ENGINEERING DRAWING
FROM THE BEGINNING

Volume 1

by

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Introduction

One of the fundamentals of good design is "taking parts off", not "putting parts on". This was said many years ago by the late Sir Horace Darwin, founder of what is now the Cambridge Instrument Company, and it was the basic principle used for all designs for which he was responsible.

To produce a good design, it is necessary to make a good drawing, which in turn must be the product of a good draughtsman.

When one travels abroad it is advisable, though not absolutely essential, to learn the language of the particular country in which one is travelling. Similarly, when entering the field of Engineering, it is advisable, though not absolutely essential, to learn the language of Engineering. This language is "Engineering Drawing" so that a draughtsman in a drawing office can convey, by lines and symbols on paper, sufficient information to enable an engineer, who also knows the language, to understand the drawing and make the part which is illustrated. The language of Engineering Drawing is international.

The aim of this book is to teach anyone willing to learn the language of Engineering Drawing.

All the work in the book is in accordance with recommendations in the latest edition of *Engineering Drawing Practice B.S. 308A.*

In order to make progress it is essential that the student should practise the Exercises at the end of each chapter before proceeding to the next.

In the opinion of the author not enough practice exercises are attempted by young students learning Engineering Drawing. With this in mind, and as an important feature, numerous Drawing Exercises are given at the end of each chapter, remembering that any Geometry Exercise is revision of that learned during earlier years. Illustrated answers to the Exercises are given at the end of each volume.

Throughout the two volumes it will be the aim of the author to pass on to the student as much as possible of the knowledge and experience gained in thirty years of drawing office work and twenty years of teaching Engineering Drawing.

In both volumes all drawings will be illustrated in first angle (English) projection and in third angle (American) projection, which will enable the student to become familiar with both types of projection.

1 · Introduction to Equipment

THIS book is primarily intended for students who have reached the age of about 15 years although it does not preclude anyone above that age. It should be possible for any age group to find the book both helpful and easy to follow.

The relationship of the position of the drawing board to the lighting available is important. To enable the student to make a good drawing, it is essential that the drawing board should be situated in such a position that the light, daylight or artificial light, for a right-handed person should fall on the right-hand side of the set-square, and for a left-handed person on the left. The student should be seated comfortably and will work more efficiently if the top of the drawing board is raised approximately 3 in. (see 1.12).

Before commencing the course of Engineering Drawing outlined in this book, it is essential that a student should obtain the following equipment.

1.1. THE DRAWING BOARD. Fig. 1(*a*)

In order to carry out the work of the course, one of the following boards should be obtained:

(*a*) A well-seasoned yellow pine board, 23 in. × 16 in. × $\frac{1}{2}$ in. thick with cross bars on the back to give it strength and prevent warping;

(*b*) A multi-ply board, 23 in. × 16 in. × $\frac{1}{2}$ in. thick.

See that one end of the board (i.e. a short side) is perfectly straight. This is important as the squareness of the drawing relies entirely on this one edge being straight.

1.2. THE TEE-SQUARE. Fig. 1(*a*)

The tee-square should have a straight blade 26 in. long × 2 in. wide × $\frac{3}{16}$ in. thick attached permanently to the head but not sunk into it. The tee-square will be found to be more useful if the blade is bevelled on the upper surface, giving an edge thickness of approximately $\frac{1}{16}$ in.

The head of the tee should be 9 in. long × 2 in. wide × $\frac{5}{8}$ in. thick with one side perfectly straight to slide on the one straight edge of the board, referred to above.

1.3. SET-SQUARES. Fig. 1(*a*)

The most useful set-squares are $\frac{1}{16}$ in. thick made of clear celluloid with plain edges, or $\frac{1}{8}$ in. thick Perspex, with bevelled edges. Figure 1(*a*) shows the 45° set-square and the 60°/30° set-square. The long edge should be about 6 or 7 in. in length. Figure 1(*b*) shows an adjustable set-square which, although very useful, is not essential.

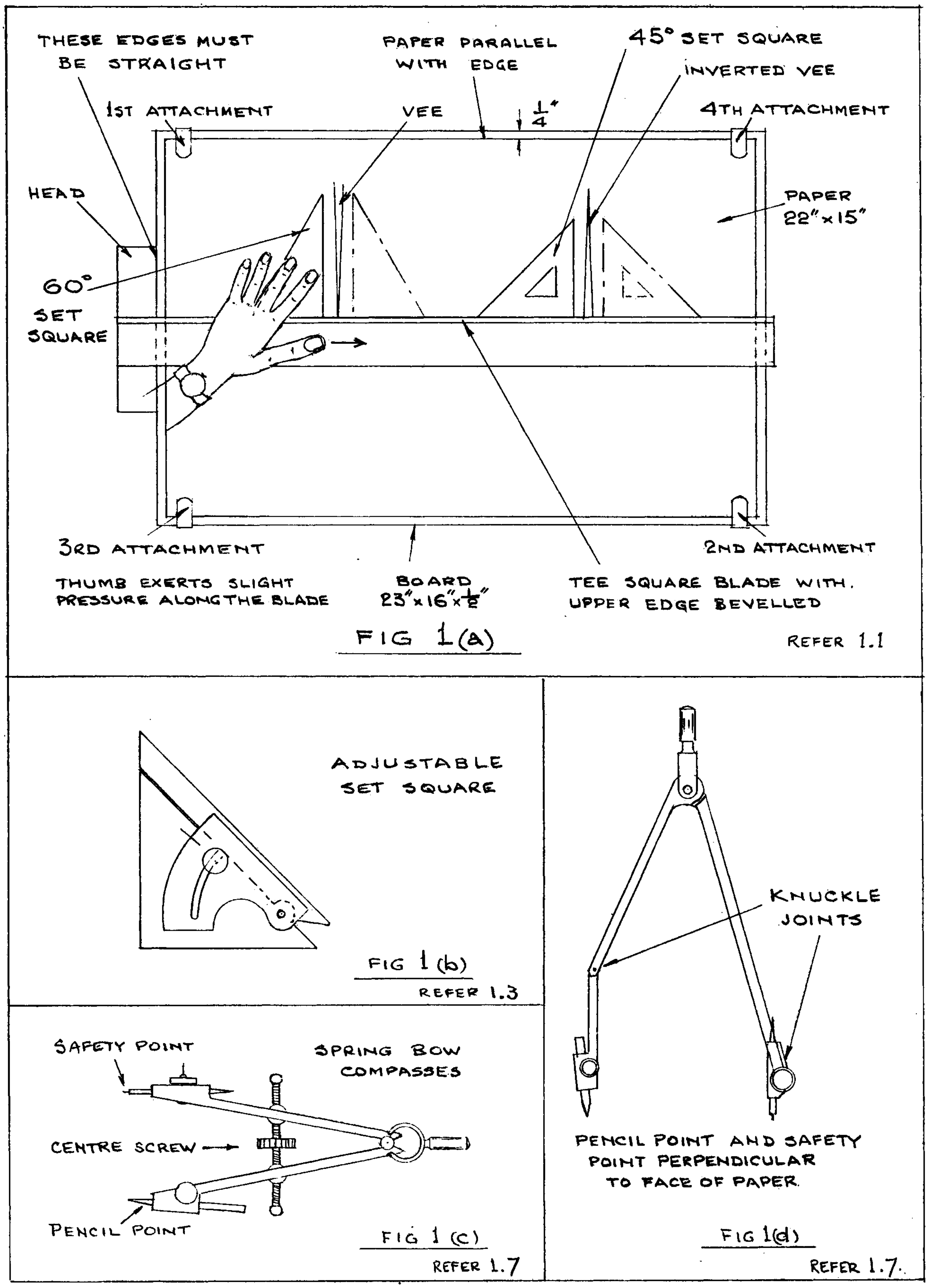

THESE EDGES MUST BE STRAIGHT
PAPER PARALLEL WITH EDGE
45° SET SQUARE
INVERTED VEE
1ST ATTACHMENT
VEE
1/4"
4TH ATTACHMENT
HEAD
PAPER 22"×15"
60° SET SQUARE
3RD ATTACHMENT
2ND ATTACHMENT
THUMB EXERTS SLIGHT PRESSURE ALONG THE BLADE
BOARD 23"×16"×1/2"
TEE SQUARE BLADE WITH UPPER EDGE BEVELLED
FIG 1(A)
REFER 1.1
ADJUSTABLE SET SQUARE
FIG 1 (b)
REFER 1.3
KNUCKLE JOINTS
SAFETY POINT
SPRING BOW COMPASSES
CENTRE SCREW
PENCIL POINT
FIG 1 (C)
REFER 1.7
PENCIL POINT AND SAFETY POINT PERPENDICULAR TO FACE OF PAPER.
FIG 1(d)
REFER 1.7.

Fig. 1

A set-square can be checked for squareness as shown in Fig. 1(*a*). Rest the set-square on the blade of the tee-square and draw one very thin vertical line on the right-hand side. Reverse the set-square and draw another very fine vertical line to the right of, and touching, the first line. If the set-square is true the two lines will be coincident. If, however, the lines form a Vee, the open end of which is more than $\frac{1}{64}$ in. wide, then the set-square should be trimmed for squareness or discarded.

1.4. PENCILS

One Grade 2H and one Grade HB of good manufacture are all that will be needed in order to make a first class drawing on the drawing paper which will be used. Hexagon, not round, pencils should be obtained.

The sharpening of pencils will be discussed later.

1.5. DRAWING PAPER

Working drawings can be made in pencil on *hand made* paper, *cartridge* paper or *detail* paper.

Hand made paper has a clean and hard drawing surface but has very rough, untrimmed edges. It can be used for pencil or ink drawings; but, owing to the fact that it is expensive, it is usually reserved for more important design work. It is supplied in sheets. We shall not, however, be using this type of paper during this course.

Cartridge paper is relatively inexpensive and is produced in various grades, being supplied in rolls and in cut sheets. At this stage you should use cut sheets of "Student's Quality" cartridge paper 22 in. × 15 in., which is Imperial size, 22 in. × 30 in., cut in halves.

Detail paper is semi-transparent and is used for both drawing and tracing of assemblies and detail parts. The paper is supplied in rolls and cut sheets. The cut sheets can have schedules, border lines and information pre-printed on them so that when a drawing is made on the cut sheet a print can be taken and used directly by the engineer. We shall not be using this paper during the present course.

1.6. ERASERS

For the work which we shall be doing it is important that the eraser, or "rubber", shall be of medium-soft grade. The harder grades are liable to remove the surface of the drawing paper and thus spoil the neatness and general "finish" of the drawing.

1.7. COMPASSES

During the course we shall be making some first class drawings. In order to do this, it is necessary to be able to draw small and large circles. This is done with the aid of one pair of small compasses and one pair of large compasses. Manufacturers cater for young students and make good quality, inexpensive instruments for this purpose. It is *not* necessary to buy a complete set of instruments at the commencement, but only to obtain one pair of 3-in. spring-bow compasses with 2H suitable lead and needle points (Fig. 1*c*), and one pair of 5-in. hinged compasses with knuckle joints and suitable 2H lead and needle points (Fig. 1*d*). The needle points should be reversible, with a plain

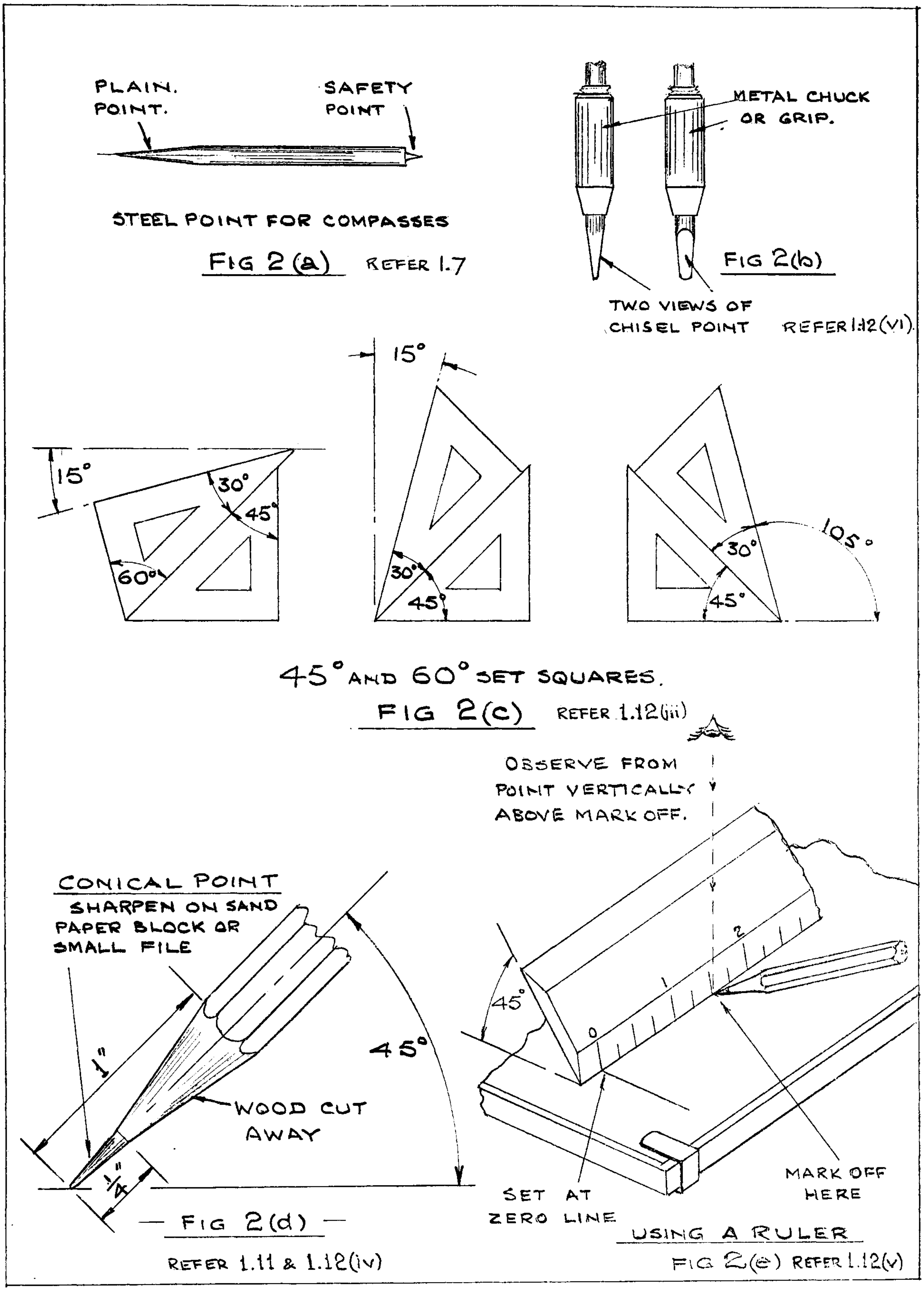

PLAIN. POINT.
SAFETY POINT
STEEL POINT FOR COMPASSES
FIG 2 (a) REFER 1.7
METAL CHUCK OR GRIP.
TWO VIEWS OF CHISEL POINT
FIG 2(b)
REFER 1.12(VI).
15°
15°
30°
45°
60°
30°
45°
30°
45°
105°
45° AND 60° SET SQUARES.
FIG 2(c) REFER 1.12(iii)
CONICAL POINT
SHARPEN ON SAND PAPER BLOCK OR SMALL FILE
1"
1/4"
45°
WOOD CUT AWAY
— FIG 2(d) —
REFER 1.11 & 1.12(iv)
OBSERVE FROM POINT VERTICALLY ABOVE MARK OFF.
45°
0
1
2
SET AT ZERO LINE
MARK OFF HERE
USING A RULER
FIG 2(e) REFER 1.12(v)

FIG. 2

point at one end and a safety point at the other end (Fig. 2*a*). The knuckle joints are necessary when drawing a circle so that both the needle point and the lead are perpendicular to the paper (Fig. 1*d*).

1.8. RULER

A good quality boxwood, or transparent, ruler 6 in. long will be required. Do not use an engineer's steel rule as this will tend to make the drawing dirty.

1.9. METHODS OF ATTACHMENT

In the past attaching drawing paper to a board was done only by the use of drawing pins. This method was satisfactory when pine drawing boards were used, but it was not suitable after the introduction of multi-ply boards, into which it was almost impossible to force a drawing pin. The two present-day methods in general use, both of which are equally good, are metal clips specially made for boards, and draughting tape $\frac{3}{4}$ in. wide cut from a roll.

The paper should be attached to the drawing board in four places, as shown in Fig. 1(*a*), making the top, left-hand corner clip, or draughting tape, the first attachment. A long side of the paper should be parallel with, and near to, the top edge of the drawing board. The second attachment should be made at the right-hand, bottom corner. The third and fourth attachments should be made at the bottom left-hand, and top right-hand, corners, respectively, lightly smoothing the paper with a duster between each attachment. This ensures that the paper lies flat on the drawing board and is free of "bumps".

1.10. PENCIL SHARPENING MEDIUM

Either a pocket knife, or pencil sharpener, are suitable for removing the wood of the pencil and a file, or sandpaper block, can be used for the lead.

1.11. PENCIL SHARPENING

The 2H pencil, which is the one used for the actual drawing, should be sharpened to a conical point, as shown in Fig. 2(*d*). To do this, cut away at least $\frac{3}{4}$ in. of wood, leaving $\frac{1}{4}$ in. of lead projecting. Round off the lead by rubbing it on a file, or sandpaper block, to form a long, conical point. The HB pencil is sharpened in the same way, but the lead need not have such a sharp point.

1.12. HOW TO USE DRAWING INSTRUMENTS

(i) *Preparation. Fig. 1*(*a*)

With the paper attached to the drawing board it will be found more comfortable, and you will be able to work more efficiently, if the board is raised with a 3-in. block (two or three books will do) placed under the edge of the board furthest from you. The slope should not be too great as the tee-square, the set-squares and the instruments will tend to slide off.

(ii) *Tee-square*

The tee-square is the next most important piece of apparatus for drawing. It consists of a blade with a straight edge at least as long as the drawing board being used, and is fitted on to, and not into, a head at right angles to the blade. It is an advantage for the upper edge of the blade to be bevelled along its entire length. When laying the tee-square in position, the head must slide along, and rest against, the left-hand edge of the drawing board. It must be understood that this edge is the only one which must be absolutely straight, so that when the head of the tee-square is moved along this edge to any position no play or movement can be felt at the extreme end of the blade. When moving the tee-square, the head should be held in the left hand with the fingers of the right hand lightly resting on, and guiding, the blade. When the blade is in the required position, the thumb of the left hand should rest on, and exert slight pressure along, the blade towards the right-hand end (see Fig. 1*a*). This will keep the head of the tee-square against the board and allow the four fingers of the left hand to manipulate the set-squares referred to in the following section. All horizontal lines must be drawn with the aid of the tee-square.

(iii) *Set-squares*

All vertical lines must be drawn with the aid of a set-square resting on the upper edge of the tee-square.

All lines at angles of 60° or 30° to the horizontal or vertical must be drawn with the aid of the 60° set-square.

All lines at an angle of 45° to the horizontal or vertical must be drawn with the aid of the 45° set-square.

Any other straight line enclosing an angle which is a multiple of 15° to a horizontal or vertical line can be constructed by using a tee-square and the 45° and 60° set-squares, as shown in Fig. 2(*c*).

(iv) *How to Use a Pencil*

The object of having a pencil with a long, conical point (sharpened as previously explained) is to draw a large number of lines without unnecessary re-sharpening. This is made possible by *a very slight rotation of the pencil* while drawing the line and guided by the tee-square or set-square. It will be easy to see that a comfortable and suitable angle to hold the pencil is at approximately 45° to the paper, but in a vertical plane to the straight edge as shown in Fig. 2(*d*). If the pencil is not rotated, the lead quickly wears to a thicker part of the conical point and will require re-sharpening much sooner. If the pencil is rotated, the wear is evenly distributed round the point and it will continue to draw sharp lines for a much longer period.

(v) *How to Use a Ruler. Fig. 2(e)*

In order to obtain accurate measurements on the drawing, the utmost use must be made of the ruler. To make a measurement, the ruler should be held at an angle of approximately 45° to the paper, and the eye should be positioned vertically above, and looking along, the marking-off line. Make a small dot with the pencil on the paper at the required position. When setting the compasses to make a measurement, the safety point should be placed at zero, or a main division, and the lead carefully moved to coincide exactly with the required measurement.

There will be a saving of time if several measurements can be made at the same time whilst the ruler is held in the hand.

(vi) *How to Use Compasses*

Spring-bow compasses (see Fig. 1*c*) are for drawing circles and radii up to 1-in. radius. The lead should be sharpened to a chisel point, i.e. two flats formed as shown in Fig. 2(*b*) by rubbing on a sandpaper block.

The needle must be fitted so that when the safety point is touching the paper, and the compasses are exactly vertical, the lead is also just touching the paper. Tighten the two clamp screws to prevent the lead or needle from moving.

To manipulate spring-bow compasses with one hand requires good instruction as well as much practice. Proceed as follows:

Take the handle of the compasses between the second finger and thumb and produce a rolling action. Repeat this several times in order to get a smooth movement. Now hold the compasses vertically on the paper and, with the first finger of the same hand, lightly press the ball end of the handle so that the safety needle point just penetrates the paper or is resting on the ruler. Holding the compasses in this position with the first finger only, adjust the centre screw with the thumb and second finger. After some practice this will become a simple and easy operation. When the correct radius has been set, the handle of the compasses should be rolled between the thumb and second finger with slight downward pressure of the lead on the paper. This will produce a circle. A great deal of practice is needed in order to get a circle of even line thickness. When drawing an arc of a circle the rolling action must be carefully controlled.

With larger compasses the action is different. The knuckle joints must first be adjusted so that when the lead is set to the correct radius both the lead and the needle are perpendicular to the paper (see Fig. 1*d*). When drawing a light constructional circle, the compasses can be rolled between the thumb and the second finger. When a heavy outline circle is being drawn, the first finger of the hand controlling the compasses puts additional downward pressure on the leg carrying the lead. This pressure must be evenly distributed to obtain a circle of even line thickness. When drawing an arc of a circle, the pressure downwards and the radial movement must be carefully controlled. Again, much practice is needed in order to get an arc of a circle of even line thickness, which must, in many cases, join two straight lines of the same thickness.

1.13. LETTERING AND FIGURING

When lettering or hand printing is used, it can be either vertical or sloping; but, of course, both types should not be used on the same drawing.

Before practising any lettering it must be stressed that a good drawing, neatly laid out and executed, can be spoiled completely by bad lettering and figuring. Therefore it is necessary that a certain style should be adopted and practised as much as possible before any attempt is made to place notes and dimensions on a drawing.

The alphabet with vertical letters and figures is illustrated in Fig. 3(*a*) and (*b*). When practising, two very faint horizontal lines, $\frac{1}{8}$ in. apart, should be drawn. To do this hold the tee-square so that the head is against the left-hand side of the board and the blade about 1 in. from the top edge

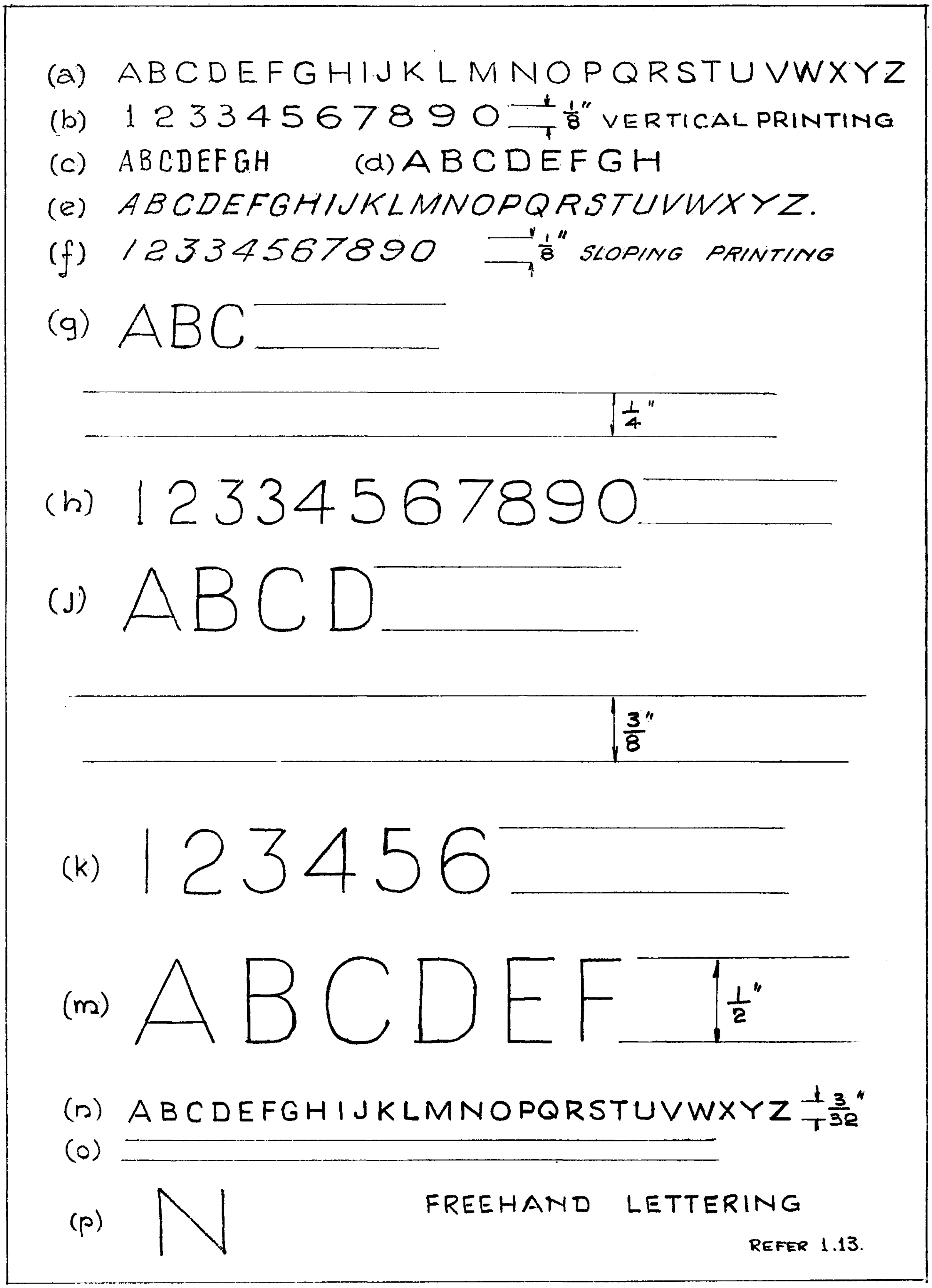

(a) ABCDEFGHIJKLMNOPQRSTUVWXYZ
(b) 1233456 7890 1/8" VERTICAL PRINTING
(c) ABCDEFGH
(d) ABCDEFGH
(e) ABCDEFGHIJKLMNOPQRSTUVWXYZ.
(f) 1233456 7890 1/8" SLOPING PRINTING
(g) ABC
1/4"
(h) 1233456 7890
(J) ABCD
3/8"
(k) 123456
(m) ABCDEF
1/2"
(n) ABCDEFGHIJKLMNOPQRSTUVWXYZ 3/32"
(o)
(p) N
FREEHAND LETTERING
REFER 1.13.

FIG. 3

of the paper. Using the HB pencil, sharpened as mentioned previously, let the pencil just *rest* on the paper and be guided by the tee-square. No pressure should be put on the pencil. Print the alphabet between these two lines and notice that *all* the letters should be constructed by "down" strokes and horizontal strokes and that there are no "up" strokes. For instance, the letter A is two down strokes and one horizontal stroke; the letter K is three down strokes; the letter M is four down strokes; the letter O is two down strokes; and the letter U is two down strokes joined at the centre. In the same way, the figure 2 is two down strokes and one horizontal stroke; the figure 6 is two down strokes; the figure 8 is two down strokes; and the figure 9 is two down strokes.

After printing one complete alphabet and one set of figures, note carefully the ones which compare unfavourably with those given in Fig. 3(*a*) and print a line of ten or more of each of them. Then repeat the complete alphabet and figures. It is only with continuous practice that improvement will be made. The distance between the lines of printing should be equal to the height of the letters, namely $\frac{1}{8}$ in. The general tendency for beginners is to print the letters much too close, as illustrated in Fig. 3(*c*). As an experiment try printing a line of letters as shown in Fig. 3(*d*), i.e. opened out (exaggerated), and then drop back to the original shape, as in Fig. 3(*a*). You will find that after printing several lines of Fig. 3(*d*), the original style of Fig. 3(*a*) will fall neatly into shape.

If you find that your lettering has improved after a reasonable amount of practice, you could then attempt the sloping alphabet and figures illustrated in Fig. 3(*e*) and (*f*). Practise several lines of each and you will soon discover which of the two styles gives the more pleasing effect.

Only after continuous practice will it be advisable to change the height of the printing. Draw two very thin lines $\frac{1}{4}$ in. apart and print an alphabet and a set of figures, as shown in Fig. 3(*g*). Continue to practise at this size until a good degree of proficiency is reached.

When you have practised the letters and figures $\frac{1}{4}$ in. high sufficiently, you can increase the distance of the lines apart to $\frac{3}{8}$ in., and then to $\frac{1}{2}$ in. printing the alphabet and figures at each size. It will be found that the larger the letters, the more practice will be required to print well. Never cramp the printing into a small space with letters which are tall and thin; open them out so that the letters and figures take on the appearance of a square block. The letter N, for instance, should be printed as shown in Fig. 3(*p*).

After a certain amount of practice at $\frac{3}{8}$ in. and $\frac{1}{2}$ in. the size of the letters should be finally reduced to something smaller than $\frac{1}{8}$ in. (your first lines of printing). Carefully draw some new lines $\frac{3}{32}$ in. apart and print the alphabet and figures. It will be found that printing at this size is easier, and if care is taken good results will be obtained.

From what has already been said, you will realize it is only after continuous practice that proficiency can be attained and that you will be able to extend to words.

1.14. PRINTED WORDS AND NOTES, ETC.

Continue to practise printing words which are likely to be used in engineering drawing at the $\frac{3}{32}$ in. and the $\frac{1}{8}$ in. size, namely SCREW, HEAD, PIN, NUT, WASHER, STUD, BOLT, RIVET, DIMENSION, DEVELOPMENT. (See Fig. 4*a*.) Print each word several times, taking care that all the letters are the same height. See that all the words are spelt correctly, and if in doubt refer to a dictionary: it is embarrassing to have drawings returned because of incorrect spelling.

When the outline of a drawing is finished and the necessary information for its manufacture is being added the following points should be noted (see Fig. 4*b*):

(i) Notes should be brief and concise but at the same time should contain sufficient information.

SCREW. PIN. NUT. WASHER.
STUD. BOLT. RIVET. SHOW.
DEVELOPMENT. DIMENSION.
DRAWING. COUNTERSUNK.
NOTE. ONE LINE OF $\frac{1}{8}''$ PRINTING IS
SEPARATED FROM THE NEXT
LINE OF PRINTING BY A SPACE
EQUAL TO THE HEIGHT OF
THE LETTERS

SCALE FULL SIZE

MAT: CAST IRON

— WORDS IN FREEHAND LETTERING —

— FIG 4(a) — REFER 1.14

NOTES SHOULD BE BRIEF AND
CONCISE BUT MUST CONTAIN
SUFFICIENT INFORMATION ~

THE CONSTRUCTION OF THE NOTE
MUST BE SIMPLE, WITHOUT "FANCY"
WORDING, AND EASILY UNDERSTOOD
WITH NO POSSIBILITY OF MISTAKE.

— COMPLETE NOTES — FIG 4(b) REFER 1.14.

Fig. 4

(ii) The construction of the notes should be simple so that the meaning can be understood quite easily with no chance of misunderstanding.

(iii) Compose the notes in such a way that they will form a neat, rectangular shape when complete.

EXERCISES ON CHAPTER 1

1. Time yourself in seconds for the following: place board on desk, tee-square on board, paper on board fixed in position. Draw one horizontal line 4 in. long and one vertical line 3 in. long joined at one end.

2. Draw four circles of each of the following sizes: $\frac{1}{8}$ in. dia., $\frac{3}{16}$ in. dia., $\frac{1}{4}$ in. dia., $\frac{3}{8}$ in. dia. The exac size must be drawn.

3. Draw four circles of each of the following sizes: $\frac{13}{16}$ in. dia., $1\frac{1}{4}$ in. dia., $1\frac{15}{16}$ in. dia., $2\frac{7}{8}$ in. dia. The exact size must be drawn.

4. Measure off and draw horizontal lines exactly $1\frac{1}{16}$ in., $1\frac{3}{16}$ in., $1\frac{11}{16}$ in., $1\frac{15}{16}$ in. long.

5. Print the following words: SHOW, SCREW, COUNTERSUNK, RECESS, and the figures 10, 59, 876, all $\frac{1}{8}$ in. high.

6. Draw two lines at angles of 30°, 45°, 60°, 75° and 105° respectively.

7. Measure off, and draw, vertical lines exactly $\frac{13}{16}$ in., $1\frac{5}{16}$ in., $1\frac{11}{16}$ in., $1\frac{15}{16}$ in. long.

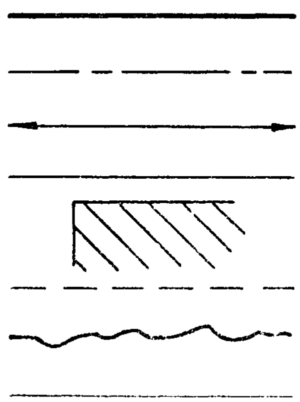
The answers to these Exercises will be found in Fig. 63.

2 · Early Work on Geometrical Construction

2.1. TYPES OF LINES

All the lines for the drawings you will be doing are from those recommended by the British Standards Institution Publication B.S. 308A (1958).

For general engineering drawings the types of lines used are shown below:



(*a*)	Main outline	continuous thick.
(*b*)	Centre line	long chain, thin.
(*c*)	Dimension line	continuous thin.
(*d*)	Projection line	continuous thin.
(*e*)	Section line	continuous thin, always at 45°.
(*f*)	Hidden detail	short dashes, thin.
(*g*)	Irregular boundary	continuous thick.
(*h*)	Construction line	continuous very thin.

Lines should be sharp and dense.

Lines specified as *thick* should be from two to three times the thickness of lines specified as *thin*. A construction line is *too thick* if it is visible at a distance of 4 ft.

If progress is to be made it is very necessary to practise the above lines as much as possible.

Refer to the above list of types of lines and draw at least twelve of each, using the tee-square for (*a*), (*b*), (*c*), (*d*) and (*f*), and a 45° set-square with the tee-square for the (*e*) lines. The (*g*) line, irregular boundary, is drawn freehand, i.e. without the aid of the tee-square. When drawing straight lines always remember to rotate the pencil slightly while guiding it with the set-square or tee-square.

After considerable practice the types of lines will become quite familiar and we can pass on to drawing geometrical shapes.

2.2. DRAWING VARIOUS SHAPES

(i) *The Rectangle*

The size of the rectangle to be drawn is $2\frac{1}{2}$ in. $\times$ $1\frac{1}{2}$ in. Proceed as follows:

First draw a horizontal construction line (i.e. with the sharpened pencil just resting on the paper and guided by the tee-square) approximately 3 in. from the top edge of the paper. Now measure

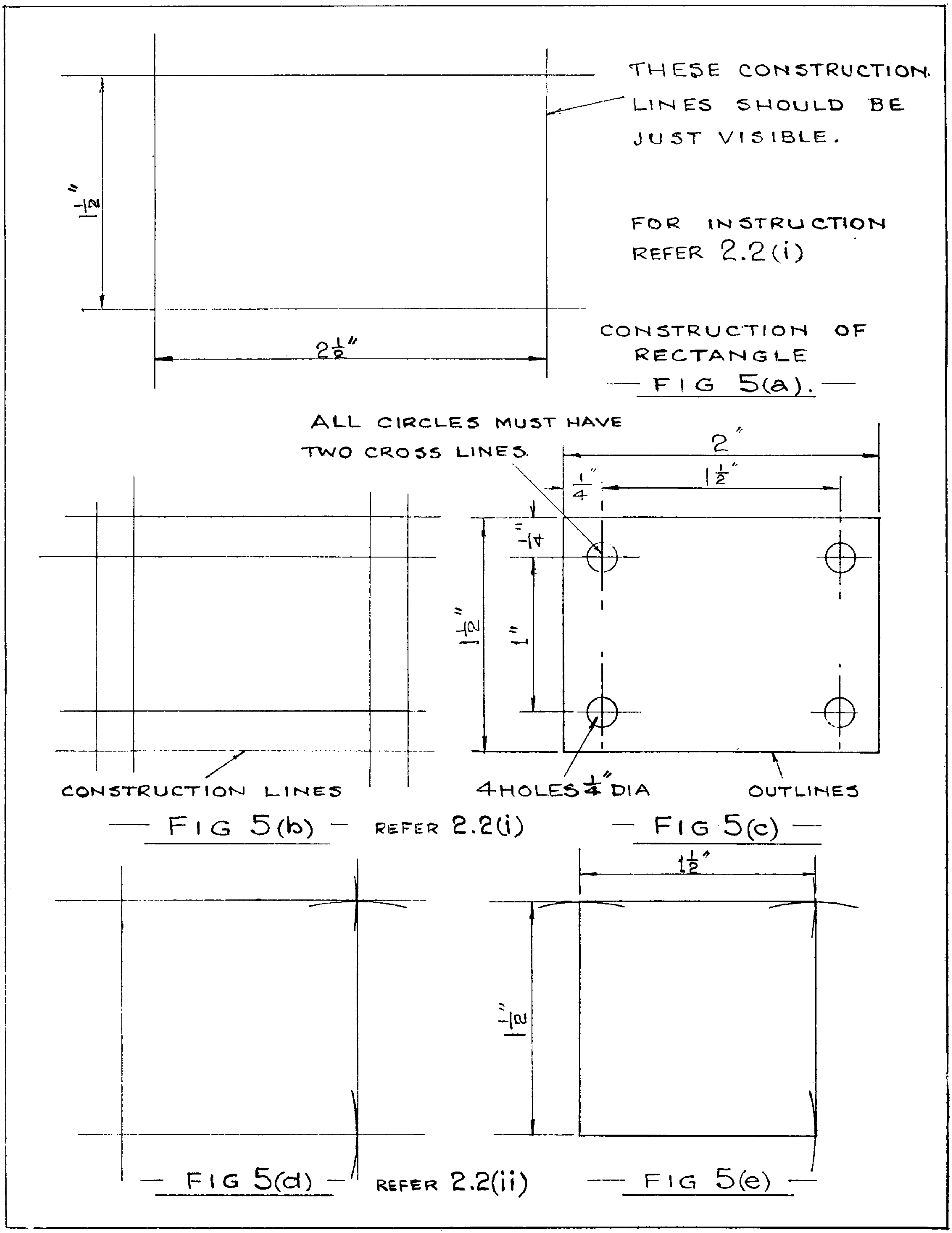

THESE CONSTRUCTION LINES SHOULD BE JUST VISIBLE.
FOR INSTRUCTION REFER 2.2(i)
CONSTRUCTION OF RECTANGLE
FIG 5(a).
1½"
2½"
ALL CIRCLES MUST HAVE TWO CROSS LINES.
2"
¼"
1½"
1½"
1"
4 HOLES ¼" DIA
OUTLINES
CONSTRUCTION LINES
FIG 5(b)
REFER 2.2(i)
FIG 5(c)
FIG 5(d)
REFER 2.2(ii)
FIG 5(e)

FIG. 5

off, and draw, another construction line exactly $1\frac{1}{2}$ in. above the first line. These lines should be longer than $2\frac{1}{2}$ in. and should be just visible. With the aid of the 60° set-square draw one vertical construction line as shown at the left of Fig. 5(*a*). From this line measure off (see Fig. 2*e*) and draw another vertical line $2\frac{1}{2}$ in. from the first line, moving the set-square to the right. As these are only very thin construction lines, the rectangle should be as shown in Fig. 5(*a*). To complete the drawing of the rectangle, outlines should be drawn over the construction lines but they should meet sharply in the corners and not overlap. *Do not* remove the surplus construction lines as these can be used later as projection lines for dimensioning.

Repeat one more rectangle of the same size and then draw one of each of the following sizes: $3\frac{1}{4}$ in. × 2 in. and $3\frac{1}{16}$ in. × $1\frac{1}{8}$ in.

To illustrate this more clearly, draw a rectangle 2 in. × $1\frac{1}{2}$ in. with one hole of $\frac{1}{4}$ in. diameter in each corner equally spaced $\frac{1}{4}$ in. from each side, as shown in Fig. 5(*c*). Notice that construction lines are just visible in Fig. 5(*b*), and that in the completed drawing the outlines cover most of the construction lines: also note that two short, thin cross lines are added to indicate the centres of all four circles. Do not add dimensions or dimension lines.

(ii) *The Square. See Fig. 5(d)*

The size of the square to be drawn is $1\frac{1}{2}$ in. Proceed as follows:

Draw a construction line (i.e. with the sharpened pencil just resting on the paper and guided by the tee-square) approximately 3 in. from the top edge of the paper. Then draw a vertical construction line to intersect with the first line. Set the large compasses to $1\frac{1}{2}$ in. radius and, with the needle point at the intersection of the lines, make an arc on both lines. From each of these arcs carefully draw a vertical and a horizontal construction line to complete the square (Fig. 5*d*). To finish the drawing of the square, outlines should be drawn over the construction lines but they should meet sharply in the corners and not overlap. Do not remove the surplus construction lines, as these can be used later as projection lines for dimensioning (Fig. 5*e*). Do not add dimensions or dimension lines.

Repeat one more square of the same size, and then draw one of each of the following sizes: $3\frac{1}{4}$ in. and $3\frac{15}{16}$ in.

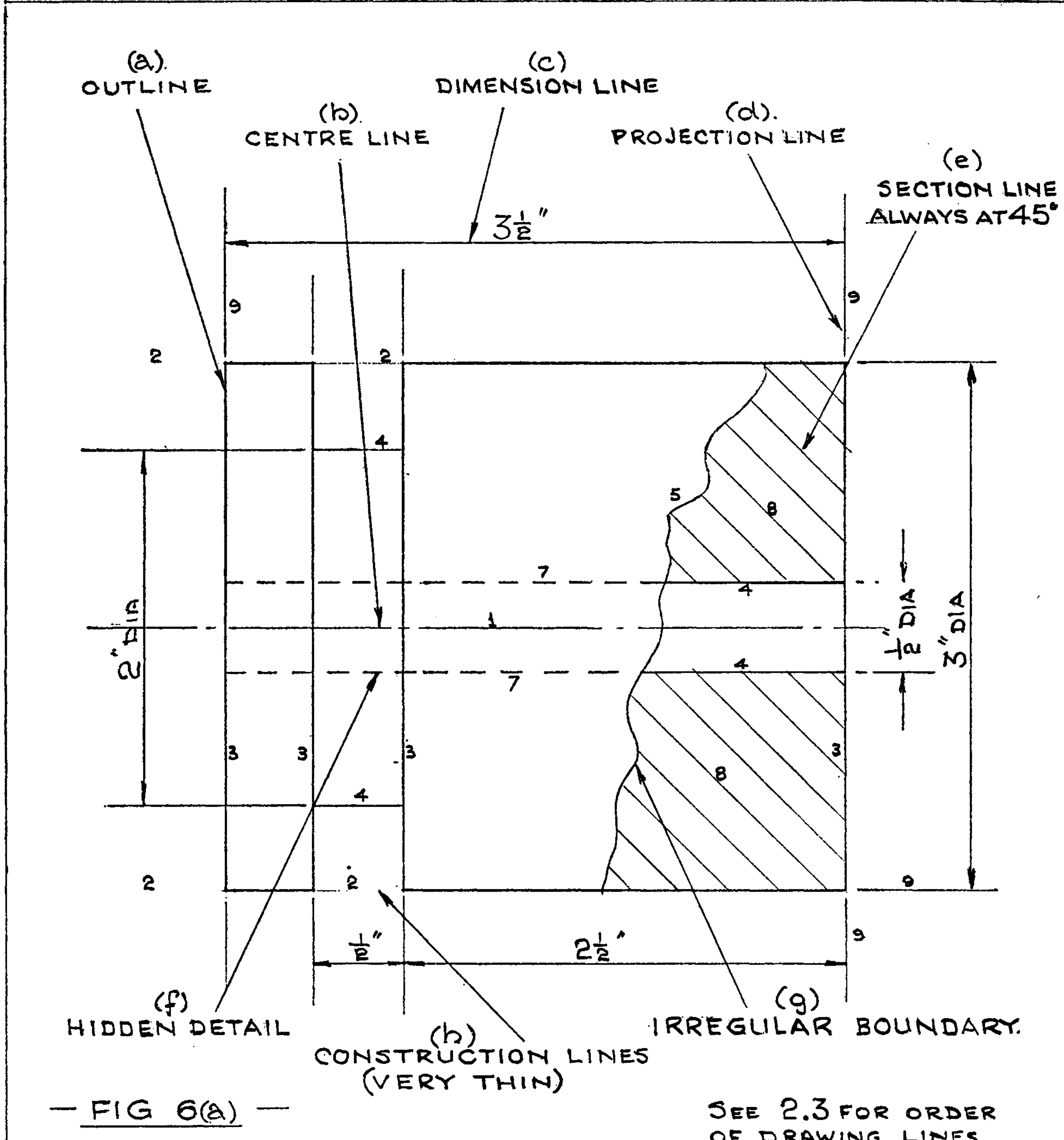
(iii) *Circles*

When a circle is to be drawn, it is *essential* that its centre is the intersection of two lines previously plotted. Therefore, in the preparation of a drawing construction lines must always intersect at the centre of a circle and be produced beyond the edge of the outline, to be used later for dimensioning.

2.3. TYPES OF LINES ILLUSTRATED

The types of lines (*a*) to (*h*) set out in section 2.1 above are all illustrated in Fig. 6(*a*). Copy this drawing, but do not worry if you do not completely understand it. It is the basis for all the drawings you will be doing later on and after further practice it will be understood without difficulty. Proceed as follows:

(1) Allowing sufficient space for the outline and the dimensions, draw the centre line (*b*).
(2) Draw two horizontal construction lines (*h*) exactly $1\frac{1}{2}$ in. each side of the centre line.
(3) Draw the four vertical construction lines.


(a).
OUTLINE
(b).
CENTRE LINE
(c)
DIMENSION LINE
(d).
PROJECTION LINE
(e)
SECTION LINE
ALWAYS AT 45°
3½"
2" DIA
½" DIA
3" DIA
½"
2½"
(f)
HIDDEN DETAIL
(h)
CONSTRUCTION LINES
(VERY THIN)
(g)
IRREGULAR BOUNDARY.
— FIG 6(a) —
SEE 2.3 FOR ORDER
OF DRAWING LINES.

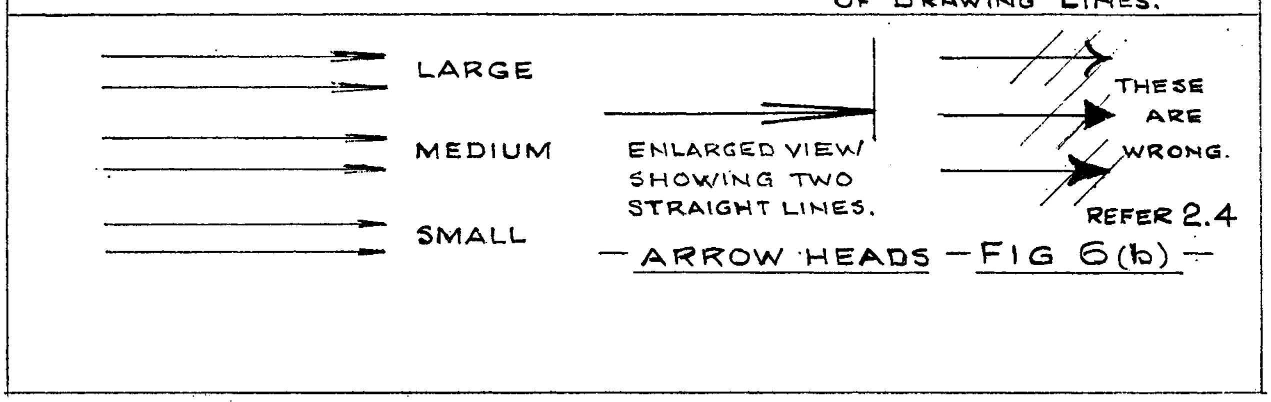

LARGE
MEDIUM
SMALL
ENLARGED VIEW
SHOWING TWO
STRAIGHT LINES.
THESE
ARE
WRONG.
REFER 2.4
— ARROW HEADS — FIG 6(b) —

FIG. 6

(4) Draw the horizontal construction lines forming the centre hole and the recess.

(5) Draw the irregular boundary line (*g*).

(6) Carefully cover the appropriate construction lines with the outlines (*a*), making the vertical and horizontal lines meet sharply at the corners.

(7) Draw the hidden detail (*f*), continuing as outline on right side of the irregular boundary line (*g*).

(8) At an angle of 45° draw the section lines at least $\frac{1}{8}$ in. apart.

(9) Draw the projection lines (*d*), which, in most cases, will cover the construction lines.

(10) One rule which should be observed is that as far as possible hidden detail should not be dimensioned. Because of this, we "break", or cut away, an imaginary part to show the hole in full outline, and then section line or cross hatch the part which has been cut away. As you will notice, this is done by line (*e*) which consists of thin continuous lines drawn at an angle of 45°.

Lines to the notes are thin continuous lines with small arrow heads at the inner end (Fig. 6*b*). These lines should never be vertical or horizontal because they could be confused with the drawing lines.

Notes should be printed between two very thin lines $\frac{3}{32}$ in. apart and should conform to the style shown in Figs. 3 and 4.

Finally, the dimensions can be inserted on the drawing if they are copied exactly as in Fig. 6(*a*); but these will be dealt with later.

2.4. ARROW HEADS. Fig. 6(*b*)

Every dimension line must be terminated at each end with an arrow head. These are made by two short, straight lines meeting at a point and touching the projection lines (*d*) (see the enlarged arrow head in Fig. 6*b*). The arrow heads are *not* made with curved lines, or "filled in" triangles, or long "filled in" heads. It is considered to be bad practice to draw the latter type of arrow head.

After considerable practice it will be found that the arrow heads on the left of Fig. 6(*b*) become very easy to draw and make the finished drawing look extremely neat.

2.5. FURTHER WORK WITH 45° AND 60° SET-SQUARES. Fig. 7

It is very easy to divide a circle into four or eight equal sectors by using the 45° set-square.

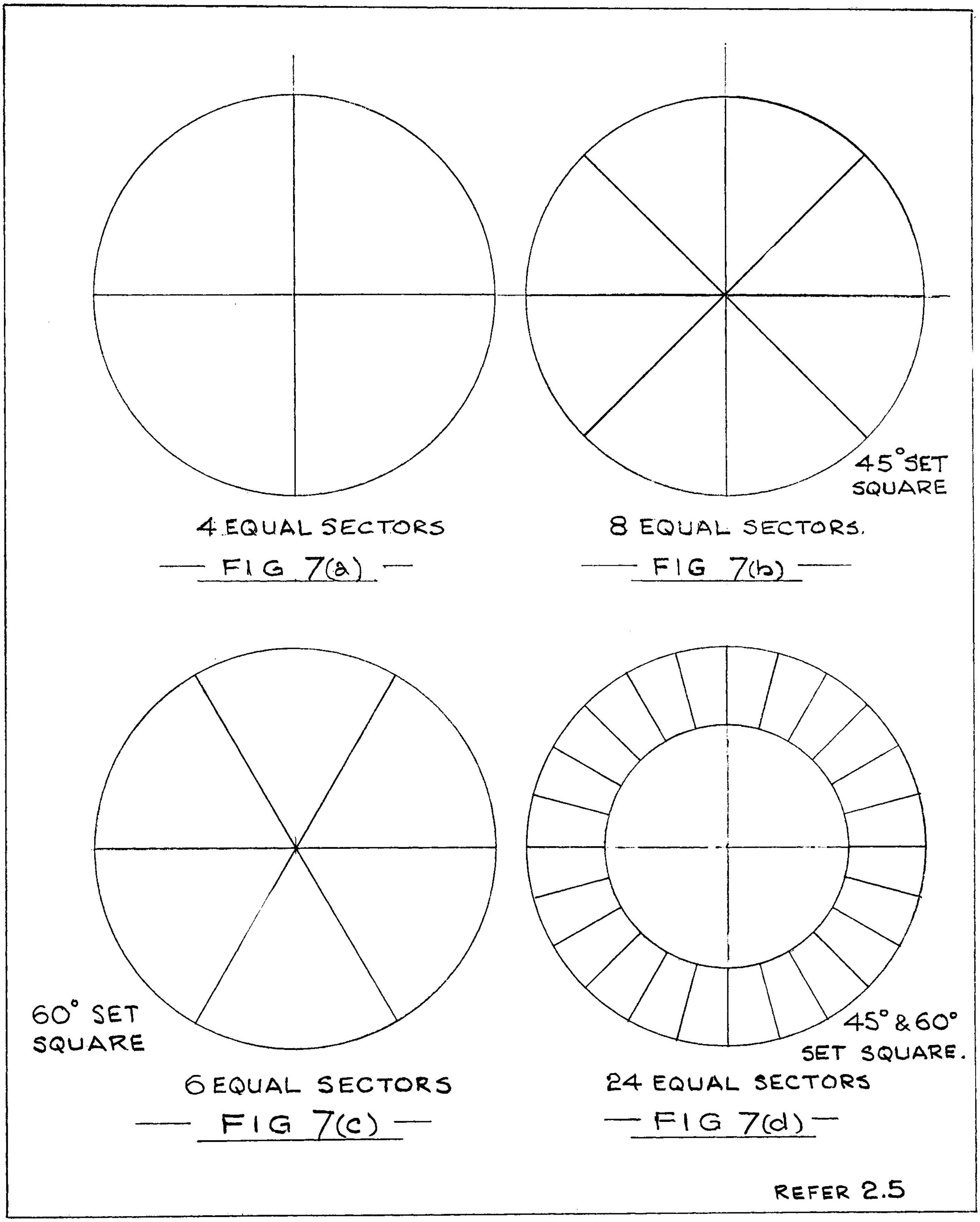
Draw a circle $2\frac{1}{2}$ in. in diameter on a construction of vertical and horizontal cross lines. Then draw the vertical and horizontal outlines, meeting exactly at the edge of the circle. This will divide the circle into four equal parts (Fig. 7*a*).

Draw another circle in the same way, with the same diameter and with vertical and horizontal outlines, as shown in Fig. 7(*a*). Then draw two outlines with the 45° set-square to pass exactly through the centre and to meet exactly at the edge of the circle. This has divided the circle into eight equal parts (Fig. 7*b*).

Using the 60° set-square it is quite easy to divide a circle into six equal sectors.

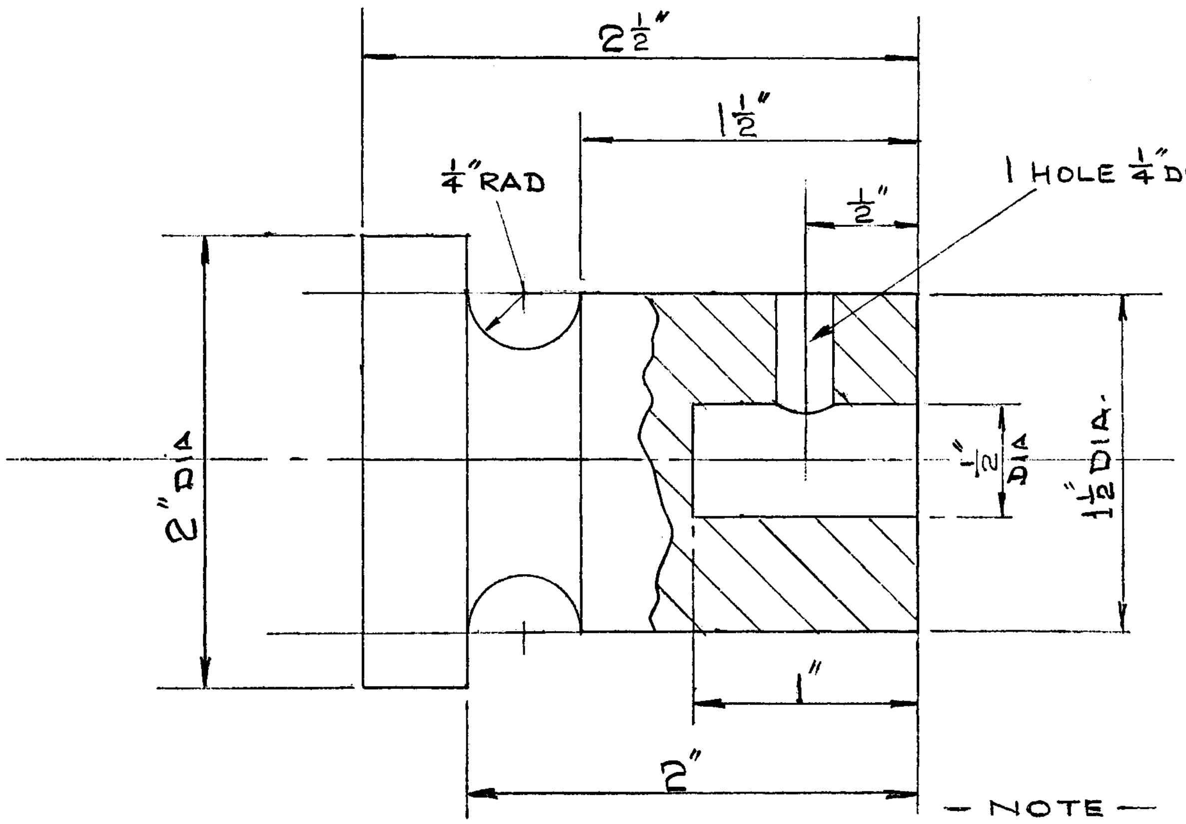
Draw a circle $2\frac{1}{2}$ in. diameter on thin construction centre lines. Then draw two lines with the 60° set-square to pass exactly through the centre. Now draw the three outlines over the construction lines. This has divided the circle into six equal sectors (Fig. 7*c*).

Draw two circles $2\frac{1}{2}$ in. diameter and $1\frac{1}{2}$ in. diameter on thin construction lines. Using the tee-square, together with the 45° and 60° set-squares combined, draw radial lines equally spaced



4 EQUAL SECTORS
— FIG 7(a) —
8 EQUAL SECTORS.
— FIG 7(b) —
45° SET SQUARE
60° SET SQUARE
6 EQUAL SECTORS
— FIG 7(c) —
45° & 60° SET SQUARE.
24 EQUAL SECTORS
— FIG 7(d) —
REFER 2.5

Fig. 7



— FIG 8(a) — REFER 2.6

— NOTE —
ILLUSTRATE ALL THE LINES USED (AS IN FIG 6(a))

THE DRAWING SHOWN IN FIG 8(a) SHOULD BE DRAWN IN FINE CONSTRUCTION LINE AND THEN OUTLINED IN FIRM LINE. DO NOT REMOVE ANY CONSTRUCTION LINES.

FOR PRACTICE IN PRINTING, COPY THE ABOVE NOTE THREE TIMES FOR STYLE AND SPACING

REFER TO SECTION 2.7

— FIG 8(b) —

FIG. 8

between the two circles at exactly 15° spacing. These lines should first be drawn as construction and then as outline (Fig. 7*d*). This has divided the circle into twenty-four equal sectors.

2.6. FURTHER WORK ON TYPES OF LINES. Fig. 8(*a*)

This drawing is similar in form to that in Fig. 6(*a*). Follow the procedure set out in section 2.3 and copy the drawing shown in Fig. 8(*a*). You should commence by drawing the centre line and continue the sequence. Print, in the form of notes, information dealing with each type of line (*a*), (*b*), etc., as shown in Fig. 6(*a*).

2.7. FURTHER LETTERING

A longer, printed note is shown in Fig. 8(*b*). This should be copied at least twice for style and spacing. The note should be arranged in a rectangular block.

Print the following words $\frac{1}{8}$ in. high at least twice:

THIRD ANGLE PROJECTION

FIRST ANGLE PROJECTION

REMOVE ALL BURRS

DIMENSIONS IN MILLIMETRES

DIMENSIONS IN INCHES

Notes similar to these will appear on most of the drawings which you will do.

2.8. CONCLUSION

It will be evident to the keen student that it is only by constant practice that the drawing of lines, circles, figures and printing can improve and become sufficiently familiar to pass on to the next chapter.

EXERCISES ON CHAPTER 2

1. Draw four of each of the following lines $2\frac{3}{4}$ in. long and letter each one: (*a*), (*b*), (*c*), (*f*), (*h*). Refer to section 2.1, types of lines.

2. Draw a rectangle $2\frac{3}{4}$ in. × $1\frac{5}{8}$ in. showing all construction lines. Refer to section 2.2(i).

3. Draw a square $1\frac{15}{16}$ in. sides and section line the area. Show construction. Refer to section 2.2(ii).

4. Draw a rectangle $3\frac{1}{16}$ in. × $2\frac{1}{16}$ in. with one hole $\frac{1}{4}$ in. in diameter in each corner spaced $\frac{7}{16}$ in. from each side. Refer to section 2.2(i).

5. Draw two circles $1\frac{1}{2}$ in. diameter and $2\frac{3}{4}$ in. diameter, and show radial lines equally spaced at 15° between these circles. Refer to section 2.2(iii).

6. Neatly print the following $\frac{3}{32}$ in. high: "The six holes must be equally spaced on a 2 in. radius at an angle of 60°." Refer to section 1.13.

The answers to these Exercises will be found in Fig. 64.

3 · Simple Geometrical Constructions

3.1. ANGLES

If a line of constant length is fixed at one end, and the other end is moved through one complete revolution, then we say that the line has moved through an angle of 360 degrees. The number 360 has been chosen because it is a very convenient number, i.e. it can be divided exactly by 1, 2, 3, 4, 5, 6, 8, 9, etc. If the same line is rotated through one quarter of a revolution, i.e. 90°, this is called *one right angle.*

To construct and measure an angle, draw a line approximately 2 in. long and from one end draw another line radiating from it. These two lines include an angle which can be measured by a protractor. See Fig. 9(*a*).

To draw a set angle use a set-square, or the combination of two set-squares, i.e. multiples of 15°, as shown in Fig. 2(*c*). An acute angle is less than a right angle. An obtuse angle is greater than one right angle and less than two right angles, i.e. between 90° and 180°.

3.2. BISECTION OF ANGLES

To bisect an angle is simply to divide the angle into two equal parts. To do this, draw two lines *AB* and *BC* at any acute angle, as in Fig. 9(*b*). From the centre point *B*, mark off with compasses two equal arcs *D* and *E*. From arcs *D* and *E* mark off two more equal arcs to intersect at *F*. Carefully draw a thin line from the centre point *B* to pass through point *F*. This has bisected the drawn angle *ABC*, i.e. the two angles *ABF* and *CBF* are equal.

3.3. TRIANGLES

A triangle is a plane closed figure bounded by three straight lines. To construct a triangle with sides $2\frac{1}{2}$ in., 2 in. and $1\frac{1}{2}$ in., draw a thin construction base-line 2 in. long (Fig. 9*c*). With the compasses set at $2\frac{1}{2}$ in. draw an arc. Repeat from the other end of the base-line with the compasses at $1\frac{1}{2}$ in. Draw lines to the intersection point. You have now drawn a *right-angled triangle.* Change the dimension of $2\frac{1}{2}$ in. to $1\frac{3}{4}$ in. and the result is shown in Fig. 9(*d*).

An *isosceles triangle* is a triangle with two sides of equal length. To construct an isosceles triangle with sides $1\frac{1}{2}$ in., 2 in. and 2 in., first draw the base-line $1\frac{1}{2}$ in. long. Then with the compasses set carefully at 2 in., draw an arc from each end of the base-line to intersect, as shown in Fig. 9(*e*). Draw lines to the intersection.

An *equilateral triangle* is a triangle with three sides of equal length. To construct an equilateral triangle with sides $1\frac{1}{2}$ in. long, draw the base-line $1\frac{1}{2}$ in. long. With compasses set carefully to $1\frac{1}{2}$ in. draw an arc from each end of the base-line to intersect, as shown in Fig. 9(*f*).

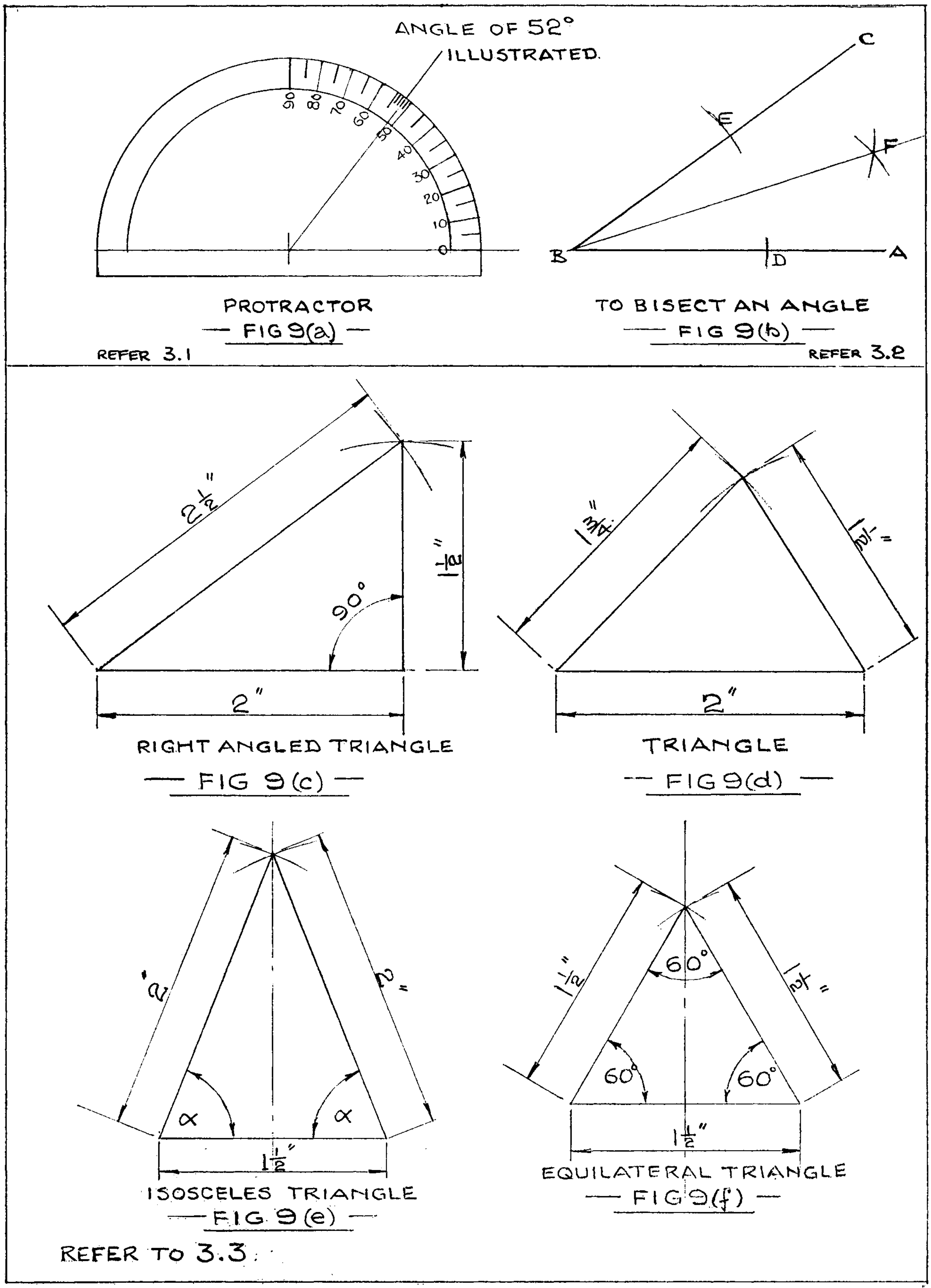

ANGLE OF 52°
ILLUSTRATED.
90
80
70
60
50
40
30
20
10
0
PROTRACTOR
— FIG 9(a) —
REFER 3.1
C
E
F
B
D
A
TO BISECT AN ANGLE
— FIG 9(b) —
REFER 3.2
2½"
1½"
90°
2"
RIGHT ANGLED TRIANGLE
— FIG 9(c) —
1¾"
1½"
2"
TRIANGLE
— FIG 9(d) —
2"
2"
α
α
1½"
ISOSCELES TRIANGLE
— FIG 9(e) —
REFER TO 3.3
1½"
1½"
60°
60°
60°
1½"
EQUILATERAL TRIANGLE
— FIG 9(f) —

Fig. 9

3.4. QUADRILATERAL

A quadrilateral is a plane, closed figure bounded by four sides with one angle or the position of one side controlled. To construct a quadrilateral *ABCD* with sides 3 in., $3\frac{1}{8}$ in., $1\frac{3}{4}$ in. and $2\frac{1}{4}$ in. (see Fig. 10*a*), first draw the base-line *BC* 3 in. long and a perpendicular line from *E*. Then construct a line *AB* $3\frac{1}{8}$ in. long. From *A* draw with compasses an arc at *D* $2\frac{1}{4}$ in. radius, and from *C* intersect with another arc at *D* $1\frac{3}{4}$ in. radius. Join up the outlines to all four points, as shown in Fig. 10(*a*). Quadrilaterals of different shapes can be constructed by varying the distance *BE*, the other dimensions remaining the same.

3.5. THE CIRCLE

You have already drawn some circles in Chapters 1 and 2, but in the present chapter the properties of a circle will be described and illustrated with the help of Fig. 10(*b*). Draw a circle 3 in. diameter and add to it all the parts described as follows:

(i) A *circle* is a plane figure bounded by one line (called the *circumference*) which is at a fixed distance (called the *radius*) from a fixed point (called the *centre*).

(ii) The *radius* is any straight line drawn from the centre to the circumference.

(iii) The *diameter* is a line passing through the centre with both ends on the circumference.

(iv) A *chord* is a line joining any two points on the circumference.

(v) An *arc* is part of the circumference of a circle.

(vi) A *segment* is part of a circle enclosed by a chord and an arc.

(vii) A *sector* is part of a circle bounded by two radii and an arc.

(viii) A *quadrant* is a quarter of a circle, i.e. a sector with an angle of 90° at the centre.

(ix) A *tangent* to a circle is a straight line touching the circle. At the point of contact on the circumference the radius and the tangent are at 90°.

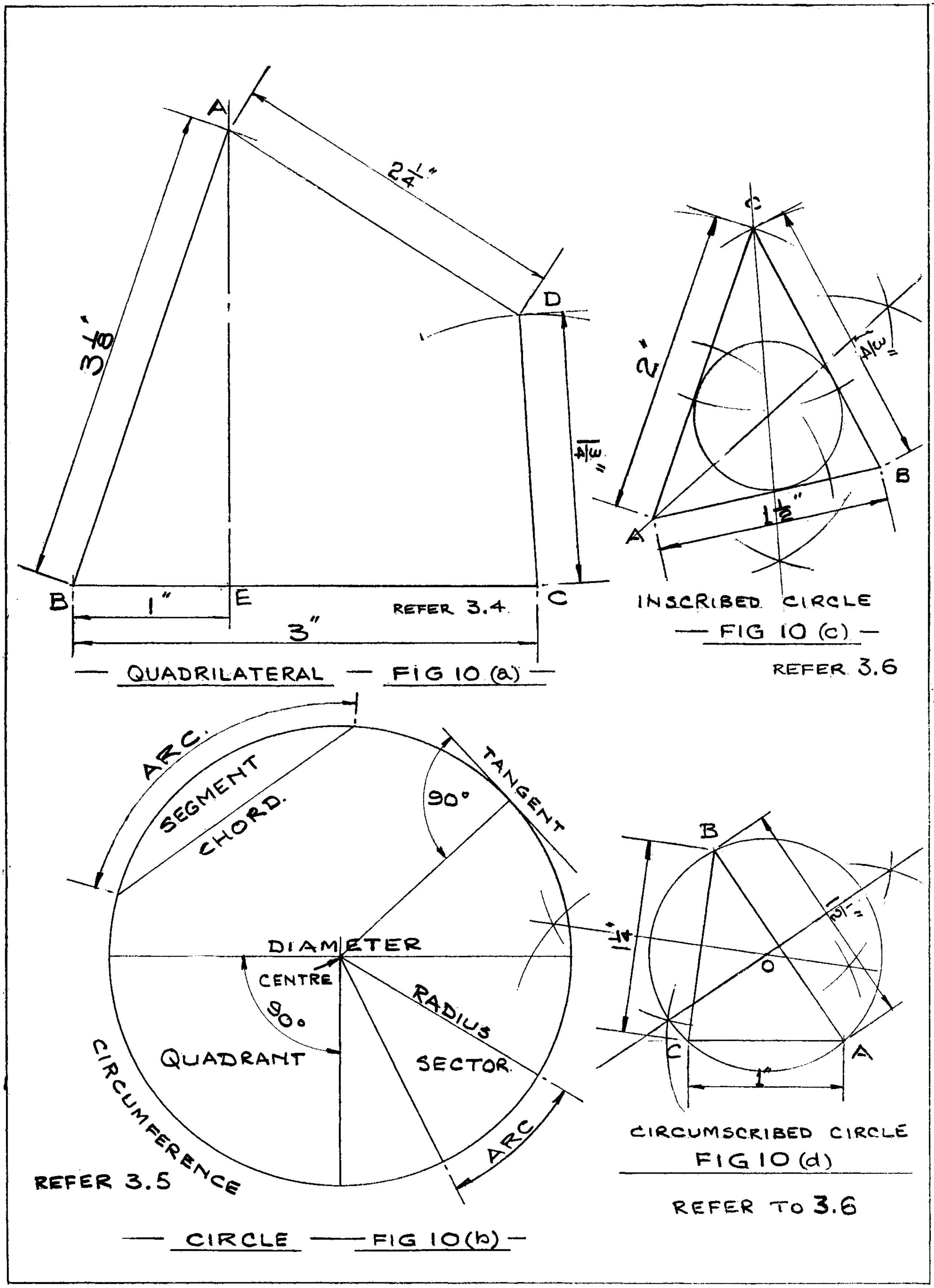
3.6. INSCRIBED AND CIRCUMSCRIBED CIRCLES

(i) An *inscribed circle* of a triangle is a circle drawn inside a triangle and touching all three sides of the triangle.

Draw a triangle *ABC* with sides $1\frac{1}{2}$ in., 2 in. and $1\frac{3}{4}$ in. respectively by the method shown in Fig. 9(*d*). Now bisect any two of the angles in the triangle, as shown in Fig. 9(*b*). Where the two bisectors intersect is the centre O of the circle, which when drawn will touch all three sides of the triangle (see Fig. 10*c*).

(ii) A *circumscribed circle* of a triangle is a circle which passes through all three points of the triangle.

Draw a triangle *ABC* with sides 1 in., $1\frac{1}{4}$ in. and $1\frac{1}{2}$ in. respectively by the method shown in Fig. 9(*d*). Now bisect any two sides and drop a perpendicular on each, as in Fig. 11(*a*) in section 3.7. Where the two bisectors intersect is the centre O of the circle, which when drawn will pass through points *A*, *B* and *C*, as in Fig. 10(*d*).



A
B
C
D
E
$3\frac{1}{8}$"
$2\frac{1}{4}$"
$\frac{3}{4}$"
1"
3"
REFER 3.4.
— QUADRILATERAL — FIG 10 (a) —
C
A
B
2"
$\frac{3}{4}$"
$1\frac{1}{8}$"
INSCRIBED CIRCLE
— FIG 10 (c) —
REFER 3.6
ARC
SEGMENT
CHORD
TANGENT
90°
DIAMETER
CENTRE
RADIUS
90°
QUADRANT
SECTOR
CIRCUMFERENCE
ARC
REFER 3.5
— CIRCLE — FIG 10 (b) —
B
O
C
A
$1\frac{1}{4}$"
$1\frac{1}{2}$"
1"
CIRCUMSCRIBED CIRCLE
FIG 10 (d)
REFER TO 3.6

FIG. 10

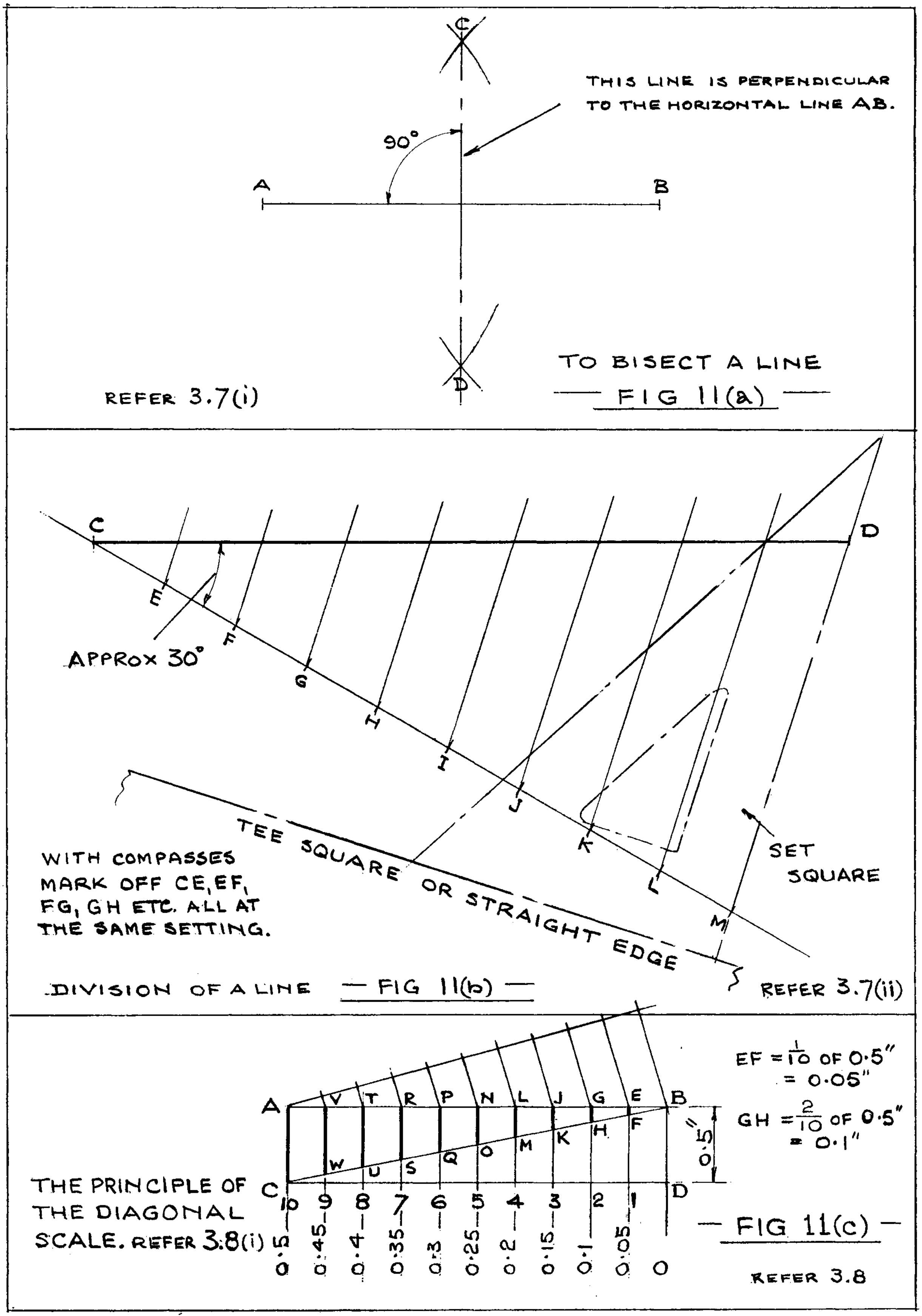

C
THIS LINE IS PERPENDICULAR TO THE HORIZONTAL LINE AB.
90°
A
B
D
TO BISECT A LINE
— FIG 11(a) —
REFER 3.7(i)
C
D
E
F
APPROX 30°
G
H
I
J
K
L
M
TEE SQUARE OR STRAIGHT EDGE
SET SQUARE
WITH COMPASSES MARK OFF CE, EF, FG, GH ETC. ALL AT THE SAME SETTING.
DIVISION OF A LINE — FIG 11(b) —
REFER 3.7(ii)
A
V
T
R
P
N
L
J
G
E
B
F
H
K
M
O
Q
S
U
W
C
D
0.5"
EF = 1/10 OF 0·5" = 0·05"
GH = 2/10 OF 0·5" = 0·1"
10 9 8 7 6 5 4 3 2 1
0·5 0·45 0·4 0·35 0·3 0·25 0·2 0·15 0·1 0·05 0
THE PRINCIPLE OF THE DIAGONAL SCALE. REFER 3.8(i)
— FIG 11(c) —
REFER 3.8

Fig. 11

3.7. THE DIVISION OF LINES

(i) *To Bisect a Line*

To bisect a line is to divide it into two equal parts. To do this, draw a line *AB* of any length and from each end describe with compasses two sets of intersecting arcs, the radius of each arc being equal and more than half the length of the line, as in Fig. 11(*a*). The line *CD* drawn between the intersecting arcs divides the line *AB* into two equal parts, and is also perpendicular to the line *AB*.

(ii) *To Divide a Line into Any Number of Equal Parts. Fig. 11(b)*

Draw a line *CD* of any length. It is required to divide *CD* into nine equal parts. Draw the line *CD* for convenience approximately 5 in. long. Then draw a construction line at an angle of approximately 30°. Set your compasses to a radius of approximately $\frac{1}{2}$ in. (plus) (the exact value is not important). With the compasses carefully mark off nine equal divisions *CE*, *EF*, *FG*, etc., along the sloping line. Join the last point *M* to the point *D* at the end of the line. With the aid of a straight edge and a set-square, draw parallel lines to *MD* from all the other points *L*, *K*, *J*, etc., to cut the line *CD*. The line *CD* has now been divided into nine equal parts. This method of dividing is extremely useful and should be practised for various lengths of lines and number of divisions. It will be found that this technique has many applications.

3.8. THE DIAGONAL SCALE

(i) *The Principle. Fig. 11(c)*

The principle of the diagonal scale is shown in Fig. 11(*c*). Draw a construction line, *AB*, of *any* convenient length (say $2\frac{1}{2}$ in.). Draw another line, *CD*, parallel to it, and half an inch from it. Close the ends so as to form a rectangle. Now divide *AB* into ten equal parts (as shown in Fig. 11*b*). Number the parts 1, 2 . . . 10. Carefully draw a diagonal line from *C* to *B*. You can now see that at the first division the length of the vertical line, *EF*, is one-tenth of 0·5 in., or 0·05 in.; at the second division the length, *GH*, is two-tenths of 0·5 in., or 0·1 in.; and each consecutive division increases until the tenth division, *AC*, equals 0·5 in.

Making further use of this principle, we can make a diagonal scale to any desired value.

(ii) *To Make a Scale to Read to 0·01 in. ($\frac{1}{100}$ in.). Fig. 12(a)*

Draw a horizontal line, *AB*, exactly 4 in. long and then draw five vertical lines carefully at each of the inch marks, marking them *A*, 0, 1, 2, *B*. Draw a line *CD* parallel to *AB*, and approximately $1\frac{1}{2}$ in. from it. Construct *AE* and divide *AC* accurately into ten equal parts. Number these divisions 0·01, 0·02, 0·03, etc., as shown. Construct *AF* and divide *A*0 and *C*0 accurately into ten equal parts. Number the divisions from 0 to *C*, 0·1, 0·2 . . . 0·9, as shown. Draw ten diagonal lines, as shown. All these lines must be drawn very thin and carefully to make it possible to read the scale to 0·01 in.

Use the scale and take measurements of 0·24 in., 1·35 in., 2·06 in. and 3·69 in.

0·24 in.: Mark off from the 0–0 vertical line to 0·2 along the base-line, 0*C*, and move up the diagonal until the 0·04-line is reached. Then set your compasses to 0*G* = 0·24 in.

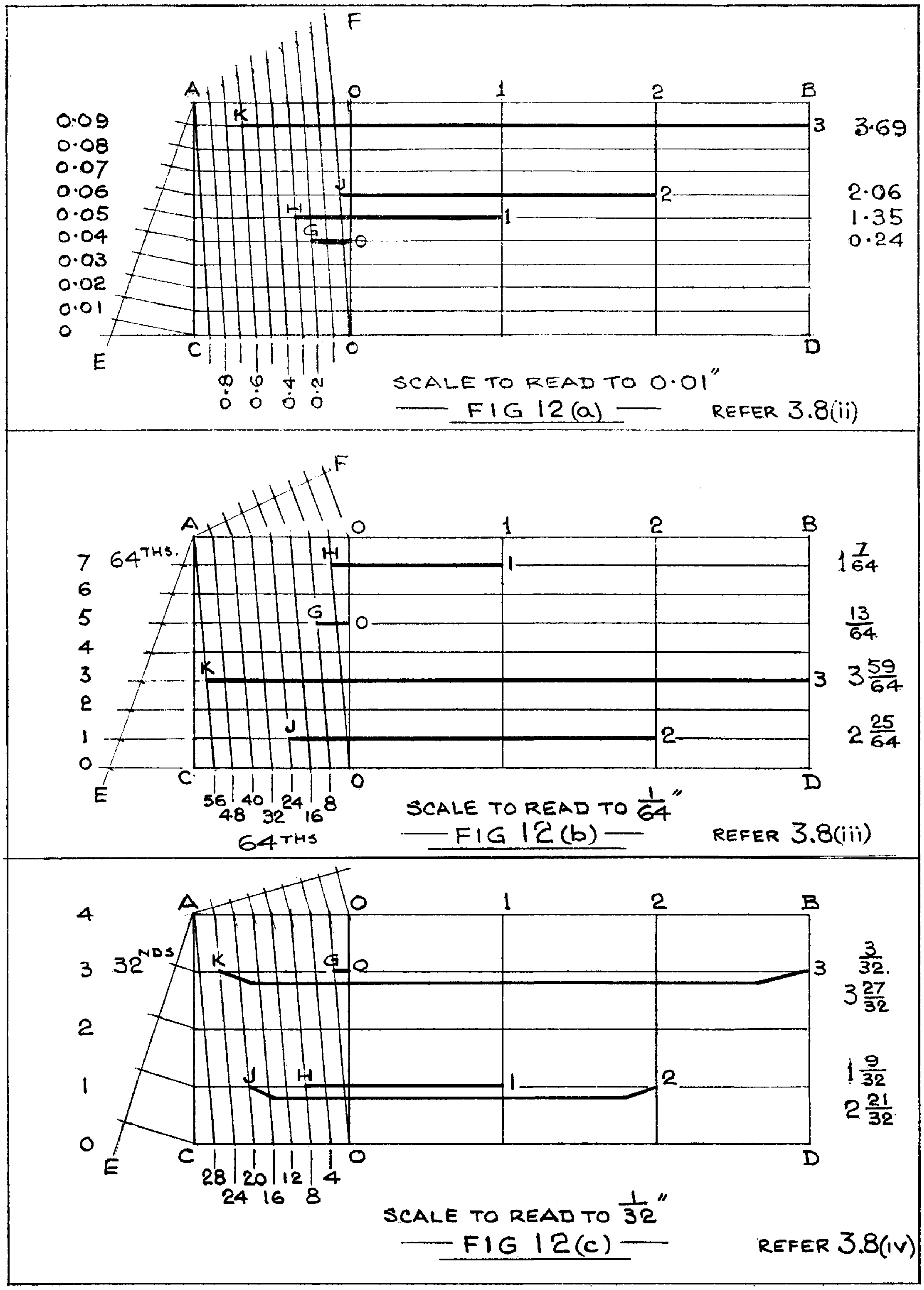

SCALE TO READ TO 0·01"
FIG 12(a)
REFER 3.8(ii)
3·69
2·06
1·35
0·24
SCALE TO READ TO 1/64"
FIG 12(b)
REFER 3.8(iii)
64THS
1 7/64
13/64
3 59/64
2 25/64
SCALE TO READ TO 1/32"
FIG 12(c)
REFER 3.8(IV)
32NDS
3/32.
3 27/32
1 9/32
2 21/32

Fig. 12

1·35 in.: Mark off from the 1–1 vertical line to 1·3 in. along the base-line and move up the diagonal until the 0·05-in. line is reached. Then set your compasses to $1H = 1{\cdot}35$ in.

2·06 in.: Mark off from the 2–2 vertical line to 2·0 in. along the base-line and move up the diagonal, until the 0·06-in. line is reached. Then set your compasses to $2J = 2{\cdot}06$ in.

3·69 in.: Mark off from the *BD* vertical line to 3·6 in. along the base-line and move up the diagonal until the 0·09-in. line is reached. Then set your compasses to $3K = 3{\cdot}69$ in.

Provided that care is taken with the construction and that very thin lines are drawn, reliable measurements can be made.

(iii) *To Make a Scale to Read to* $\frac{1}{64}$ *in. Fig. 12(b)*

Construct the scale, as in Fig. 12(*a*), but instead of dividing into ten equal parts divide both the horizontal and vertical scales into eight equal parts, numbering them as indicated in Fig. 12(*b*). Use the scale and take measurements of $\frac{13}{64}$ in., $1\frac{7}{64}$ in., $2\frac{25}{64}$ in., and $3\frac{59}{64}$ in.

$\frac{13}{64}$ in.: Mark off from the 0–0 line to $\frac{8}{64}$ in. along the base-line and move up the diagonal to the fifth line, making $0\text{–}G\ \frac{8}{64} + \frac{5}{64} = \frac{13}{64}$.

$1\frac{7}{64}$ in.: Mark off from the 1–1 line to the 0 line along the base and move up the diagonal until the seventh line, making $1H = 1\frac{7}{64}$ in.

$2\frac{25}{64}$ in.: Mark off from the 2–2 line to the twenty-fourth line along the base and move up the diagonal until the first line, making $2J = 2\text{ in.} + \frac{24}{64} + \frac{1}{64} = 2\frac{25}{64}$ in.

$3\frac{59}{64}$ in.: Mark off from the *BD* line to the fifty-sixth line along the base and move up the diagonal until the third line, making $3K = 3\text{ in.} + \frac{56}{64} + \frac{3}{64}$.

(iv) *To Make a Scale to Read to* $\frac{1}{32}$ *in. Fig. 12(c)*

Construct the scale as in Fig. 12(*a*), but instead of dividing into ten equal parts, divide the horizontal into eight equal parts and the vertical into four equal parts, and number, as in Fig. 12(*c*).

Use the scale and take measurements of $\frac{3}{32}$ in., $1\frac{9}{32}$ in., $2\frac{21}{32}$ in., $3\frac{27}{32}$ in.

$$0G = \tfrac{3}{32}\text{ in.,}\quad 1H = 1\text{ in.} + \tfrac{8}{32} + \tfrac{1}{32} = 1\tfrac{9}{32}\text{ in.}$$

$$2J = 2\text{ in.} + \tfrac{20}{32} + \tfrac{1}{32} = 2\tfrac{21}{32},\quad 3K = 3\text{ in.} + \tfrac{24}{32} + \tfrac{3}{32} = 3\tfrac{27}{32}\text{ in.}$$

The author attaches great importance to section 3.8(i), (ii), (iii) and (iv), as for the first time it is shown how precise measurements and drawings can be made by the exercise of care and the proper use of instruments.

EXERCISES ON CHAPTER 3

1. Draw an angle of 120° using the tee-square and set-square making the radius lines $1\frac{1}{2}$ in. long. Divide the angle into eight equal parts using compasses and the method of bisecting angles.

2. Draw two triangles with sides $2\frac{1}{4}$ in., $1\frac{3}{4}$ in., $1\frac{1}{2}$ in. and $2\frac{1}{2}$ in., $1\frac{3}{4}$ in., $1\frac{3}{8}$ in. respectively.

3. Draw an isosceles triangle with sides $2\frac{1}{4}$ in., $2\frac{1}{4}$ in., $1\frac{3}{4}$ in.

4. Draw an equilateral triangle with sides $1\frac{3}{4}$ in. long.

5. Draw a circle of 2 in. diameter and show the following: (*a*) diameter, (*b*) chord $1\frac{1}{4}$ in. long, (*c*) sector with 75° angle, (*d*) quadrant, (*e*) tangent.

6. Draw an inscribed circle in a triangle whose sides measure $2\frac{1}{2}$ in., $1\frac{1}{2}$ in., 2 in.

7. Draw a circumscribed circle of a triangle with sides $1\frac{1}{4}$ in., $1\frac{1}{2}$ in., $1\frac{3}{4}$ in.

8. Divide a line $2\frac{1}{2}$ in. long into seven equal parts.

9. Make a diagonal scale to read to 0·01 in. and take readings 0·26 in., 1·38 in., 2·03 in. and 3·74 in.

The answers to these Exercises will be found in Fig. 65.

4 · Types of Projection

4.1. SIMPLE PERSPECTIVE DRAWING. Fig. 13

The perspective method of illustration is the simplest and easiest to understand. It has been used by artists for hundreds of years and is still used for illustrating articles in journals where a photograph would be unsuitable.

Perspective drawing means putting down on paper what is seen when looking at an object with normal vision. It can be easily understood that when an object moves away from you it appears to get smaller. Therefore parallel, horizontal lines appear to get closer together and vanish on the horizon.

Figure 13(*a*) shows a typical perspective drawing of a rectangular block 2 in. high × 3 in. wide × 6 in. long. You will notice that no lines are parallel but that they gradually get closer until they eventually meet at a vanishing point.

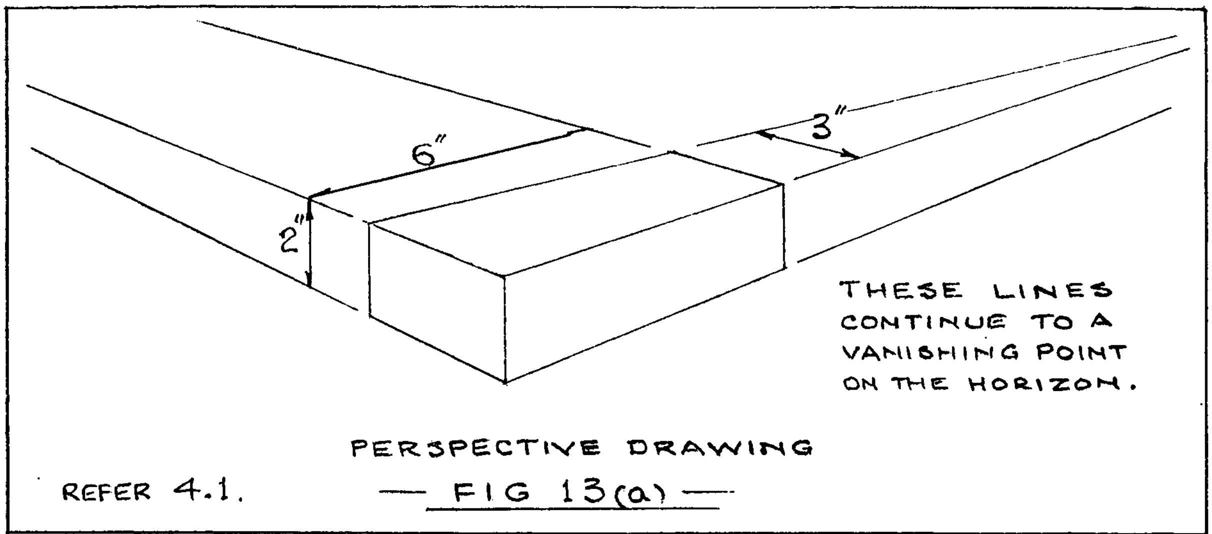
Vertical lines on a tall building, or sky-scraper, will gradually get closer according to the position of the observer. Figure 13(*b*) illustrates the latter type of perspective drawing, and Fig. 13(*c*) shows the same building from a different viewpoint.

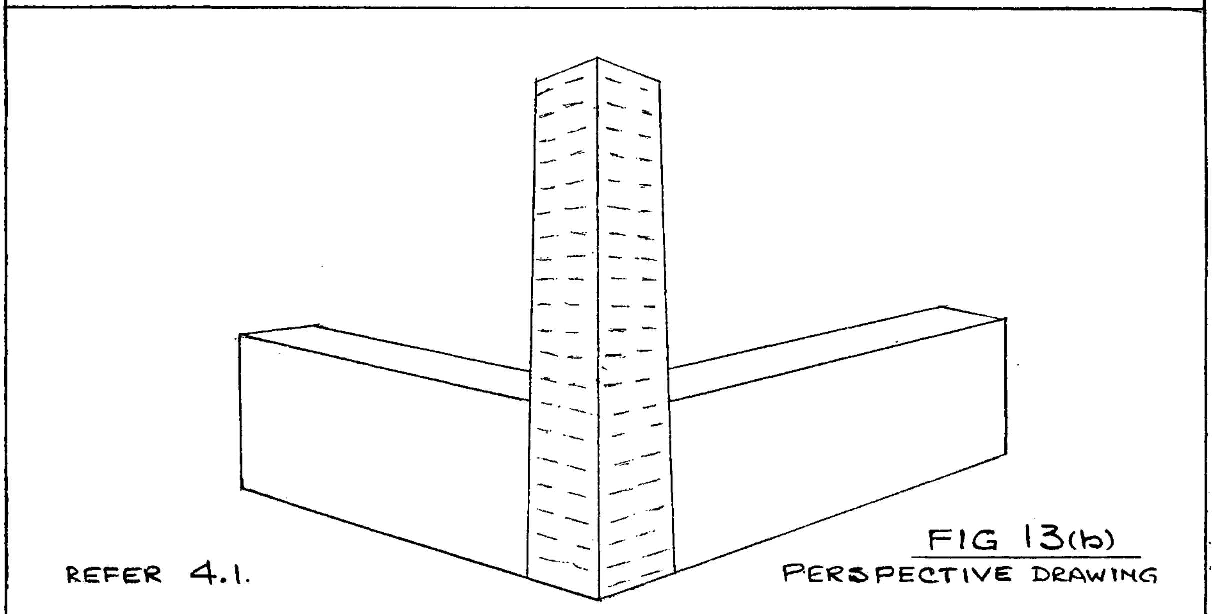
4.2. SIMPLE ISOMETRIC DRAWING. Fig. 14

Pictorial drawings are very useful to the student when models for drawing exercises are not available, because from them he can visualize what the object looks like. One form of pictorial drawing is known as *isometric*, in which all lines are drawn either vertically or at 30° to a horizontal line. This is illustrated in Fig. 14(*a*). A rectangular block, 2 in. high × 3 in. wide × 6 in. long (the same size as in Fig. 13*a*), is shown in Fig. 14(*b*) as an isometric drawing. You will see that the "width" and "length" lines are drawn at 30° to the horizontal and the "height" lines are drawn vertical. The drawing shown in Fig. 14(*c*) is a line-by-line construction of Fig. 14(*b*). To make the drawing shown, you must commence with a horizontal base-line *AB*, leaving a space of at least 6 in. above the line. Remember to draw *all* lines in construction. From a point *C*, a little to the left of the centre, draw a vertical construction line from *C* of any length, and two lines *D* and *E* at 30° to the base-line *AB*.

At this point it must be explained that all dimensions are measured directly along the appropriate lines.

Measure, and mark, the 2 in. along the vertical line *CF*, the 3 in. along the line *DC* and the 6 in. along the line *CE*. Draw vertical lines at *D* to *G* and *E* to *H*. Draw lines at 30° from *F* to *G*, and from *F* to *H*. Finally, draw lines at 30° from *G* to *K*, and from *H* to *K*. Now fill in the outline by drawing all left-hand sloping lines first, followed by all right-hand sloping lines, and finally by all vertical lines. Leave any construction lines which are still showing.


6"
3"
2"
THESE LINES CONTINUE TO A VANISHING POINT ON THE HORIZON.
PERSPECTIVE DRAWING
REFER 4.1.
FIG 13(a)


REFER 4.1.
FIG 13(b)
PERSPECTIVE DRAWING

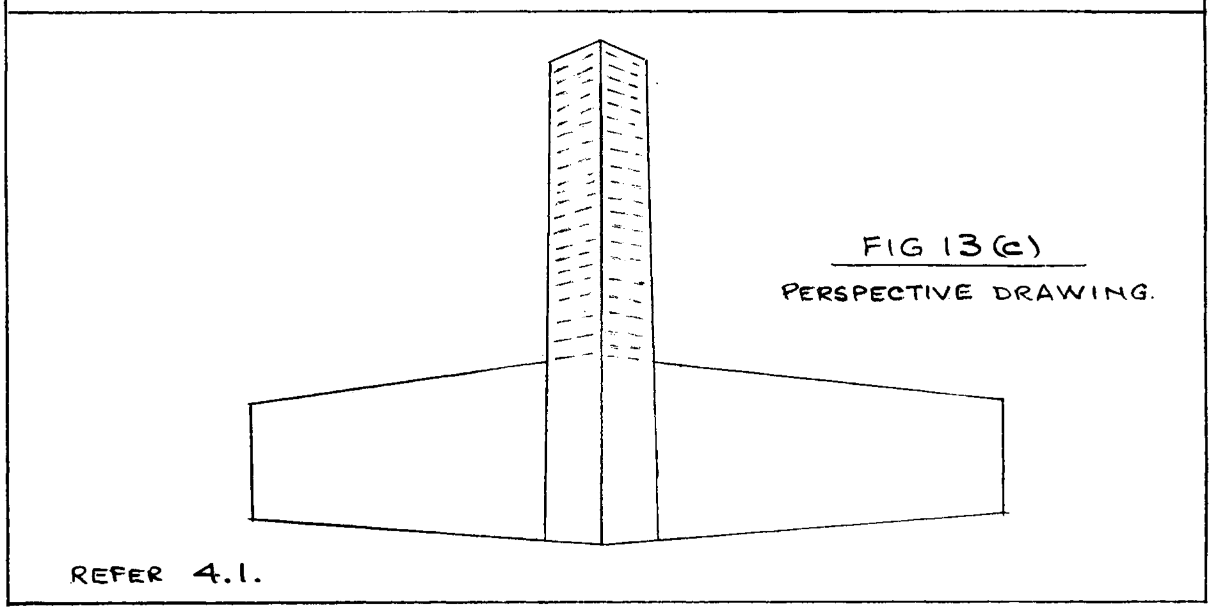
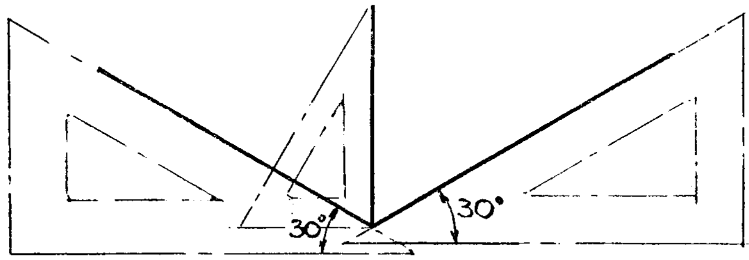
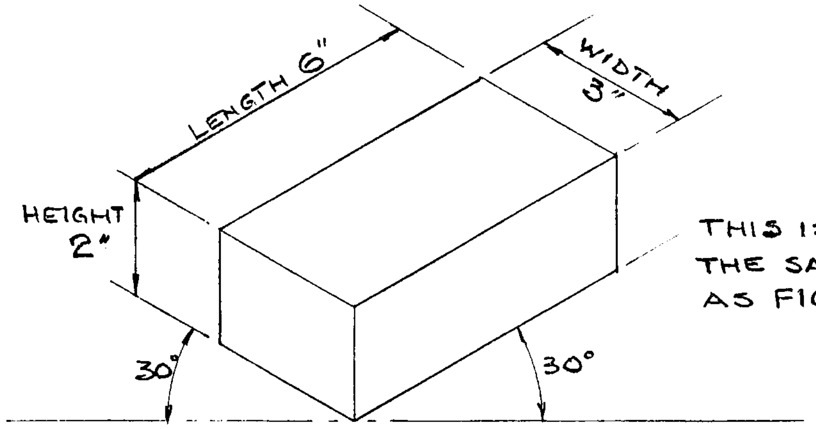


FIG 13(c)
PERSPECTIVE DRAWING.
REFER 4.1.

Fig. 13



REFER 4.2 — FIG 14(a) —

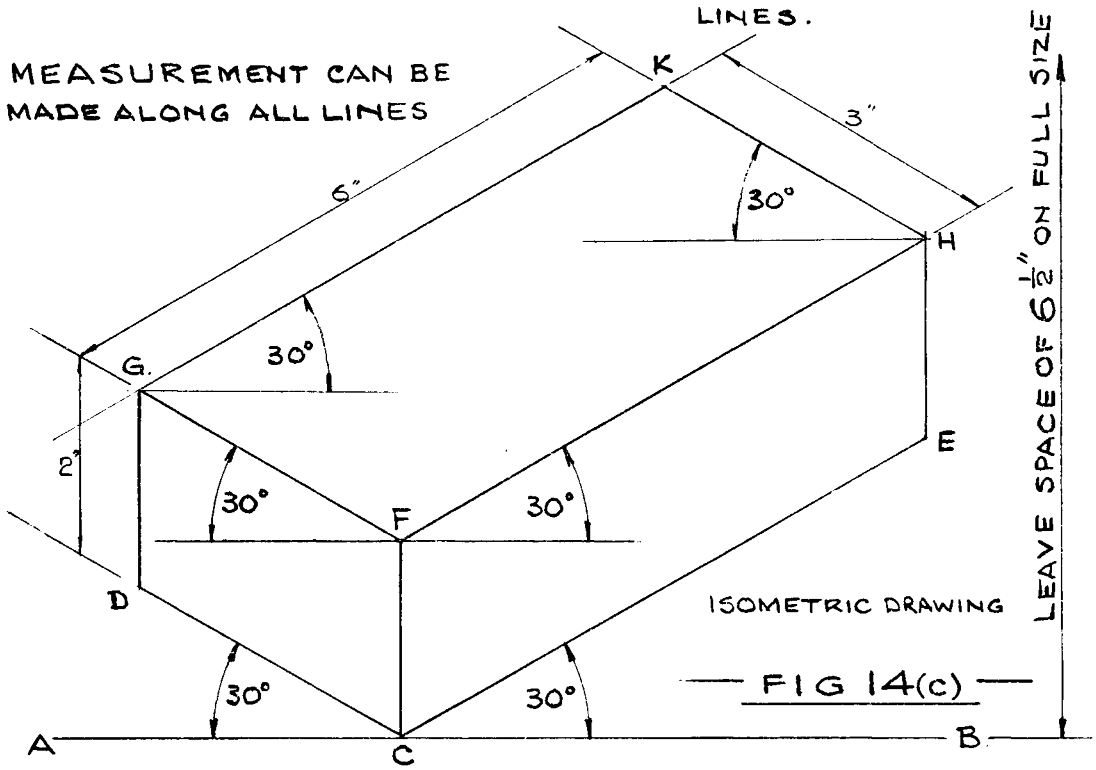


THIS IS DRAWN TO THE SAME SCALE AS FIG 13(a)

REFER 4.2 ISOMETRIC DRAWING — FIG 14(b) —

LEAVE CONSTRUCTION LINES.

MEASUREMENT CAN BE MADE ALONG ALL LINES



ISOMETRIC DRAWING

— FIG 14(c) —

REFER 4.2.

4.3. ORTHOGRAPHIC PROJECTION

Orthographic (or *orthogonal*) *projection* is a method of illustrating an object by drawings and views projected by lines perpendicular to the plane of projection, or in simpler terms "projecting views at right angles to one another".

All engineering drawing in Great Britain uses orthographic projection; but unfortunately there are two distinct methods, namely the "English first angle projection", and the "American third angle projection". For an engineer to read a drawing correctly he must know which method of projection is being used, and the draughtsman must indicate on *all* drawings whether the method of projection is "First Angle" or "Third Angle".

4.4. FIRST ANGLE PROJECTION (English). Fig. 15

The principle involved in first angle projection is that each view is drawn exactly as it is seen; that each view is projected orthographically; and that each view is turned through 90° from its adjacent view.

We will take a simple object shown as an isometric drawing in Fig. 15(*a*). This is a rectangular block 2 in. × 2½ in. × ½ in. with a raised shoulder at one end 1 in. high × ½ in. wide. To make a drawing in first angle projection proceed as follows:

(i) Look at the object in the direction of arrow A and draw the shape exactly as you see it. Draw it in thin construction lines and also between parallel construction lines 2½ in. apart drawn vertically, as at *VV*, and three horizontal lines, ½ in. apart, as at *HHH*. This view is called the *front elevation*, A.

(ii) Leave a space of 1½ in. under the front elevation and draw the next two construction lines, *H*1 and *H*2, parallel and 2 in. apart. You have now drawn a constructional view of what you can see looking in the direction of the arrow C. This view is called the *plan*, C, and is obtained by turning the object *towards* you through 90°. At first this may be difficult to understand but it will become clearer as we proceed.

(iii) Leave a space of 1 in. to the right of the front elevation and draw two construction lines, *V*1 and *V*2, parallel and 2 in. apart. You have now drawn a constructional view of what you can see looking in the direction of the arrow B. This view is called an *end view*, or *end elevation*, B, which is obtained by turning the object from the front elevation to the right through 90°.

(iv) Leave a space of 1 in. to the left of the front elevation and draw two construction lines, *V*3 and *V*4, parallel and 2 in. apart. You have now drawn a constructional view of what you can see looking in the direction of the arrow D. This view is also called an *end view*, or *end elevation*, D, which is obtained by turning the object from the front elevation to the left through 90°.

(v) Draw one line, *V*5, in construction from the front elevation to the plan.

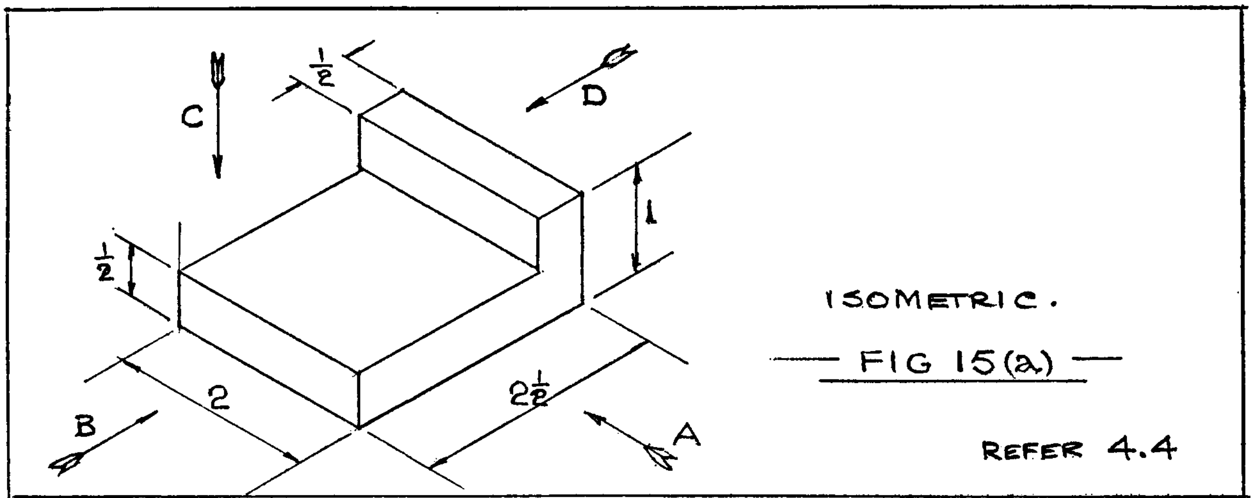
You should now have a drawing with four views, as shown in Fig. 15(*b*).

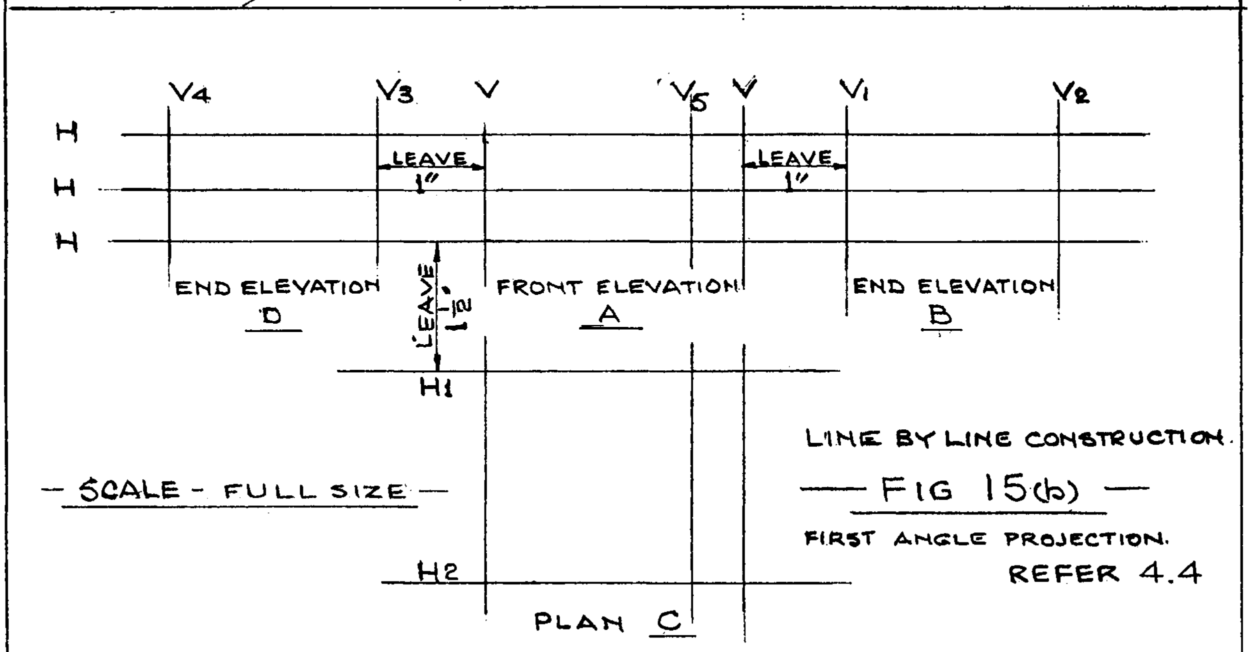
There are several points which should be noticed about the drawing in Fig. 15(*b*).

The spaces between the views *need not* be the same, but should not be less than 1 in. These spaces are left so that projection lines and dimensions can be conveniently inserted. Note also that the views shown are projected vertically, or horizontally (i.e. orthographically).

Construction lines must be thin, as was pointed out in Chapter 2, and should not be removed.

First angle projection will be dealt with further in a later chapter and will become clearer as we proceed.


C
D
1/2
1
1/2
2
2 1/2
B
A
ISOMETRIC.
FIG 15(a)
REFER 4.4


V4
V3
V
V5
V
V1
V2
H
H
H
LEAVE 1"
LEAVE 1"
LEAVE 1 1/2"
END ELEVATION D
FRONT ELEVATION A
END ELEVATION B
H1
LINE BY LINE CONSTRUCTION.
SCALE - FULL SIZE
FIG 15(b)
FIRST ANGLE PROJECTION.
REFER 4.4
H2
PLAN C

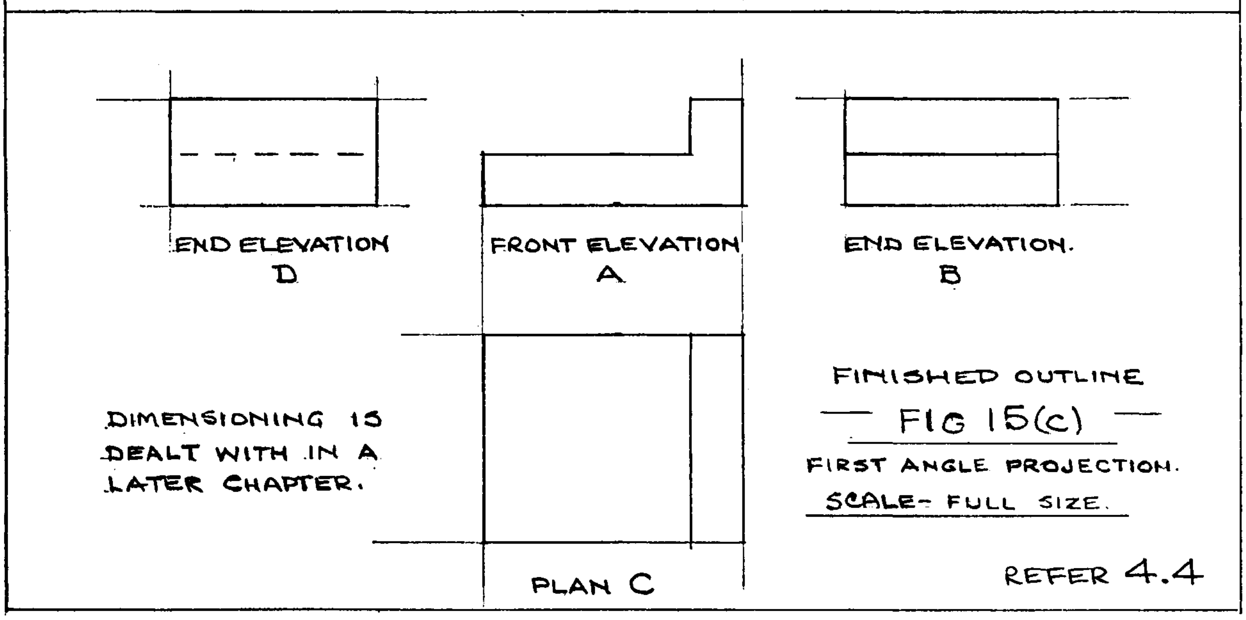

END ELEVATION D
FRONT ELEVATION A
END ELEVATION. B
FINISHED OUTLINE
DIMENSIONING IS DEALT WITH IN A LATER CHAPTER.
FIG 15(c)
FIRST ANGLE PROJECTION.
SCALE- FULL SIZE.
REFER 4.4
PLAN C

FIG. 15

Now you have seen what the four views look like, complete each view in outline, so that the final drawing looks like that shown in Fig. 15(*c*).

The dimensions of the drawing are omitted intentionally as there is a separate chapter dealing with the system of dimensioning.

4.5. FIRST ANGLE PROJECTION (continued). Fig. 16

After carefully completing section 4.4 and the drawing in Fig. 15(*c*), we can now make a similar drawing but slightly more difficult.

The isometric drawing in Fig. 16(*a*) shows a rectangular block 2 in. × 3 in. × 1 in. with a straight slot on the underside and a tee slot on the upper face.

To make a drawing in *first angle projection* proceed as follows:

(i) Plot out the areas and positions of the four views as a "thumbnail" sketch, which is a free-hand sketch about 3 in. × 2 in. showing the proposed four views.

(ii) Look at the object in the direction of the arrow, A, and draw the shape exactly as you see it. Do this in thin construction lines, and also between parallel construction lines 3 in. apart, drawn vertically, as at *VV* at least 6 in. long, and four horizontal lines as at *HHHH* at least 10 in. long. Draw three vertical lines, *V*1, *V*2 and *V*3, any length and in construction. Not a single *outline* should have been drawn as yet. This view is called the *front elevation*, A.

(iii) Leave a space of $1\frac{1}{2}$ in. under the front elevation and draw the next five horizontal parallel lines, *H*1, *H*2, *H*3, *H*4 and *H*5 with the dimensions found from Fig. 16(*a*). This view is called the *plan*, C, and is obtained by turning the object *towards* you through 90° and drawing exactly what you see.

(iv) Leave a space of 1 in. to the right of the front elevation and draw five vertical lines *V*6 . . . *V*10. These distances can be measured by compasses from the *plan* at *H*1 . . . *H*5. You have now drawn a constructional view of what you see looking in the direction of the arrow, B, and this view is called an *end view* or *end elevation*, B. It is obtained by turning the object from the front elevation to the *right* through 90° and drawing exactly what you see.

(v) Leave a space of 1 in. to the left of the front elevation and draw five vertical lines, *V*11 . . . *V*15. To save time, these lines should be marked off with compasses *at the same time* as the lines *V*6 . . . *V*10; but notice very carefully that, when measuring, *H*1 corresponds to *V*10 and *V*11, and *H*5 corresponds to *V*6 and *V*15. *H*2, *H*3 and *H*4 also correspond with *V*7, *V*8 and *V*9, and *V*14, *V*13 and *V*12 respectively.

The spaces between the views *need not* be the same, but should not be less than 1 in. These spaces are left so that projection lines and dimensions can be conveniently inserted. All the views shown are projected vertically or horizontally (*orthographically*).

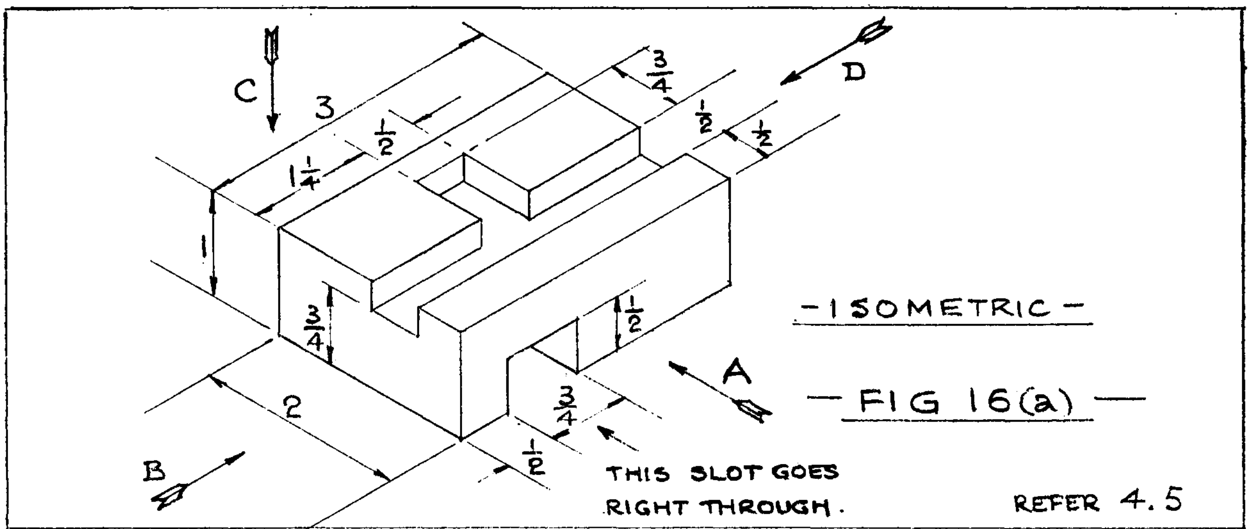
Construction lines must be thin, as was pointed out in Chapter 2, and therefore need not be removed.

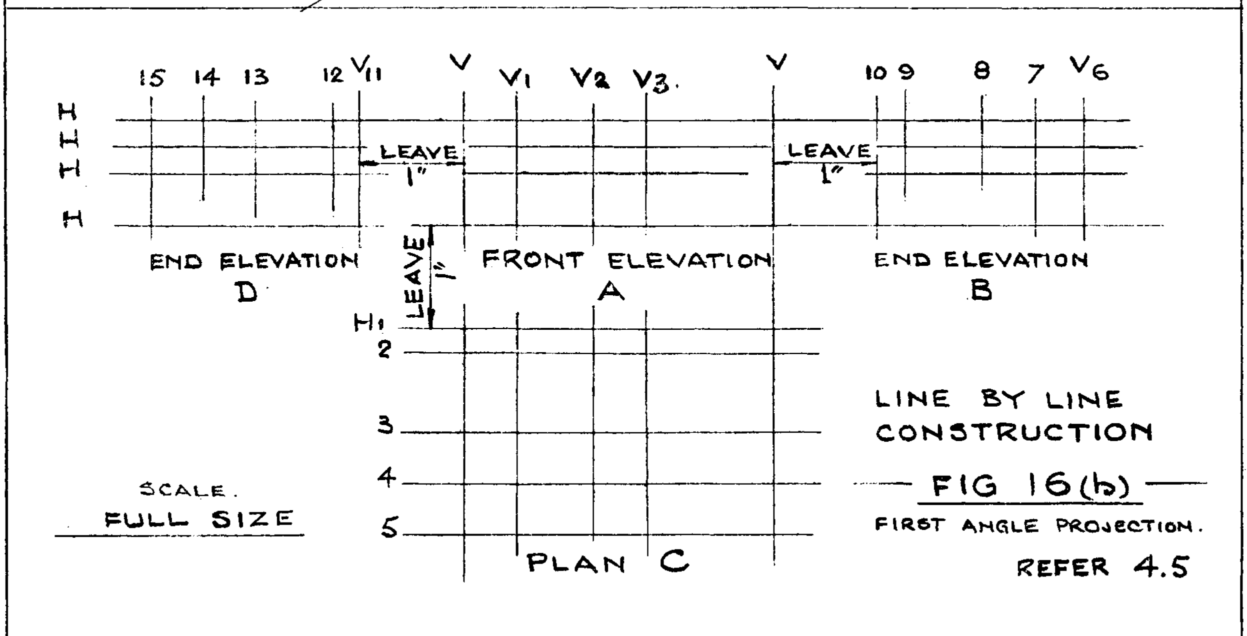
No outlines should be drawn until *all* the views have been completed in construction.

Special Note

The drawings in Figs. 15 and 16 which you have just completed have been explained line by line as it has been the author's experience that this is the best method of teaching beginners.

You should now be able to complete each view in outline so that the final drawing is like that shown in Fig. 16(*c*).


C
D
3
1¼
½
¾
½
½
1
¾
½
2
A
B
¾
½
-ISOMETRIC-
FIG 16(a)
THIS SLOT GOES RIGHT THROUGH.
REFER 4.5


15 14 13 12 V11 V V1 V2 V3. V 10 9 8 7 V6
H
H
H
H
LEAVE 1"
LEAVE 1"
LEAVE 1"
END ELEVATION D
FRONT ELEVATION A
END ELEVATION B
H1
2
3
4
5
PLAN C
LINE BY LINE CONSTRUCTION
FIG 16(b)
FIRST ANGLE PROJECTION.
REFER 4.5
SCALE.
FULL SIZE

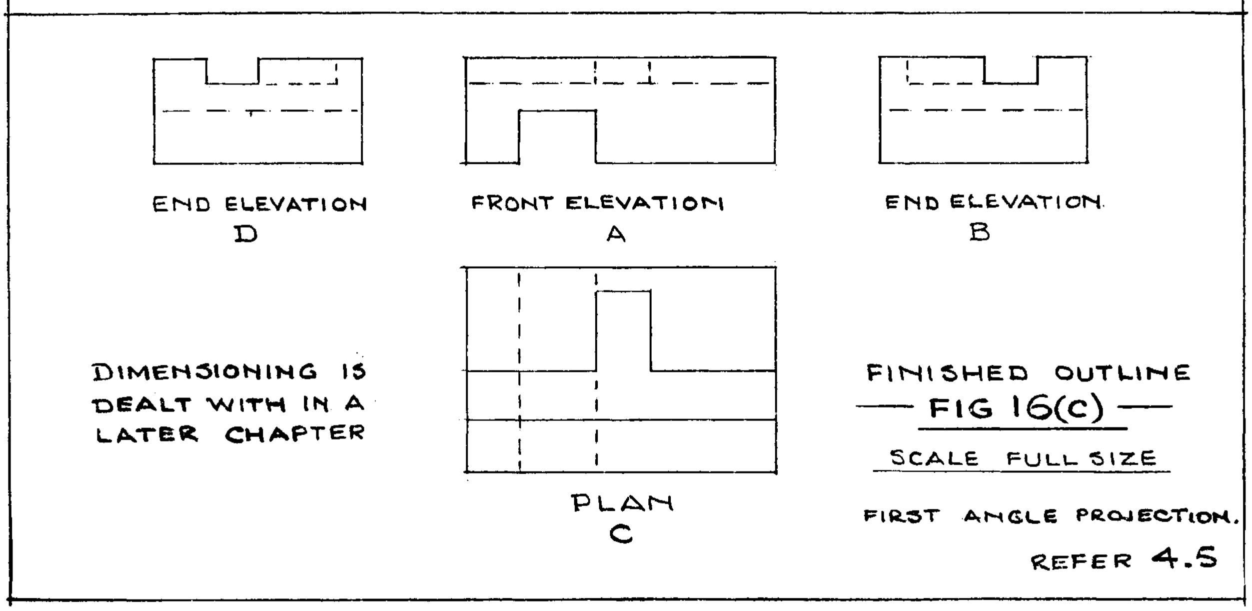

END ELEVATION D
FRONT ELEVATION A
END ELEVATION B
PLAN C
DIMENSIONING IS DEALT WITH IN A LATER CHAPTER
FINISHED OUTLINE
FIG 16(c)
SCALE FULL SIZE
FIRST ANGLE PROJECTION.
REFER 4.5

FIG. 16

The dimensions are again purposely omitted as they will be dealt with in a separate chapter on the system of dimensioning.

Comparing the drawing you have completed with that shown in Fig. 16(*c*) there are several points to notice with reference to first angle projection.

(1) The plan is below the front elevation.

(2) The plan is projected from the front elevation.

(3) The end elevations are projected from the front elevation and placed at the opposite end from which they are viewed.

(4) The space between the views need not be the same.

4.6. THIRD ANGLE PROJECTION (American). Fig. 17

In the previous sections 4.4 and 4.5 it was concluded that if the plan was placed *below* the front elevation, then you knew at once that the drawing was in first angle projection.

Alternatively, if the plan is placed *above* the front elevation you know that the drawing is in third angle projection.

The author has designed a small card model (inserted into the book, p. 136) which, when cut out and bent as instructed in Fig. 17(*b*), will enable a beginner to master the difficulties of third angle projection in a very short time.

When the cut-out card is removed from the book it should be bent to the shape shown in Fig. 17(*a*) with the connecting pieces carefully folded under. It is quite easy to see that the sketch is an isometric view of the card model. To draw the object in third angle projection proceed as follows:

Draw a thin horizontal construction line, *XY*, with the tee-square, allowing a clear space of 3 in. above and below the line. Open the model and lay it flat on the drawing paper, holding it in position so that the top edges of the three lower pieces or views are along the line *XY*. With a sharpened pencil, draw carefully very fine construction lines all round the edges of the four pieces and connecting strips. Remove the card model. Now draw with a set-square, etc., all the views in outline, but do not draw the connecting strips. These strips show clearly how the front elevation is projected from the plan, and the two end elevations are projected from the front elevation and drawn at the same end that you see them. This also explains orthographic projection, referred to in section 4.3.

Examining the finished drawing shown in Fig. 17(*c*) several points should be noticed regarding third angle projection.

(1) The plan is above the front elevation.

(2) The front elevation is projected from the plan.

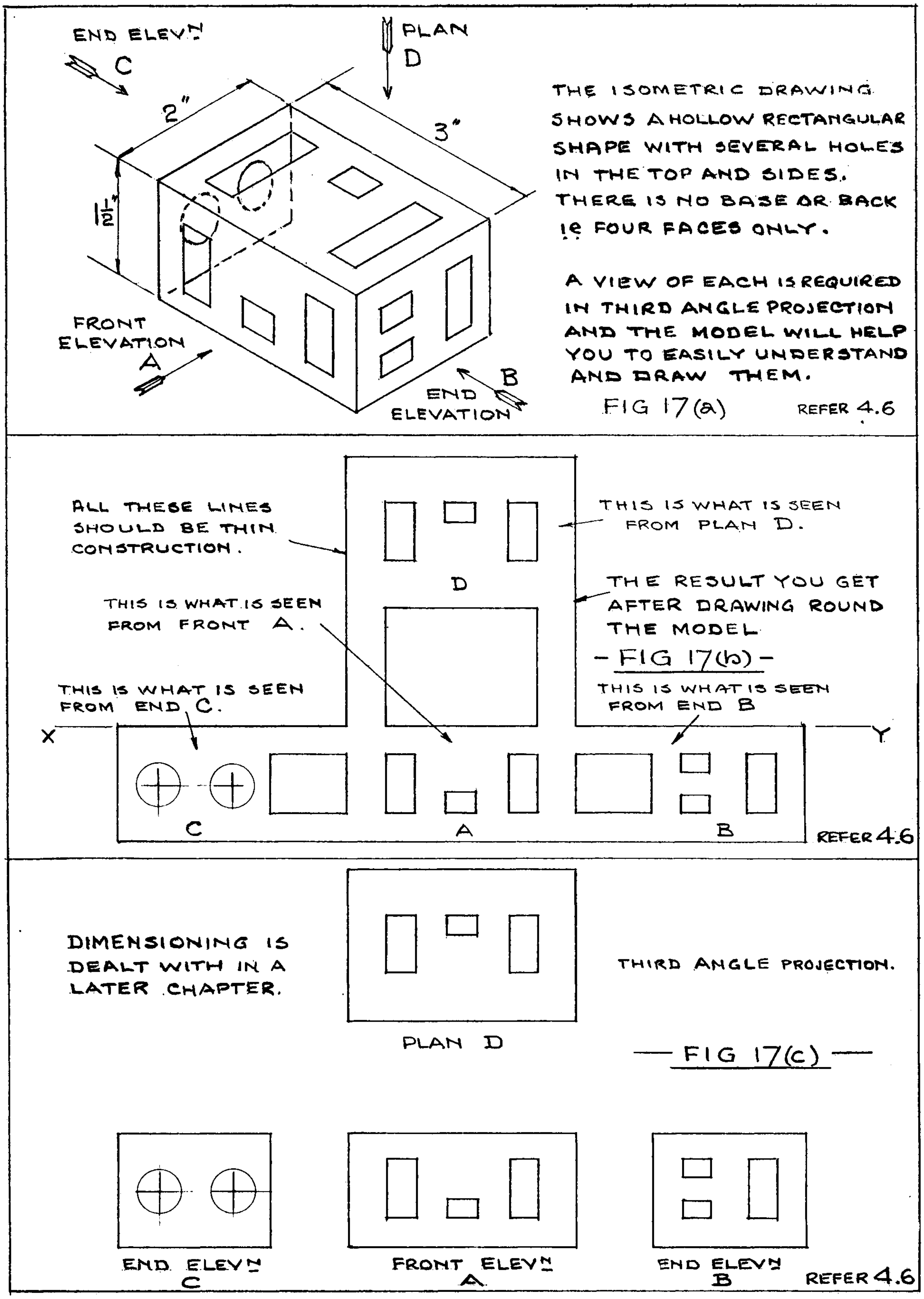
(3) The end elevations are projected from the front elevation at the appropriate ends.

(4) The space between the views need not be the same.

4.7. THIRD ANGLE PROJECTION (continued). Fig. 18

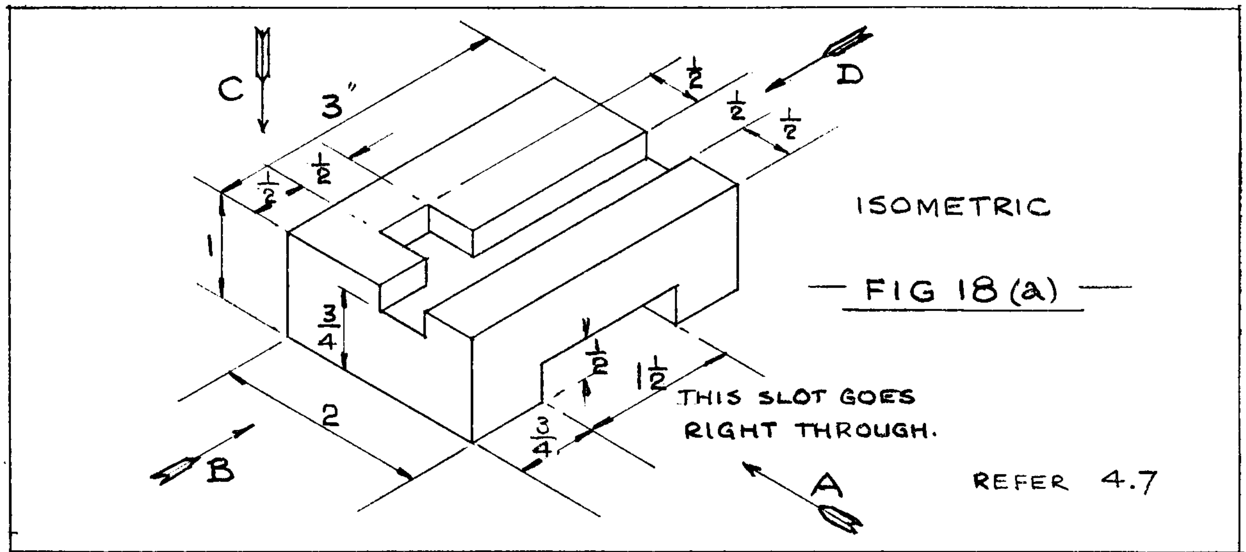
In order to realize more clearly the difference between first and third angle projection, let us now proceed to draw the object shown in Fig. 18(*a*) (which is slightly different from that shown in Fig. 16*a*), in third angle projection.

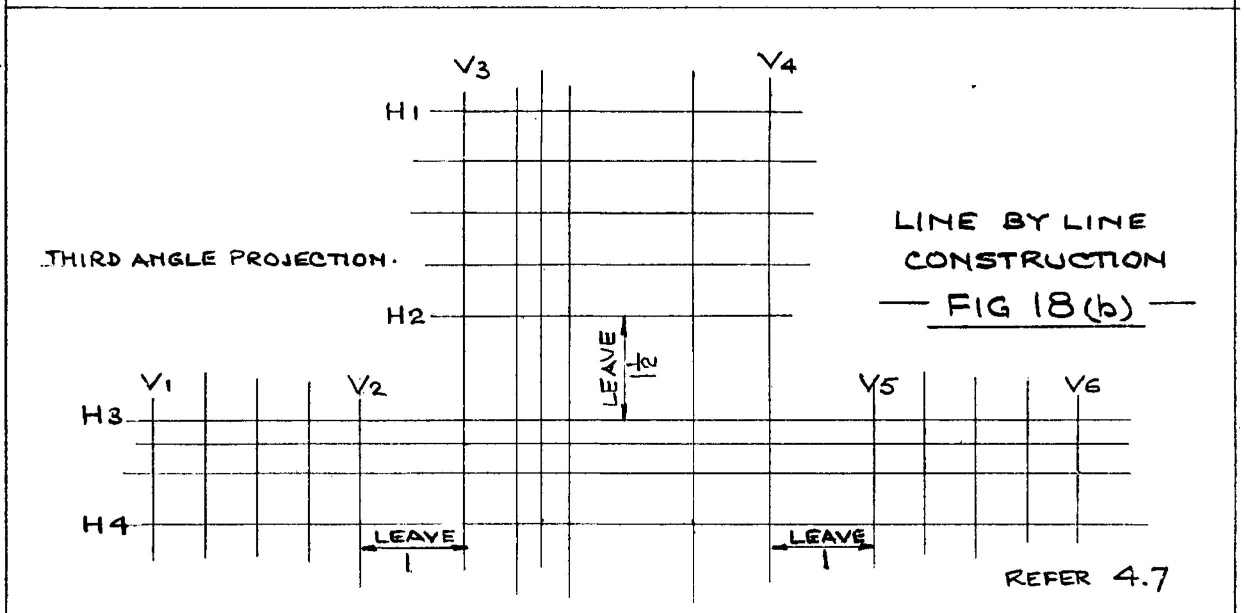
With the card model laid flat in front of you, it should be easy to visualize the four views required and their appropriate positions. Draw six vertical lines, *V*1 . . . *V*6, and four horizontal



END ELEVN
C
PLAN
D
2"
3"
1½"
THE ISOMETRIC DRAWING SHOWS A HOLLOW RECTANGULAR SHAPE WITH SEVERAL HOLES IN THE TOP AND SIDES. THERE IS NO BASE OR BACK IE FOUR FACES ONLY.
A VIEW OF EACH IS REQUIRED IN THIRD ANGLE PROJECTION AND THE MODEL WILL HELP YOU TO EASILY UNDERSTAND AND DRAW THEM.
FRONT ELEVATION
A
B
END ELEVATION
FIG 17(a)
REFER 4.6
ALL THESE LINES SHOULD BE THIN CONSTRUCTION.
THIS IS WHAT IS SEEN FROM PLAN D.
D
THIS IS WHAT IS SEEN FROM FRONT A.
THE RESULT YOU GET AFTER DRAWING ROUND THE MODEL
FIG 17(b)
THIS IS WHAT IS SEEN FROM END C.
THIS IS WHAT IS SEEN FROM END B
X
Y
C
A
B
REFER 4.6
DIMENSIONING IS DEALT WITH IN A LATER CHAPTER.
THIRD ANGLE PROJECTION.
PLAN D
FIG 17(c)
END ELEVN C
FRONT ELEVN A
END ELEVN B
REFER 4.6

FIG. 17


C
3"
½
½
½
½
½
D
1
¾
2
B
½
1½
¾
THIS SLOT GOES
RIGHT THROUGH.
A
ISOMETRIC
FIG 18 (a)
REFER 4.7


V3
V4
H1
THIRD ANGLE PROJECTION.
H2
LEAVE ½
LINE BY LINE
CONSTRUCTION
FIG 18 (b)
V1
V2
V5
V6
H3
H4
LEAVE 1
LEAVE 1
REFER 4.7

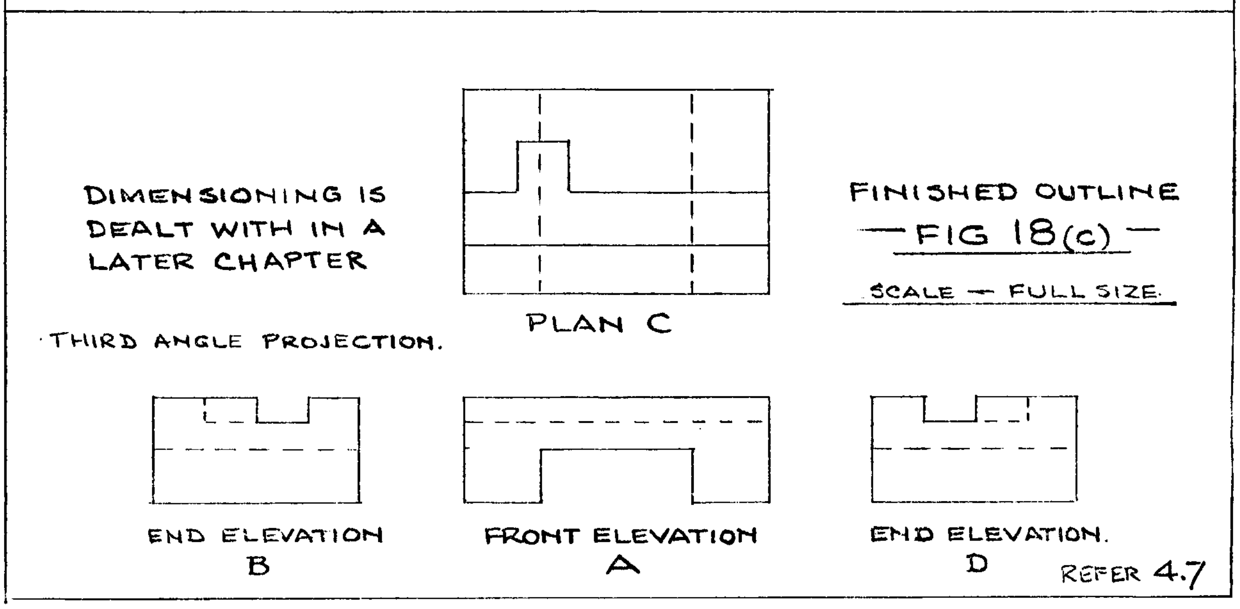

DIMENSIONING IS
DEALT WITH IN A
LATER CHAPTER
THIRD ANGLE PROJECTION.
PLAN C
FINISHED OUTLINE
FIG 18 (c)
SCALE — FULL SIZE.
END ELEVATION
B
FRONT ELEVATION
A
END ELEVATION.
D
REFER 4.7

Fig. 18

lines, $H1 \ldots H4$ in construction to dimensions shown in Fig. 18(*a*), leaving $1\frac{1}{2}$ in. and 1 in. respectively between the views.

Now in construction draw the slots in position, not completing one view at a time but projecting all the dimensioned parts from one view to another vertically and horizontally as continuous lines. The drawing should now be like that shown in Fig. 18(*b*).

Finally the four views should be filled in in outline. As each view is drawn you should watch carefully the appropriate view in the isometric drawing Fig. 18(*a*) to see what should be shown as full lines or hidden detail. When completed, your drawing should be as shown in Fig. 18(*c*). Remember that construction lines should be so thin that it is not necessary to remove them.

Do not add any dimensions. You should notice the four points referred to in section 4.6 above (Fig. 17*c*), viz.

(1) The plan is above the front elevation.
(2) The front elevation is projected from the plan.
(3) The end elevations are projected from the front elevation at the appropriate ends.
(4) The space between the views need not be the same.

Doubtless the student is beginning to wonder "Why all this construction?" The art of drawing and design is to do as much construction as possible, conveying your ideas to paper before a single outline is put on the paper. When a draughtsman starts a design he has certain calculations to make, together with a lot of construction, and it is sometimes a week or more before any outline or final design is commenced.

Important Note

The drawings in this and the preceding chapters have contained up to four views with the following sub-titles: "front elevation", "plan", and "end elevations". These sub-titles have been put in for information only. From Chapter 5 onwards the drawings will have *no* sub-titles except where the view is a *section*. This view will be called "*section AA*", etc., which will indicate the position of viewing.

EXERCISES ON CHAPTER 4

(Note: Do not dimension any of the drawings.)

1. Draw a freehand perspective drawing of a rectangular block $\frac{1}{2}$ in. high $\times$ 1 in. wide $\times$ 2 in. long.
2. Draw a simple isometric drawing of a rectangular block $\frac{3}{4}$ in. high $\times$ $1\frac{3}{4}$ in. wide $\times$ $2\frac{1}{2}$ in. long.
3. Copy the isometric drawing shown in Fig. 15(*a*).
4. Copy the isometric drawing shown in Fig. 16(*a*).
5. Draw four views in first angle projection of the object shown in Fig. 19(*a*).
6. Draw four views in third angle projection of the object shown in Fig. 19(*b*).
7. Using the card model, draw the four views exactly as shown in Fig. 17(*b*) and (*c*).
8. Draw four views in first angle projection of the object shown in Fig. 19(*c*).

The answers to these Exercises will be found in Fig. 66.

5 · The System of Dimensioning

5.1. INTRODUCTION

In Chapter 4 you made some drawings, but although the outline was completed the drawings as a whole were unfinished because no dimensions were added. It will be realized that dimensions on a drawing are sometimes more important than the outline itself. With this in mind, dimensions must be placed in such a position as to convey their importance to the reader of the drawing. As every drawing is different in its conception, so the system of placing dimensions varies.

The following sketches will help to show a few ways in which dimensions should be placed on a drawing to the best advantage.

These sketches are shown in Figs. 19, 20, 21, 22 and 23, and you will notice that the number of views can be one, two or three. The main purpose of a drawing of an object with dimensions is to enable someone to make that object, so it is essential to put on the drawing sufficient information in views and in dimensions.

In order to learn how to dimension, the sketches with their dimensions must be carefully copied, together with the printed heading. You should make use of the knowledge gained in the preceding chapters, and although you are copying the sketches it is important that you should draw with construction lines only in the first instance, and then complete the outline, making use of the over-run construction lines as dimension lines.

The first and very important thing to remember about dimensioning is that "Where you see the shape, or profile, that is where to place the dimensions". Before commencing the drawings, first refer to Fig. 23(*a*) and (*b*) showing dimension lines and projection lines, which you learnt in Chapter 2.

5.2. DIMENSION LINES NOT TO INTERSECT. Fig. 19(*a*) and (*b*)

The first drawings with dimensions which we shall do are shown in Fig. 19(*a*) in first angle projection, and Fig. 19(*b*) in third angle projection. The object consists of a bar of metal $\frac{1}{2}$ in. wide by $\frac{1}{8}$ in. thick $\times$ $1\frac{3}{4}$ in. long, with two holes drilled on the centre line $1\frac{1}{4}$ in. apart. The heading given to the drawing is "Dimension lines must not intersect". This means that the smaller the dimension, the closer it is to the outline. The wrong method is shown as an inset, and you will notice the confusion which could be caused by the overlapping or intersection of dimension lines. The dimensions must not be placed closer than $\frac{3}{8}$ in. to the outline and when finished should make a complete picture and not cause confusion in the mind of the person making the object. The difference between first angle projection and third angle projection is that, although the dimensions are the same, the position of the views is different. It will be seen that the holes show very clearly in the plan, and, of course, that is where the dimensions should be placed.

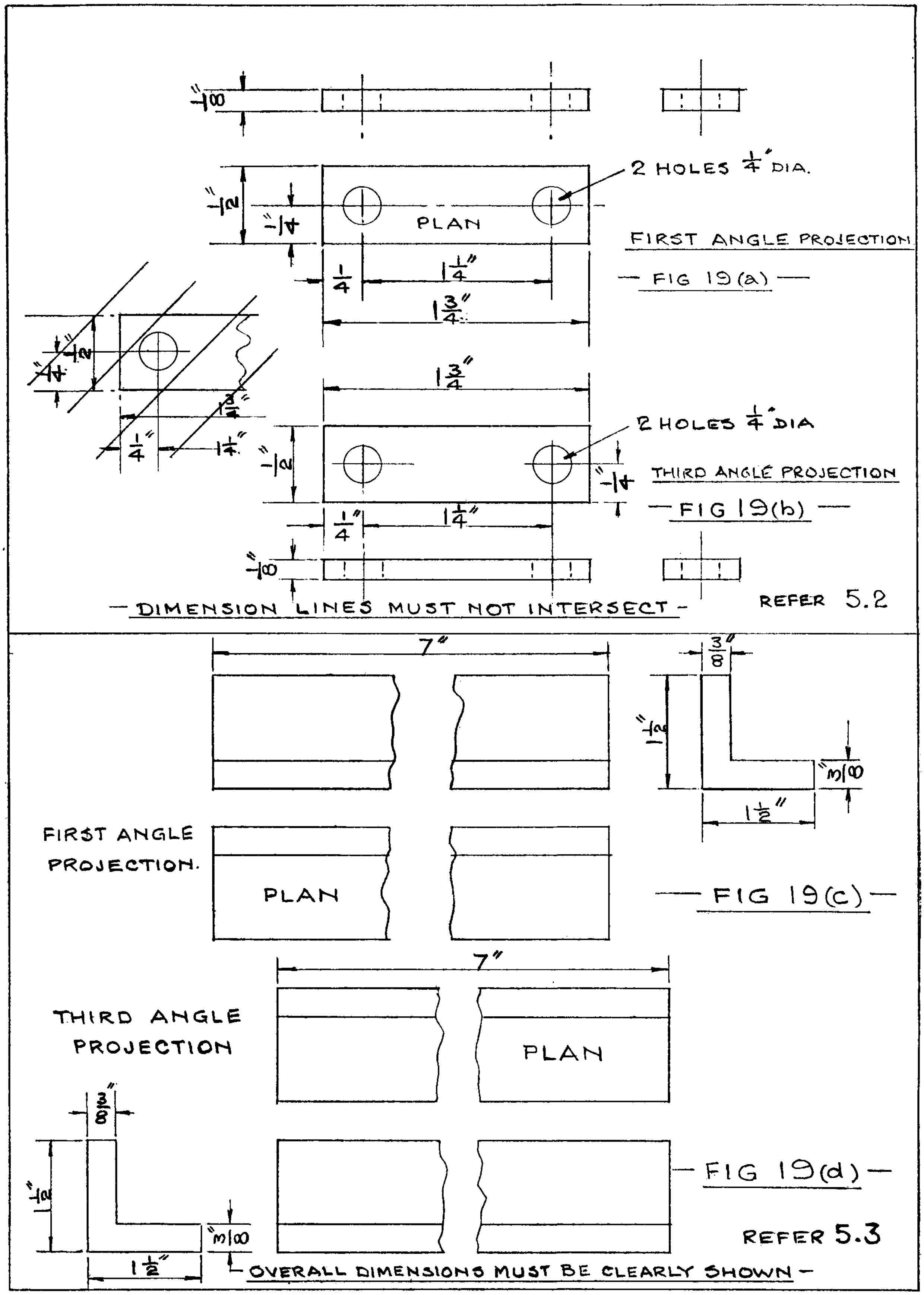

2 HOLES 1/4" DIA.
PLAN
FIRST ANGLE PROJECTION
FIG 19(a)
2 HOLES 1/4" DIA
THIRD ANGLE PROJECTION
FIG 19(b)
DIMENSION LINES MUST NOT INTERSECT
REFER 5.2
7"
FIRST ANGLE PROJECTION.
PLAN
FIG 19(c)
7"
THIRD ANGLE PROJECTION
PLAN
FIG 19(d)
REFER 5.3
OVERALL DIMENSIONS MUST BE CLEARLY SHOWN

FIG. 19

5.3. OVERALL DIMENSIONS TO BE CLEARLY SHOWN. Fig. 19(*c*) and (*d*)

This drawing is shown both in first angle projection and in third angle projection, and is headed "Overall dimensions must be clearly shown". It should not be necessary for the craftsman to have to do any calculations in order to make the particular object. You will notice in Fig. 19(*c*) and (*d*) that a break is shown in the centre of the elevation and plan. This break illustrates that the object is too long to get on to a drawing and therefore the dimension gives the important information. It can be well imagined that instead of the part being 7 in. long it could be 7 ft long, but in either case it is the dimension that must be read. The end elevation shows the dimensions very clearly so that from the drawing the part could easily be checked on a stock list of material.

5.4. CORRESPONDING DIMENSIONS IN CORRESPONDING PLACES Fig. 20(*a*) and (*b*)

The drawings in this figure show a first angle projection and a third angle projection of a piece of material $\frac{1}{2}$ in. × $\frac{5}{8}$ in. × 2 in. long, and at one end a portion is removed $\frac{1}{4}$ in. thick × $\frac{3}{4}$ in. long. The heading "Corresponding dimensions must be in corresponding places" means that where the piece of material is removed it is there that the dimensions must be placed.

5.5. DIMENSIONS FROM TWO FACES AT RIGHT ANGLES. Fig. 20(*c*)

This drawing is of a plate $2\frac{3}{8}$ in. × $1\frac{7}{8}$ in. with three holes at various positions. The heading "Dimension from two faces at right angles" means that for accurate positioning of the holes the plate should be machined at right angles at *AA* and *BB*, and the dimensions taken from those two faces. In this we have followed the earlier rules, that is that the overall dimensions are clearly shown and the smaller dimensions are closer to the outline. It should be noted that the dimension figure is placed at right angles to the dimension line and read from the normal for horizontal lines, or from the right-hand side of the drawing for vertical lines. You will see that there are two centre lines for each hole, and that in the case of the lower hole the dimension is placed at the side nearest to the hole.

5.6. DOUBLE DIMENSIONING MUST BE AVOIDED. Fig. 21(*a*) and (*b*)

The drawing is shown both in first angle projection and in third angle projection and it is of a bar of material $\frac{5}{8}$ in. × $\frac{1}{2}$ in. × 2 in. long with a slot at one end $\frac{1}{4}$ in. wide × $\frac{1}{2}$ in. deep. The heading "Double dimensions must be avoided" means that where you see the shape that is where the dimensions are placed, and therefore it must be shown only once on a drawing and any duplicate dimensions must be avoided. The reason for this is that if a dimension needs to be changed during manufacture, then the draughtsman making the alteration to the drawing knows it has to be found in one position only and needs to be altered in that position.

5.7. DIMENSIONS FROM "CORNER TO CORNER". Fig. 21(*c*) and (*d*)

These drawings show first angle projection and third angle projection of a more elaborate shape. The heading "Dimensions must be from corner to corner, and not from line to line" is very important in this case. If you were to try to dimension the plan it would be from "line to

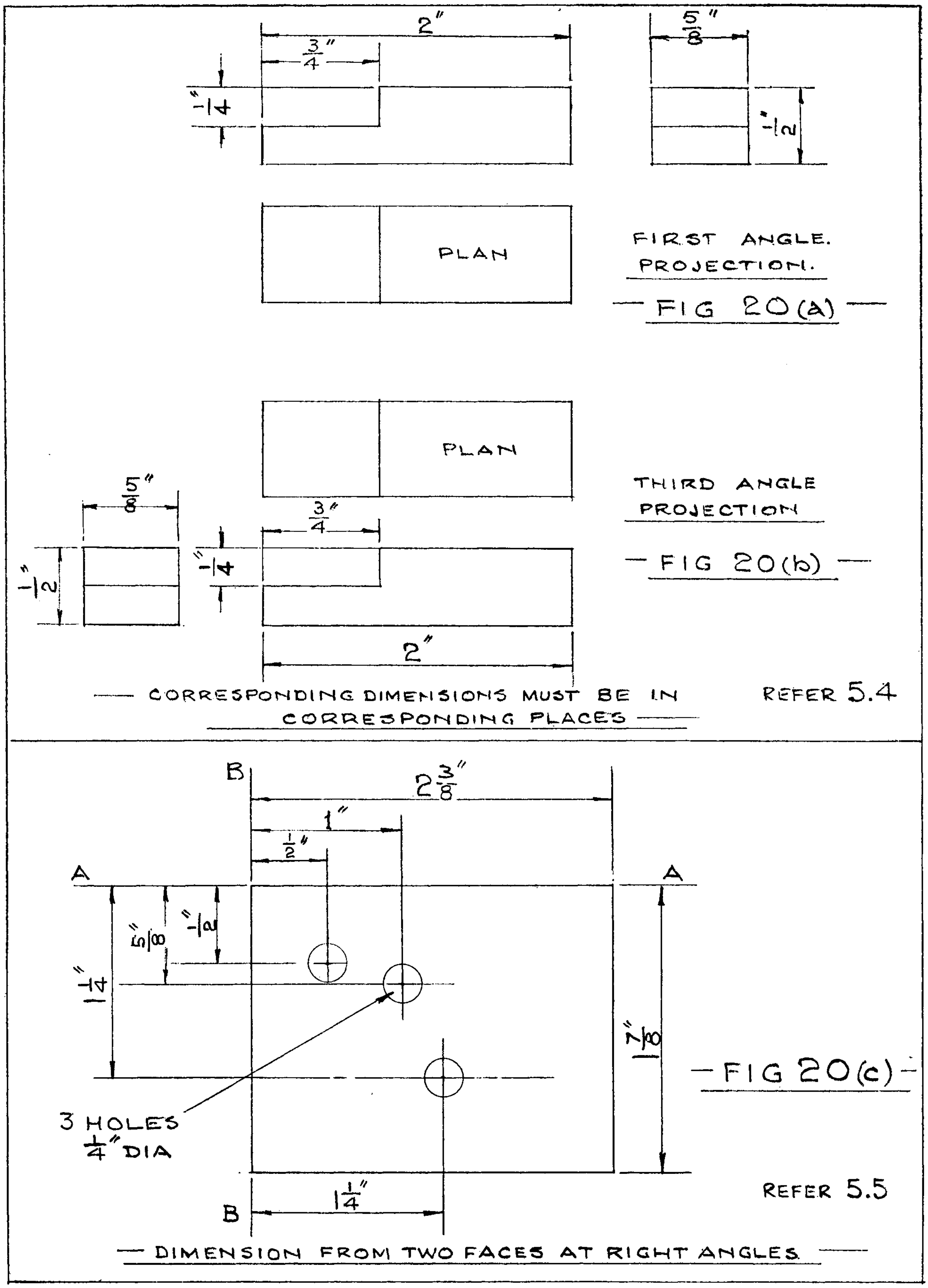
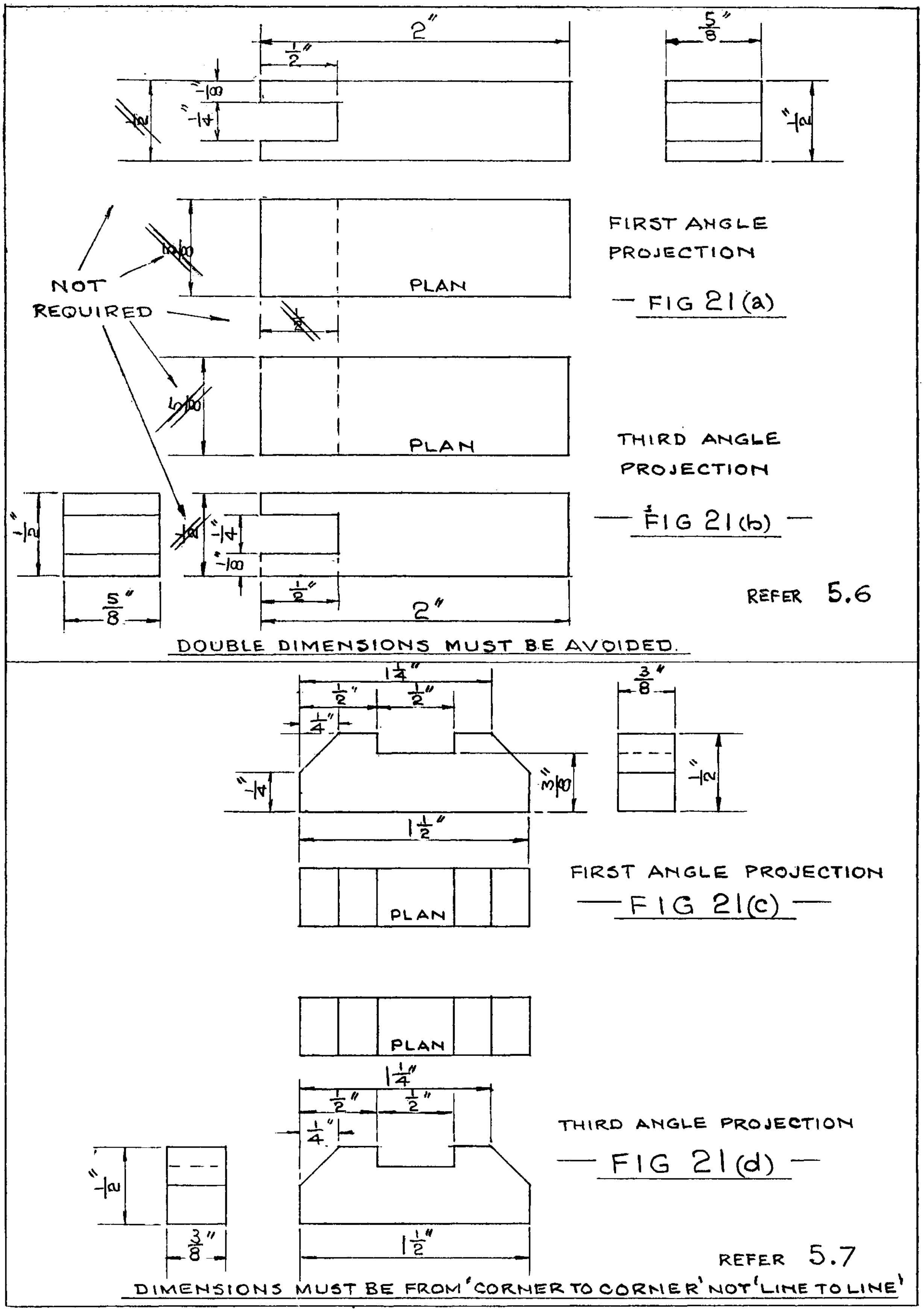

2"
3/4"
1/4"
5/8"
1/2"
PLAN
FIRST ANGLE. PROJECTION.
FIG 20(a)
PLAN
THIRD ANGLE PROJECTION
FIG 20(b)
5/8"
3/4"
1/2"
1/4"
2"
CORRESPONDING DIMENSIONS MUST BE IN CORRESPONDING PLACES
REFER 5.4
B
2 3/8"
1"
1/2"
A
A
5/8"
1/2"
1 1/4"
7/8"
FIG 20(c)
3 HOLES 1/4" DIA
1 1/4"
B
REFER 5.5
DIMENSION FROM TWO FACES AT RIGHT ANGLES

Fig. 20



2"
1/2"
5/8"
1/8"
1/4"
1/2"
NOT
REQUIRED
PLAN
FIRST ANGLE
PROJECTION
— FIG 21 (a)
PLAN
THIRD ANGLE
PROJECTION
— FIG 21 (b) —
REFER 5.6
DOUBLE DIMENSIONS MUST BE AVOIDED.
1 1/4"
1/2"
1/2"
3/8"
1/4"
3/8"
1 1/2"
FIRST ANGLE PROJECTION
— FIG 21(c) —
PLAN
THIRD ANGLE PROJECTION
— FIG 21(d) —
REFER 5.7
DIMENSIONS MUST BE FROM 'CORNER TO CORNER' NOT 'LINE TO LINE'

FIG. 21

line" and you will see that it would be impossible to dimension the shape in that way. You would therefore dimension from "corner to corner" in the elevation, as shown.

5.8. FOR TURNED PARTS GIVE DIAMETERS, NOT RADII. Fig. 22(*a*), (*b*) and (*c*)

This drawing shows a piece of material that has been turned, or machined, in a lathe. It is essential that diameters should be given and not radii. It should be noted that the part is shown as it would be turned or machined in a lathe. If there is sufficient space the dimension can be placed across the diameter, as shown in Fig. 22(*a*); but if there is not sufficient space then the diameters should be projected and dimensioned as in Fig. 22(*b*). The diameters should never be given as shown in Fig. 22(*c*) as this would cause confusion.

5.9. SYMMETRICAL SHAPES. Fig. 22(*e*)

This drawing shows a special shape and when, as in this case, a shape is symmetrical about a centre line, then the dimensions can be taken from that centre line. Great care must be taken to ensure that sufficient dimensions are given without duplication to enable the part to be manufactured correctly.

A general observation on dimensioning is that *a dimension must be placed where the well-trained person would expect to find it.* It is very important to notice that only detailed parts are dimensioned fully, and that assemblies, or assembly drawings, including sub-assemblies, are never covered with hundreds of dimensions. The only dimensions that should appear on an assembly drawing are the major overall dimensions, such as height, width and length, or a few specification dimensions that would be required if a certain machine were being purchased.

5.10. POINTS NOT COVERED BY FOREGOING RULES

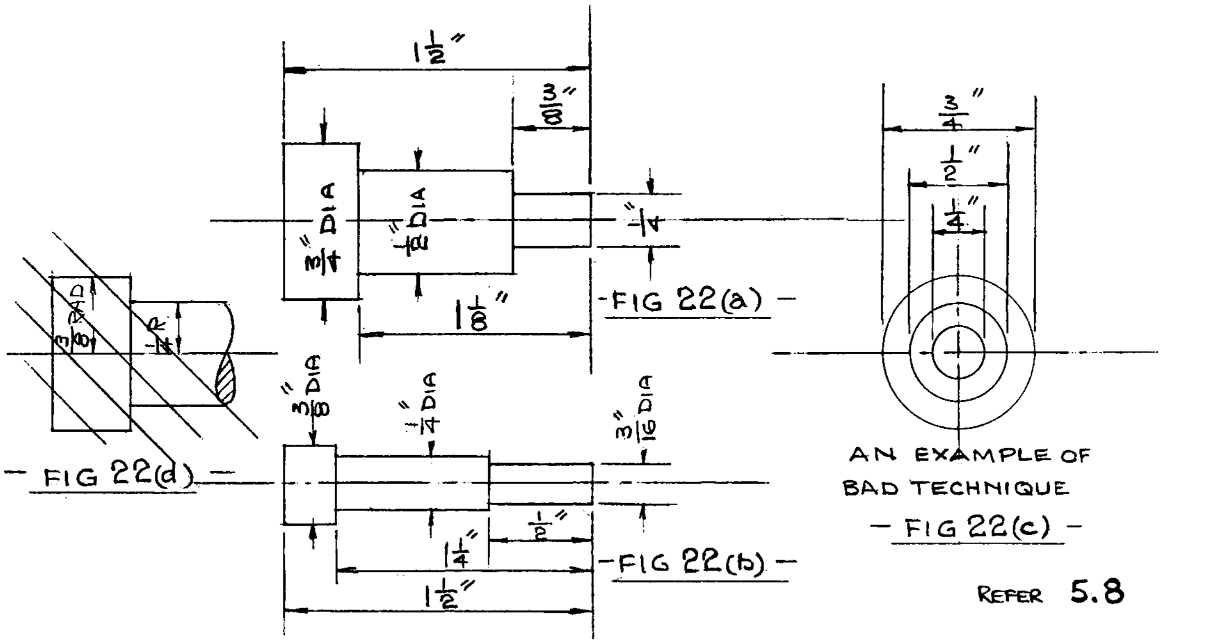
There are some points that are not covered by the foregoing rules but they are explained and illustrated in Fig. 23(*a*), (*b*) and (*c*). We will take each one in order.

Figure 23(*a*): Part of an outline 2½ in. long is shown. The projection lines (thin) should not touch the outline but should have a small break. The dimension line with arrow heads must extend as far as the projection lines. The dimension figure is placed above the line and perpendicular to it.

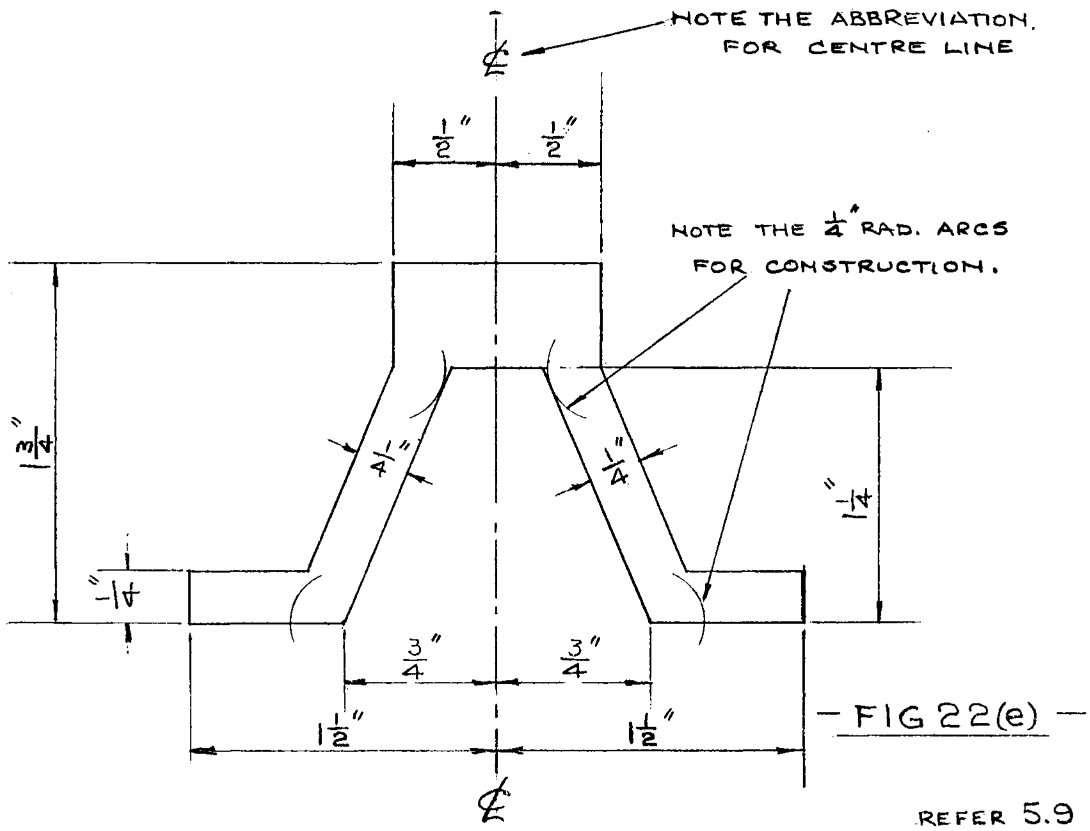
Figure 23(*b*): Part of an outline 1¼ in. is shown. The projection lines and dimension lines are exactly as in Fig. 23(*a*), but as the lines are vertical the dimension figure is placed above the line and perpendicular to it and read from the right-hand side of the drawing sheet.

Figure 23(*c*): Two views are shown of a machined part and dimensioned as in Fig. 20(*a*) and (*b*). When a dimension is less than ⅜ in. and drawn full size, the arrow heads can be placed on the outside of the projection lines but pointing inwards, as shown in two places where the ¼ in. is marked.

Figure 23(*d*): Another machined part is shown and we have followed the earlier rules in giving clear overall and cut-away dimensions. It must be clearly understood that there is no dimension where the asterisk is placed. The reason for this is that the overall length and all dimensions leading up to the ¼-in. slot are given. At a later stage we shall learn about "tolerances" and how confusion can be caused by adding the last figure at the asterisk.



FOR TURNED PARTS DIAMETERS MUST BE GIVEN, NOT RADII



WHEN THE SHAPE IS SYMMETRICAL, TAKE DIMENSIONS FROM THE ℄

FIG. 22

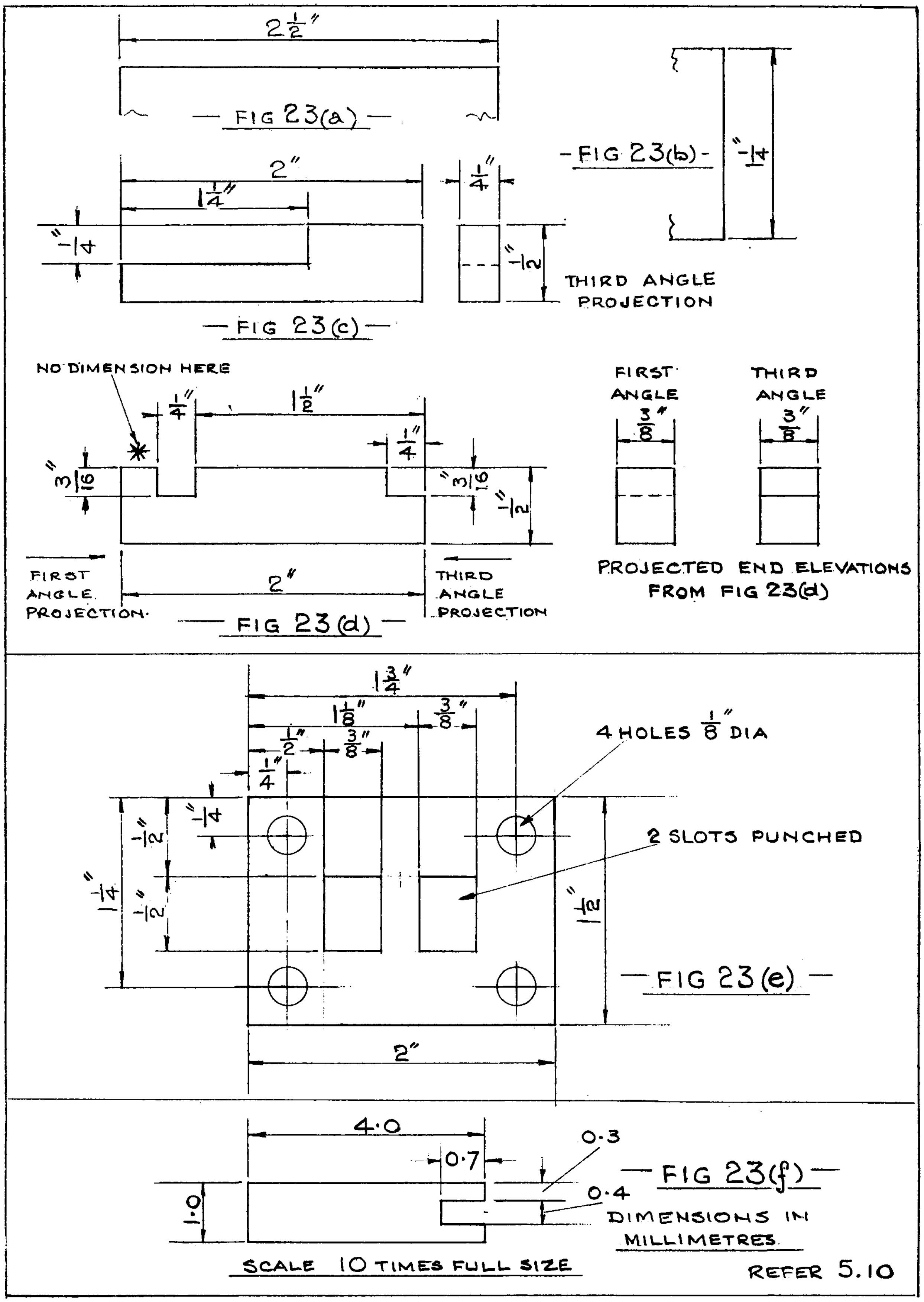


FIG 23(a)
FIG 23(b)
THIRD ANGLE PROJECTION
FIG 23(c)
NO DIMENSION HERE
FIRST ANGLE PROJECTION
THIRD ANGLE PROJECTION
FIG 23(d)
FIRST ANGLE
THIRD ANGLE
PROJECTED END ELEVATIONS FROM FIG 23(d)
4 HOLES 1/8" DIA
2 SLOTS PUNCHED
FIG 23(e)
FIG 23(f)
DIMENSIONS IN MILLIMETRES
SCALE 10 TIMES FULL SIZE
REFER 5.10

FIG. 23

Figure 23(*e*): This drawing shows a plate with four circular holes and two rectangular slots. It is dimensioned generally as in section 5.5, Fig. 20(*c*). You will notice that the slots are dimensioned from the two sides, but that the width and length of the slots are given. This system gives the draughtsman the opportunity of closely controlling the dimensions of the slots and the position of them from the sides.

Figure 23(*f*): A very small part has been drawn ten times full size. When parts are drawn to a scale (magnified or reduced) it is essential that the actual dimensions are added. In this case the outline was drawn 10 mm by 40 mm but the actual dimensions of 1 mm by 4 mm are shown. A tolerance can be added to any dimension on any drawing.

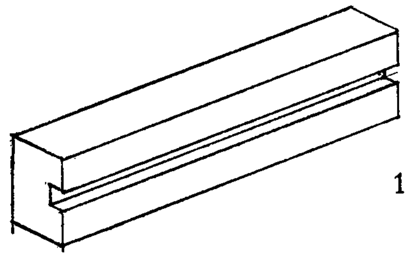
Scale drawings, both magnified and reduced, are dealt with in greater detail in Chapter 6, section 6.3, Figs. 26 and 27.

Dimensions are an important contribution to a drawing and the following is a brief summary of the system of dimensioning:

(1) Dimension where the *shape* can be seen.
(2) Dimension from corner to corner and not line to line.
(3) Dimension all scale drawings full size.
(4) Dimension from two faces at right angles (where applicable).
(5) Dimension from the centre line on symmetrical outlines (where applicable).
(6) Longer dimensions should be placed farther from the outline than the shorter ones.
(7) Avoid double dimensioning.
(8) Do not place dimensions closer to the outline than $\frac{3}{8}$ in.
(9) Never fully dimension assembly drawings.
(10) Always place a dimension where a well trained person would expect to find it.

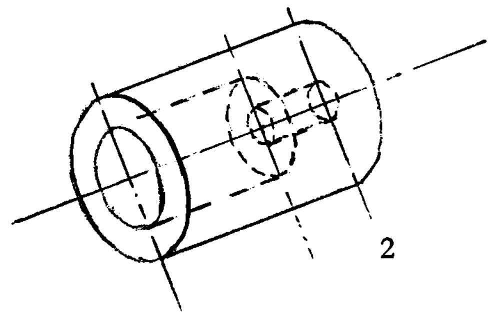
EXERCISES ON CHAPTER 5

1. A piece of brass $\frac{3}{4}$ in. × 1 in. is 9 in. long and a groove $\frac{1}{4}$ in. wide × $\frac{1}{4}$ in. deep is cut through the 1 in. face along its centre line. Draw this bar in first angle projection and fully dimension it.



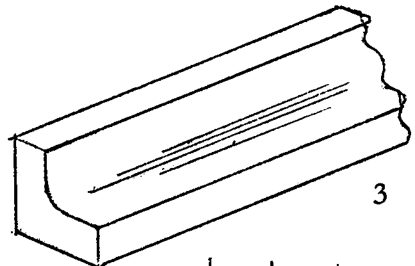
1

2. A cylindrical bush is machined from steel rod to the following specification: outside diameter 1·25 in., length 1·5 in. The inside is bored 0·75 in. diameter × 1·0 in. deep with a concentric hole drilled 0·25 in. diameter. Draw this in third angle projection, one view being a section through the horizontal centre, and dimension it.



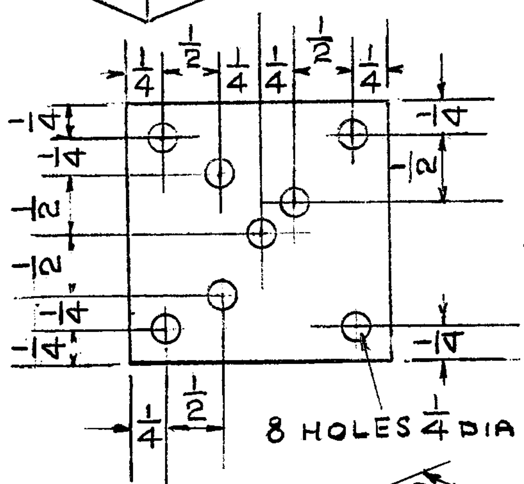
2

3. Draw in third angle projection and fully dimension three views of a right-angle section brass bar to the following dimensions: length 7 ft., section 2 in. × 2 in. × $\frac{1}{2}$ in. thick with $\frac{1}{2}$ in. radius at the inside corner.



3

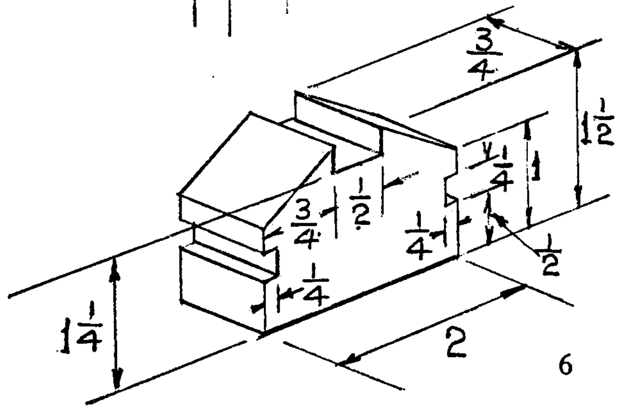
4. A plate is shown which has been dimensioned in an unorthodox manner. Re-draw this plate and dimension the drawing correctly.



4

5. A special platinum contact is $\frac{1}{8}$ in. diameter × $\frac{5}{32}$ in. long overall. From one end a shoulder is machined $\frac{1}{16}$ in. diameter × $\frac{3}{32}$ in. long. Draw the contact at least six times full size and fully dimension.

6. In the isometric drawing a special section of brass is shown. Draw three views in first angle projection fully dimensioned.



6

Note: The sketches are not drawn to scale. *All* the drawings should be drawn full size except No. 5, which should be drawn six times full size.

The answers to these Exercises will be found in Fig. 67.

6 · First Angle, or English, Projection

All the drawings in this chapter are first angle, or English, projection. Chapter 7 will follow exactly the same pattern, but all the drawings will be in third angle, or American, projection. Some sketches, for the purpose of illustration, are isometric.

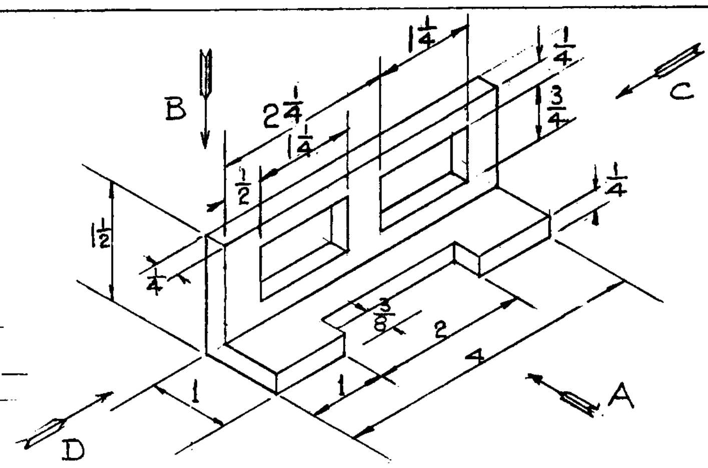
6.1. ORTHOGRAPHIC PROJECTION

In Chapter 4 we learnt the general principles of orthographic projection in first angle (English). This should be learned thoroughly before reading this chapter. First angle projection is the "turning of an object through one angle of 90°" and then drawing exactly what is seen to make an adjacent view.

We continue with an isometric drawing (that is, with lines at 30° and measurements taken along the lines) of an "angle bracket" with two rectangular ports in the upright limb and part of the base removed, as shown in Fig. 24(*a*).

You will now draw in first angle projection four views as seen from the direction of the arrows. This drawing will be explained line by line.

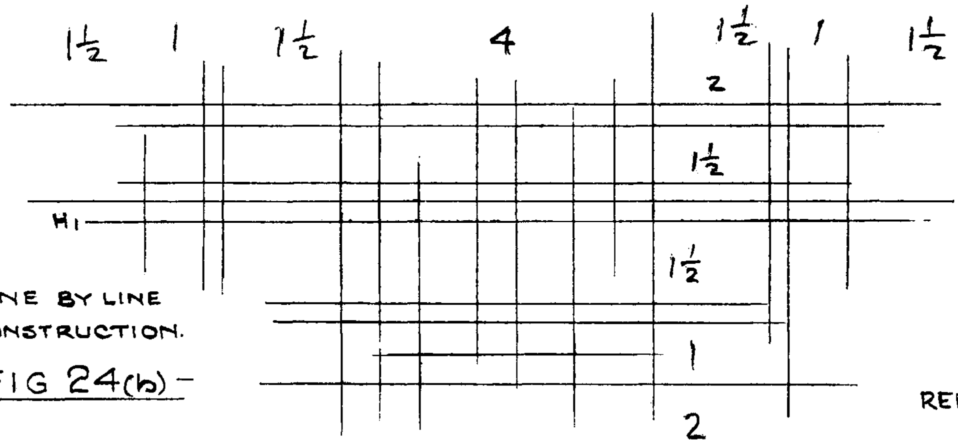
With the paper fastened on the board and your pencil sharpened you should allow an area of approximately 12 in. horizontally × 8 in. vertically. The 12 in. is made up by 4 in. for the elevation, 1½ in. space each side, plus 1 in. for each of the end views, plus 1½ in. each end for dimensions, etc. The 8 in. is made up from 1½ in. in the elevation, plus 1½ in. space, plus 1 in. in the plan, plus approximately 2 in. above and below for dimensions. Remember all lines must be drawn as thin construction lines. Draw a horizontal line *H*1 approximately 4 in. from the top edge of the paper and follow it by another line 1½ in. above it and parallel with it. Now draw one more line 1½ in. below your first line, and another line 1 in. below and parallel with that. Now draw a vertical line in the centre of the space allocated. On each side of this, draw a line 2 in. from it, both of these lines being parallel and continuing through the four horizontal lines previously drawn. Draw two more vertical lines 3 in. each side of the centre line, and a further two lines 4 in. each side of the centre line. Still drawing construction lines, you must consider the elevation in the direction of arrow A and draw one line ½ in. above the original first line which you drew, and a second line 1¼ in. above the first line. Still looking in the direction of the arrow A, draw two more lines ¼ in. each side of the centre line, and a further two lines 1½ in. each side of the centre line. The thickness of the base in the elevation and the two end views is ¼ in., and therefore a line should be drawn parallel with the base line but ¼ in. above it. Two vertical lines should be drawn parallel with, and ¾ in. from, the two outer lines. To show the recess in the elevation and the plan a line should be drawn vertically each side of the centre line and 1 in. from it. To show the thickness of the back in the plan, a line should be drawn ¼ in. below the second



— ISOMETRIC —

— FIG 24(a) —

REFER 6.1

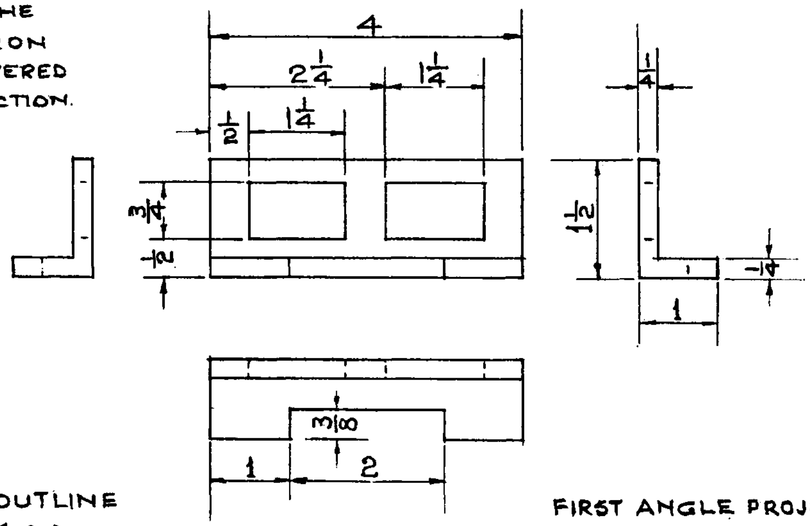


LINE BY LINE CONSTRUCTION.

— FIG 24(b) —

REFER 6.1.

NOTE HOW THE CONSTRUCTION LINES ARE COVERED BY THE PROJECTION. LINES.



FINISHED OUTLINE

— FIG 24(c) —

FIRST ANGLE PROJECTION.

— ANGLE BRACKET —

MATERIAL BRASS

FULL SIZE

REFER 6.1

Fig. 24

line from the bottom and parallel with it. A further line should be drawn $\frac{3}{8}$ in. from the bottom line and parallel with it. Your drawing should now resemble Fig. 24(*b*), and all the lines should be very thin construction lines.

Now proceed to outline the front elevation, A, and in doing so the lines should be firm, all the corners sharp, and it should be like the front elevation shown in Fig. 24(*c*). For first angle projection, if you take the object and turn it through 90° to the right you will get an L-shaped end elevation, or end view, D. This, then, can now be filled in in outline. Again turning the object in the front elevation one angle to the left through 90° will give us a reversed L end elevation, C. If you take the object in elevation and turn it through 90° towards you, you will get the plan, B, which can be shown in outline. For correct projection the two ports must be shown in hidden detail in both the end elevations and the plan. The recess is also shown in hidden detail in the two end elevations.

Dimensions should now be placed where you see the shape of a particular part. Also by one of the dimensioning rules, the dimensions should be taken from two faces at right angles, and, in addition, the overall dimensions must be shown clearly. You can place the dimensions as shown in Fig. 24(*c*), and after printing the title and the scale, the finished drawing should look like that shown in Fig. 24(*c*).

6.2. ORTHOGRAPHIC PROJECTION. Fig. 25

In this section, we shall draw in first angle projection (four views) the bracket shown in isometric projection Fig. 25(*a*). This will be done without line-by-line instruction, but a line construction drawing is shown in Fig. 25(*b*).

The bracket is a block of metal with a machined step. In the step is a groove parallel with the front. Looking from the direction of arrow A, we have the front elevation, and centrally spaced is a recess in the front face and a recess in the back rib.

First, draw all the construction lines in a similar manner to those drawn in Fig. 24(*b*) but, of course, to the appropriate dimensions. The front elevation should be exactly what you see when looking in the direction of arrow A. Turning the bracket through 90° to the right hand, draw exactly what you see in the direction of the arrow D. Again taking the bracket and turning it through 90° to the left, draw exactly what you see looking in the direction of arrow C. Now take the elevation of the bracket and turn it towards you through 90° and draw exactly what you see looking in the direction of arrow B. Up to this point, all your drawing should be in thin construction lines. You should now compare your drawing with Fig. 25(*b*). Carefully add any lines that have been omitted.

As hidden detail must never be dimensioned a "draughtsman's licence" is exercised. A section is cut through the bracket at *XX* (Fig. 25*c*) and projected to the left-hand side. It should be noticed that this is the only view with a caption. As from this drawing *all* captions, i.e. front elevation, plan and end elevation, will be omitted. Only sections and auxiliary views will have a caption.

After further examination of Fig. 25(*a*), you should be able to draw the four views in outline. All the lines should be firm and all the corners sharp.

Dimensions are taken from three master faces, that is the back face, the left-hand face and the base, so that in *each view* the dimensions are taken from two faces at right angles. Print the title and the scale, and in this instance complete the drawing by a border outline 14 in. × $8\frac{1}{2}$ in. neatly spaced. The completed drawing should look like Fig. 25(*c*).

You should practise as often as possible the drawings shown in Figs. 24 and 25. After completing them the first time, the paper should be removed from the board and the drawing should be

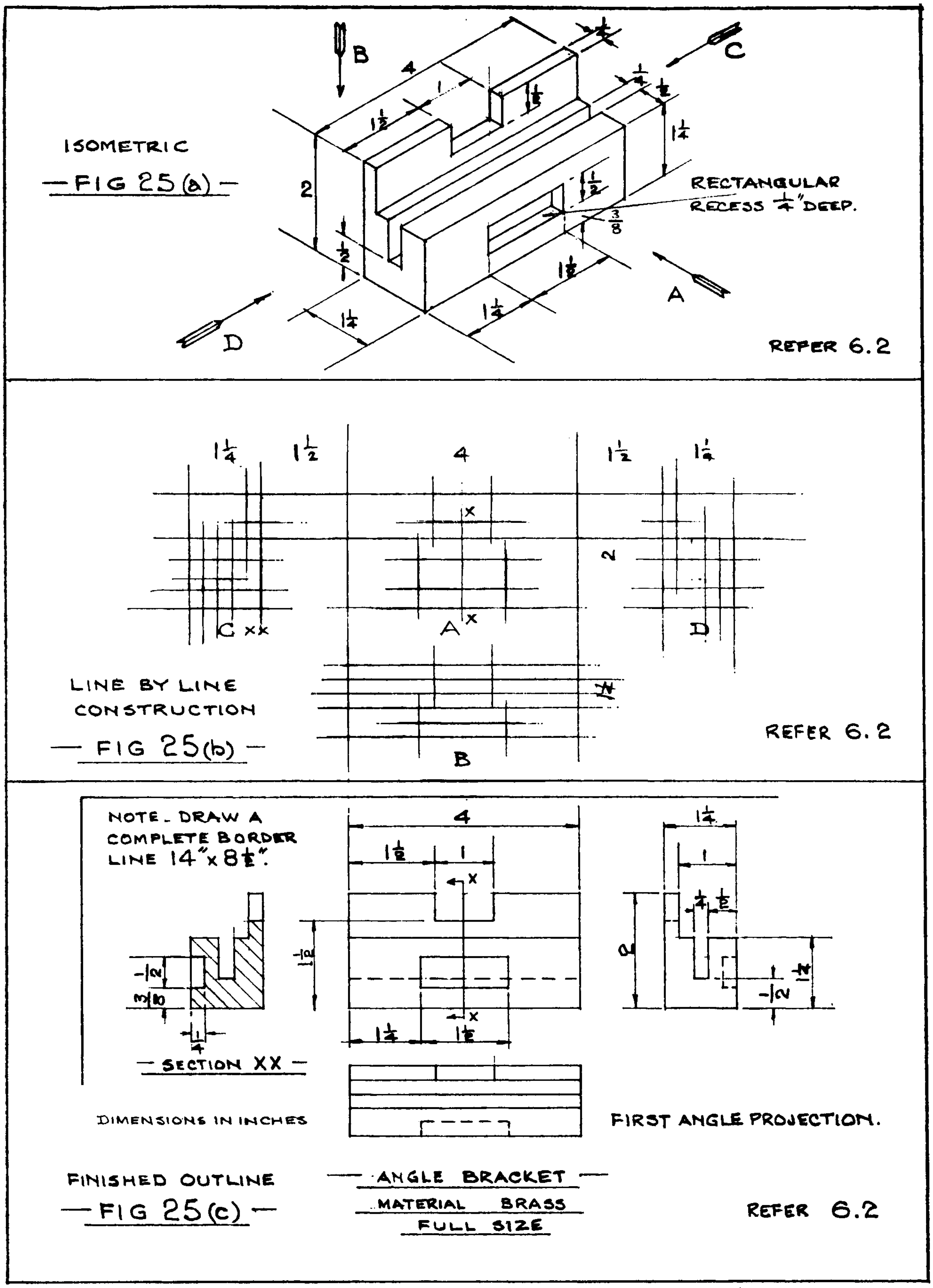

ISOMETRIC
— FIG 25(a) —
RECTANGULAR RECESS 1/4" DEEP.
REFER 6.2
LINE BY LINE CONSTRUCTION
— FIG 25(b) —
REFER 6.2
NOTE - DRAW A COMPLETE BORDER LINE 14"x8 1/2".
— SECTION XX —
DIMENSIONS IN INCHES
FIRST ANGLE PROJECTION.
FINISHED OUTLINE
— FIG 25(c) —
— ANGLE BRACKET —
MATERIAL BRASS
FULL SIZE
REFER 6.2

FIG. 25

re-drawn on a clean sheet. You should then compare the two results and check that the second is an improvement on the first, and in particular notice the quality of the construction lines and the outlines. Notice also the dimension lines and figures, and improve them if necessary. If there is little improvement the drawing should be done a third time, as it is only with constant practice that proficiency can be achieved.

6.3. SCALE DRAWINGS. Fig. 26

When a machine of a relatively small size is made it is possible that all the assembly and detail part drawings can be drawn to full size scale. If, however, the machine is relatively large, then it is not possible to make drawings equal in size but it will be necessary to scale them down. This means that if the size of a part is, say, 4 ft × 3 ft × 1 ft 6 ins., then it can be drawn to a scale of (*a*) half full size, or (*b*) one-quarter full size, or even (*c*) one-twelfth full size. All the views on one drawing must be drawn to the same scale. In this instance the size of the drawing would be (*a*) 2 ft × 1 ft 6 ins. × 9 in., or (*b*) 1 ft × 9 in. × $4\frac{1}{2}$ in., or (*c*) 4 in. × 3 in. × $1\frac{1}{2}$ in. In each case the drawing could be made on a standard size of drawing paper. The scale is calculated in the proportion of the overall size of the object to the available size of drawing sheet. If, however, the object is minute, then the drawing can be made many times full size. For example, to make a drawing of part of a watch, the drawing may be made ten, or even fifty, times full size. Scale rules are manufactured with eight scales, 1 to 1, $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, $\frac{3}{4}$, $\frac{3}{8}$, $1\frac{1}{2}$, and 3 marked on the two sides. A typical scale rule is shown in Fig. 26(*a*). It should be noticed that only one section is divided, the other sections being in whole numbers so that if a dimension of $2\frac{3}{8}$ in. is required to a half full size scale, then the dimension is read from the 2 mark, past the zero point to the $\frac{3}{8}$ mark, as indicated. For a scale of one and a half times full size, as shown in Fig. 26(*b*), the dimension of $2\frac{3}{8}$ is measured from the 2 mark, through the zero to the third division past it, which gives a measurement of $2\frac{3}{8}$ to a scale of one and a half times full size. Figure 26(*c*) shows a measurement of $2\frac{3}{8}$ in. taken on a scale of a quarter full size.

To illustrate the use of scale drawings, we will first of all make a full size drawing of the isometric sketch shown in Fig. 26(*d*). When this is finished, and following the instructions given in sections 6.1. and 6.2. a drawing of four views should be made in first angle projection to a scale full size; that is, 1 to 1. When this is finished, a further drawing should be made of four views in first angle projection drawn to a scale of $\frac{1}{2}$, or 1 to 2, in which every inch of the object is drawn $\frac{1}{2}$ in. on the drawing. You will notice that the scale of $\frac{1}{2}$ actually makes a drawing $\frac{1}{4}$ of the area.

We will now make a drawing a quarter full size; i.e., every inch of the object equals one quarter of an inch on the drawing. In this case you will notice that the drawing appears exceptionally small because the area is now only one-sixteenth of the first full size drawing, although it is one-quarter full size in linear dimension. It must be pointed out here, whatever the scale to which you are working, the dimension figure is always the actual size. This means that although a 2 in. dimension drawn to a scale of one-quarter is only half an inch long, the dimension figure that you place against this measurement must be 2 in. On a previous page we referred to a drawing being made of a part of a watch to a magnified scale of 10, or even 50. This is illustrated in Fig. 27(*a*). The part shown is a roller stone for a lady's wrist-watch and it is 0·6 mm long × 0·2 mm diameter and is to be made from half-round glass. This drawing is a hundred times full size and as will be seen it is now clear for manufacturing purposes.

Another example of this is of a tiny screw which can only be seen clearly with an eye-glass magnifier. Figure 27(*b*) shows such a screw and the drawing is to a scale of fifty times full size.

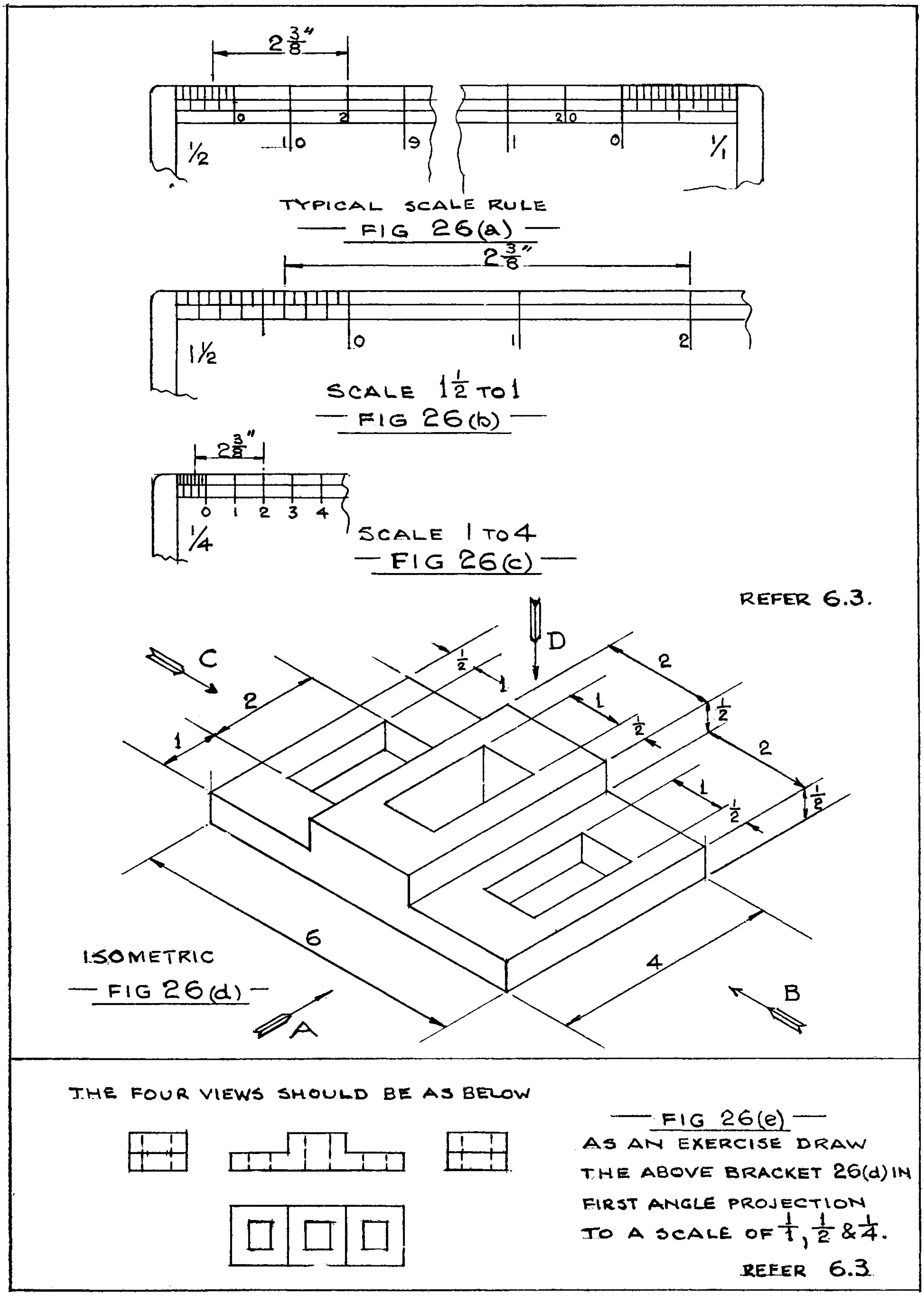
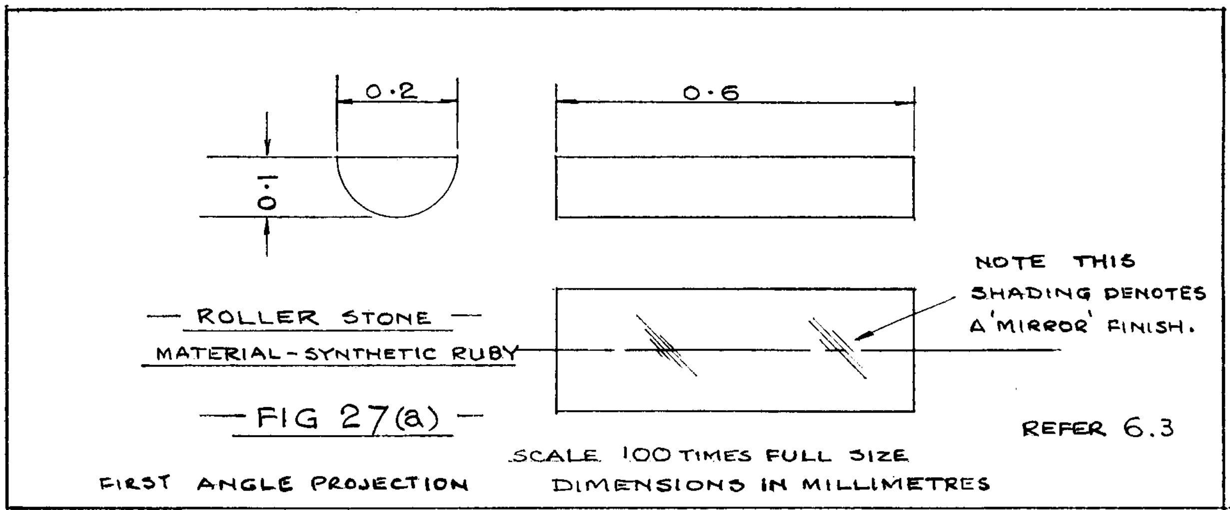
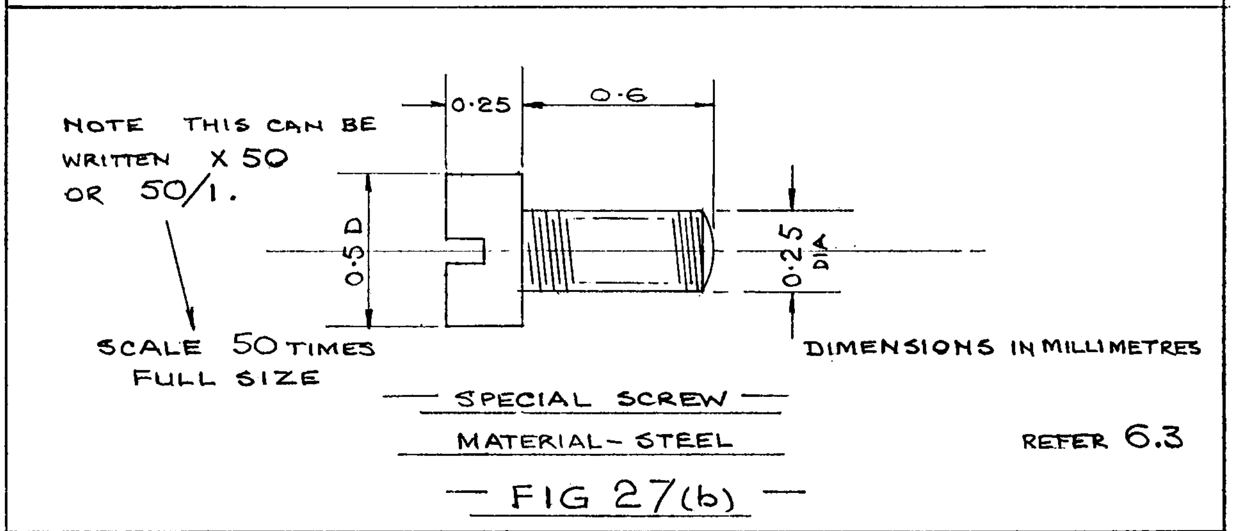

2 3/8"
1/2
1/1
TYPICAL SCALE RULE
FIG 26(a)
2 3/8"
1 1/2
SCALE 1 1/2 TO 1
FIG 26(b)
2 3/8"
1/4
SCALE 1 TO 4
FIG 26(c)
REFER 6.3.
C
D
A
B
ISOMETRIC
FIG 26(d)
THE FOUR VIEWS SHOULD BE AS BELOW
FIG 26(e)
AS AN EXERCISE DRAW
THE ABOVE BRACKET 26(d) IN
FIRST ANGLE PROJECTION
TO A SCALE OF 1/1, 1/2 & 1/4.
REFER 6.3

Fig. 26


0·2
0·6
0·1
NOTE THIS SHADING DENOTES A 'MIRROR' FINISH.
— ROLLER STONE —
MATERIAL - SYNTHETIC RUBY
— FIG 27(a) —
REFER 6.3
SCALE 100 TIMES FULL SIZE
FIRST ANGLE PROJECTION
DIMENSIONS IN MILLIMETRES


0·25
0·6
NOTE THIS CAN BE WRITTEN X 50 OR 50/1.
0·5 D
0·25 DIA
SCALE 50 TIMES FULL SIZE
DIMENSIONS IN MILLIMETRES
— SPECIAL SCREW —
MATERIAL - STEEL
REFER 6.3
— FIG 27(b) —

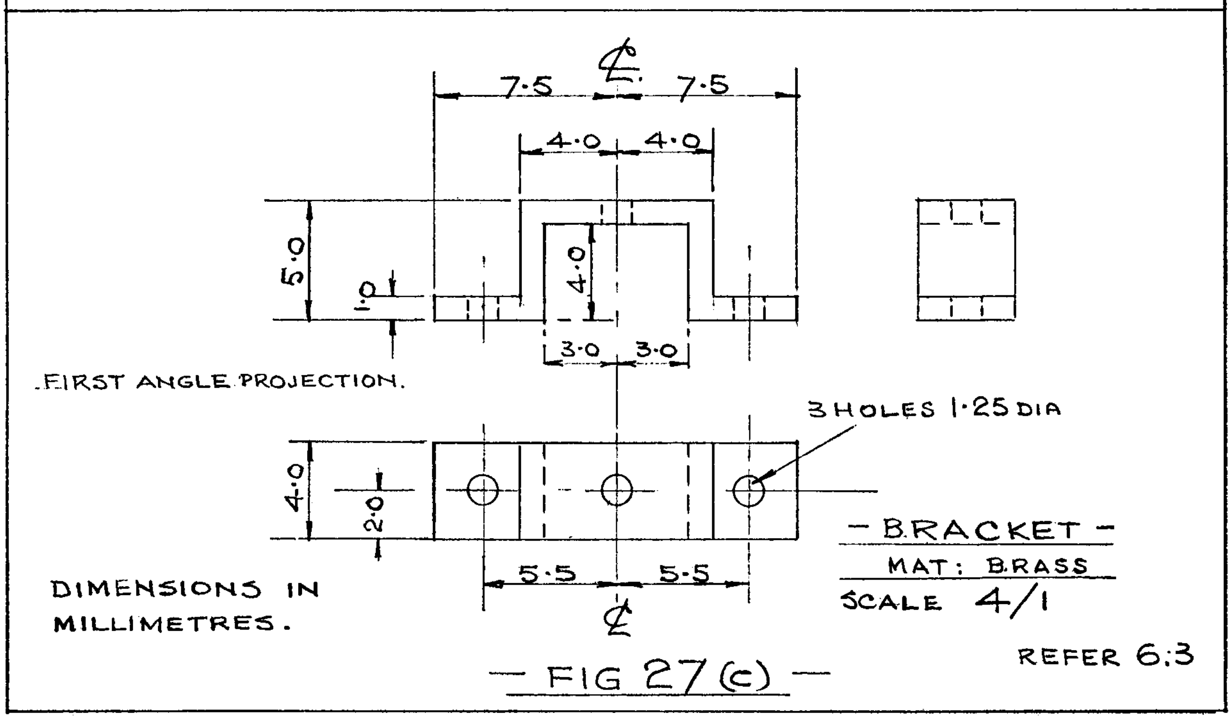

7·5
7·5
4·0
4·0
5·0
1·0
4·0
3·0
3·0
FIRST ANGLE PROJECTION.
3 HOLES 1·25 DIA
4·0
2·0
- BRACKET -
MAT: BRASS
SCALE 4/1
5·5
5·5
DIMENSIONS IN MILLIMETRES.
REFER 6:3
— FIG 27(c) —

FIG. 27

A third example is of a small bracket which is fitted into an instrument. Figure 27(*c*) shows this bracket drawn to a scale four times full size. You will notice that the drawing is quite clear for manufacturing purposes.

It should be quite obvious from these three drawings shown in Fig. 27 that the scale of a drawing, whether magnified or reduced, is decided so that the finished drawing is perfectly clear for manufacture.

6.4. FULL SECTIONS AND HIDDEN DETAIL

When a drawing of an object is made, only the external view (i.e. the part that you see) is shown in outline. If, however, there is some feature that cannot be seen it must be shown *in hidden detail*. A general rule is that a draughtsman should never dimension hidden detail. He can, however, draw what is known as *a section*. This is an imaginary cut taken through any plane in elevation, or plan, or end view. The fact that this is a section should be clearly marked on the drawing. Figure 28(*a*) shows a turned part with a concentric hole and counter bore. While the external dimensions can be clearly shown, it is very difficult to dimension the hole and counter bore clearly. Figure 28(*b*) shows the same part re-drawn with a full section and the same end view. It will be noticed that the section is cut through the vertical plane and is projected in the direction of the arrows XX. This, then, shows the hole and the counter bore quite clearly, and enables the part to be dimensioned clearly and correctly. A full view is not required because all the necessary information for manufacture is given.

A further example of the necessity for a sectional view is shown in Fig. 28(*c*). The drawing shows a small rectangular flanged cover with a hole at one end. Three views are given, but the inside of the cover must be shown in hidden detail. This means that the dimensions for the inside of the cover cannot be given. The same small cover has been re-drawn in Fig. 28(*d*) and again shows the three views in first angle projection, but two of them are full sectional views. The elevation is a section through plane AA and the direction in which the view is taken is shown by the arrows. The right hand view is a section BB and is taken through the centre of the elevation, the direction being shown by the arrows and marked BB. This enables the draughtsman to dimension the inside and the outside of the cover quite clearly. As an exercise Fig. 28(*d*) should be drawn in third angle projection to a full size scale.

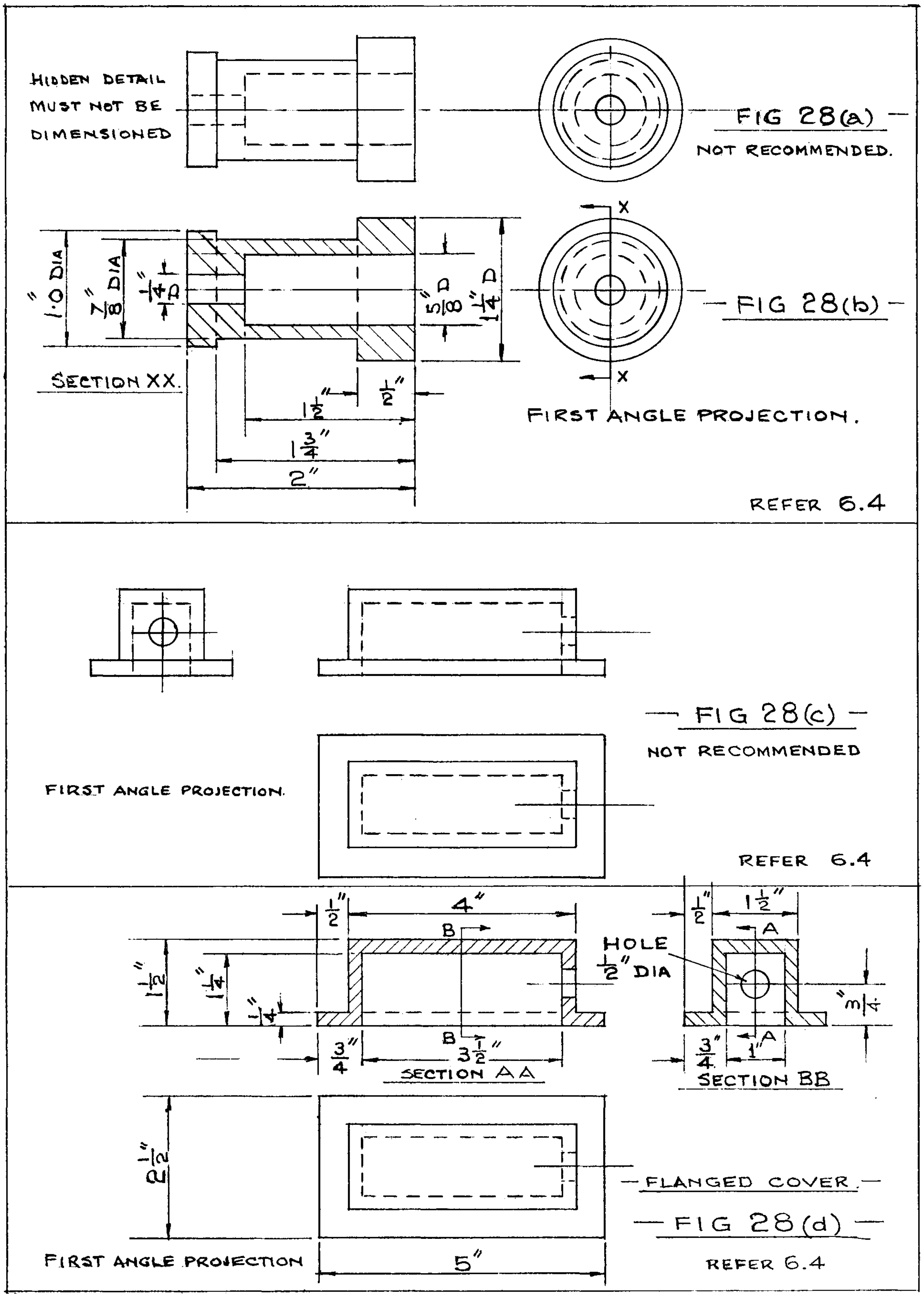
6.5. HALF-SECTIONS

In order to economize in drawing time it is often permissible to draw what is known as a "half-section".

Figure 29(*a*) shows a turned part with a parallel concentric hole and a side hole tapped (i.e. threaded) $\frac{1}{8}$ in. B.S.W. and counter bored. This drawing cannot be clearly dimensioned.

Figure 29(*b*) shows a method of making the drawing and the dimensioning more clear. The half of the elevation that shows the thread and counter bore can be shown in half section. This enables the drawing to be made to show clearly the construction and the dimensions.

Figure 29(*c*) shows a pipe clamp made in two duplicate parts. As this drawing is a sub-assembly it must not be fully dimensioned. The half section shows clearly that the two halves are the same, and it also shows the method of clamping. As stated previously, only specification dimensions may be shown.



HIDDEN DETAIL
MUST NOT BE
DIMENSIONED
FIG 28(a)
NOT RECOMMENDED.
SECTION XX.
1·0 DIA
FIG 28(b)
FIRST ANGLE PROJECTION.
REFER 6.4
FIG 28(c)
NOT RECOMMENDED
FIRST ANGLE PROJECTION.
REFER 6.4
HOLE
½" DIA
SECTION AA
SECTION BB
FLANGED COVER.
FIG 28(d)
FIRST ANGLE PROJECTION
REFER 6.4

FIG. 28

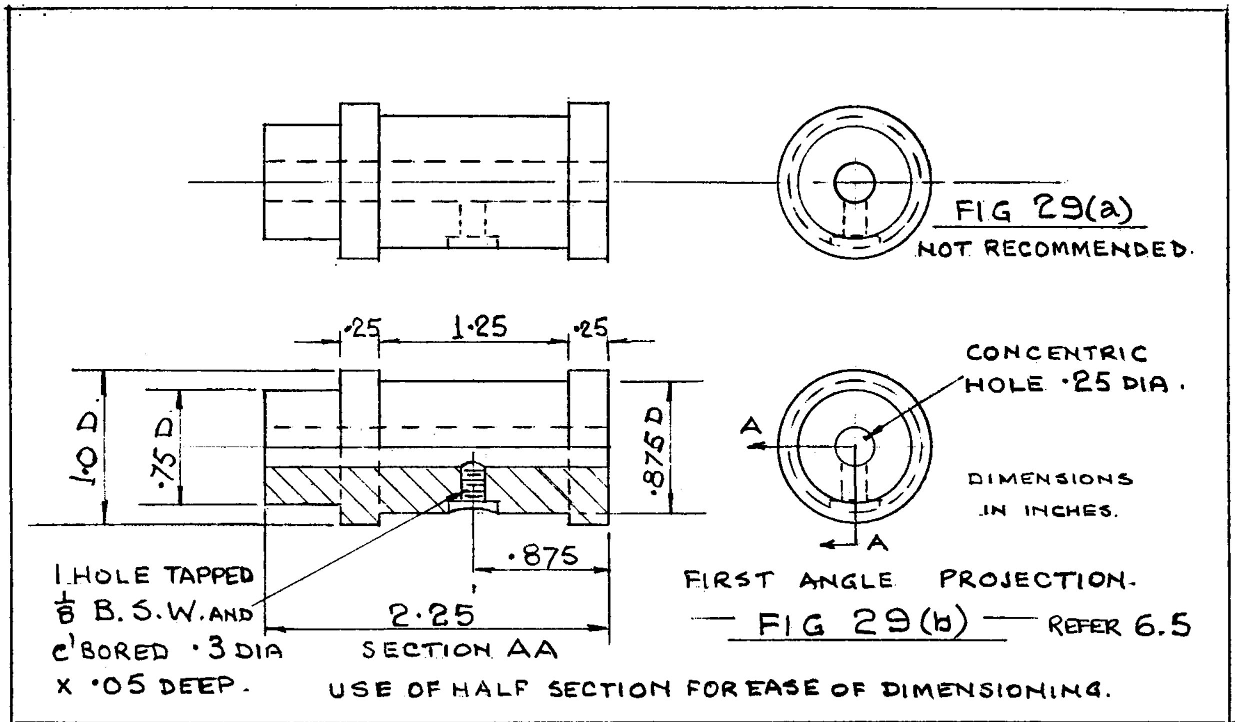


FIG 29(a)
NOT RECOMMENDED.
·25
1·25
·25
1·0 D
·75 D
·875 D
CONCENTRIC HOLE ·25 DIA.
A
DIMENSIONS IN INCHES.
A
·875
1 HOLE TAPPED 1/8 B.S.W. AND C'BORED ·3 DIA x ·05 DEEP.
2·25
SECTION AA
FIRST ANGLE PROJECTION.
FIG 29(b)
REFER 6.5
USE OF HALF SECTION FOR EASE OF DIMENSIONING.

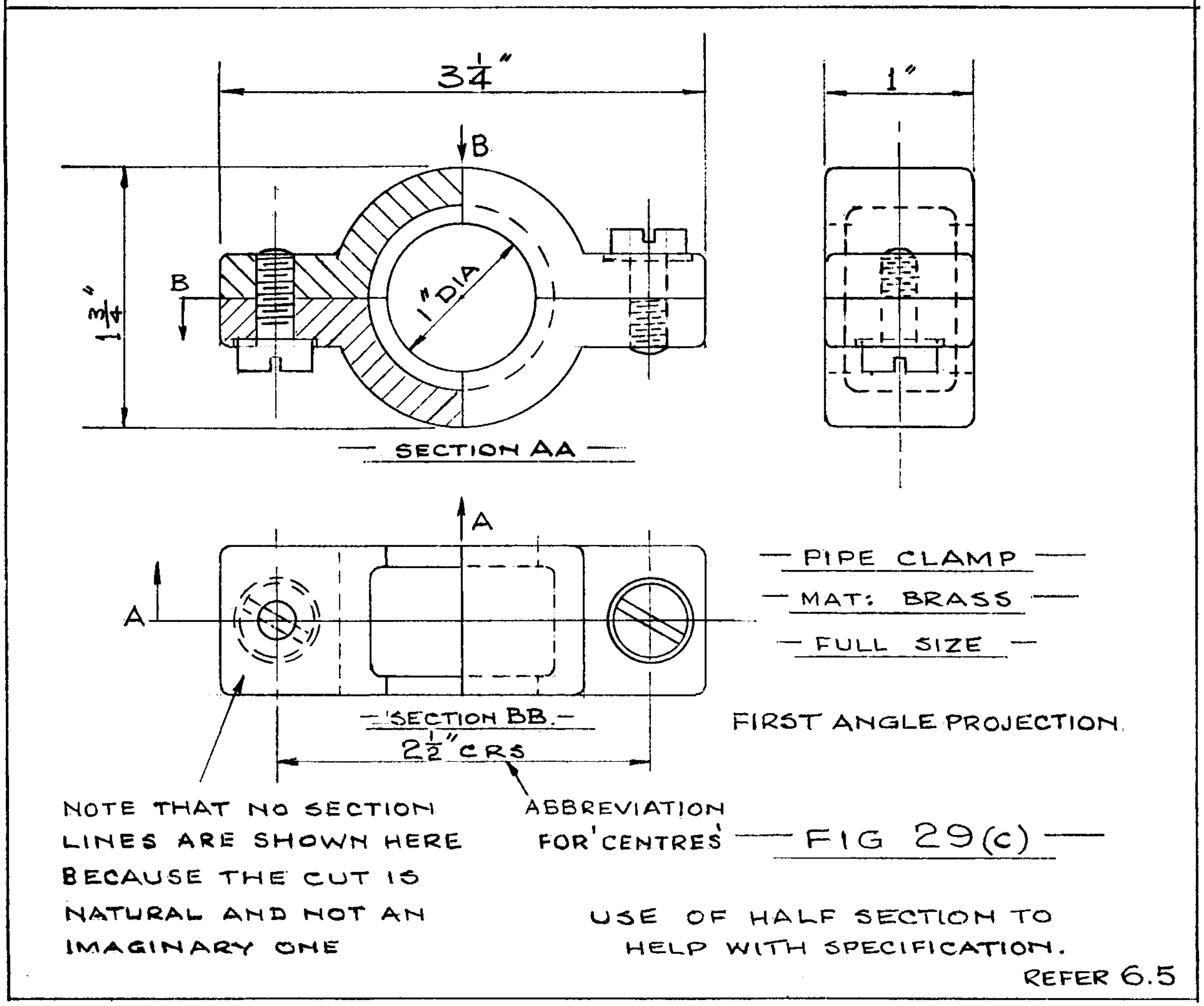

3 1/4"
1"
B
B
1" DIA
1 3/4"
SECTION AA
A
A
PIPE CLAMP
MAT: BRASS
FULL SIZE
SECTION BB.
2 1/2" CRS
FIRST ANGLE PROJECTION.
NOTE THAT NO SECTION LINES ARE SHOWN HERE BECAUSE THE CUT IS NATURAL AND NOT AN IMAGINARY ONE
ABBREVIATION FOR 'CENTRES'
FIG 29(c)
USE OF HALF SECTION TO HELP WITH SPECIFICATION.
REFER 6.5

FIG. 29

Particular notice should be taken of the lower half-section BB. No section lines are shown here because the cut is a natural one where the halves separate and is not an imaginary sectional cut requiring cross-hatching.

It must be repeated that continuous practice is the only way to success. Before proceeding to the next chapter, all the sketches and drawings in the present chapter should be completed at least once, and for greater proficiency the drawings should be repeated.

6.6. DRAWINGS OF SIMPLE OBJECTS. (Refer to Figs. 30(i) and 36)

We will now confine ourselves to drawing in first angle projection four views of each of the objects shown in Fig. 30. A short explanation of each one will be given and you should compare your results with the drawings shown in Fig. 31. Remember to do all the preliminary work in thin construction lines.

6.7. EXERCISE A. Fig. 30(*a*)

A simple Vee block is shown in isometric projection. The block is 2 in. × 2 in. × 1 in. with a 90° Vee ½ in. deep on the centre line.

Draw the isometric view full size. When you draw the Vee, remember that if it is half an inch deep then the distance across the top will also be ½ in. each side of the centre line, and is measured along the 30° line, as shown in inset. This drawing should be done in construction before any outline is added.

Now draw the four views in first angle projection in the direction of the arrows indicated.

Compare your results with the drawing shown in Fig. 31(*a*).

6.8. EXERCISE B. Fig. 30(*b*)

A ribbed angle bracket is shown in isometric projection. The overall dimensions are 2 in. × 2 in. × 2 in. with a general thickness of ½ in. A 45° angle stiffener is ½ in. thick and falls short by ¼ in. of the two edges.

Draw the isometric view full size. There should be no difficulty with this drawing provided that you remember to measure along the lines and to work to the centre line. Make your drawing in construction lines before adding any outline.

Now draw the four views in first angle projection in the direction of the arrows indicated.

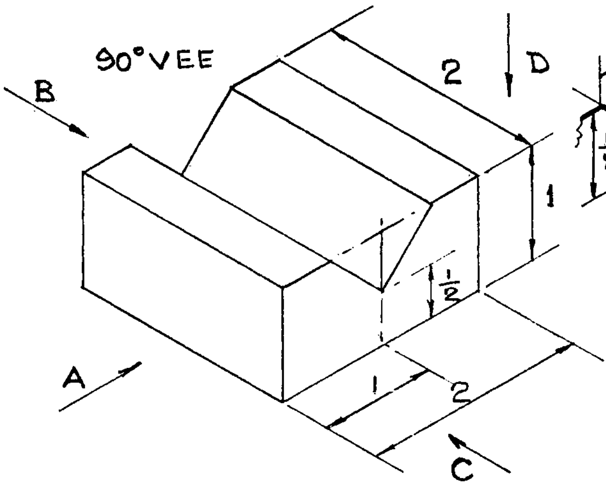
Check your results with the drawing shown in Fig. 31(*b*).

6.9. EXERCISE C. Fig. 30(*c*)

A simple Tee bracket is shown in isometric projection. It consists of a back plate 3 in. × 1¼ in. × ½ in. with a projection 1¼ in. × ⅜ in. in which there is a rectangular hole.

Draw the isometric view full size. This is a simple drawing. Remember to lay out your dimensions along the lines and notice that the rectangular hole is completely through the projection.

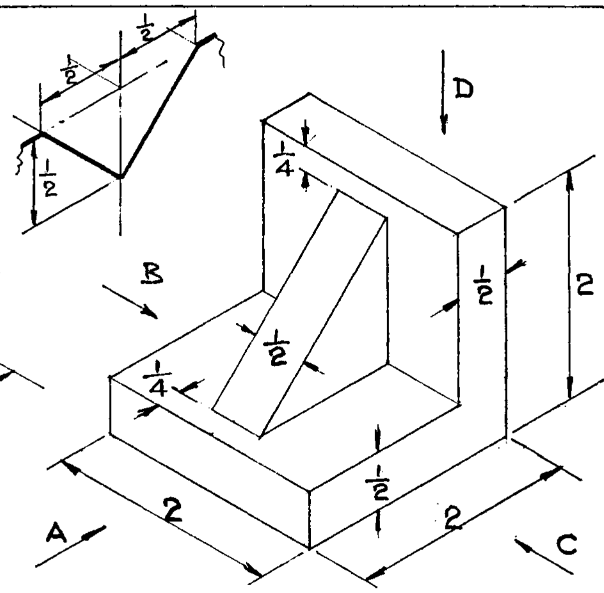
Now draw the four views in first angle projection in the direction of the arrows indicated, making A the front elevation. Compare your results with the drawing shown in Fig. 31(*c*).



SIMPLE VEE BLOCK

— FIG 30(a) —

REFER 6.7 & 7.6

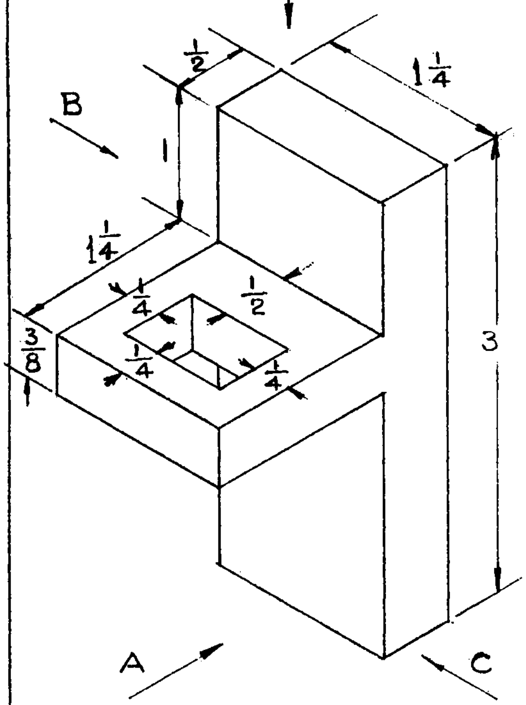


RIBBED BRACKET

— FIG 30(b) —

REFER 6.8 & 7.7

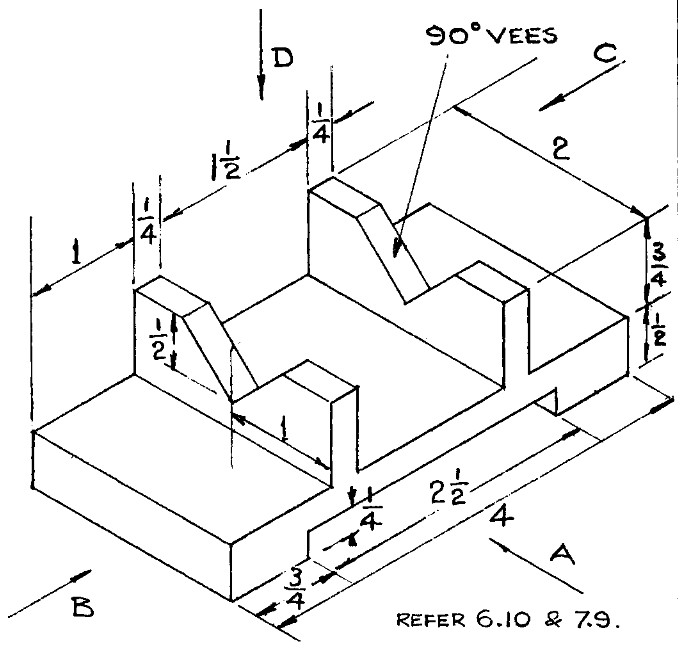
ALL DIMENSIONS IN INCHES.



TEE BRACKET

— FIG 30 (c) —

REFER 6.9 & 7.8



REFER 6.10 & 7.9.

DOUBLE VEE BRACKET

— FIG 30(d) —

THE ABOVE OBJECTS ARE TO BE DRAWN IN

(i) FIRST ANGLE PROJECTION (ENGLISH) REFERENCE CHAPTER VI

OR

(ii) THIRD ANGLE PROJECTION (AMERICAN) REFERENCE CHAPTER VII

FIG. 30

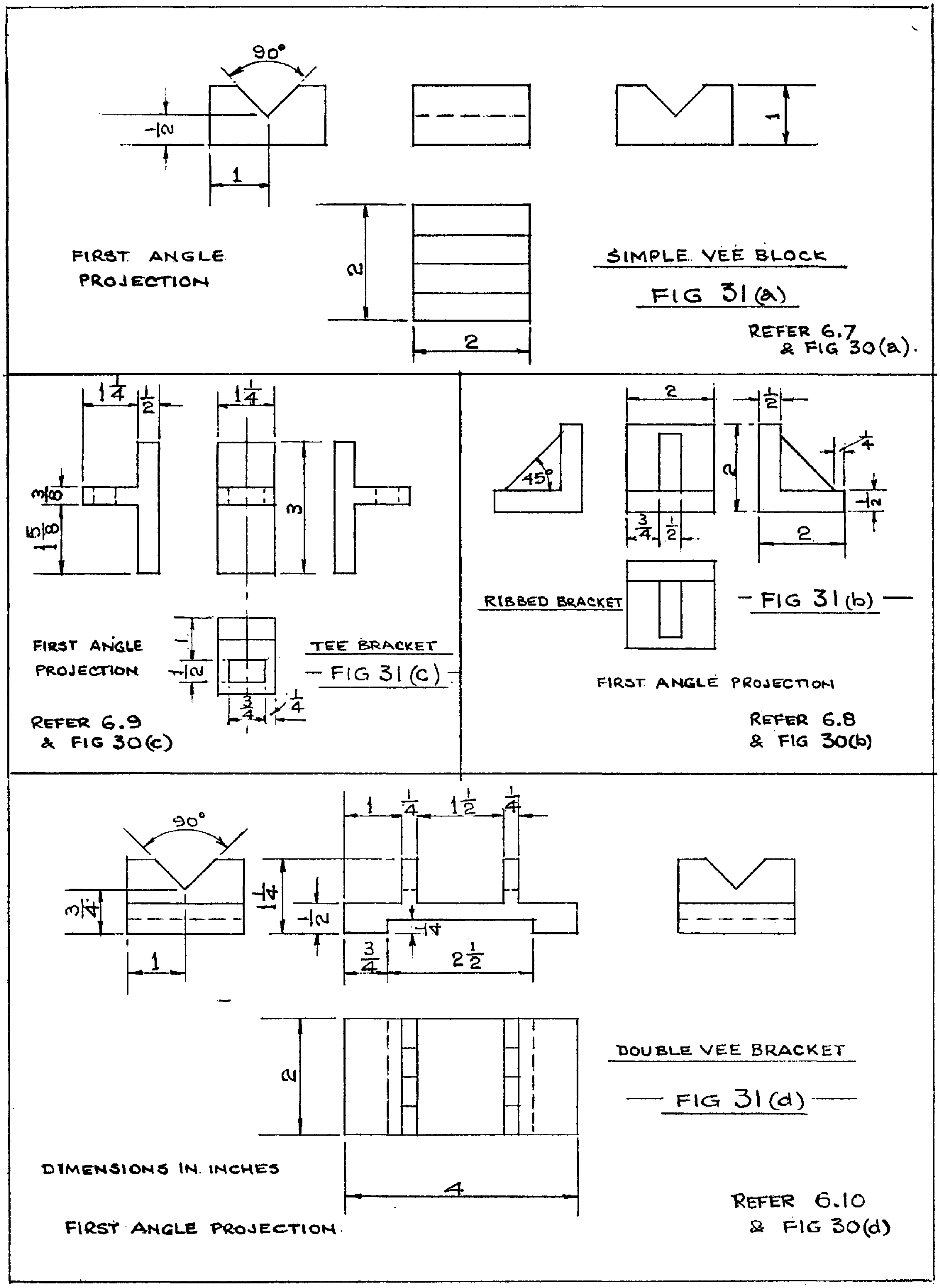

90°
FIRST ANGLE PROJECTION
SIMPLE VEE BLOCK
FIG 31 (a)
REFER 6.7 & FIG 30(a).
FIRST ANGLE PROJECTION
TEE BRACKET
FIG 31 (c)
REFER 6.9 & FIG 30(c)
45°
RIBBED BRACKET
FIG 31 (b)
FIRST ANGLE PROJECTION
REFER 6.8 & FIG 30(b)
90°
DOUBLE VEE BRACKET
FIG 31 (d)
DIMENSIONS IN INCHES
FIRST ANGLE PROJECTION
REFER 6.10 & FIG 30(d)

FIG. 31

6.10. EXERCISE D. Fig. 30(*d*)

A double Vee bracket is shown in isometric projection. The base is 4 in. × 2 in. × ½ in. and is recessed on the under side. The top has been cut away to form two vertical ribs with 90° Vees on the centre line of each rib.

Draw the isometric view full size. When you draw the two Vees remember the method used when drawing the Vee in Fig. 30(*a*) and refer to the inset. As nothing is shown to the contrary you should assume that the recess on the underside 2½ in. × ¼ in. goes completely through. This drawing should also be drawn in construction before any outline is added.

Now draw the four views in first angle projection in the direction of the arrows.

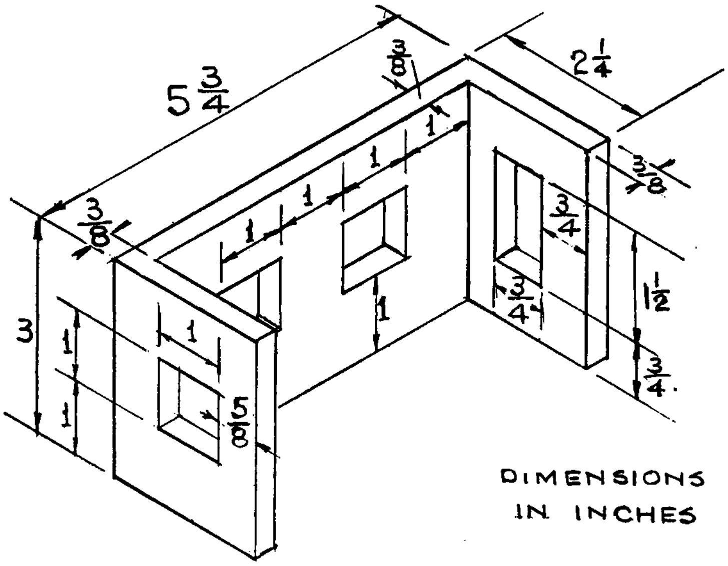
Compare your results with the drawing shown in Fig. 31(*d*).

See that the hidden detail is shown in all the appropriate views. Make sure also that all the drawings are correctly dimensioned. To each of the drawings add a title, neatly printed, together with the words "full size" and "first angle projection".

This chapter has been devoted to drawings made from isometric into first angle projection and dimensioning.

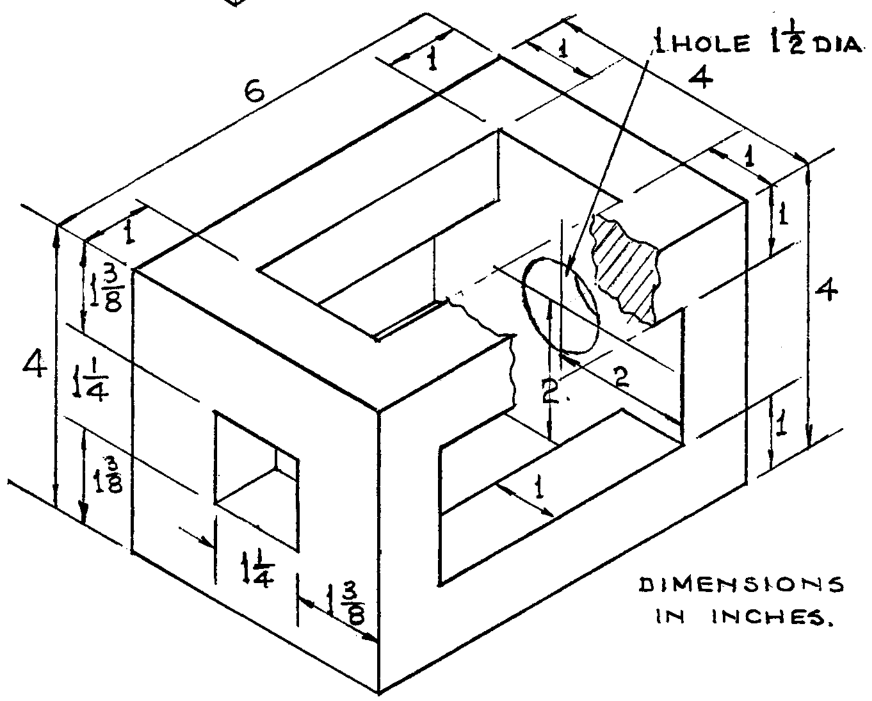
Before proceeding to the next chapter you should practise all the examples as many times as possible to become proficient.

You should keep your first drawing of Fig. 30(*a*) and the orthographic drawings (Fig. 31*a*) made from it for comparison at a later stage to see what progress has been achieved.



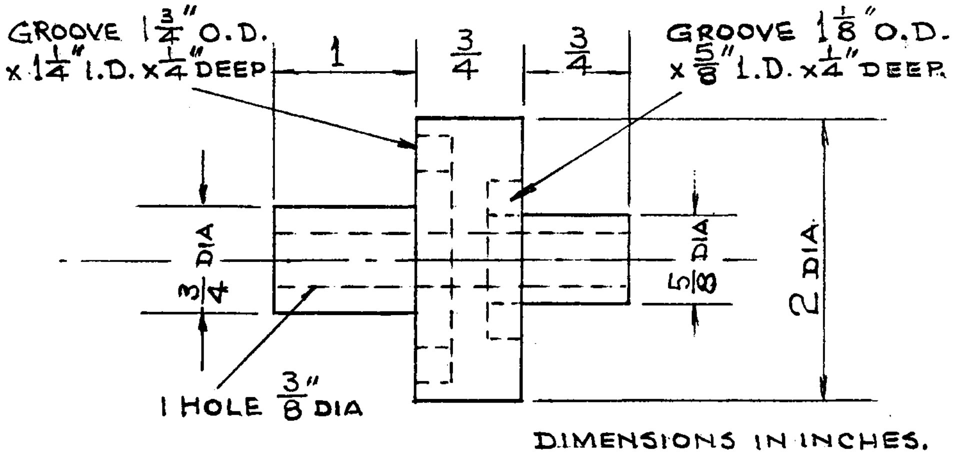
EXERCISES ON CHAPTER 6

1. Draw full size four views in first angle projection of the brass frame shown and fully dimension. Show all hidden detail.



2. A cast aluminium frame is shown which has a port through each of the six faces. Draw full size four views in first angle projection and fully dimension. Show all hidden detail.

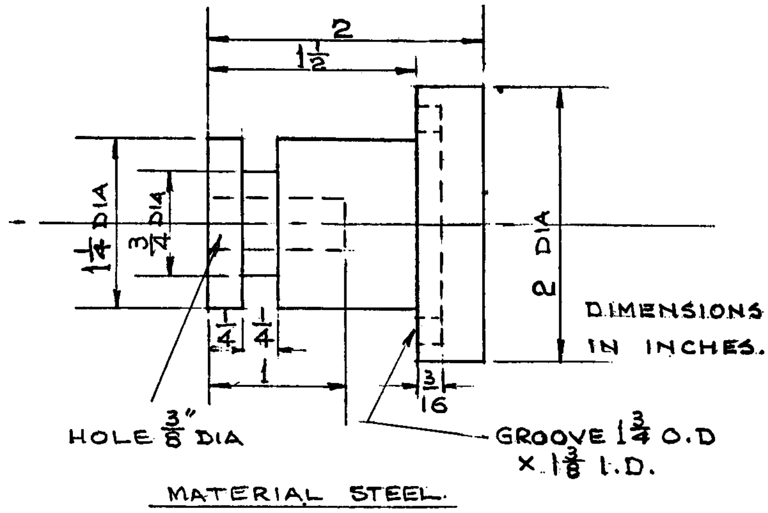
Each of the above drawings should include a printed title, scale, material, first angle projection, and dimensions in inches or millimetres.



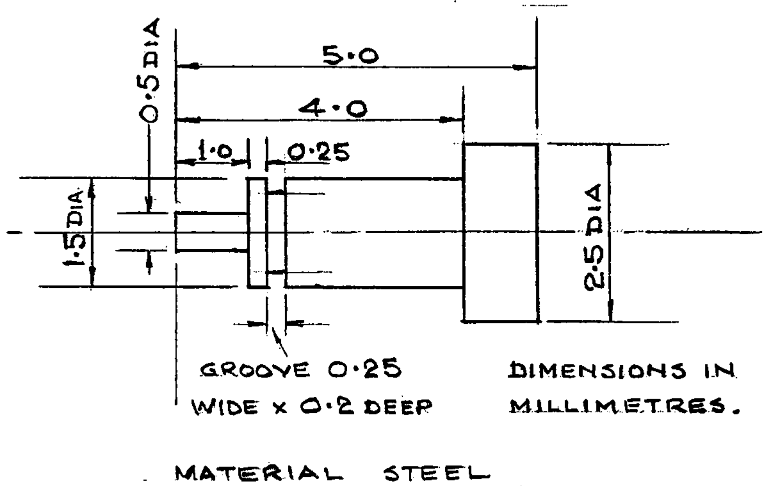
3. The drawing shows a double-ended flange machined from 2-in. diameter brass rod. Make a drawing full size in first angle projection and fully dimension, one of the views being a full sectional elevation through the centre line.

The answers to these Exercises will be found in Fig. 68.

4. The drawing shows a single-ended flange machined from 2-in. diameter steel rod. Make a drawing full size in first angle projection and fully dimension, one of the views being a half sectional elevation.

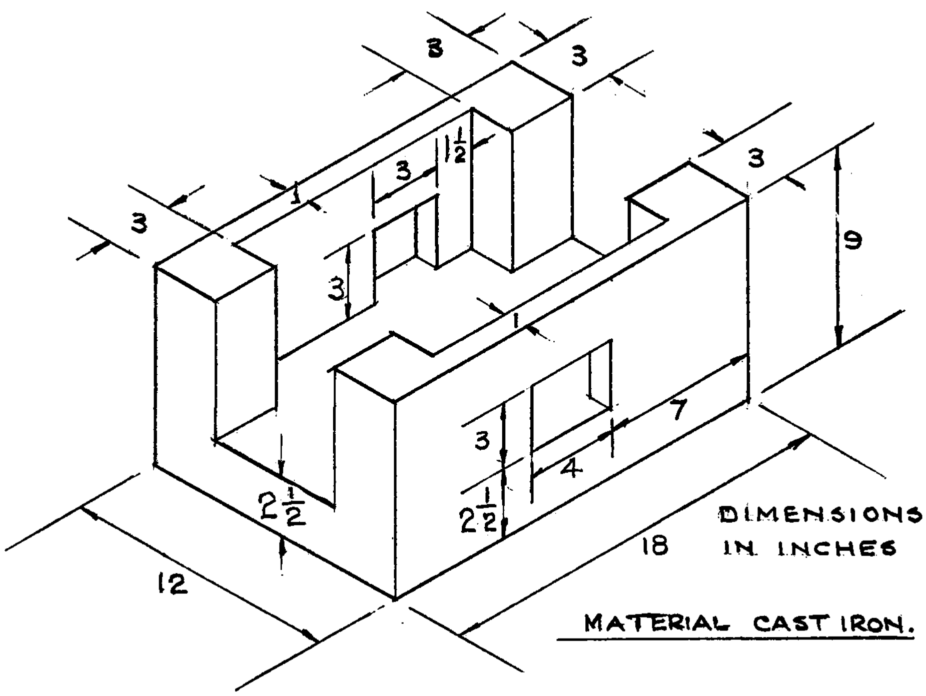


5. In a very small mechanism there is a special steel shoulder pin, as shown in the sketch. Draw this pin, ten times full size, in first angle projection and fully dimension.



6. The cast iron base in this sketch is too large to draw full size. Draw the bracket in first angle projection to a scale a quarter full size and fully dimension.

The answers to these Exercises will be found in Fig. 69.



7 · Third Angle, or American, Projection

All the drawings in this chapter are in third angle, or American, projection. It follows exactly the same pattern as Chapter 6, in which all the drawings were in first angle, or English, projection.

7.1. ORTHOGRAPHIC PROJECTION

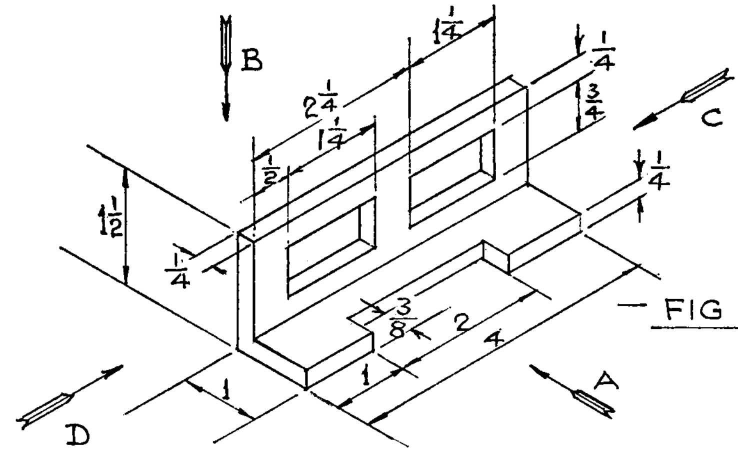
In Chapter 4 we learnt the general principles of orthographic projection in third angle (American). This should be thoroughly understood before reading this chapter. Third angle projection is "the turning of an object through three angles of 90°" and then drawing exactly what is seen to make an adjacent view. This is more easily understood if use is made of the card model supplied in an earlier chapter.

We continue with an isometric drawing (that is, with lines at 30° and measurements taken along the lines) of an angle bracket with two rectangular ports in the upright limb and part of the base removed, as shown in Fig. 32(*a*).

We will now draw in third angle projection four views as seen from the direction of the arrows. This drawing will be explained line by line.

With the paper fastened on the drawing board and your pencil sharpened allow an area approximately 12 in. horizontally × 8 in. vertically. The 12 in. is made up of 4 in. for the elevation, $1\frac{1}{2}$ in. space each side of it, plus 1 in. for each of the end views, plus $1\frac{1}{2}$ in. for dimensions. The 8 in. is made up of $1\frac{1}{2}$ in. for the elevation, plus $1\frac{1}{2}$ in. space, plus 1 in. for the plan, plus approximately 2 in. above and below for dimensions. Remember that all your lines must be drawn as thin construction lines. Draw a horizontal line, *H*1, approximately 6 in. from the top edge of the paper and follow it by one line, *H*2, $1\frac{1}{2}$ in. above it and parallel to it. Now draw two more lines, *H*3 and *H*4, $3\frac{1}{2}$ in. and $4\frac{1}{2}$ in. respectively above your first line and parallel to it. Draw a vertical line in the centre of the space allocated. On each side of this line draw lines *V*1 and *V*2 2 in. from it, both of these lines being parallel and continuing through the four horizontal lines previously drawn. Draw two more vertical lines, *V*3 and *V*4, $3\frac{1}{2}$ in. each side of the centre line, and a further two lines, *V*5 and *V*6, $4\frac{1}{2}$ in. each side of the centre line. Still drawing construction lines, you must consider the elevation in the direction of the arrow A, remembering that in third angle projection the plan is drawn above the front elevation. Now draw one line, *H*5, $\frac{1}{2}$ in. above, and a second line, *H*6, $1\frac{1}{4}$ in. above, the original first line. Still looking in the direction of the arrow A, draw two more lines, *V*7 and *V*8, $\frac{1}{4}$ in. each side of the centre line, and a further two lines, *V*9 and *V*10, $1\frac{1}{2}$ in. each side of the centre line. The thickness of the base of the elevation and the two end views is $\frac{1}{4}$ in., therefore a line, *H*7, should be drawn parallel to the base-line but $\frac{1}{4}$ in. above it. Two vertical lines, *V*11 and *V*12, should be drawn parallel to, and $\frac{1}{4}$ in. from, the two outer lines. To show the recess in the elevation and the plan lines *V*13 and *V*14 should be

— ISOMETRIC —

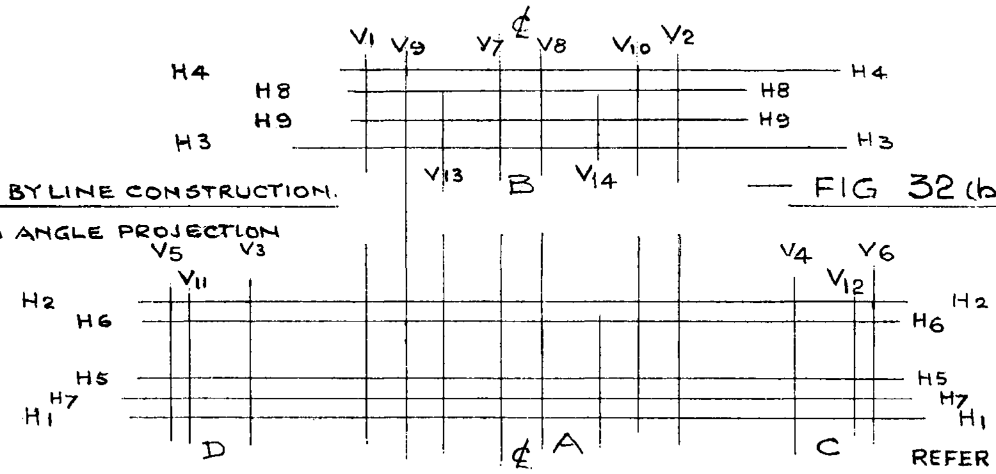


— FIG 32 (a) —

REFER 7.1

LINE BY LINE CONSTRUCTION.

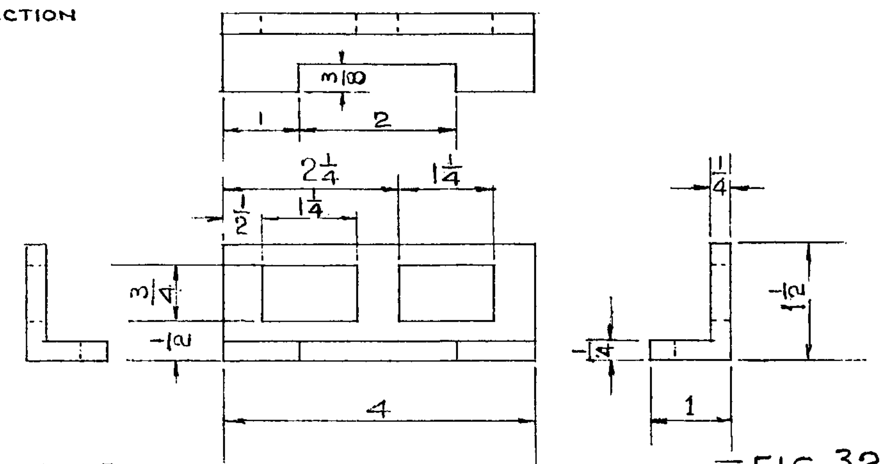
THIRD ANGLE PROJECTION



— FIG 32 (b) —

REFER 7.1

NOTE HOW THE CONSTRUCTION LINES ARE COVERED BY THE PROJECTION LINES.



·- FINISHED OUTLINE

THIRD ANGLE PROJECTION

— ANGLE BRACKET —

— MATERIAL BRASS —

— FULL SIZE —

— FIG 32 (c) —

REFER 7.1

FIG. 32

drawn vertically each side of the centre line and 1 in. from it. To show the thickness of the back in the plan, a line *H*8 should be drawn $\frac{1}{4}$ in. below the top line and parallel to it. A further line, *H*9, should be drawn $\frac{5}{8}$ in. from the top line and parallel to it. The drawing should now resemble that shown in Fig. 32(*b*), and all the lines should be thin construction lines.

We will now proceed to outline the front elevation looking from arrow A, and in doing so the lines should be firm, all the corners sharp, and it should be like the front elevation shown in Fig. 32(*c*). For third angle projection, if you draw exactly what you see looking in the direction of the arrow C, you will get a reversed L-shaped elevation or end view, which should be placed at the right-hand side. This can then be completed in outline. Again looking in the direction of the arrow D, draw exactly what you see and place it to the left-hand side of the elevation. In this case you will get an L-shaped end elevation. This can also be filled in in outline. Looking in the direction of arrow B, you can now draw the plan in outline, which will be above the front elevation. For correct projection the two ports must be shown in hidden detail in both the end elevations and the plan. The recess is also shown in hidden detail in the two end elevations. When filling in the outline follow each view in the isometric drawing to see which lines are full or in hidden detail.

Dimensions should now be placed where you see the shape of a particular part, and following the dimensioning rules, the dimensions should be taken from two faces at right angles. In addition the overall dimensions must be clearly shown. Place the dimensions as shown in Fig. 32(*c*), and after printing the title and the scale, the finished drawing should look like Fig. 32(*c*). Enclose the drawing in a border line rectangle 14 in. × $8\frac{1}{2}$ in.

7.2. ORTHOGRAPHIC PROJECTION. Fig. 33

In this section we shall draw in third angle projection (four views) the bracket shown in isometric projection Fig. 33(*a*). This will be done without line-by-line instruction.

The bracket is a block of metal with a machined step. In the step is a groove parallel to the front. Looking from the direction of the arrow A, we have the front elevation, and centrally spaced is a recess in the front face and a recess in the back rib.

First, draw all the construction lines in a similar manner to those drawn in Fig. 32(*b*), but to the appropriate dimensions. The front elevation should be exactly what you see when looking in the direction of the arrow A. The left-hand end elevation is projected from the front elevation and you draw at that end exactly what you see in the direction of the arrow D. The right-hand end elevation is projected from the front elevation, and you draw at that end exactly what you see in the direction of the arrow C. The plan is drawn above the front elevation and is in the direction of the arrow B. All the drawings should be in thin construction lines. Compare your results with Fig. 33(*b*). Carefully add any lines that have been omitted.

After further examination of Fig. 33(*a*), you should be able to draw the four views in outline. All your lines should be firm and all the corners sharp. When filling in the outline follow each view in the isometric drawing to see which lines are full and which are in hidden detail.

Dimensions are taken from three master faces; i.e. the back face, the left-hand face and the base, so that in each view the dimensions are taken from two faces at right angles. Print the title and scale, and in this instance complete the drawing by a border line 14 in. × $8\frac{1}{2}$ in. neatly spaced. The completed drawing should look like Fig. 33(*c*).

The drawings shown in Figs. 32 and 33 should be practised as often as possible. After completing them once, the paper should be removed and the drawing re-drawn on a clean sheet of paper.

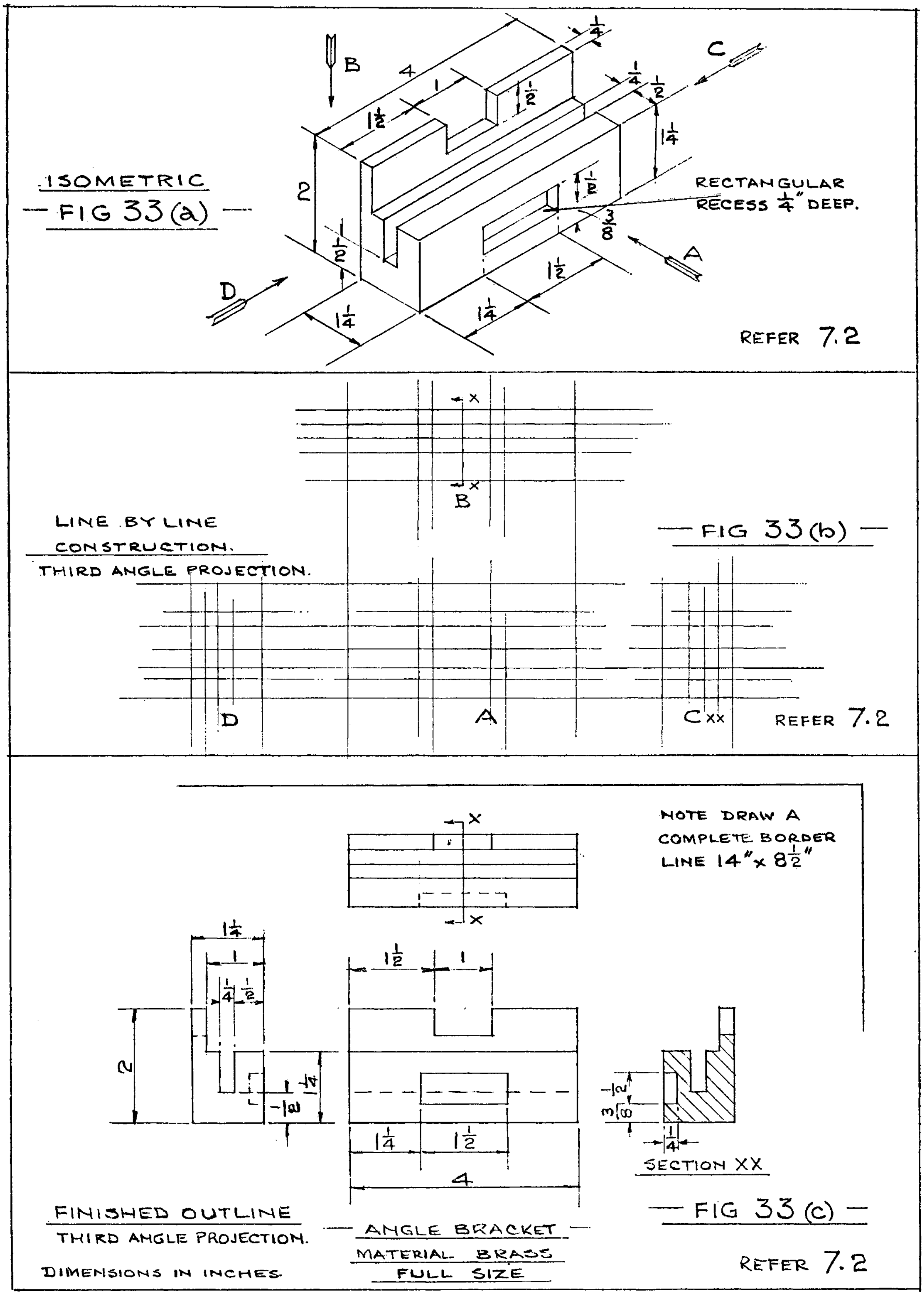

ISOMETRIC
FIG 33 (a)
RECTANGULAR RECESS 1/4" DEEP.
REFER 7.2
LINE BY LINE CONSTRUCTION.
THIRD ANGLE PROJECTION.
FIG 33 (b)
REFER 7.2
NOTE DRAW A COMPLETE BORDER LINE 14" x 8 1/2"
SECTION XX
FINISHED OUTLINE
THIRD ANGLE PROJECTION.
DIMENSIONS IN INCHES.
ANGLE BRACKET
MATERIAL BRASS
FULL SIZE
FIG 33 (c)
REFER 7.2

Fig. 33

You should then compare the two results and the second drawing should be an improvement on the first. Notice, in particular, the quality of the construction lines and outlines. Notice also the dimension lines and figures and improve them if necessary. If there is little improvement the drawing should be made a third time, as it is only with constant practice that greater proficiency will be achieved.

Scale Drawings

For details of drawings made to a magnified or reduced scale, refer to Chapter 6, section 6.3, and Figs. 26 and 27.

7.3. FULL SECTIONS. Fig. 34

When a drawing of an object is made, only the external view (that is, the part which you see) is shown in outline. If, however, there is some feature that cannot be seen, it must be shown in hidden detail. A very general rule is that a draughtsman must never dimension hidden detail. He can, however, draw what is known as a section. This is an imaginary cut taken through any plane in elevation, or plan, or end view. The fact that a section is shown must be clearly marked on the drawing.

The drawings which will now be referred to are drawn in third angle projection. Figure 34(*a*) shows a turned part with a concentric hole and counterbore. While the external dimensions can be clearly shown, it is difficult to dimension the hole and the counterbore clearly. Figure 34(*b*) shows the same part re-drawn with a full section, and the same end view. It will be noticed that the section is cut through the vertical plane, and is exactly what you see when looking in the direction of the arrows AA. This, then, shows the hole and the counterbore quite clearly and enables the part to be dimensioned clearly and correctly. A full view is not required because all the necessary information for manufacture is clearly given.

A further example of the necessity for a sectional view is shown in Fig. 34(*c*). The drawing shows a small rectangular flanged cover with a hole at one end. Three views are given, but the inside of the cover is shown in hidden detail. This means that the dimensions for the inside of the cover cannot be given. The same small cover has been re-drawn in Fig. 34(*d*) and again shows the three views in third angle projection, but two of them are full sectional views. The front elevation is a section through plane AA, and the direction of the view taken is shown by the arrows. The left-hand view is a section BB and is taken through the centre of the elevation, the direction being shown by the arrows and marked BB. This enables the draughtsman to dimension the inside and outside of the cover quite clearly. You will notice, again, that the plan is above the elevation as the drawing is in third angle projection.

7.4. HALF-SECTIONS. Fig. 35

In order to economize in drawing time it is often permissible to draw what is known as a half-section.

Figure 35(*a*) shows a turned part with a parallel concentric hole and a side hole tapped (threaded) and counterbored. This drawing cannot be clearly dimensioned.

Figure 35(*b*) shows a method of making both the drawing and the dimensioning more clear. The half of the elevation which shows the thread and counterbore can be shown in half-section.

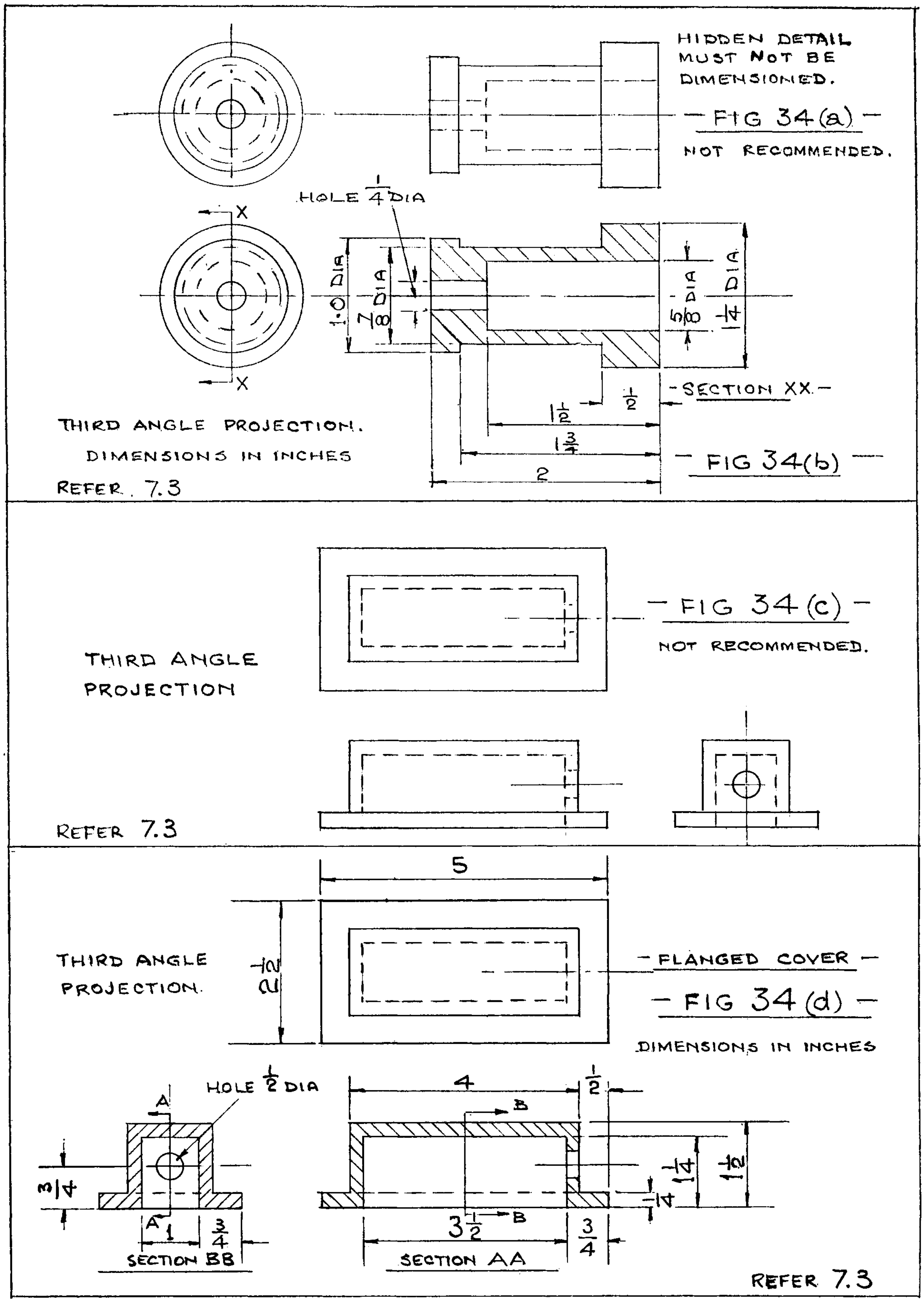

HIDDEN DETAIL MUST NOT BE DIMENSIONED.
FIG 34(a)
NOT RECOMMENDED.
HOLE 1/4 DIA
X
X
1.0 DIA
7/8 DIA
5/8 DIA
1 1/4 DIA
SECTION XX.
1/2
1 1/2
1 3/4
2
THIRD ANGLE PROJECTION.
DIMENSIONS IN INCHES
REFER. 7.3
FIG 34(b)
FIG 34 (c)
NOT RECOMMENDED.
THIRD ANGLE PROJECTION
REFER 7.3
5
THIRD ANGLE PROJECTION.
2 1/2
FLANGED COVER
FIG 34 (d)
DIMENSIONS IN INCHES
HOLE 1/2 DIA
A
A
3/4
1
3/4
SECTION BB
4
1/2
B
B
1/4
1 1/2
1/4
3 1/2
3/4
SECTION AA
REFER 7.3

FIG. 34

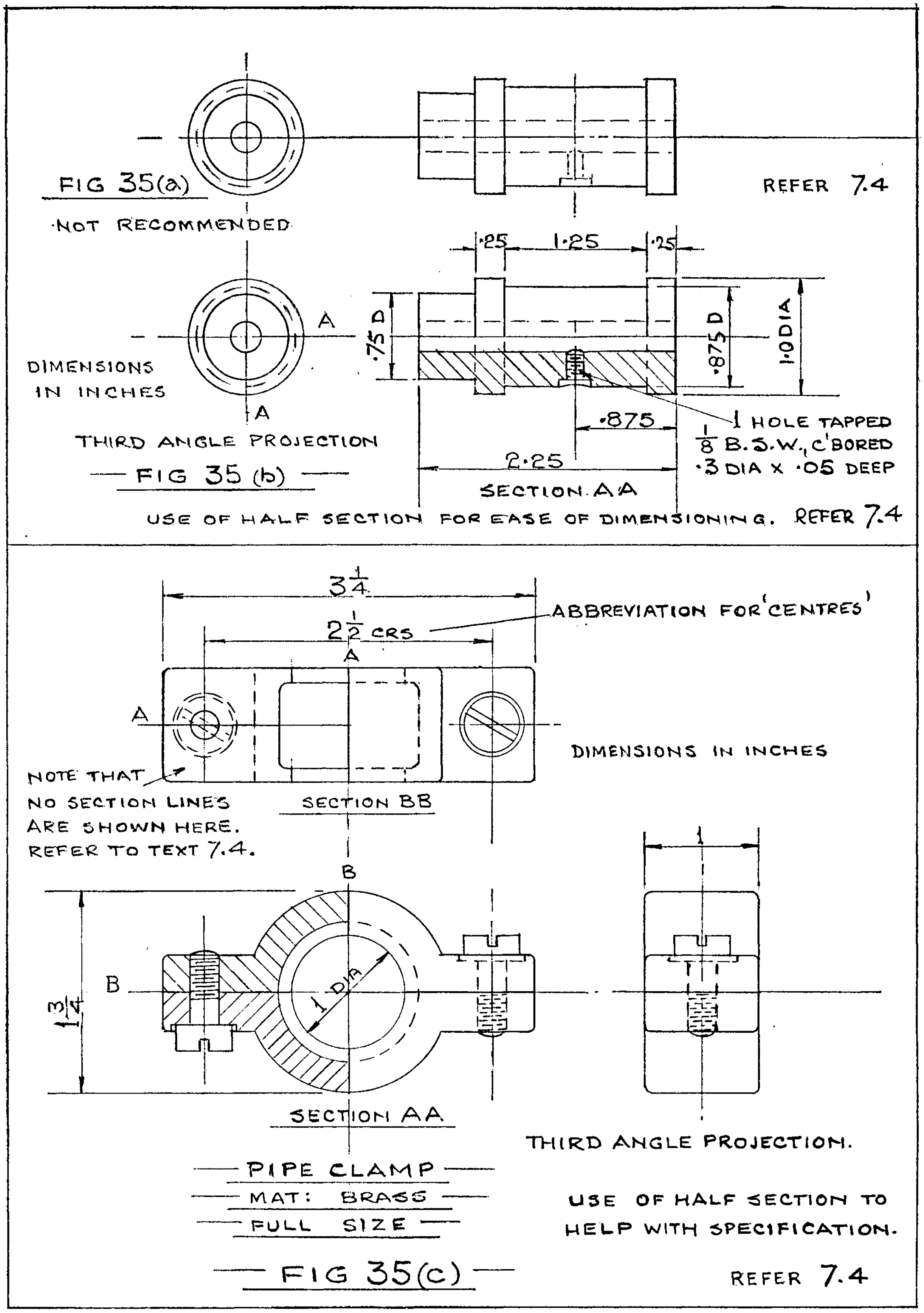


FIG 35(a)
·NOT RECOMMENDED·
REFER 7.4
·25
1·25
·25
·75 D
·875 D
1·0 DIA
A
A
DIMENSIONS IN INCHES
·875
1 HOLE TAPPED 1/8 B.S.W., C'BORED ·3 DIA X ·05 DEEP
2·25
THIRD ANGLE PROJECTION
FIG 35 (b)
SECTION AA
USE OF HALF SECTION FOR EASE OF DIMENSIONING. REFER 7.4
3 1/4
2 1/2 CRS
ABBREVIATION FOR 'CENTRES'
A
A
DIMENSIONS IN INCHES
NOTE THAT NO SECTION LINES ARE SHOWN HERE. REFER TO TEXT 7.4.
SECTION BB
1
B
B
1 3/4
1 DIA
SECTION AA
THIRD ANGLE PROJECTION.
PIPE CLAMP
MAT: BRASS
FULL SIZE
USE OF HALF SECTION TO HELP WITH SPECIFICATION.
FIG 35(c)
REFER 7.4

Fig. 35

This enables the drawing to be made to show clearly the construction and the dimensions. All the drawings are in third angle projection.

Figure 35(*c*) shows a pipe clamp made in two duplicate parts. As this drawing is a sub-assembly it must not be fully dimensioned, but the half-section clearly shows how the two halves are the same and the method of clamping. As mentioned previously, only specification dimensions may be shown.

The drawings in Fig. 35 are all in third angle projection and should be compared with those in Fig. 29, which are in first angle projection. It will be noticed that in Fig. 29(*c*) the plan is at the bottom, whereas in Fig. 35(*c*) the plan is at the top.

7.5. DRAWINGS OF SIMPLE OBJECTS. (Refer to Figs. 30(ii) and 36)

We will now confine ourselves to drawing in third angle projection four views of each of the objects shown in Fig. 30. A short explanation will be given of each one and you should compare the results with the drawings shown in Fig. 36. Remember, again, to do all the preliminary work in thin construction lines.

7.6. EXERCISE A. Figs. 30(*a*) and 36(*a*)

A simple Vee block is shown in isometric projection. The block is 2 in. × 2 in. × 1 in. with a 90° Vee ½ in. deep on the centre line.

Draw the isometric view full size. When drawing the Vee remember that since it is ½ in. deep, the distance across the top is also ½ in. each side of the centre line, and is measured along the 30° line, as shown in inset. The drawing should be made in construction before any outline is added.

Now draw the four views *full size* in third angle projection in the direction of the arrows indicated.

Compare your results with the drawing shown in Fig. 36(*a*).

7.7. EXERCISE B. Figs. 30(*b*) and 36(*b*)

A ribbed angle bracket is shown in isometric projection. It measures 2 in. × 2 in. × 2 in. and has a general thickness of ½ in. A 45° angle stiffener is ½ in. thick and falls short by ¼ in. of the two edges.

Draw the isometric view full size. There should be no difficulty with this drawing provided you remember to measure along the lines and work to a centre line. Make the drawing in construction lines before adding any outline.

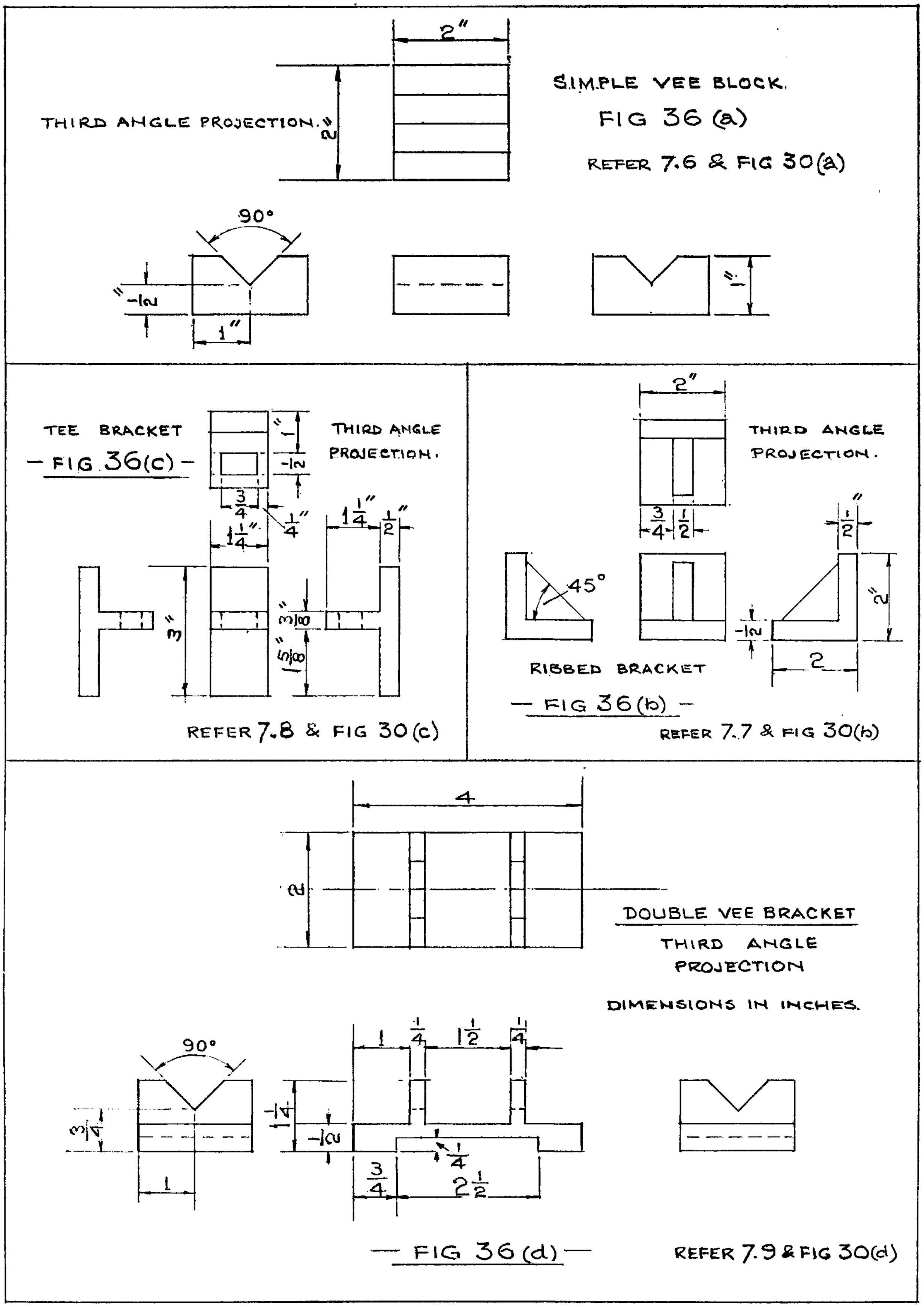
Now draw the four views *full size* in third angle projection in the direction of the arrows indicated.

Check your results with the drawing shown in Fig. 36(*b*).

7.8. EXERCISE C. Figs. 30(*c*) and 36(*c*)

A simple Tee bracket is shown in isometric projection. It consists of a back plate measuring 3 in. × 1¼ in. × ½ in. with a projection 1⅜ in. × ⅜ in. in which there is a rectangular hole.

Draw the isometric view full size. There should be no difficulty with this simple drawing.



SIMPLE VEE BLOCK.
FIG 36 (a)
REFER 7.6 & FIG 30(a)
THIRD ANGLE PROJECTION.
2"
90°
1"
TEE BRACKET
FIG 36(c)
THIRD ANGLE PROJECTION.
3"
REFER 7.8 & FIG 30(c)
2"
THIRD ANGLE PROJECTION.
45°
RIBBED BRACKET
FIG 36(b)
2
REFER 7.7 & FIG 30(b)
4
DOUBLE VEE BRACKET
THIRD ANGLE PROJECTION
DIMENSIONS IN INCHES.
90°
1
FIG 36 (d)
REFER 7.9 & FIG 30(d)

Fig. 36

Remember to lay out your dimensions along the lines and notice that the rectangular hole passes completely through the projected piece.

Now draw the four views *full size* in third angle projection in the direction of the arrows indicated, making A the front elevation. Compare the results with the drawing shown in Fig. 36(*c*).

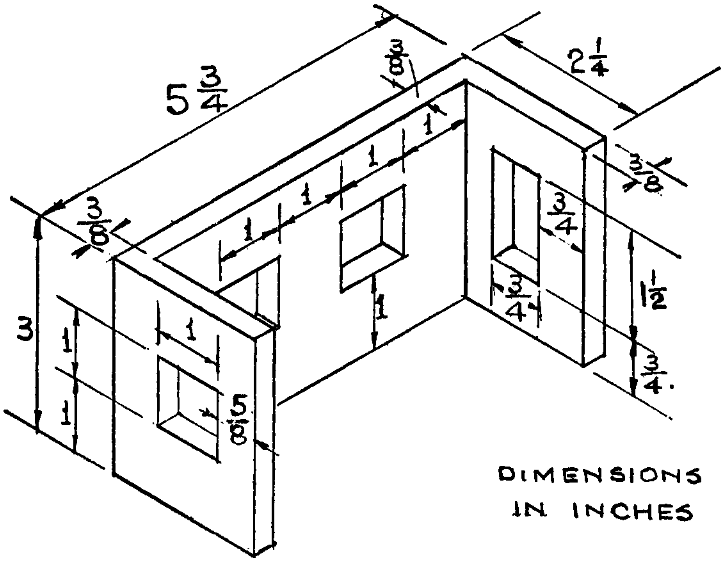
7.9. EXERCISE D. Figs. 30(*d*) and 36(*d*)

A double Vee bracket is shown in isometric projection. The base measures 4 in. × 2 in. × 1 in. and is recessed on the underside. The top has been cut away to form two vertical ribs with a 90° Vee on the centre line of each rib.

Draw the isometric view full size. When drawing the two Vees remember the method used when drawing Fig. 30(*a*) and refer to the inset. As nothing is shown to the contrary, you must assume that the recess on the under side 3 in. × $\frac{1}{2}$ in. passes completely through. This drawing should also be drawn in construction before any outline is added.

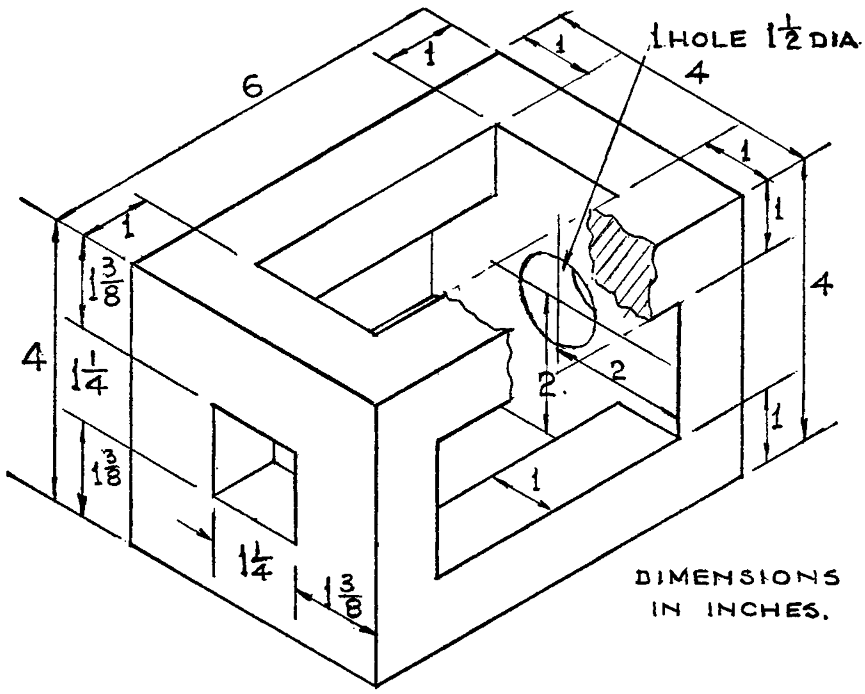
Now draw the four views *full size* in third angle projection in the direction of the arrows indicated. Compare your results with Fig. 36(*d*).

See that the hidden detail is shown in all the appropriate views, and make sure that all the drawings are correctly dimensioned. To each of the drawings add a title neatly printed, together with the words "full size" and "third angle projection".



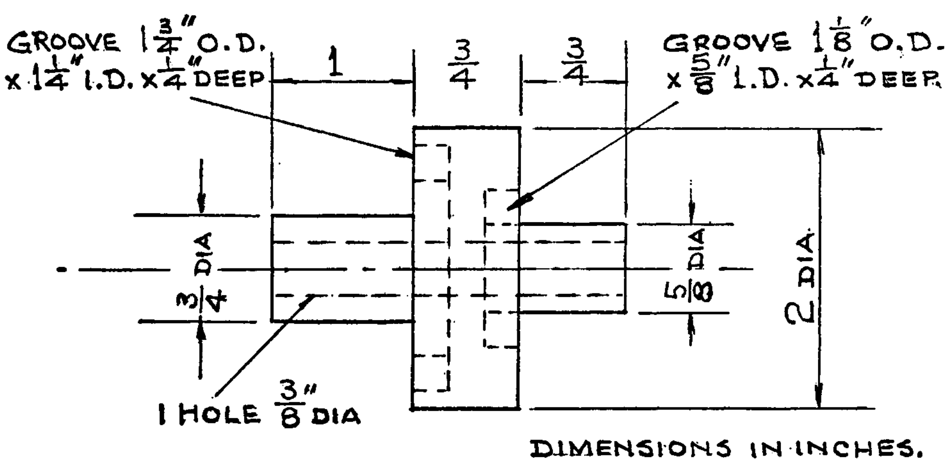
EXERCISES ON CHAPTER 7

1. Draw full size four views in third angle projection of the brass frame shown and fully dimension. Show all hidden detail.



2. A cast aluminium frame is shown which has a port through each of the six faces. Draw full size four views in third angle projection and fully dimension. Show all hidden detail.

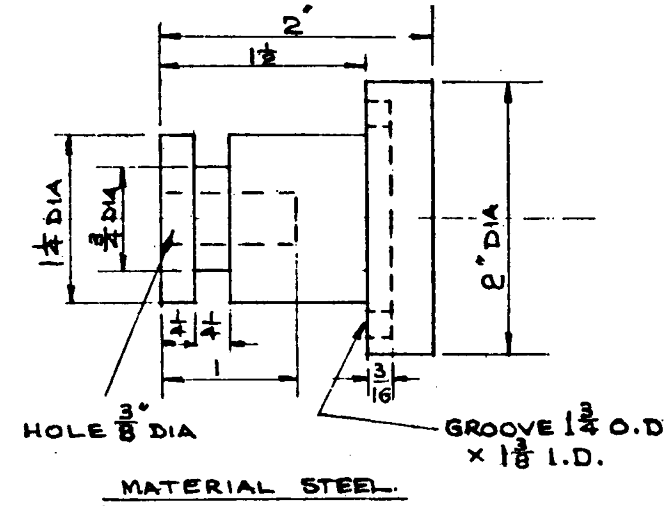
Each of the above drawings should include a printed title, scale, material, third angle projections and dimensions in inches or millimetres.



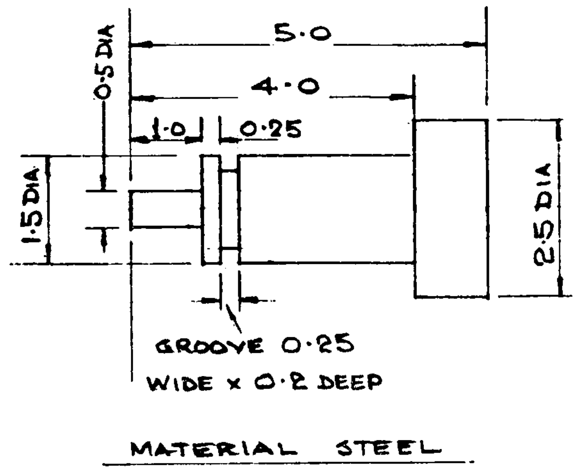
3. The drawing shows a double-ended flange machined from 2-in. diameter brass rod. Make a drawing full size in third angle projection and fully dimension, one of the views being a full sectional elevation through the centre line.

Answers to these Exercises will be found in Fig. 70.

4. The drawing shows a single-ended flange machined from 2-in. diameter steel rod. Make a drawing full size in third angle projection and fully dimension, one of the views being a half sectional elevation.

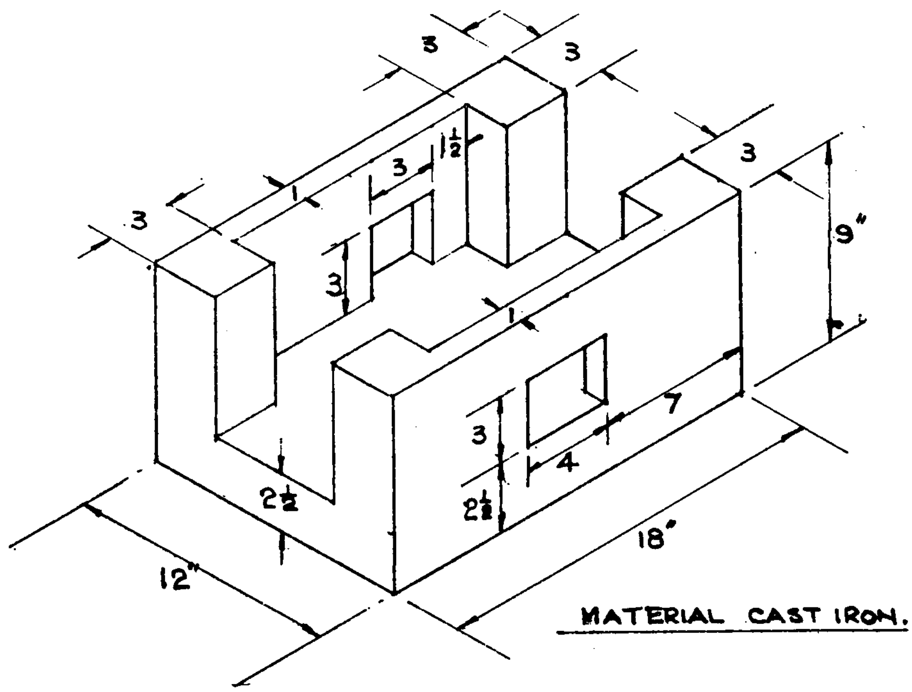


5. In a very small mechanism there is a special steel shoulder pin, as shown in the sketch. Draw this pin, ten times full size, in third angle projection and fully dimension.



6. The cast iron base in this sketch is too large to draw full size. Draw the base in third angle projection to a scale one-quarter full size and fully dimension.

Answers to these Exercises will be found in Fig. 71.



8 · Screw Threads

IN THIS chapter we shall be dealing with screw threads as used generally in the British engineering industry. There are many publications which deal with European and American threads used in specialized and other industries and these can, if necessary, be easily obtained.

The principal screw thread systems which have been used in Great Britain are the British Standard Whitworth (B.S.W.) and the British Association (B.A.).

The American National Thread system developed from the Sellers thread is used in Canada and in the United States.

The need for a common standard for screw threads has been felt for many years, and after a provisional British Standard for Unified Screw Threads was published in 1949 a new British Standard, B.S. 1580 for unified screw threads, was published in 1953.

8.1. A TYPICAL SCREW. Fig. 37

A screw thread is a helical groove machined on a cylinder so that the distance from a point on one turn, to a corresponding point one turn along the cylinder, is constant. This distance is known as the "pitch". The two main types of threads are "square" and "Vee". Of the two types, the Vee thread is the stronger; but as the faces of the Vee are inclined to the line of thrust (that is, to the axis of the bolt) the frictional resistance to motion is greater. The high frictional resistance is advantageous in many instances for it helps in preventing the nut from slackening. Square threads are used mostly for power transmission, but are now being superseded by "acme" or similar threads, which are more readily cut in thread milling machines.

A typical screw is shown in Fig. 37(*a*). Points to notice are: the angle, the diameter *D*, and the length which is measured under the head of the screw. A full definition of terms is given below.

Pitch is the distance from a point on one thread to the corresponding point on the next.

Lead is the axial advance per rotation of the moving member of a screwed pair. Note that on single start threads "pitch" and "lead" are equal.

Slope is equal to half the "pitch".

Hand describes the rotation of a nut on to the bolt. When a clockwise rotation of a nut screws it *on*, a bolt is said to be right-handed; when a clockwise rotation of a nut screws it *off*, a bolt is said to be left-handed.

Angle is the space subtended by the two sloping faces of the screw thread.

All these terms are illustrated in Fig. 37(*a*).

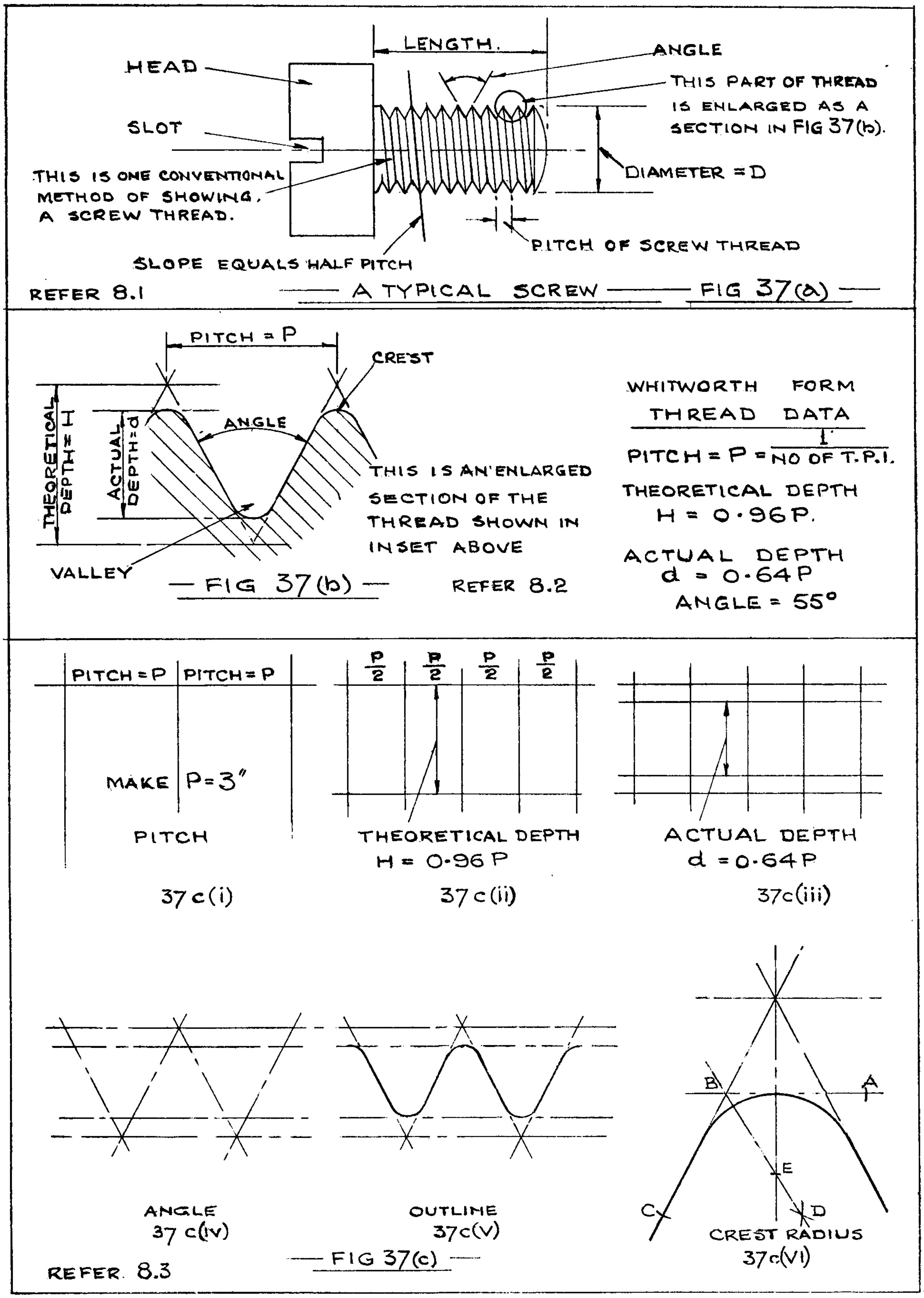

LENGTH.
HEAD
ANGLE
THIS PART OF THREAD IS ENLARGED AS A SECTION IN FIG 37(b).
SLOT
DIAMETER = D
THIS IS ONE CONVENTIONAL METHOD OF SHOWING A SCREW THREAD.
PITCH OF SCREW THREAD
SLOPE EQUALS HALF PITCH
REFER 8.1
A TYPICAL SCREW
FIG 37(a)
PITCH = P
CREST
THEORETICAL DEPTH = H
ACTUAL DEPTH = d
ANGLE
WHITWORTH FORM THREAD DATA
PITCH = P = 1/NO OF T.P.I.
THEORETICAL DEPTH H = 0·96P.
THIS IS AN ENLARGED SECTION OF THE THREAD SHOWN IN INSET ABOVE
ACTUAL DEPTH d = 0·64P
ANGLE = 55°
VALLEY
FIG 37(b)
REFER 8.2
PITCH = P
PITCH = P
MAKE P = 3"
PITCH
37 c(i)
P/2
P/2
P/2
P/2
THEORETICAL DEPTH H = 0·96 P
37 c(ii)
ACTUAL DEPTH d = 0·64P
37c(iii)
ANGLE
37 c(iv)
OUTLINE
37c(V)
B
A
E
C
D
CREST RADIUS
37c(VI)
FIG 37(c)
REFER 8.3

FIG. 37

8.2. THREAD SECTION DATA. Fig. 37(*b*)

This is an enlarged section of a thread shown in the inset in Fig. 37(*a*) and illustrates the terms used. All the dimensions of the thread form are proportional to the pitch, *P*.

8.3. WHITWORTH THREAD, STEP-BY-STEP CONSTRUCTION. Fig. 37(*c*)

In this section six small drawings are shown and they illustrate the construction of a Whitworth thread form as follows:

(i) Draw three vertical lines, each the distance of one pitch, *P*, apart. Consult the table in Fig. 37(*b*) and you will see that the pitch, *P*, equals the reciprocal of the number of threads per inch. On our drawing we will make the pitch equal to 3 in.

(ii) To the above drawing now add the lines which divide the pitch, *P*, into two equal parts. Also add the two horizontal lines which show the theoretical depth, *H*, which is equal to 0·96 *P* (i.e. 2·88 in. when $P = 3$ in.).

(iii) Draw two more parallel lines to show the actual depth, *d*, which is equal to 0·64 *P* (i.e. 1·92 in. when $P = 3$ in.). These two lines must be spaced equidistant between the other two parallel lines which are 2·88 in. apart.

(iv) Form two Vees by drawing diagonal lines joining the full-pitch marks to the half-pitch marks. The angle now subtended by these diagonal lines should measure 55°, which is the standard Whitworth thread angle.

(v) The form of thread can now be filled in in outline, but the curves forming the crest and the valley should be drawn first, as explained in the following paragraph.

(vi) In order to find the centre of the curve, bisect the angle *ABC*. The bisector, *BD*, passes through the centre line at *E*, the centre of the radius of the curve. Once the compasses have been set, all five radii can be drawn at the same time.

Finally, in this section it should be noted that the typical screw in Fig. 37(*a*) illustrates one conventional method of drawing a screw thread. Two others are given in Fig. 38(*b*) and Fig. 39(*d*).

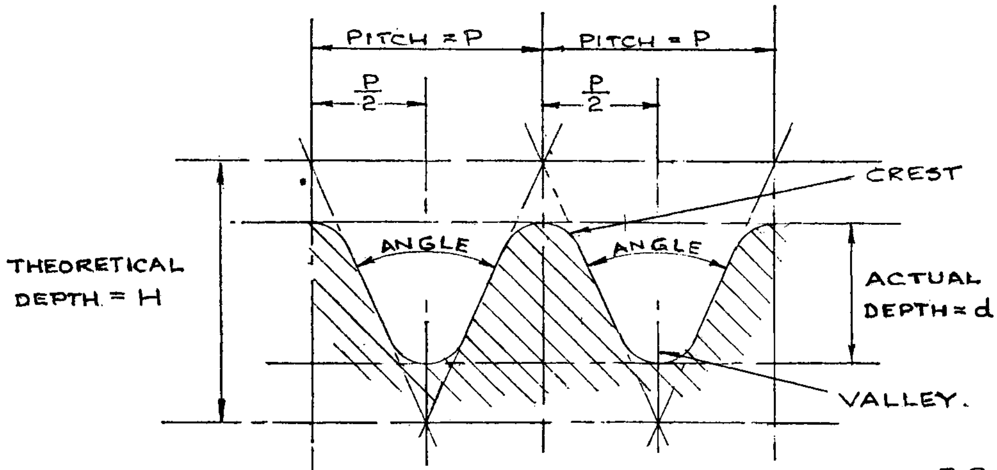
8.4. B.A. THREAD. Fig. 38(*a*)

A very general rule is to use the British Standard Whitworth for threads of ¼ in. diameter and above, and the British Association for threads below ¼ in. (Note that the largest B.A. size is 0 B.A. and measures 6 mm in diameter, which is slightly smaller than ¼ in.)

With the help of the table shown in Fig. 38(*a*), draw a section of a B.A. thread to a pitch of 3 in. It should be constructed following the same procedure as used for the Whitworth thread. Compare your results with Fig. 38(*a*) and notice that the B.A. angle is 47½°, whereas the Whitworth angle is 55°.

These angles of 47½° and 55° are maintained throughout all sizes of B.A. and B.S.W. screws respectively.

Another conventional method of showing a screw thread is illustrated in Fig. 38(*b*). The thread is indicated by lines sloping approximately 2½° to the vertical and spaced approximately half the pitch apart, the long lines being in outline and the half-pitch lines slightly shorter but thicker. A right-hand thread is represented by lines sloping to the left, as in Fig. 38(*b*), and a left-hand thread by lines sloping to the right.



BRITISH ASSOCIATION (B.A.) FORM.
THREAD DATA.

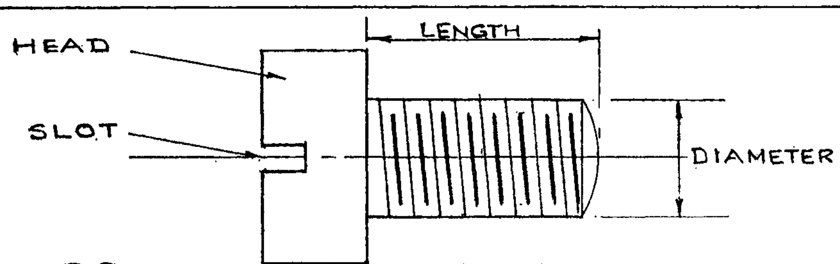
— FIG 38 (a)
REFER 8.4.

PITCH = P = $\frac{1}{\text{NO OF T.P.I.}}$. THEORETICAL DEPTH = H = 1·136 P.

ACTUAL DEPTH = d = 0·6 P   ANGLE = $47\frac{1}{2}°$

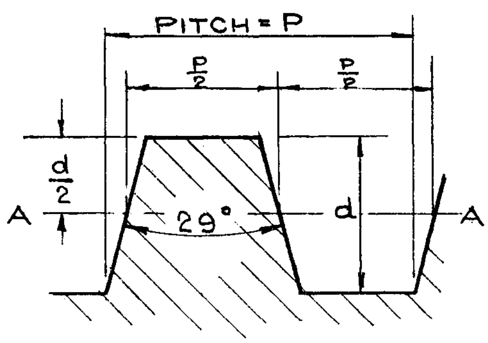
THE LARGEST B.A. THREAD IS Nº 0 BA 6 MILLIMETRES DIA.

THE SMALLEST B.A. THREAD IS Nº 22 B.A 0·37 M.M. DIA.



— FIG 38 (b) —
REFER 8.4.

THIS IS A CONVENTIONAL METHOD OF SHOWING A SCREW THREAD.

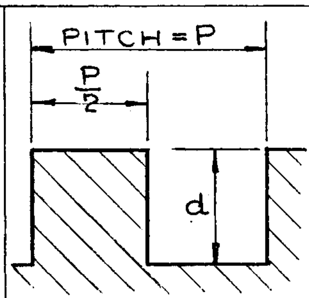


ACTUAL DEPTH = d = 0·5 P + 0·01″

ACME THREAD

FIG 38 (c) —

REFER 8.5



ACTUAL DEPTH
d = 0·5 P

SQUARE THREAD

FIG 38 (d)

REFER 8.6

WHITWORTH

	THREADS PER INCH	
DIA	B.S.W.	B.S.F
¼″	20	26
½″	12	16
1″	8	10
1½″	6	8

BRITISH ASSOCIATION (B.A.)

Nº B.A.	DIA	T.P. INCH
0	6·0 MM	25·4
13	1·2 "	101·6
22	0·37 "	254·0

— FIG 38 (e) —
REFER 8.6

FIG. 38

8.5. ACME THREAD. Fig. 38(*c*)

The drawing in Fig. 38(*c*) shows the acme thread. This is very much like a square thread but has an angle of 29°. When drawing this thread form the pitch can be marked off along the line AA. This thread is readily cut in a thread milling machine and is used mainly for power transmission.

8.6. SQUARE THREAD. Fig. 38(*d*)

The thread shown in Fig. 38(*d*) is commonly known as a square thread and has a depth and width of $\frac{1}{2}P$.

Although it is still extensively used for power transmission, the square thread is more difficult to machine than the acme thread. Another advantage of the acme thread is that the nut can be readily adjusted for wear, whereas the square threaded nut is more difficult to adjust.

It is sometimes desirable to use a thread with a finer pitch than the B.S.W. For this purpose there is a British Standard Fine thread which, although of smaller pitch, still has the same form and is as shown in the Table for British Standard Whitworth in Fig. 37(*c*). To indicate the difference in the number of threads per inch of British Standard Whitworth and British Standard Fine, a table giving the number of threads per inch for four selected sizes is shown in Fig. 38(*e*), together with the equivalent diameter of the bolt. A few selected sizes of British Association threads are also given, including the largest and the smallest.*

8.7. UNIFIED THREAD. Fig. 39(*a*)

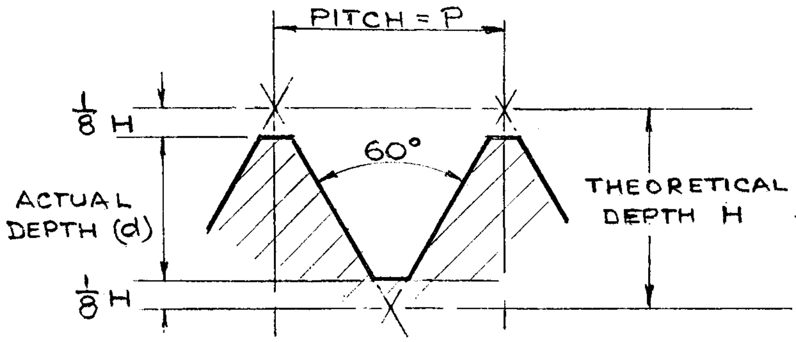
For many years the main thread used in the United States was the Sellers thread. The basic form of this thread is shown in Fig. 39(*a*). You will notice that the main angle is always 60°, and that there is a flat at the top and at the bottom of the thread.

The Sellers thread has now been superseded by the "unified screw thread", the basic form of which is illustrated in Fig. 39(*b*). It should be noticed that the angle of 60° is the same, and that there is a flat $\frac{1}{8}H$ deep at the crest of the thread. In practice, the crest may be slightly rounded. The bottom of the thread is rounded $\frac{1}{6}H$ deep from the theoretical depth.

Although the basic form remains the same as that shown in Fig. 39(*b*) there are two series of threads similar to the British Standard Whitworth and the British Standard Fine. The coarse thread is known as the "unified coarse thread", designated U.N.C., and the "unified fine thread", designated U.N.F. The Table of four selected sizes shown in Fig. 39(*c*) should be compared with that shown in Fig. 38(*c*). It will be seen that the U.N.C. thread is approximately the same as the B.S.W. in the number of threads per inch, but of course the form is different. The U.N.F. thread is much finer than the B.S.F.

A third conventional method of showing a screw thread is given in Fig. 39(*d*) and consists of two parallel lines each approximately $\frac{1}{8}D$ from the outer lines. It is drawn in outline for the length of the thread on the screw shank.

* Tables of all sizes of B.S.W. and B.A. screw threads are published and can be obtained if required.



$d = 0{\cdot}6495\,P$
$H = 0{\cdot}86\,P$

FIG 39(a)

BASIC FORM OF SELLERS THREAD

REFER 8.7

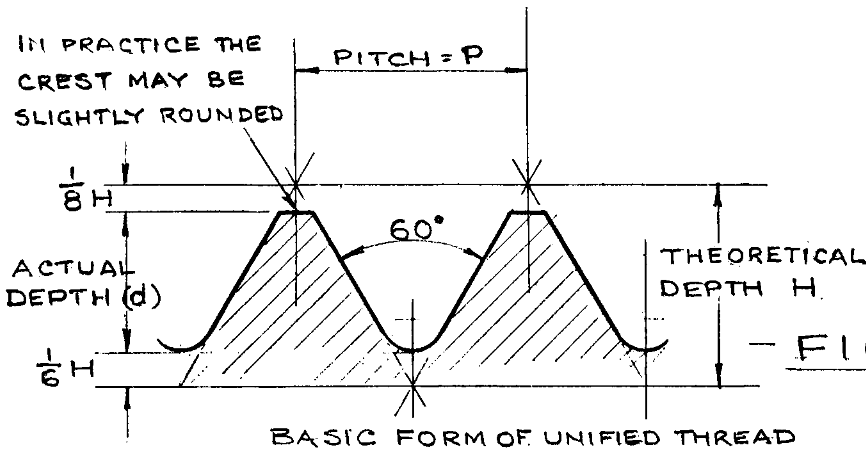


FIG 39(b)

BASIC FORM OF UNIFIED THREAD

REFER 8.7

THE UNIFIED FINE THREAD DESIGNATED U.N.F.

THE UNIFIED COARSE THREAD DESIGNATED U.N.C.

DIAM.	T.P.I. U.N.C.	T.P.I. U.N.F.
1/4	20	28
1/2	13	20
1	8	12
1½	6	12

THIS TABLE SHOULD BE COMPARED WITH THE TABLE OF B.S.W. AND B.S.F. SCREW THREADS SHOWN IN FIG 38(e)

FIG 39(c)

REFER 8.7

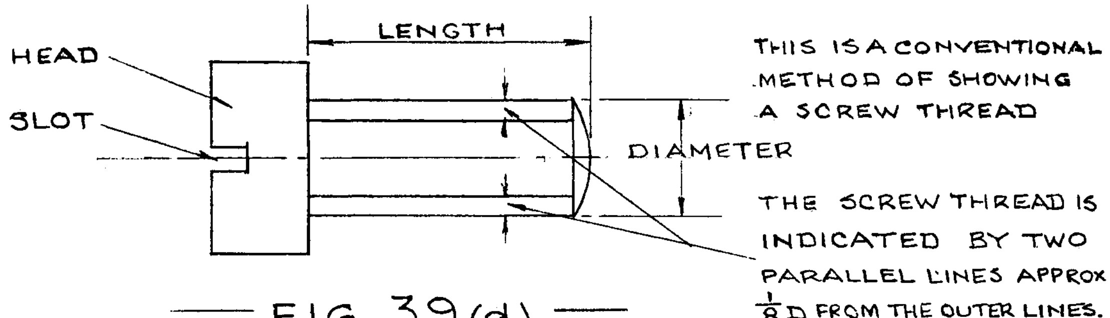


FIG 39(d)

REFER 8.7

FIG. 39

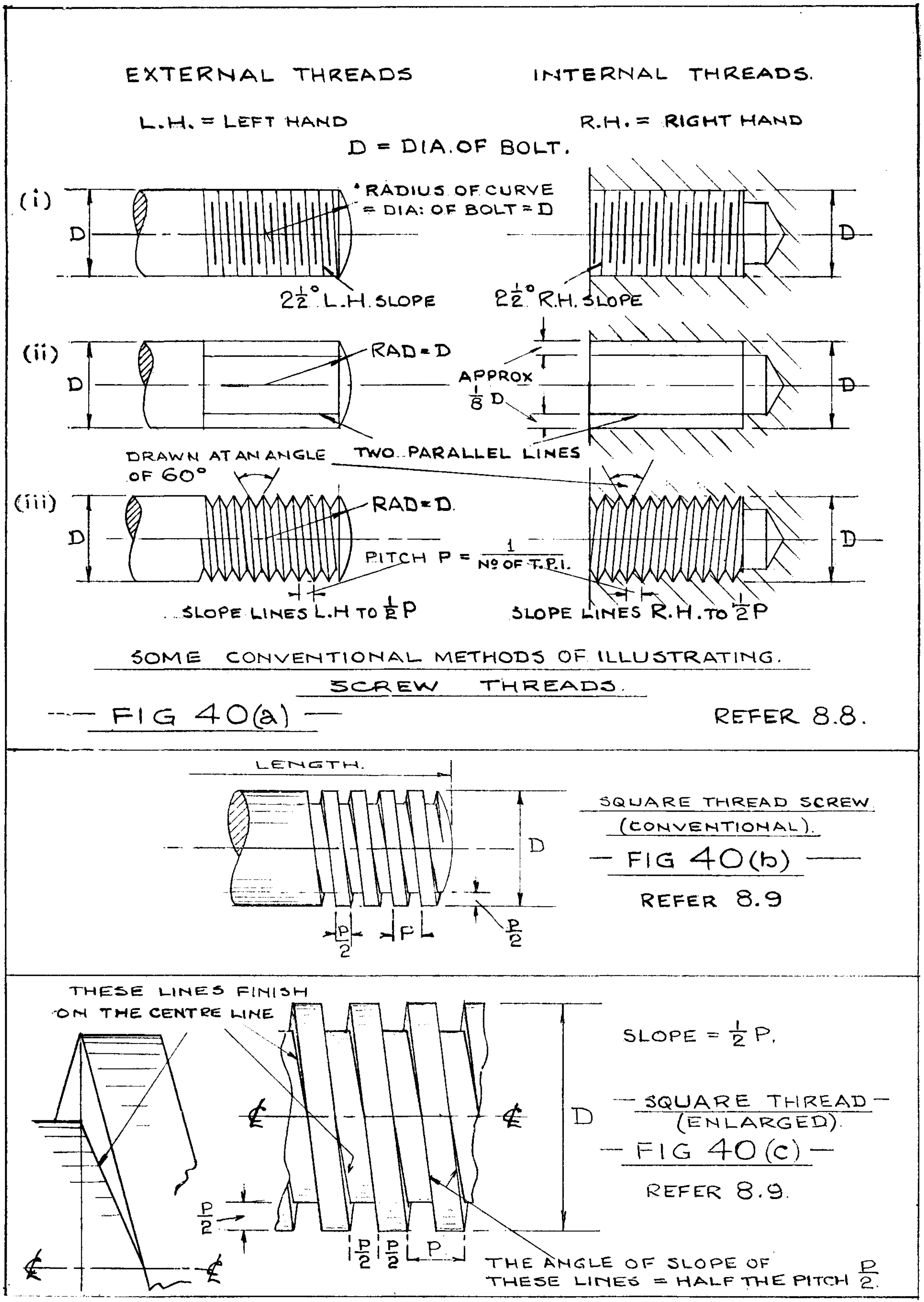

EXTERNAL THREADS
INTERNAL THREADS.
L.H. = LEFT HAND
R.H. = RIGHT HAND
D = DIA. OF BOLT.
(i)
(ii)
(iii)
D
* RADIUS OF CURVE = DIA: OF BOLT = D
2½° L.H. SLOPE
2½° R.H. SLOPE
RAD = D
APPROX ⅛ D
DRAWN AT AN ANGLE OF 60°
TWO PARALLEL LINES
RAD = D.
PITCH P = 1 / Nº OF T.P.I.
SLOPE LINES L.H TO ½ P
SLOPE LINES R.H. TO ½ P
SOME CONVENTIONAL METHODS OF ILLUSTRATING.
SCREW THREADS.
FIG 40(a)
REFER 8.8.
LENGTH.
SQUARE THREAD SCREW (CONVENTIONAL).
FIG 40(b)
REFER 8.9
P/2
P
THESE LINES FINISH ON THE CENTRE LINE
SLOPE = ½ P.
SQUARE THREAD (ENLARGED).
FIG 40 (c)
REFER 8.9.
THE ANGLE OF SLOPE OF THESE LINES = HALF THE PITCH P/2.

FIG. 40

8.8. SCREW THREADS (Convention). Fig. 40

Some conventional methods of illustrating screw threads have been given in Figs. 37, 38 and 39. We illustrate more clearly in Fig. 40 the external threads as well as the internal threads. All the sketches should now be copied and drawn to a scale of $D = 1$ in. The external threads, that is the screws, are shown on the left-hand side of Fig. 40(*a*). The internal threads, that is the nuts or screwed holes, are shown on the right-hand side and should mate with the screw shown on the left. It should be noticed in Fig. 40(*a*)(iii) that for ease of drawing the angle is $60°$ and not $55°$ or $47\frac{1}{2}°$ (Whitworth and B.A. respectively) and a set-square can be used. Only one method should be shown on any one drawing and the method should be used consistently throughout one series of drawings.

8.9. SQUARE THREAD (Convention). Fig. 40(*b*)

A conventional method of showing a square thread is illustrated in Fig. 40(*b*). As its name implies, the width of the thread is $\frac{1}{2}P$, the width of the groove is $\frac{1}{2}P$, and the depth of the groove is $\frac{1}{2}P$. For the purpose of drawing only, the slope of the thread form is shown as half the pitch. This is demonstrated clearly in an enlarged view of the thread in Fig. 40(*c*). This shows the method of joining the lines to give the effect of a helical thread. Notice that the lines from the base of the thread meet on the centre line the lines from the top of the thread. The angle of the lines to the rear is the same as the slope of the front line but in reverse (see the inset). Draw this thread to a scale of $D = 4$ in. and $P = 1$ in. This will give you a thread of $\frac{1}{2}$ in. with a groove of $\frac{1}{2}$ in. wide $\times$ $\frac{1}{2}$ in. deep. For a right-hand thread the direction of slope of the lines is to the left, as shown.

The student is again reminded that he should practise the drawings as much as possible, drawing as many construction lines as possible, drawing the outlines firm by rotating the pencil slightly whilst doing so, and keeping the drawing clean.

EXERCISES ON CHAPTER 8

1. Draw an external and internal screw thread in each of three conventional methods to a scale of diameter $D = 1$ in. Each thread should be $\frac{3}{4}$ in. long. See Fig. 40(*a*).

2. Draw a conventional square thread 2 in. outside diameter (O.D.) $\frac{1}{2}$ in. pitch and $1\frac{1}{2}$ in. long. See Fig. 40(*b*).

3. Draw a section of a British Association (B.A.) form to a scale of pitch $P = 1$ in. See Fig. 38(*a*).

4. Draw a section of a British Standard Whitworth (B.S.W.) form to a scale of pitch $P = 1$ in. See Fig. 37(*b*).

5. Draw a section of a basic form of a unified thread (U.N.F. and U.N.C.) to a scale of pitch $P = 1$ in. See Fig. 39(*b*).

6. Draw a section of British acme thread form to a scale of pitch $P = 2$ in. See Fig. 38(*c*).

7. Explain the meaning of "pitch".

The answers to these Exercises will be found in Fig. 72.

9 · Freehand Drawing of Engineering Parts

9.1. FREEHAND DRAWING

For the purpose of the freehand drawings or sketches which you will be making during this course, it must be clearly understood that you will be expected to make them without the aid of any mechanical devices such as compasses, set-squares, straight edges or rulers. You will need a well sharpened HB pencil and a "rubber", or eraser.

The object of this chapter is to assist the student in the production of a sketch or drawing which has to be made freehand on a sketch pad away from a desk and without the aid of drawing board or instruments.

During the processes of design or manufacture, it is sometimes necessary to modify one or more features of a component. It is also necessary, on occasion, to receive verbal instructions about an assembly or component. In neither instance can the draughtsman be expected to remember all the details and dimensions and it may therefore become necessary to make a freehand drawing.

With the help of some sketches it will be shown how the important features can be noted. At this stage only simple sketches will be used.

It is essential that all engineers, whether mechanical or electrical, should be able to convey ideas gained from experience in the workshop or laboratory in the form of freehand drawing, which must be both clear and concise as well as in good proportion. As a general rule it is far more important to be able to make a freehand drawing in good proportion than it is to make a scale drawing.

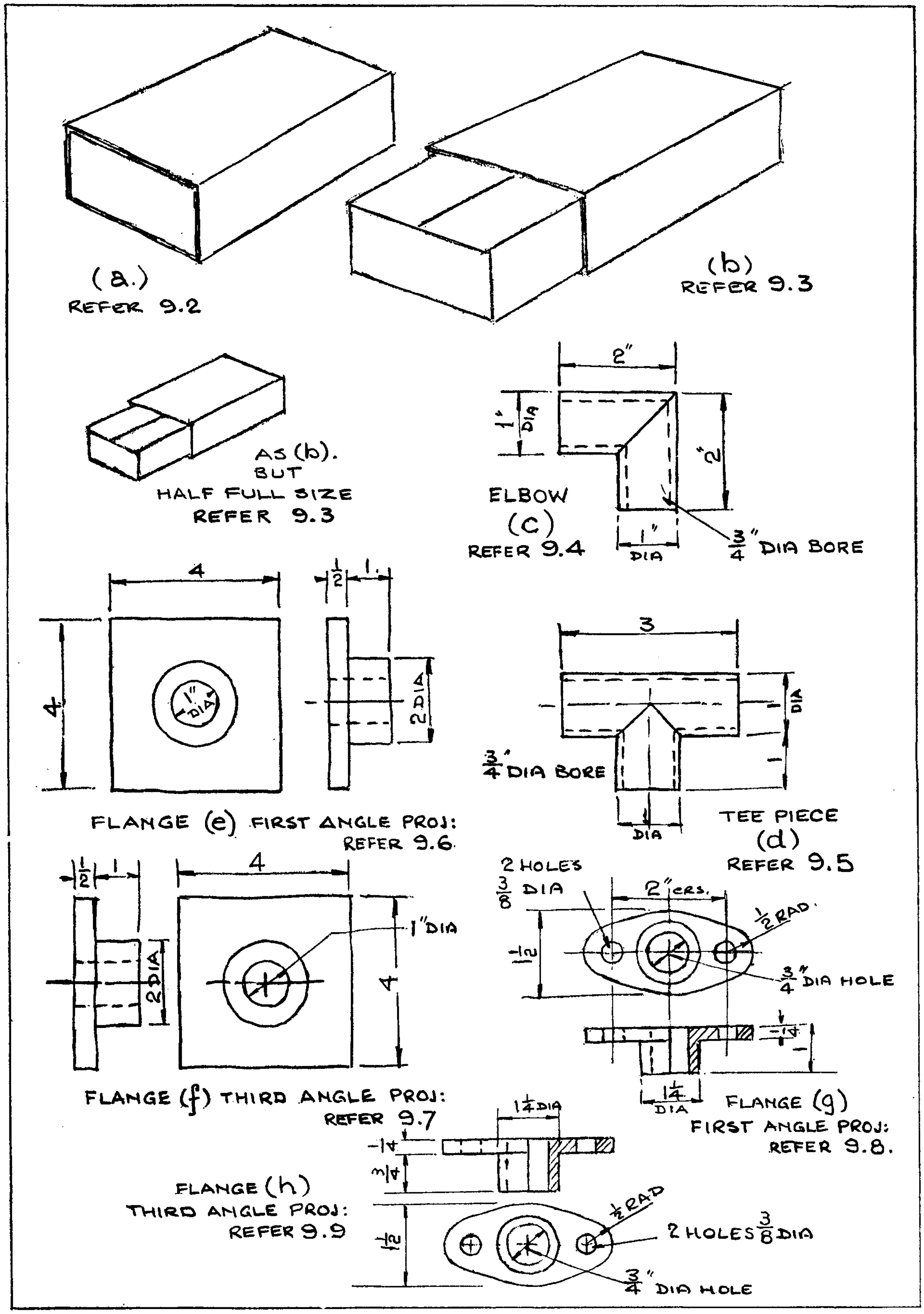
In the present chapter we shall try to indicate the best way to produce a presentable freehand drawing of some simple engineering parts.

All drawings should be made in thin construction lines before any firm outlines are inserted.

9.2. FREEHAND ISOMETRIC. Fig. 41(*a*)

To commence our series of freehand drawings, let us start with a general household article, a match-box. The shape of the box, and the method of construction, are designed for economical manufacture.

A drawing of a closed empty box is shown in Fig. 41(*a*) and its dimensions are 2 in. $\times$ $1\frac{1}{2}$ in. $\times$ $\frac{3}{4}$ in. Place the box on the table in front of you and make a freehand isometric sketch in good proportion without the use of a ruler. Remember to draw the sketch in thin lines at first and then outline it with firm lines, making them as straight as possible. Measure the lines with a ruler and see if the drawing is out of proportion. Some practice at guessing an inch-long line and checking it with a ruler will give greater confidence when drawing the next sketch. When using



(a.)
REFER 9.2
(b)
REFER 9.3
AS (b).
BUT
HALF FULL SIZE
REFER 9.3
ELBOW
(c)
REFER 9.4
2"
1" DIA
2"
1" DIA
3/4" DIA BORE
4
1/2
1
1" DIA
2 DIA
FLANGE (e) FIRST ANGLE PROJ:
REFER 9.6
3
DIA
3/4" DIA BORE
DIA
TEE PIECE
(d)
REFER 9.5
4
1" DIA
2 DIA
FLANGE (f) THIRD ANGLE PROJ:
REFER 9.7
2 HOLES
3/8 DIA
2" CRS.
1/2 RAD.
3/4" DIA HOLE
1 1/4 DIA
FLANGE (g)
FIRST ANGLE PROJ:
REFER 9.8.
1 1/4 DIA
FLANGE (h)
THIRD ANGLE PROJ:
REFER 9.9
1/2 RAD
2 HOLES 3/8 DIA
3/4" DIA HOLE

a sketch pad a helpful suggestion is to guide the pencil with the third finger running down the side of the pad. This method cannot, of course, be used for freehand isometric drawing but only for sketches where the lines run approximately parallel to the sides of the pad.

9.3. FREEHAND ISOMETRIC. Fig. 41(*b*)

For the next sketch, open the match-box and make a freehand isometric drawing approximately full size and in good proportion. Now make a similar sketch but half full size and in good proportion. Check the drawings with a ruler and compare them with Fig. 41(*b*). If they are out of proportion re-draw them.

9.4. FREEHAND ORTHOGRAPHIC. AN ELBOW. Fig. 41(*c*)

Although it is good practice to be able to make freehand isometric sketches, it is much more useful, and in fact essential, to be able to make freehand sketches in first angle projection and third angle projection.

An example of this is shown in Fig. 41(*c*). The drawing is of an elbow which is, in effect, two tubes joined together with their axes at 90°. Draw it half full size and in good proportion. When you have finished, check the drawing with that shown in Fig. 41(*c*). You will notice that only one view is required in this instance.

9.5. FREEHAND ORTHOGRAPHIC. A TEE-PIECE. Fig. 41(*d*)

The next example, shown in Fig. 41(*d*), is a Tee-piece. The drawing is, in effect, of three pieces of tube joined together. It should be drawn half full size and in good proportion. Check your drawing with that shown in Fig. 41(*d*). Again, you will notice that only one view is required.

9.6. FREEHAND FIRST ANGLE PROJECTION. A SQUARE FLANGE. Fig. 41(*e*)

Figure 41(*e*) is a drawing of a square flange with a circular concentric boss with a hole through the centre and is drawn in first angle projection. Draw it quarter full size and in good proportion. Note that two views are required. Check your drawing with a ruler.

9.7. FREEHAND THIRD ANGLE PROJECTION. A SQUARE FLANGE. Fig. 41(*f*)

This is a drawing of the same flange shown in Fig. 41(*e*) but it is drawn in third angle projection. Notice that although the various sketches are drawn a quarter, or a half, full size the full size dimensions should be shown.

9.8. FREEHAND FIRST ANGLE PROJECTION. OVAL FLANGE. Fig. 41(*g*)

The sketch shown in this figure is an oval flange in first angle projection. In this case it is clearer to make a half-section in the elevation. Two views are required. Make the drawing half full size and in good proportion. Care should be taken to see that the curves join and that the sketch is clear and presentable.

The flange is $\frac{1}{4}$ in. thick and has two holes $\frac{3}{8}$ in. in diameter and 2 in. apart. The centre of the flange is $1\frac{1}{2}$ in. wide and $\frac{1}{2}$ in. radius at each end. The centre tube has an outside diameter of $1\frac{1}{4}$ in., has a $\frac{3}{4}$-in. diameter hole, and is 1 in. long. It will be noticed that the half-section is cut through one end hole and half of the centre hole.

9.9. FREEHAND THIRD ANGLE PROJECTION. OVAL FLANGE. Fig. 41(*h*)

This is a sketch of the same flange as that shown in Fig. 41(*g*) but it is in third angle projection. Notice that so far all the sketches have been made with not more than two views and that they contain all the information necessary for manufacture. In Fig. 42 we shall make sketches of objects which require three views to give the necessary information for manufacture.

9.10. FREEHAND FIRST ANGLE PROJECTION. STUD. Fig. 42(*a*)

Figure 42(*a*) shows a special square-headed stud and it is a freehand drawing in first angle projection. It should be drawn approximately half full size and in good proportion. Three views are necessary to show all the details for manufacture. At the end opposite the square head a shoulder is turned and two flats are machined each side of the shoulder, as shown. These flats are indicated by two crossed lines on the machined face.

9.11. FREEHAND THIRD ANGLE PROJECTION. STUD. Fig. 42(*b*)

This is a drawing of the same stud shown in Fig. 42(*a*) but is drawn freehand in third angle projection. Three views are required to show all the necessary information for manufacture. You will notice in Fig. 42(*a*) and Fig. 42(*b*) that when a flat is machined on a cylindrical surface it is indicated by two diagonal crossed lines.

9.12. FREEHAND FIRST ANGLE PROJECTION. SHEET METAL BRACKET. Fig. 42(*c*)

Figure 42(*c*) shows a bracket bent from strip material and drawn in freehand isometric and freehand first angle projection. It will be seen that part of the sloping arm is cut away and it is therefore necessary to show the relative position of the cut-away portion. The dimensions should be indicated on the first angle projection, the isometric projection showing the relative position of the cut-away portion.

9.13. FREEHAND THIRD ANGLE PROJECTION. SHEET METAL BRACKET Fig. 42(*d*)

Figure 42(*d*) is a drawing of the same bracket as that shown in Fig. 42(*c*) but is drawn in freehand isometric and freehand third angle projection. It must be stressed that it is important to indicate clearly on which side the cut-away is made.

9.14. FREEHAND FIRST ANGLE PROJECTION. CAST COVER. Fig. 42(*e*)

Figure 42(*e*) is a freehand drawing in first angle projection of a small rectangular casting with two raised prints inside. In this case, you will notice that the end elevation and the front elevation

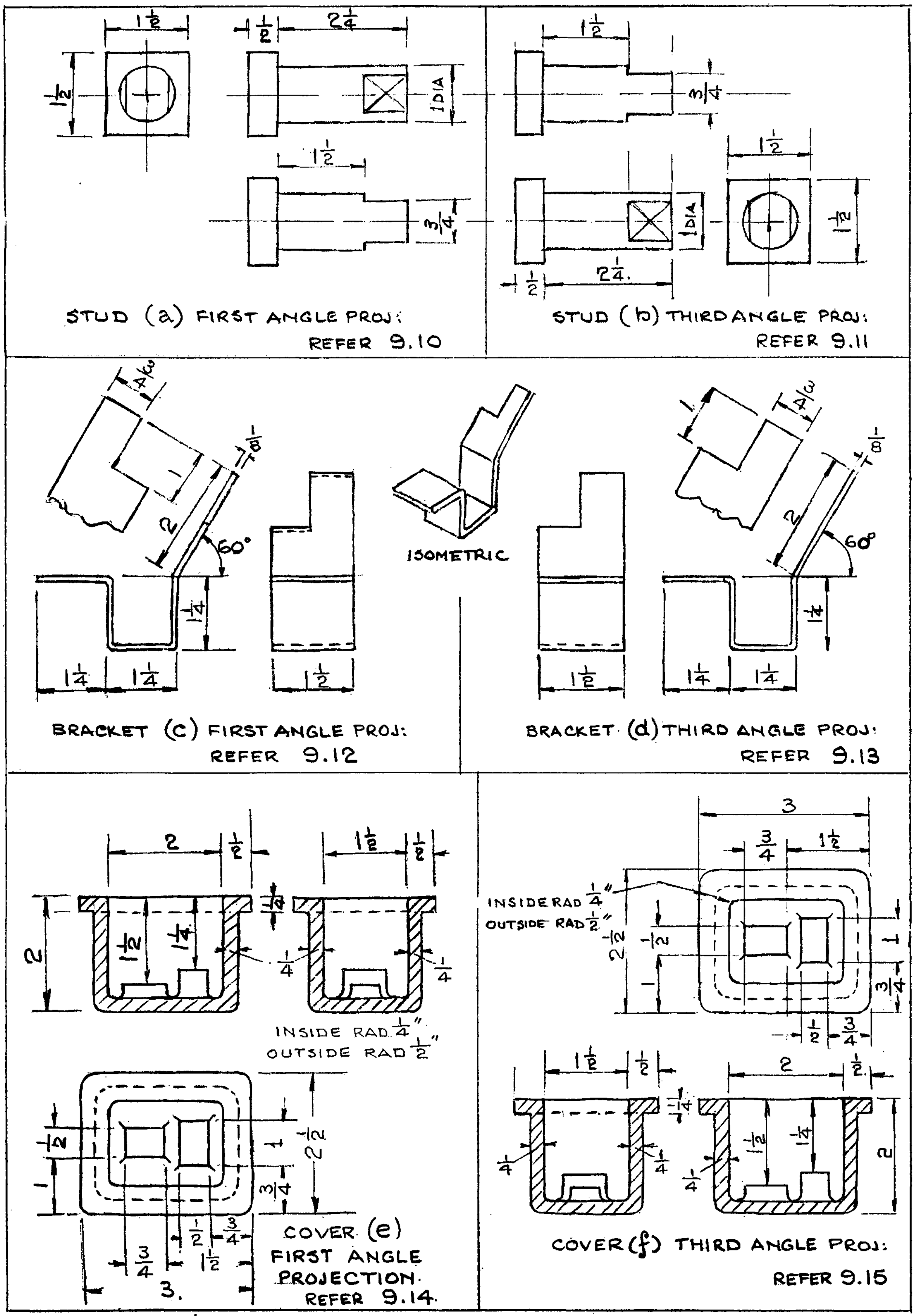

STUD (a) FIRST ANGLE PROJ:
REFER 9.10
STUD (b) THIRD ANGLE PROJ:
REFER 9.11
ISOMETRIC
BRACKET (c) FIRST ANGLE PROJ:
REFER 9.12
BRACKET (d) THIRD ANGLE PROJ:
REFER 9.13
INSIDE RAD 1/4"
OUTSIDE RAD 1/2"
COVER (e)
FIRST ANGLE
PROJECTION.
REFER 9.14.
COVER (f) THIRD ANGLE PROJ:
REFER 9.15

FIG. 42

are both shown in section to indicate the position and height of the raised prints. A plan is necessary to show that the prints are square, or rectangular, and not round, and also to show the rounded corners, which cannot, or course, be shown in the two elevations. The sketch should be made in good proportion half full size. Remember that construction lines should be used in the first instance.

9.15. FREEHAND THIRD ANGLE PROJECTION. CAST COVER. Fig. 42(*f*)

This figure shows the same casting as that in Fig. 42(*e*) but it is drawn freehand in third angle projection. The two elevations are shown in section to indicate the two raised prints and a plan is necessary to show the position and shape of the prints as well as the rounded corners of the casting. The three views should be drawn half full size and in good proportion.

9.16. ISOMETRIC SKETCHES FOR FREEHAND DRAWING. Figs. 43(*a*), 44(*a*), 45(*a*)

We come now to Fig. 43, which shows drawings of engineering parts in isometric projection.

Figure 43(*a*) shows a special bracket made from $1\frac{1}{2}$ in. wide $\times$ $\frac{1}{32}$ in. aluminium strip. Copy this view freehand and in good proportion. Notice that for ease of manufacture, and economy in tooling, the tongue at one end of the strip is the same size as the slot at the other end. This should be indicated clearly in your drawing by careful dimensioning. After completing this view, make similar drawings in first angle projection and in third angle projection. It will be found that four views are necessary in order to make the drawings clear for manufacture. Compare your results with Fig. 44(*a*) for first angle projection and Fig. 45(*a*) for third angle projection. It will be noticed that as the dimensions are taken from the bottom and the ends of the strip it is clear that the tongue and the groove are exactly the same shape.

9.17. ISOMETRIC SKETCHES FOR FREEHAND DRAWING. Figs. 43(*b*), 44(*b*), 45(*b*)

Figure 43(*b*) shows a freehand isometric drawing of a specially shaped wall mounted box made in cast iron. The box has four sides and a back with two wall mounting lugs at the top with one hole in each lug. There is a semi-circular portion cut away in the top and in the bottom of the box, and a rectangular hole cut in the right-hand side. Copy this view freehand and in good proportion, taking care to include all the dimensions. After completing this view make drawings in first angle projection and in third angle projection. To make the drawings clear for manufacture four views are necessary. Compare your results with Fig. 44(*b*) for first angle projection, and Fig. 45(*b*) for third angle projection. To enable the back of the box to be dimensioned it will be necessary to show a part section through X–X. This shows very clearly the construction of the box and the semi-circular cut-away at the top.

9.18. ISOMETRIC SKETCHES FOR FREEHAND DRAWING. Figs. 43(*c*), 44(*c*), 45(*c*)

Figure 43(*c*) shows a freehand isometric drawing of a rectangular box cast in aluminium. The box has four sides, two extended flanges and a rectangular hole through the base. At each corner inside the box is a quarter round rib with a hole in the top of each rib. Copy this view freehand and in good proportion. Notice how the front is cut away to enable the rectangular hole in the base to be shown clearly. This is known as a "broken section". After completing this view

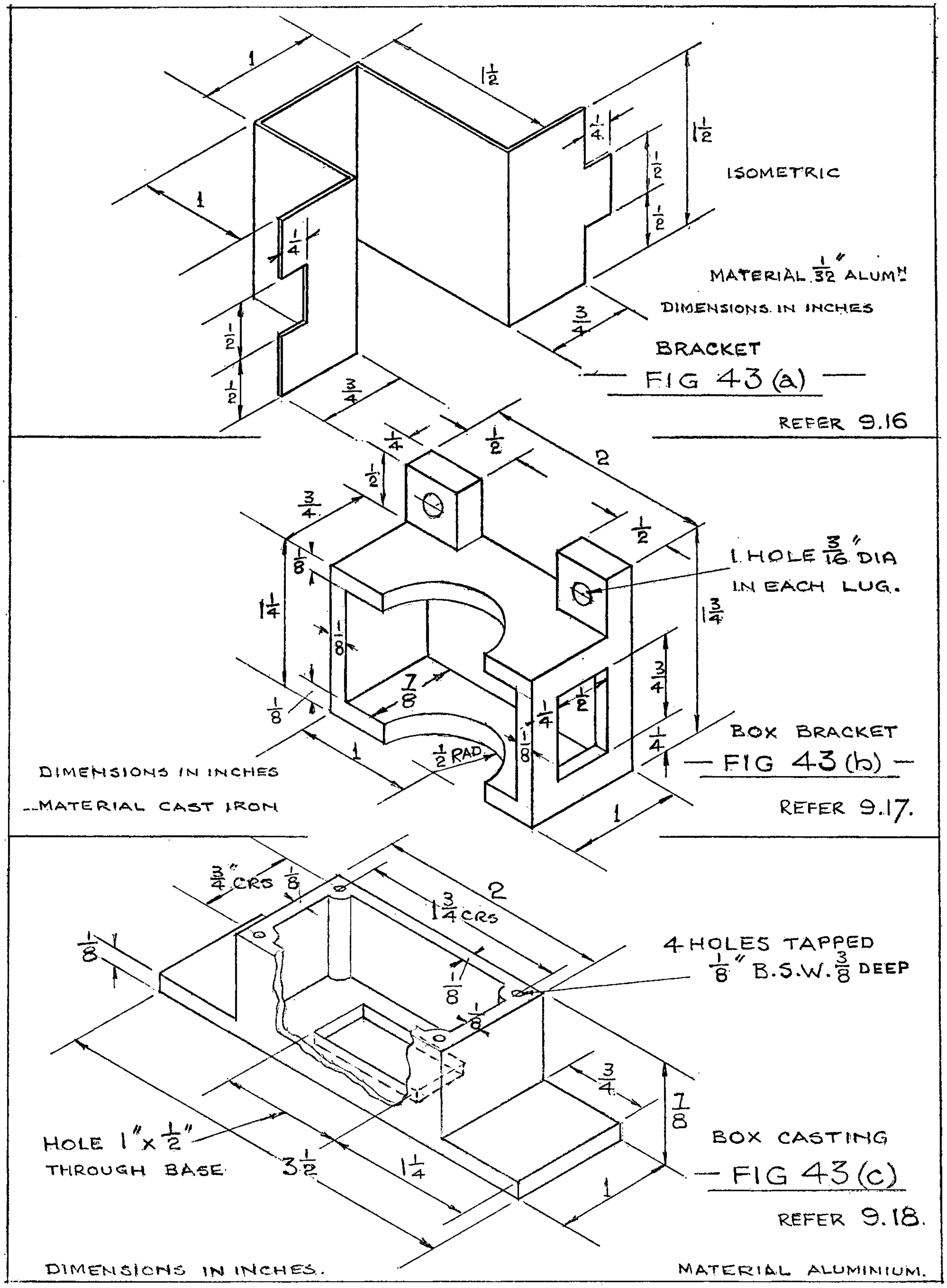

ISOMETRIC
MATERIAL 1/32" ALUMN.
DIMENSIONS IN INCHES
BRACKET
FIG 43 (a)
REFER 9.16
1 HOLE 3/16" DIA
IN EACH LUG.
1/2 RAD.
DIMENSIONS IN INCHES
MATERIAL CAST IRON
BOX BRACKET
FIG 43 (b)
REFER 9.17.
3/4" CRS
1 3/4 CRS
4 HOLES TAPPED
1/8" B.S.W. 3/8 DEEP
HOLE 1" x 1/2"
THROUGH BASE
BOX CASTING
FIG 43 (c)
REFER 9.18.
DIMENSIONS IN INCHES.
MATERIAL ALUMINIUM.

Fig. 43

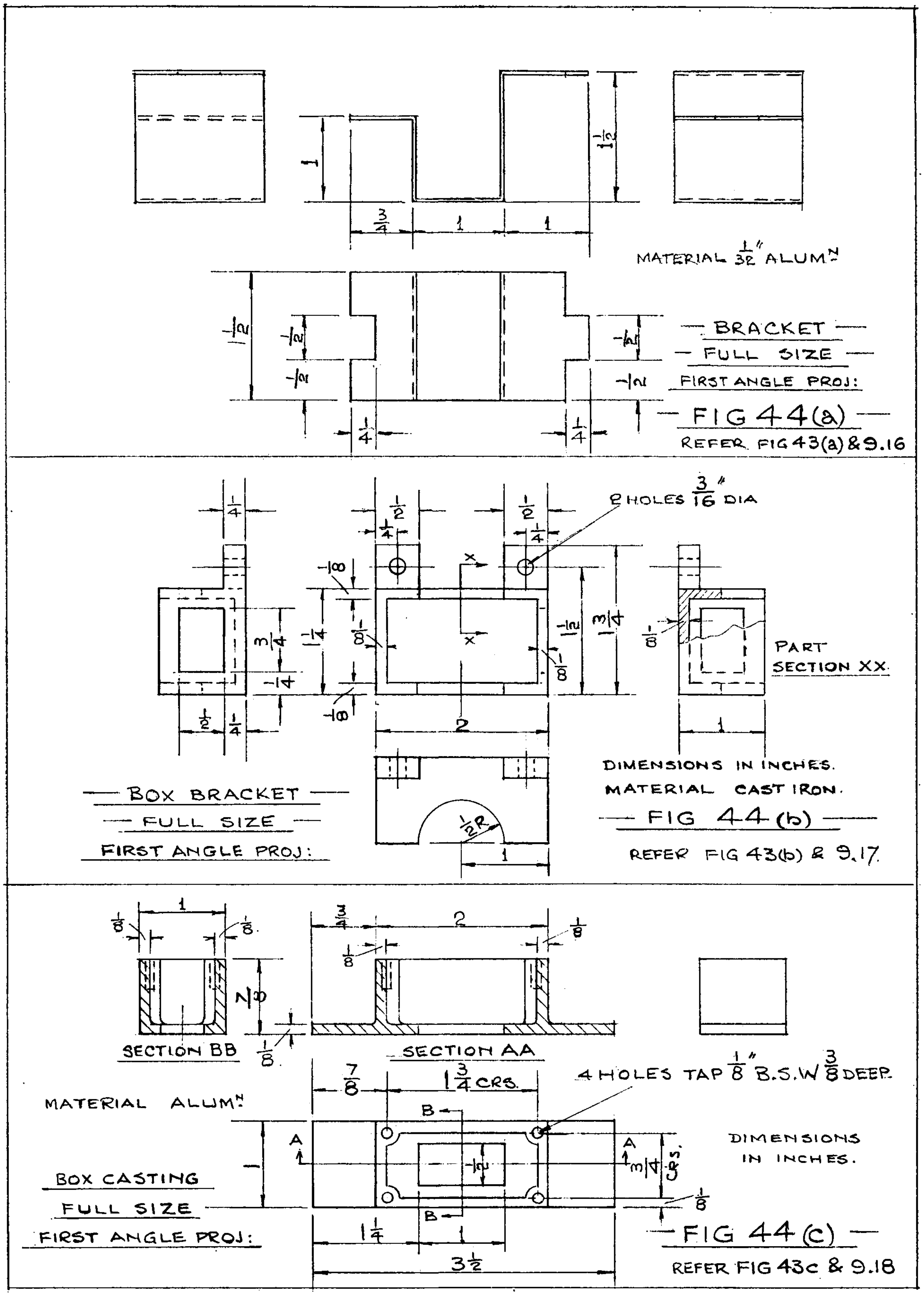
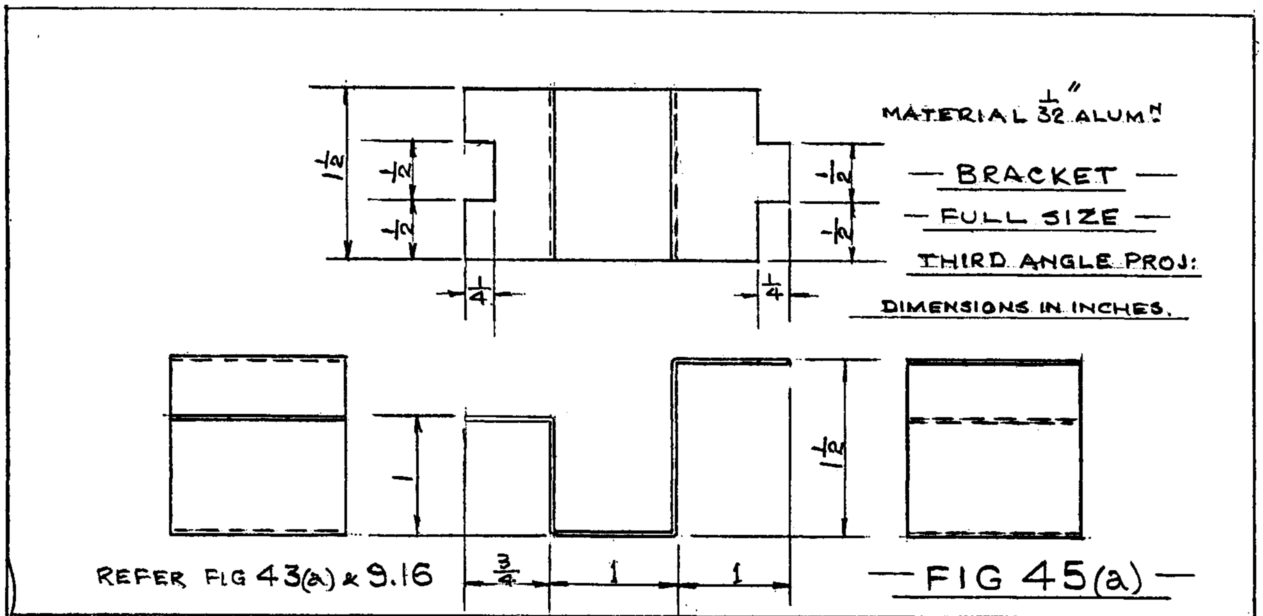
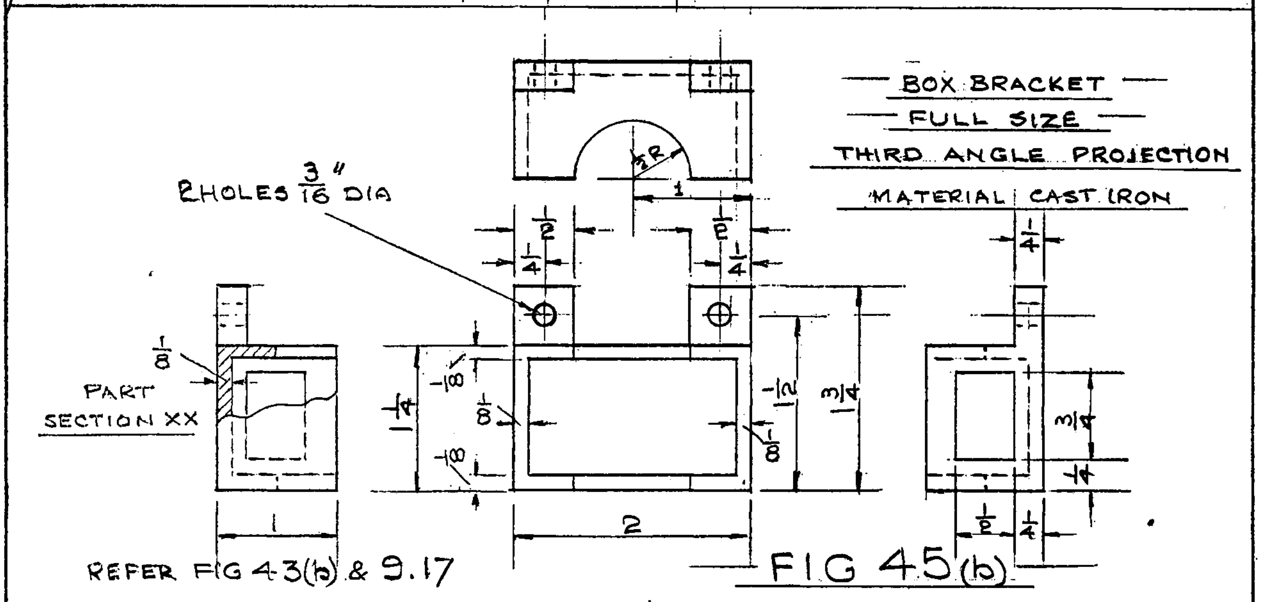

MATERIAL 1/32" ALUMN.
BRACKET
FULL SIZE
FIRST ANGLE PROJ:
FIG 44(a)
REFER FIG 43(a) & 9.16
2 HOLES 3/16" DIA
PART SECTION XX.
DIMENSIONS IN INCHES.
MATERIAL CAST IRON.
FIG 44 (b)
REFER FIG 43(b) & 9.17
BOX BRACKET
FULL SIZE
FIRST ANGLE PROJ:
SECTION BB
SECTION AA
4 HOLES TAP 1/8" B.S.W 3/8 DEEP.
MATERIAL ALUMN.
DIMENSIONS IN INCHES.
BOX CASTING
FULL SIZE
FIRST ANGLE PROJ:
FIG 44 (c)
REFER FIG 43c & 9.18

Fig. 44


MATERIAL 1/32" ALUM^N
— BRACKET —
— FULL SIZE —
THIRD ANGLE PROJ:
DIMENSIONS IN INCHES.
REFER FIG 43(a) & 9.16
— FIG 45(a) —


— BOX BRACKET —
— FULL SIZE —
THIRD ANGLE PROJECTION
MATERIAL CAST IRON
2 HOLES 3/16" DIA
PART SECTION XX
REFER FIG 43(b) & 9.17
FIG 45(b)

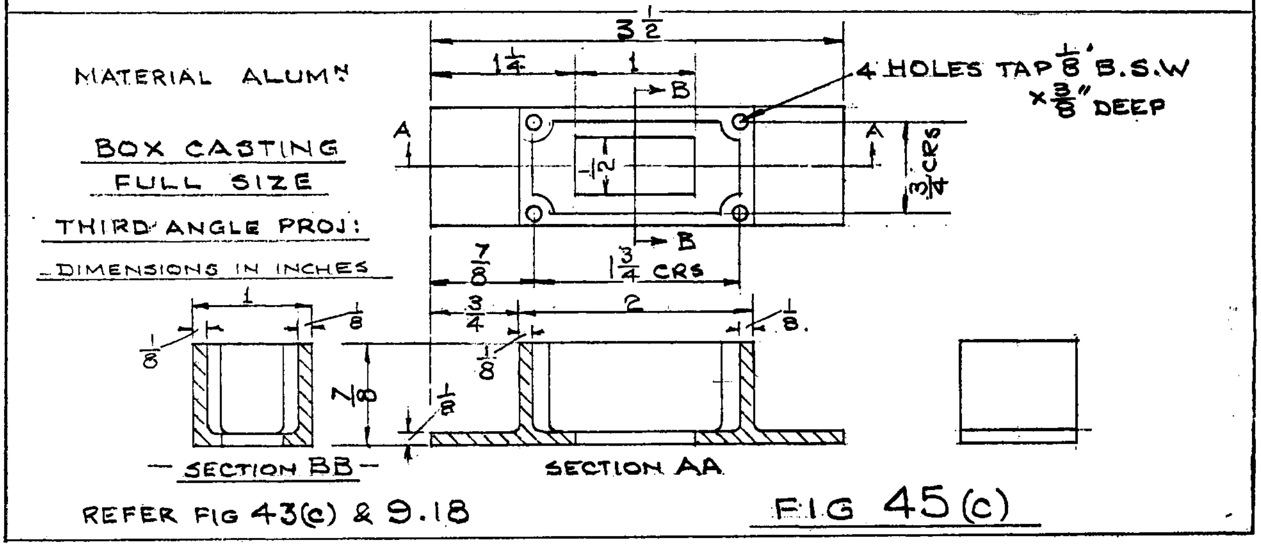

MATERIAL ALUM^N
BOX CASTING
FULL SIZE
THIRD ANGLE PROJ:
DIMENSIONS IN INCHES
4 HOLES TAP 1/8" B.S.W × 3/8" DEEP
3/4 CRS
1 3/4 CRS
— SECTION BB —
SECTION AA
REFER FIG 43(c) & 9.18
FIG 45(c)

Fig. 45

make freehand drawings in first angle projection and in third angle projection. To make the drawings clear four views are necessary. Two of these views should be sections cut through the front and end elevations respectively. Compare your results with Fig. 44(*c*) for first angle projection, and Fig. 45(*c*) for third angle projection.

You are again reminded that when drawing freehand all the preliminary work should be done in thin construction lines.

The author feels confident that to most students the last three drawings will not prove difficult. Anyone who has found them difficult is recommended to put the completed drawings aside and repeat all the drawings in the chapter again, beginning with Fig. 41(*a*). After making the drawings a second, or even a third, time it will be found that considerable improvement will be achieved and comparison with earlier drawings removed from the board should show this improvement.

EXERCISES ON CHAPTER 9

1. Draw in good proportion and freehand isometric the flange shown in Fig. 41(*e*) and (*f*).
2. Draw the same flange full size (three views) in third angle projection and fully dimension.
3. The bracket in Fig. 43(*a*) is shown from a right-hand viewpoint. Turn the bracket through 90° clockwise and make a freehand isometric drawing from a left-hand viewpoint. The drawing should be in good proportion with no dimensions.
4. Make a freehand isometric drawing, in good proportion, of the cover shown in Fig. 42(*e*). The front side should be a "broken section" to show particulars of the raised prints. Do not dimension the drawing.
5. From the isometric drawing made in No. 4 above, make a full-size drawing (three views) of the cover in first angle projection and fully dimension. This should *not* be a freehand drawing.
6. Draw, full size, three freehand orthographic views of an empty matchbox with the slide half open. Show all hidden detail. Measure the box and dimension your drawing accordingly in inches or millimetres. State which *projection angle* has been used.

The answers to the Exercises will be found in Fig. 73.

10 · Mechanical and Electrical Detail Parts

AFTER the considerable practice obtained from the work of previous chapters, we will, in this chapter, learn about, and make drawings of, mechanical and electrical detail parts used in engineering. It must always be remembered by both mechanical and electrical engineering students that everything that is used to-day is based on good mechanical engineering practice.

MECHANICAL DETAIL PARTS

10.1. FASTENINGS (screws and bolts). Fig. 46(*a*)

In Chapter 8 we dealt with screw threads of various types, and the conventional methods of illustrating screw threads.

In this section we shall deal with various types of screw heads commonly used in industry. These are shown in Fig. 46(*a*). The dimensions given are for easy drawing only, as the manufacturers sometimes vary the sizes very slightly according to methods of production.

The *cheese* head screw (abbreviated CH.HD) is probably the most used as it requires only a drilled and tapped hole for the bolt to fit in, and great force can be exerted by the flat underside of the head and slot.

The *fillister* head screw (abbreviated FIL.HD), similar to the cheese head screw but with a convex top head which can be polished, is used mainly in the instrument industry and where a first class finish is required.

The *countersunk* head screw (abbreviated CSK) is fitted into a hole countersunk at 45° to bring the flat face of the head flush with the panel into which it is screwed.

The *instrument*, or *Swiss*, head screw (abbreviated SW.HD) is similar to the countersunk head but has a convex top which can be polished. This screw is used in the instrument industry and where a first class finish is required.

The *round* head screw (abbreviated RD.HD) is fitted in many cases in place of cheese head or fillister head screws as it is much easier to finish and can be polished, plated or enamelled.

10.2. HEXAGON NUT. Fig. 46(*b*)

This figure shows a hexagon (six-sided) nut drawn in first angle projection and third angle projection. The hexagon dimensions of the nut are set to a British Standard and measured across the flats. The nuts shown in Fig. 46(*b*) are drawn by a quick drawing-office method and are based on the distance across the corners being $2D$, where D is the diameter of the bolt. To draw a hexagon nut by this method we refer to Fig. 47(*a*), in which a line-by-line method is illustrated.

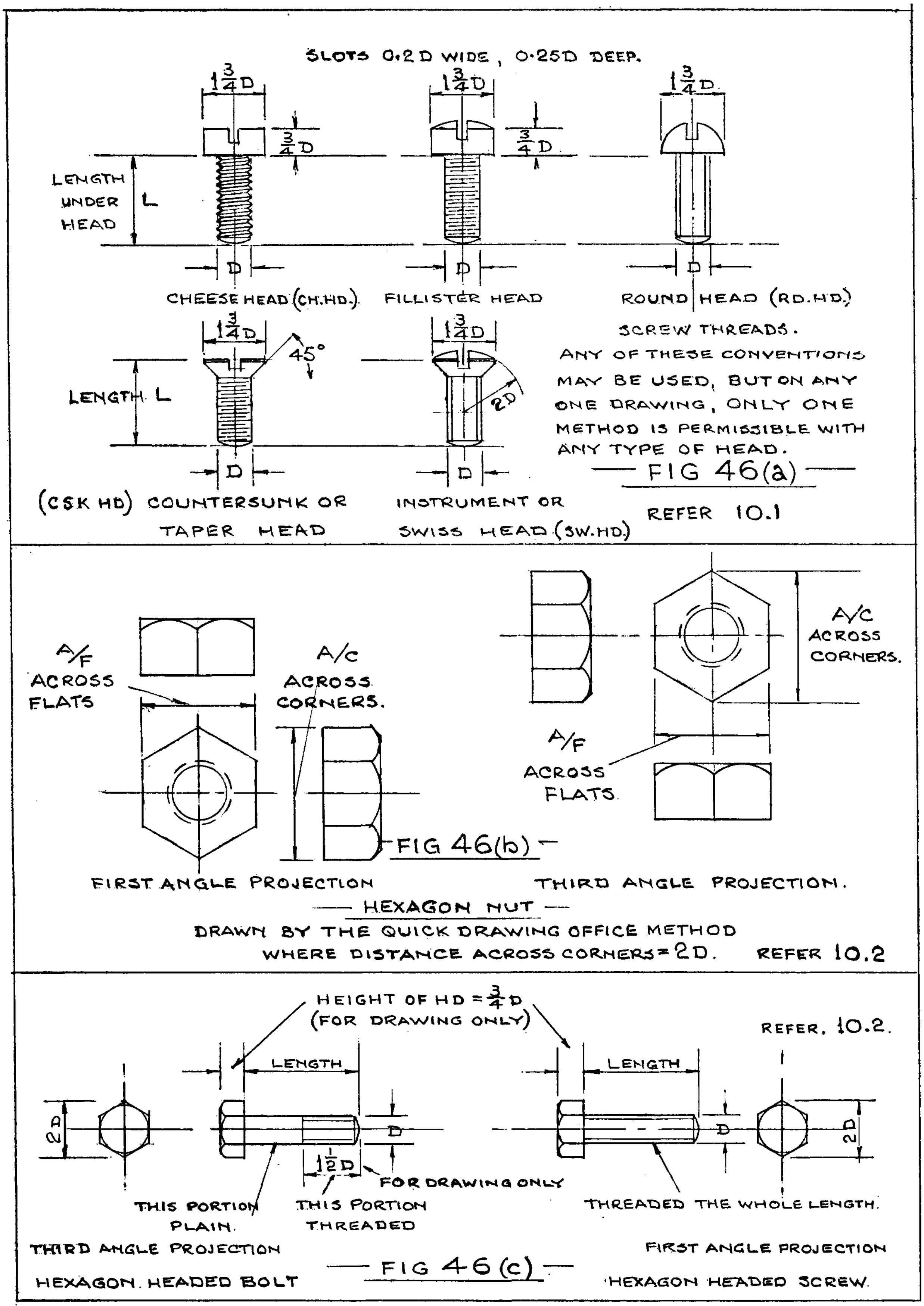

SLOTS 0·2D WIDE, 0·25D DEEP.
$1\frac{3}{4}$D
$\frac{3}{4}$D
LENGTH UNDER HEAD
L
D
CHEESE HEAD (CH.HD.)
FILLISTER HEAD
ROUND HEAD (RD.HD.)
SCREW THREADS.
ANY OF THESE CONVENTIONS MAY BE USED, BUT ON ANY ONE DRAWING, ONLY ONE METHOD IS PERMISSIBLE WITH ANY TYPE OF HEAD.
45°
2D
LENGTH L
FIG 46(a)
(CSK HD) COUNTERSUNK OR TAPER HEAD
INSTRUMENT OR SWISS HEAD (SW.HD)
REFER 10.1
A/F ACROSS FLATS
A/C ACROSS CORNERS.
FIG 46(b)
FIRST ANGLE PROJECTION
THIRD ANGLE PROJECTION.
HEXAGON NUT
DRAWN BY THE QUICK DRAWING OFFICE METHOD WHERE DISTANCE ACROSS CORNERS = 2D.
REFER 10.2
HEIGHT OF HD = $\frac{3}{4}$D (FOR DRAWING ONLY)
REFER. 10.2.
LENGTH
2D
D
$1\frac{1}{2}$D
FOR DRAWING ONLY
THIS PORTION PLAIN.
THIS PORTION THREADED
THREADED THE WHOLE LENGTH.
THIRD ANGLE PROJECTION
FIRST ANGLE PROJECTION
FIG 46 (c)
HEXAGON. HEADED BOLT
HEXAGON HEADED SCREW.

FIG. 46

10.3. TO DRAW A HEXAGON NUT BY A QUICK METHOD. Fig. 47(*a*)

It must be understood that this quick drawing-office method is intended for the *drawing of hexagon nuts and hexagon heads only*, and that if any other hexagon object has to be drawn to the correct size the tables of standard hexagon dimensions must be consulted. These tables are published and can be obtained, if required.

For this drawing, assume that $D =$ diameter of the bolt $= 1$ in., and that we shall draw the nut in third angle projection.

In construction draw the horizontal centre line *H*1 about 5 in. long. Then draw two lines at *H*2 and *H*3 parallel with *H*1 and 1 in. above and below it respectively. Draw four lines, *H*4, *H*5 and *V*1, *V*2 1 in. apart. Draw a vertical centre line *V*3, 3 in. from the left-hand line *V*1. Draw a line *AA* at 30° to the horizontal, passing through the intersection of *V*3, *H*3. Draw a circle, *G* with centre at *O*. Now add the other sides of the hexagon *H*, *J*, *K*, *L* and *M*, using the set-square in successive positions resting on the tee-square.

Draw horizontal lines *H*6, *H*7, 1 in. apart, and add a dotted circle of 1 in. diameter at *Q*. Draw a curve of radius $1{\cdot}2\,D = 1{\cdot}2$ in., and where this curve touches line *H*7 draw a vertical line at *V*4, and a horizontal line at *H*8. Draw bevels at 45° on the left-hand side elevation. Note that square corners are shown in the front elevation at *S* and *S*, and that no bevels are necessary in this view. Figure 46(*c*) shows the difference between a hexagon headed bolt and a hexagon headed screw. The bolt is shown drawn in third angle projection and is also detailed in Fig. 47(*b*). The screw has a thread the whole length of the stem, while the bolt has the thread length controlled. For the purpose of drawing the length of thread on a bolt is $1\frac{1}{2}\,D$.

Draw curves at *T* and *T*; the radius, which can be found by trial, is approximately $\frac{1}{8}D$. To find a radius by trial and error means that the compasses should be set at approximately $\frac{1}{8}D$ and a very fine line drawn with centre at *T*. If the curved line does not touch the three points, as shown, then the radius and the centre should be adjusted very slightly until they do. The two curves at *U* and *U* can be drawn by trial so that the curves meet neatly at the horizontal line.

Fill in the outline and dimension the drawing, omitting the letters for line-by-line construction.

For first angle projection the views should be constructed as in Fig. 47(*a*) but positioned as shown in Fig. 46(*b*).

10.4. HEXAGON HEADED BOLT. Fig. 47(*b*)

In Fig. 47(*b*) a hexagon headed bolt is shown in first angle projection. A quick drawing-office method of drawing the hexagon is as shown in Fig. 47(*a*). The hexagon is built on a constructed circle and the curves for the bevel are exactly the same as before. The only difference is that the height of the head is $\frac{7}{8}\,D$, whereas the height of a nut is *D*. The length of a bolt or screw is measured from under the head to the end of the rounded or flat end as the case may be. In this drawing we show a conventional method for threading which is two parallel lines close to the outline and one line across the diameter at a position where the thread terminates. Philips heads, socket heads, and other special headed screws are manufactured and lists are published and can be obtained for all sizes.

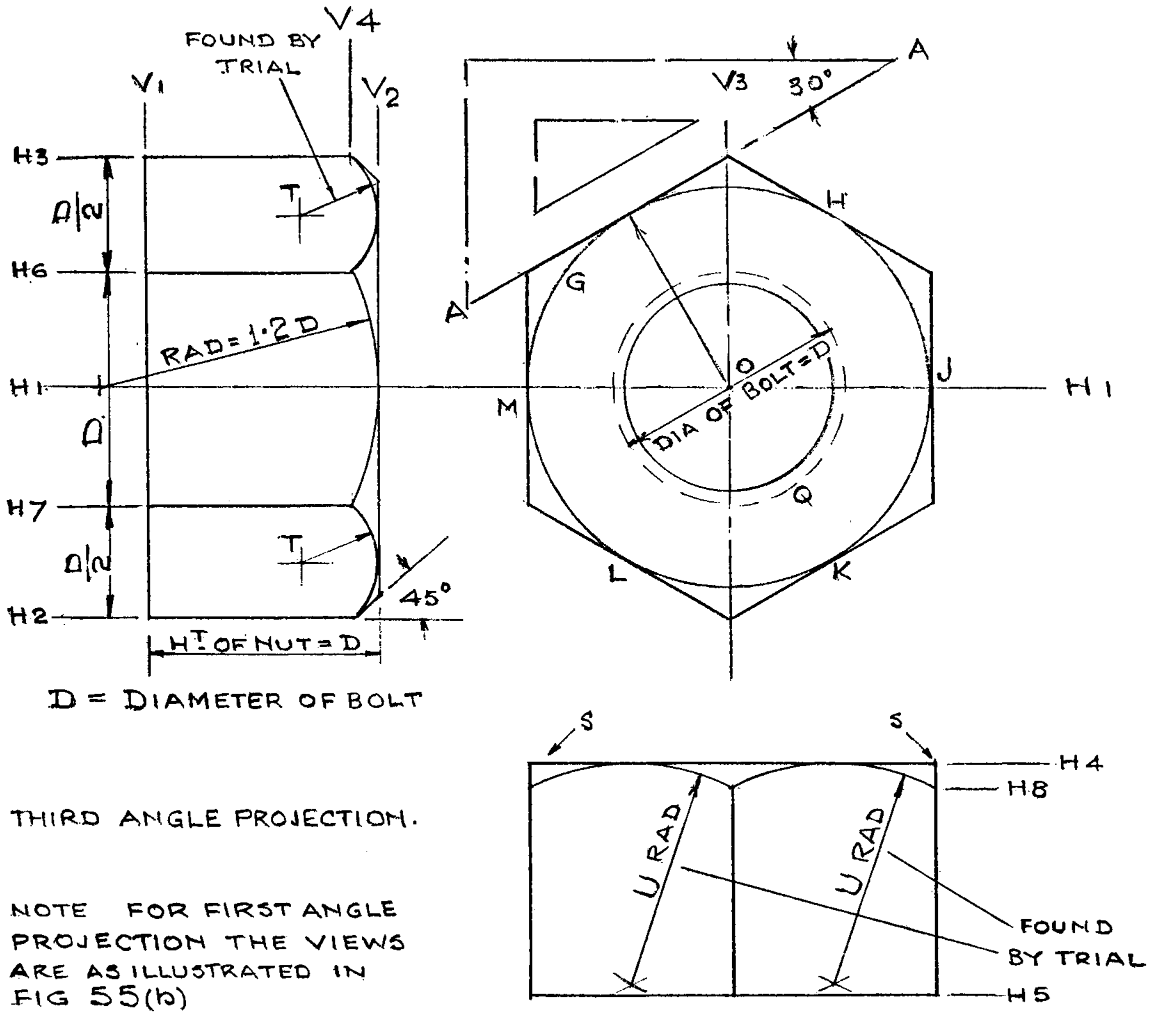


FIG 47(a)

HEXAGON NUT

REFER 10.3 & FIG 46(b)

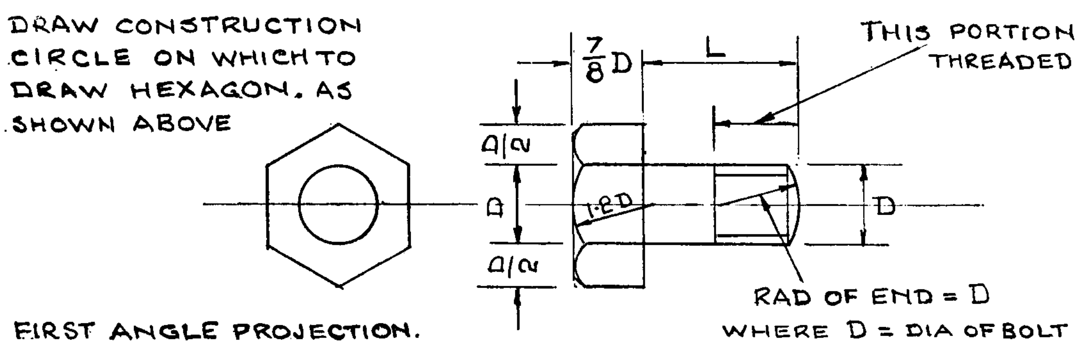


FIG 47(b)

HEXAGON HEADED BOLT

REFER 10.4

10.5. STUDS. Fig. 48(*a*)

A stud is a piece of rod screwed at both ends in the same direction with a plain piece between the threaded ends and is used to hold down such things as cylinder heads on car engines, or to secure a cover plate in position when it is difficult or impractical to use screws or bolts. The lower portion is screwed over-size and fits very tightly into the body so that a nut will screw easily on and off the normally threaded part. The method of drawing a stud is shown in Fig. 48(*a*). Notice that the length is given over the rounded ends and that the conventional thread is shown by two parallel lines. The ends are curved to radius *D*. The diameter of the stud is *D*.

10.6. KEYS. Fig. 48(*b*)

A key is a shaped piece of steel inserted between the joint of two fitted parts to prevent relative movement, or as a piece inserted in an axial direction between a shaft and a hub to prevent relative rotation. Keys are always made of steel as they are subjected to considerable crushing and shearing stresses. Various types of keys are shown in Fig. 48.

Taper Key. Fig. 48(*b*)(i)

The key most commonly used is the taper key which is a piece of steel, rectangular or square section and tapered $\frac{1}{8}$ in. per ft, or 1 in 100. This key is a good sliding fit in a keyway in the shaft and a mating keyway in the hub, and is forced home on the tapered faces. The nominal thickness is measured at the larger end. The ends may be squared or rounded.

Parallel Key. Fig. 48(*b*)(ii)

This key may be of a rectangular or square section and is taperless. The ends may be squared or rounded. It is used when the pulley or mating piece is required to slide along the shaft.

Feather Key. Fig. 48(*c*)

A feather key is a sunken key fastened to either the shaft *or* the hub to permit axial movement.

The feather key shown in Fig. 48(*c*) is sunk half depth and fastened to the shaft. The key is also fitted in a keyway in the hub, which allows it to be driven radially and to slide axially along the shaft while in contact with the key.

The second feather key shown in Fig. 48(*c*) has a double gib head which when fitted to the hub allows axial movement of the hub while being driven radially. In this arrangement the keyway must reach the end of the shaft, otherwise it cannot be assembled.

Flat Saddle Key. Fig. 48(*d*)

This is a taper key fitting in a keyway in the hub and on to a flat on the shaft. It is only used for light loads and is shown in Fig. 48(*d*)(i).

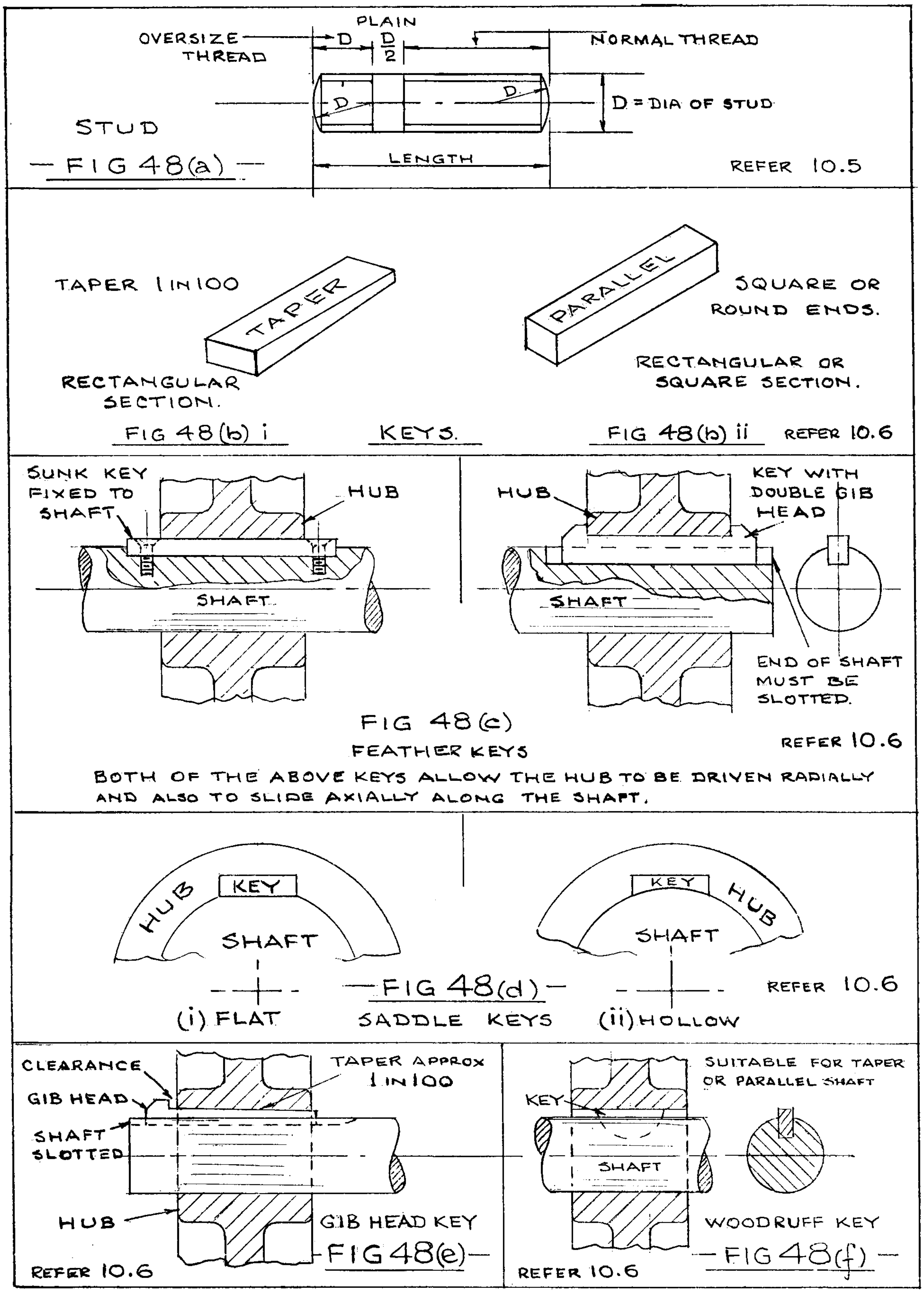

OVERSIZE THREAD
PLAIN
D
D/2
NORMAL THREAD
D
D
D = DIA OF STUD
STUD
LENGTH
— FIG 48(a) —
REFER 10.5
TAPER 1 IN 100
TAPER
RECTANGULAR SECTION.
PARALLEL
SQUARE OR ROUND ENDS.
RECTANGULAR OR SQUARE SECTION.
FIG 48(b) i
KEYS.
FIG 48(b) ii
REFER 10.6
SUNK KEY FIXED TO SHAFT
HUB
SHAFT
HUB
KEY WITH DOUBLE GIB HEAD
SHAFT
END OF SHAFT MUST BE SLOTTED.
FIG 48(c)
FEATHER KEYS
REFER 10.6
BOTH OF THE ABOVE KEYS ALLOW THE HUB TO BE DRIVEN RADIALLY AND ALSO TO SLIDE AXIALLY ALONG THE SHAFT.
HUB
KEY
SHAFT
KEY
HUB
SHAFT
— FIG 48(d) —
REFER 10.6
(i) FLAT
SADDLE KEYS
(ii) HOLLOW
CLEARANCE
GIB HEAD
SHAFT SLOTTED
TAPER APPROX 1 IN 100
HUB
GIB HEAD KEY
- FIG 48(e) -
REFER 10.6
SUITABLE FOR TAPER OR PARALLEL SHAFT
KEY
SHAFT
WOODRUFF KEY
- FIG 48(f) -
REFER 10.6

Fig. 48

Hollow Saddle Key. Fig. 48(*d*)(ii)

This is a taper key fitting in a keyway in the hub but with no flat on the shaft. It has a purely wedge action and, as it holds only by friction, it cannot be used for other than light loads. This is shown in Fig. 48(*d*)(ii).

Gib Head. Fig. 48(*e*)

Some keys are made with a gib head to enable the key to be removed without difficulty. Figure 48(*e*) illustrates a taper key fitted with gib head.

Woodruff Key. Fig. 48(*f*)

This key is part of a cylindrical disc and is sunk into a recess made by a Woodruff cutter of the same diameter and width as the key. This allows the key to tilt to any angle and to be fitted to a parallel or a taper shaft and mating hub.

ELECTRICAL DETAIL PARTS

In this section some drawings will be made of electrical components. These are components used in the electrical engineering industry although basically their manufacture is normally the concern of the mechanical or production engineer. From a wide range of components referred to in B.S. 31 (1940) our first selection is a Tee for $\frac{3}{4}$-in. screwed metal conduit.

10.7. $\frac{3}{4}$-in. TEE. Fig. 49(*a*)

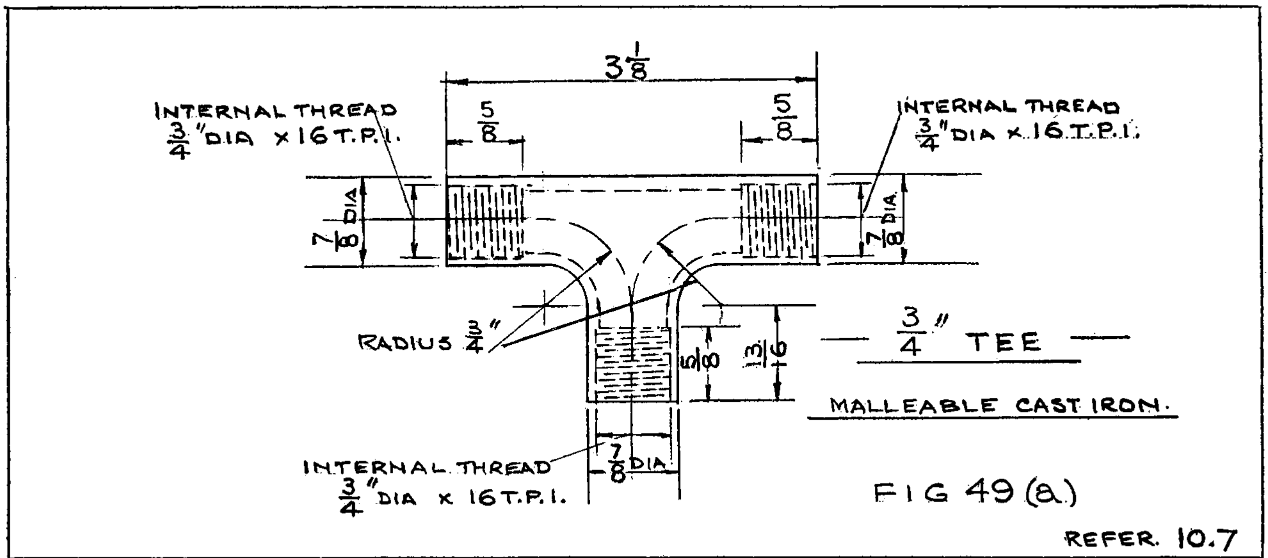
This fitting is used to join three $\frac{3}{4}$-in. screwed conduits to form a branch in a straight circuit. Usually made of malleable cast iron, it is designed with smooth curves inside to facilitate the easy movement of wires. The drawing shows the three entries screwed internally $\frac{3}{4}$-in. diameter × 16 T.P.I. These threads are shown by convention and are dotted sloping lines. Notice the generous radius and the straight portion for screwing.

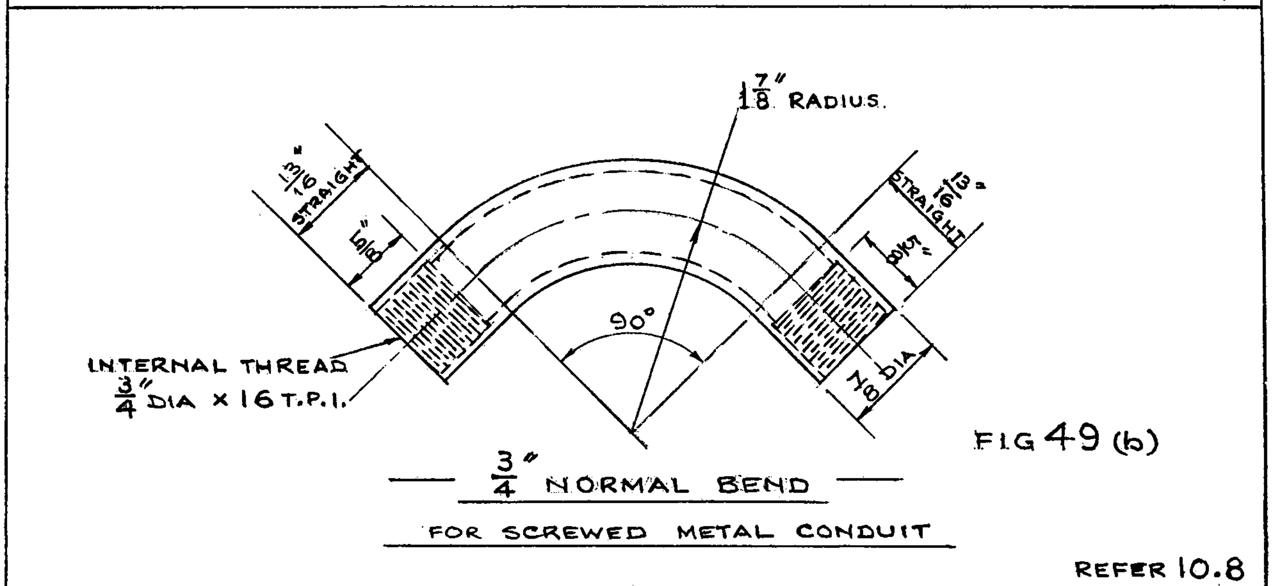
10.8. $\frac{3}{4}$-in. NORMAL BEND. Fig. 49(*b*)

The normal bend shown in this figure is a 90° bend with generous radius and extended straight portions screwed internally $\frac{3}{4}$ in. × 16 T.P.I. for $\frac{3}{4}$-in. screwed metal conduit. This normal bend is distinct from the elbow, which has a 90° bend with small radius, or the half-normal bend which has a 45° bend with generous radius.

10.9. $\frac{3}{4}$-in. SINGLE SADDLE. Fig. 49(*c*)

The saddle shown in Fig. 49(*c*) is for holding down $\frac{3}{4}$-in. diameter screwed metal conduit. The groove, or flute, is punched to shape during manufacture to give strength to the saddle when clamping the conduit. The number of flutes is optional to the manufacturer.


3 1/8
5/8
5/8
INTERNAL THREAD 3/4" DIA x 16 T.P.I.
INTERNAL THREAD 3/4" DIA x 16 T.P.I.
7/8 DIA
7/8 DIA
RADIUS 3/4"
5/8
13/16
3/4" TEE
MALLEABLE CAST IRON.
INTERNAL THREAD 3/4" DIA x 16 T.P.I.
7/8 DIA
FIG 49 (a)
REFER. 10.7


1 7/8" RADIUS.
13/16" STRAIGHT
5/8"
13/16" STRAIGHT
5/8"
90°
INTERNAL THREAD 3/4" DIA x 16 T.P.I.
7/8 DIA
FIG 49 (b)
3/4" NORMAL BEND
FOR SCREWED METAL CONDUIT
REFER 10.8

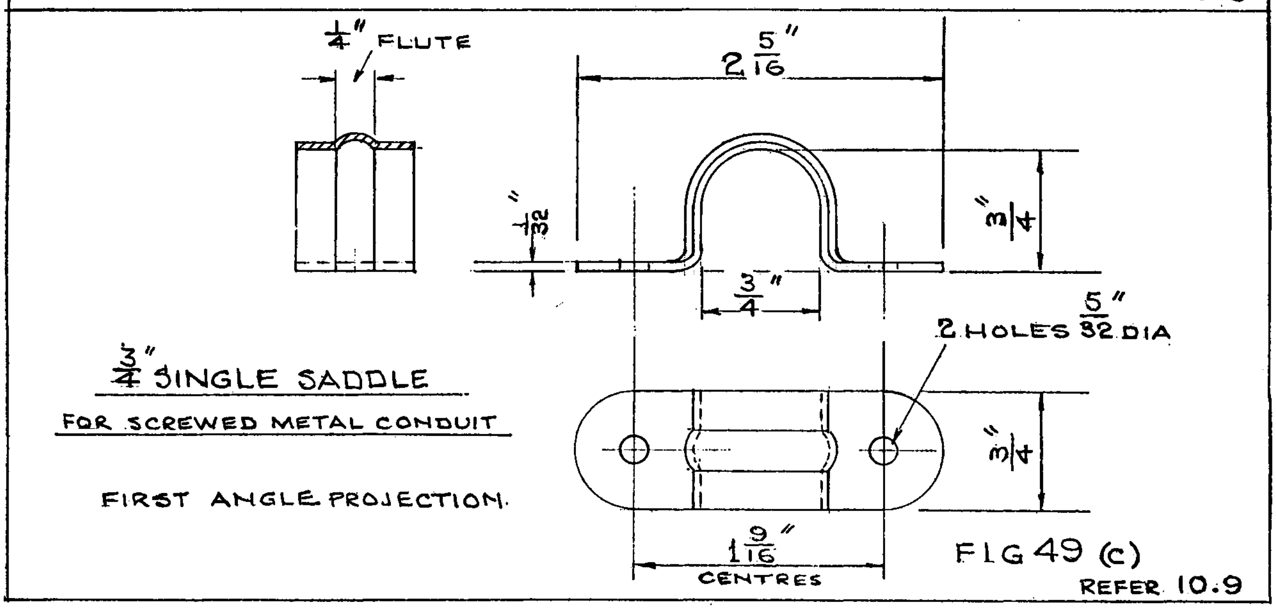

1/4" FLUTE
2 5/16"
1/32"
3/4"
3/4"
5/32" 2 HOLES DIA
3/4" SINGLE SADDLE
FOR SCREWED METAL CONDUIT
FIRST ANGLE PROJECTION.
3/4"
1 9/16" CENTRES
FIG 49 (c)
REFER 10.9

FIG. 49

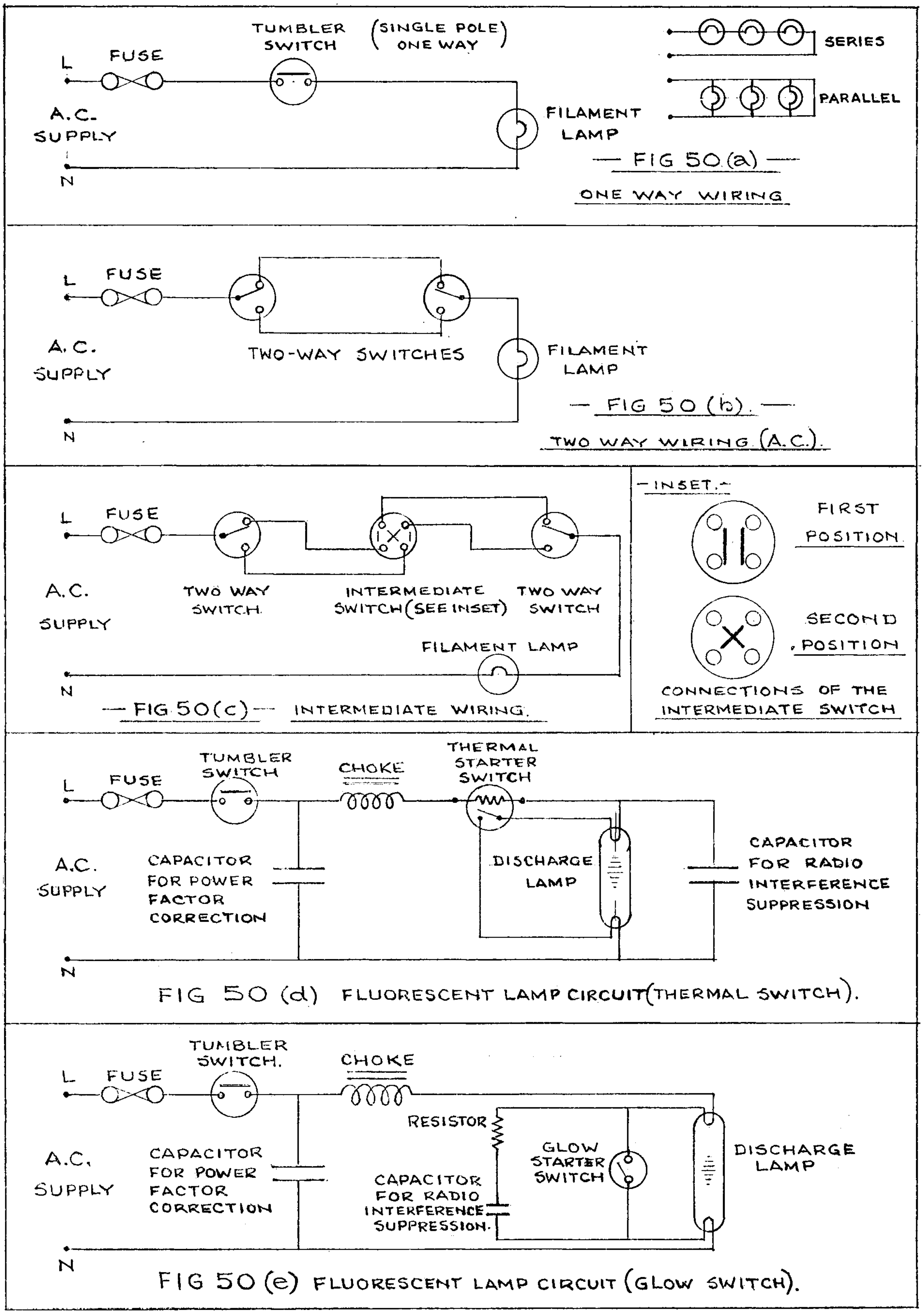


Fig. 50 (Refer 10.10)

10.10. WIRING DIAGRAM. Fig. 50

The drawings which are of direct concern to the electrical engineer are wiring diagrams for electrical circuits. These circuits may be quite simple, such as those for domestic house wiring, or most complex, such as those for electronic circuits. In this section some drawings will be made of simple wiring circuits using the recommended graphical symbols. Electrical wiring diagrams are circuit diagrams indicating the connections of supplies, switches, apparatus, instruments, etc., and are not meant to indicate the exact physical positions of each of these components. They are of direct use to the circuit designer and do not indicate directly to a craftsman installing the circuit, making repairs or carrying out routine maintenance on the circuit, the exact positions of the components. The latter are normally indicated on separate architect or lay-out drawings prepared for the builder and production engineer respectively. Separate location symbols will be used normally on these latter drawings with details of the exact nature of the installation.

One-way Wiring (A.C.). Fig. 50(a)

This diagram shows a simple circuit consisting of a single-phase fused A.C. supply feeding a filment lamp via a tumbler switch. Series and parallel connections are also shown.

Two-way Wiring (A.C.). Fig. 50(b)

The diagram shows another simple circuit which in principle is a change-over switch allowing one lamp to be switched from one of two positions, i.e. at the two ends of a long passage.

Intermediate Wiring. Fig. 50(c)

To have a third control position in the circuit in Fig. 50(*b*) it is necessary to add an intermediate switch. This is shown in Fig. 50(*c*) and the exact connections of the intermediate switch are shown in inset.

Fluorescent Lamp Circuit (Thermal Switch). Fig. 50(d)

Various symbols with explanations are shown in this circuit.

Fluorescent Lamp Circuit (Glow Switch). Fig. 50(e)

Various symbols with explanations are also shown in this circuit.

EXERCISES ON CHAPTER 10

1. Draw one of each of the following screws 1 in. long: (*a*) OBA CH.HD; (*b*) OBA CSK.HD; (*c*) OBA SW.HD. (An OBA screw is 6 mm in diameter.)

2. Draw two views of a hexagon headed bolt 1½ in. diameter, 3 in. long, and screwed 1 in. B.S.W. for 1½ in. (Refer to section 10.3 and Fig. 47*b*.) (1½ in. B.S.W. is 1½ in. diameter × 8 T.P.I.)

3. Refer to section 10.3 and Fig. 47(*a*) and draw three views in third angle projection of a hexagon nut to fit the bolt in Question 2.

4. Show by means of a cross-sectional elevation a feather key ¼ in. thick × 2 in. long sunk into a 1¼-in. diameter shaft and allowing a maximum axial movement of ½ in. by a hub 1¼ in. thick. (Refer to section 10.6 and Fig. 48*c*.)

5. Construct and draw one view of a normal bend for a 1-in. screwed metal conduit. (Refer to section 10.8 and Fig. 49*b*.) Details for 1 in. normal bend are 2½ in. radius with 1 in. straight. Outside diameter of tube is 1⅜ in.

6. Refer to Fig. 50(*a*) and draw an electrical circuit diagram for lighting two filament lamps controlled from one point by one single-pole one-way switch. (The second lamp is connected in parallel.)

The answers to 1, 2 and 3 of these Exercises will be found in Fig. 74, and to 4, 5 and 6 in Fig. 75.

11 · Simple Assemblies

In this chapter you will be making your first assembly drawings. In Chapter 10 you were shown how to make part drawings. When a complete set of parts are grouped or assembled together they form a complete assembly. We shall only deal with small assemblies consisting of a small number of parts (say two, three or four).

Let us deal first of all with *bearings*, one of the most common of all engineering assemblies. Bearings are to be seen on all wheels, engines, pumps, etc., indeed on every mechanism that has moving parts.

11.1. BEARINGS. Fig. 51

The three principal classes of bearings are shown in Fig. 51. They include journal bearings, footstep or pivot bearings and thrust bearings.

Figure 51(*a*): In this figure we show sections through two journal bearings in which the supporting pressure on the bearing is at right angles to the shaft axis. The unbushed bearing, Fig. 51(*a*)(i) shown on the left, is the simplest of all bearings. It consists of a block of material in which a hole is drilled and reamed, and the shaft rotates in this hole. Lubrication is required between the shaft and bearing surfaces. The drawing, Fig. 51(*a*)(ii) shown on the right-hand side, is a bushed journal bearing. It consists of a shaft running in a bearing bush which is in two halves, and these are held by two halves of the main block. The main block is called a plummer block. A simple oil hole is drilled through the top half of the block and the top bearing bush to allow for lubrication to be provided.

A simple, unbushed bearing is used for shafts which rotate slowly, or at infrequent intervals.

Bushed metal bearings are used for high speed shafting where wear occurs and the bushes are made of brass, white metal or gun metal. When the bushes wear they are easily removed and renewed. The bushes must be provided with some means of preventing their rotation and stopping axial movement along the shaft. Some means of lubrication must be provided for all metal bearings.

The bearing block, or plummer block as it is called, is usually made of cast iron and is made in two halves to facilitate the replacement of worn bushes.

Figure 51(*b*): A footstep or pivot bearing is one in which the supporting pressure is vertically upwards and parallel to the shaft axis, the end of which rests within the bearing. The drawing Fig. 51(*b*)(i) on the left-hand side shows an unbushed bearing block in which there is a vertical shaft. The upper end of the hole is counterbored to retain oil for lubricating the bearing. The drawing on the right-hand side, Fig. 51(*b*)(ii), shows a similar block, but in this case the bearing is vertical and runs in a vertical bush made of brass, white metal or gun metal. The end of the

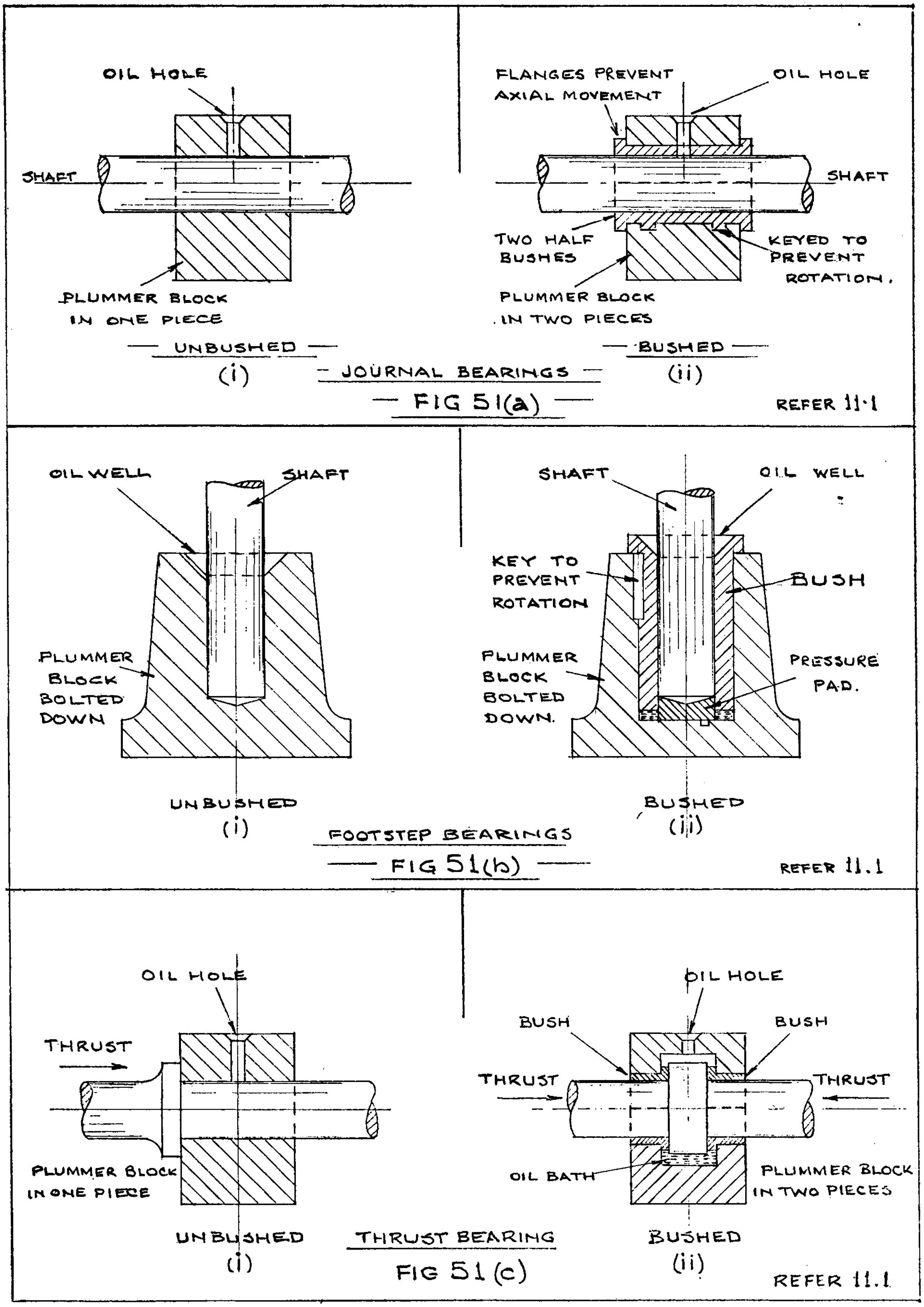


FIG 51(a)

FIG 51(b)

FIG 51(c)

FIG. 51

shaft rests on a bearing pad, or pressure pad. The top of the bearing bush is counterbored to contain oil for lubricating the shaft.

Figure 51(*c*)(i) shows a thrust bearing in which the pressure is largely parallel to the axis of the shaft (having end thrust) which passes through and beyond the bearing, as in propeller drives, etc. The drawing on the left-hand side shows a shaft shouldered, running in a plummer block, and lubricated through the oil hole in the top of the block. The thrust is along the axis of the shaft towards the bearing block.

The drawing on the right-hand side, Fig. 51(*c*)(ii), is of a bearing which can take thrust in both directions. The shaft, which has an enlarged centre, runs in a recess in the bearing block, which is split on the centre line for assembly. Lubrication is through a hole in the top of the upper part of the block and this hole runs into an enlarged recess. Thrust is taken between the block and either side of the enlarged centre.

As a drawing exercise all the six bearings should be drawn freehand in good proportion. Remember to draw as many construction lines as possible and to make the outlines firm and the notes neat and clear. Whenever possible use the side of the sketch pad as a guide for your fingers for any horizontal or vertical straight lines which may be drawn.

11.2. ISOMETRIC AND THIRD ANGLE PROJECTION OF FOOTSTEP BEARING Figs. 52(*a*) and 53

Bushed Footstep Bearing

The drawing in Fig. 52(*a*) shows an isometric detailed assembly of a bushed footstep bearing.

Make an isometric drawing, full size, by copying the drawing shown. This should be done before commencing the main assembly drawing which we shall be doing later, under instruction, in first and third angle projection. Insets (1) and (2) will help with the construction of the bearing bush and pressure pad respectively.

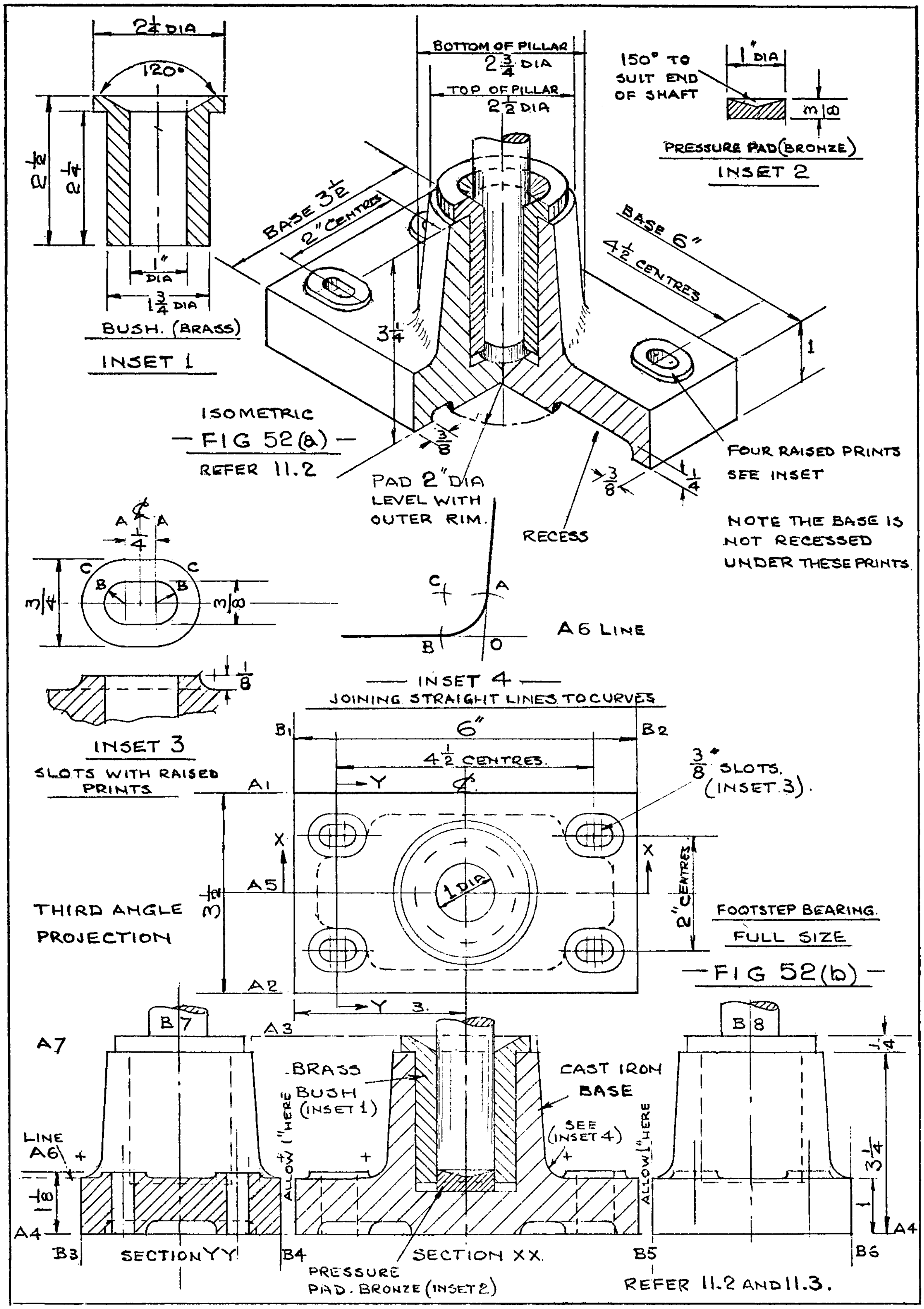
From the information given in the isometric drawing we shall now make an assembly drawing, full size, in third angle projection.

Prepare the drawing sheet on the board and sharpen the 2H pencil, as instructed. Allow sufficient space to group four views neatly and to give room for dimensions and notes, as explained in Chapter 6.

When you look first at the isometric drawing you should try to visualize the shape of each part and its particular function. Remembering the information given in Fig. 51(*b*), we know that the flanged piece in the centre is a bearing bush; that it fits into the main base; that it is made of a bearing material; and that the shaft rotates in it about a vertical axis. Secondly, we see that the shaft rests on a pressure pad and that all the parts are fitted in a strong and heavy cast iron base which has holes for bolting it down.

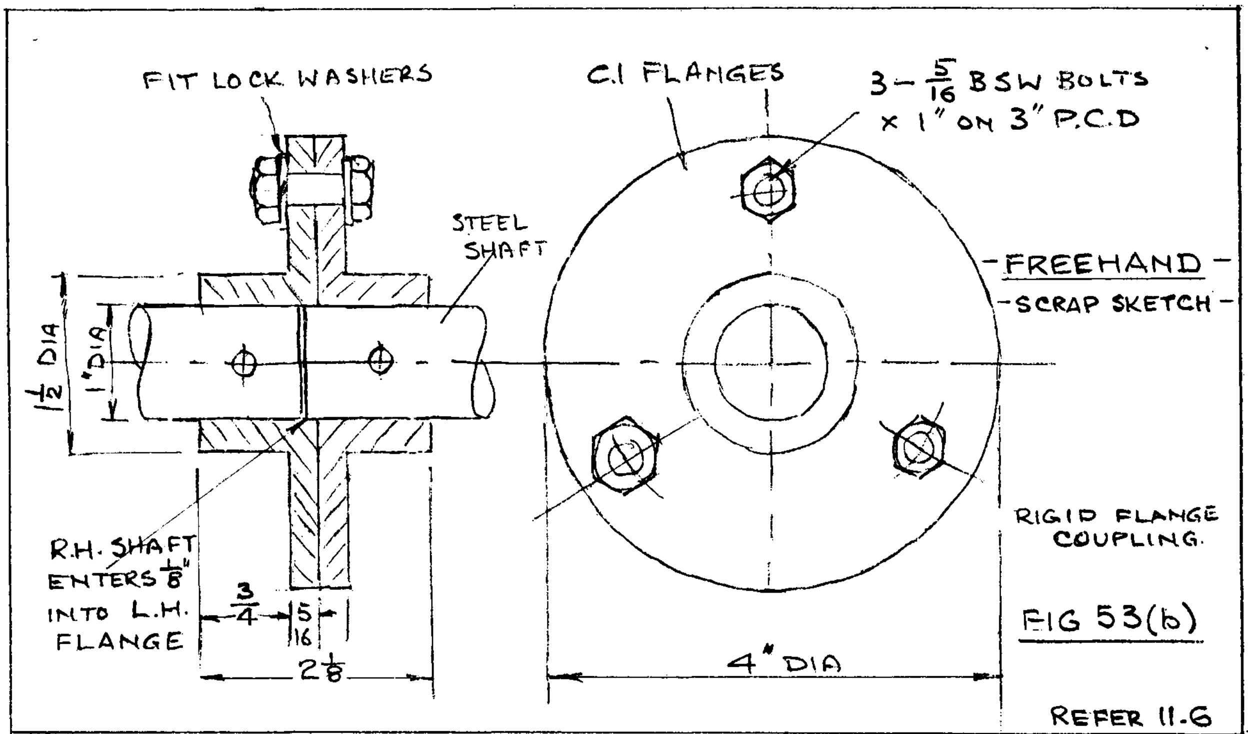
As all the above information is important, we must make full use of sectional elevations, otherwise we shall be drawing views which will be full of lines showing hidden detail.

Using construction lines only, lay out the views as follows: Checking the overall dimensions carefully we find that the width is 3½ in., the length 6 in., and the height 3½ in. Allowing a horizontal space of 1 in. between the views, and 2½ in. at each end, we reach an overall length of 20 in. Allowing a vertical space of 2 in. between the plan and elevation and 2½ in. above and below the views, we reach an overall height of 14 in. Find the vertical centre of the above space



INSET 1
BUSH. (BRASS)
ISOMETRIC
— FIG 52(a) —
REFER 11.2
PRESSURE PAD (BRONZE)
INSET 2
150° TO SUIT END OF SHAFT
BOTTOM OF PILLAR
TOP OF PILLAR
BASE 6"
CENTRES
PAD 2" DIA LEVEL WITH OUTER RIM.
RECESS
FOUR RAISED PRINTS SEE INSET
NOTE THE BASE IS NOT RECESSED UNDER THESE PRINTS.
A6 LINE
— INSET 4 —
JOINING STRAIGHT LINES TO CURVES
INSET 3
SLOTS WITH RAISED PRINTS
THIRD ANGLE PROJECTION
CENTRES.
SLOTS. (INSET 3).
FOOTSTEP BEARING.
FULL SIZE
— FIG 52(b) —
BRASS BUSH (INSET 1)
CAST IRON BASE
SEE (INSET 4)
LINE A6
SECTION YY
SECTION XX.
PRESSURE PAD. BRONZE (INSET 2)
REFER 11.2 AND 11.3.

FIG. 52


FIT LOCK WASHERS
C.I FLANGES
3 – 5/16 BSW BOLTS × 1" ON 3" P.C.D
STEEL SHAFT
FREEHAND SCRAP SKETCH
1½ DIA
1" DIA
R.H. SHAFT ENTERS 1/8" INTO L.H. FLANGE
3/4
5/16
2⅛
4" DIA
RIGID FLANGE COUPLING.
FIG 53(b)
REFER 11.6

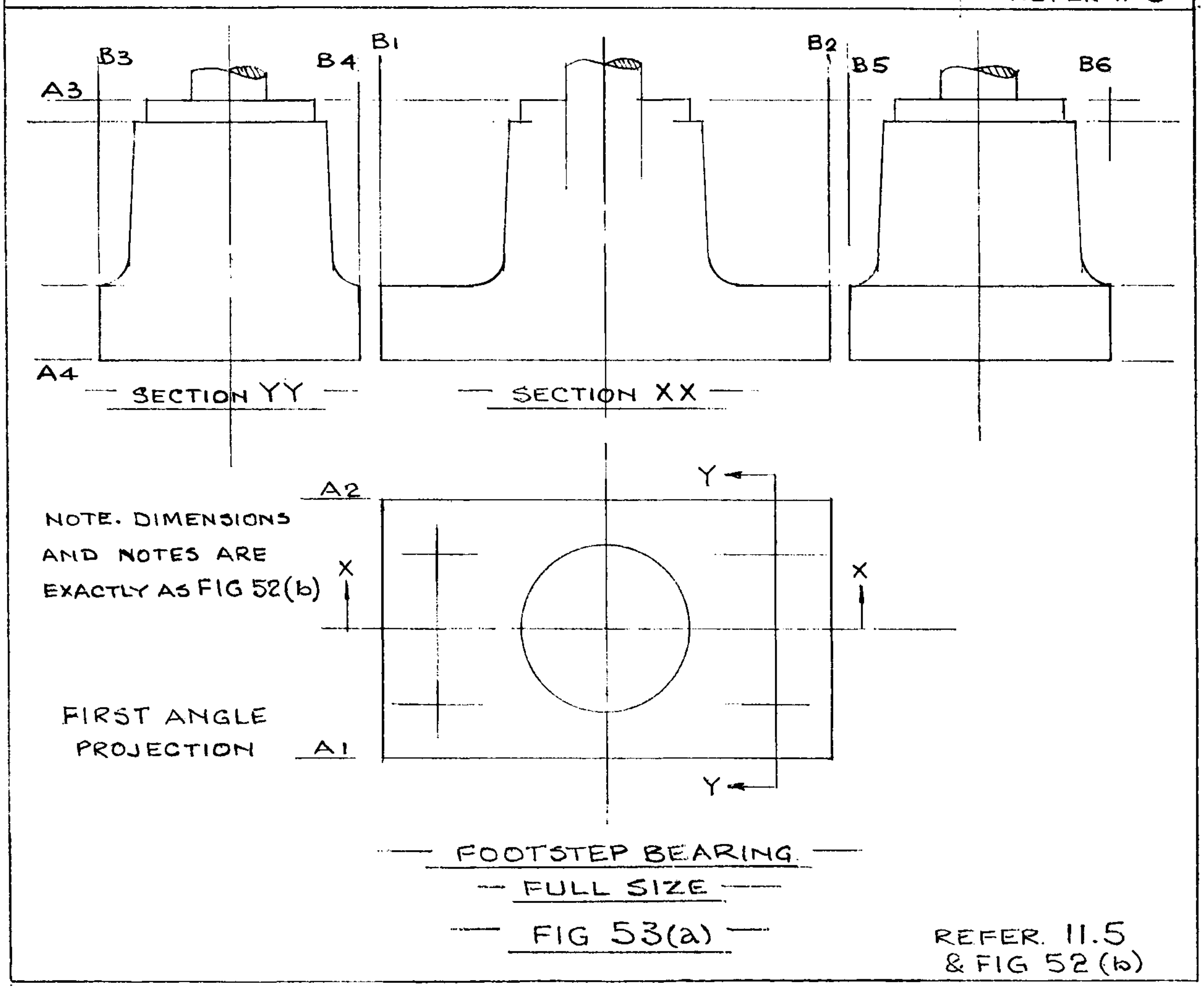

B3
B4
B1
B2
B5
B6
A3
A4
SECTION YY
SECTION XX
A2
A1
X
Y
NOTE. DIMENSIONS AND NOTES ARE EXACTLY AS FIG 52(b)
FIRST ANGLE PROJECTION
FOOTSTEP BEARING.
FULL SIZE
FIG 53(a)
REFER 11.5 & FIG 52 (b)

Fig. 53

and draw a centre line 3 in. from the top edge. Draw two horizontal lines $3\frac{1}{2}$ in. apart at *A*1 and *A*2. Leaving a $1\frac{1}{2}$ in. space, draw two more horizontal lines $3\frac{1}{2}$ in. apart at *A*3 and *A*4, the bottom line being the base-line for the front elevation and the two end elevations. Now draw two vertical lines 6 in. apart, that is, 3 in. each side of the centre line at *B*1 and *B*2. Leaving a space of 1 in. each side of *B*1 and *B*2, draw *B*3, *B*4, *B*5 and *B*6 the same distance apart as *A*1 and *A*2. You have inserted the main centre line, so now the centre lines of the end elevations should be inserted at *B*7 and *B*8. You will notice that the centre line can be indicated by the abbreviation ℄. Very carefully halve the distance between *A*1 and *A*2 and insert a horizontal line *A*5. Two more useful lines to add are the thickness of the base at *A*6 and the height of the pillar at *A*7. With compasses set at the radius of the shaft, draw a circle on the centre line of the plan 1 in. diameter, at the same time marking off the distance on either side of the centre line of the front elevation. Draw the next larger circle in the plan, and mark off the position in the elevation. When drawing the outer circle in the plan the compasses should be retained at the setting to mark off each side of *B*7 and *B*8. You will notice that marking off the other views whilst the compasses are set at one radius saves considerable time since it then becomes unnecessary to have to mark off three distinct positions with a ruler. This is a most important principle—wherever possible mark off three or four views at a time whilst the compasses are set for drawing a particular circle.

We can now draw in construction lines the bearing bush and pressure pad, taking care to show the clearance at the bottom of the bush hole.

The next step is to plan out in construction the position of the bolt-holes in the base. This will be done in the plan, and as we wish to show details under the main base we show a section *Y–Y* through two of the bolt-holes in the left-hand end elevation and a section *X–X* in the front elevation. The holes take the form of slots with rounded ends and you mark out the centre line of each slot either side of the main centre line. This is shown in detail in inset (3).

There are now several small, but nevertheless important, things to add in construction before the final outline is put in. In the front elevation you should show the recess on the underside, and also show it in hidden detail in the plan and right-hand end elevation. Also show the diameter of the shoulder of the bearing bush in all three elevations. Construct the sloping sides of the centre pillar by marking off the top and bottom diameters each side of the centre line with the compasses. Join these points with sloping lines. Carefully add the curves (still in construction), as shown in inset (4). With the sloping line crossing *A*6 at 0, set the compasses at $\frac{3}{8}$ in. and mark off two arcs at *A* and *B*. With the compasses still set at $\frac{3}{8}$ in. carefully mark two arcs to intersect at *C*. From this intersection you can then draw $\frac{3}{8}$ in. radius line from *A* to *B*. Repeat this six times for the three pillars. Finally, in the plan and three elevations show the raised prints which are part of the base around the four holes and slightly higher so that the upper faces round the bolt-holes can be machined easily. Draw these slots and prints as shown in inset (3). On the horizontal centre line of each slot carefully mark off, and draw, two vertical lines at *A–A*. With the compasses set at $\frac{3}{16}$ in. draw (in construction) the end curves of the slots at *B–B*. Then, with the compasses set at $\frac{3}{8}$ in. draw in construction the end curves of the raised prints at *C–C*. Draw horizontal construction lines to pass through the curves at a tangent. If the straight lines do not meet the curves exactly, then the centres of the curves must be adjusted to the same horizontal centre line. Your drawing should now be compared with Fig. 52(*b*) with the obvious exception that no letters or numbers such as *A*1, *B*1, etc., are required on the lines.

11.3. OUTLINING THE ASSEMBLY

Before starting the outline, see that your pencil is sharpened to a true conical point, as previously instructed.

Minimum time for outlining can be achieved by drawing all the horizontal lines first and then all the vertical lines. With the tee-square held firmly, as instructed, slide it to the highest line on the drawing, in this case line *A*1. Draw the outline from *B*1 to *B*2, starting the line sharply and finishing it sharply at each corner, neatly covering the construction line. Continue drawing horizontal lines, working downwards. When you come to line *A*3 you should draw, at the same setting, that part of the line appearing in each elevation. It is essential that you should follow this procedure to ensure that one view is directly projected from the other.

When all the horizontal lines have been completed, draw the four circles in the plan and re-set the compasses to draw the eight semi-circles for the slots, and the eight larger semi-circles for the raised prints. Then draw the short lines joining the semi-circles. If the construction is exact, then the lines should make good joints with the semi-circles. There should not be any overlap at the joints because the construction shows exactly the position at which to stop drawing.

At this stage the curves shown in inset (4) can be added. The construction tells you exactly where to start and where to stop the outline without overlap. You will notice that we are outlining the curves first, and then joining the straight lines to the curves. A simple rule to remember is "curves first".

It is necessary to explain what happens when the raised faces are drawn in the plan. You will see in the elevation, inset (3), that there is a radius from the flat to the edge of the print. This is called a "fillet" and is always to be found in the corners of good castings to prevent uneven shrinkage and consequent cracking. It also adds to the appearance by removing unnecessary sharp corners. However, when this radius, or fillet, is projected to the plan no sign of it is seen and therefore only the outline is shown, as already illustrated in inset (3). The fillets will be shown as $\frac{1}{8}$ in. radii in the elevations.

Continuing with the outline, start with the right-hand side of the drawing and draw all the vertical lines with the aid of the set-square, which should be under control with the left hand and resting and sliding easily on the top of the tee-square.

The following is a quick and useful method for positioning the set-square relative to the line to be drawn. Instead of sliding the set-square along the tee-square, and carefully judging where the position is correct, place the point of the pencil on the construction line and slide the set-square along until it touches the pencil point. Hold the set-square firmly and draw the outline. This method needs some practice, but once it is mastered it will save considerable drawing time.

When all the vertical lines have been completed, draw the six sloping lines. Here again the method to use is to place the point of the pencil exactly on the top end of the curve, slide the set-square up to the point of the pencil and tilt it to line up with the construction line, and then draw the outline. You will find that this method will make the sloping line meet the curve exactly.

After completing the outline, draw in the cross-hatching, or section lines, which must be thin continuous lines to make the outline stand out quite clearly. These lines must be drawn about $\frac{1}{8}$ in. apart in the area of the bearing bush, but they must be farther apart, and evenly spaced, for the area of the base. All section lines must be at 45°, but when adjacent pieces are sectioned the lines should be drawn in different directions. This is difficult in the case of the pressure pad, so in this instance, as there is only a small area to cover, the section lines can be $\frac{1}{16}$ in. apart and in the same direction as the base.

11.4. DIMENSIONING AN ASSEMBLY DRAWING

An assembly drawing should never be completely dimensioned. As you can well imagine, it is both unnecessary and difficult to accomplish because all dimensions are shown essentially on the detailed part drawings. The only dimensions which should be shown on an assembly drawing are known as "specification dimensions". This means that important points of construction must be specified. In the case of the footstep bearing the following details will be required: (1) the diameter of the shaft hole; (2) the overall dimensions; (3) the size and position of slots; (4) material for the parts; (5) notification of two sectional planes; (6) general title; (7) scale; (8) third angle projection; and (9) any other important additional information.

A border line, that is a firm outline, approximately 20 in. × 14 in., should be drawn as a rectangle neatly spaced outside the four views. This gives a "finish" to the drawing. In a drawing office the drawings (assembly, sub-assembly and details) are always drawn on standard sheets selected to the appropriate size. This allows for satisfactory storage of drawings.

Your assembly drawing is now complete and should be compared with that shown in Fig. 52(*b*).

11.5. FIRST ANGLE PROJECTION OF FOOTSTEP BEARING. Fig. 53(*a*)

Study the line-by-line construction as directed for third angle projection but position the views as shown in Fig. 53(*a*). All the instructions are applicable to both drawings and you must become familiar with both methods of projection for all your assembly drawings.

11.6. COUPLINGS. Figs. 53(*b*) and 54

This section will present a very good example of working with compasses.

Shaft couplings are divided into three classes, i.e. rigid, semi-rigid and flexible. In this chapter we shall consider and draw one example of a rigid flange coupling. Figure 53(*b*) shows a draughtsman's typical freehand scrap sketch of such a coupling. It consists of two cast iron flanges, each pinned to a $1\frac{1}{4}$-in. diameter shaft and held firmly together by three hexagon steel bolts $\frac{5}{16}$ in. B.S. Whitworth × 1 in. long on a 3-in. diameter pitch circle.

It is required that an assembly drawing be made showing a full front elevation, a sectional plan and an end view in first angle projection as shown in Fig. 54.

You will notice that in this drawing compasses play a large part in its construction.

Allow a space approximately 11 in. vertically × $9\frac{1}{2}$ in. horizontally. Sharpen your pencil as instructed, and proceed as follows. Draw all lines in construction before drawing the outline. Draw the two horizontal centre lines and the two vertical centre lines, the left-hand one of the latter being through the mating faces of the flanges. Set the compasses to the outside diameter of 4 in. and draw a circle on the right-hand centre lines, at the same time marking off the outside diameter in the two other views. Again, set the compasses to the boss diameter of $1\frac{1}{2}$ in. and draw a circle, at the same time marking the other two views. Draw the 1-in. diameter circle for the shaft and mark off in the other views. Now set the compasses at $\frac{5}{16}$ in. and mark off the thickness of flange from the centre line. Again set the compasses at $1\frac{1}{16}$ in. and mark off the length of the boss each side of the centre line. Set the compasses again at $\frac{3}{4}$ in. and mark off the centre

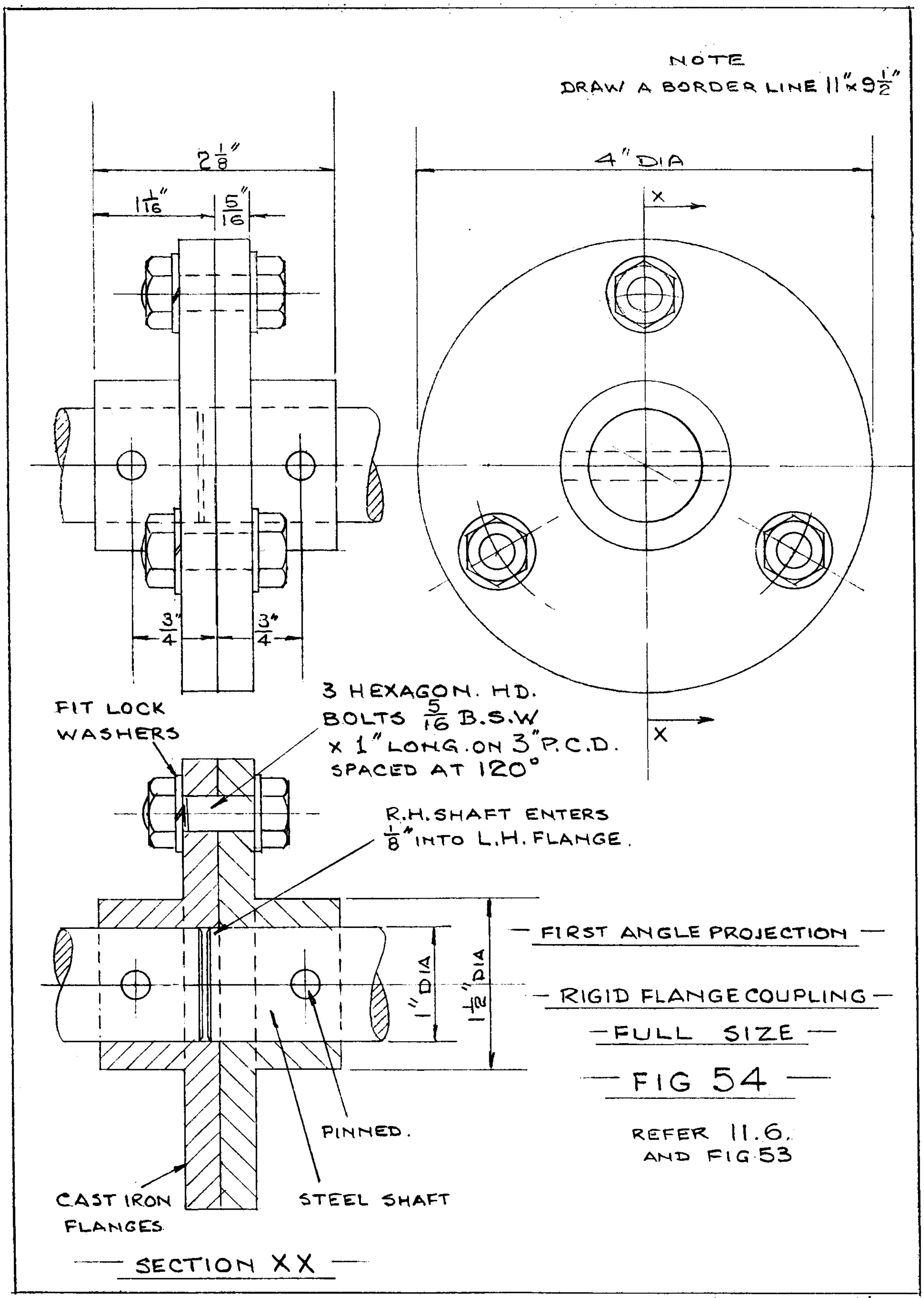

NOTE
DRAW A BORDER LINE 11" x 9½"
2 1/8"
1 1/16"
5/16"
4" DIA
X
3/4"
3/4"
3 HEXAGON. HD. BOLTS 5/16 B.S.W x 1" LONG. ON 3" P.C.D. SPACED AT 120°
FIT LOCK WASHERS
R.H. SHAFT ENTERS 1/8" INTO L.H. FLANGE.
1" DIA
1½" DIA
FIRST ANGLE PROJECTION
RIGID FLANGE COUPLING
FULL SIZE
FIG 54
REFER 11.6. AND FIG 53
PINNED.
STEEL SHAFT
CAST IRON FLANGES
SECTION XX

FIG. 54

lines of the pin holes. Set the compasses at $1\frac{1}{2}$ in. radius and draw a circle very thinly for the centre line of the three bolts. The note "3-in. P.C.D." means 3-in. pitch-circle diameter and is a circle 3 in. in diameter on which the bolt centres are pitched. In this case the radii from the bolt centres to the centre of the main circle are 120° apart.

Starting at the top of the drawing and working downwards, you can now draw all the horizontal construction lines. Working from the right-hand side of the drawing, you can draw all the vertical lines, including the centre lines. The centre line of the two lower bolts is drawn at 30° to the horizontal through the centre.

After completing the main outline, you should draw in the hexagon bolts, nuts and the pins. Most of these are drawn with the compasses. The method of clamping is shown in the section. You will notice under the nut a lock washer, and this is $\frac{1}{16}$ in. thick. The ends of the shafts are shown "broken", this being part of a figure of eight and shaded to show the break. In the section view show the shaft on the right-hand side partly entering ($\frac{1}{8}$ in.) the flange on the left-hand side.

The sectioning should be drawn at 45° and the lines should be about $\frac{1}{8}$ in. apart, not closer. As the two flanges are adjacent to one another, and not the same piece of material, the lines should be at 45° but left and right hand.

Only specification dimensions are necessary, and being very simple they consist of the following: overall diameter of the flange, thickness of the flange, diameter of the shaft, including other items such as size and length of the bolts, material for the flanges and shafts.

The title, scale and the words "first angle projection" should be neatly printed and a border line drawn as a rectangle clearing the outline by about 1 in.

Check your drawing with that shown in Fig. 54 and see that all the outlines are of the same firmness, including the circles, and that improvement in general appearance and neatness is being maintained.

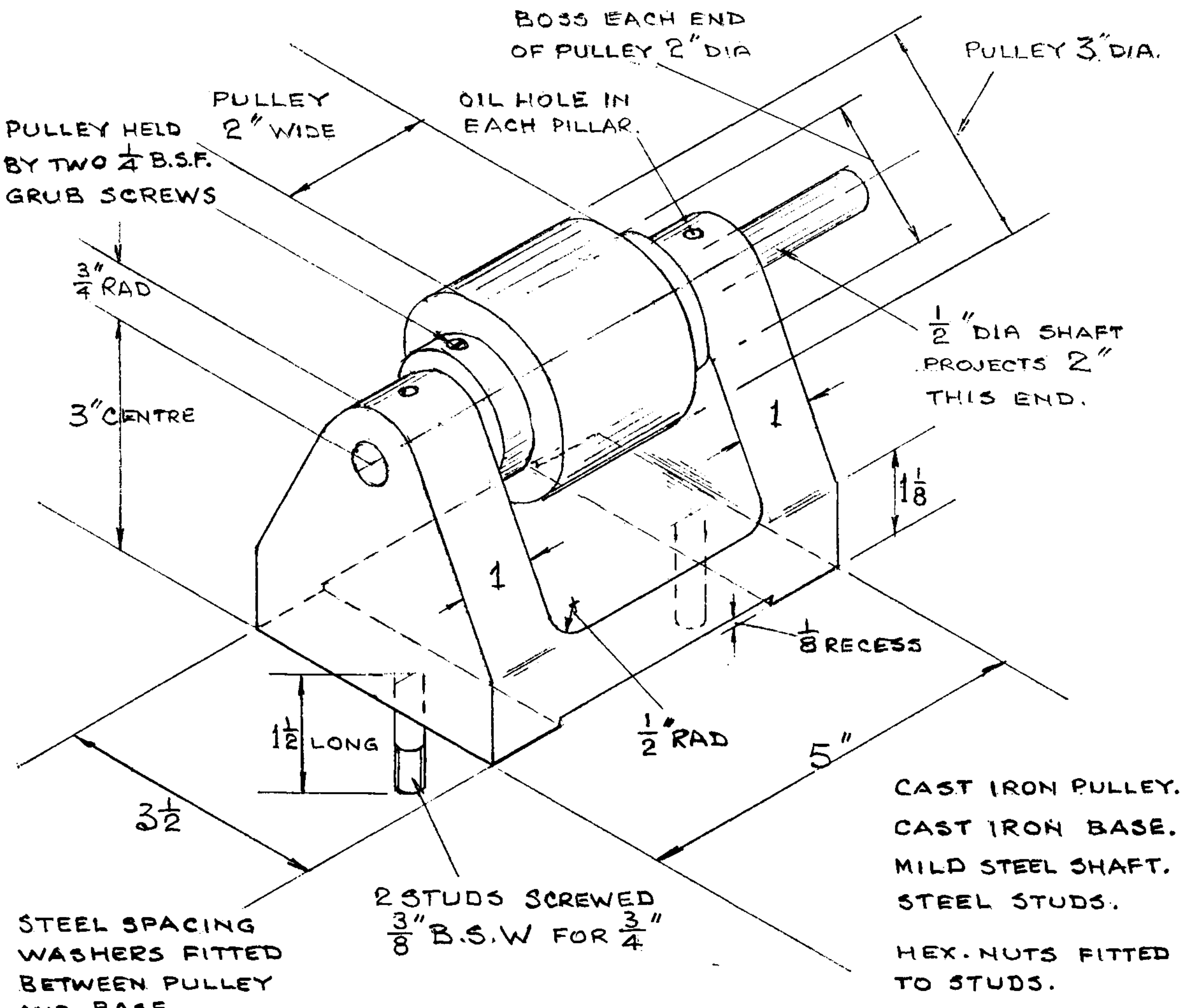
Before proceeding to the next section it would be good practice to re-draw Fig. 54 and note the improvement made.

11.7. COUPLING IN THIRD ANGLE PROJECTION. Fig. 55(*b*)

When an object is circular and symmetrical on a centre line there is very little difference between first angle and third angle projection. This can be seen by examining Fig. 55(*b*) and comparing it with Fig. 54. It will be noticed that the views are in different positions, and that the end view is the only one which has changed slightly. In this view you now look at the head of the bolt and not the nut and end of the bolt. Apart from this, the only change is that the words "third angle projection" are used instead of "first angle projection".

11.8. SIMPLE PULLEY AND BRACKET. Fig. 55(*a*)

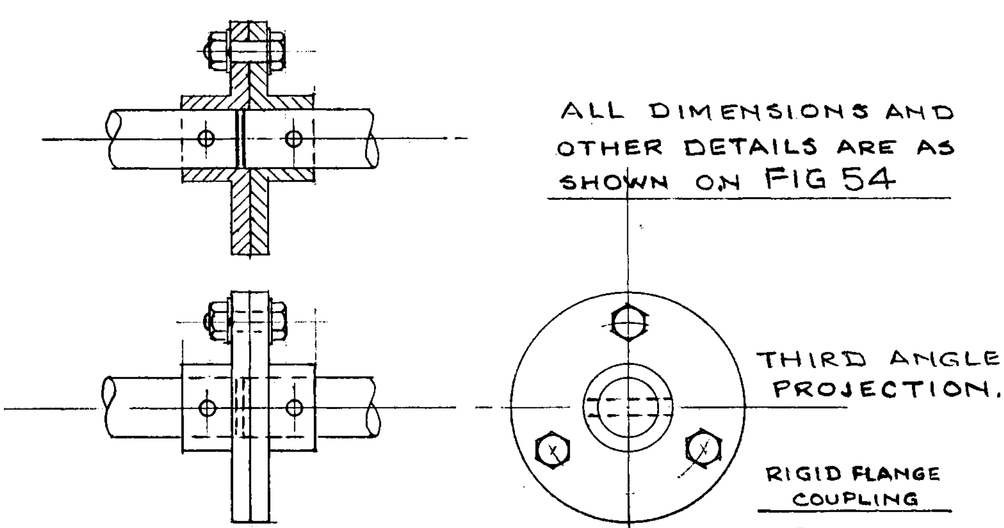
The assembly shown in Fig. 55(*a*) is a very simple mechanism. It consists of a cast iron single-step pulley fixed to a steel shaft running in bearings in a cast iron base which can be held down by two studs, as shown, or screwed bolts. The shaft extends 2 in. and rotates when the pulley is driven. Oil holes are provided for lubrication of each bearing. This drawing will now be made in third angle projection.



SIMPLE PULLEY AND BRACKET

FIG 55 (a)

REFER 11.8



REFER 11.7

FIG 55 (b)

FIG. 55

11.9. ASSEMBLY IN THIRD ANGLE PROJECTION. Fig. 56

With your pencil sharpened, as instructed, and the paper fastened on to the board, allow a drawing space of approximately 16½ in. × 14 in. This space is planned after examining Fig. 55(*a*) as 7 in. × 3½ in. for the plan, 7 in. × 6 in. for the front elevation, 3½ in. × 6 in. for the end elevation, plus 1 in. space between the front elevation and end elevation, 1½ in. space between the plan and front elevation, and an additional length of 2½ in. outside the views horizontally and 1½ in. vertically.

Referring to Fig. 56, we begin our line-by-line construction by working from the top border and drawing the first line, *H*1, 3¼ in. to the centre of the plan. The next line, *H*2, is 4¾ in. to the centre line of the pulley. Three inches below this line we draw the base-line, *H*3, for the front elevation and end elevation. The next useful line to draw is the vertical centre line, *V*1, of the end elevation 4¼ in. from the right-hand side of the paper. Follow this with the end of the shaft, *V*2, 7 in. from the right-hand side of the paper. Two inches to the left of this line draw *V*3, and follow with *V*4, 5 in. from it, which is the length of the front elevation. This should now leave a space of approximately 2½ in. from the border.

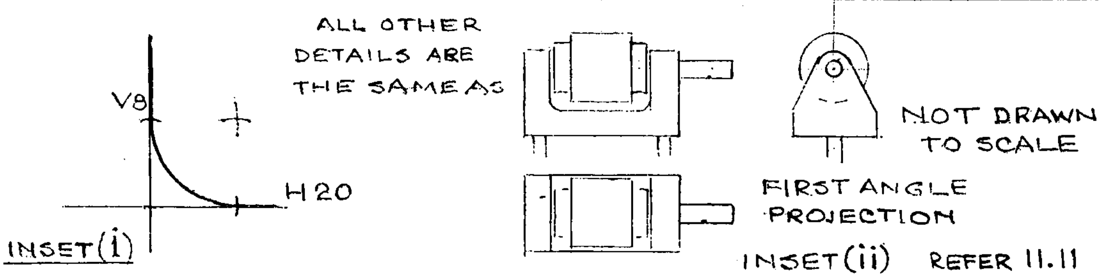
A considerable amount of the work in this drawing is symmetrical and we can make use of the compasses quite early in the construction. Set the compasses at 1½-in. radius and draw in *C*1, the circumference of the pulley in the end elevation. With the compasses still set, mark off the pulley in the front elevation and plan at *H*4, *H*5 and *H*6, *H*7 respectively. Draw the circle, *C*2, for the shaft and mark off each side of *H*1 and *H*2 to show it in both the front elevation and plan by drawing *H*8, *H*9, *H*10 and *H*11. With the compasses set at 1¾-in. radius mark off the base in the end elevation and the plan at *V*5, *V*6 and *H*12, *H*13. Set the compasses at ¾-in. radius and draw the semi-circle at *C*3, and mark off the top of the bearings at *H*14, *H*15. With the compasses set at 1-in. radius draw the end view of the boss at *C*4, and mark off this dimension in the plan at *H*16, *H*17, and in the front elevation at *H*18, *H*19. Draw vertical lines at *V*7 and *V*8 and mark the centre of the bearing pillars at *V*9, *V*10. The thickness of the base should be shown at *H*20. Draw in the curves between *H*20 and *V*7 and *V*8, as shown in inset (i). Draw the two studs in the front elevation and end elevation, drawing the hexagon nuts as already instructed, and showing the screw thread according to standard convention. Draw the two sloping lines, which should neatly join the curve *C*3 with the corners on line *H*20. As we are showing the front elevation in section, the oil holes, drawn $\frac{3}{16}$ in. diameter in the plan at *V*9, *V*10, should be marked off and drawn in the section. The grub screws can also be drawn on *V*11, *V*12 centre lines and marked off in the section.

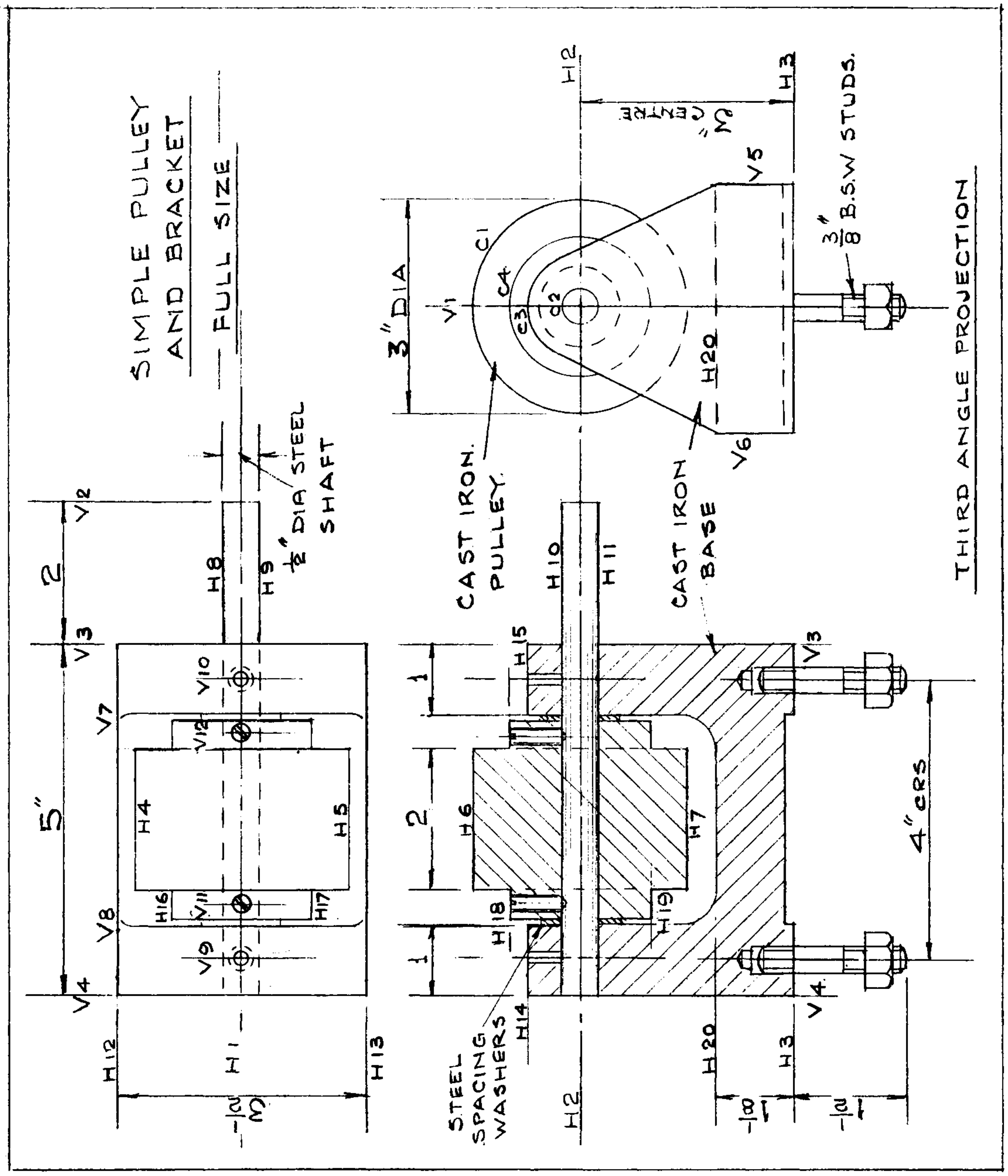
Compare your construction drawing with the numbered lines in Fig. 56.

11.10. OUTLINING THE ASSEMBLY

After sharpening the pencil to a fine, conical point, start outlining from the top of the paper all the horizontal lines. The lines must be firm and start and finish sharply at each of the corners, neatly covering all the relevant portions of the construction lines. With all the construction lines in the correct position it is simple to start and stop the outline without overlap.

Continuing the outline, start with the right-hand side of the drawing and draw all the vertical lines with the aid of the set-square. The set-square must be under control with the left hand and it should rest and slide easily on the top edge of the tee-square. Remember the quick and useful





NOTE. DRAW BORDER LINE $16\frac{1}{2}" \times 14"$

REFER 11.9 AND 11.10

THE NUMBERS H, V & C ARE FOR LINE BY LINE INSTRUCTION AND SHOULD NOT BE PRINTED ON THE ASSEMBLY DRAWING.

FIG. 56

method for positioning the set-square relative to the line to be drawn. Again there should be no overlap at the joints because the construction lines show exactly the position to stop drawing. The circles and radii should be of the same firmness as the outline, and do not forget the rule "curves first", which means outlining the curves first and then joining the straight lines to the curves.

After completing the outline, draw in the cross-hatching or section lines. These should be drawn at least $\frac{1}{8}$ in. apart in the area of the pulley, but farther apart, evenly spaced and at alternate 45° for the main base. The section lines for the spacing washers can be close together as there is such a small area to be covered. The section lines should be thin, continuous lines in order to make the outline stand out quite clearly. It should be remembered that only specification dimensions are required on assembly drawings.

When complete, the drawing should be compared with that shown in Fig. 56.

11.11. ASSEMBLY IN FIRST ANGLE PROJECTION. Fig. 56, inset (ii)

In an assembly drawing, when parts of the object are circular and symmetrical on a centre line, there is very little difference between first angle and third angle projection. This can be seen by examining inset (ii) in Fig. 56, which shows the simple pulley and bracket in first angle projection. You will notice that the views are in different positions, but none of them is changed in appearance. Apart from the views being in different positions the only change is that you put the words "third angle projection" instead of "first angle projection".

In conclusion, the author suggests that the student should practise the line-by-line construction of these simple assemblies as much as possible, so that when coming to more difficult assemblies in the next chapter he will have a very good idea of the necessary approach.

EXERCISES ON CHAPTER 11

1. Draw a cross-section of a bushed journal bearing for a 1-in. diameter shaft. The bush is $2\frac{1}{2}$ in. long and is fitted into a 2-in. plummer block. The centre height of the bearing is $1\frac{1}{2}$ in. Only one view is required. (Refer Fig. 51(*a*)(ii).)

2. Draw a cross-section of a bushed thrust bearing for a 1-in. diameter shaft. The plummer block is 3 in. × 3 in. and the centre height of bearing is $1\frac{1}{2}$ in. The bushes are $1\frac{1}{4}$ in. diameter with flanges $1\frac{3}{4}$ in. diameter and $\frac{1}{4}$ in. thick. The thrust flange is 2-in. diameter × 1 in. thick. Only one view is required. (Refer Fig. 51(*c*)(ii).)

3. Draw a cross-section of a bushed footstep bearing for a 1-in. diameter shaft. The plummer block is 4 in. square × $3\frac{1}{2}$ in. high. The bush is $1\frac{3}{4}$ in. diameter with a flange 2 in. × $\frac{3}{8}$ in. thick. The pressure pad is $\frac{3}{8}$ in. thick. Only one view is required. (Refer Fig. 51(*b*)(ii).)

4. Figure 52(*a*), inset (3), shows the construction of a raised print around a $\frac{3}{8}$-in. slot with $\frac{1}{4}$-in. centres. Draw a raised print around a 1-in. slot with $1\frac{1}{8}$-in. centres. The print is 2 in. across and $\frac{5}{16}$ in. high.

5. Figure 56 shows the assembly of a pulley, shaft and bearing bracket. Draw an assembly (three views, one being a section) of a 4-in. diameter pulley fitted on a $\frac{1}{2}$-in. diameter shaft. No bearing bracket is required. The lengths are the same as in Fig. 56. The drawing should be made in first angle projection.

The answers to these Exercises will be found in Fig. 76.

12 · Simple Machine Tools and Components

12.1. REVISION OF USEFUL DATA

Before commencing the main work of the final chapter of this volume it is useful to spend a short time revising important items, methods of construction, and the finish of a drawing.

Some students experience difficulty when joining curves to straight lines. In this respect refer to the following insets in Fig. 57(*c*).

Inset (i) illustrates a curve joining lines at an angle of 90° to each other. Set your compasses to a radius of $\frac{1}{2}$ in. and mark off two arcs. From these arcs mark off two intersecting arcs, which give the centre of the curve to be drawn. This must be drawn extremely accurately, of course, and the curve must be outlined *before* the two straight lines are added.

Inset (ii) shows a curve joined to two lines at an angle of say 60°. With the compasses set at the required radius of $\frac{3}{8}$ in. mark off four arcs, as shown, and draw two parallel construction lines. The intersection of these lines is the centre of the curve to be drawn. This method can be used to join any curve to two straight lines and at any angle.

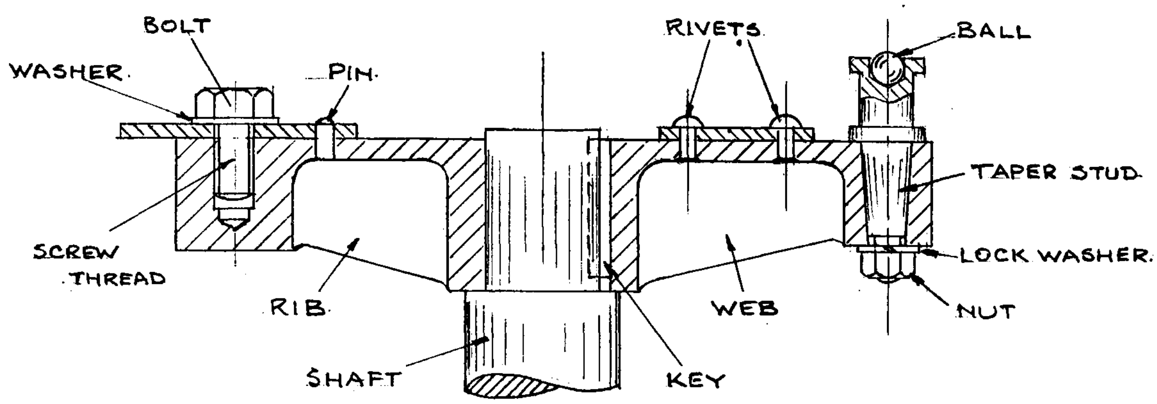
Inset (iii) shows two curves of $\frac{3}{8}$-in. radius joining two circles of 1-in. and $\frac{5}{8}$-in. diameter on $1\frac{1}{16}$-in. centres. The method is clearly shown and is quite simple. Draw the circles in construction at $1\frac{1}{16}$-in. centres and then describe four arcs, each made up of the radius of a circle plus the radius of the given curve, i.e. $(y + a)$ radius and $(x + a)$ radius respectively. Where these larger construction arcs intersect gives the centres from which to draw the final curves of radius (a), where $a = \frac{5}{16}$ in., $x = \frac{5}{16}$ in. and $y = \frac{1}{2}$ in.

Inset (iv) shows two curves of $\frac{5}{16}$ in. radius on $\frac{3}{4}$-in. centres joined by two straight lines. This is fairly easy provided the centres of the constructed curves are very carefully positioned on the cross lines. Draw the curves first and then join the straight lines to the curves.

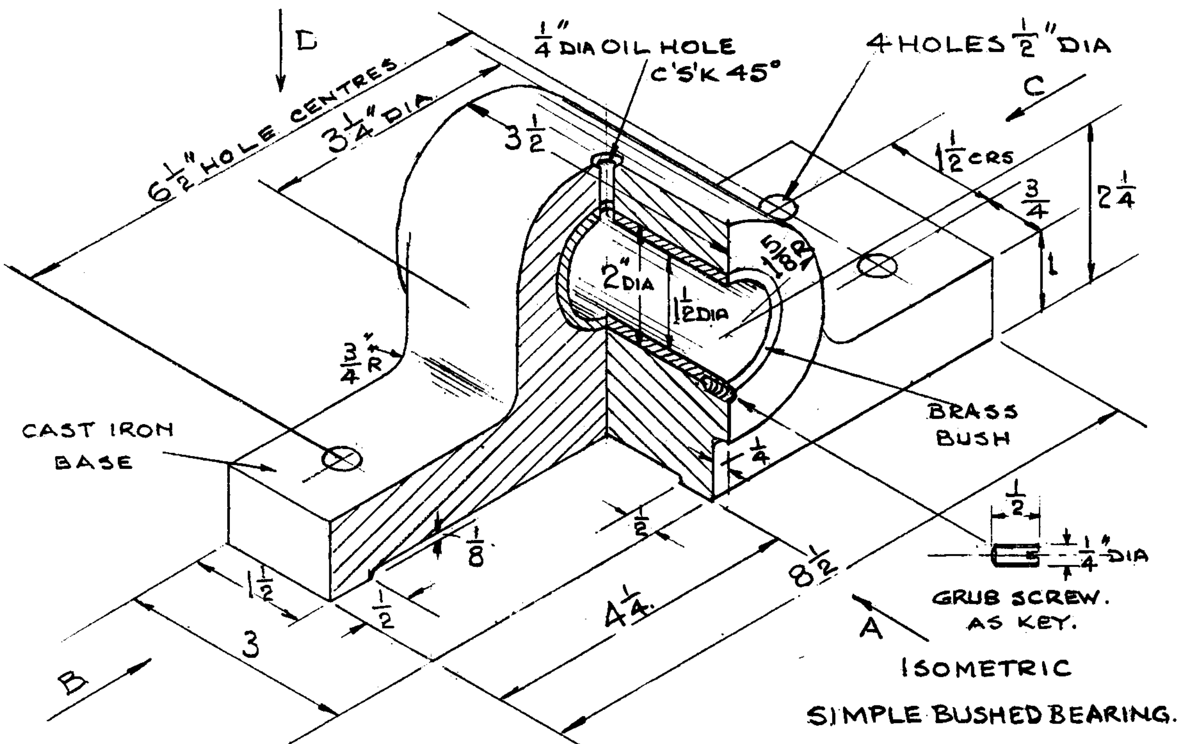
12.2. THE DRAWING OF A SECTION

Cross-hatching, or section lining, has been referred to briefly in previous chapters and in line-to-line drawing instruction. It will now be considered in more detail because in future drawings you will have to decide where a section, if any, will be made. Sections are required to show hidden detail to better advantage. Section lines must be drawn thin, always at 45°, spaced about $\frac{1}{8}$ in. apart on small areas, or $\frac{1}{4}$ in. apart on larger areas.

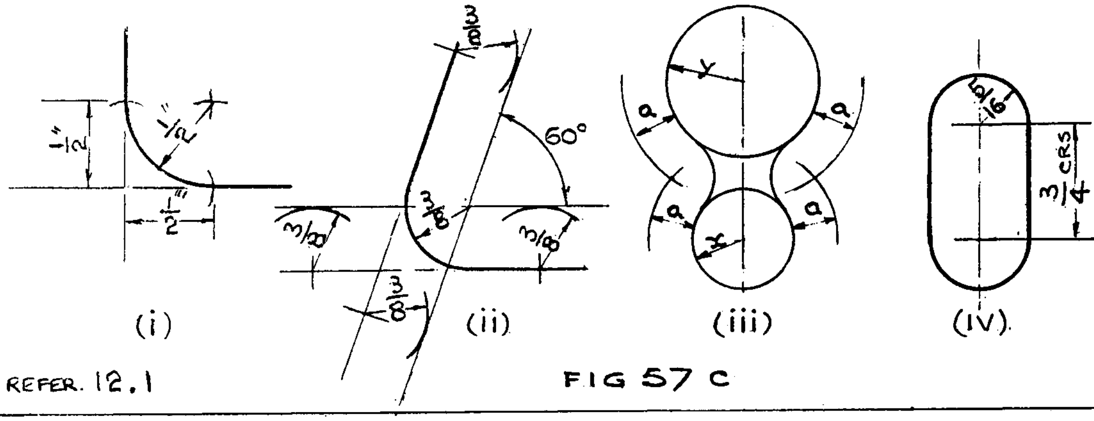
The drawing of a section is more easily understood if you imagine a saw-cut across the required plane and assume that the saw-cut marks are represented by the section lines. If the saw cuts through a hole, since there is nothing to saw through there is no section lining required. It must be clearly understood that as the part is not *actually* cut away, then the other views remain unaffected.



REFER 12.3 PARTS NOT SECTIONED — FIG 57(a) —



REFER 12.4 FIG 57 (b)



REFER. 12.1 FIG 57 C

FIG. 57

All metal parts drawn in section are shown by the same type of section line, i.e. thin lines at 45° and varying distances apart according to the area to be covered. It is undesirable to rely on various conventions of section lining to differentiate between different materials. It is therefore recommended by B.S. 308A that, with the exception of insulation, glass, wood, concrete and water, ordinary section lining be used in all cases where materials are shown in section. (See page 18 of B.S. 308A.)

12.3. PARTS NOT SECTIONED. Fig. 57(*a*)

The following is a list of parts not sectioned but shown in full outline in a sectional drawing: bolts, screws, nuts, studs, shafts, webs, balls, rollers, rivets, cotters, pins. The sketch shown in Fig. 57(*a*) illustrates a large number of these parts when a section is cut through an elevation.

When Whitworth screw threads are mentioned in any of your future drawings they should be referred to as British Standard Whitworth (B.S.W.) screws, as shown in Chapter 8 (Fig. 37).

In the following sections of this chapter we shall be making drawings of small mechanical assemblies and the extracted detailed parts. The assemblies will be taken either from draughtsman's sketches or from views drawn in isometric projection.

12.4. SIMPLE BUSHED BEARING. Fig. 57(*b*)

The assembly shown in isometric projection in Fig. 57(*b*) consists of a strong cast iron base into which is fitted a bearing-bush keyed to prevent rotation of the bush. The assembly consists of a group of three items and it is the work of the draughtsman to make drawings of these parts so that, when manufactured, they will fit together perfectly. At this stage we shall not be dealing with tolerances, but only normal fits. We shall, however, deal with the production of drawings for each part with sufficient dimensions and information to enable that part to be manufactured.

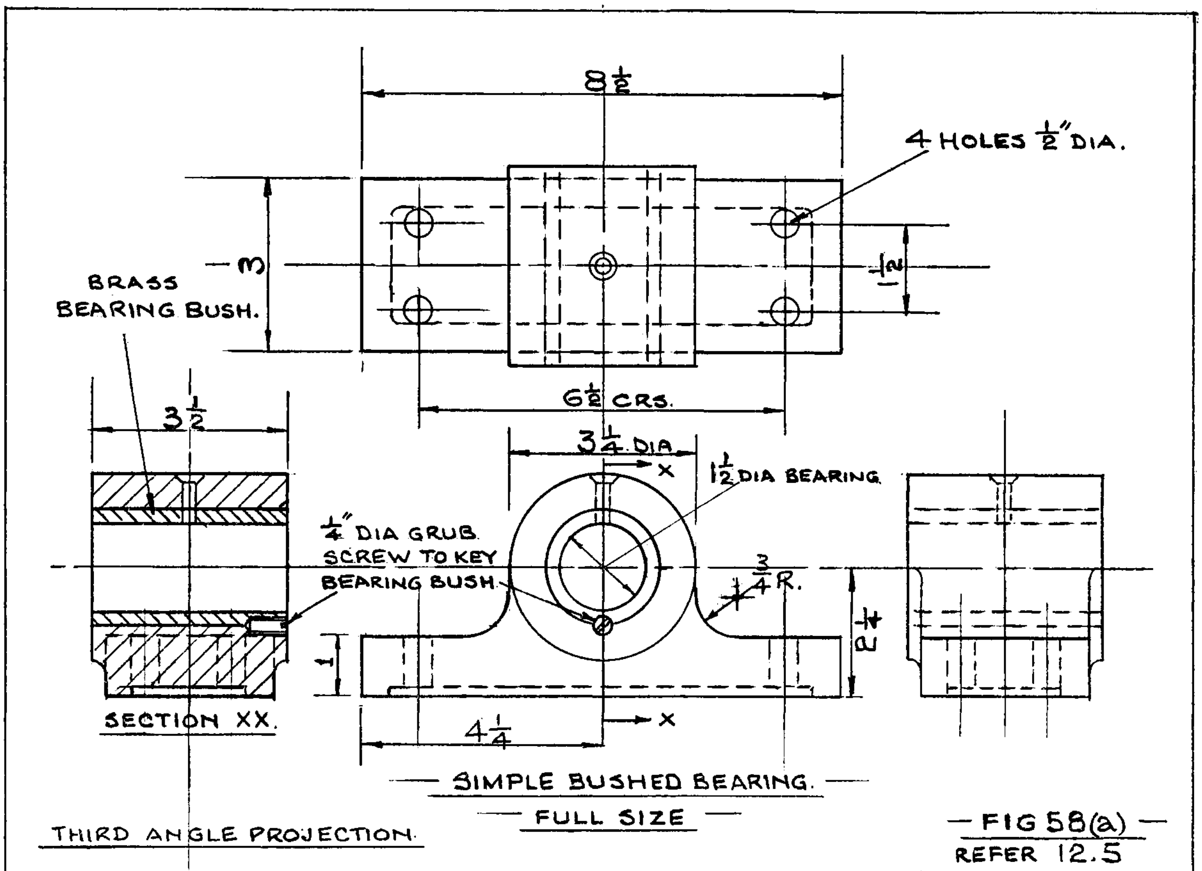
Line-by-line instruction will not be given in this chapter but drawings should follow the procedure given in earlier chapters which included this instruction. Briefly, before commencing a drawing, a very small freehand sketch, about 4 in. × 3 in., sometimes known as a "thumbnail sketch", should be made to include the three or four views which you intend to show on the main drawing. The "thumbnail sketch" should also include the overall dimensions of each view and the space between the views. Adding the dimensions of the relevant views will indicate clearly, if the drawing is made full size, whether the size of drawing sheet is correct.

Although line-by-line instruction will not be given, the following method of producing the drawings will be useful.

12.5. METHOD OF PRODUCING THE DRAWING IN THIRD ANGLE PROJECTION Fig. 58(*a*)

(1) Examine Fig. 57(*b*) and add together all the relevant overall dimensions and allow spaces for four views, making the view in direction *A* the front elevation.

(2) Plan out the "thumbnail sketch" approximately 4 in. × 3 in., placing the views in the correct order for third angle projection with the plan viewed from direction *D* at the top; the sectional elevation viewed from direction *B* at the bottom left hand; the front elevation viewed from direction *A* under the plan; and the end elevation *C* at the bottom right hand. It is necessary to explain that the isometric view, Fig. 57(*b*), shows a quarter cut-away in section. *This is an*


8½
4 HOLES ½" DIA.
3
½
BRASS
BEARING BUSH.
3½
6½ CRS.
3¼ DIA.
1½ DIA BEARING
¼" DIA GRUB
SCREW TO KEY
BEARING BUSH.
¾ R.
2¼
1
4¼
X
X
SECTION XX.
SIMPLE BUSHED BEARING.
FULL SIZE
THIRD ANGLE PROJECTION.
FIG 58(a)
REFER 12.5

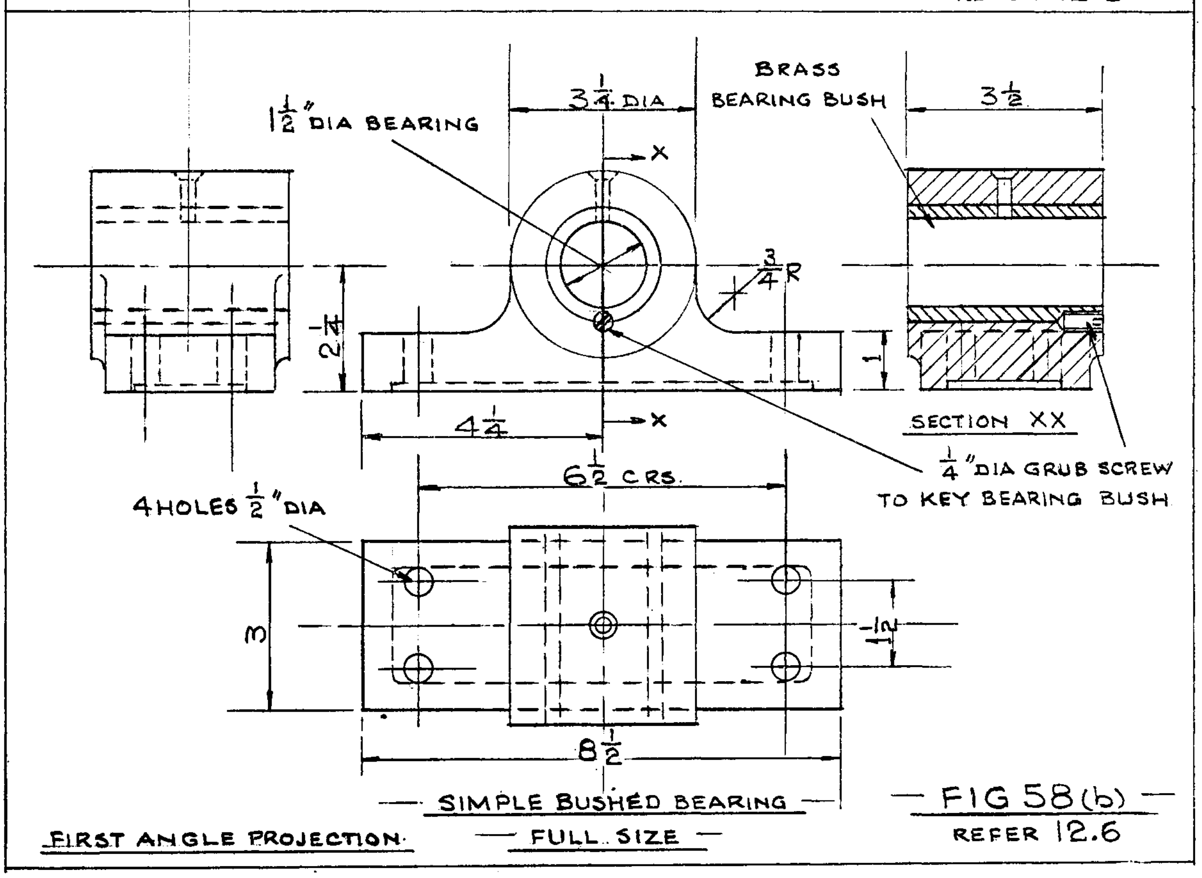

BRASS
BEARING BUSH
3¼ DIA
3½
1½" DIA BEARING
X
¾ R
2¼
1
4¼
X
SECTION XX
¼" DIA GRUB SCREW
TO KEY BEARING BUSH
6½ CRS.
4 HOLES ½" DIA
3
½
8½
SIMPLE BUSHED BEARING
FULL SIZE
FIRST ANGLE PROJECTION.
FIG 58(b)
REFER 12.6

Fig. 58

imaginary cut only and must not lead to confusion. You must show the plan *D* as a *complete view* (not three-quarters of a view), and a complete sectional elevation *B* (not a half-sectional view).

(3) Mark off, and draw, construction lines, as explained in the earlier line-by-line instruction. These should completely cover the projection from one view to another, and included with these lines should be the centre line, the circles, slots, radial corners and hidden detail. Remember that all circles must have two cross lines. Remember also that it is "curves first" and straight lines joined to them afterwards.

(4) If you feel satisfied with the construction which you have drawn, then you should fill in the outline with firm lines. If you are not fully satisfied then you should consult the drawing shown in Fig. 58(*a*). You will notice that a complete section is shown on the left which illustrates an imaginary cut through the vertical centre line and shows the base, the bearing bush, the key for the bearing bush and also the oil hole.

(5) When the outline is complete you may dimension the drawing, remembering that for assemblies only "specification dimensions" are required, such as the overall length, width and height, the centres and size of the mounting holes, the diameter and centre height of the bearing, and any other useful information.

12.6. METHOD OF PRODUCING THE DRAWING IN FIRST ANGLE PROJECTION Fig. 58(*b*)

(1) Examine Fig. 57(*b*) and add all the relevant overall dimensions and allow spaces for four views, making *A* the front elevation.

(2) Plan out the "thumbnail sketch", approximately 4 in. × 3 in., placing the views in the correct order for first angle projection with the plan *D* at the bottom, the section elevation *B* at the top right hand, the front elevation *A* above the plan, and the end elevation *C* at the top left hand. In the isometric view Fig. 57(*b*) a quarter is cut away in section. *This is an imaginary cut only* and must not lead to confusion. You must show the plan *D* as a complete view (not three-quarters of a view), and a complete sectional elevation *B* (not a half-sectional view).

(3) Mark off, and draw, construction lines as explained earlier in the line-by-line instruction. These lines should completely cover the projection from one view to the other, and included in these lines should be the centre lines, the circles, slots, radial corners and hidden details. Remember that all circles must have two cross lines. Remember also "curves first" and straight lines joined to them.

(4) If you feel satisfied with the construction which you have drawn, then you should fill in the outline with a firm line. If you are not fully satisfied, then you should consult the drawing shown in Fig. 58(*b*). You will notice that a complete section is shown on the right and illustrates an imaginary cut through the vertical centre line, showing the base, the bearing bush, the key for the bearing bush and also the oil hole.

(5) When the outline is complete you may dimension the drawing, remembering that for assemblies only "specification dimensions" are required.

You will notice that the difference between Fig. 58(*a*) and Fig. 58(*b*) is the position of the projected views. This is mainly because the object is symmetrical. The difference between first angle projection and third angle projection is not always as simple as in this example.

12.7. DETAILED PARTS, THIRD ANGLE PROJECTION. Fig. 59

The following are detailed parts taken from the assembly drawing shown in Fig. 58(*a*).

Base. Fig. 59(a)

Sharpen your pencil and do the construction work. The drawing of the base takes the same form as Fig. 58(*a*) with the exception that the bearing bush is not fitted and consequently the screw pin, or key, is not shown.

In this case there should be sufficient dimensions to enable the part to be manufactured. We shall give a nominal size for the bearing bush hole; the holes must be dimensioned; and the overall dimensions must be clear and the other dimensions taken from two faces at right angles. Instructions dealing with dimensioning were given in Chapter 5. The border should be drawn 21 in. × 15 in.

The Bearing Bush. Fig. 59(b)

Remember, construction first with a correctly sharpened pencil. This drawing requires only two views and is a brass tube, accurately machined, to be a force fit in the 2-in. diameter hole in the base (*A*). The inside of the bush is a running fit for a $1\frac{1}{2}$-in. diameter steel shaft. The oil hole is drilled through after the tube is fitted. The border should be drawn 13 in. × 7 in.

Key. Fig. 59(c)

Again remember a correctly sharpened pencil and construction first. This is a case where the object is small and so it should be drawn twice full size. It is a steel pin $\frac{1}{4}$ in. diameter, screwed $\frac{1}{4}$ in. B.S.F., and is drilled and screwed to prevent the bush (Fig. 59*b*) from rotating. Remember the dimensions must be given full size. The border should be drawn 6 in. × 3 in.

12.8. HEADSTOCK FOR SMALL LATHE. Fig. 60(*a*)

We see in Fig. 60(*a*) a draughtsman's rough sketch of part of a small lathe. You will notice that no time has been wasted by the draughtsman to "finish" the drawing, but all the necessary details are included in order to make a complete detailed assembly, as in Fig. 60(*b*). Briefly, it consists of an aluminium three-step Vee-pulley fitted to a hollow steel mandrel which runs in a bushed bearing bracket. End play is "taken up" by a screwed collar, and the whole of the assembly is held down on the lathe bed by one stud and nut. The hollow mandrel is coned at one end to accept split collets. Let us draw in first angle projection four views of the assembly, making the main view a sectional elevation. The two end elevations and the plan will be full views. Following this, we shall draw each part separately.

12.9. ASSEMBLY IN FIRST ANGLE PROJECTION. Fig. 60(*b*)

Prepare the drawing paper and sharpen your pencil correctly. Examine the views in Fig. 60(*a*) and after reading the explanation given in section 12.8 you should then visualize the detailed construction. Allowing suitable space between the four views, and also between the views and

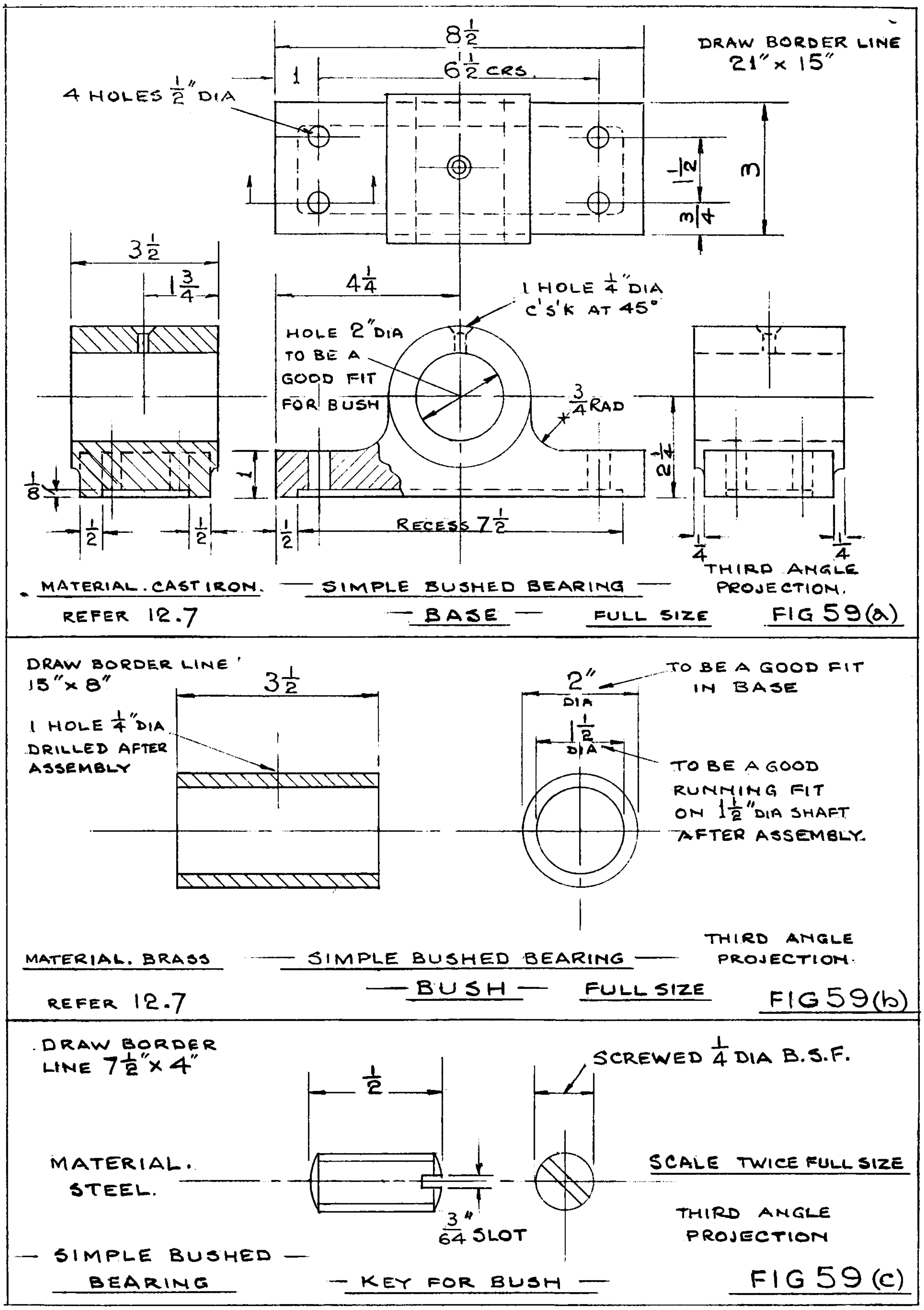
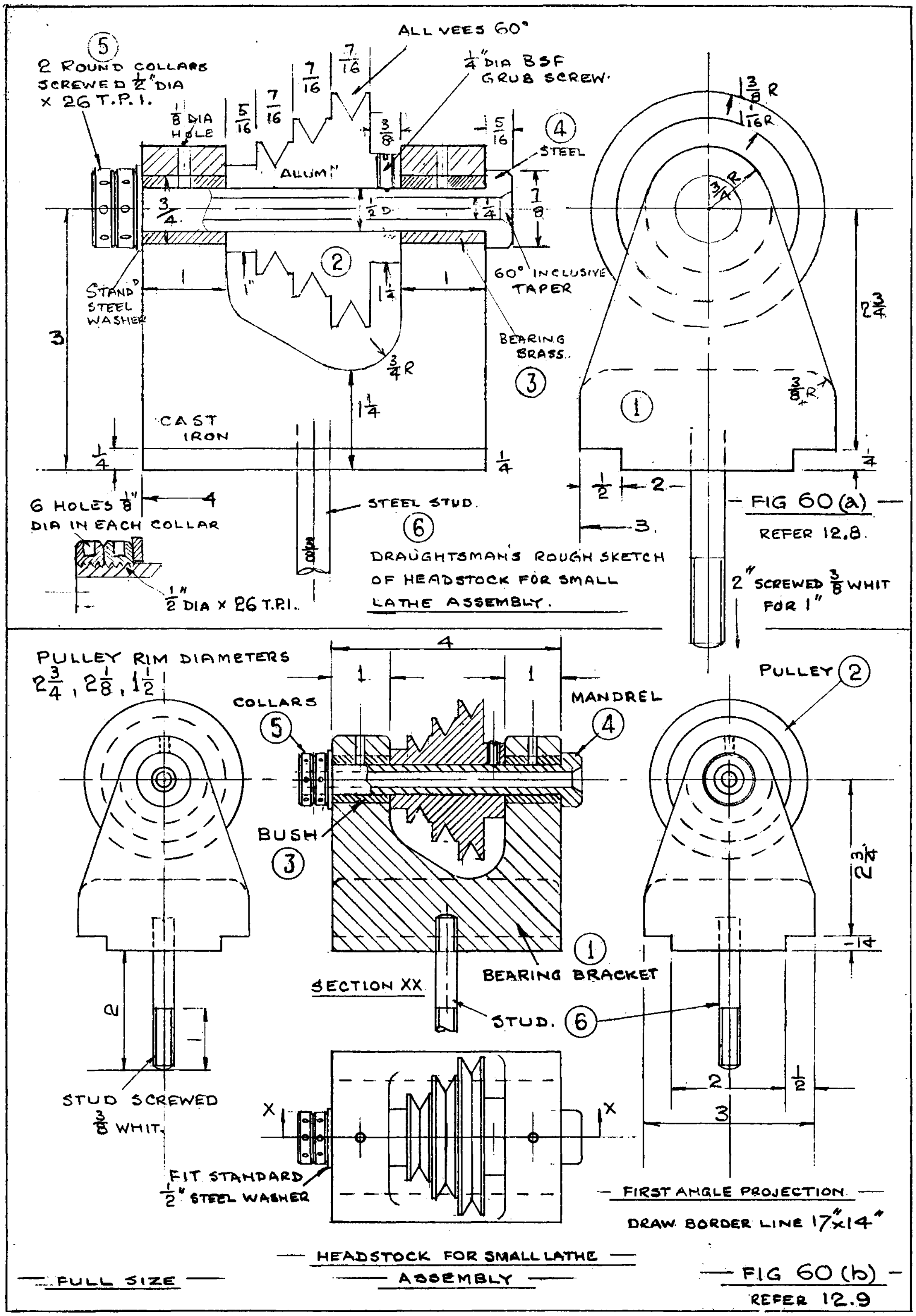


FIG. 59 (Refer to 12.7)



ALL VEES 60°
2 ROUND COLLARS SCREWED ½" DIA × 26 T.P.I.
⅛ DIA HOLE
ALUMᴺ
¼" DIA BSF GRUB SCREW.
STEEL
STANDᴰ STEEL WASHER
60° INCLUSIVE TAPER
BEARING BRASS.
CAST IRON
6 HOLES ⅛" DIA IN EACH COLLAR
½" DIA × 26 T.P.I.
STEEL STUD.
DRAUGHTSMAN'S ROUGH SKETCH OF HEADSTOCK FOR SMALL LATHE ASSEMBLY.
2" SCREWED ⅜ WHIT FOR 1"
FIG 60 (a)
REFER 12.8.
PULLEY RIM DIAMETERS 2¾, 2⅛, 1½
COLLARS
MANDREL
PULLEY
BUSH
SECTION XX
BEARING BRACKET
STUD.
STUD SCREWED ⅜ WHIT.
FIT STANDARD ½" STEEL WASHER
FIRST ANGLE PROJECTION
DRAW BORDER LINE 17"×14"
HEADSTOCK FOR SMALL LATHE ASSEMBLY
FULL SIZE
FIG 60 (b)
REFER 12.9

FIG. 60

the border, make a "thumbnail sketch" approximately 3 in. × 4 in. After you have checked your dimensions very carefully plan out in construction lines the four views on the drawing paper. The *sectional* front elevation should be at the top centre, the end elevations projected to the top right hand and the top left hand, and the plan projected under the sectional front elevation. The drawing should be full size.

There are several points to be stressed:

(1) Each of the Vees in the pulley should be drawn with an angle of 60°.
(2) Show the screw thread by the convention as seen in inset.
(3) The bearing bushes are a force fit and the oil holes are continued through them.
(4) Any dimensions not given must be assumed.
(5) A standard stud is screwed into the base.
(6) The corners of the bracket should be shown square in the plan and not curved.
(7) The conical hole inside the mandrel should be drawn at an inclusive angle of 60°.

The outline should now be drawn with firm lines. Remember, when drawing the outline, to start at the top of the drawing and draw as many horizontal lines as possible. Then, starting from the right-hand side, draw all the vertical lines. When you come to use the compasses remember "curves first" and straight lines joined to them afterwards.

As this is an assembly drawing which will be detailed, each of the parts will be numbered. This will reduce the number of notes required. The part numbers will be as follows:

No. 1. Bearing bracket.
No. 2. Pulley.
No. 3. Bushes.
No. 4. Mandrel.
No. 5. Screwed collar.
No. 6. Stud.

Place the numbers, which should each be contained in a ½-in. diameter circle, neatly around the drawing, and draw neat straight lines from the circle to the part. An arrow head or dot should be placed at the end of each line. All lines from notes should slope and never be drawn horizontal or vertical. The title should be neatly printed, together with "first angle projection", the scale, and "full size". The border line 17 in. × 14 in. should be neatly drawn in outline.

Compare your drawing with Fig. 60(*b*). If you find any major differences between your drawing and that in Fig. 60(*b*) you should look for a reasonable explanation and alter your drawing accordingly.

12.10. THIRD ANGLE PROJECTION, EXPLANATION

As so much of the assembly is symmetrical, the third angle projection will vary little from the first angle projection drawing in Fig. 60(*b*). The sectional front elevation should be in the centre at the bottom, and the plan should be projected from it at the top. The two end elevations should be at the bottom of the left-hand and right-hand corners respectively. The title should be neatly printed "headstock for small lathe", together with the scale, "full size" and "third angle projection".

12.11. DETAILED DRAWING OF A BEARING BRACKET. Part No. 1. Fig. 61(*a*)

When the assembly has been drawn successfully to include a sectional elevation, then it is comparatively easy to draw in detail any selected part. We will now draw each part in first angle projection.

Care must be taken in deciding how many views are required, and whether one, two, three, four or more, are sufficient to give the necessary information. It is the draughtsman's job to *supply that information* on the drawing.

As the bracket we are going to draw is symmetrical, there is need for only three views, sectional front elevation, end elevation and plan. You should know these views by name now, but the only one to have a sub-title is the section, which is the front elevation. Approach the work with paper prepared and pencil correctly sharpened. Measure the assembly dimensions to get the required space for three views plus the separating spaces, and lightly draw the border line. Next plan all the horizontal lines in construction, and then the vertical lines, starting at the right-hand side and making sure that two cross lines are drawn for the centre line of each hole. Construct the curve in the end elevation and join the sloping lines to it to make a clean, continuous line. Remember the method of pivoting the straight edge of the set-square, or ruler, round the pencil point until it lines up exactly with the curve.

The diameter of the holes shown in full in the front elevation and end elevation, and hidden detail in the plan, should be the outside diameter of the bush, part No. 3. These will be a nominal size and we shall deal with tolerances in a later volume. The hole in the centre to take the stud may be shown by any conventional method.

After completing the construction to your satisfaction, you can draw in the outline in firm lines, seeing that all corners are sharp and lines clean, all hidden detail neatly shown, and the section lining drawn with thin lines all at 45° and approximately $\frac{3}{16}$ in. apart and evenly spaced.

Finish the drawing by neatly printing the title "bearing bracket", "full size", "first angle projection", "part No. 1", "1 off", and "material, cast iron".

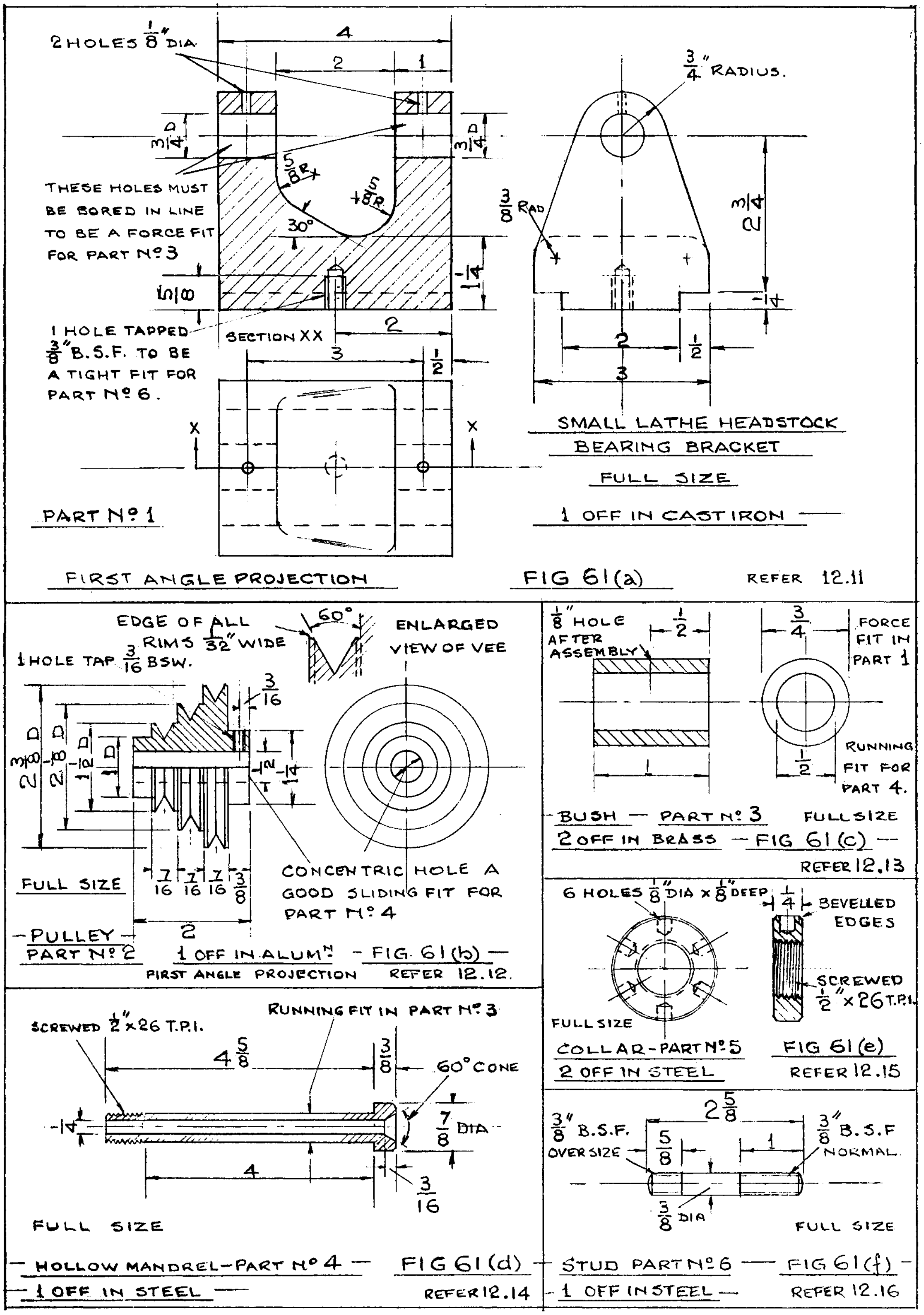
Dimensions play an important part in detail drawings. Refresh your memory by referring to Chapter 5 on dimensioning. In this drawing of the bearing bracket the important dimensions are the centre height of the hole, the distance apart of the bearing faces, the size of the holes to take the bushes, and the distance apart of the shoulders in the end elevation. Finally, draw a neat border line and then compare your drawing with Fig. 61(*a*).

12.12. PULLEY. Part No. 2. Fig. 61(*b*)

This three-step Vee-pulley is machined from round bar, and as it is circular it needs only two views. We will draw the pulley in first angle projection.

Each Vee needs careful construction and should be drawn as in inset. The Vees have 60° angles and are drawn with the 60° set-square. Note the $\frac{1}{32}$-in. shoulder between each Vee. Measurements are taken at the top of each Vee and are concentric on the centre line. The pulley is drilled and reamed to be a good sliding fit to part No. 4.

After the construction is finished draw in the outline, working from the top of the drawing and from the right-hand side of the drawing as far as possible. Fit two stock grub-screws to hold the pulley on the mandrel. These grub-screws are steel and screwed $\frac{3}{16}$ in. Whitworth with no heads but slotted. Print the title, scale, material, number off, "part No. 2" and "first angle projection". Draw a border line to clear the outline by 2 in.



Headstock for Small Lathe. Detail Parts. FIG. 61

12.13. BEARING BUSH. Part No. 3. Fig. 61(*c*)

This bush is made from bearing brass and is in the form of a sleeve to be a force fit, one in each hole of part No. 1. A quick method of drawing the bush is as follows. Draw in construction the horizontal centre line and a vertical centre line. Set the compasses at $\frac{1}{4}$ in. and draw a $\frac{1}{2}$-in. diameter circle, at the same time marking off each side of the centre line for the sectional view. Re-set the compasses at $\frac{3}{8}$ in. and draw a $\frac{3}{4}$-in. diameter circle, and also mark off from the centre line in the section. Mark off, and draw, two vertical construction lines 1 in. apart and 1 in. from the vertical centre line of the hole. The outline can now be completed and the section lining filled in at 45° and about $\frac{1}{16}$ in. apart. Only three dimensions are necessary, the inside and outside diameters, and the overall length.

12.14. HOLLOW MANDREL. Part No. 4. Fig. 61(*d*)

As this mandrel is entirely symmetrical and has no end slots, only one view is required. It is machined from steel, has an external shoulder at one end, and has a screw thread $\frac{1}{2}$ in. $\times$ 26 T.P.I. at the other to suit part No. 5. The hole through the centre is suitable for a collet chuck, and the end of the hole is conical with an included angle of 60°. Draw it first in construction, and then finish with a firm outline and thin section lines at 45°. The important dimensions are the size of the hole through the centre, the outside diameter below the shoulder, the angle and depth of the cone, the overall length, the length under the shoulder, and the size of the thread.

12.15. SCREWED COLLAR. Part No. 5. Fig. 61(*e*)

These collars are turned from steel rod and threaded $\frac{1}{2}$ in. $\times$ 26 T.P.I. to suit the end of part No. 4. The circular faces must be turned true with the thread so that they can be locked together to allow no end play for part No. 4 when assembled. The small holes drilled in the sides are for pin tightening. The outline border should be the same size as part No. 3. Neatly print the title, "part No. 5", the number off, "first angle projection" and the scale.

12.16. STUD. Part No. 6. Fig. 61(*f*)

The stud is made from steel, the long threaded end being screwed $\frac{3}{8}$ in. Whitworth B.S.F. normal, and the short threaded end $\frac{3}{8}$ in. Whitworth B.S.F. oversize, leaving a plain stem 1 in. long. This part can also be drawn with the same area as parts No. 3 and No. 5. When adding dimensions, notice that the length is given over the rounded end. After completing the drawing in outline, neatly add the title, "part No. 6", 1 off in steel, the scale and "first angle projection".

All the above drawings should now be carefully compared with Fig. 61. If any amendments are necessary they should be added. If the drawings do not appear entirely satisfactory then it would be good practice to repeat them.

EXERCISES ON CHAPTER 12

1. Construct, and draw, the following:

(*a*) Two straight lines, each 1 in. long, joining a $\frac{3}{4}$-in. radius curve at 90°. (See Fig. 57(*c*)(i).)

(*b*) Two straight lines, each 1 in. long, joining a $\frac{5}{8}$-in. radius curve at 45°. (See Fig. 57(*c*)(ii).)

(*c*) Two circles, $1\frac{1}{4}$ in. diameter and $\frac{3}{4}$ in. diameter, on $1\frac{1}{2}$ in. centres joined by two curves of $\frac{3}{4}$ in. radius. (See Fig. 57(*c*)(iii).)

(*d*) Two semi-circles of $\frac{5}{8}$ in. radius on 1 in. centres joined by two straight lines. (See Fig. 57(*c*)(iv).)

2. Figure 62(*a*) shows a bracket in which all parts are symmetrical on a vertical centre line. By measurement draw a sectional elevation (one view only).

3. Draw a three-step pulley in third angle projection similar to Fig. 61(*b*) but with diameters of 2 in., 3 in. and 4 in. at the top of the Vees. The depth of Vees and all other dimensions remain the same. (Refer 12.12 and Fig. 61(*b*).)

4. Copy, full size, the isometric drawing of the cast iron box assembly shown in Fig. 62(*b*). Show all construction and print the title and dimensions.

5. Draw, full size, four views in first angle projection of the cast iron box shown in Fig. 62(*b*). One view should be in section. Print the title, scale and add specification dimensions only.

6. Draw, full size, part drawings in first angle projection of the following items taken from the assembly drawing in Question 5:

(*a*) Base
(*b*) Cover
(*c*) Gasket
(*d*) Gland
(*e*) Screw

The answers to 1, 2 and 3 of these Exercises will be found in Fig. 77, and to 5 and 6 in Fig. 78.

See page 134 for the answer to 4.

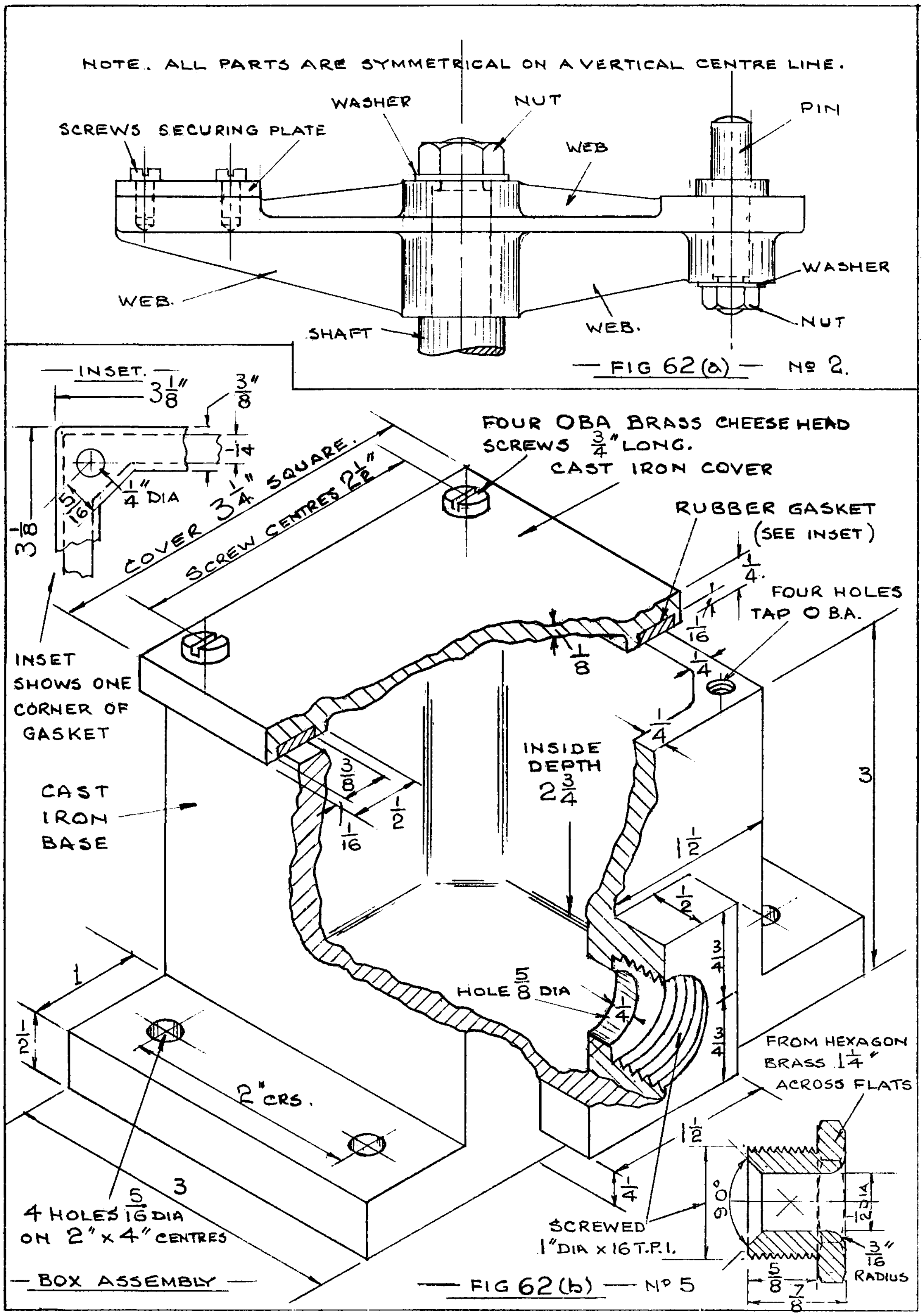


Fig. 62 (Refer to page 133)

Answers

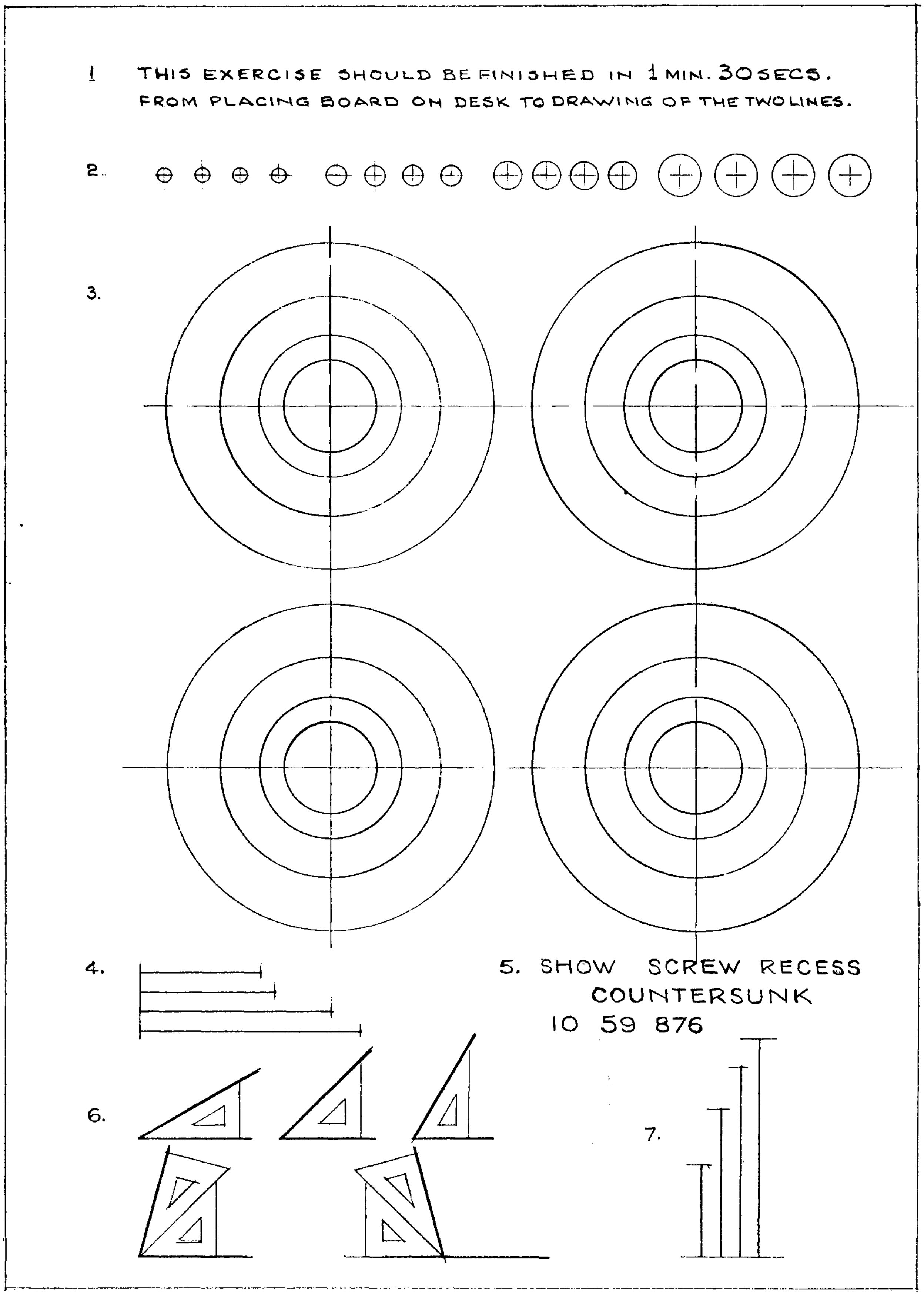

1 THIS EXERCISE SHOULD BE FINISHED IN 1 MIN. 30 SECS.
FROM PLACING BOARD ON DESK TO DRAWING OF THE TWO LINES.
2.
3.
4.
5. SHOW SCREW RECESS
COUNTERSUNK
10 59 876
6.
7.

Fig. 63

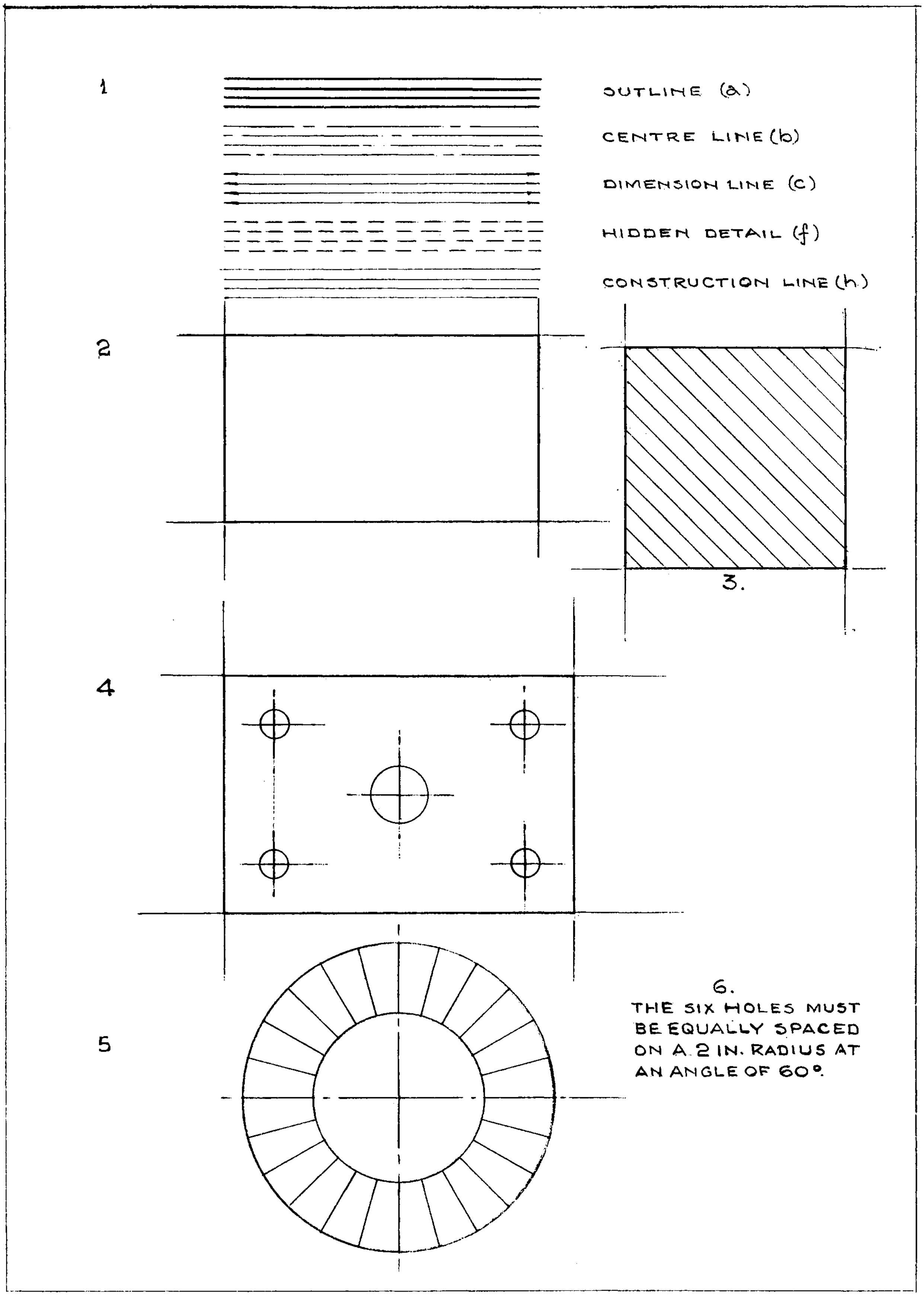

1
OUTLINE (a)
CENTRE LINE (b)
DIMENSION LINE (c)
HIDDEN DETAIL (f)
CONSTRUCTION LINE (h)
2
3.
4
5
6.
THE SIX HOLES MUST BE EQUALLY SPACED ON A 2 IN. RADIUS AT AN ANGLE OF 60°.

FIG. 64

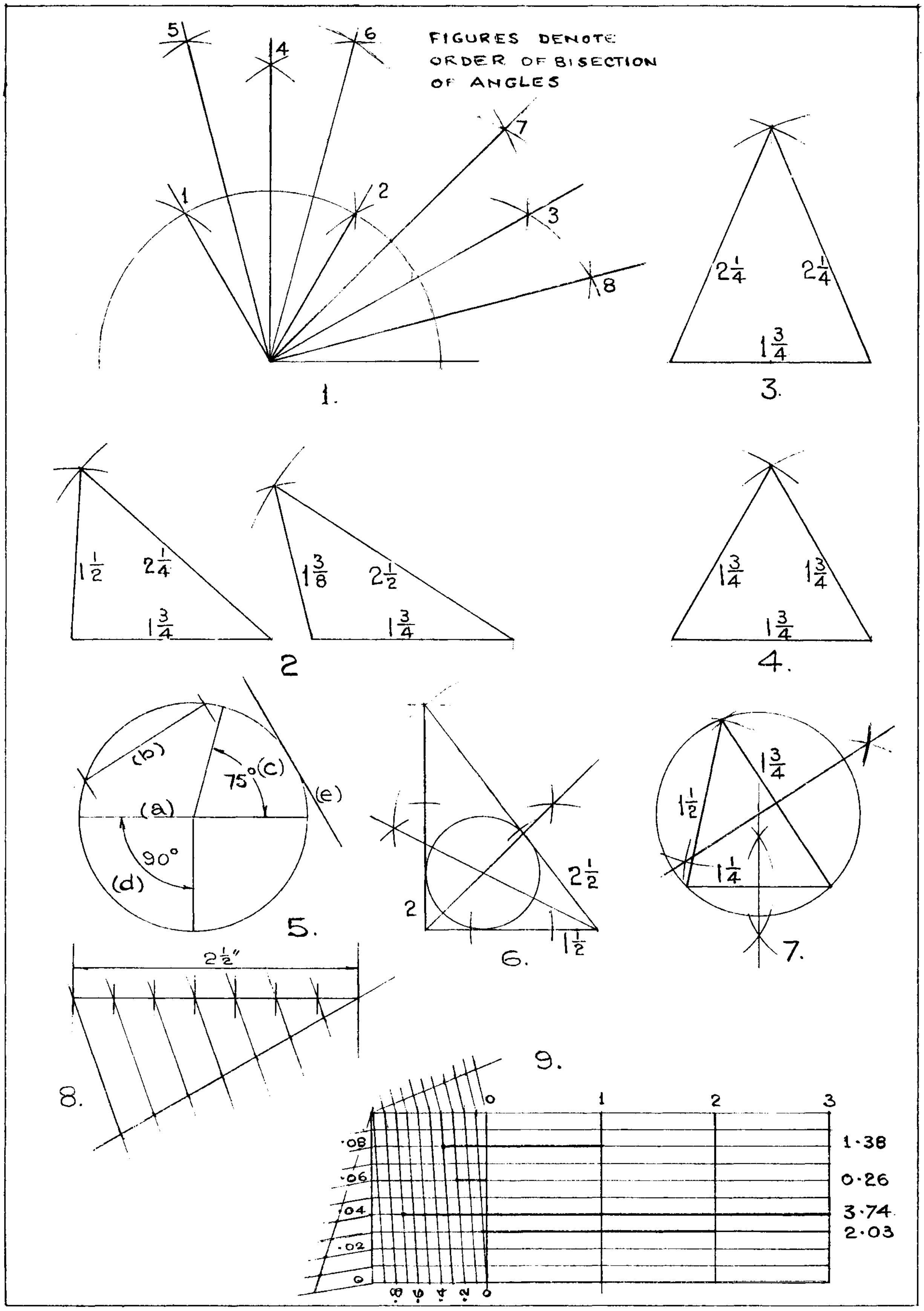
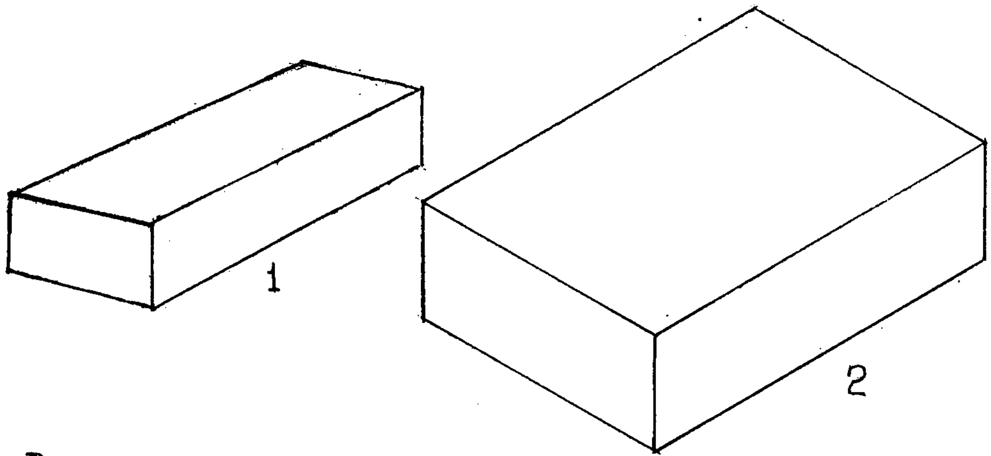

FIGURES DENOTE ORDER OF BISECTION OF ANGLES
1.
2
3.
4.
5.
6.
7.
8.
9.
(a)
(b)
75°(c)
90°
(d)
(e)
2½″
1·38
0·26
3·74
2·03

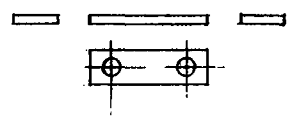
FIG. 65



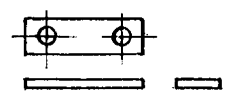
3. SEE FIG 15(a)

4. SEE FIG 16(a)

5 THIS WILL BE EXACTLY AS FIG 19(a) BUT WITH THE ADDITION OF A VIEW SIMILAR TO THE END ELEVATION BUT ON THE LEFT OF THE FRONT ELEVATION. REMEMBER IN FIRST ANGLE PROJECTION THE PLAN IS BELOW THE FRONT ELEVATION.



6 THIS WILL BE EXACTLY AS FIG 19(b) BUT WITH THE ADDITION OF A VIEW SIMILAR TO THE END ELEVATION BUT ON THE LEFT OF THE FRONT ELEVATION, REMEMBER IN THIRD ANGLE PROJECTION THE PLAN IS ABOVE THE FRONT ELEVATION



7. THIS IS AN EXERCISE USING THE CARD MODEL TO ILLUSTRATE THIRD ANGLE PROJECTION AND YOUR RESULT SHOULD BE SIMILAR TO FIGS 17(b) AND 17(c)

8. THIS WILL BE EXACTLY AS FIG 19(c) BUT WITH THE ADDITION OF A VIEW SIMILAR TO THE END ELEVATION BUT REVERSED AND PLACED ON THE LEFT OF THE FRONT ELEVATION. REMEMBER IN FIRST ANGLE PROJECTION THE PLAN IS BELOW THE FRONT ELEVATION.

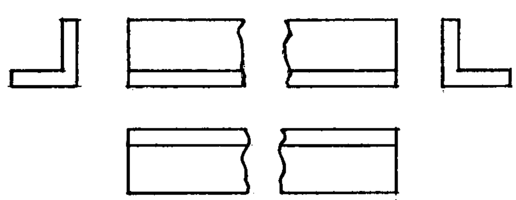


Fig. 66

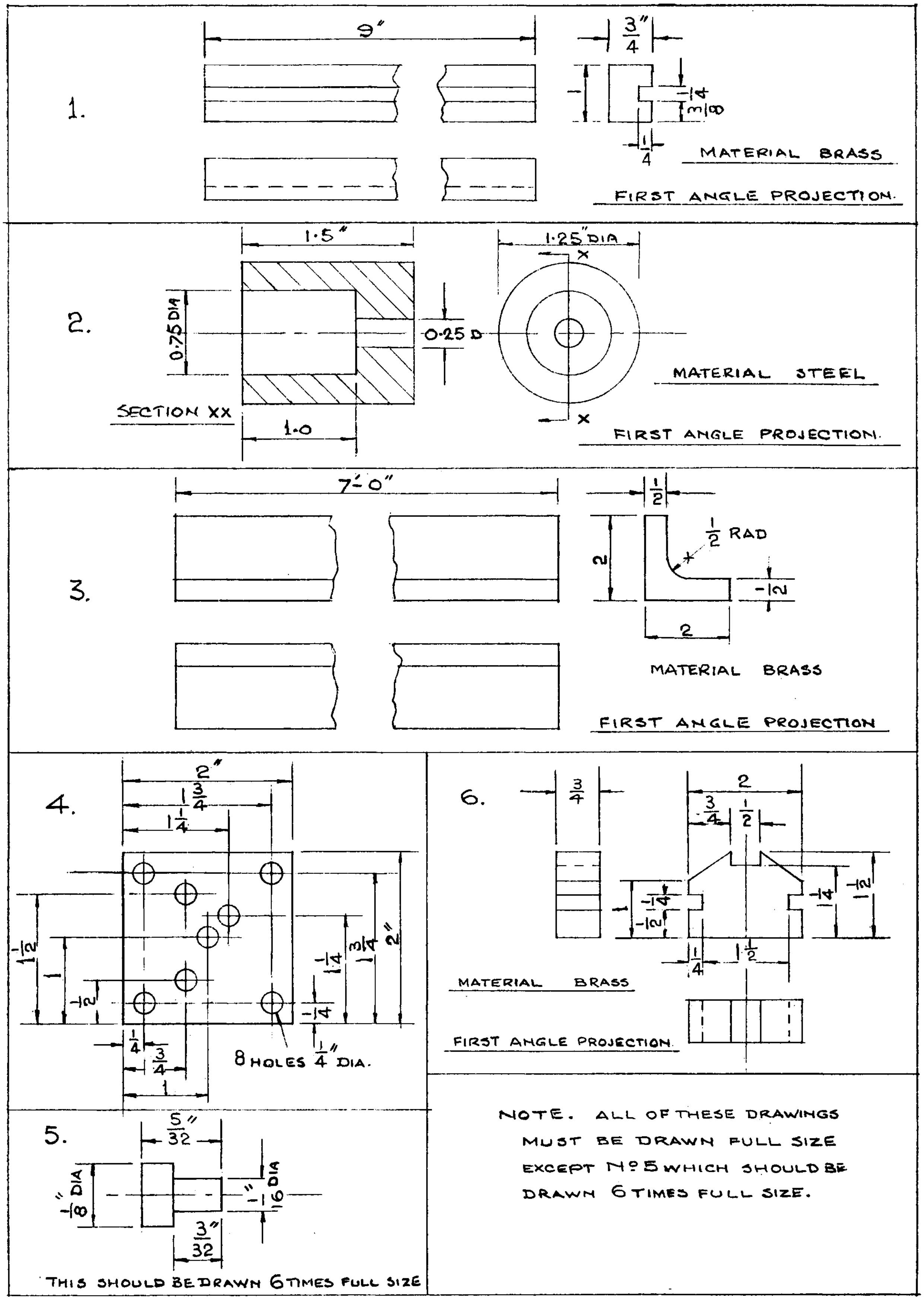

1.
MATERIAL BRASS
FIRST ANGLE PROJECTION.
2.
SECTION XX
MATERIAL STEEL
FIRST ANGLE PROJECTION.
3.
½ RAD
MATERIAL BRASS
FIRST ANGLE PROJECTION
4.
8 HOLES ¼" DIA.
6.
MATERIAL BRASS
FIRST ANGLE PROJECTION.
5.
THIS SHOULD BE DRAWN 6 TIMES FULL SIZE
NOTE. ALL OF THESE DRAWINGS MUST BE DRAWN FULL SIZE EXCEPT Nº 5 WHICH SHOULD BE DRAWN 6 TIMES FULL SIZE.

Fig. 67

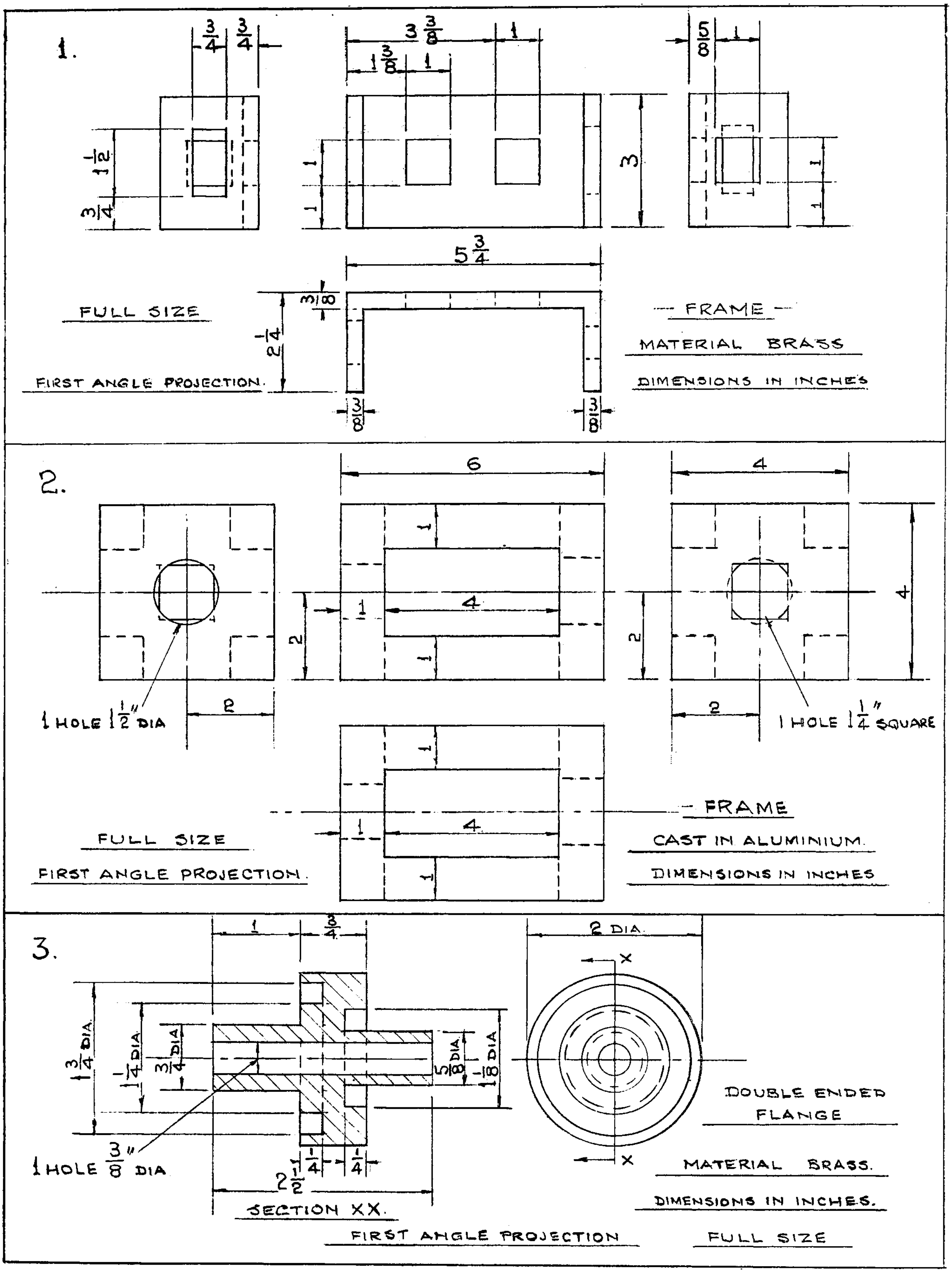

1.
FULL SIZE
FIRST ANGLE PROJECTION.
— FRAME —
MATERIAL BRASS
DIMENSIONS IN INCHES
2.
1 HOLE 1½" DIA
1 HOLE 1¼" SQUARE
FULL SIZE
FIRST ANGLE PROJECTION.
— FRAME
CAST IN ALUMINIUM.
DIMENSIONS IN INCHES
3.
1 HOLE ⅜" DIA
SECTION XX.
DOUBLE ENDED FLANGE
MATERIAL BRASS.
DIMENSIONS IN INCHES.
FIRST ANGLE PROJECTION
FULL SIZE

Fig. 68

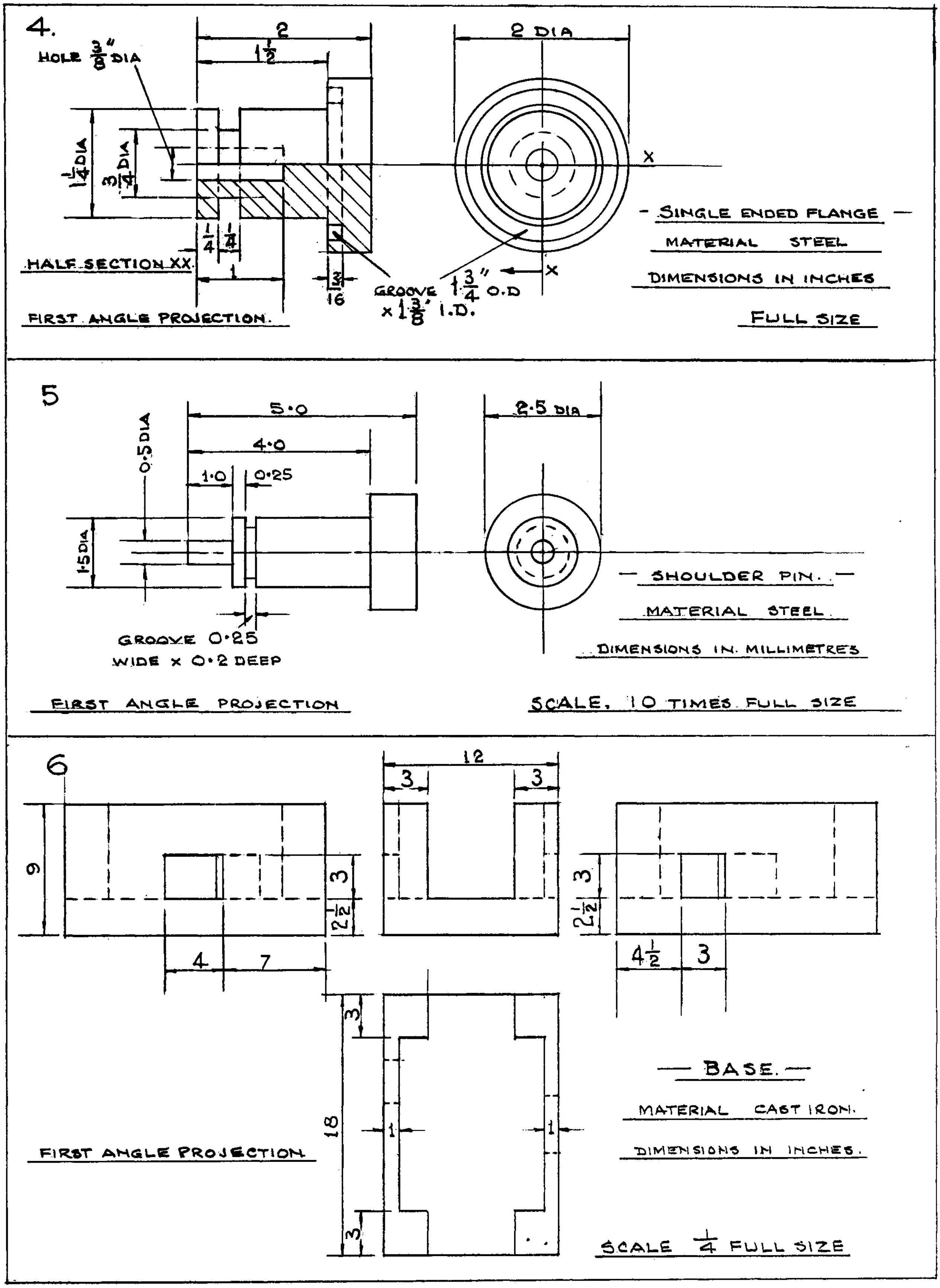

4.
HOLE 3/8" DIA
2
1 1/2
1 1/4 DIA
3/4 DIA
X
1/4
1/4
HALF SECTION XX
1
3/16
GROOVE 1 3/4" O.D × 1 3/8" I.D.
FIRST ANGLE PROJECTION.
2 DIA
— SINGLE ENDED FLANGE —
MATERIAL STEEL
DIMENSIONS IN INCHES
FULL SIZE
5
0·5 DIA
5·0
4·0
1·0
0·25
1·5 DIA
GROOVE 0·25 WIDE × 0·2 DEEP
FIRST ANGLE PROJECTION
2·5 DIA
— SHOULDER PIN. —
MATERIAL STEEL.
DIMENSIONS IN MILLIMETRES
SCALE. 10 TIMES FULL SIZE
6
9
3
2 1/2
4
7
12
3
3
3
2 1/2
4 1/2
3
3
18
1
1
3
FIRST ANGLE PROJECTION.
— BASE. —
MATERIAL CAST IRON.
DIMENSIONS IN INCHES.
SCALE 1/4 FULL SIZE

FIG. 69

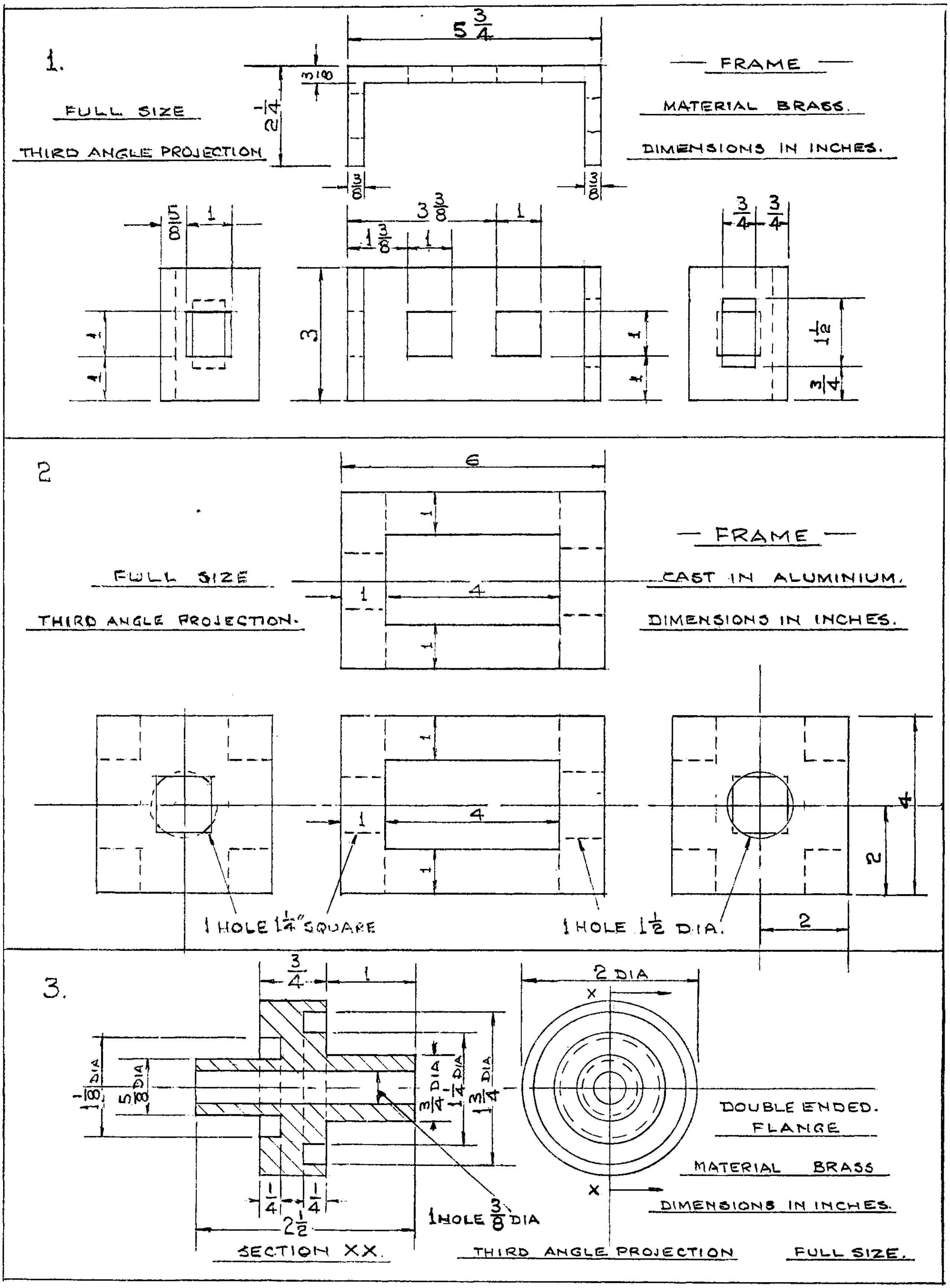

1.
FULL SIZE
THIRD ANGLE PROJECTION
FRAME
MATERIAL BRASS.
DIMENSIONS IN INCHES.
2
FULL SIZE
THIRD ANGLE PROJECTION.
FRAME
CAST IN ALUMINIUM.
DIMENSIONS IN INCHES.
1 HOLE 1¼" SQUARE
1 HOLE 1½ DIA.
3.
2 DIA
DOUBLE ENDED.
FLANGE
MATERIAL BRASS
DIMENSIONS IN INCHES.
1 HOLE ⅜ DIA
SECTION XX.
THIRD ANGLE PROJECTION
FULL SIZE.

Fig. 70

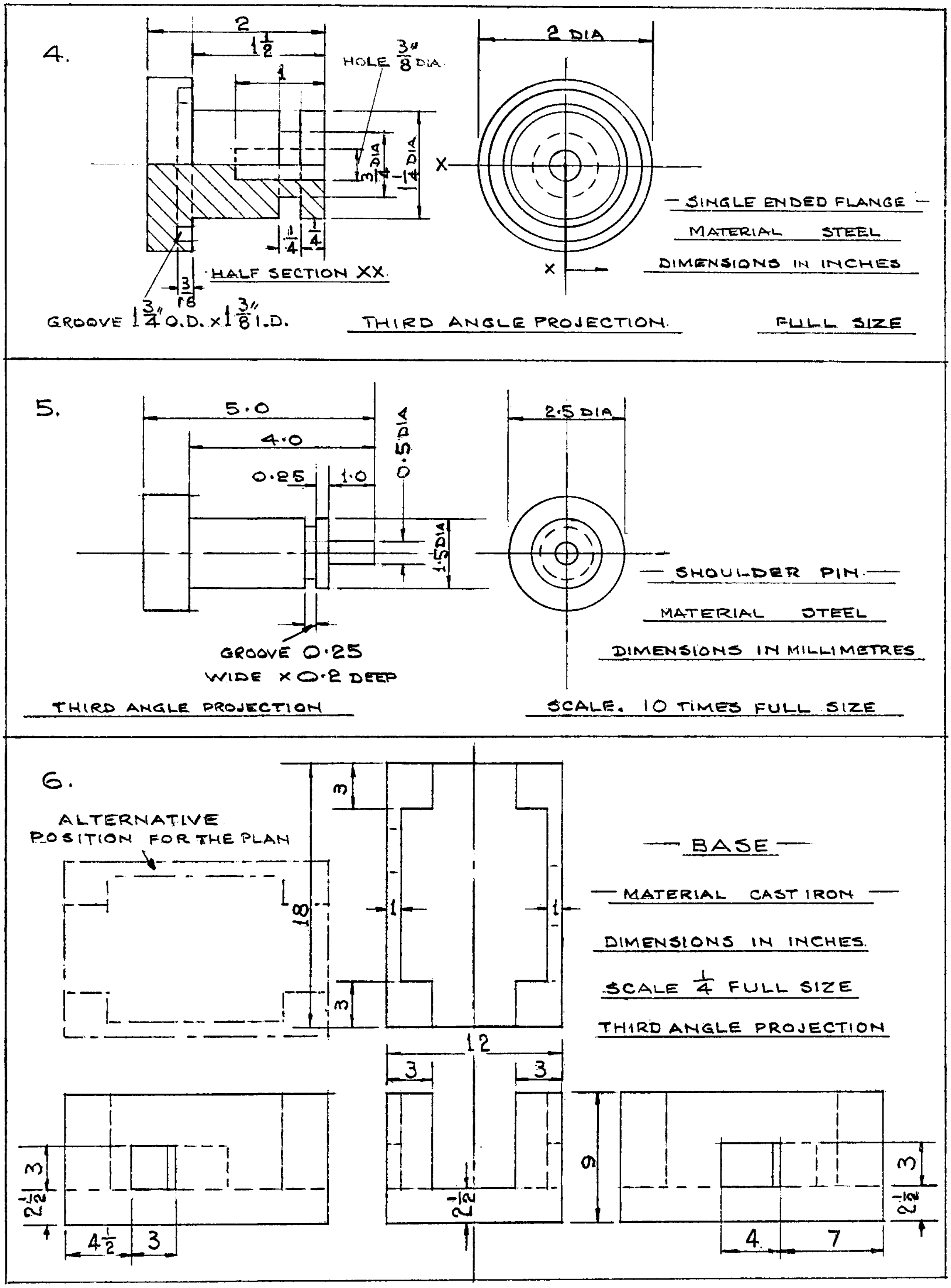

4.
HOLE 3/8" DIA.
2 DIA
X
HALF SECTION XX.
GROOVE 1 3/4" O.D. x 1 3/8" I.D.
THIRD ANGLE PROJECTION.
— SINGLE ENDED FLANGE —
MATERIAL STEEL
DIMENSIONS IN INCHES
FULL SIZE
5.
5·0
4·0
0·25
1·0
0·5 DIA
1·5 DIA
2·5 DIA
GROOVE 0·25 WIDE x 0·2 DEEP
— SHOULDER PIN —
MATERIAL STEEL
DIMENSIONS IN MILLIMETRES
THIRD ANGLE PROJECTION
SCALE. 10 TIMES FULL SIZE
6.
ALTERNATIVE POSITION FOR THE PLAN
— BASE —
— MATERIAL CAST IRON —
DIMENSIONS IN INCHES.
SCALE 1/4 FULL SIZE
THIRD ANGLE PROJECTION
12
3
18
9
4 1/2
4
7

Fig. 71

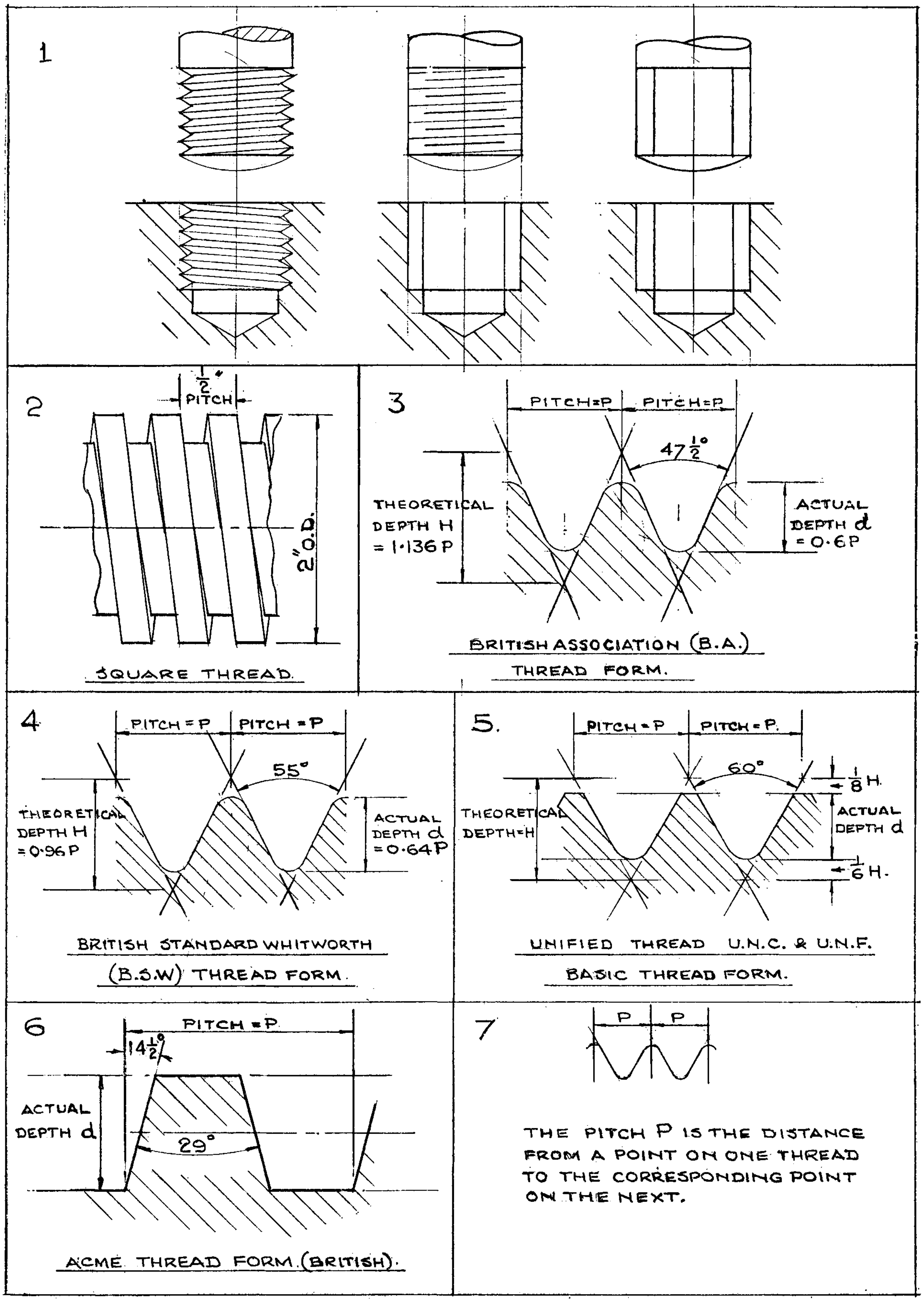
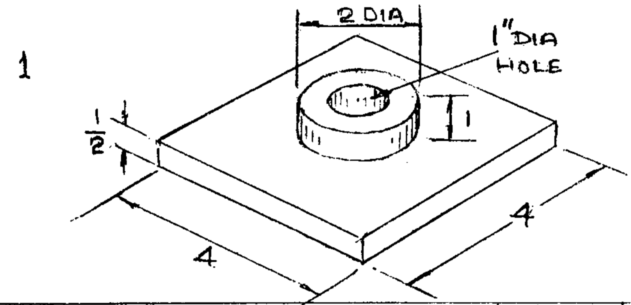
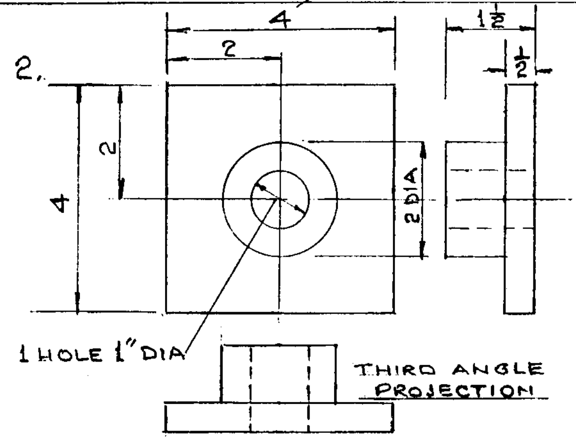
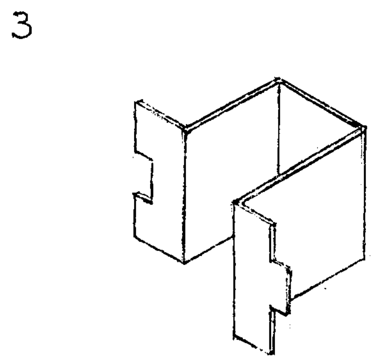
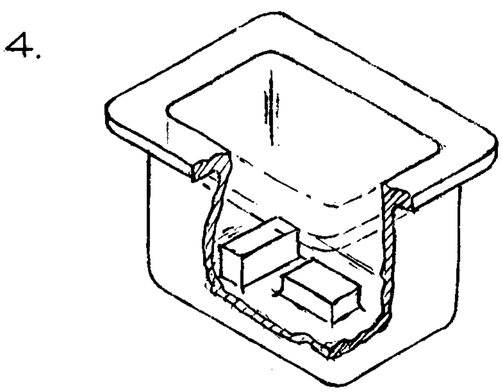

1
2
1/2" PITCH
2" O.D.
SQUARE THREAD.
3
PITCH=P
PITCH=P
47 1/2°
THEORETICAL DEPTH H = 1·136 P
ACTUAL DEPTH d = 0·6P
BRITISH ASSOCIATION (B.A.)
THREAD FORM.
4
PITCH = P
PITCH = P
55°
THEORETICAL DEPTH H = 0·96 P
ACTUAL DEPTH d = 0·64P
BRITISH STANDARD WHITWORTH
(B.S.W) THREAD FORM.
5.
PITCH = P
PITCH = P.
60°
1/8 H.
THEORETICAL DEPTH=H
ACTUAL DEPTH d
1/6 H.
UNIFIED THREAD U.N.C. & U.N.F.
BASIC THREAD FORM.
6
PITCH = P.
14 1/2°
ACTUAL DEPTH d
29°
ACME THREAD FORM.(BRITISH).
7
P
P
THE PITCH P IS THE DISTANCE
FROM A POINT ON ONE THREAD
TO THE CORRESPONDING POINT
ON THE NEXT.

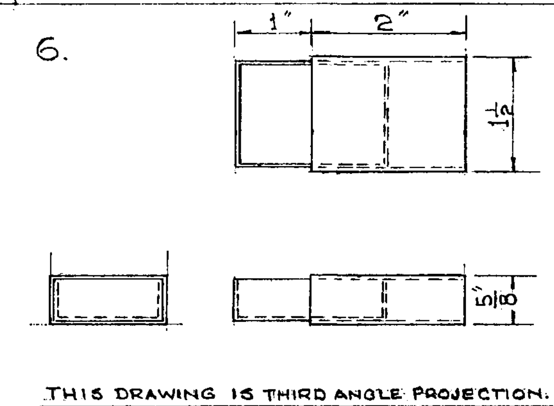
FIG. 72

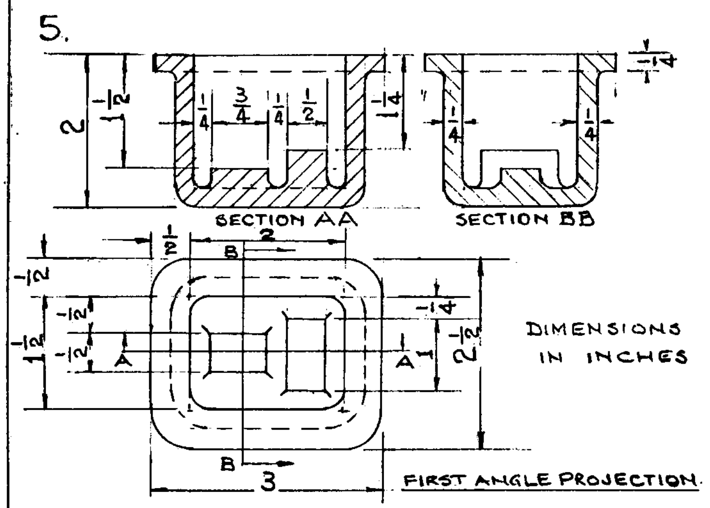












NOTE. ALL OF THESE DRAWINGS MUST BE DRAWN FULL SIZE.

NO DIMENSIONS ARE REQUIRED FOR QUESTIONS NUMBER 3 AND 4.

FIG. 73

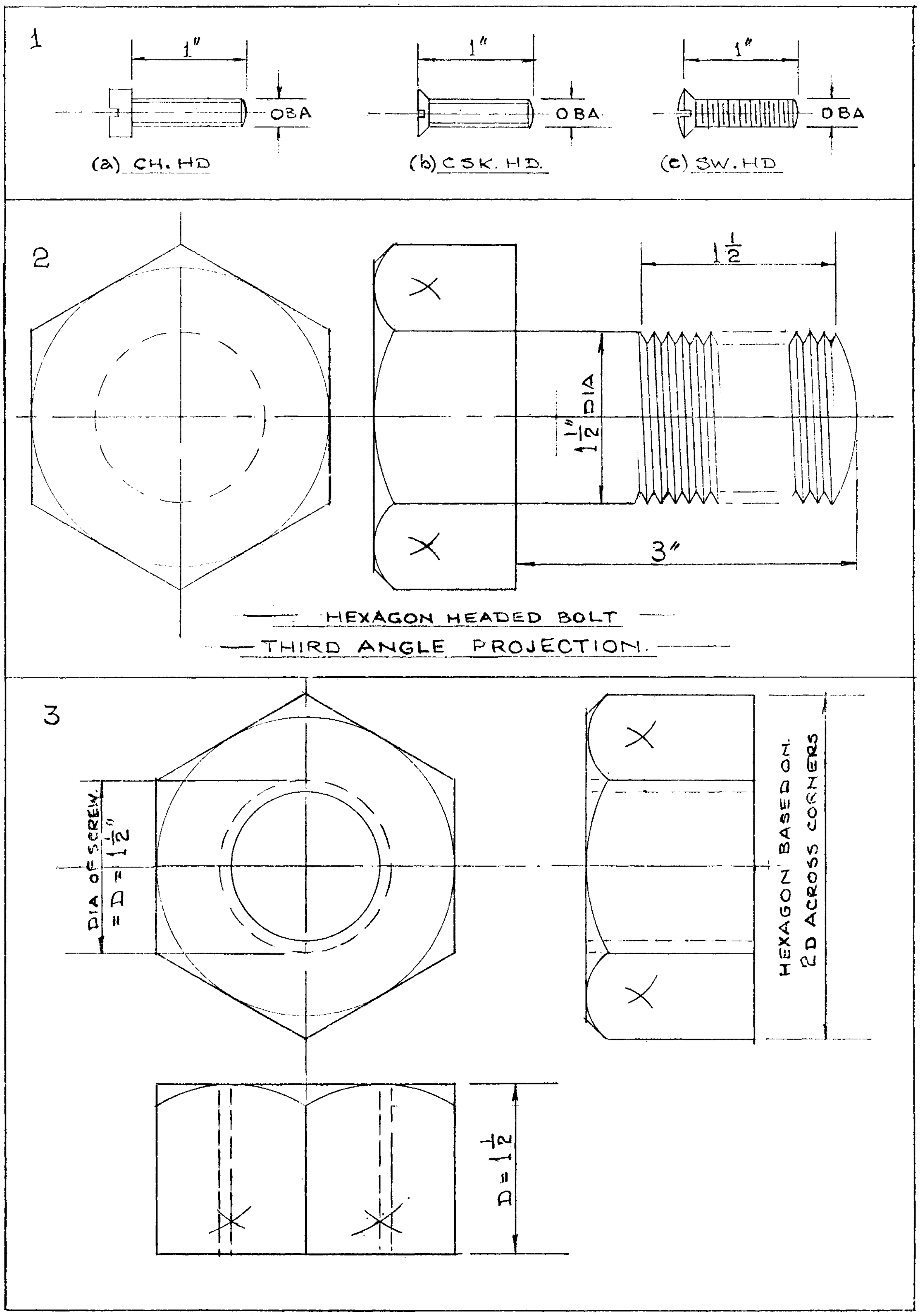
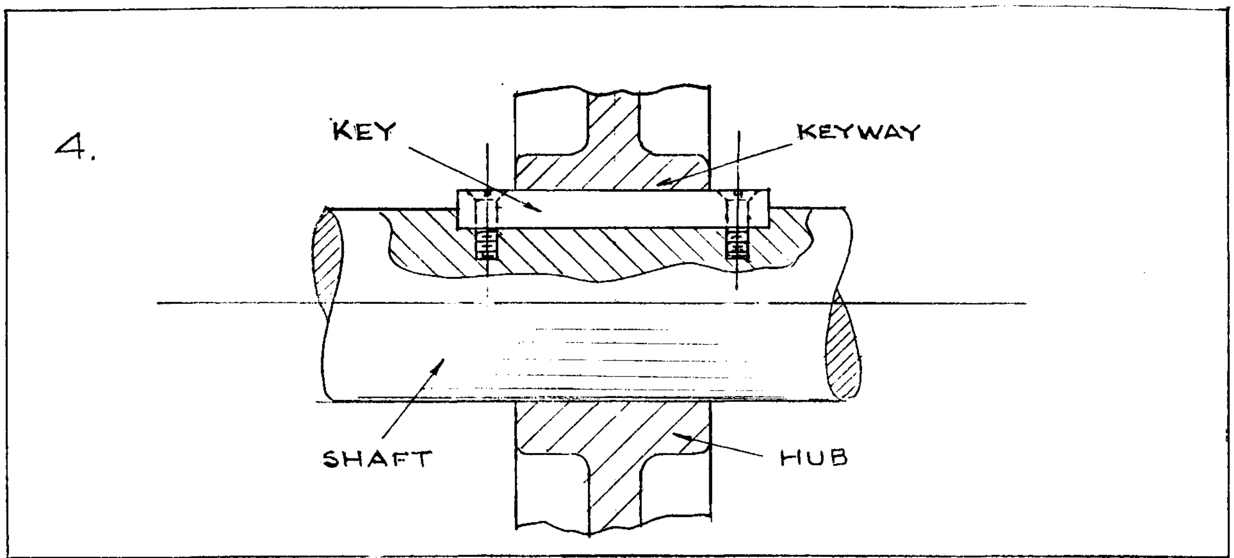
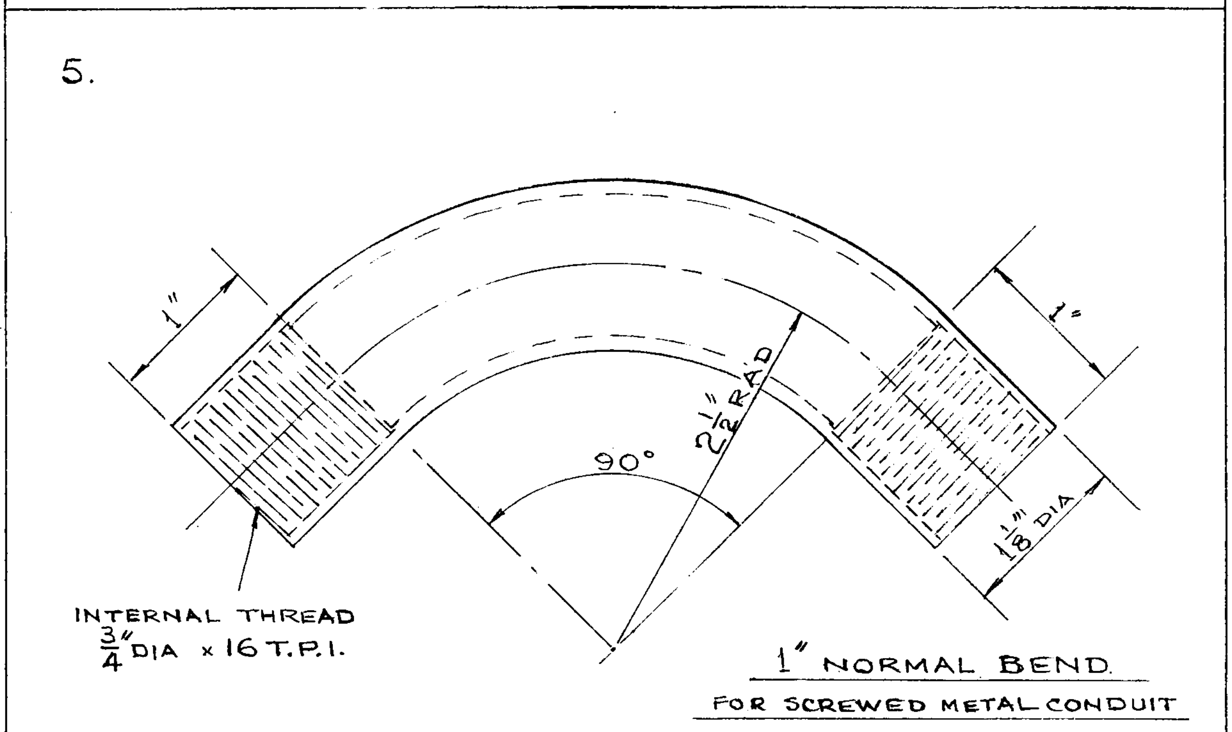

1
1"
OBA
(a) CH. HD
(b) CSK. HD.
(c) SW. HD
2
1½
1½" DIA
3"
HEXAGON HEADED BOLT
THIRD ANGLE PROJECTION.
3
DIA OF SCREW = D = 1½"
HEXAGON BASED ON 2D ACROSS CORNERS
D = 1½

FIG. 74


4.
KEY
KEYWAY
SHAFT
HUB


5.
1"
1"
$2\frac{1}{2}$" RAD
90°
$1\frac{1}{8}$" DIA
INTERNAL THREAD
$\frac{3}{4}$" DIA x 16 T.P.I.
1" NORMAL BEND
FOR SCREWED METAL CONDUIT

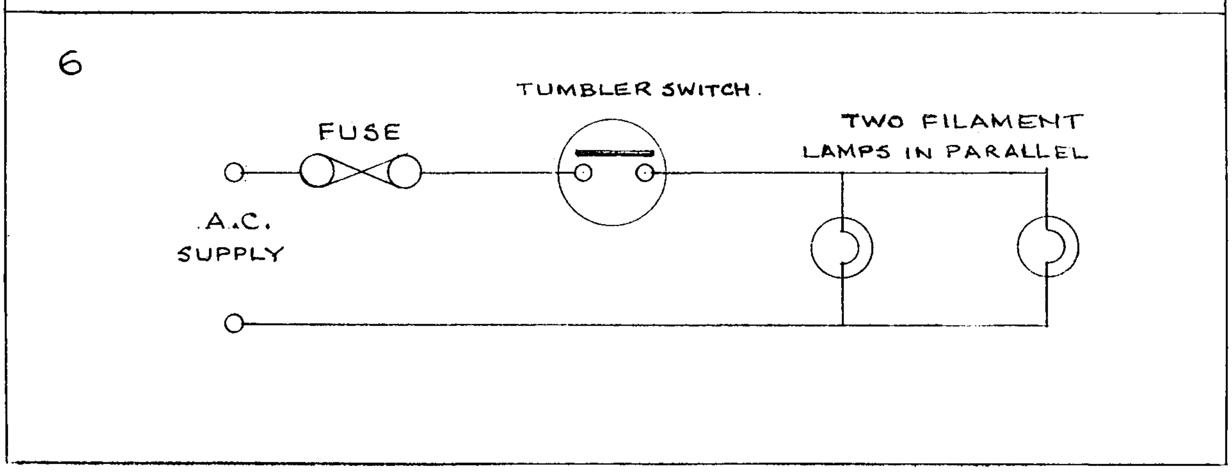

6
TUMBLER SWITCH.
FUSE
TWO FILAMENT
LAMPS IN PARALLEL
A.C.
SUPPLY

Fig. 75

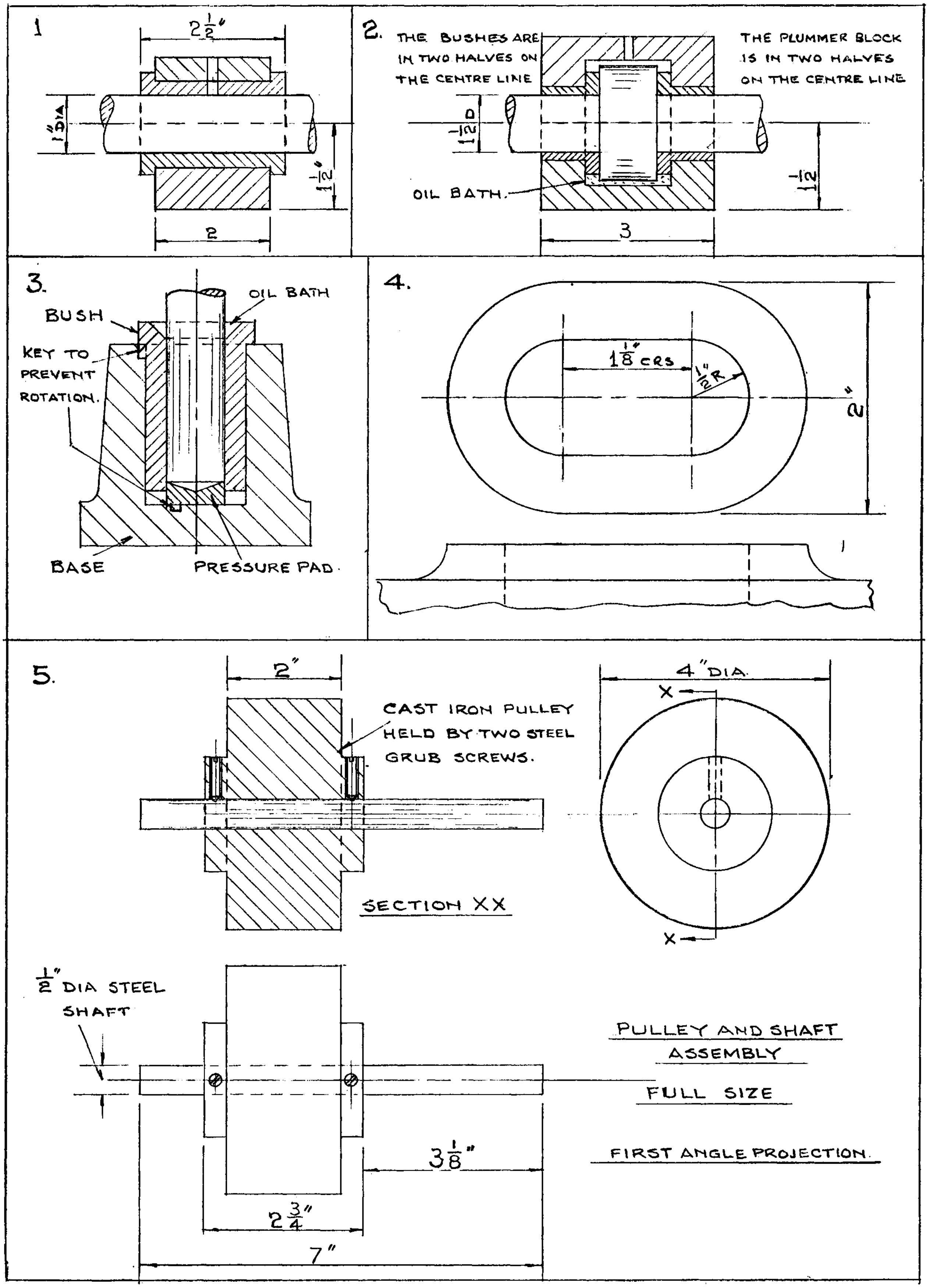

1
2½"
1" DIA
1½"
2
2.
THE BUSHES ARE IN TWO HALVES ON THE CENTRE LINE
THE PLUMMER BLOCK IS IN TWO HALVES ON THE CENTRE LINE
½ D
OIL BATH.
½
3
3.
BUSH
OIL BATH
KEY TO PREVENT ROTATION.
BASE
PRESSURE PAD.
4.
1⅛" CRS
½" R
2"
5.
2"
CAST IRON PULLEY HELD BY TWO STEEL GRUB SCREWS.
4" DIA.
X
SECTION XX
½" DIA STEEL SHAFT
PULLEY AND SHAFT ASSEMBLY
FULL SIZE
FIRST ANGLE PROJECTION.
3⅛"
2¾"
7"

Fig. 76

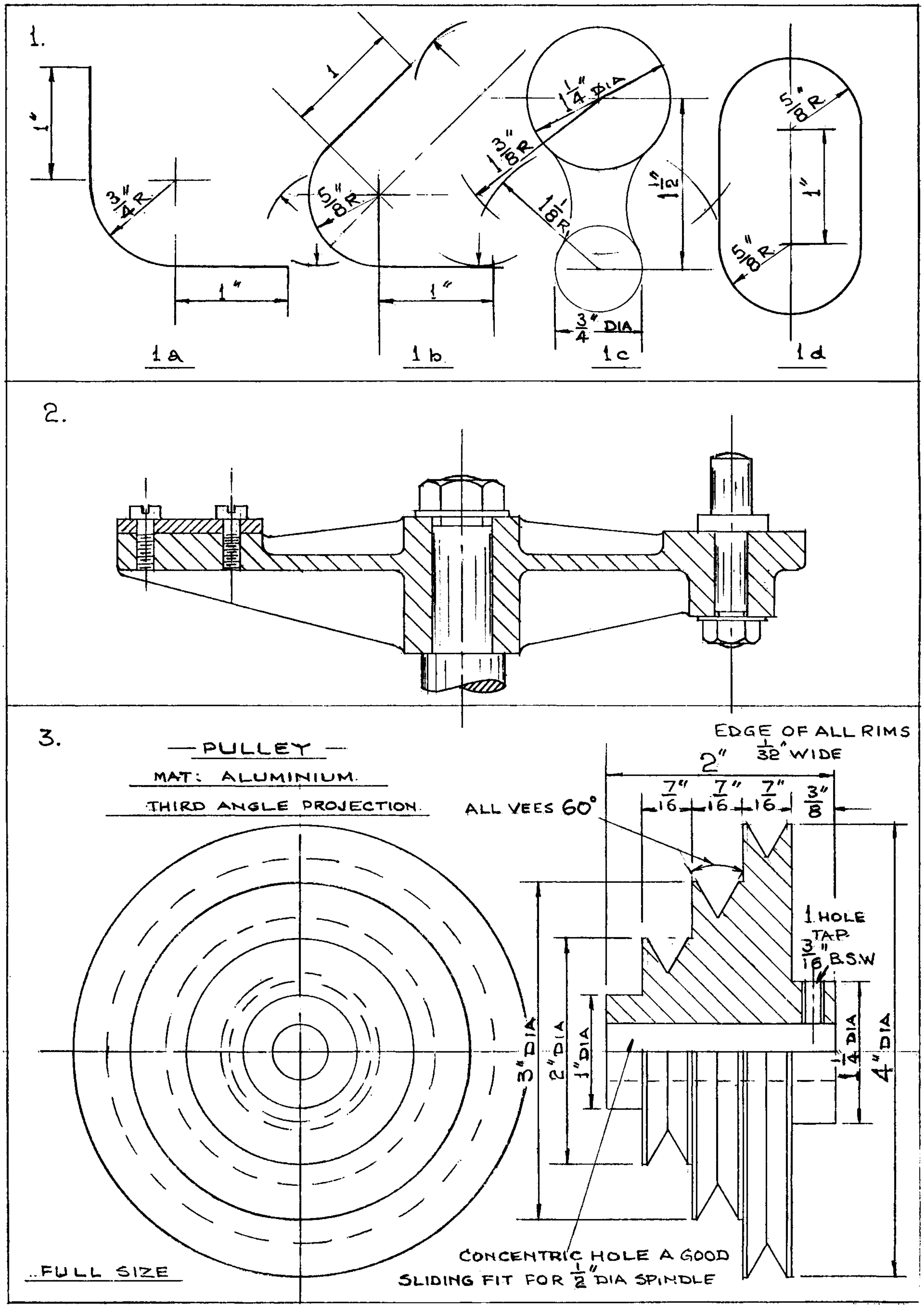

1.
1a
1b
1c
1d
3/4" R
5/8" R
1 3/8" R
1 1/4" DIA
1 1/8" R
3/4" DIA
1 1/2"
5/8" R
2.
3.
— PULLEY —
MAT: ALUMINIUM.
THIRD ANGLE PROJECTION.
EDGE OF ALL RIMS 1/32" WIDE
2"
7/16" 7/16" 7/16" 3/8"
ALL VEES 60°
1 HOLE TAP 3/16" B.S.W
3" DIA
2" DIA
1" DIA
1 1/4" DIA
4" DIA
CONCENTRIC HOLE A GOOD SLIDING FIT FOR 1/2" DIA SPINDLE
FULL SIZE

Fig. 77

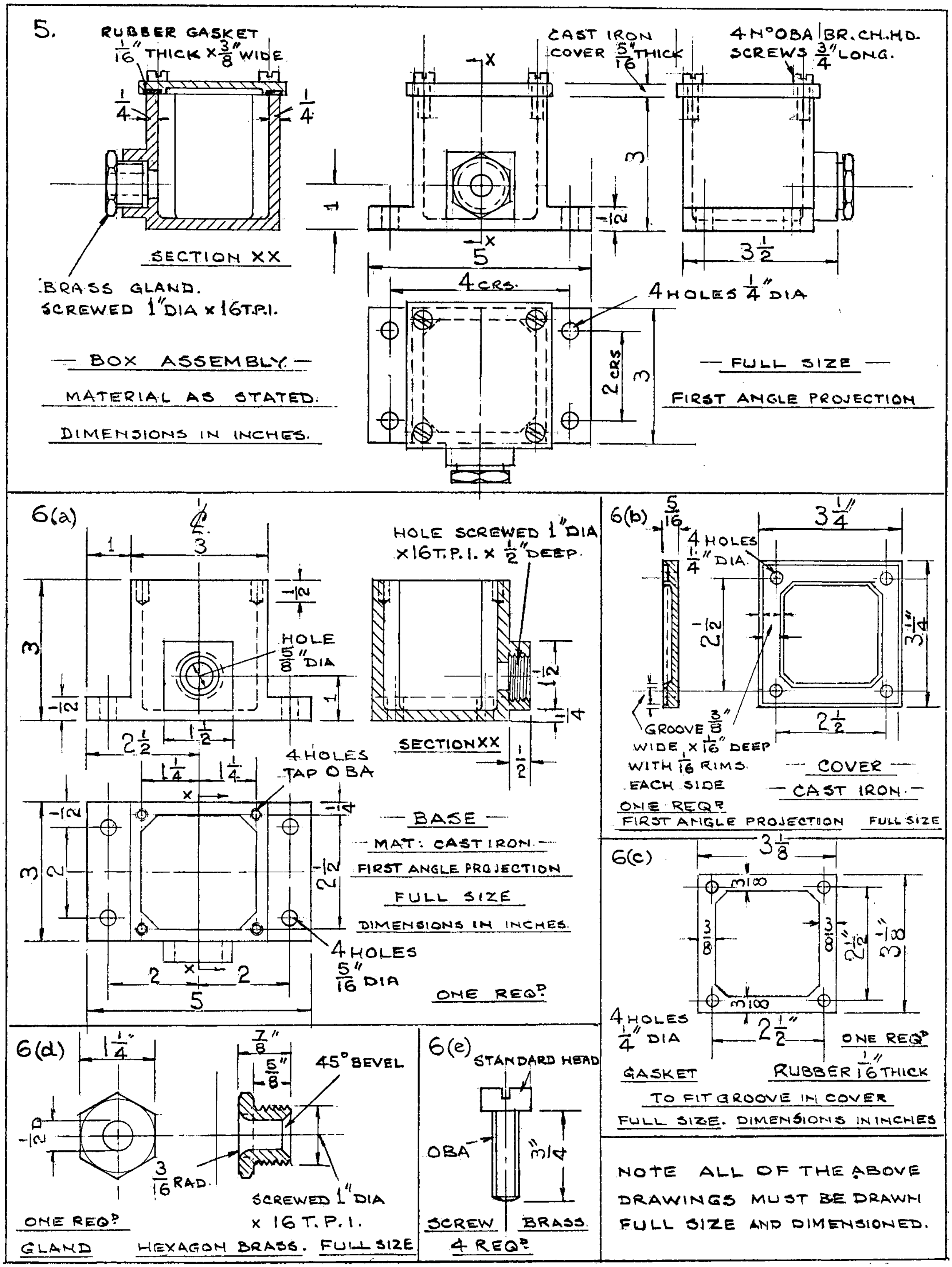

5.
RUBBER GASKET 1/16" THICK × 3/8" WIDE
CAST IRON COVER 5/16" THICK
4 Nº OBA BR. CH. HD. SCREWS 3/4" LONG.
SECTION XX
BRASS GLAND. SCREWED 1" DIA × 16 T.P.I.
4 CRS.
4 HOLES 1/4" DIA
2 CRS
— BOX ASSEMBLY —
MATERIAL AS STATED.
DIMENSIONS IN INCHES.
— FULL SIZE —
FIRST ANGLE PROJECTION
6(a)
HOLE 5/8" DIA
HOLE SCREWED 1" DIA × 16 T.P.I. × 1/2" DEEP.
SECTION XX
4 HOLES TAP O BA
— BASE —
— MAT: CAST IRON —
FIRST ANGLE PROJECTION
FULL SIZE
DIMENSIONS IN INCHES.
4 HOLES 5/16" DIA
ONE REQD.
6(b)
4 HOLES 1/4" DIA.
GROOVE 3/8" WIDE × 1/16" DEEP WITH 1/16 RIMS. EACH SIDE
— COVER —
— CAST IRON —
ONE REQD.
FIRST ANGLE PROJECTION
FULL SIZE
6(c)
4 HOLES 1/4" DIA
ONE REQD.
GASKET
RUBBER 1/16" THICK
TO FIT GROOVE IN COVER
FULL SIZE. DIMENSIONS IN INCHES
6(d)
45° BEVEL
3/16 RAD.
SCREWED 1" DIA × 16 T.P.I.
ONE REQD.
GLAND
HEXAGON BRASS. FULL SIZE
6(e)
STANDARD HEAD
OBA
SCREW
BRASS.
4 REQD.
NOTE ALL OF THE ABOVE DRAWINGS MUST BE DRAWN FULL SIZE AND DIMENSIONED.

FIG. 78

Author's Note

Now that the end of Volume I has been reached, the author hopes that the student, after much diligence and constant practice, will have reached a state of keenness to wish to attempt Volume II

When writing this book, the intention was to enable the student to learn from it the art of engineering drawing, possibly without the help of a teacher if one was not immediately available.

That object will have been achieved in large part if the student reaches this point satisfactorily, for if more students can *make* an engineering drawing, then more potential engineers will be able to *read* a drawing with intelligence and speed, and thereby effectively contribute to the efficiency of the national engineering education.