AIRCRAFT ENGINE DRAFTING ROOM PRACTICE

NOVEMBER 1, 1941

Society of Automotive Engineers, Inc.
29 West 39th Street
New York

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CONTENTS

INTRODUCTION

The rapid expansion of the aircraft engine industry has demonstrated the necessity of a standardized procedure for the preparation of the mechanical drawings that serve as the means of communication between the engineering, manufacturing, and inspection branches of the industry and its subcontractors.

To fulfill this need, Subcommittee E-8 of the Aircraft Engine Subdivision, Aeronautics Division, Society of Automotive Engineers, has prepared this manual of "Aircraft Engine Drafting Room Practice." In compiling these recommended practices, the Committee has consulted all available manuals, both published and unpublished, prepared by the Air Corps and various aircraft engine manufacturers to suit their individual needs. The new SAE Aircraft Engine Drafting Room Practice embodies information which these reference manuals were found to have in common, as well as heretofore controversial practices on which agreement has been obtained, and insofar as possible conflict with individual requirements has been avoided.

It is believed, therefore, that this manual forms a sound basis for a uniform and standardized drafting (room) procedure which, followed by aircraft engine draftsmen, will result in the preparation of drawings complete in their attention to the detail necessary if they are to serve their intended purpose — a common language for all who must use them.

Subcommittee E-8 on Drafting Room Practices will continue to function, and additional material for inclusion in this manual will be published in loose leaf form as work progresses. Constructive criticism and suggestions from qualified sources will be welcomed.

The Committee wishes to acknowledge the use of the American Standards Association Manual ASA-Z14.1-1935, as well as the individual aircraft engine company manuals made available to the entire committee by its member representatives from the various organizations.

November 1, 1941

SECTION A

PREPARATION OF DRAWING

ARRANGEMENT OF VIEWS

1 All views should be **third angle projection.**

OPTIONS

2 The methods of dimensioning and the preparation of drawings outlined herein are the **preferred forms,** but acceptable options are also shown. Each organization should decide on a preferred option and consistently follow same in its own drafting room practice.

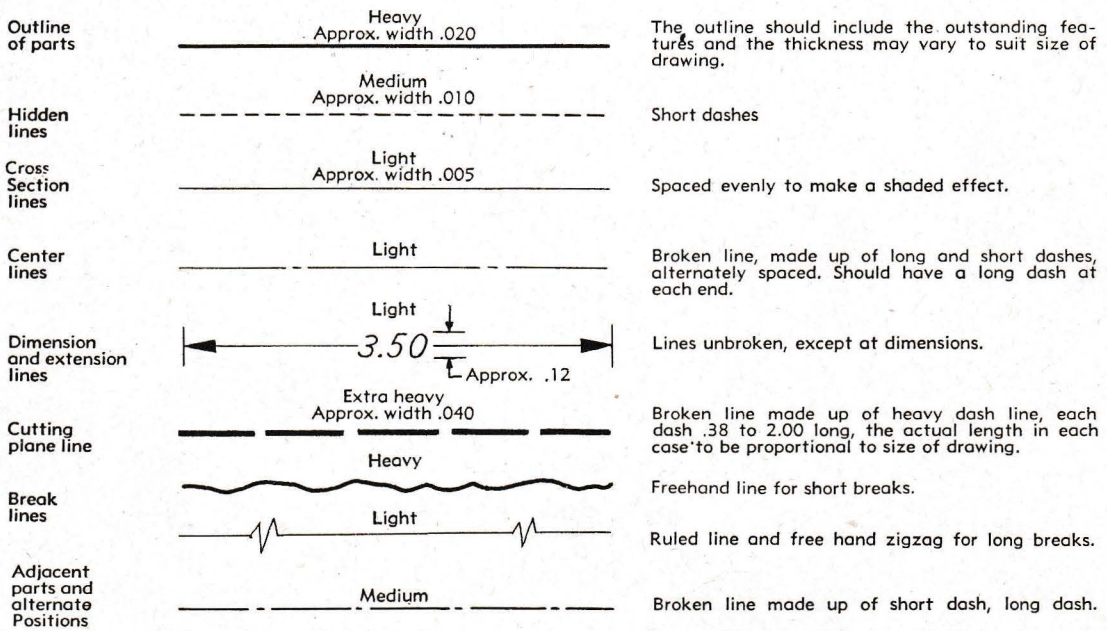
LINES AND LINE WORK

3 LINE CHARACTERISTICS. It is recommended that the conventional line symbols shown in Fig. 1 be used on all engineering drawings. All lines should be clean and black, to permit of process reproduction of the drawing. As few hidden lines as practicable should be shown as sections are preferable in most cases. The actual width of each type of line should be governed by the size and style of the drawing. The relative widths of the lines should be approximately in accordance with those shown in Fig. 1.

4 Four **weights** of lines, extra heavy, heavy, medium and light, are shown and are considered desirable on finished ink drawings, because of improved legibility and appearance. However, in simplified practice, and in particular on penciled drawings from which blueprints are to be made, this may be reduced to two weights, medium and light.

5 For **pencil drawings** the lines should be in proportion to the ink lines, medium for outlines, hidden, cutting-plane, short breaks, adjacent-part and alternate-position lines and light for section, center, extension, dimension and long break lines.

Fig. 1



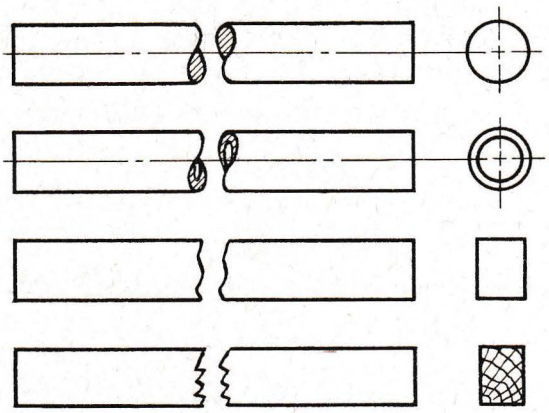


Fig. 2

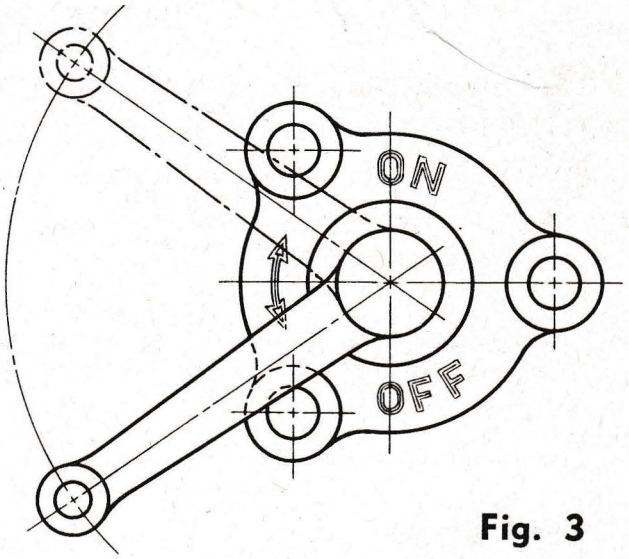


Fig. 3

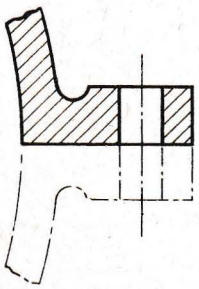


Fig. 4

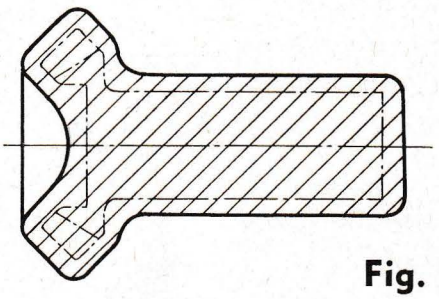


Fig. 5

6 Dimension lines should be light lines, unbroken except for the space left for the dimension. Extension lines should be light full lines of the same weight as dimension lines and should not touch the outline of the object. See paragraph 23.

7 Break lines may be used on both detail and assembly drawings. On small parts heavy freehand lines are best, while on assemblies or large parts the second form, made with light ruled lines with freehand zigzags is preferred. The method of indicating the ends of shafts, rods, tubes, etc., which have a portion of the length broken out is shown in Fig. 2.

8 An alternate position, or indication of the limiting positions of a moving part should be shown by a line made up of long and short dashes of medium weight as shown by Fig. 3.

Adjacent parts added on a drawing to indicate the position or use of the piece represented are drawn with the same type of long and short dash lines as shown by Fig. 4. This line is also used in showing lugs cast on for holding purposes, which are to be removed later and is used to indicate finished contours of parts on drawings of forgings and castings. See Fig. 5.

9 On layouts, adjacent parts may be shown as solid red lines instead of black short and long dash lines when this is acceptable to the chief draftsman.

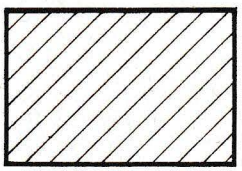
SECTIONAL VIEWS

10 GENERAL. Cross sectional views commonly referred to as "sections" should be used when the interior construction cannot be shown clearly by outside views. A sectional view should be made as if the nearest part of the object were cut or broken away. The exposed cut surface of the material is indicated by "cross sectioning" with uniformly spaced light lines. Hidden lines and details beyond the cutting plane should be omitted unless required for the necessary description of the object.

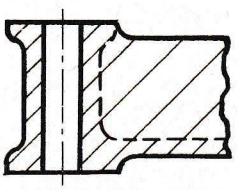
Symbolic cross sectioning for the graphic indication of various materials of con-

Fig. 6

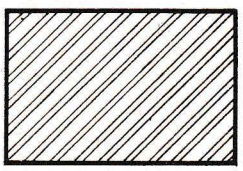
Symbols for Cross Sections



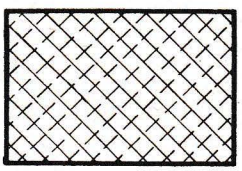
CAST IRON



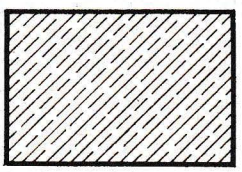
METHOD OF CROSS SECTIONING RIBS AND WEBS



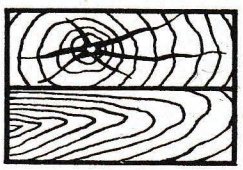
STEEL



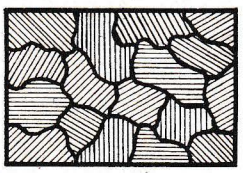
MAGNESIUM, ALUMINUM AND ALUMINUM ALLOYS



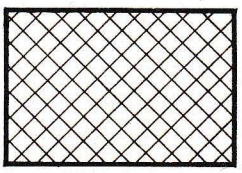
BRONZE, BRASS, COPPER AND COMPOSITIONS



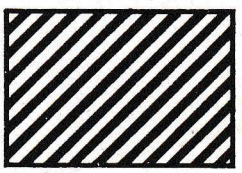
WOOD



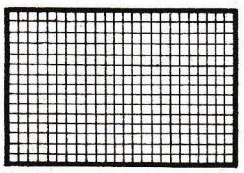
ASBESTOS



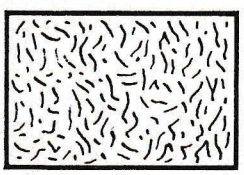
LEAD, BABBITT, ZINC, WHITE METAL AND ALLOYS



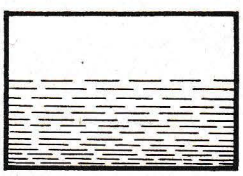
ELECTRIC INSULATION, RUBBER, PLASTIC, FIBRE, MICA, ETC.



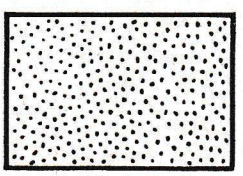
ELECTRIC WINDINGS, ETC.



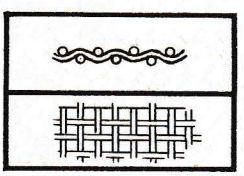
CORK, FELT AND LEATHER



LIQUID



SALT



WIRE MESH

struction may be used when it is desired to call special attention to, or to identify certain parts. See Fig. 6.

All assembly drawings should be cross-sectioned as specified for the pertinent materials.

All detail drawings should be cross-sectioned as cast iron, except details of multi-material parts, which may be cross-sectioned as specified for assembly drawings.

Layouts which will not be printed for distribution outside the plant may have sections lightly colored with crayon when preferred.

11 CUTTING PLANE. The cutting plane on which a section has been taken should be indicated by an extra heavy dash line and lettered at the ends, as shown by Section B-B in Fig. 7. Section identification lettering should be made to read horizontally and should not be underlined. Arrows should be used to indicate the direction in which the section is viewed. It is not necessary for the cutting plane to be a single continuous plane; it may be bent or offset if, by this practice, the construction can be shown to better advantage. See Section B-B Fig. 7. When the cutting plane extends entirely

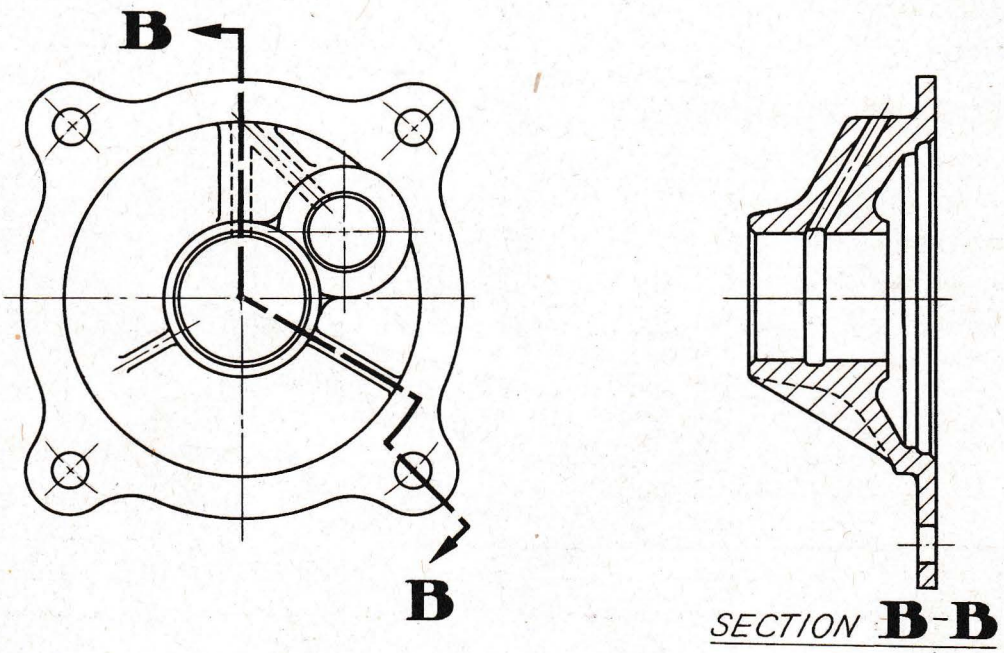


Fig. 7

across the object, a full section is obtained. A symmetrical object may be drawn as a half section showing one half (up to the centerline) in section and the other half in full, as illustrated by Fig. 8. For sections taken on the centerline the extra heavy line, letters and arrows may be omitted. Cross sectional views should be projected from, and perpendicular to, the cutting plane, wherever possible.

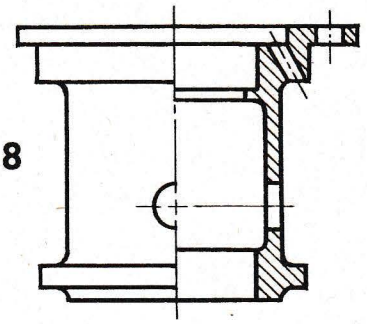


Fig. 8

12 REVOLVED SECTIONS. Revolved sections are designed to show the shape of the cross section on the actual view of a part (such as a wrench), the cutting plane being rotated in place. See Fig. 9. Detail sections should be drawn similarly except that they should be placed to one side. See Section B-B of Fig. 7. They are often made to larger scale than the view on which they are indicated.

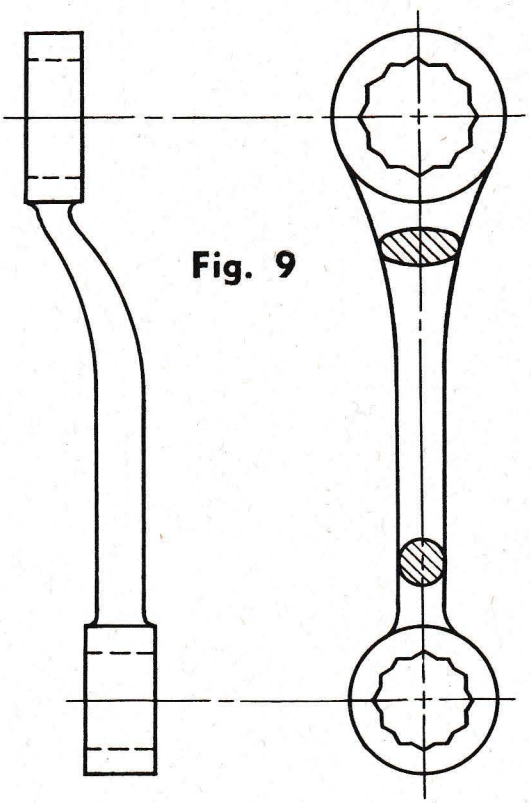


Fig. 9

13 OTHER TYPE OF SECTIONS. Broken-out sections should be used where a sectional view of only a portion of an object is needed. See Fig. 12.

14 CROSS SECTIONING. Cross sectioning should be made with light parallel lines at an angle of 45 deg. to the base line of the section and should be spaced from .03 in. to .25 in. depending on the size of the drawing and of the part. Two adjacent parts should be sectioned in

Fig. 10

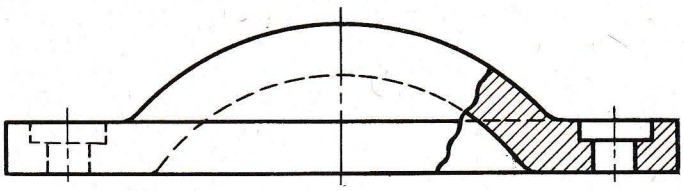
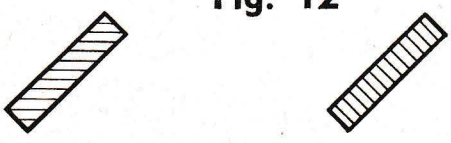


Fig. 12



CORRECT *INCORRECT*

CORRECT

Fig. 11

INCORRECT

different directions. A third part, adjacent to both, should be sectioned at an angle of 30 deg. or 60 deg. If cut in more than one place the sectioning of any part should be the same in direction and spacing. If the shape or position of the part causes 45 deg. sectioning to be parallel or nearly parallel to one of the sides, another angle should be chosen. See Fig. 11.

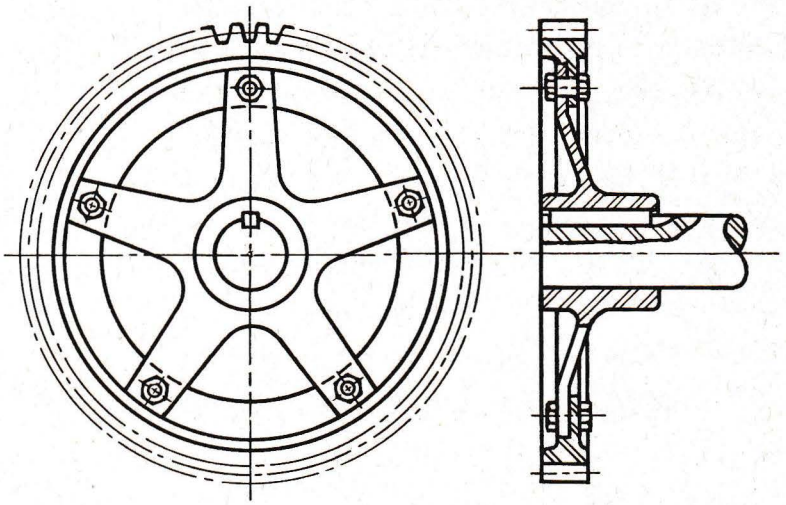


Fig. 13

15 Proper cross-sectioning when three parts of the same or a different material are adjacent is shown in Fig. 10.

16 EXCEPTIONS. There is one important departure from the conventional theory of cross-sectioning practice that is made in the interest of clarity. When the cutting plane passes through a rib, web, or similar parallel element, section lines should be drawn with the rib cross-sectioned with one-half the number of lines as the web. See Fig. 7 and Fig. 6, rib and webs. Shafts, bolts, nuts, rods, rivets, keys, pins and similar parts whose axes lie in the cutting plane should not be sectioned. See Fig. 13.

When the true projection may be misleading, portions such as ribs or arms should be rotated until parallel to the plane of the section or projection. The method of representation shown in Fig. 13, for example, is preferred to the true projection.

DIMENSIONING

17 GENERAL. All drawings should be so dimensioned that nothing is left to judgment. Original details should be drawn to scale. The dimensions given should include all sizes and distances necessary to provide a complete working drawing and should be so presented that computations will not be necessary.

18 Dimensions should not be duplicated and none should be given except those required to produce and inspect the part.

19 Decimals should be used throughout. (See Section B, Decimal System of Dimensioning).

20 When dimensioning wire, tubing walls, sheet metal, standard structural sections, etc., thickness should be given with decimals and tolerances arranged according to the method outlined in Section F.

21 DIMENSION LINES, EXTENSION LINES AND LEADERS. Dimension lines should be light full lines (broken where dimension is inserted) so as to contrast with the heavier outline of the drawing, and should be placed outside the figure wherever possible. Dimension lines should be at least .50 away from outlines and uniformly spaced at least .38 distant from each other. See Fig. 14.

22 Dimension lines should be terminated by carefully made arrow-heads with sharp point and square back not more than .06 wide and .16 long. The distance from tip to tip of the arrow-heads indicates the extent of the dimension.

23 Extension lines indicate the distance measured when the dimension is placed outside the figure. They are made as light, full lines starting approximately .03 away from the outline and extending approximately .10 beyond the dimension line. See Fig. 14.

24 Leaders should be made up of light straight lines terminated by arrow-heads. See Fig. 15. They should be curved only where absolutely necessary.

25 A center line should never be used as a dimension line. A line of the piece or part illustrated or an extension of such a line should not be used as a dimension line. See Fig. 16.

26 DIMENSION FIGURES. A dimension line must not pass through a dimension

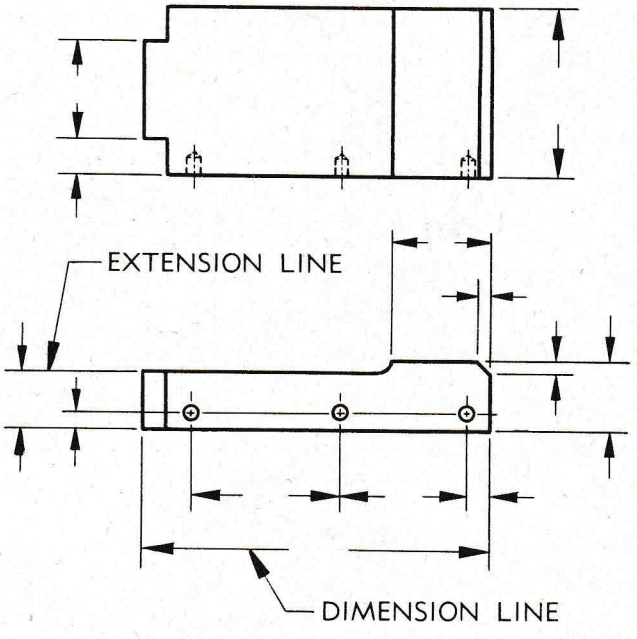


Fig. 14

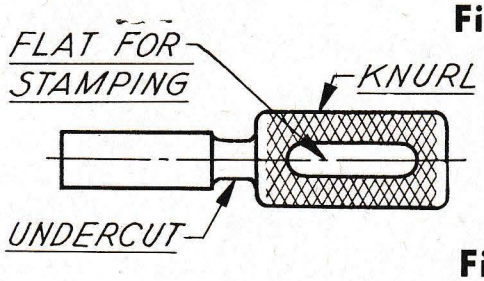


Fig. 15

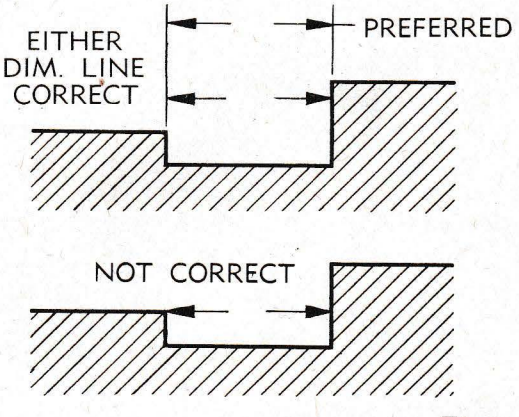
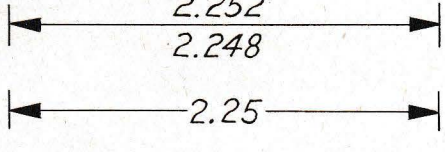


Fig. 16

Fig. 18



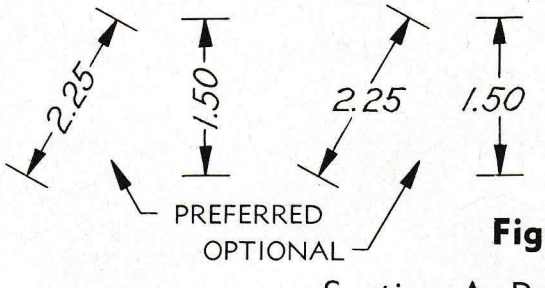


Fig. 17

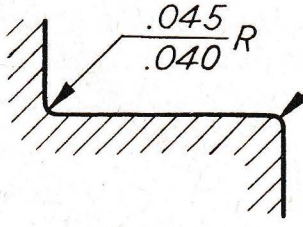
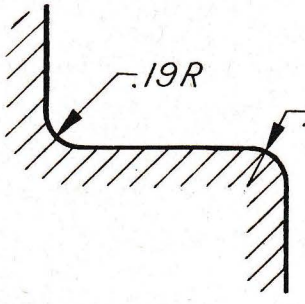
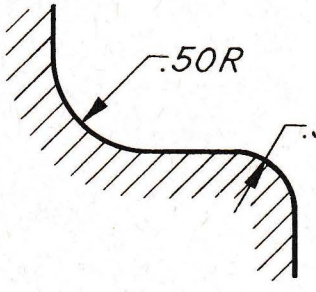


Fig. 19

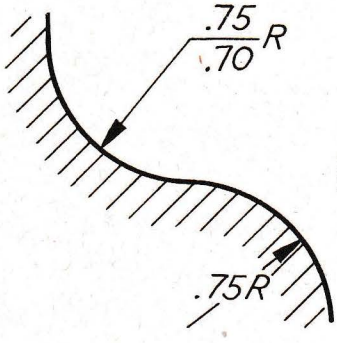
For radii up to .13 leader must pass thru center when dimensioned from concave side of arc; leader extended should pass thru center when dimensioning from convex side of arc.



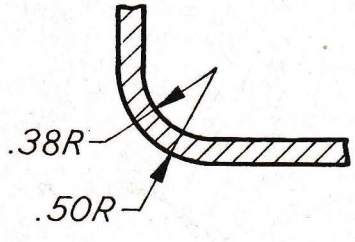
For radii from .13 to .25.



For radii from .25 to .63.



For radii .63 and larger.



Method of dimensioning radii close together.

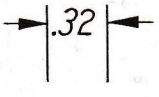
figure. Dimension lines should be broken where single dimensions and/or notes are inserted and may be continuous where figures are placed above and below line as in limits. See Fig. 18.

27 All dimension lines and their corresponding dimensions should be placed so that they may be read from the bottom or right hand edges of the drawing. See Fig. 17.

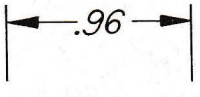
28 When there are several parallel dimension lines the dimensions should be staggered to avoid confusion. See Fig. 21.

29 Dimensions should be given from a base line, a center line, an important hole or a finished surface that can be readily established. See Fig. 22.

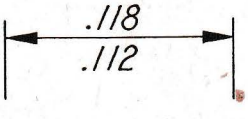
Arrangement of dimensions up to .31.



Arrangement of dimensions from .32 up to .50.



Arrangement of dimensions above .50. Arrangement of dimensions without limits.



Arrangement of dimensions with limits.

Fig. 20

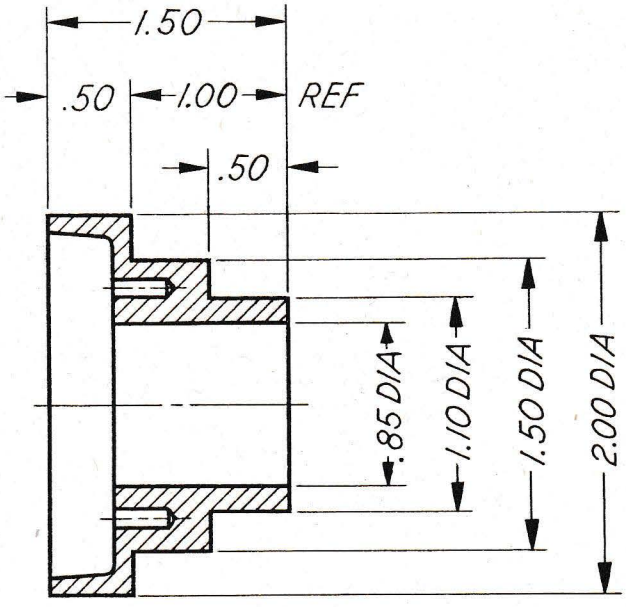


Fig. 21

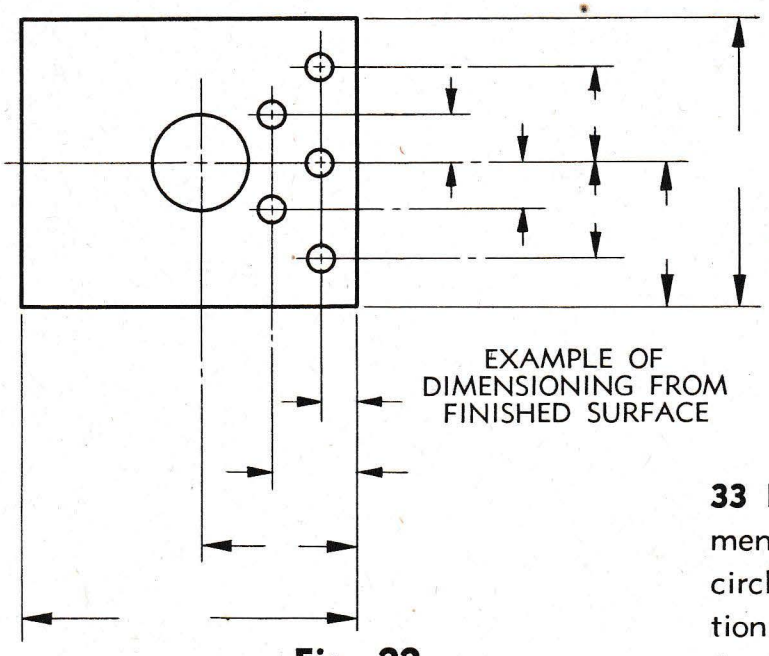


Fig. 22

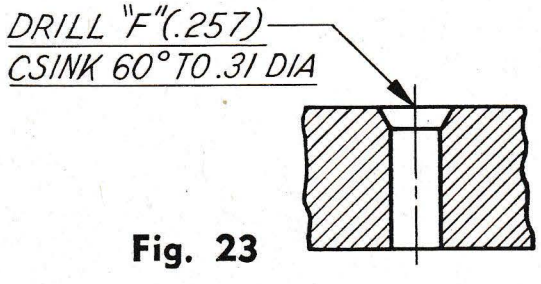


Fig. 23

30 Over-all dimensions should be placed outside the intermediate dimensions, as illustrated by Fig. 21 and Fig. 22. In dimensioning with tolerances, if an over-all dimension is used one intermediate distance should not be dimensioned, unless for reference and so noted. See Fig. 21.

31 For dimensioning in limited space the arrow-heads should be reversed and methods shown in Fig. 20 may be used.

32 In dimensioning angles an arc should be drawn, using the apex of the angle as its center, and the dimension placed so as to read from the horizontal position. See Fig. 24.

33 DIMENSIONING CIRCLES. A dimension indicating the diameter of a circle shold be followed by the abbreviation DIA except where it is obvious from the drawing that the dimension is a diameter. See Fig. 25.

The dimension of a radius should always be followed by the abbreviation R, and the dimension lines should have one arrow-head only. See Fig. 19. The center may be indicated by a cross, dot or circle.

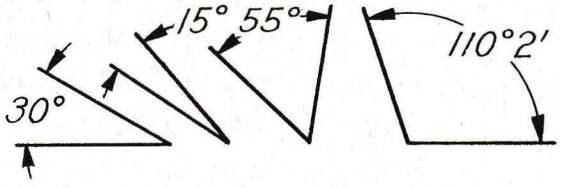


Fig. 24

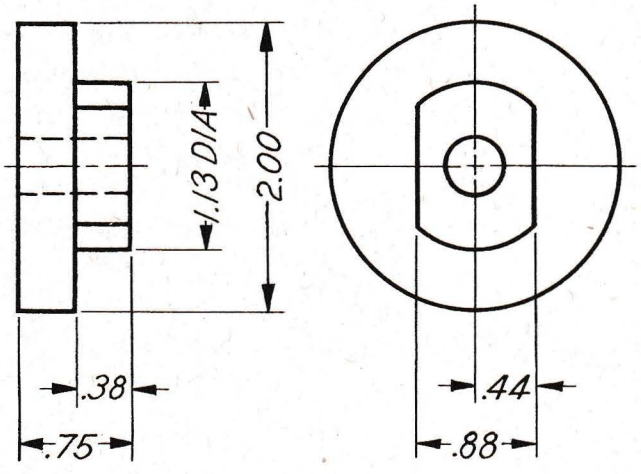


Fig. 25

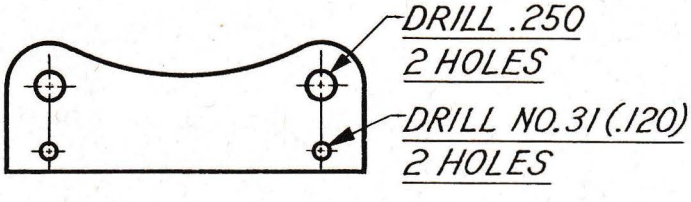


Fig. 26

34 DIMENSIONING HOLES. Holes which are to be drilled, reamed, punched, swaged, or cored should have the diameter, given preferably on a leader, preceded by the word indicating the operation, and followed by the number of holes to be so made. See Fig. 26.

35 For counterbored holes the diameters and depths should be given and for countersunk holes the angles and diameters should be given. See Fig. 23. The value of the countersink angle should be given as the included angle.

36 METHODS OF DIMENSIONING HOLES IN BOSSES, FLANGES, ETC. Figures 27, 28 and 29 illustrate the coordinate method of dimensioning of holes. The actual numerical values shown for the location of holes in these figures have been included for illustrative purposes only. The alignment of holes in two or more parts requires similar dimensioning from a common datum point. The recommended tolerances on the location of holes are as follows:

(a) Dowel holes ±.001
(b) Gasket holes ±.01
(c) All other holes ±.005

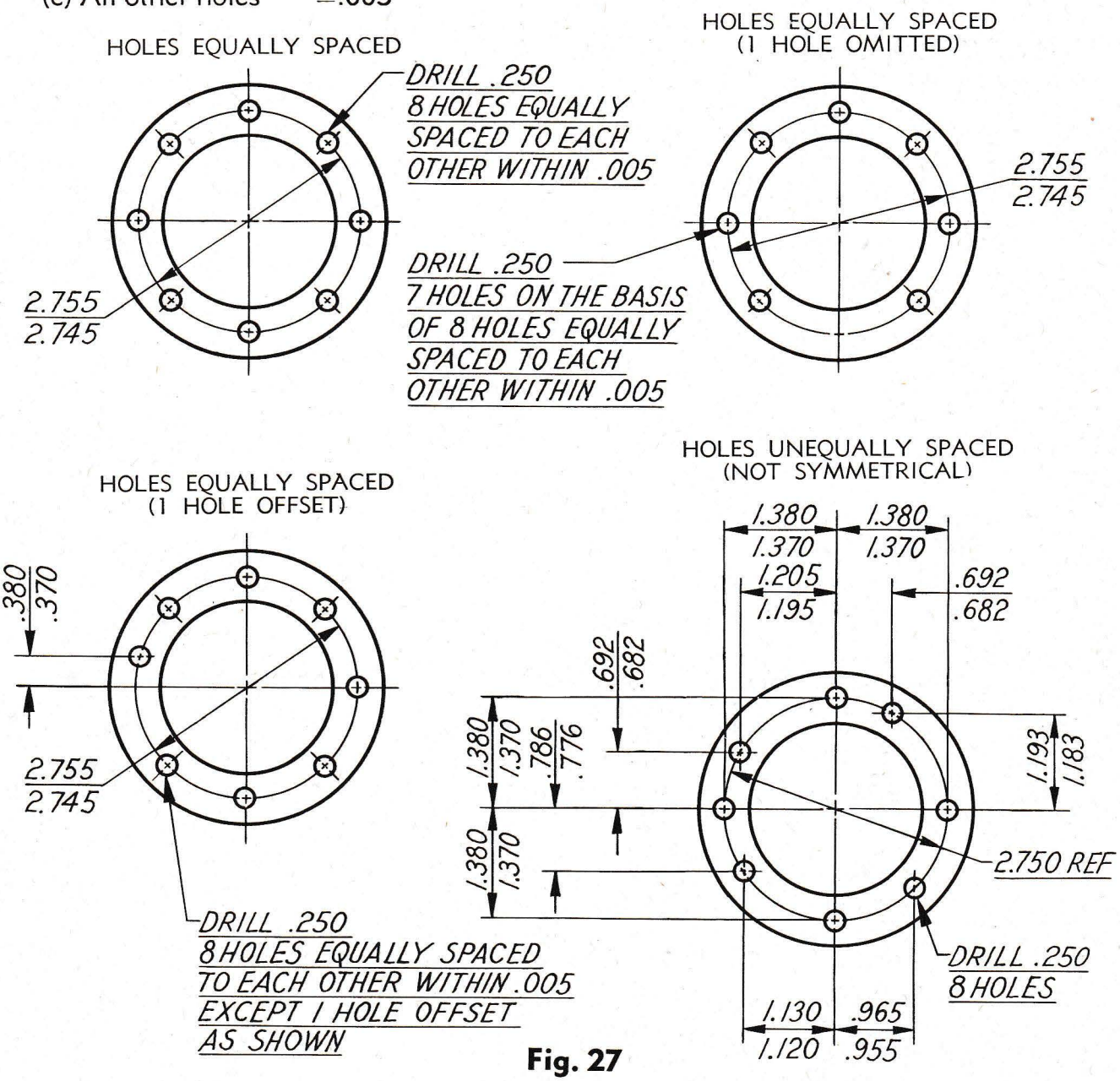


Fig. 27

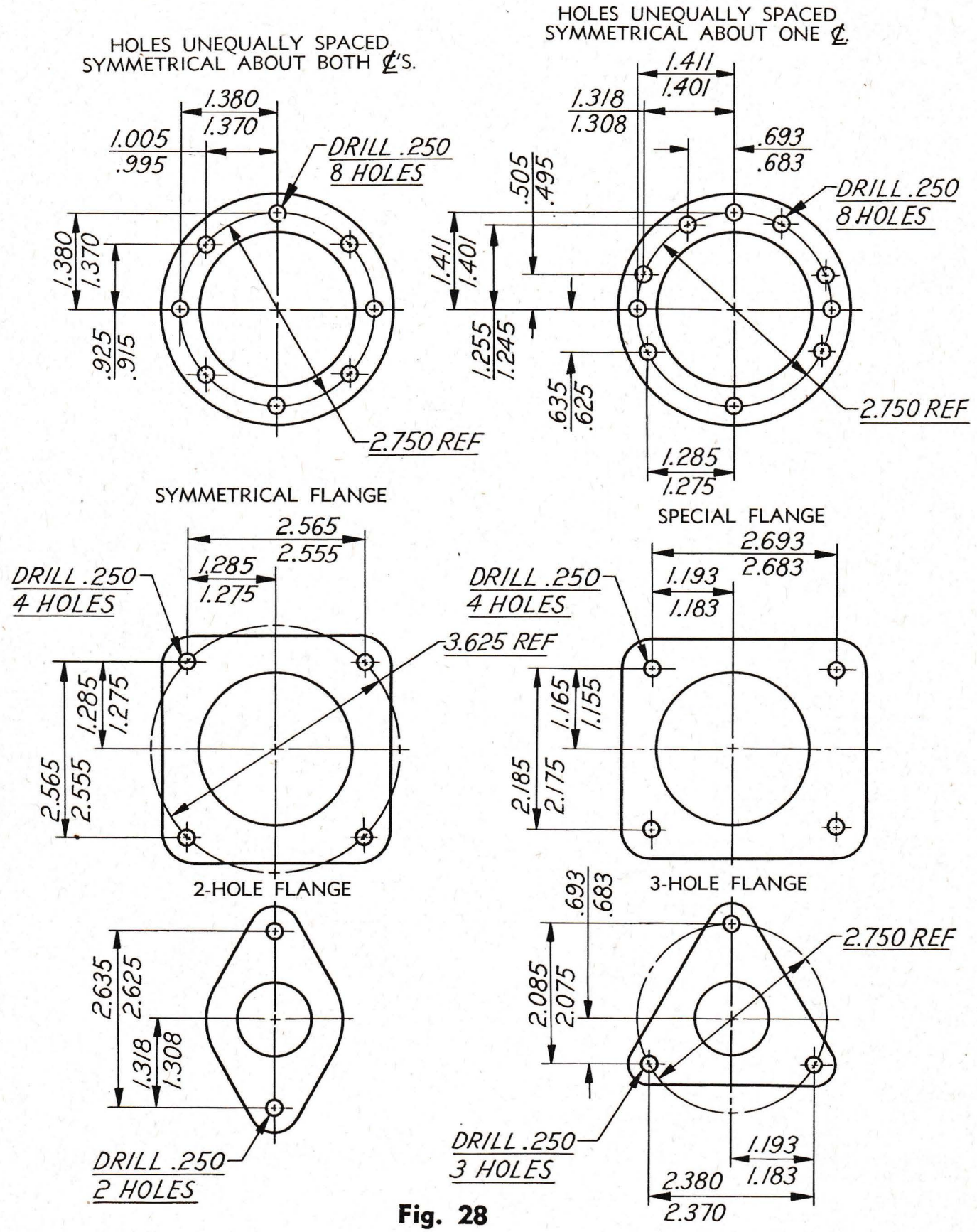
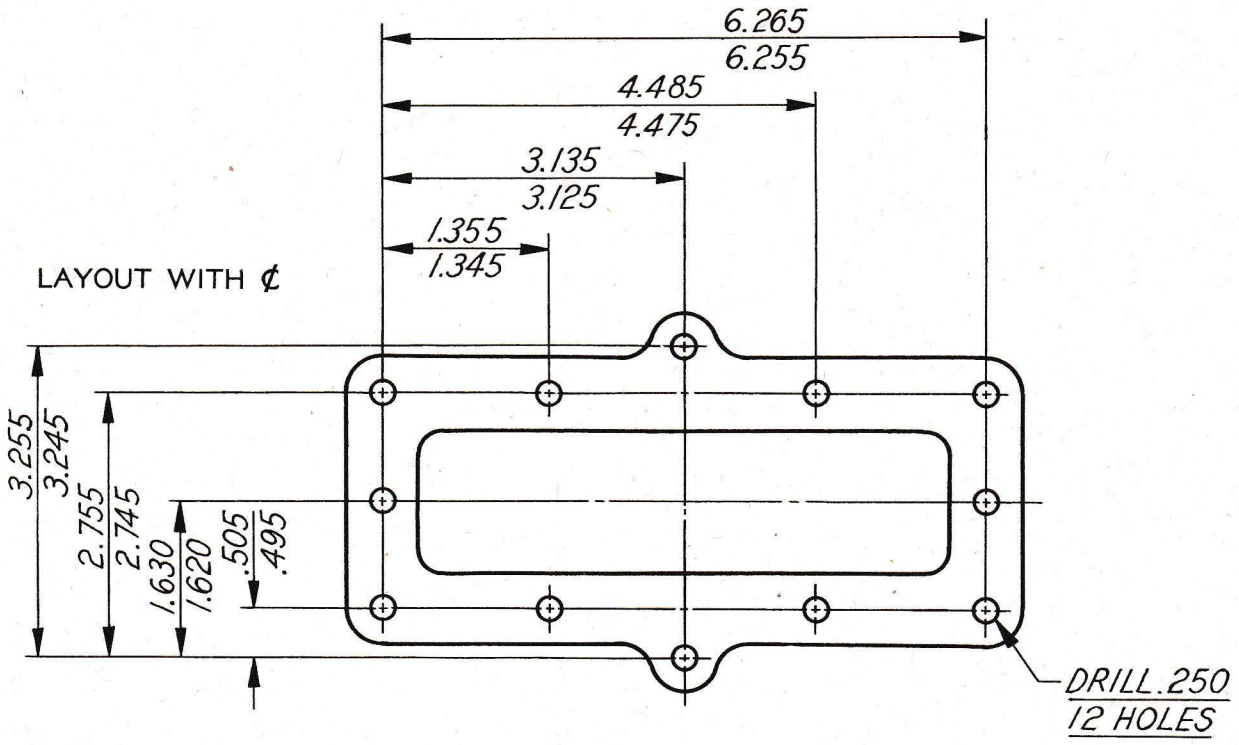
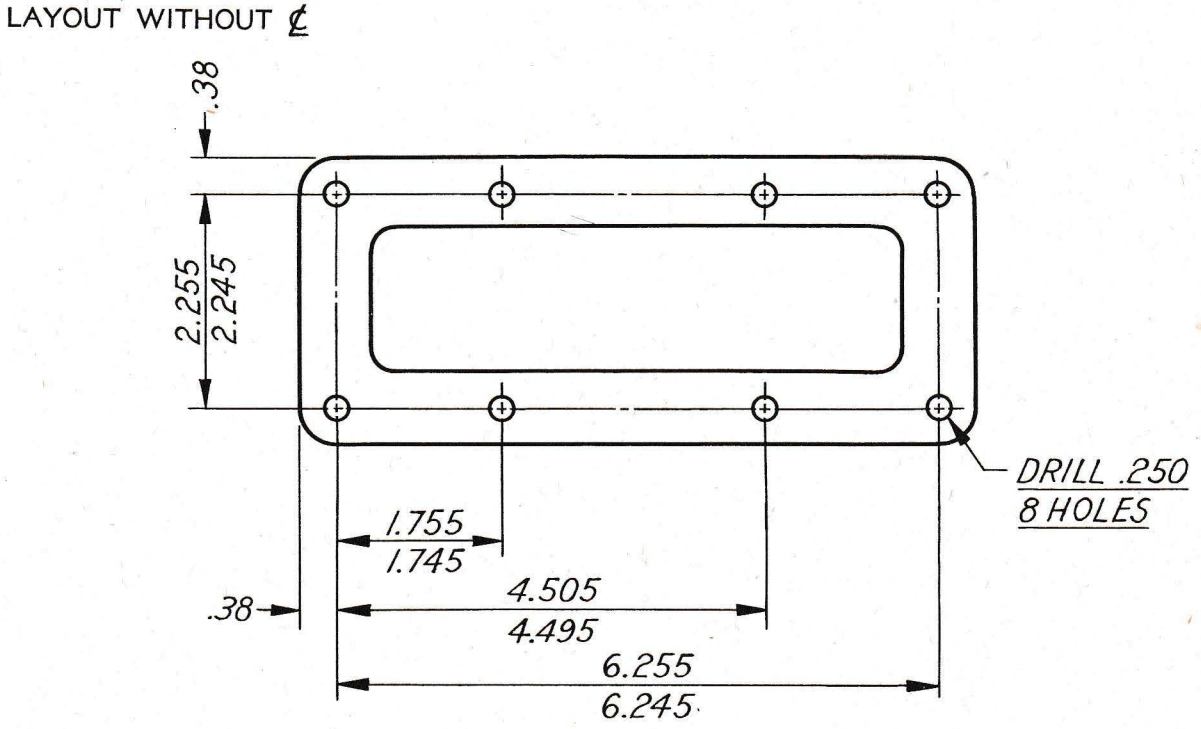

HOLES UNEQUALLY SPACED
SYMMETRICAL ABOUT BOTH ℄'S.
1.380
1.370
1.005
.995
DRILL .250
8 HOLES
1.380
1.370
.925
.915
2.750 REF
HOLES UNEQUALLY SPACED
SYMMETRICAL ABOUT ONE ℄.
1.411
1.401
1.318
1.308
.693
.683
.505
.495
DRILL .250
8 HOLES
1.411
1.401
1.255
1.245
.635
.625
2.750 REF
1.285
1.275
SYMMETRICAL FLANGE
2.565
2.555
DRILL .250
4 HOLES
1.285
1.275
3.625 REF
2.565
2.555
2-HOLE FLANGE
2.635
2.625
1.318
1.308
DRILL .250
2 HOLES
SPECIAL FLANGE
2.693
2.683
DRILL .250
4 HOLES
1.193
1.183
1.165
1.155
2.185
2.175
3-HOLE FLANGE
.693
.683
2.750 REF
2.085
2.075
DRILL .250
3 HOLES
1.193
1.183
2.380
2.370

Fig. 28





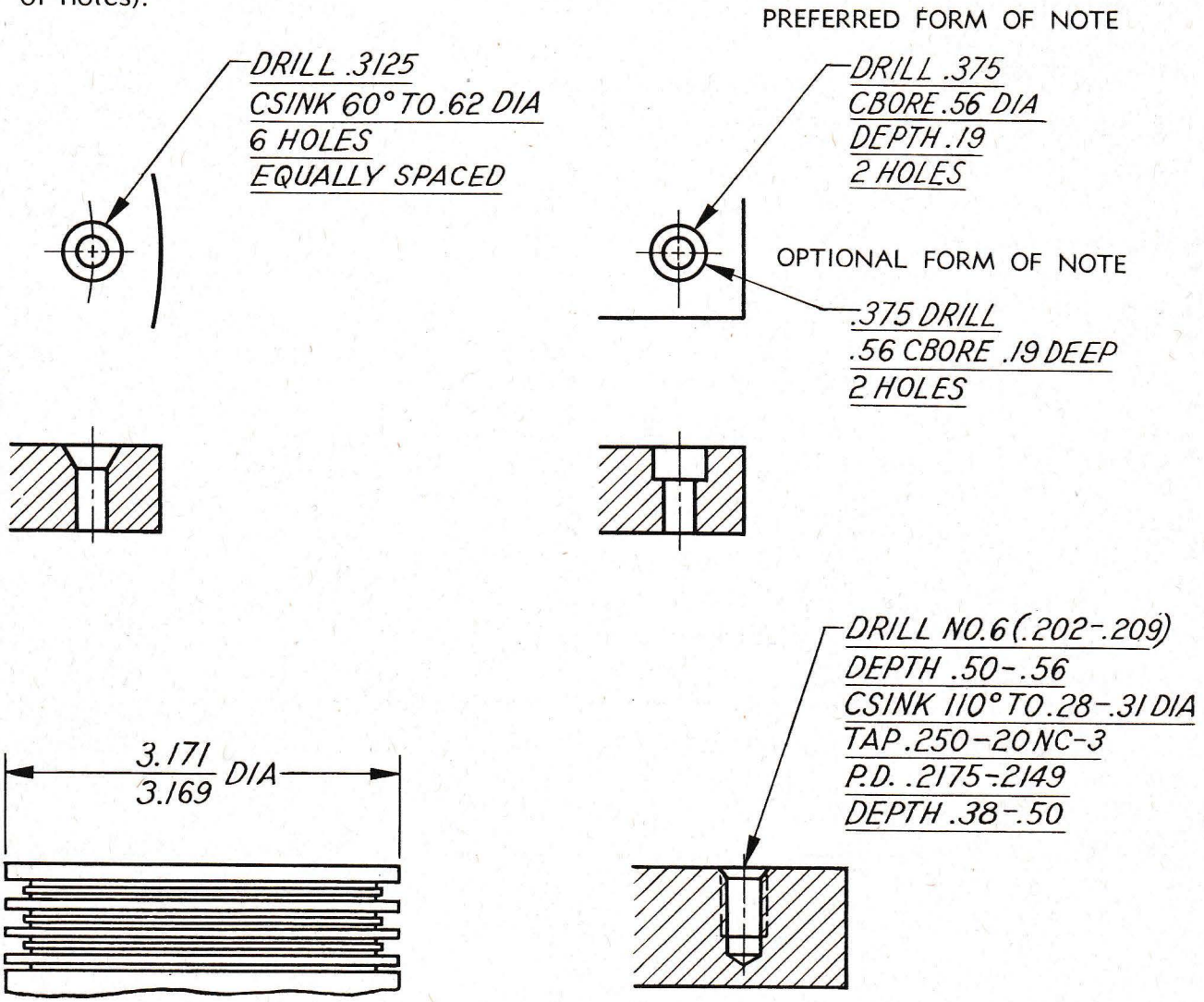
NOTE: In cases where a large number of holes are involved it may be desirable to use the "progressive" method of dimensioning as illustrated by Fig. 32.

Fig. 29

37 USE OF NOTES AND TABLES. The legibility and appearance of drawings may often be improved by specifying dimensions representing a series of tool operations by notes instead of using figured dimensions. Fig. 30 illustrates several examples. See also Section C, Page 6

38 It is customary to note changes in dimensions in a tabulation on the drawing and to refer to them by letters or symbols placed after the altered dimensions. For information on locating changes on "R" sized drawings, see Page 23 .

39 Notes, in addition to dimensions, should be given wherever clarity demands. All notes should read horizontally and should be underlined, except words in title block, or words in other locations which are mechanically printed. (See Section C for example of notes).



NOTE: See Miscellaneous General Note No. 26 to be used in conjunction with specifying tap depth.

Fig. 30

40 DIMENSIONING FITS. The dimensions and tolerances given in the drawings of parts having a cylindrical fit determine the clearances (or interferences) between these parts. The desired fits should be determined by each individual manufacturer.

41 DIMENSIONING TAPPED HOLES AND THREADED PARTS. The aircraft engine industry will use Specification AN-GGG-S-126 as a basis for Threaded Parts. See Section E.

42 CURVES AND ANGLES. A curved line may be dimensioned either by radii or by ordinates. See Figs. 31 and 32. In the case of dimensioning by ordinates the progressive method of dimensioning to locate the stations as illustrated by Fig. 32 is recommended.

43 The use of angular measurements, such as degrees, minutes and seconds to locate holes and parts requiring accurate placement should be avoided as much as possible. Linear measurements from a vertical and horizontal datum point should be specified.

Where it is necessary to use angular dimensions, tolerances should be specified if greater accuracy is required than implied in the tolerance specified in the "Unless otherwise specified" general note.

Such basic angles as Pitch Angles of Bevel Gears should be marked "Ref " and will carry no tolerance.

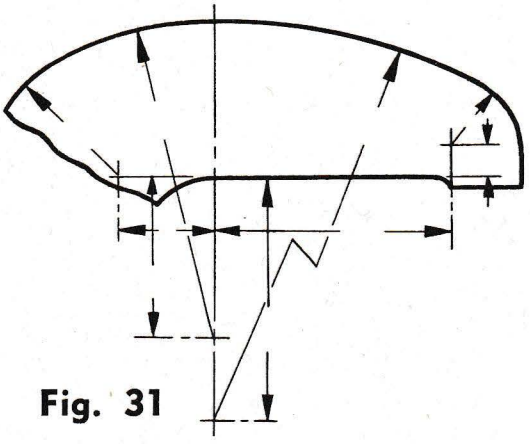


Fig. 31

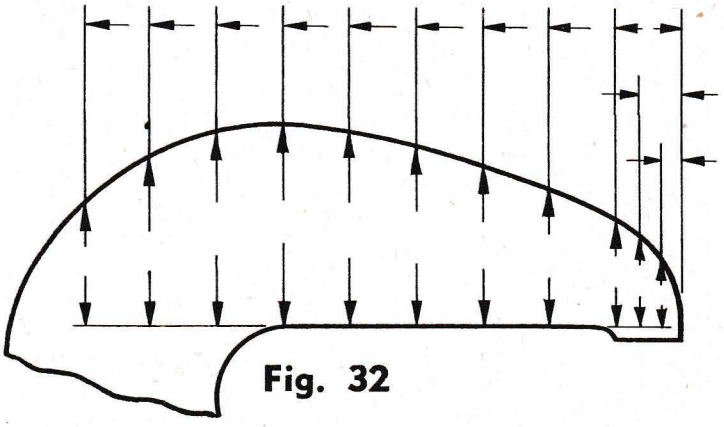
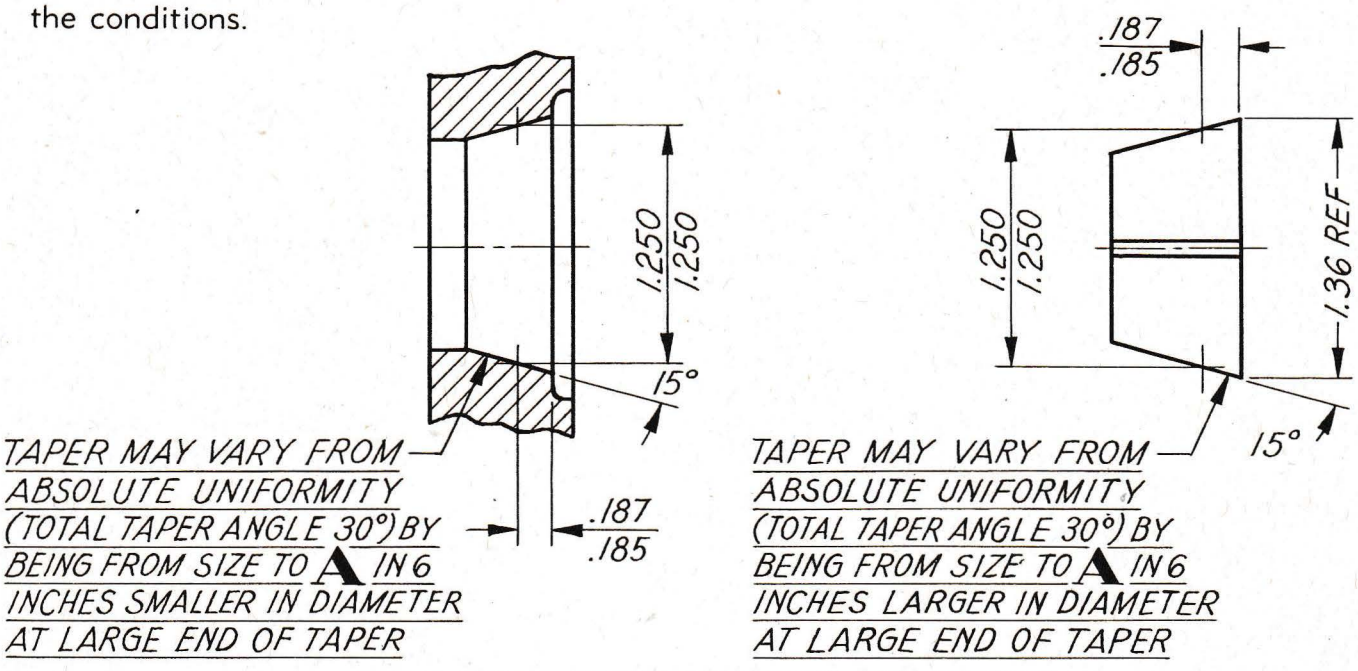


Fig. 32

44 Figure 33 illustrates the proper method of dimensioning tapered surfaces where accuracy is required so as to obtain a close fit between internal and external tapers. The tolerance on the diameter at the gage line is ± 0 and the tolerance on the angle is as shown in the table. The tolerance for the location of the gage line may be varied to suit the conditions.



TAPER TOLERANCE		
LENGTH OF TAPER	A	APPROX VARIATION IN TOTAL TAPER ANGLE
UP TO 2	.001	0° 1' 34"
2.01 TO 6	.002	0° 1' 9"
6.01 & OVER	.003	0° 1' 43"

Fig. 33

45 Figure 34 illustrates the proper method of dimensioning tapered surfaces that do not require extreme accuracy such as is necessary to obtain close fits. With exception of the diameter at the gage line, which is ± 0, all tolerances should be as broad as conditions will permit.

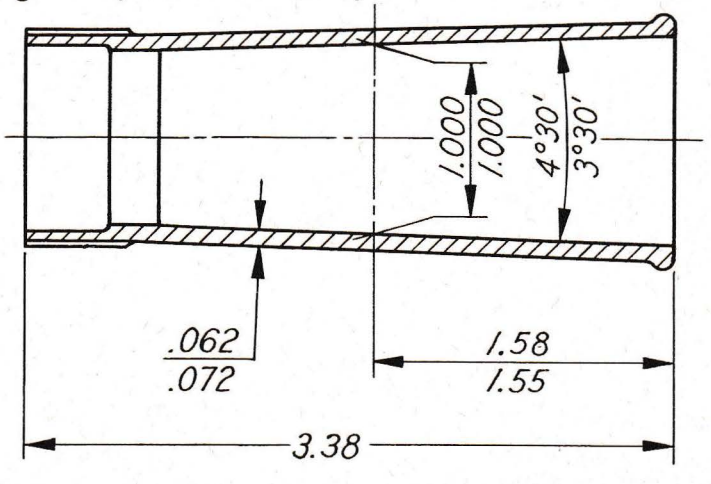


Fig. 34

46 The method shown in Fig. 33 and 34 to indicate gage dimension of 1.250 and 1.000 respectively is preferred. However an optional method is to give the dimension, without tolerance, and to add an explanatory word such as "gage."

SCREW THREAD REPRESENTATIONS FOR THREADED PARTS

a) DOT AND DASH LINES

b) SHORT DASH LINES

c) FULL LINES

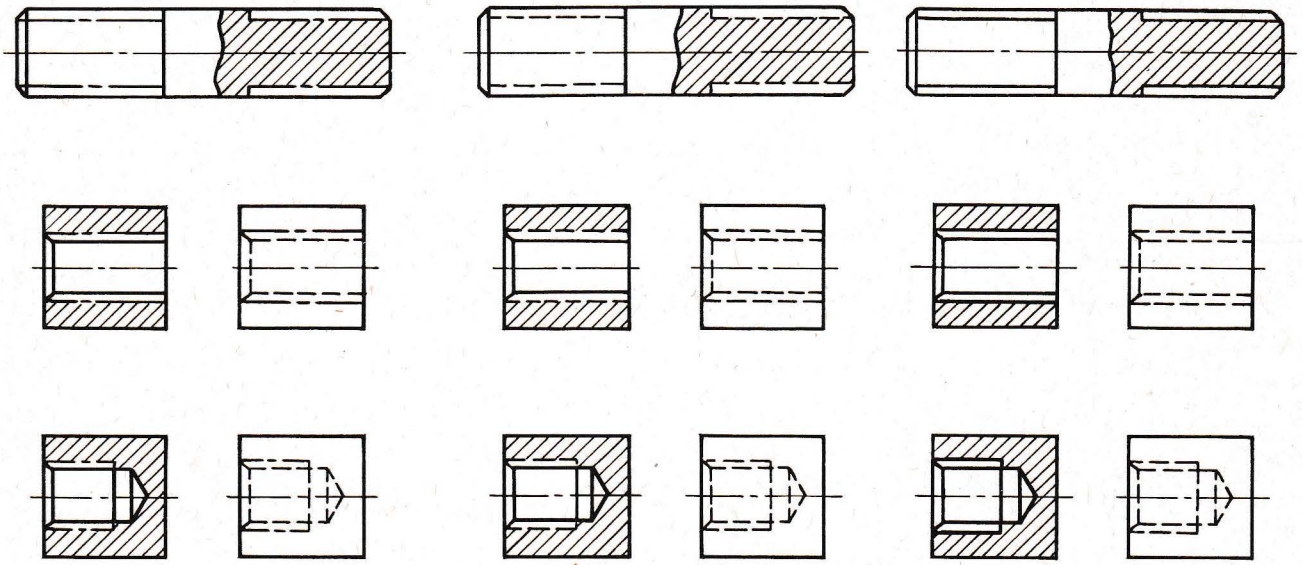


Fig. 35 STRAIGHT THREADS

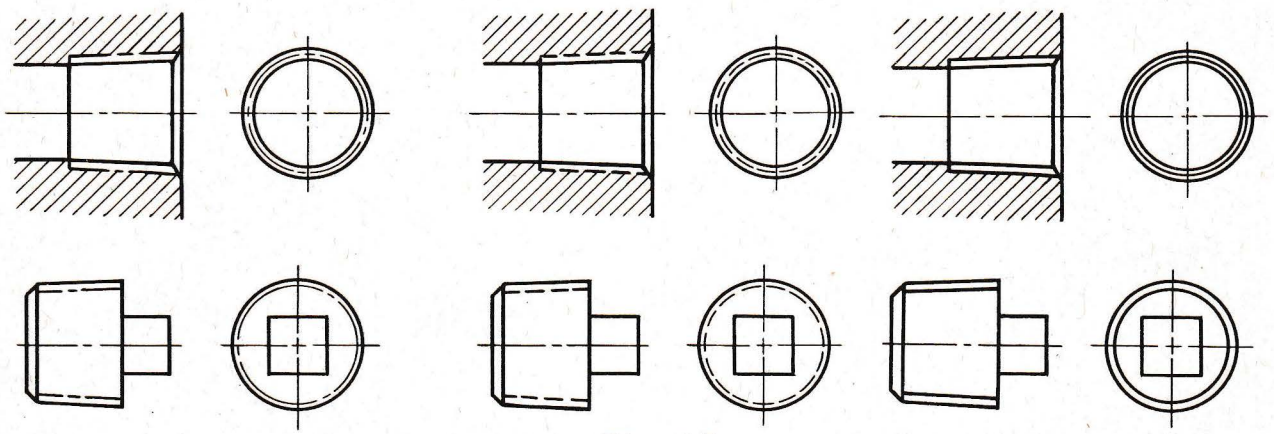


Fig. 36 TAPER THREADS

47 SCREW THREAD REPRESENTATION. Screw threads may be indicated by simplified symbols as shown in Fig. 35. Three different methods may be used. The dot and dash method illustrated under (a) is preferred, but the other methods illustrated under (b) and (c) are considered acceptable alternates, provided they are followed consistently.

48 PIPE THREADS. Taper pipe threads should be represented in the same manner as straight threads except that lines will form an angle of 3° with axis. See Fig. 36.

49 When advisable, threads may be shown in more detail (e.g.—in checking layouts and assemblies) for clarity.

LETTERING

50 GOTHIC STYLE. The most important requirement for lettering as used on working drawings is **legibility,** the second is ease and rapidity of execution. These two requirements are met in the single stroke commercial gothic letter, now in almost universal use throughout the technical world. Preference seems to be divided between the vertical and the inclined styles, although the majority recommends the inclined style.

The following standard practice is recommended:

All general lettering should be of the single stroke commercial Gothic style. Figures and letters, when made by hand without a guide, should be inclined approximately

INCLINED LETTERING (Recommended)

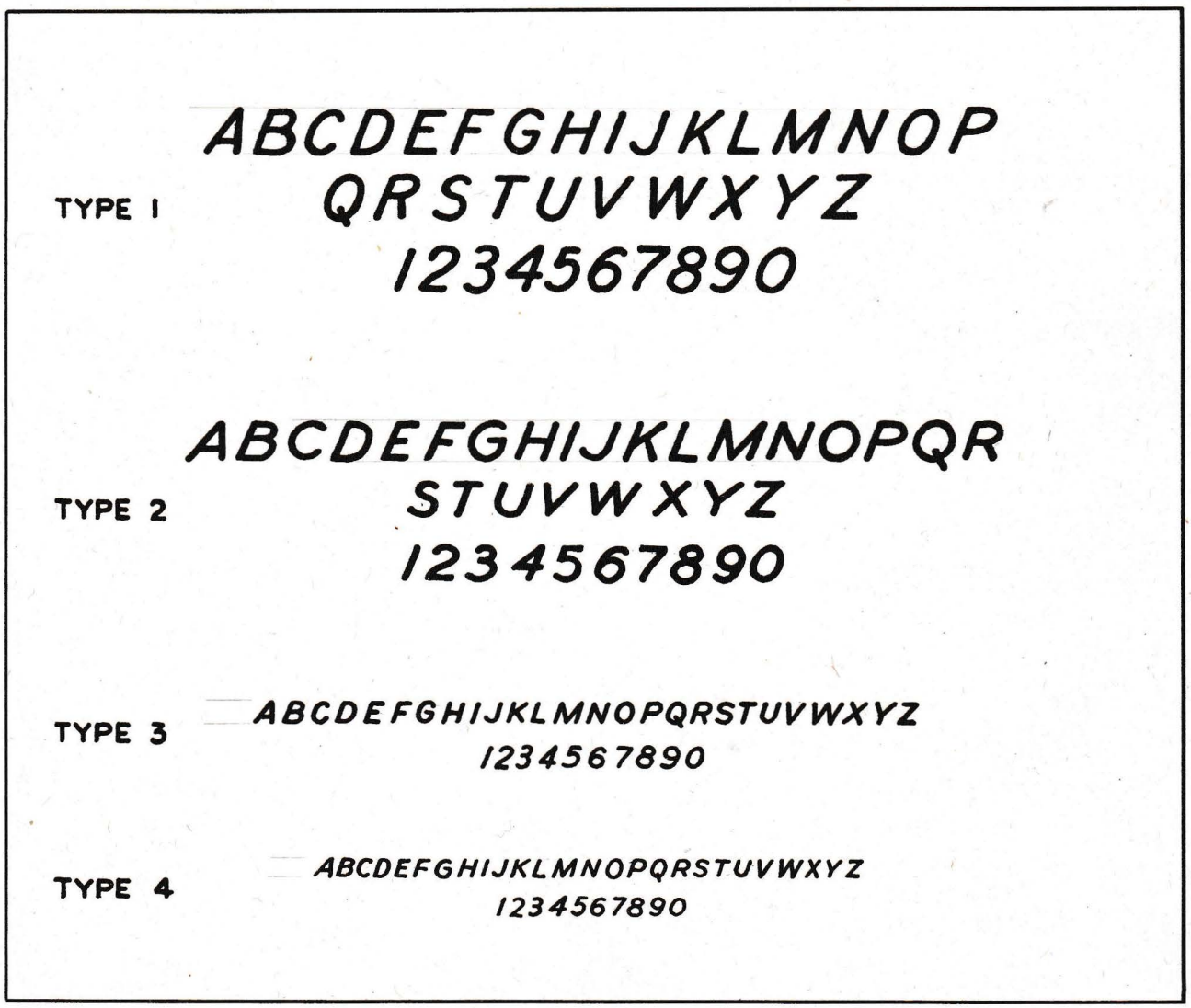


Fig. 37

VERTICAL LETTERING (Optional)

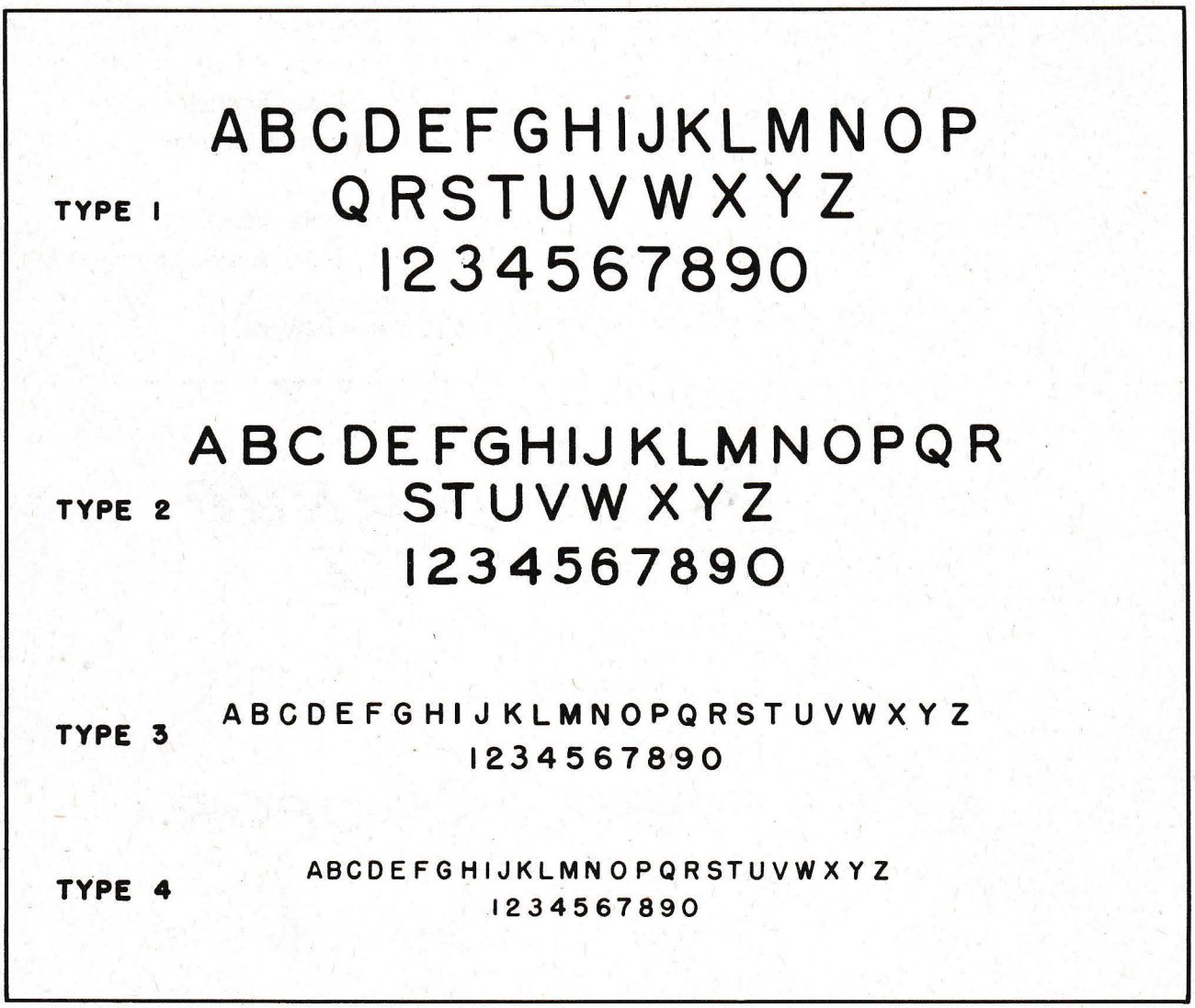


Fig. 38

25-30 degrees from the vertical, as shown in lettering sample. The lettering shall be evenly spaced and of sufficient density to make good reproductions. Letters and figures shall be placed on the drawing in such a manner that they may all be read when the drawing is viewed from the bottom or right hand edge of the drawing. The use of a free hand lettering guide facilitates lettering.

Lettering should be underlined except words in title-block, or words in other locations which are mechanically printed.

Approved specimens of inclined and vertical letters are shown in Figures 37 and 38.

51 ROMAN STYLE. In addition to the various types of vertical and inclined single stroke letters illustrated in Figs. 37 and 38, it is useful to have a Roman alphabet for distinguishing sections and symbolized general notes. Fig. 39 illustrates a .19 inch vertical shaded alphabet which is suggested as a guide for identifying sections and symbolized general notes.

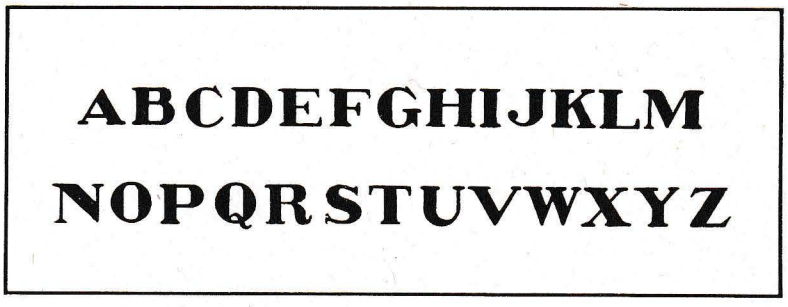


Fig. 39

DRAWING SHEET SIZES AND ARRANGEMENT

52 DRAWING SHEET SIZES. The basic sheet size should be 8.5 x 11 in. The following sizes of flat sheets, the size to be designated as shown, are recommended: (Dimensions indicated are outside dimensions of tracing and trimming lines for blue prints).

SHEET SIZES
(To be filed Flat)

Width	Length	Designation
8.5 in.	11 in.	A
11 in.	17 in.	B
17 in.	22 in.	C
22 in.	34 in.	D

Flat sheets larger than 22 in. x 34 in. should not be used.

Roll sizes should be restricted to 25.5 in., 30 in., 34 in., 36 in., 42 in., and 54 in. wide with lengths in multiples of 11 in. as required. These roll drawings are normally designated "R" sizes.

53 TITLE AND NUMBER BLOCKS. The title block with appropriate space for the identifying number should be located at the lower right-hand corner. Accordion folding of blueprints is recommended. In order to file blueprints which have been accordion folded so that the closed fold will be up and the number still visible, it is necessary to add a supplementary number block (1.75 in. x .5 in.) to each size sheet as illustrated by Figure 40.

This supplementary number block may be either parallel or normal to the borderline of the drawing. If change notes or general notes reach this supplementary number block, a minimum clearance of .25 in. should be left above and below the block.

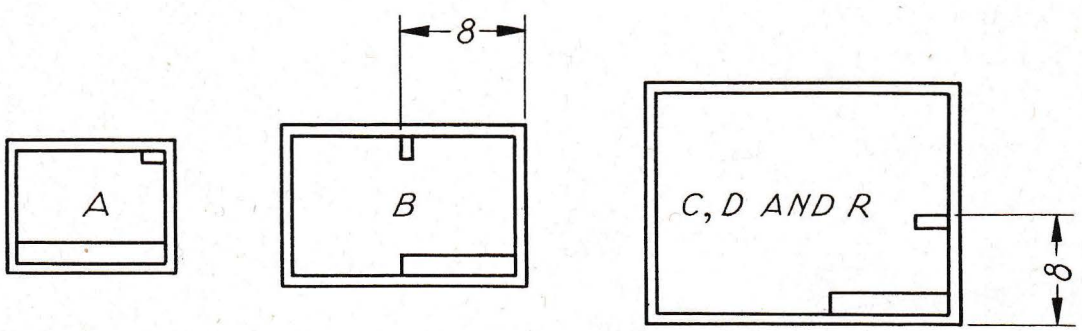


Fig. 40

54 ZONING SYSTEM. The lower and right-hand borders of the larger size drawings, and particularly those of the "R" size, should be ruled and marked as indicated in Figure 41, to provide zones for reference purposes. The location of the change on the drawing should be referenced in the change block. For example, a change referenced in location b2 would be found upward from "b" and over from "2". Each change should be identified by a reference letter which should be located on the drawing near the change and in a position where it can be readily seen. For purposes of clarity a circle approximately .30 in. in diameter should be drawn around the change letter, as illustrated by Figure 41. To avoid misinterpretation and resultant errors, the letters "I", "O" "Q" should not be used for change letters.

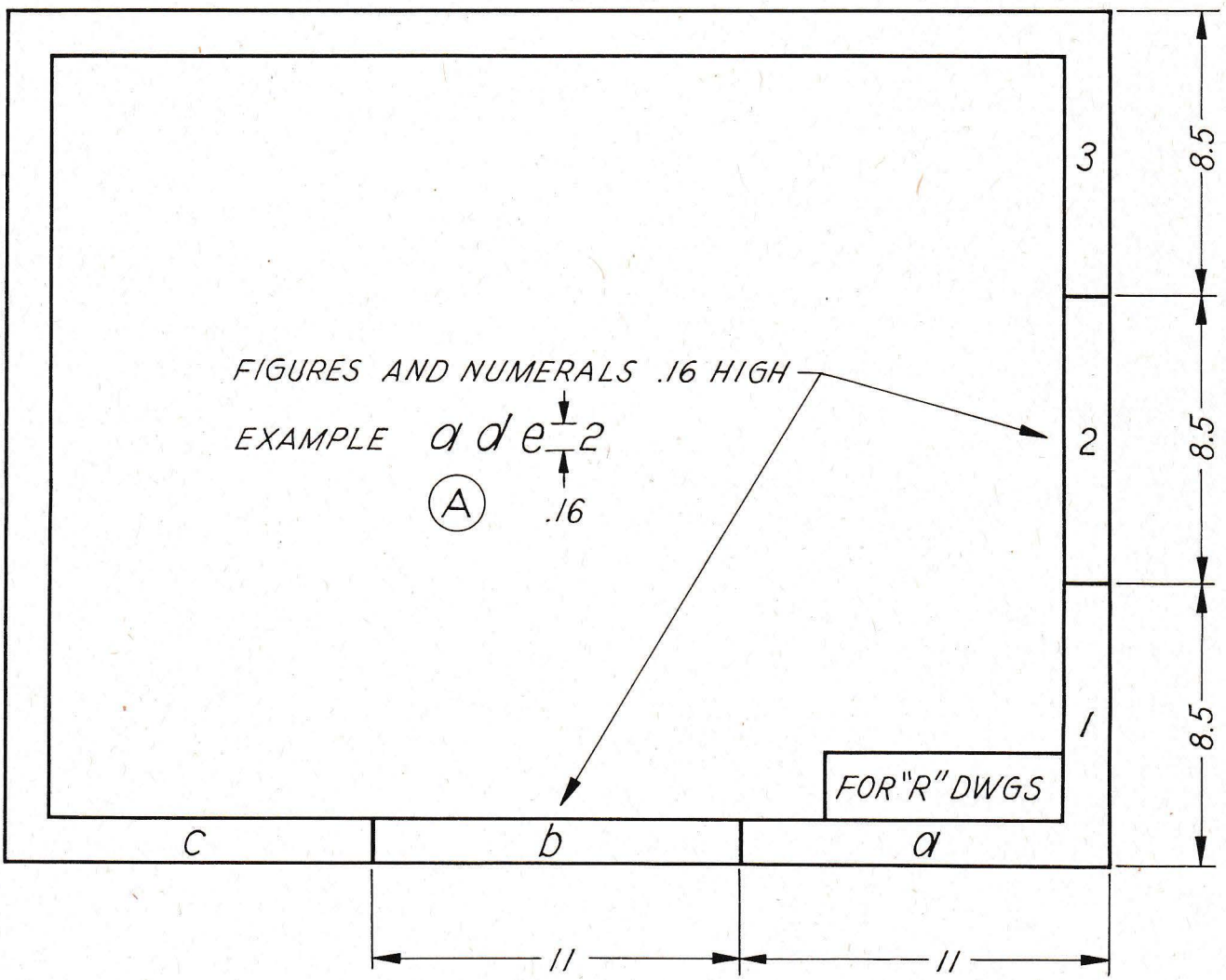


Fig. 41

SECTION B

DIMENSIONING BY THE DECIMAL SYSTEM

1 A complete decimal system of dimensioning should be used in place of the combined decimal and fraction system.

2 The complete decimal system is generally applicable to new design drawings only, and is not necessarily retroactive. In some instances, however, where an existing design is slightly changed and a new part number is allocated, it may be advisable to utilize the complete decimal system. This will be decided in each case by the individual company.

3 The fundamental basis of the complete decimal system is the use of a two place decimal, i.e., a decimal consisting of two figures after the decimal point. In all dimensions where a fraction would ordinarily be used, the two place decimal can be applied. The figures after the decimal point, where applicable, should be in fiftieths (eg. .02, .04, .24, .84) so that when halved (e.g. diameters to radii) even two place decimals will result. Exceptions of course will have to be made, but they should be kept to a minimum.

4 In connection with the complete decimal system of dimensioning, the use of a tolerance written as ±.XXX, **on manufacturing drawings,** should be discontinued, except as follows:

Tolerances may be expressed by means of basic figure with:

±.XXX (when bilateral values are equal) or

$^{+.XXX}_{-.XXX}$ (when bilateral values are unequal)

in the following cases only:

a) In installation drawings where it is desirable to retain the plus and minus values of accumulative tolerance.

d) In drawings of design standards where it is desirable to record a basic dimension.

c) In angular dimensioning, e.g.—XX° XX′ $^{+\ 0°\ 8'}_{-\ 0°\ 0'}$

Limits representing the maximum and minimum dimension allowed shall be specified for all dimensions where the tolerance is other than ±.01. The method of writing these limits on the drawing should be as shown below:

Dimensional Form: $\frac{X.XXXX}{X.XXXX}$ $\frac{X.XX}{X.XX}$

Note Form: BREAK SHARP EDGES .XX—.XX

It is important that the high limit (max. figure) be placed above the line, and the low limit (min. figure) be placed below the line when written in the dimensional form, and when written in the note form, with both figures on the same line, the low limit (min. figure) is always placed first.

5 The complete decimal system of dimensioning requires the use of tenths, fiftieths, (.02), hundredths and/or thousandths as outlined below:

a) TWO PLACE DECIMALS (e.g. - .XX.)
When the tolerance as applied to the dimension is ± .01 or greater, only two place decimal dimensions should be used.

aa) OPTIONAL
In order to pave the way for the transition from fractions to decimals, it may be expedient to start with three-place decimals as an approach to the ultimate two place decimal system. In this case all dimensions should be done in thousandths instead of fiftieths and hundredths, and the procedure would then be as follows:

CONVERTING COMMON FRACTIONS TO DECIMAL FRACTIONS
In converting fractions to decimals where the fraction as used implies a tolerance of ± .010, three decimals should be used.

e.g 1/16 with an implied ± .010 becomes .063.
$9\frac{57}{64}$ ± .010 (9.8906 ± .010) becomes 9.891 .

in this case a dimension carrying a three place decimal without any tolerance, would be understood to imply ± .010.

The simplicity of the two-place decimal in dimensioning tolerances greater than .010 $\left\{\begin{matrix}\text{e.g. } 1.20\\ \quad .60\end{matrix}\right\}$ is lost when three place decimals are used as a base in dimensioning, for it is somewhat incongruous to specify a tolerance of .60 as $\left\{\begin{matrix}1.200\\ .600\end{matrix}\right\}$

b) THREE PLACE DECIMALS (e.g. - .XXX)
When the tolerance applied to the dimension is less than ± .01 and not less than ± .001, three place decimal dimensions should be used.

c) FOUR PLACE DECIMALS (e.g. - .XXXX)
When the tolerance applied to the dimension is less than .001, four place decimal dimensions should be used.

NOTE EXCEPTIONS: Where three or four place decimals are used in conversion of commercial sizes of drills, sheet and bar material, tolerances should be given according to specifications and tables governing such cases.

(This is to explain an apparent inconsistency in specifying a 5/16 (.3125) drilled hole with a tolerance by $\left\{\begin{matrix}.3175\\ .3105\end{matrix}\right\}$).

6 "Rounding Off" Decimal Values. When a decimal value obtained by converting common fractions to decimals is to be rounded off to a lesser number of places than the total number available, the procedure should be as follows:

When the figure next beyond the last figure to be retained is less than 5, the last figure retained should not be changed. Example: 3.46325 if cut off to three places, should be 3.463.

When the figures beyond the last place to be retained amount to more than 5 in the next place beyond that to be retained, the last figure retained should be increased by 1. Example: 8.37652 if cut off to three places, should be 8.377.

When the figure next beyond the last place to be retained is exactly 5 with only zeros beyond, the last figure retained if even, should be unchanged; if odd it should be increased by 1. Example: 4.365 becomes 4.36 when cut off to two places. Also 4.355 becomes 4.36 when cut off to two places.

7 On **details** of newly designed parts which are similar to or duplicates of production parts formerly dimensioned in common fractions, and therefore subject to the same tooling, the high and low limit dimensions must be established, where possible, so as to keep the limits outside the present range of existing tools and gages, so that parts which have been made to these tools and gages shall pass inspection to the drawing.

8 **Commercial parts** which have to interchange with commercial parts are to be dimensioned with three place or four place decimals as required.

9 The following **examples** give detailed explanations of the complete decimal system of dimensioning:

DRILLED HOLES

Fractional size drills should be specified by the decimal equivalent written as a three or four place decimal as applicable for commercial standards. Number and letter size drills should be specified by the number or letter and the decimal equivalent. The tolerance for drilled holes is ± .010 unless otherwise specified. When the tolerance is other than ± .010 the high and low limits are to be specified as follows: (for cotter pin, tap drill, rivet holes, etc.) See Drill Tolerance Table Section G.

Letter and Number size drills drill No. XX (.XXXX- .XXXX DRILL). Fractional size drills drill .XXXX- .XXXX DRILL.

REAMED HOLES

Fractional (commercial) size reamers should be specified up to and including one inch in three or four place decimals (as applicable to commercial standards).

BORED HOLES AND GROUND HOLES

All holes over one inch in diameter should be specified as a decimal, using two, three or four place decimals as required. High and low limits are to be specified where the tolerance is other than ± .010.

TAPPED HOLES

Low and high limits should be specified for the pitch diameter and written in the note form.

THREAD SIZES

Should be dimensioned in three or four place decimals as applicable to commercial standards.

APPROXIMATE RADII

Specify with high and low limits. Omit the words **MAX.** and **MIN.**

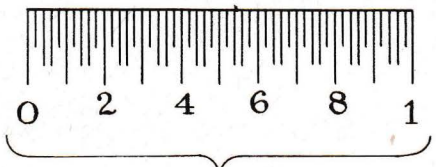
MILLING CUTTERS, GEAR CUTTERS, CBORES, Etc.

Specify the decimal equivalent written as a three or four place decimal as applicable. Where possible use high and low limits, allowing for ample wear on the diameter of the cutter.

COMMERCIAL BAR STOCK

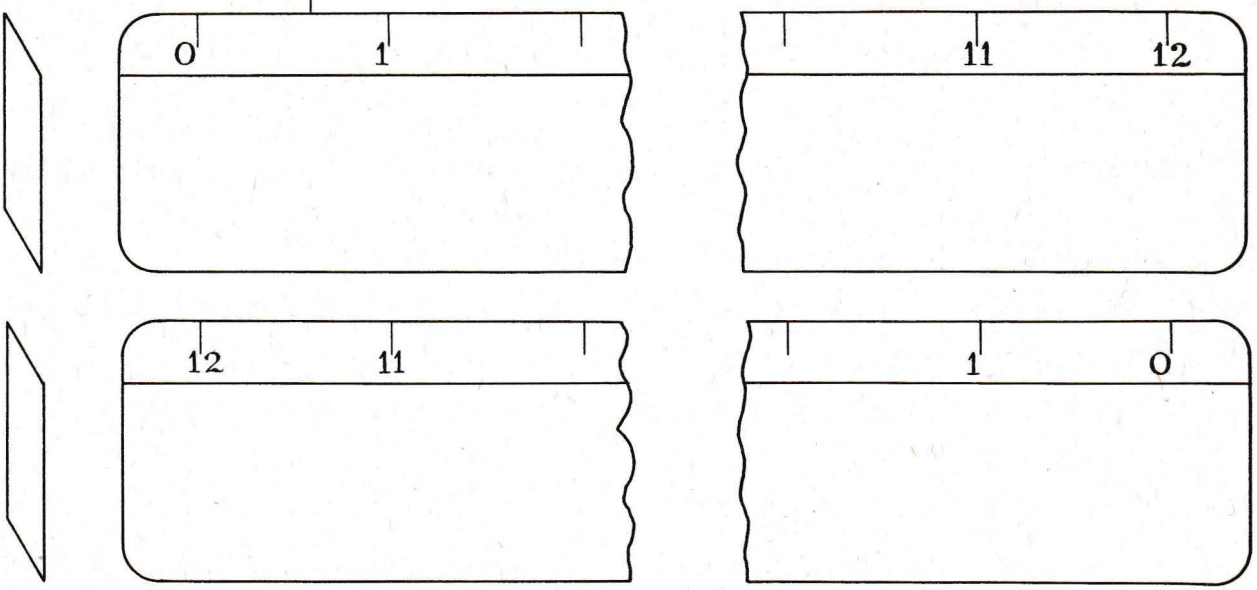
Hexagon and other bar sizes should be dimensioned with the fractional (commercial) size written as a three or four place decimal.

10 The type of drafting room scale calibrated as illustrated in Fig. 1 is suggested.



ENLARGED VIEW SHOWING GRADUATIONS BETWEEN EACH INCH IN 50THS OF ONE INCH.

Fig. 1



SECTION C

STANDARDIZED NOTES

1 Notes are supplementary to dimensioning and are used to indicate necessary information on the drawing in a condensed and systematic manner.

2 Notes are classified as **general** and **local** according to their character.

GENERAL NOTES

3 General notes should be placed in the lower right corner of the drawing above the title block. General notes, as the name implies, means those notes which refer to the part as a whole, e.g.:

FINISH ALL OVER.

4 Also classified as general notes, are notes that apply to dimensions of the part and which might be repeated many times if general notes were not used, e.g.:

ALL DRAFT ANGLES X°, UNLESS OTHERWISE SPECIFIED.

LOCAL NOTES

5 Local notes are those that apply to local operations only and should be placed adjacent to the point at which such operations are to be performed, e.g.:

DRILL .248–.255, 4 HOLES.

MISCELLANEOUS GENERAL NOTES

6 The following miscellaneous General Notes are suggested for use where necessary. (Wherever the abbreviation "AN" is used, it is intended to mean Army-Navy.)

(1) FINISH ALL OVER.

(2) FINISH ALL OVER EXCEPT—

(3) BREAK SHARP EDGES .01—.03 APPROX R UNLESS OTHERWISE SPECIFIED.

(4) BREAK SHARP EDGES .003—.015 UNLESS OTHERWISE SPECIFIED.

(5) BREAK SHARP EDGES .003—.015 ON ALL (DRILLED HOLES) (CHAMFERS) (COUNTERSINKS) UNLESS OTHERWISE SPECIFIED.

(6) ALL (CASTING) (FORGING) (FINISHED) RADII .XXX—.XXX UNLESS OTHERWISE SPECIFIED.

(7) ALL DRAFT ANGLES X° UNLESS OTHERWISE SPECIFIED.

(8) ATTACH TAG SHOWING PART NUMBER AND LAST CHANGE LETTER.

(9) ENGINEERING SOURCE APPROVAL REQUIRED.

(10) ALL DIMENSIONS TO BE MET AFTER PLATING.

(11) MUST BE FLAT AND FREE FROM BURRS.

(12) ALL SMALL UNFINISHED RADII AND FILLETS .XX UNLESS OTHERWISE SPECIFIED.

(13) REMOVE BURRS.

(14) SCALE X TIMES SIZE.
(Words instead of Figures are to be used to designate scale "X")

(15) APPROXIMATE DEVELOPED LENGTH X.XX.

(16) THREADS TO BE GROUND.

(17) INTERSECTING OIL HOLES MUST LINE UP WITH EACH OTHER WITHIN .XX.

(18) FINISH PER SPEC. XXXX EXCEPT **G** SURFACES.

(19) TO BE IN ACCORDANCE WITH CURRENT ISSUE OF AIR CORPS SPEC. No. XXXXX. AND/OR NAVY SPEC. No. XXXXX.

(20) SIMILAR TO AIR CORPS DRAWING No. XXXXX AND/OR NAVY DEPT. DRAWING No. XXXXX.

(21) OPTIONAL PART **AN** No. XXXXX.

(22) SIMILAR TO **AN** DRAWING No. XXXXX.

(23) REFERENCE **AN** No. XXXXX.

(24) EDGES MUST BE FREE FROM TEARS. (Applies to Gaskets)

(25) NOTIFY ENGINEERING DEPARTMENT WHEN NECESSARY TO RESINK DIE.

(26) MIN. DEPTH SHOWN FOR ALL TAPPED HOLES MEANS FULL THREADS. MAX. DEPTH MEANS FULL OR IMPERFECT THREADS.

STANDARDIZED NOTES (Symbolized)

7 Symbolized notes are intended to supplement dimensioning and to indicate necessary information on the drawing in a condensed and systematic manner and are to appear in the area designated for general notes.

8 A scheme for symbolizing concentricity, parallelism, circularity, case hardening, and nitriding notes is outlined below, thereby removing such notes from body of drawing to the area for general notes.

(Symbols are not yet standardized, but those shown are suggested. **X** is used instead of **A** by some companies.)

A SURFACES MUST BE CONCENTRIC, PARALLEL, FLAT, SQUARE, AND TRUE (AS APPLICABLE) TO EACH OTHER WITHIN .XXX FULL INDICATOR READING UNLESS OTHERWISE SPECIFIED.

See (**) below

A SURFACES AND PD OF ( ) MUST BE CONCENTRIC, PARALLEL, FLAT, SQUARE AND TRUE (AS APPLICABLE) TO EACH OTHER WITHIN .XXX FULL INDICATOR READING UNLESS OTHERWISE SPECIFIED.

See (**) below

( ) Insert one or more of the following as required:—

GEAR — GEARS SPLINE — SPLINES THREAD — THREADS

C SURFACES TO BE CASE HARDENED DEPTH OF FINISH CASE .XXX - .XXX.

G SURFACES TO BE GROUND OR EQUIVALENT.

Subject to changes when profilometer designations are adopted.

N SURFACES TO BE NITRIDED .XXX - .XXX DEEP.

Z DIAMETERS MUST BE CIRCULAR WITHIN .XXXX PARALLEL WITHIN .XXXX AND STRAIGHT WITHIN .XXXX.

For diameters, the circularity, taper and straightness of which must be held closer than the diameter tolerance or **A** note would insure.

Z DIAMETERS MUST BE CIRCULAR, PARALLEL AND STRAIGHT WITHIN .XXXX.

Same as above except the circularity, taper and straightness require the same degree of accuracy.

(**) A general control for the points of accuracy indicated. When the indicator reading shown in the note does not apply to all points, the amount OTHERWISE SPECIFIED can be shown on the body of the drawing.

APPLICATION OF GENERAL NOTES

9 Examples of the proper methods of applying the **A, C, G, N** and **Z** notes are shown in Fig. 1 and 2.

10 Detailed information for **C, G, N** and **Z** notes is to be found in this manual and is self-explanatory.

11 The following explanation in connection with the **A** note is for the purpose of clarifying their various applications and to establish a uniform interpretation of their requirements:

12 The **A** note on drawings is a simplified method of controlling the accuracy of certain surfaces by the use of the letter **A** rather than by a series of individual notes.

13 Wording of the general **A** note to include concentric, parallel, flat, square and true (as applicable) is to make the note universal in its application by having it cover all phases of accuracy likely to be required. Absence of one or more phases in connection with a given surface is anticipated by the use of (as applicable) for example, if concentricity in relation to a given surface does not exist, it therefore follows that the note would not be applicable in that respect.

14 The phrase "to each other" must always be kept in mind when interpreting the **A** note, for upon a clear understanding of this phrase, depends the correct application of the note itself.

15 Fig. 1 illustrates a simple application of the **A** note when used either by itself or in conjunction with the pitch diameter of a thread and/or a gear. The full indicator reading specified in the general note applies in all directions by any method of checking.

16 It is sometimes wrongly assumed that individual surfaces are tied together by a particular **A.** Where the letter has two or more leaders that point to different surfaces it is merely a matter of convenience and is in no way intended to set these surfaces apart from any others. The note reads "to each other" and surfaces can be indicated individually or in groups without affecting the meaning of the note.

17 For nitrided parts the letter **N** would be used in place of the letter **C.**

18 This broad interpretation is necessary to permit the shop unrestricted use of production and inspection facilities.

19 In this particular application (Fig. 1), the limits for all surfaces marked **A** are the same and are specified in the general note.

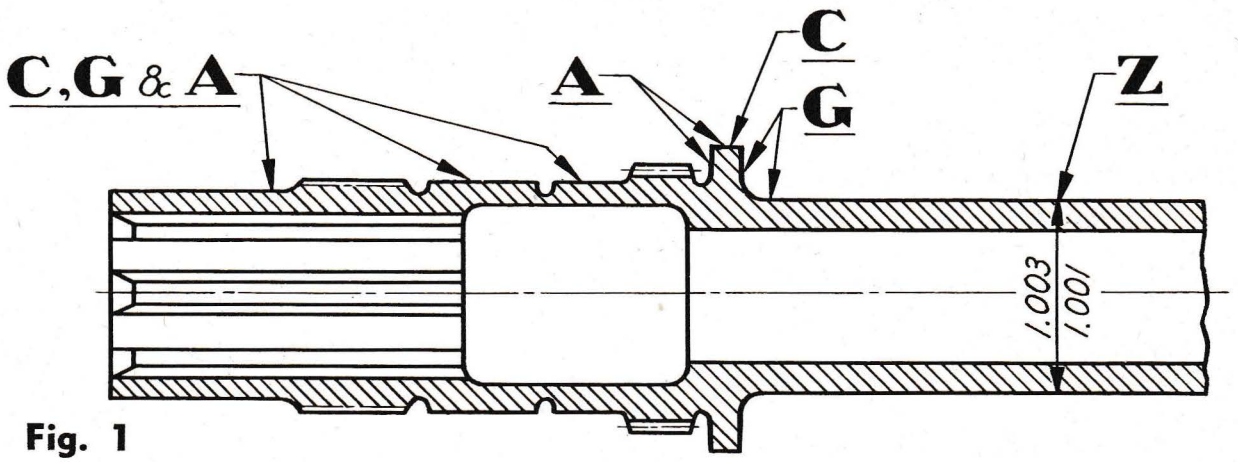


Fig. 1

20 When the limit for surfaces marked **A** (expressed as the full indicator reading) varies, the value most commonly applicable should be placed in the general note and all other values indicated adjacent to the letter **A** as shown in Fig. 2. This illustration is a slightly more involved application of the **A** note although the interpretation is practically the same as for Fig. 1. The note under this condition means that each surface indicated must not vary in relation to any other surface by an amount greater than that specified either in the general note or adjacent to the letter **A.** When checking such parts it is important that any error indicated by a given surface be compensated for when checking some other surface by the same setup.

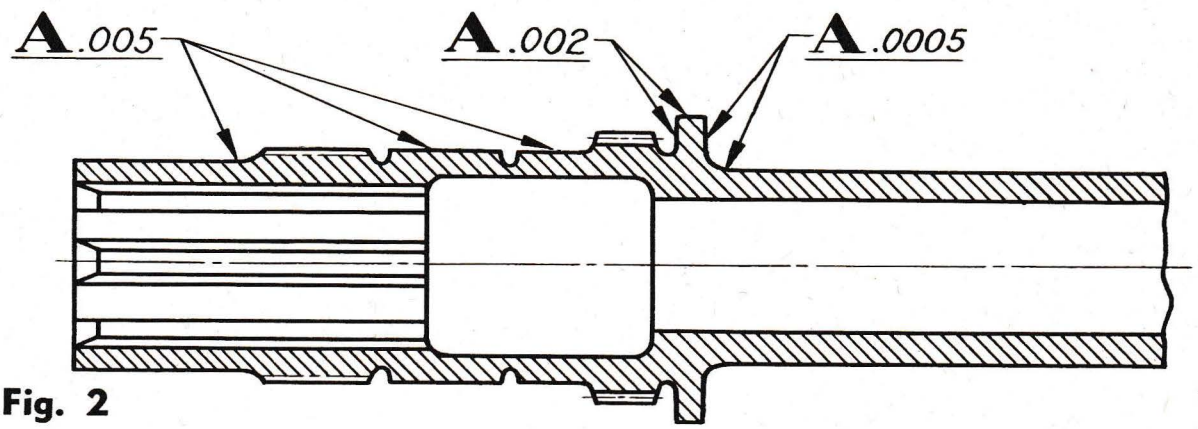


Fig. 2

EXAMPLES OF LOCAL NOTES

21 Examples of the use of local notes are shown below.

DRILLING

DRILL .XXX - .XXX THRU
CSINK XX° TO .XXX DIA
XX HOLES

DRILL No. 51 (.065 - .072) DEPTH .50-.56
(FOR COTTER PIN, TAP DRILL, RIVET HOLES AND HOLES REQUIRING A TOLERANCE OTHER THAN ±.010.)

DRILL & REAM

DRILL FOR REAMING
DEPTH .XX - .XX
REAM .XXXX - .XXXX
DEPTH .XX

TAPPING-Thru Holes

DRILL "F" (.255 - .262)
CSINK 110° TO .32 - .35 DIA
TAP .3125-18 NC-3
P.D. .2764 - .2794
6 HOLES

TAPPING — Blind Holes

DRILL NO. 6 (.202-.209)
DEPTH .50 - .56
CSINK 110° TO .28 - .31 DIA
TAP .250 - 20 NC-3
P.D. .2175 - .2201
DEPTH .38 - .50

22 AMS SPECIFICATIONS. To eliminate putting notes on drawings regarding requirements on finish, cadmium plating, magnetic inspection, etc., the number(s) of the AMS process specifications which are applicable should be noted in the space provided in title block, e.g.:

AMS 2400 Plating, Cadmium
AMS 2470 Protective Treatments for Aluminum Base Alloys
AMS 2475 Protective Treatments for Magnesium Base Alloys
AMS 2503 Black Finishing — Low Baking
AMS 2510 Engine Gray Finishing — Low Baking
AMS 2640 Magnetic Inspection
AMS 2800 Identification — Machined Parts
AMS 2804 Identification — Castings
AMS 2808 Identification — Forgings
AMS 2606 Pressure Testing

23 In cases where the pertinent AMS specification(s) is not applicable to the entire part, supplementary information should be added as a General Note.

SECTION E

THREAD SPECIFICATIONS

DETAIL DATA FOR THIS SECTION

TO BE SUPPLIED LATER.

SECTION F

MATERIALS

1 MATERIAL GAGE STANDARDS. The gages listed on this page are standard for the materials indicated and should be used for all parts where applicable.

2 Detail drawings should not specify either the gage number or name. The desired size should be chosen from the tables on the following page and the commercial tolerance for the material used should be applied, so as to obtain the high and low limit dimensions to be specified on the drawing. The tolerance should be obtained from the applicable Aeronautical Materials Specifications (AMS).

MATERIAL	GAGE
SHEET STOCK	
Aluminum Magnesium Brass Bronze	B&S
Copper	B&S
Steel—Hot Rolled —Cold Rolled —Corrosion Resisting —Galvanized —Plates —Strips	U.S.S.
TUBING	
Aluminum Magnesium Brass—Seamless Copper—Seamless	B.W.
Fibre	Decimal Sizes
Steel—Cold Drawn Seamless —Corrosion Resisting —Welded	B.W.
WIRE	
Aluminum Magnesium Brass Bronze Copper	B&S
Iron—Soft	W&M
Steel—Cold Drawn —Corrosion Resisting —Music —Spring	W&M B&S WEBB W&M

MATERIAL GAGE SIZES

Gage Number	(B&S) American or Brown & Sharpe	(B.W.) Birmingham or Stubb's Iron Wire	(W.&M.) Washburn & Moen, American Steel & Wire Co.	(U.S.S.) United States Std. for Steel Sheets & Plates	(Webb) Music Wire Gage
7/0			.4900	.5000	
6/0	.5800		.4615	.4688	
5/0	.5165	.500	.4305	.4375	
4/0	.4600	.454	.3938	.4063	
3/0	.4096	.425	.3625	.3750	
2/0	.3648	.380	.3310	.3438	.0085
0	.3249	.340	.3065	.3125	.009
1	.2893	.300	.2830	.2813	.010
2	.2576	.284	.2625	.2656	.011
3	.2294	.259	.2437	.2500	.012
4	.2043	.238	.2253	.2344	.013
5	.1819	.220	.2070	.2188	.014
6	.1620	.203	.1920	.2031	.016
7	.1443	.180	.1770	.1875	.018
8	.1285	.165	.1620	.1719	.020
9	.1144	.148	.1483	.1563	.022
10	.1019	.134	.1350	.1406	.024
11	.0907	.120	.1205	.1250	.026
12	.0808	.109	.1055	.1094	.028
13	.0720	.095	.0915	.0938	.030
14	.0641	.083	.0800	.0781	.032
15	.0571	.072	.0720	.0703	.034
16	.0508	.065	.0625	.0625	.036
17	.0453	.058	.0540	.0563	.038
18	.0403	.049	.0475	.0500	.040
19	.0359	.042	.0410	.0438	.042
20	.0320	.035	.0348	.0375	.044
21	.0285	.032	.0317	.0344	.046
22	.0253	.028	.0286	.0313	.048
23	.0226	.025	.0258	.0281	.051
24	.0201	.022	.0230	.0250	.055
25	.0179	.020	.0204	.0219	.059
26	.0159	.018	.0181	.0188	.063
27	.0142	.016	.0173	.0172	.067
28	.0126	.014	.0162	.0156	.071
29	.0113	.013	.0150	.0141	.074
30	.0100	.012	.0140	.0125	.078
31	.0089	.010	.0132	.0109	.082
32	.0080	.009	.0128	.0102	.086
33	.0071	.008	.0118	.0094	.091
34	.0063	.007	.0104	.0086	.095
35	.0056	.005	.0095	.0078	.100
36	.0050	.004	.0090	.0070	.105
37	.0045		.0085	.0066	.110
38	.0040		.0080	.0063	.115
39	.0035		.0075		.120
40	.0031		.0070		.125
41	.0028		.0066		
42	.0025		.0062		
43	.0022		.0060		
44	.0020		.0058		
45	.00176		.0055		
46	.00157		.0052		
47	.00140		.0050		
48	.00124		.0048		
49	.00099		.0046		
50	.00088		.0044		

SECTION G
MISCELLANEOUS
ABBREVIATIONS AND SYMBOLS FOR USE ON DRAWINGS

(Apostrophes and periods are omitted except in case of abbreviation for inch)

A	ampere (s) (when preceded by a figure)
AC	alternating current
AL	aluminum
APPROX	approximate (ly)
ASSY	assembly (s)
BHP	brake horsepower
B/M	bill of material
B/P	blueprint
BMEP	brake mean effective pressure
BRG	bearing (s)
BTU	British thermal unit (s)
C	centigrade (when preceded by XX°)
CI	cast iron
CU	cubic
CYL	cylinder (s)
CBORE	counterbore
CDRILL	counterdrill
CSINK	countersink
COMM	commercial
COMP	complete
DC	direct current
DR	drive (s)
DIA	diameter (s)
DIM	dimension
DIMS	dimensions
DWG	drawing
EX	experimental
F	Fahrenheit (when preceded by XX°)
FT	foot (feet)
FHP	friction horsepower
FIG	figure (s)
G	grind
GA	gauge or gage
GAL	gallon (s)
H	harden
HP	horsepower
HEX	hexagon
ID	inside diameter
IN.	inch (es)
INCL	inclusive
LB	pound
LBS	pounds
LH	left hand
MM	millimeter (s)
MAX	maximum
MIN	minimum
MPH	miles per hour
MACH	machine (ing)
MATL	material
OA	overall
OD	outside diameter
OZ	ounce (s)
PROD	production
PD	pitch diameter
R	radius
RH	right hand
RED	reduction
REQ	required
REV	revolution (s)
RPM	revolutions per minute
SQ	square
STD	standard
SECT	section
SPEC	specification
SPECS	specifications
SPHER	spherical
THD	thread
THDS	threads
THRU	through
V	volt (s) (when preceded by a numeral)

SYMBOLS

@	at
&	and
℄	centerline
✓	finish
—	minus
+	plus
%	per cent

TOLERANCES ON DRILLED HOLES

(Where other than ± .01 tolerance is required)

CONTROLLED HOLES (For cotter pins, rivets and tapping, etc.)

No. 60 (.040") to .750" Drill (inclusive)	+.005 −.002
.7656" to 1.00" Drill (inclusive)	+.007 −.002
1.0039" to 2.00" Drill (inclusive)	+.010 −.002

HOLES FOR PINS

Drilled holes for pins which are to be a drive fit (e.g. pins to locate bushings in place) should carry a tolerance of ±.001.

SECTION D

GEARS

GEARING NOMENCLATURE AND ABBREVIATIONS

DETAIL DATA FOR THIS SECTION

TO BE SUPPLIED LATER.