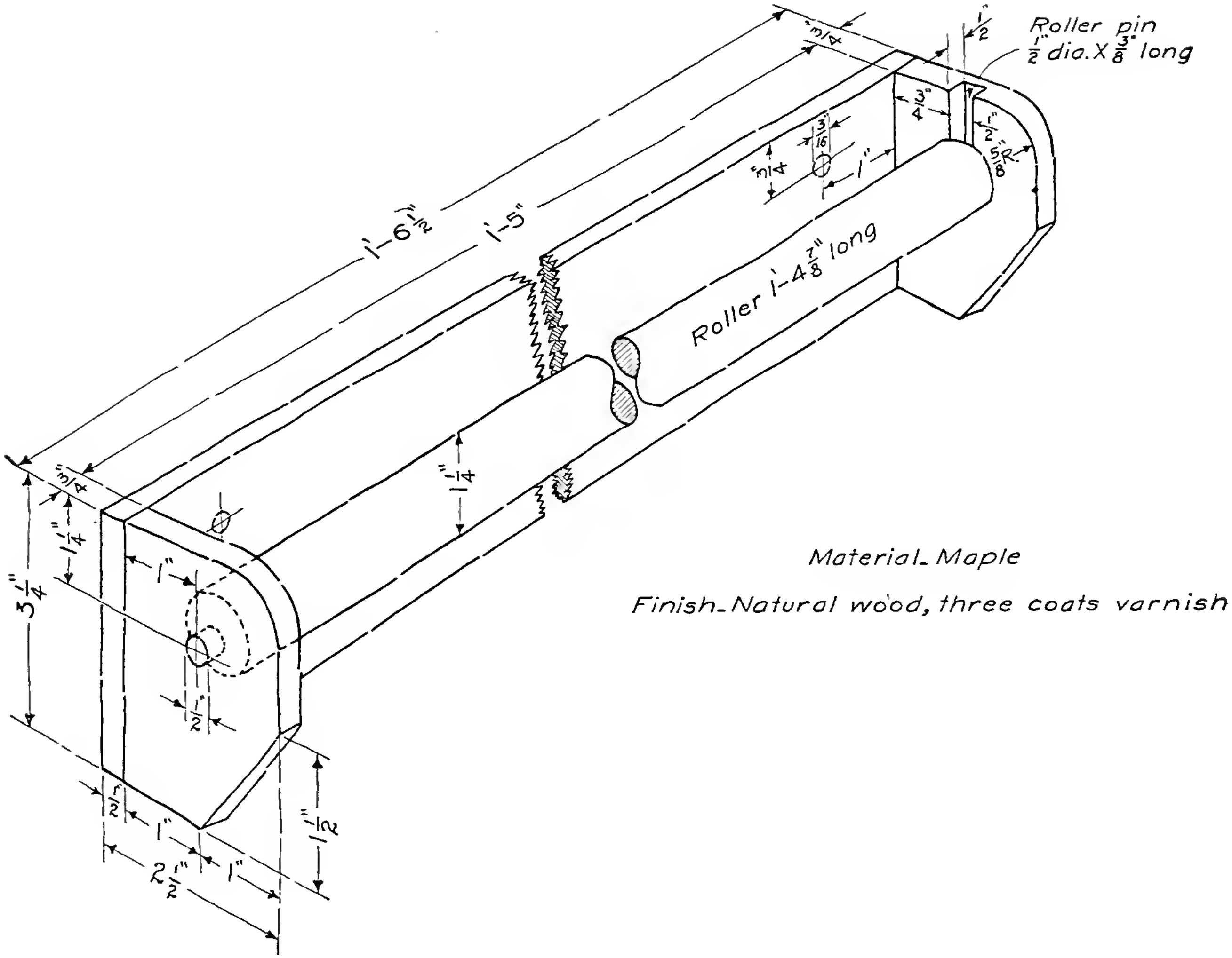
Another feature that is important and one which will bear repetition is that the student is obliged to transpose a perspective drawing into a mechanical one, thus causing him to make use of his knowledge of orthographic projection.

LESSON.—Our first assembly drawing is to illustrate the parts of a towel roller fastened together.

From the sketch on Drawing C–1017, the student is expected to make a three-view mechanical drawing. These three views should represent the top, front, and one end of the towel roller.

Make this drawing full-size scale, with the exception of the length, which should be taken care of by "breaking" out sufficient material to allow the views to be arranged properly on the drawing paper.

All hidden surfaces and all necessary dimensions must be shown, so that the finished result is a complete working drawing.



Material_Maple

Finish_Natural wood, three coats varnish

TOWEL ROLLER

CLASS Industrial

NAME John W. Roberts DATE Mar_12_15.

SCALE

DWG. No_C_1017

LESSON No. 26.

COUPLING.—From the sketch shown on Drawing C–1018, make an accurate half-size pencil drawing and tracing of the Safety Flange Coupling.

This coupling derives its name from the flanges that extend out over the bolt heads and nuts, keeping the workman's clothing from being caught, thus preventing many serious accidents.

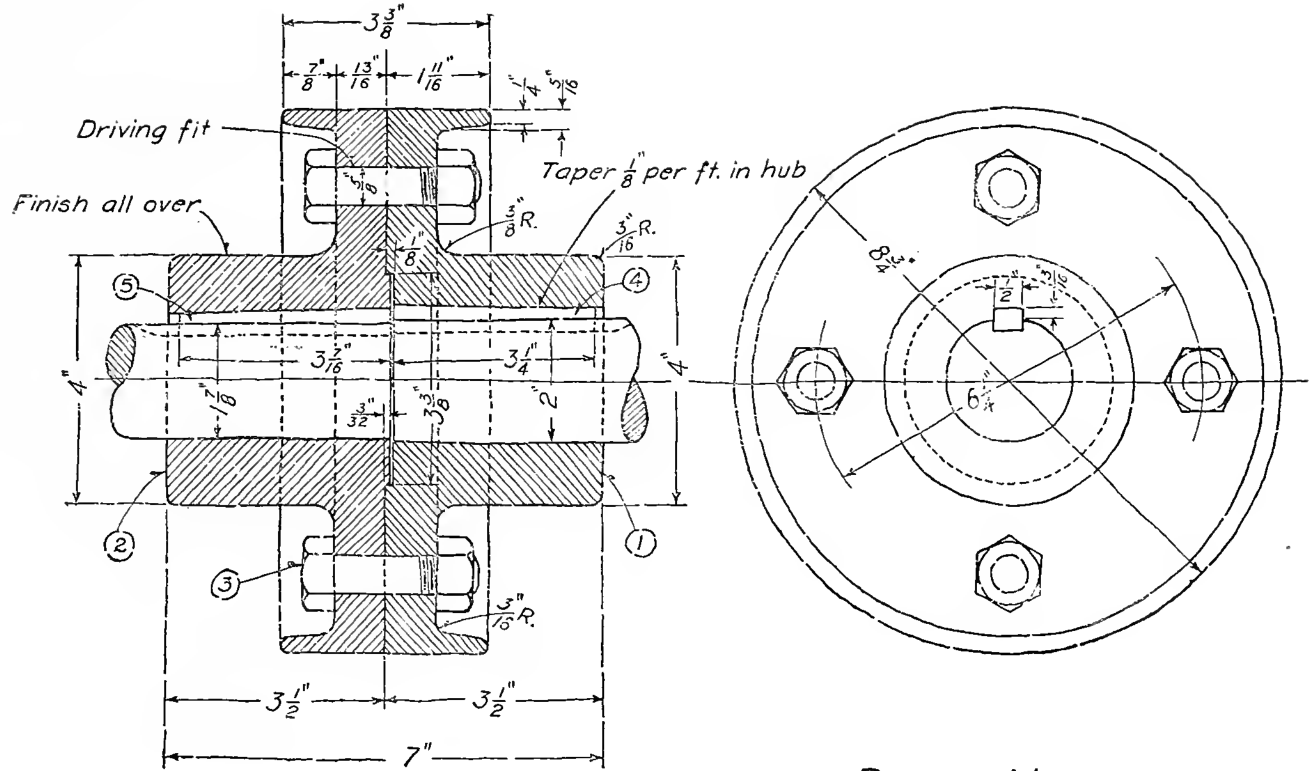
Note that the shafts are of different diameters and that each half coupling is fitted with a taper key. These keys are tapered on one side only—that which is set in the hub of the coupling. When assembling, the half coupling is forced onto the shaft and the keys are fitted before the two halves are bolted together; this brings the large end of the key at the end of the shaft, so that when the halves are fastened together the keys cannot work loose.

Observe that one-half of the coupling is made with a recess $3\frac{3}{8}$ inches diameter by $\frac{1}{8}$ inch deep, to receive the boss on the other half coupling; this is for the purpose of keeping the halves in line with each other.

The student should take especial notice of the "Bill of Material" shown on the drawing. This is a device to aid the clerical force, who usually order the materials from which the mechanism is produced.

When items are not exactly alike they must be given separate item numbers. Frequently the same pattern will do for both halves of a machine part even though they are finished differently and have different item numbers.

Remember that *neat, accurate* work is expected, not work done in careless fashion.



BILL OF MATERIAL

Item No.	Description and Material	Pat. No.	Req.
1	Half Coupling, C.I.	A.201	1
2	" " "	"	1
3	5/8 X 2 1/4" Machine Bolt with Nut		4
4	3/8 X 1/2" X 3 1/4" Taper Key, C.R.		1
5	3/8 X 1/2 X 3 7/16" " " "		1

SAFETY FLANGE COUPLING

CLASS Industrial

NAME John W. Roberts DATE Nov. 16-06.

SCALE 1/2 Size

DWG. NO. C-1018.

LESSON No. 27.

COUPLING.—The assembly drawing used for the present lesson is of a "Compression Shaft Coupling."

This coupling can be clamped around the ends of two shafts, the two halves of the coupling being held together by means of the bolts shown. The upper half of the coupling is fitted with a key which keeps the shafts in line.

No dimensions are shown for the bolts and nuts used on this coupling, but the student will find the diameter of bolts given on the drawing and by means of the reference sheet, Lesson No. 17, he can calculate the dimensions necessary for laying out these parts.

In laying out the frame for the "Bill of Material," the student is expected to use the same dimensions as were given in our previous lesson.

LESSON.—Make a half-size pencil drawing and tracing of the coupling shown on Drawing C–1019.

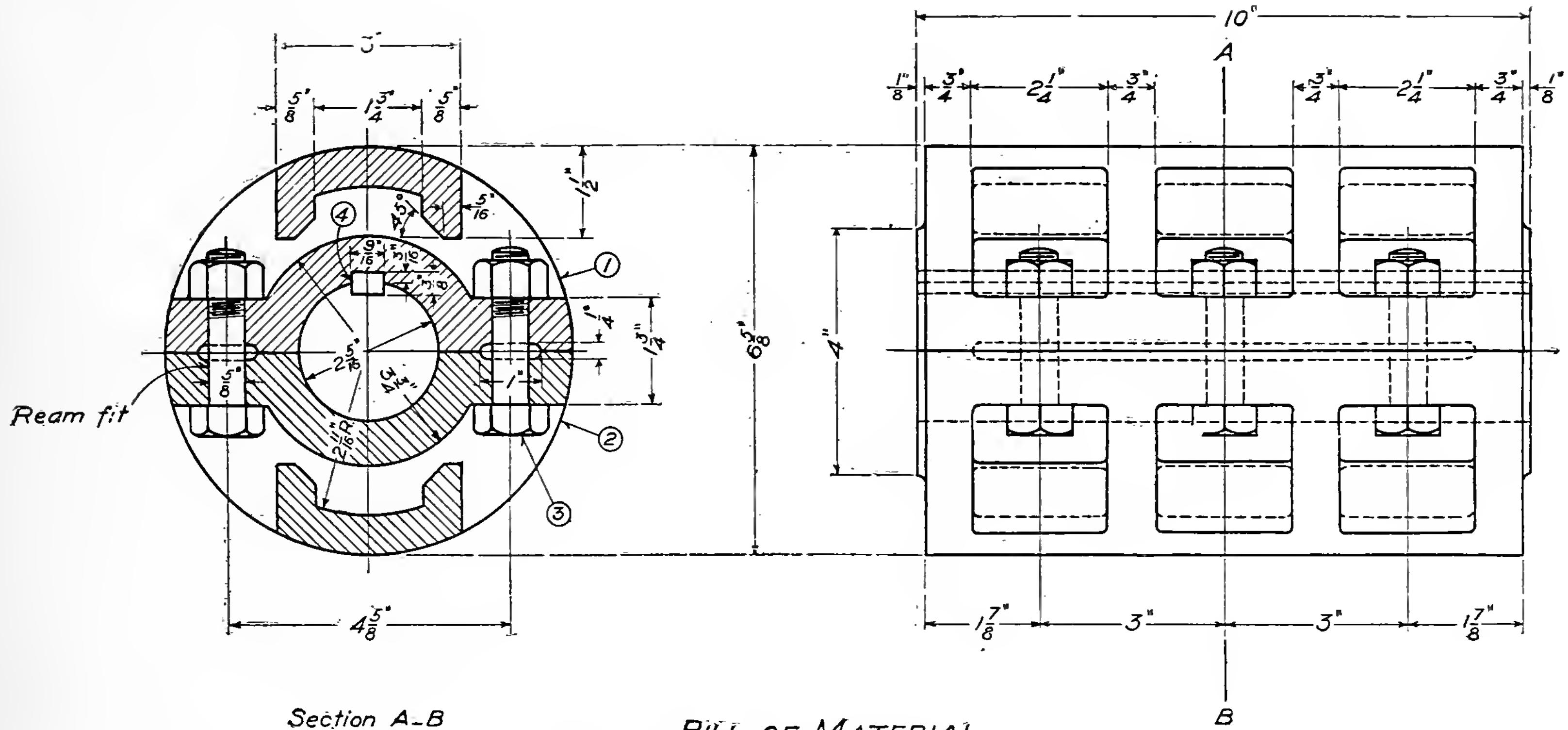
It is expected that the student will *not* copy the views as they are shown, but will lay them out as follows: Section A–B, to be shown as at present, except that the view is to be revolved on its axis (clockwise) 90° or one-fourth turn, bringing the bolts *horizontal*, with the nuts on the right-hand side.

This change in Section A–B will necessitate the lengthwise view being revolved on its axis one-fourth turn toward us, bringing the ends of the nuts on all six bolts into view.

It is understood that the dimensions given on the present illustration are to be used on the rearranged views.

As a result of these changes the lengthwise view of the coupling will present a very different appearance from the present one, consequently the student will be obliged to reason out for himself just how this view will appear, and as he places the lines of the drawing, so will he indicate his ability to represent the various surfaces properly.

While accuracy and neatness are important features of this work, mental effort is of equal or greater importance, and the student should do all in his power to stimulate the reasoning faculties.



Section A-B

BILL OF MATERIAL

Item No.	Description and Material	Pat. No.	Req.
1	Half Coupling C. I.	A-200	1
2	" " "	"	1
3	$\frac{5}{8}$" x $2\frac{1}{2}$" M.B. Tap Bolt with Nut		6
4	$\frac{3}{8}$" x $\frac{9}{16}$" x 10" Key		1

COMPRESSION SHAFT COUPLING

CLASS Industrial

NAME John W. Roberts DATE Oct. 20-06.

SCALE $\frac{1}{2}$ Size DWG NO. C-1019

LESSON No. 28.

SPECIFICATION.—In most of our previous lessons the student has had a graphic illustration to work from; in our present lesson he will have a written description of an object, which for lack of a better name we have termed a specification.

The main purpose of this lesson is to further strengthen the student's faculty for making *mental pictures*, by causing him to make a freehand drawing of something not shown, but for which it is necessary for him to use his imagination.

The student is expected to make freehand a two-view sketch of the pulley described. He is to complete this sketch fully and carefully, with all dimensions, so that using it as a guide he may lay out a half-size two-view mechanical drawing.

When laying out the sectional view, keep in mind the instructions given in Lesson No. 23, on the conventional method of sectioning for pieces of this type.

PULLEY.—From the following data make a freehand sketch showing a side view and a sectional view of the pulley described:

Diameter of the pulley, 1 foot 2 inches at the crown (or greatest diameter); face or width, 6 inches; taper of crown equals $\frac{1}{4}$ inch per foot.

Diameter of hub, $3\frac{3}{4}$ inches; length of hub, 4 inches; bore, $1\frac{7}{8}$ inches; with keyway $\frac{7}{16}$ inch wide by $\frac{3}{16}$ inch high.

Rim to be made with rib around inside where joined to arms. Rim $\frac{1}{4}$ inch thick at edge, and $\frac{9}{16}$ thick through crown and rib; inside of rim to be straight to arms.

Number of arms, 6; arms to be $1\frac{1}{4}$ inches wide by $\frac{5}{8}$ inch thick at rim, and $1\frac{5}{8}$ inches wide by $\frac{13}{16}$ inch thick at hub; $\frac{1}{4}$-inch fillets (or rounded corners) at side of arms at hub, and at side and edge of arms at the rim; $\frac{5}{8}$-inch radius at the junction of the arms near the hub.

When locating the keyway in the side view showing the end of the hub, be sure to place it central with one of the arms, as this will give a stronger hub section than if the keyway is placed midway between two arms.

The completed pencil drawing should be given the title of 14″ Pulley, Drawing C–1020.

LESSON No. 29.

ENGINEERING CURVES.—The principle of this lesson is to *generate the path of a moving point.* The curves illustrated are constantly used in engineering work, and a knowledge of their construction should be both interesting and valuable to the student.

The cycloid is the curve generated by a point on the circumference of a circle when rolled along a straight line. When the generating circle is rolled *upon* another circle, an epicycloid will be generated.

When the generating circle is rolled *under* another circle, a hypocycloid will be generated.

To generate the cycloid mechanically, lay off the base and center lines; set the dividers to any short space (so that the length of the chord is about equal to the arc), in this instance $\frac{1}{4}$ inch, and step off 16 or 18 points on the base line. Erect perpendiculars through these points; swing in the generating circle from these different points, so as to place the circle in the different positions which it would assume in making one complete revolution. Now, with the dividers, step off on the second circle the distance it has rolled along the base line, in this case $\frac{1}{4}$ inch. Repeat for each new position of the generating circle (measuring with the dividers the distance around the circle that it has rolled along the base line), until a complete revolution has been made, then trace the curve through the points thus found.

The epicycloid and hypocycloid are generated in the same manner, the base circle replacing the base line of the cycloid.

The involute is the curve generated by every point in a cord as it is wrapped upon or unwound from a cylinder.

To develop the involute mechanically, unwind a little bit of the cord at a time, and step off upon the line the distance unwound.

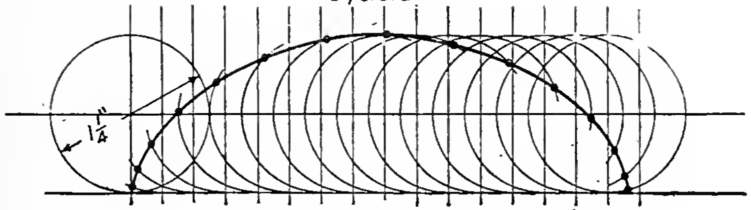
Set the dividers to $\frac{1}{4}$ inch and step off 10 or 12 divisions upon the base circle; from these points draw tangent lines to represent the cord in different positions when being unwound.

The helix or screw is the curve which would be generated upon a cylinder revolved at a constant speed against a point, the point moving along at a constant speed parallel with the axis of the cylinder.

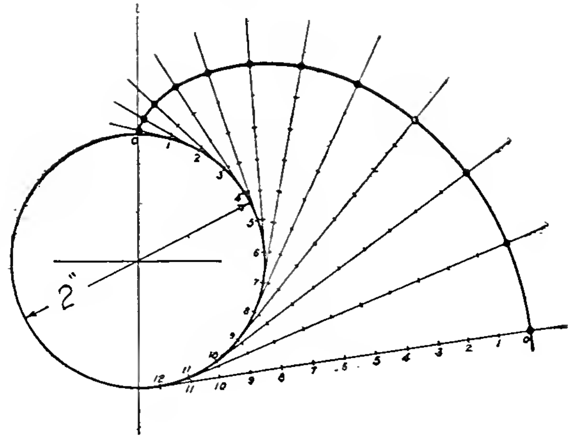
To generate this curve mechanically, divide the circumference of the cylinder into any number of equal parts, in this case 25, numbering these points from the left on the center line, as shown. Divide the pitch distance on the cylinder into the same number of equal spaces (25) by which the circumference of the cylinder was divided.

Now locate points on the side view of the cylinder at the intersection of the vertical division lines with the horizontal projection lines (these lines being projected from the points on the end view of the cylinder); then trace the curve through the points thus formed. This subject requires very accurate and careful work on the part of the student.

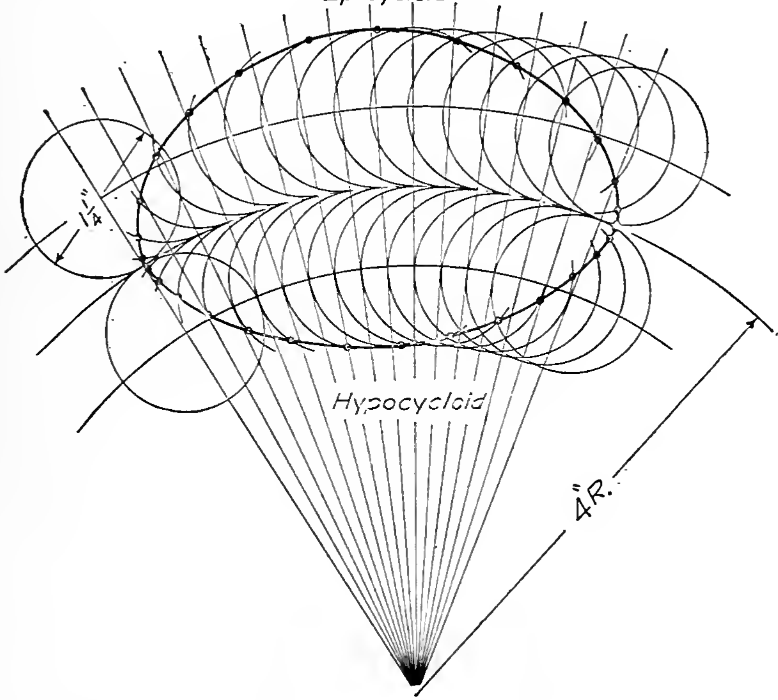
Cycloid



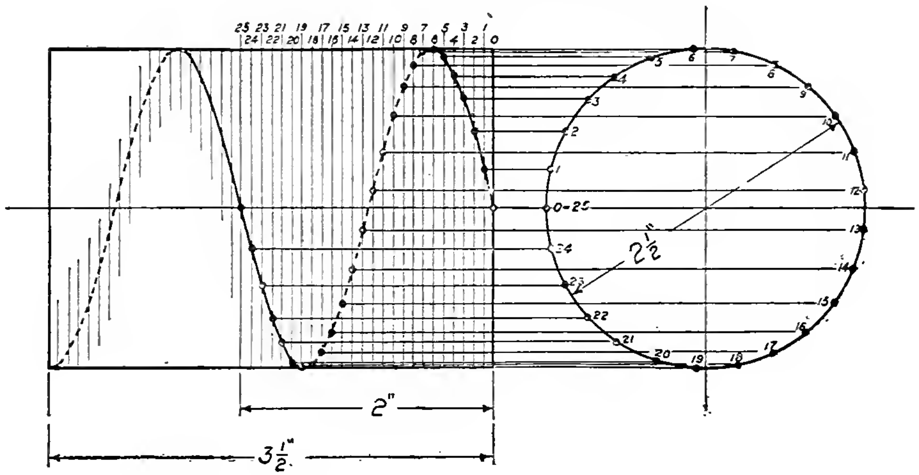
Involute



Epicycloid



Helix or Screw _ 2" Pitch



CLASS Industrial

NAME John W. Roberts   DATE Feb. 6_07.

ENGINEERING CURVES
THE PATH OF A MOVING POINT

SCALE Full Size   DWG. NO. C_1021

LESSON No. 30.

CONIC SECTIONS.—The fundamental principle involved in this lesson is the projection of a *point*.

A thorough knowledge of this subject is of great value when drawing pieces of such shape that it is difficult to project correctly the necessary views. From this lesson the student should realize that curves and circular figures may be projected in a very simple manner if taken point by point.

The figures shown on Drawing C-1022 illustrate a cone cut by a plane in two different ways. When a cone is cut by a plane which passes between the apex and the base at any angle (except a right angle), the section will be an ellipse. If the cone is cut by a plane which is parallel with one side, the section made is a parabola.

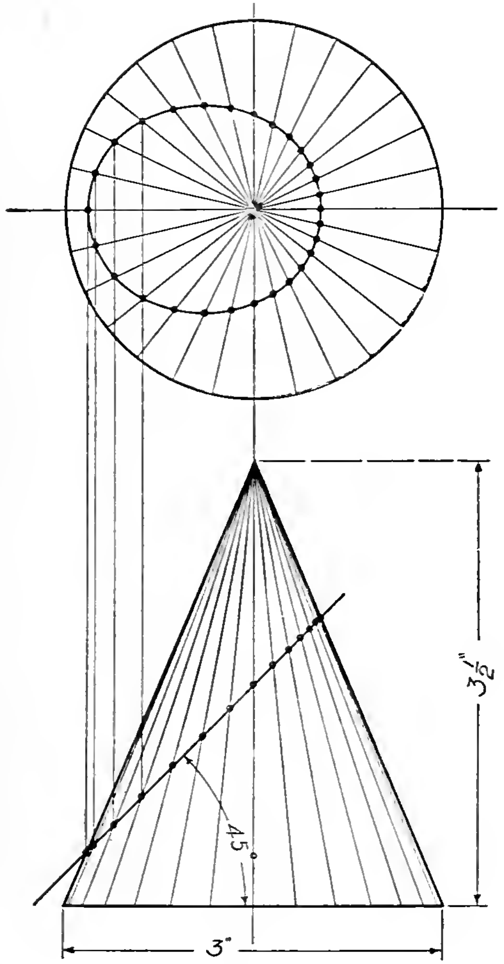
Lay out the cones to the dimensions given. Divide the base circle of the top view into any number of points equally or unequally spaced; from these points draw lines to the apex; now project the lines down onto the side view. The student will find it a convenience to make the line spacing on the upper half of the top view a duplicate of that on the lower half.

To develop the ellipse, cut the cone as shown; the points made by the intersection of the cutting plane with the slope lines should then be projected to the *same lines* in the top view. By connecting these points we have a true ellipse.

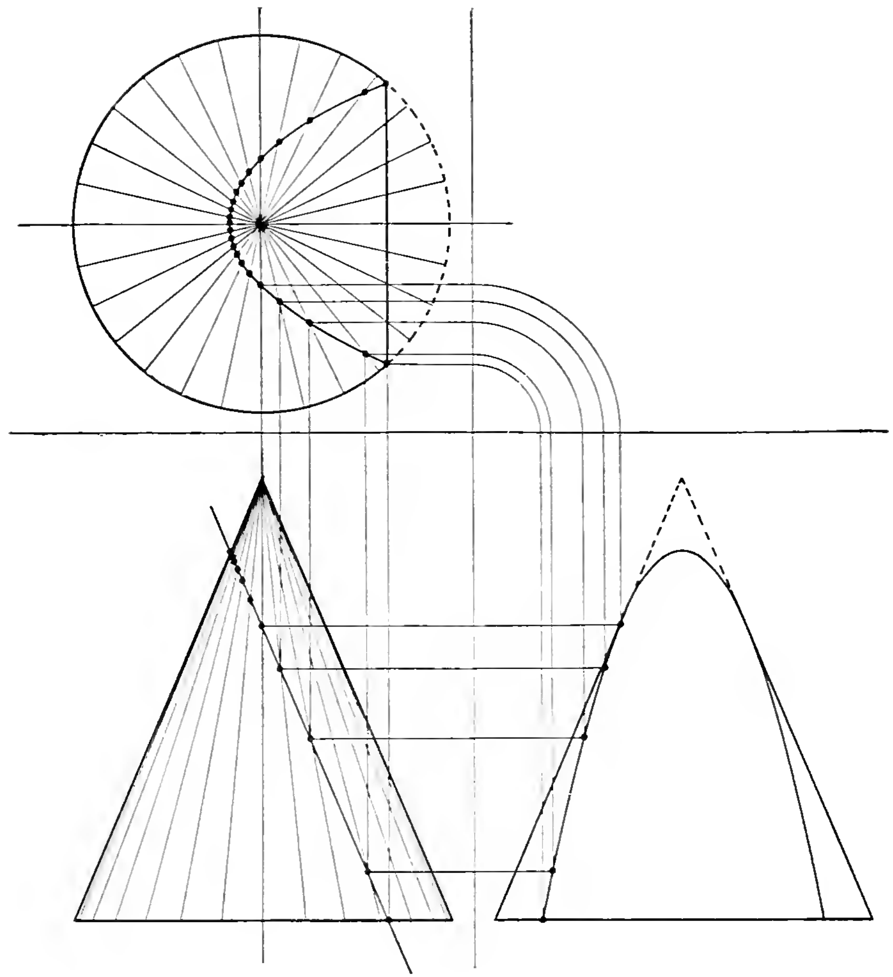
The top view of the parabola is projected in the same manner as the ellipse. With the top and side views complete, it is quite a simple matter to develop the front view point by point, as shown in the illustration.

By this method of projection the student can easily lay out the parabolic curve in the front view first, and then draw the cone around the curve.

Do this work very carefully, as one of the valuable points to be gained from this lesson is the ability to do *accurate* work.



Ellipse



Parabola

CONIC SECTIONS

CLASS *Industrial*

NAME *John W. Roberts* DATE *Mar. 28_07.*

SCALE *Full Size* DWG NO. *C.1022*

LESSON No. 31.

ISOMETRIC PROJECTION.—It is frequently necessary for the mechanical draftsman to make one-plane projection drawings of certain forms of construction. If these illustrations are prepared as they would appear from a single viewpoint, they are termed perspective drawings.

Perspective drawings best illustrate this type of work from the fact that they represent the object as it would appear to the eye; at the same time there are certain disadvantages connected with this system. The main objection is that these drawings cannot be laid out from dimensions as mechanical drawings are, and this one disadvantage is quite serious from the point of view of the draftsman.

Isometric, or *equal measure* projection, is a fairly satisfactory substitute for perspective drawing for certain classes of work.

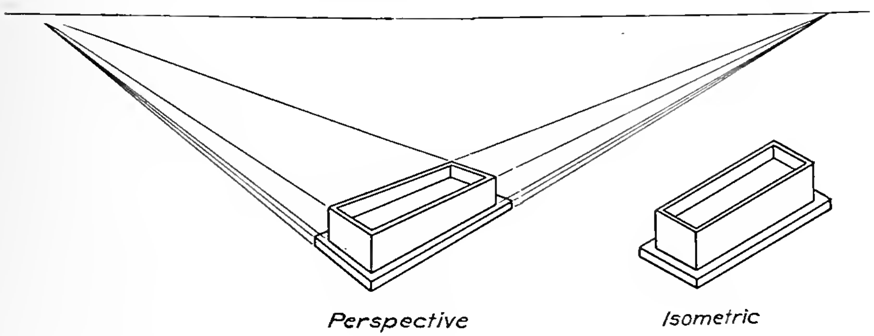


FIG. 16.

This method may be termed approximate perspective, as it represents an object in such fashion that it looks approximately as it would appear to the eye. The primary difference between two drawings of an object, one in perspective and the other in isometric, is that in the perspective drawing the surface lines converge at a certain distance from the object, as shown in Fig. 16, while in the isometric drawing these same surface lines are parallel.

For certain shapes, or at least for some views, isometric drawings are not satisfactory, as the figure appears badly distorted and unpleasing to the eye, but for most subjects it will be found quite satisfactory.

Isometric Projection is based on the theory that the object is

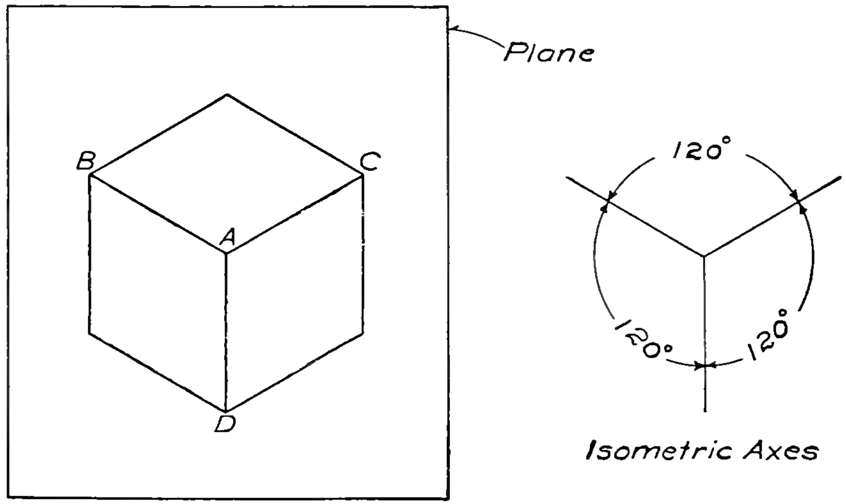


FIG. 17.

viewed through a plane with which certain main features of the body are equally foreshortened. To illustrate, the cube shown in Fig. 17 is tilted forward until the edges A–B, A–C, and A–D are equally foreshortened as seen through the plane.

This figure also illustrates what are known as the Isometric Axes and their origin, as these three edges of the cube (A–B, A–C, and A–D) considered as lines, are separated by an equal angular

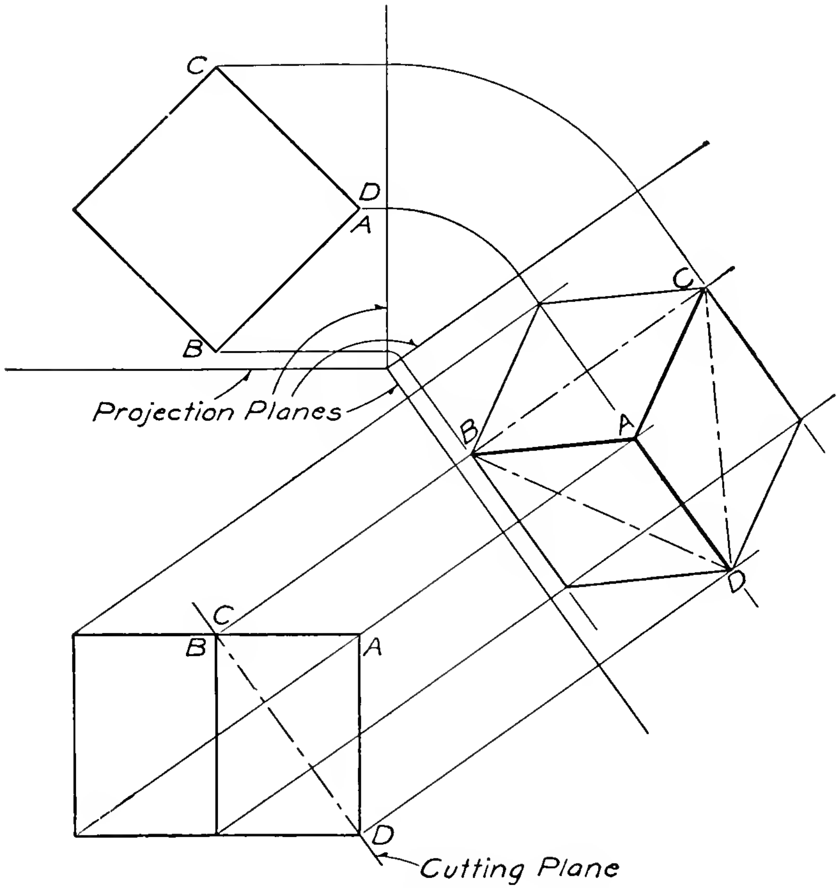


Fig. 18.

space and correspond to the three dimensions, length, breadth, and height.

Fig. 18 represents a two-view mechanical drawing of a cube, from which is projected (orthographically), an isometric view of the cube. This illustration shows the transformation from mechanical to isometric, the relationship between these two methods, and makes clear the sound basis from which isometric projection is derived.

To demonstrate the theory that the surfaces of the body are equally foreshortened, we place the cutting plane through points B, C and D of the cube, then as the projection plane is located parallel with the cutting plane, the portion of the cube cut away (as indicated by the dash lines in the isometric view) forms a triangular pyramid with corners of equal length.

The student should try to remember the following fundamental principles of isometric projection:

There are three basic lines known as isometric axes;

Isometric axes are separated by an equal angular space, and correspond to the dimensions, length, breadth and height;

Vertical lines on the object are vertical lines on the drawing. Lines parallel on the object are parallel on the drawing. Right angles on the object are either 60° or 120° on the drawing;

Lines not parallel to one of the isometric axes are termed non-isometric lines. Measurements may be made only on isometric lines.

ISOMETRIC DRAWING.—When a drawing has been made according to the rules of isometric *projection*, the isometric lines forming this drawing are eighty-one hundredths (.81) of their true length. As this necessitates using an isometric scale, it is generally considered good practice to use an ordinary scale and to lay out the figure to the dimensions given. The result will be an isometric *drawing*, not a projection, but as the only difference is in the *size* of the figure, this is of little importance.

COORDINATE AXES.—When laying out isometric drawings of certain shapes, a very convenient aid is the related axes, usually termed coordinate axes. Fig. 19 illustrates this feature, as it shows how the isometric view of a triangular pyramid may be constructed with the aid of these axes and the mechanical views.

To construct Fig. 19, lay out the mechanical views as shown,

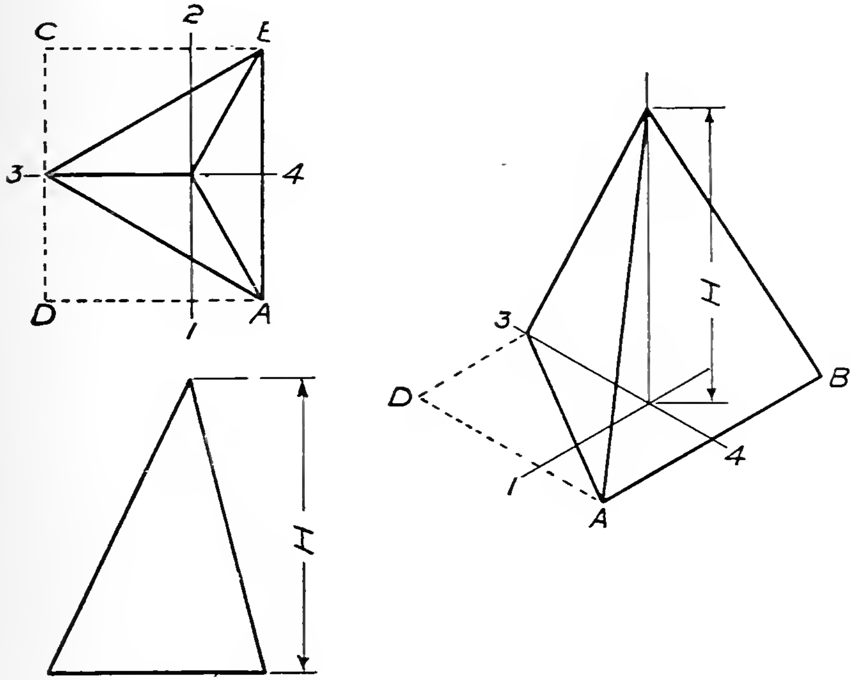


Fig. 19.

then draw a rectangular figure about the top view (as indicated by ABCD). This gives a figure that parallels the isometric axes and on which we may locate the base of the pyramid. After this has been done, find the point of intersection of the axes (1–2 and 3–4) on this figure, and from this point erect a perpendicular on which lay off the height of the pyramid. Now connect the apex point with the corners on the base and the figure is complete.

To emphasize the convenience of these related axes, the student is reminded that measurements may be made only on isometric lines, and as the lines forming the outline of the pyramid base are not at right angles with each other, only one side may be placed on an isometric axis.

Fig. 20 shows the application of the coordinate axes to quite a differently shaped figure from our last illustration. The mechan-

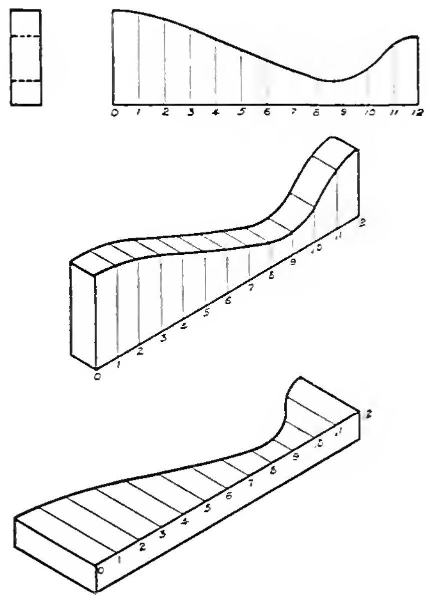


Fig. 20.

ical view of the side of the piece is divided into a certain number of parts (any number), spaced either evenly or unevenly, then these lines or axes are used as shown when constructing the isometric view. Two applications are shown, one of which is pleasing to the eye, and the other quite the reverse.

ISOMETRIC CIRCLES.—The methods of constructing isometric circles should require little explanation and their application to rounded corners should be readily understood from the illustration, Fig. 21.

For general purposes the four-center method will be found satisfactory, and, with a little study of the illustration, the student should be able to apply this method to his work.

One feature which it is well for the student to bear in mind is

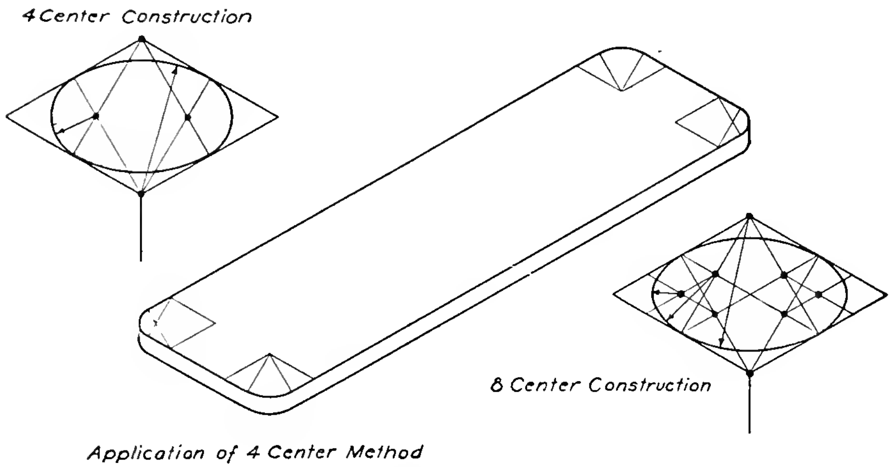


FIG. 21.

that to construct any circle arc, he should lay out an isometric square of the *circle diameter*, as a means of locating the position of the radius center.

BROOM HOLDER.—Fig. 22 shows a two-view mechanical drawing of a broom holder. From this illustration the student is expected to lay out a full-size isometric drawing of the figure. No hidden surfaces need be shown, as this is seldom done in drawings of this nature. The title is to be "Broom Holder, Drawing C-1023."

The student is expected to lay out a view which shows the top,

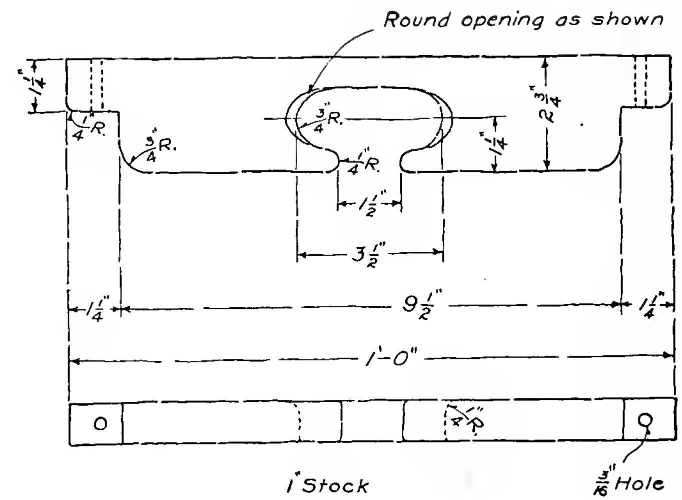


FIG. 22.

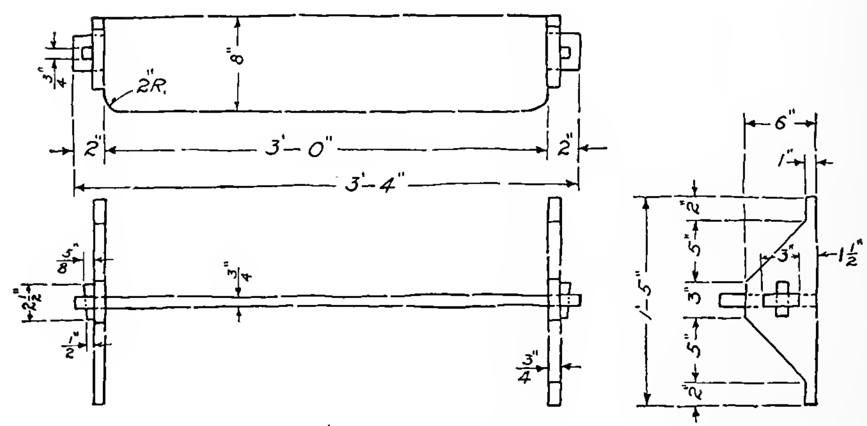


FIG. 23.

the front, and the left-hand end, as this view will be most pleasing to the eye. Do not overlook the small screw-holes near the ends, as they should be shown.

No dimensions need be placed upon any of these isometric drawings unless for some special reason the teacher may desire it.

WALL SHELF.—On Fig. 23 is shown a three-view mechanical drawing of a wall shelf. From the information given the student is expected to lay out a quarter-size isometric drawing of the object. Show no hidden surfaces, but draw in all parts which would be in sight naturally from a single view-point.

The same view suggested for the broom holder will be found to be satisfactory, that is, one showing the top, the front and the left-hand end.

To lay out this drawing correctly will require careful workmanship, and the student will find that this subject offers several opportunities for making mistakes if he fails to keep in mind the principles of isometric drawing.

The title of this lesson is "Wall Shelf. Drawing C-1024."

LESSON No. 32.

TOOL-REST DETAILS.—Most of the parts or details of a speed-lathe tool rest are shown on Drawing C–1025; part of these details are drawn half size, and the rest full size.

Make an accurate pencil drawing and tracing of the details shown.

The hand wheel is very similar to one drawn in an earlier lesson, with the exception that it is an "offset" wheel, that is, the rim is not central over the arms, but set to one side. The necessary radii with the location of their centers are shown, so that the student should be able to draw this hand wheel without difficulty.

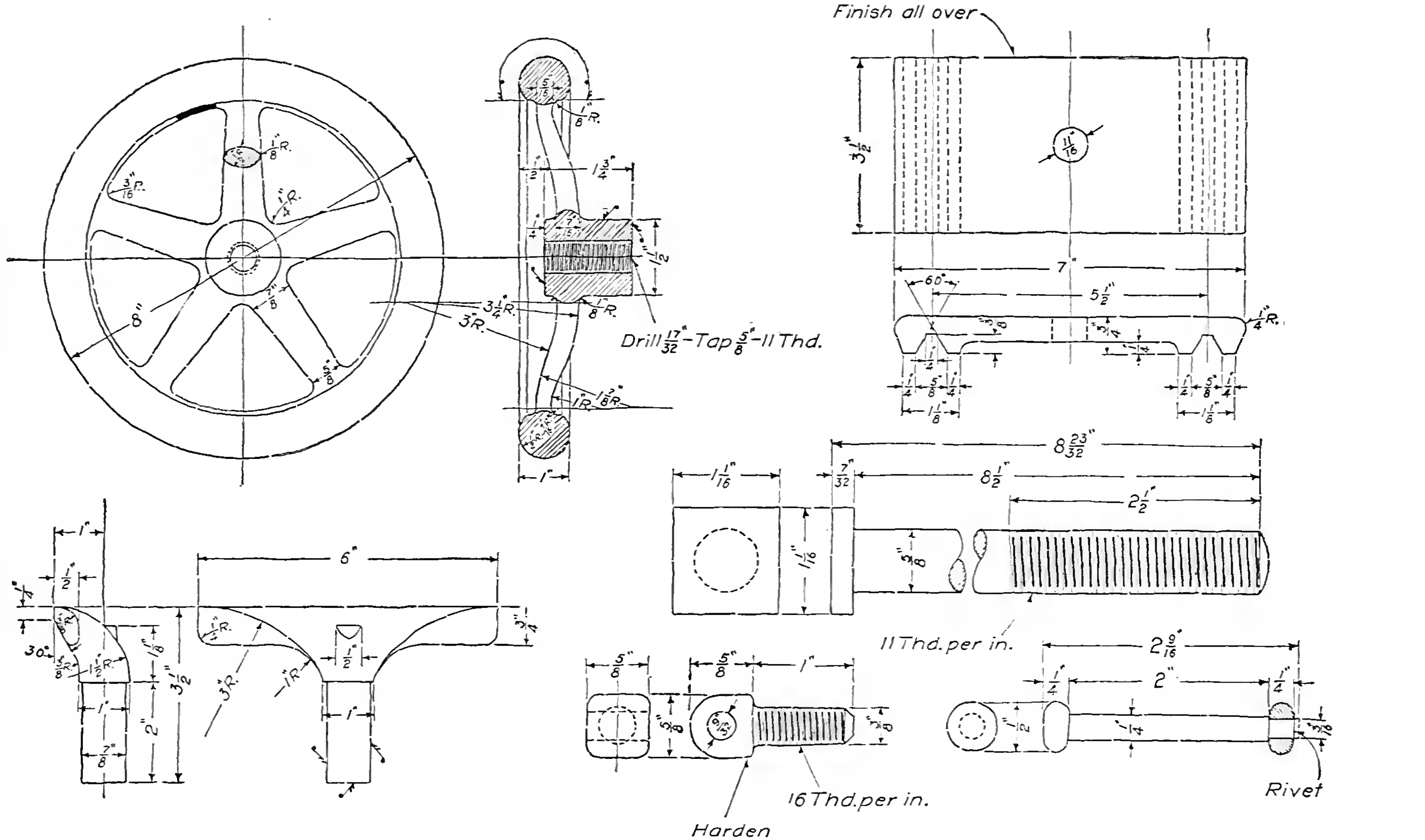
When drawing the arms of the hand wheel, bear in mind what was said in the earlier hand-wheel lesson, in regard to using a straight line for the purpose of joining two curves.

The student should take note of the "finish mark" used on the hand wheel and the tool rest. This symbol indicates that the surface on which it is placed is to be finished.

On such pieces as bolts, screws, pins, shafts, spindles, and many similar shapes it is not necessary to place a finish mark, as it is understood that these pieces are usually finished all over.

Do not overlook any of the dimensions on the various details, for you must remember that you are furnishing the man in the shop with the necessary information to machine these parts correctly.

Use great care with the lettering and figures.



12" Speed Lathe
Tool Rest Details

CLASS Industrial

NAME John W. Roberts DATE Dec. 12_07.

SCALE $\frac{1}{2}$ & Full Size DWG. NO. C_1025

LESSON No. 33.

TOOL-REST ASSEMBLY.—Drawing C–1026 is an assembly drawing of the complete tool rest.

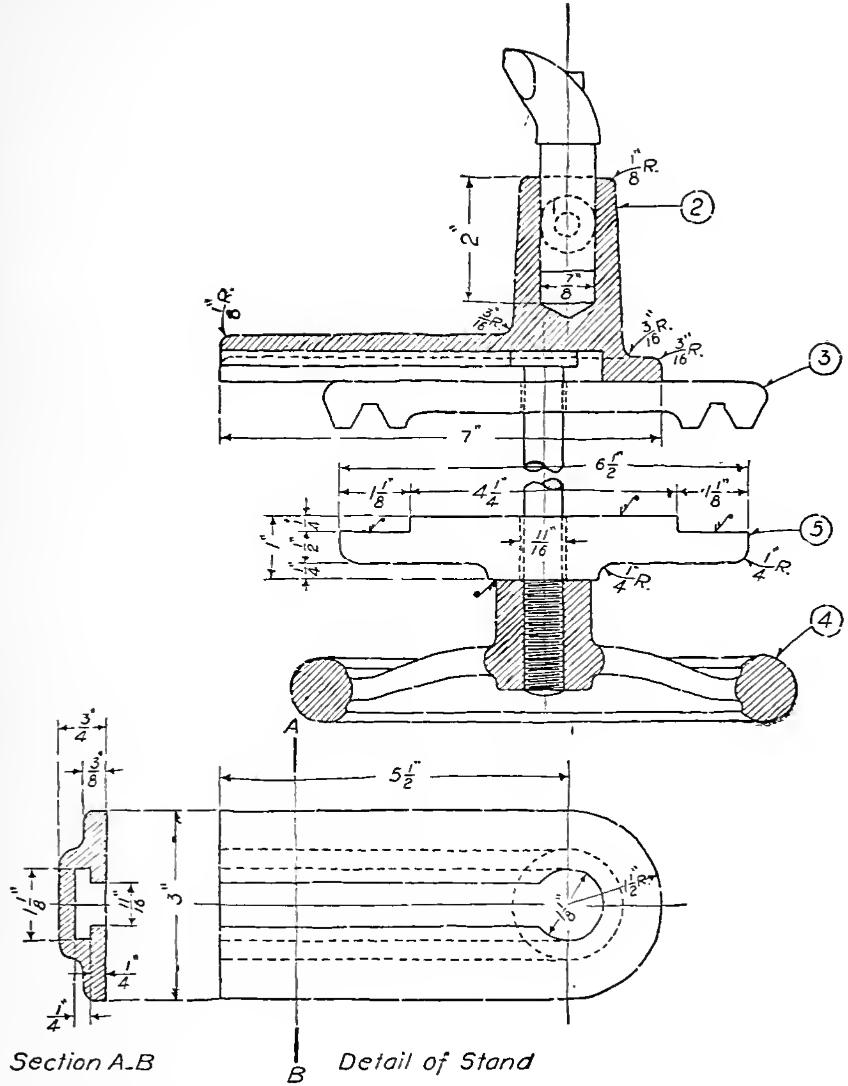
This drawing is used for the purpose of showing how the different parts are fastened together, or assembled, as it is termed.

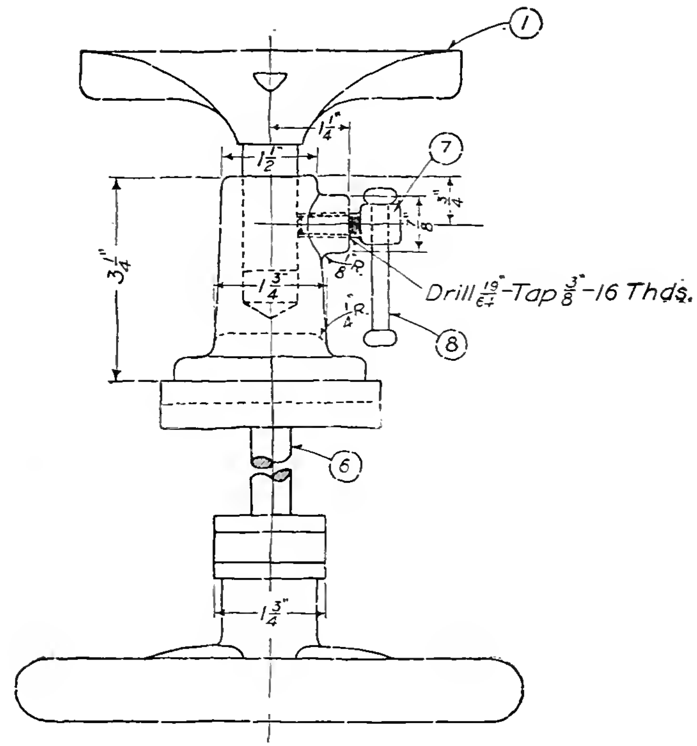
The only parts dimensioned are the stand and clamp, all of the other details being machined from Drawing C–1025. This assembly drawing is, therefore, used as a detail drawing also, as the stand and clamp may be machined from it.

When drawing the parts that are not dimensioned, the student must necessarily refer to the detail drawing to obtain the sizes needed.

Study the drawing carefully so as to obtain a clear understanding of the meaning of each line. Do not simply copy the various lines because they are shown on the original; satisfy yourself as to their meaning.

Think for yourself.





Bill of Material

Item No.	Description and Material	Pat. No.	Req.
1	Tool Rest, C.I.	79	1
2	" " Stand, C.I.	80	1
3	" " Base, C.I.	81	1
4	" " Hand Wheel, C.I.	82	1
5	" " Clamp, W.I.		1
6	Clamp Bolt, W.I.		1
7	Adjusting Screw, C.R.		1
8	Adj. Screw Lever, C.R.		1

12" Speed Lathe
Tool Rest Assembly

CLASS Industrial

NAME John W. Roberts DATE Dec. 24-07.

SCALE 1/2 Size DWG. No. C-1026

LESSON No. 34.

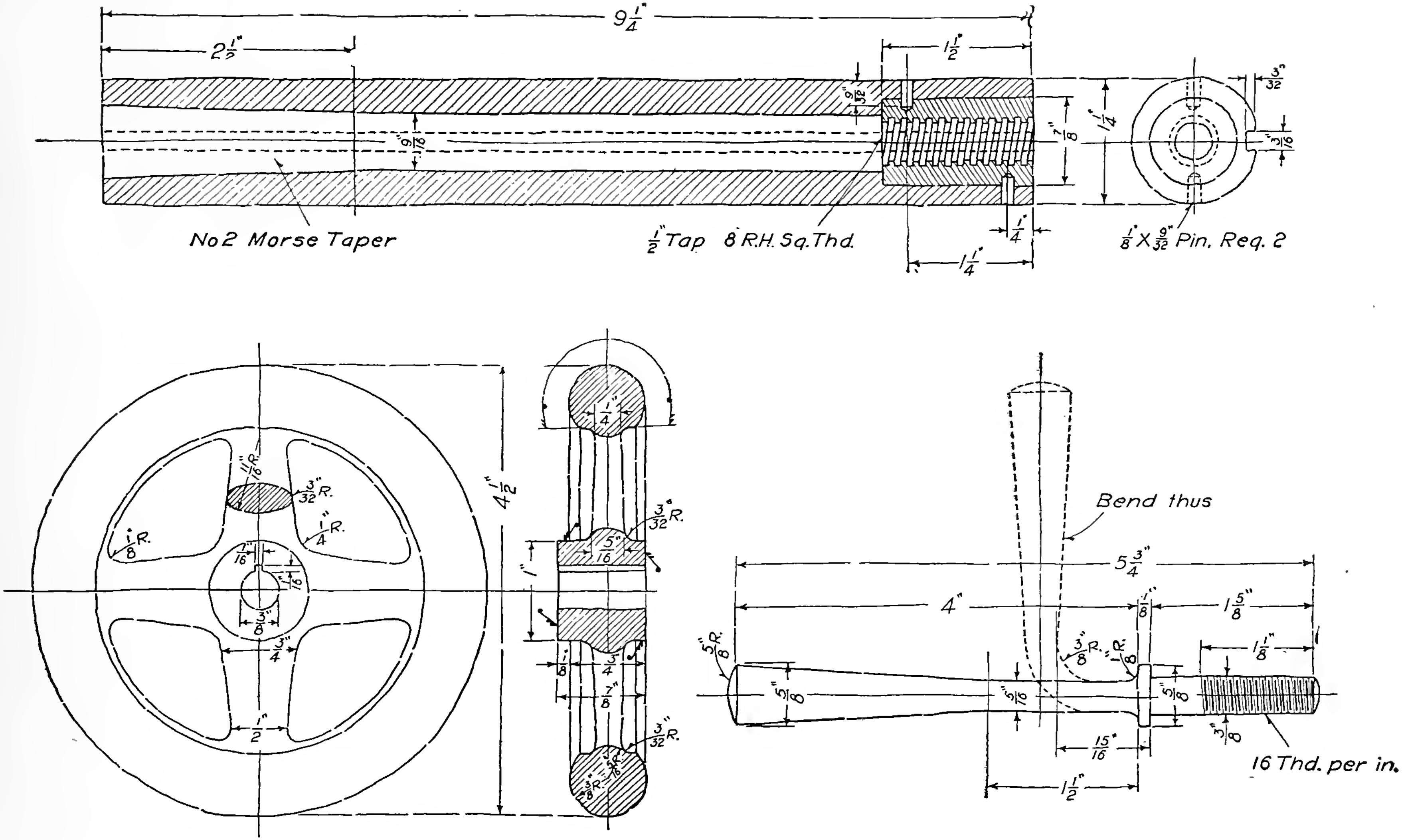
TAILSTOCK DETAILS.—Part of the details of a lathe tailstock are shown on Drawing C–1027.

The sectional view of the spindle shows the taper bore in one end, and the method of fastening the bronze nut in the other end.

The end of the spindle is bored to a taper of approximately $\frac{5}{8}$ inch per foot, or the "Morse Taper," a name by which this particular taper is known in shops and drafting rooms. By a taper of $\frac{5}{8}$ inch per foot, we mean that a cylindrical piece 12 inches long and 1 inch in diameter at the small end will be $1\frac{5}{8}$ inches in diameter at the large end. In other words, the piece is $\frac{5}{8}$ inch larger in diameter at one end than at the other.

By this time the student should be sufficiently familiar with hand wheels to need no instruction on this subject.

The binding screw shown is an illustration which shows the value of a knowledge of shop practice. This screw is machined in a lathe in the manner shown by the solid lines; after being finished, it is placed in a special forming tool, where it is bent to the shape shown by the dash lines. Make a tracing of the finished pencil drawing.



12" SPEED LATHE
TAILSTOCK DETAILS

CLASS Industrial

NAME John W. Roberts DATE Dec. 30_07.

SCALE Full Size DWG. No. C_1027

LESSON No. 35.

TAILSTOCK DETAILS.—The rest of the details of the lathe tailstock are shown on Drawing C–1028.

The square-thread screw is used to move the spindle in and out of the tailstock barrel. The manner in which the thread is shown on the screw indicates that it is to be cut the full length to the collar. The main object in showing the thread in this manner is to save the draftsman's time.

The small key set into the stem of the screw is known as a Woodruff key. This key resembles a portion of a washer driven into a slot milled in the screw.

The small T-shaped key shown is the spindle key, and is used to prevent the spindle from revolving.

The wrench shown is used to tighten the nut on the clamp bolt, thus fastening the tailstock to the bed.

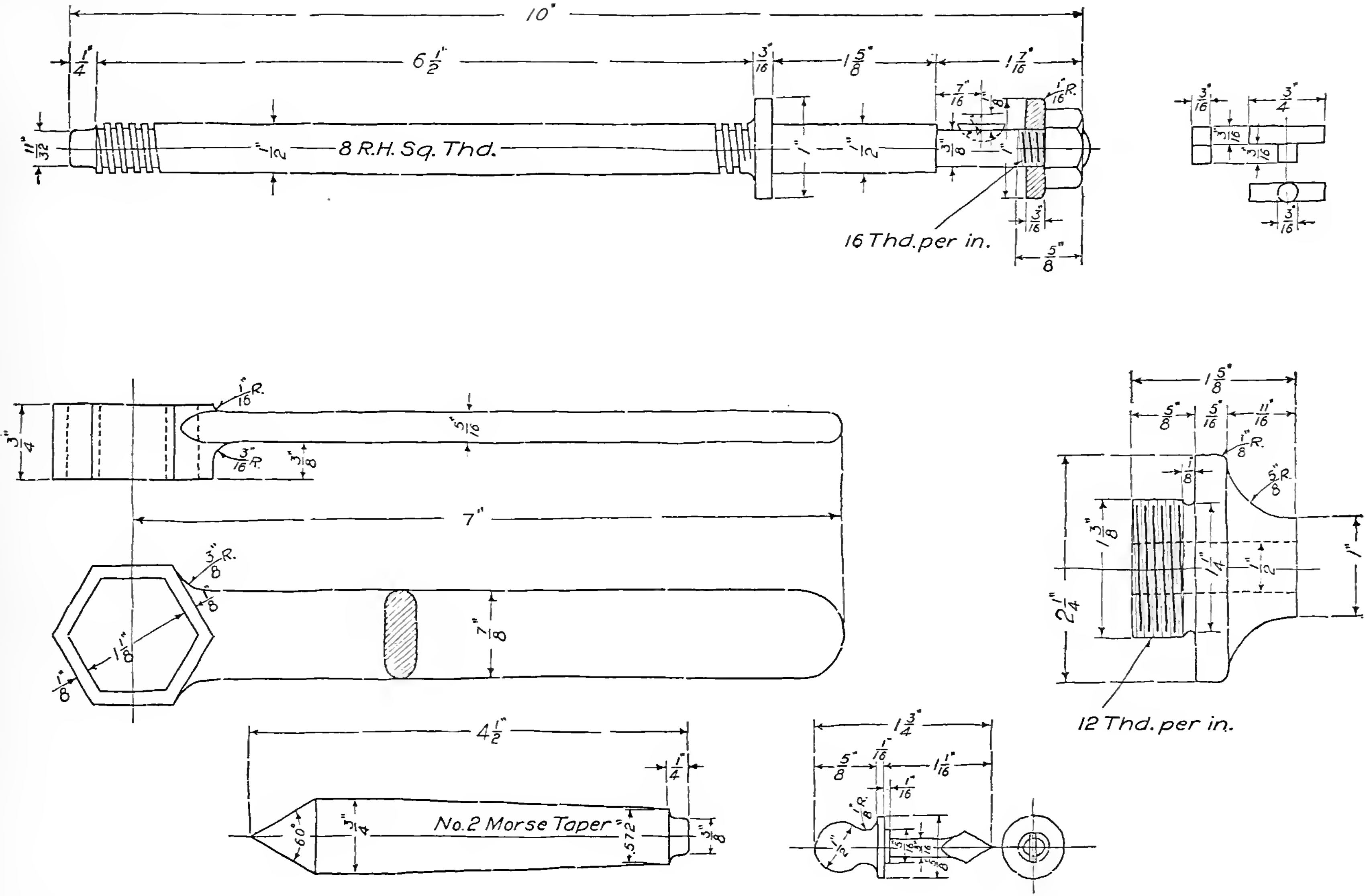
The tailstock plug, or bell as it is usually termed, is screwed into the rear end of the tailstock barrel for the purpose of supporting the spindle screw.

The center illustrated is made of tool steel and hardened. Two of these centers are used on each lathe, one being fitted into the tailstock spindle, the other in the nose of the headstock spindle, the former being known as the "dead center," the latter as the "live center."

The stem of the center is turned to a taper of approximately $\frac{5}{8}$ inch per foot, or what is known as the Morse taper.

The small steel oiler is used to drop oil on the centers.

When making a pencil drawing and tracing of this lesson, do the very best work of which you are capable.



CLASS Industrial

NAME John W. Roberts   DATE Jan. 6-08.

12" SPEED LATHE
TAILSTOCK DETAILS

SCALE Full Size   DWG. NO. C-1028

LESSON No. 36.

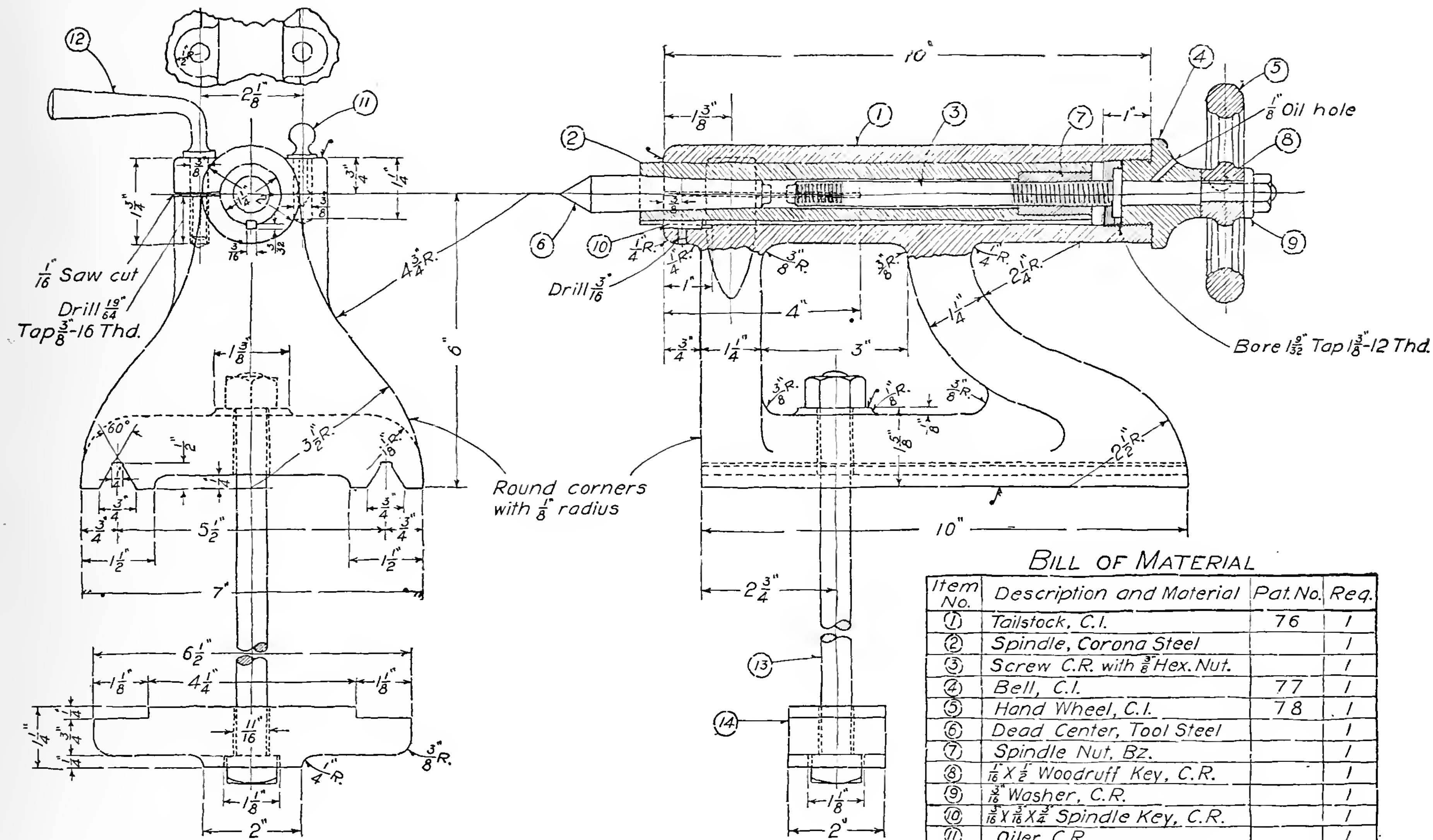
TAILSTOCK ASSEMBLY. — Drawing C-1029 shows the tailstock completely assembled, with all the details numbered to correspond with the numbers in the "Bill of Material."

Where dimensions are not shown on certain parts, the student is expected to refer to the detail drawings for the necessary information.

The saw cut on the side of the tailstock barrel is for the purpose of allowing this part to clamp tightly around the spindle when the binding screw is tightened down.

The oil hole shown in the bell should be drilled after it is in place in the barrel, as it should of necessity be on the upper side of the bell.

Make this drawing and tracing very carefully; do not overlook any dimensions or notes. Bear in mind that nothing is good enough but the best work you are able to do.



Note: For details see Dwgs. C_1027 & C_1028

Bill of Material

Item No.	Description and Material	Pat. No.	Req.
1	Tailstock, C.I.	76	1
2	Spindle, Corona Steel		1
3	Screw C.R. with 3/8" Hex. Nut.		1
4	Bell, C.I.	77	1
5	Hand Wheel, C.I.	78	1
6	Dead Center, Tool Steel		1
7	Spindle Nut, Bz.		1
8	1/16" X 1/2" Woodruff Key, C.R.		1
9	3/16" Washer, C.R.		1
10	3/16" X 3/16" X 3/4" Spindle Key, C.R.		1
11	Oiler, C.R.		1
12	Binding Screw, C.R.		1
13	5/8" X 8" Clamp Bolt with Hex. Nut		1
14	Clamp, W.I.		1

12" Speed Lathe
Tailstock Assembly

CLASS Industrial

NAME John W. Roberts DATE Jan. 12_08.

SCALE 1/2 Size DWG. NO. C_1029

LESSON No. 37.

ARCHITECTURAL DRAWINGS.—Up to the present time most of our mechanical drawings have dealt with some form of machinery, whereas in the following lessons we shall devote our attention to some of the drawings used in building construction.

In taking up the subject of architectural drawing, we shall deal only with some of the simpler phases of this work. Briefly, architectural drawings of dwelling houses consist of floor plans, elevations and details, with a set of written specifications to cover the materials used and the mode of erection.

For simple dwellings there is little need of detail drawings, as such features as doors and windows with frames, stairs with rails and posts, may be ordered from a manufacturer of such house details.

Usually an elevation drawing represents some view of a house as seen from the outside, as a front elevation, Fig. 24, or a side elevation, Fig. 25, but it is sometimes desirable to show a sectional elevation, that is, a vertical section as seen from one side.

In the main, elevation drawings of dwellings are of value to show certain vertical measurements, such as the height of foundation walls, floors, ceilings, and windows, and in addition to give a general idea of the outside appearance.

Floor plans represent views seen from *above* when a horizontal section is taken through the building, these horizontal sections being cut through the windows and doors.

The floor plans show clearly the plan of arrangement of the various rooms, the positions of doors and windows, stairways, closets, lighting and plumbing fixtures, etc.

In addition it is from the floor plans that the builder obtains the thickness of walls and partitions, the size of rooms and doors, and

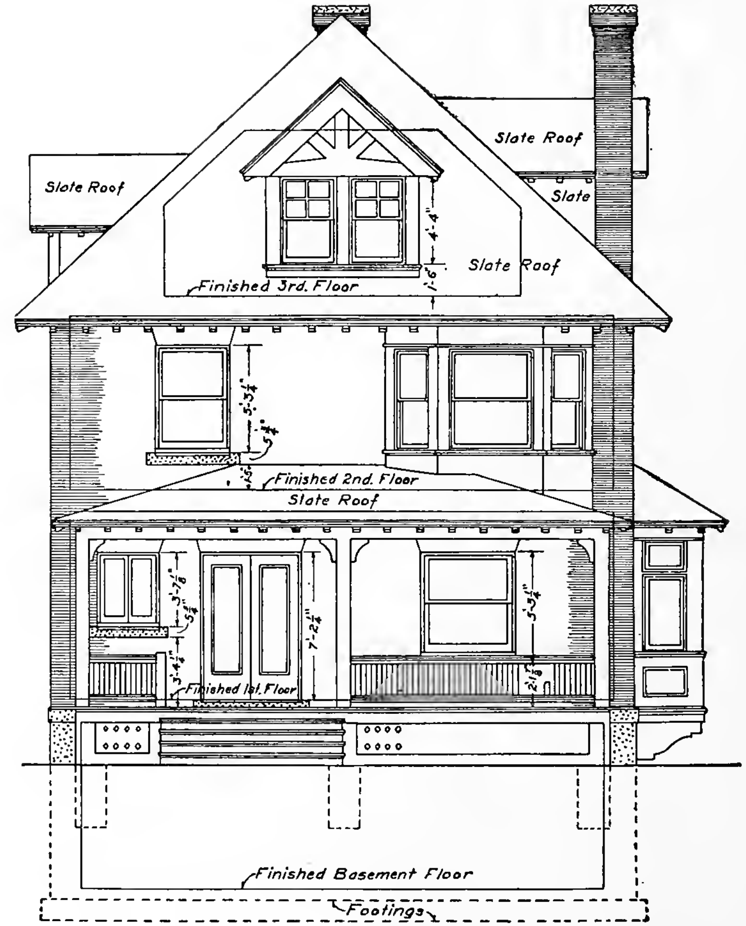


FIG. 24.

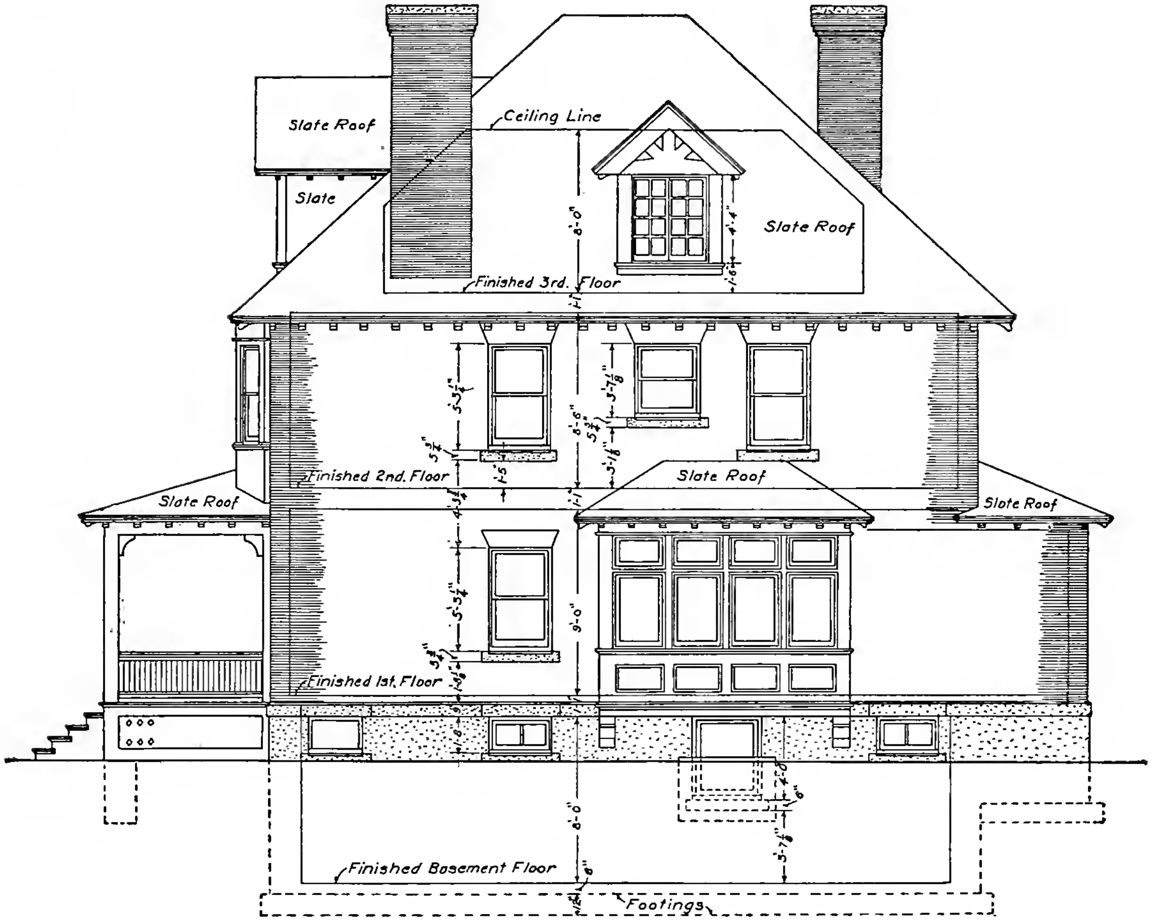

Slate Roof
Slate
Ceiling Line
Slate Roof
Finished 3rd. Floor
Finished 2nd. Floor
Slate Roof
Slate Roof
Slate Roof
Finished 1st. Floor
Finished Basement Floor
Footings

FIG. 25.

the various measurements which are necessary, aside from the heights given on the elevation drawings.

In the lessons which follow we shall take up floor plans only, as it is not deemed advisable to go into the subject to any greater extent in this series of lessons.

BASEMENT PLAN.—The basement plan, which furnishes us with the needed information in regard to the thickness and location of the foundation walls of our dwelling house, is shown on Drawing C–1030.

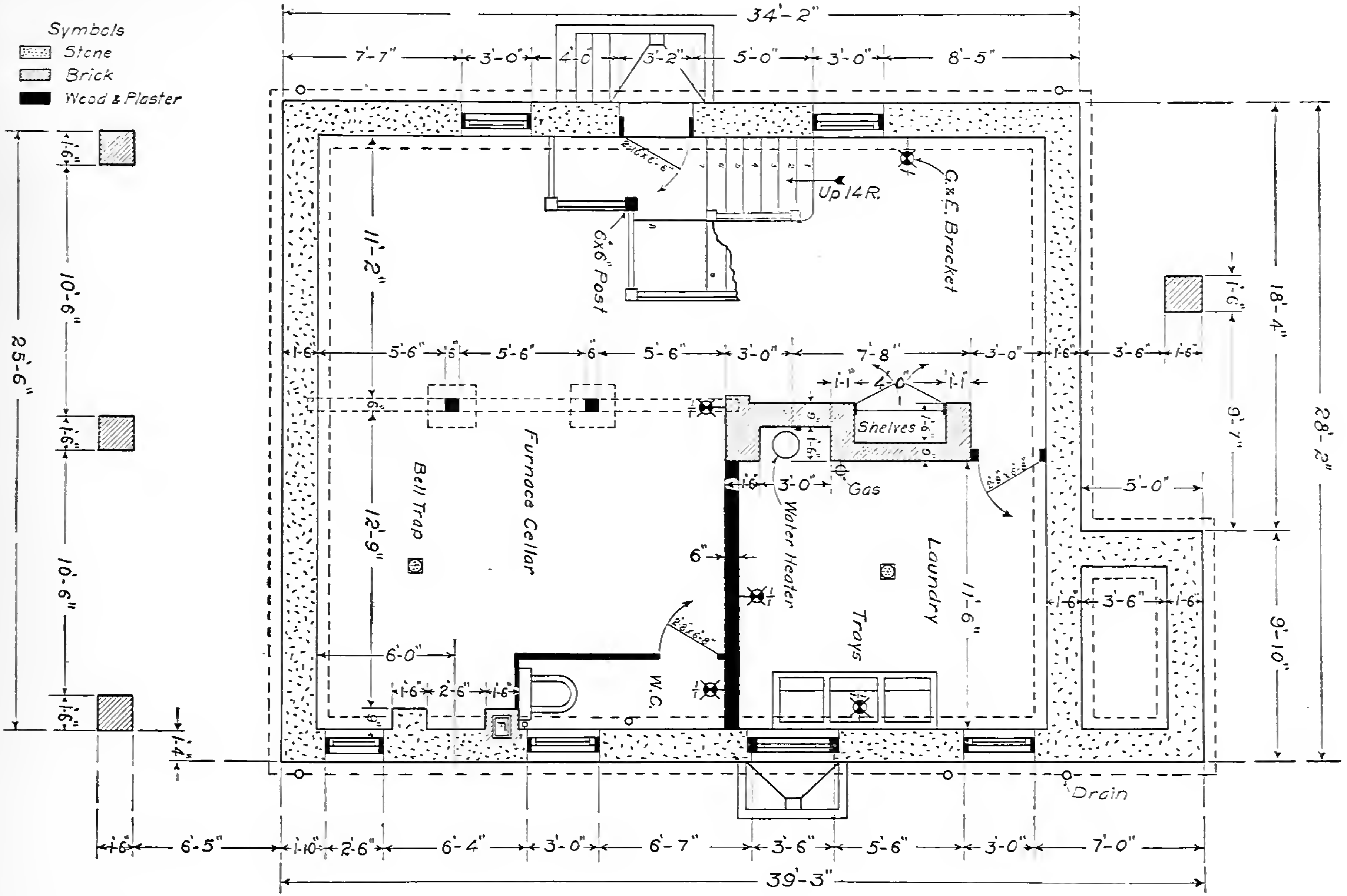
By referring to Figs. 24 and 25, as well as Drawing C–1030, the student will note that the foundation walls rest on a base termed a "footing," which extends on each side of the walls about 6 inches and has a depth of 12 inches. The foundations for the front and rear porches are shown in their proper location to the rest of the building.

The positions and widths of the windows are shown, as well as the outside entrance to the cellar, which opens onto the landing of the stairway leading from the kitchen to the cellar.

The double dash lines connecting the front wall with the chimney foundation are to indicate the timbers which rest on the two 6-inch posts and support the floors above.

LESSON.—The student is expected to lay out a pencil drawing of this basement plan to a scale of $\frac{1}{4}$ inch equals 1 foot, as shown on Drawing C–1030. This method of indicating the scale is commonly used on architectural drawings and should be carefully noted, as the methods followed on machinery drawings are not used on drawings of buildings.

Take especial note also of the location of the lighting and plumbing fixtures, the chimney foundations and flues, for it is by a study of all of the various details that we may form some idea of the convenience of the basement arrangement.



CLASS Industrial

NAME John W. Roberts DATE Mar-16-15.

RESIDENCE
BASEMENT PLAN

SCALE $\frac{1}{4}''=1'-0''$

DWG. NO. C-1030

LESSON No. 38.

FIRST FLOOR PLAN.—This plan shows the arrangement of the rooms on the first floor with the positions of the various fixtures indicated.

A flight of steps lead up to the porch and a single step from the porch into the vestibule, which has outer and inner double doors connecting with the front hall.

From the hall one may enter through sliding doors into the parlor, which opens through sliding doors into the dining room. A swinging door connects the dining room with the pantry. The kitchen is connected with the front hall by a short passageway and a door also leads into the pantry.

The stairway in the front hall leads to the second floor. This stairway can be reached also by a flight of steps from the kitchen. There is another stairway from the kitchen to the cellar.

To the left of the hall when entering the front doors is an alcove with a seat on each side. Another seat is shown in the bay window in the dining room.

If the student will study this floor plan and at the same time refer to the front elevation, Fig. 24, and the side elevation, Fig. 25, he will gain a clearer idea of the house plan than if he studies the floor plan only.

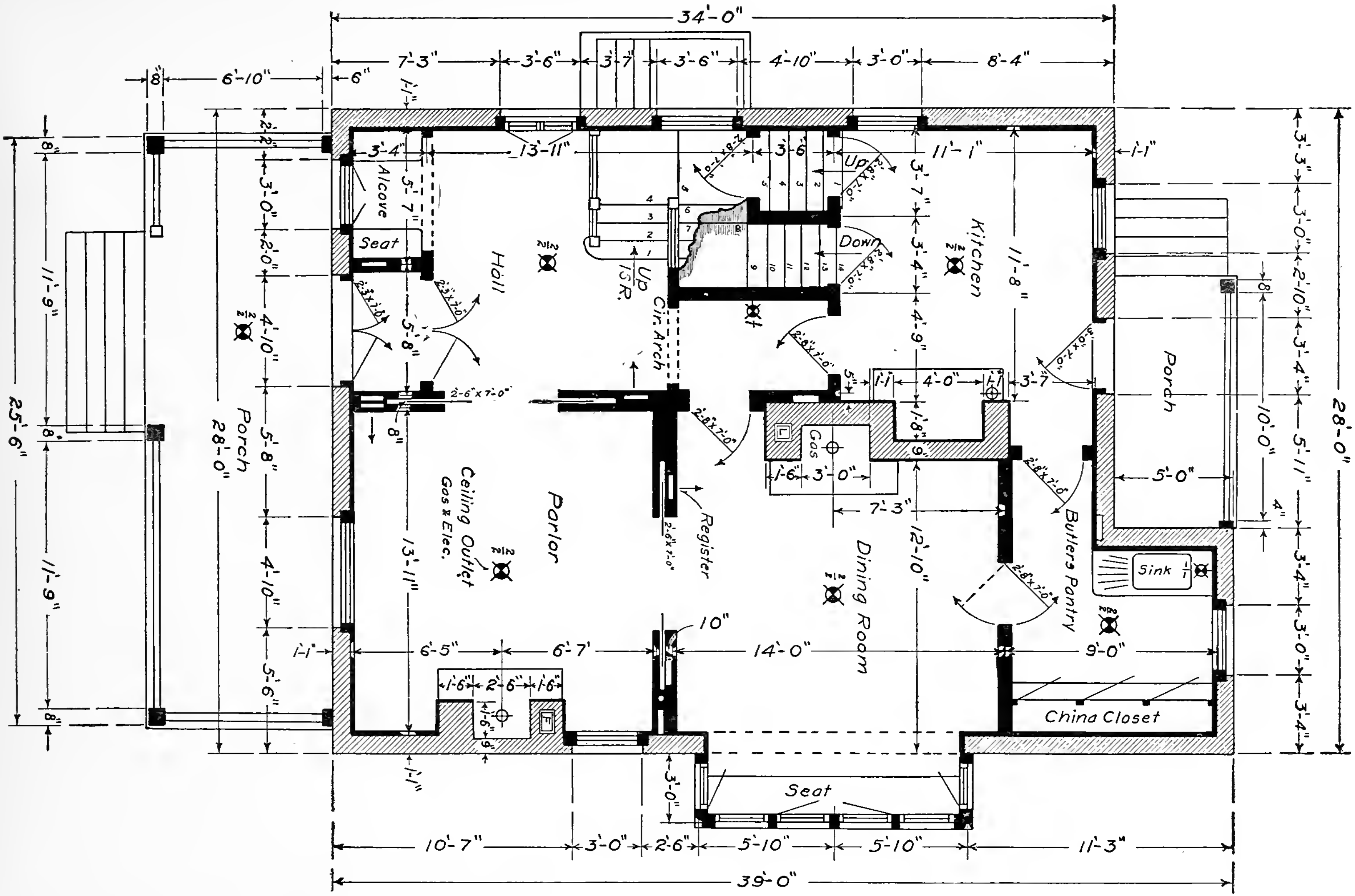
LESSON.—Lay out a pencil drawing of the floor plan shown on Drawing C–1031, using a scale of $\frac{1}{4}$ inch equals 1 foot.

This dwelling is built of brick with 13-inch walls and wood and plaster partitions. Where no dimensions are given, these partitions are about 6 inches thick, being formed of 2-inch by 4-inch uprights (known as studding) with plaster on each side.

The student should note carefully the symbols used to indicate the positions of the lighting and heating fixtures. The wall and ceiling fixtures are for both gas and electric light, while the symbol in the grates in the parlor and dining room and near the hearth in the kitchen indicates gas only.

The dash lines at the entrance to the alcove in the front hall, and those marked "circular arch," indicate an arch *overhead* and not something below the floor, as one might infer who is familiar with drawings of machinery.

Notice should be taken of the rectangular openings in the room partitions, as these openings are the hot-air ducts from the furnace to the various rooms.



CLASS Industrial

NAME John W. Roberts DATE Mar. 25. 15.

RESIDENCE
FIRST FLOOR PLAN

SCALE $\frac{1}{4}" = 1'-0"$

DWG. No. C-1031

LESSON No. 39.

SECOND FLOOR PLAN.—The student should have little difficulty with this floor plan after completing the basement and the first floor plans.

At the head of the stairway is an upper hall from which doors lead into all four bedrooms and into the bathroom. There is also a door opening from this hall onto the stairway which leads up to the attic rooms.

On the illustration near the head of the stairway is a note which reads "Down 16 R"; translated, this means down 16 "risers" or steps.

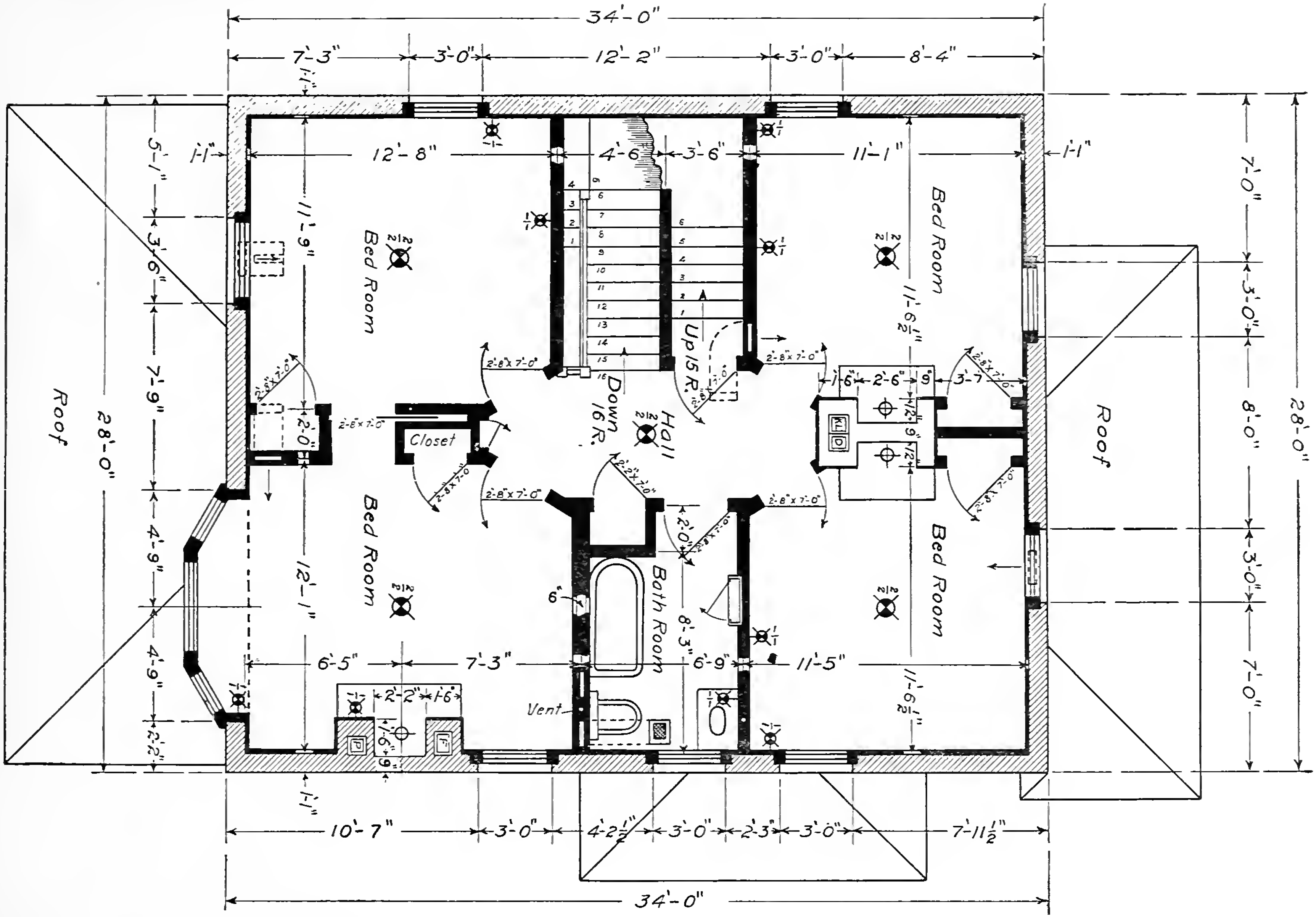
Note the convenient arrangement of the bedrooms and that each of the rooms is supplied with a closet, with an additional one located in the hall adjoining the bathroom.

Three of the bedrooms are heated by the furnace register and gas grates, while the other one has the furnace register only. In the bathroom the furnace register is located in the floor, instead of in the side wall.

LESSON.—Lay out a neat pencil drawing of the floor plan shown on Drawing C–1032, using a scale of $\frac{1}{4}$ inch equals 1 foot.

When drawing the outlines of the roofs over the bay window and the two porches, let these outlines extend out over the bay window and the porches about 12 inches on each of the sides away from the wall.

The shaded section of the stairway joining the broken line indicates a place where one may pass under, in this case from the landing, step 5, down into the kitchen. On Drawing C–1031 this same feature is illustrated on the stairway leading from the kitchen to the cellar.



CLASS *Industrial*

NAME John W. Roberts DATE April 6-15.

RESIDENCE
SECOND FLOOR PLAN

SCALE $\frac{1}{4}'' = 1'-0''$ DWG. No. C-1032