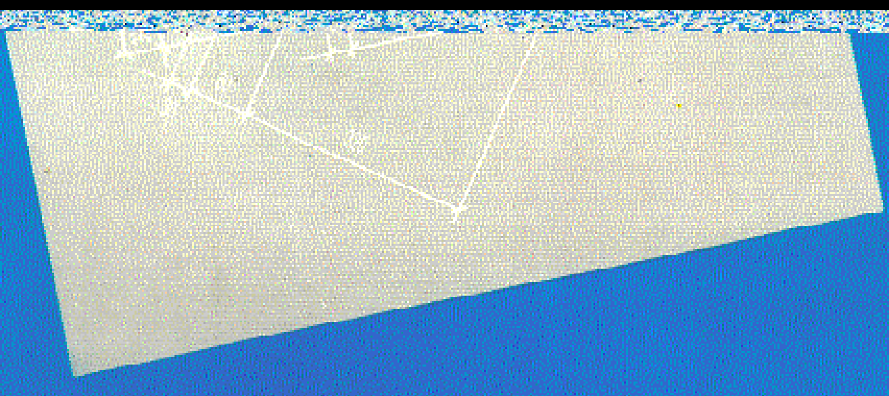

BUREAU OF INDIAN STANDARDS

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0. FOREWORD

0.1 In all the three types of exchanges like exchanges of goods, exchanges of services and exchanges of information, technical drawings form an essential component.

Goods of a technical nature in national and international trade nearly always need to be accompanied by service diagrams, or other technical drawings illustrating the components, their assembly and their use.

Exchanges of services may involve, for example, consultancy work or the design of an assembly in one [redacted] cating instructions or advice.

In exchanges of information, especially where different languages are involved, the technical drawings can clarify ambiguities or help to resolve problems in communicating by spoken or written word across language barriers.

0.2 To achieve these objectives, IS:696 'Code of practice for general engineering drawing' was originally issued in 1955 and revised twice in 1960 and 1972. Since the publication of the said standard, considerable progress has been achieved in the field of standardization of engineering drawing by mutual agreement between various countries and has taken the shape of firm standard. The growing international cooperation, introduction of foreign technology and export of technology has necessitated to develop internationally unified method and symbols for indicating in engineering drawing.

0.3 To meet the above necessity, the contents of IS:696-1972 'Code of practice for general engineering drawings *(second revision)*' have been harmonized with the relevant subject matter of ISO technical drawings and published a series of standards on technical drawing. IS:696 was so long being used by the students of technical institutions as a guide in engineering drawing. The technical committee responsible felt the need to bring out a special publication containing relevant information in the field of drawing standard in one document to meet the requirements of the students. This publication also includes geometrical tolerancing, guide for selection of fits in addition to the general principles and convention of engineering drawing to make the [redacted]

0.4 This publication is not intended to be a replacement for the complete standards on technical drawings and any parts omitted from this publication should not be considered as less important to the engineering profession than those included.

0.5 It is expected that educational institutions will have complete set of Indian Standards accessible in technical drawing classes.

NOTES ON THE USE OF THIS PUBLICATION

1. Except for the drawings shown in Appendix A, the figures used in the document are not intended to be examples of fully dimensioned working drawings. They are drawn to show the point explained in the text.
2. Examples of both FIRST ANGLE and THIRD ANGLE methods of projections are given (*see* Projections).
3. Values of dimensions and tolerances are typical examples only.

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SECTION 1 SIZES AND LAYOUT OF DRAWING SHEETS

1.1 Scope – This section specifies sizes of blank and pre-printed drawing sheets for use with all technical drawings in any field of engineering.

1.2 Basic Principles – The basic principles involved in arriving at the sizes are:

(a) $x : y = 1 : \sqrt{2}$ (b) $xy = 1$

where x and y are the sides and having a surface area of $1 m^2$ so that $x = 0.841$ m and $y = 1.189$ m.

1.2.1 Two series of successive format sizes are obtained by halving along the length or doubling along the width. The areas of the two sizes are in the ratio 1 : 2 (*see* Fig. 1.1).

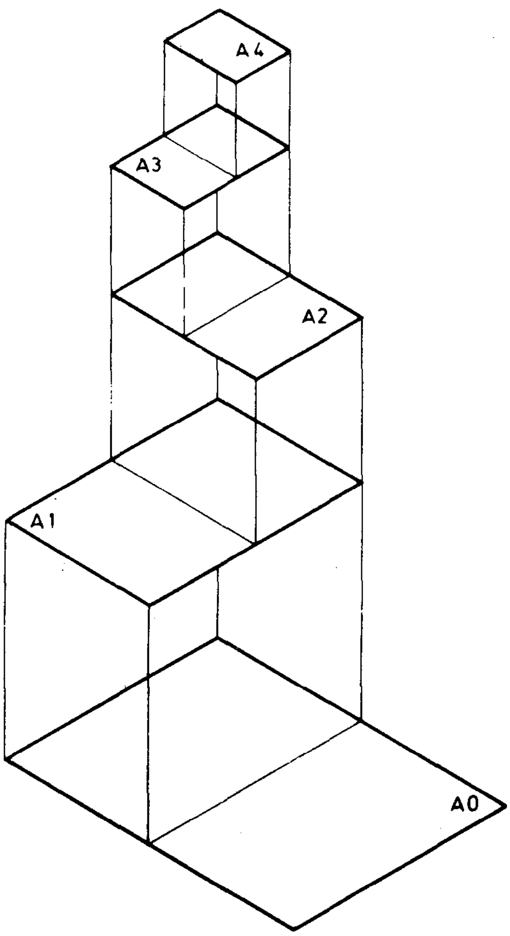


FIG. 1.1

1.2.2 The forms are similar to one another and hence the equation $x : y = 1 : \sqrt{2}$ is obtained for the two sides x and y of a format (*see* Fig. 1.2), consequently the ratio between both sides is the same as that of the sides of a square to its diagonal (*see* Fig. 1.3).

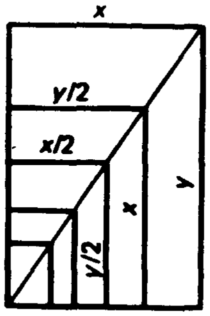


FIG. 1.2 SIMILARITY OF FORMATS

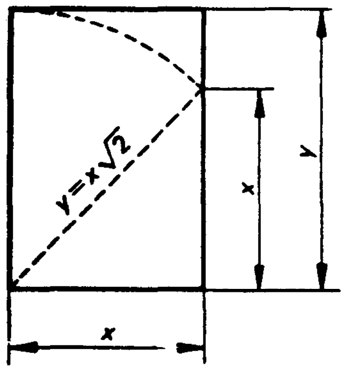


FIG. 1.3 RELATIONSHIP BETWEEN TWO SIDES

1.3 Designation of Sizes

1.3.1 *Sizes Series ISO-A (First Choice)* -- The preferred sizes of the trimmed sheets as selected from the main ISO-A Series are given in Table 1.1.

1.3.2 *Special Elongated Sizes (Second Choice)* – When a sheet of greater length is needed, one of the sizes in Table 1.2 should be used. These sizes are obtained by extending the shorter sides of a format of the ISO-A series to lengths that are multiples of the shorter sides of the chosen basic format.

TABLE 1.1

Designation	*Dimensions*, mm
A0	841 x 1 189
A1	594 x 841
A2	420 x 594
A3	297 x 420
A4	210 x 297

1.3.3 *Exceptional Elongated Sizes (Third Choice)* When a very large or extra elongated sheet is essential, one of the size in Table 1.3 should be used. These sizes are obtained by extending the shorter sides of a format of the ISO-A series to lengths that are multiples of the shorter sides of the chosen basic format.

TABLE 1.2

Designation	*Dimensions* mm
A3 × 3	420 × 891
A3 × 4	420 × 1 189
A4 × 3	297 × 630
A4 × 4	297 × 841
A4 × 5	297 × 1 051

TABLE 1.3

Designation	*Dimensions*, mm
A0 × 2*	1 189 × 1 682
A0 × 3	1 189 × 2 523†
A1 × 3	841 × 1 783
A1 × 4	841 × 2 378†
A2 × 3	594 × 1 261
A2 × 4	594 × 1 682
A2 × 5	594 × 2 102
A3 × 5	420 × 1 486
A3 × 6	420 × 1 783
A3 × 7	420 × 2 080
A4 × 6	297 × 1 261
A4 × 7	297 × 1 471
A4 × 8	297 × 1 682
A4 × 9	297 × 1892

* This size is equal to 2A0 of the ISO-A series.

† For practical reasons, the use of these sizes is not advisable.

1.4 Selection of Sizes - The original drawing should be made on the smallest sheet permitting the necessary clarity and resolution. The choice of sizes of the original drawing and its reproduction shall be made from the series shown in Tables 1.1, 1.2 and 1.3 in that order. Drawing sheets may be used with their longer sides positioned either horizontally (*see* Fig. 1.4) or vertically (*see* Fig. 1.5). The general features of a drawing sheet is as shown in Fig. 1.9.

1.5 Title Block

1.5.1 *Position*

1.5.1.1 The position of the title block should be within the drawing space (*see* Fig. 1.9) such that the portion of the title block containing the identification of the drawing (registration number, title, orgin, etc) is situated in the bottom right-hand corner of the drawing space, both for sheets positioned horizontally (Type X) (*see* Fig. 1.4) or vertically (Type Y) (*see* Fig. 1.5). The direction of the viewing of the title block should correspond, in general, with that of the drawing.

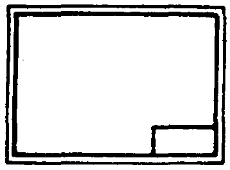


FIG. 1.4 SHEET TYPE X HORIZONTAL

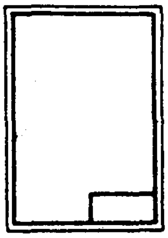


FIG. 1.5 SHEET TYPE Y VERTICAL

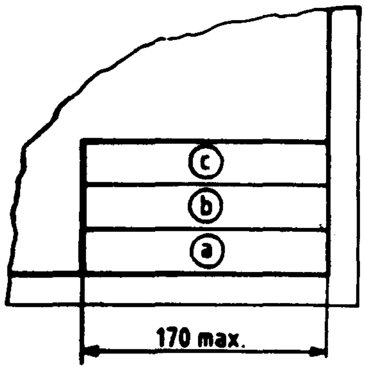


FIG. 1.6

1.5.1.2 Title block should preferably consist of one or more adjoining rectangles. These may be sub-divided into boxes for the insertion of specific information (*see* Fig. 1.6, 1.7 and 1.8).

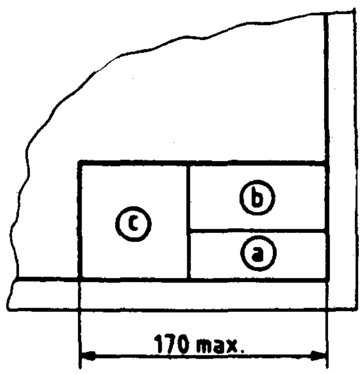


FIG. 1.7

1.6 Borders and Frames – Borders enclosed by the edges of the trimmed sheet and the frame limiting the drawing space shall be provided with all sizes. It is recommended that these borders have the minimum width of 20 mm for size A0 and A1, and a minimum width of 10 mm for size A2, A3 and A4 (*see* Fig.1.9).

1.7 Centring Marks – Four centring marks shall be provided on all drawings in order to facilitate the positioning of the drawing when reproduced or microfilmed.

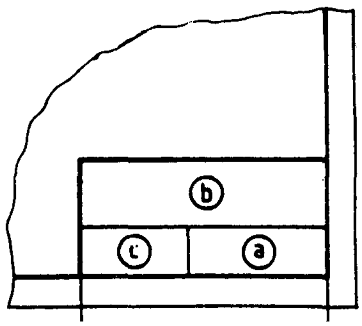


FIG. 1.8

1.8 Grid Reference

1.8.1 The provision of grid reference system is recommended for all sizes, in order to permit easy location on the drawing of details, additions, modifications, etc. The number of divisions should be divisible by two and be chosen in relation to the complexity of the drawing. It is recommended that the length of any side of the rectangles comprising the grid shall not be less than 25 mm and not more than 75 mm.

1.8.2 The rectangles of the grid should be referred by means of capital letters along one edge and numerals along the other edge. The numbering direction may start at the sheet corner opposite to the title block and be repeated on the opposite sides.

1.9 Multiple Sheet Drawings – Multiple sheet drawings marked with the same registration or identification number should be indicated by means

example :

Sheet No. = n/p

where

n is the sheet number, and
p is the total number of sheets.

An abbreviated title block, containing only the identification zone, may be used for all sheets after the first sheet.

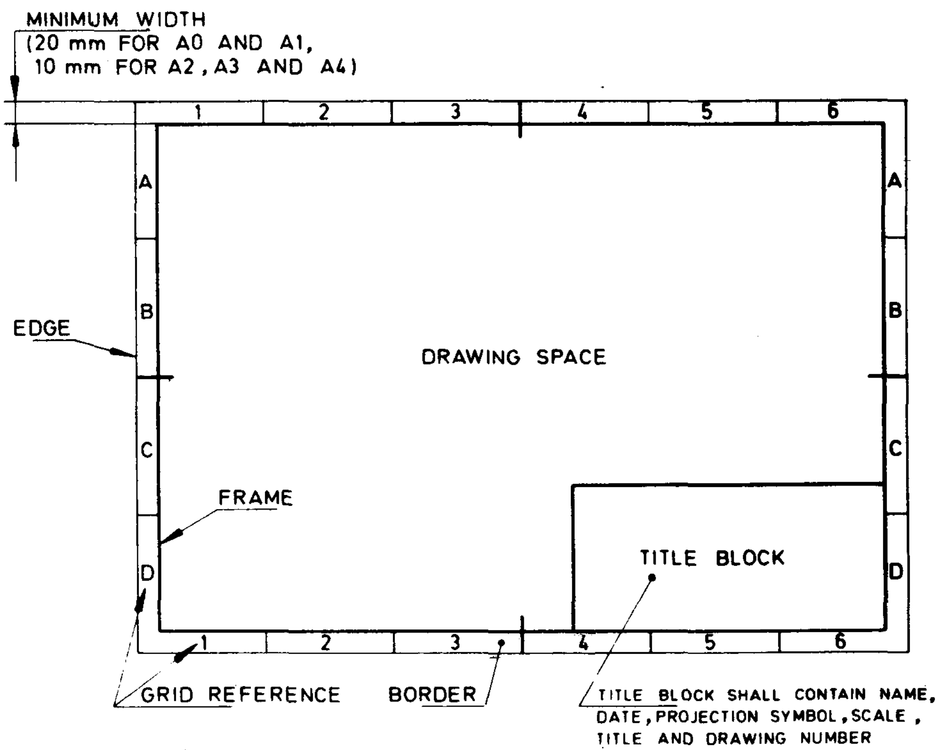


FIG. 1.9

SECTION 2 ITEM REFERENCES ON DRAWINGS AND ITEM LISTS

2.1 Scope – This section gives guidance and recommendations on establishment of item reference and item list for use with technical drawings.

2.2 Item References – The item references should be assigned in sequential order to each component part shown in an assembly and/or each detailed item on the drawing. Further identical parts shown in the same assembly should have the same item reference. All item references shall be shown in an item list (*see* Fig. 2.4 and Table 2.1).

2.3 Presentation

2.3.1 Item references should generally be composed of Hindu-Arabic numerals only. They may, however, be augmented by capital letters when necessary.

2.3.2 All item references on the same drawing shall be of the same type and height of lettering. They shall be clearly distinguishable from all other indications. This can be achieved, for example, by:

a) using characters of a larger height, for example, twice the height as used for dimensioning and similar indications;

b) encircling the characters of each item reference, in that case all such circles shall have the same diameter and to be drawn with continuous thin line (Type B) (*see* Fig. 2.3).

c) combining methods (a) and (b).

2.3.3 Item references shall be placed outside the general outlines of the items concerned.

2.3.4 Each item reference should be connected to its associated item by a leader line (*see* Fig. 2.1, 2.2, and 2.3).

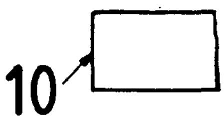


FIG. 2.1

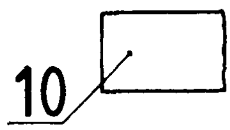


FIG. 2.2

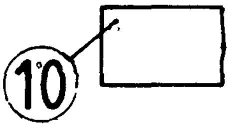


FIG. 2.3

2.3.5 Leader lines shall not intersect. They should be kept as short as practicable and generally should be drawn at an angle to the item reference. In case of encircled item references, the leader line shall be directed towards the centre of the circle.

2.3.6 Item references of related items may be shown against the same leader line (*see* Fig. 2.4, items 8, 9, 10 and 11).

2.3.7 Item references of identical items need only be shown once, provided their is no risk of ambiguity.

2.4 Item List

2.4.1 Item lists are complete lists of the items constituting an assembly (or a sub-assembly), or of detailed parts, presented on a technical drawing. It is not necessary for all these items to be detailed on an end-product drawing. The association between the items on an item list and their representation on the relevant drawing (or on other drawings) is given by the item references.

2.4.2 The item lists may be included on the drawing itself or be a separate document.

2.4.3 When included on the drawing, the position of the item list should be such as to be read in the viewing direction of the drawing. The list may be in conjunction with the title block. Its outlines may be drawn with continuous thick lines (type A).

2.4.4 Where the item list is shown on a separate document, this shall be identified by the same number as that of the parent drawing.

2.4.5 However, to distinguish this identification from that of the parent drawing, it is recommended that the item list number be preceded by the prefix item list (or a similar term in the language used on the documents).

2.4.6 *Layout* – It is recommended that the item list be arranged in columns by means of continuous thick or thin lines (type A or B) to allow information to be entered under the following headings (the sequence of these is optional):

a) item,
b) description,
c) quantity,
d) reference,
e) material

NOTE – If necessary, more columns can be added to cover specific requirements.

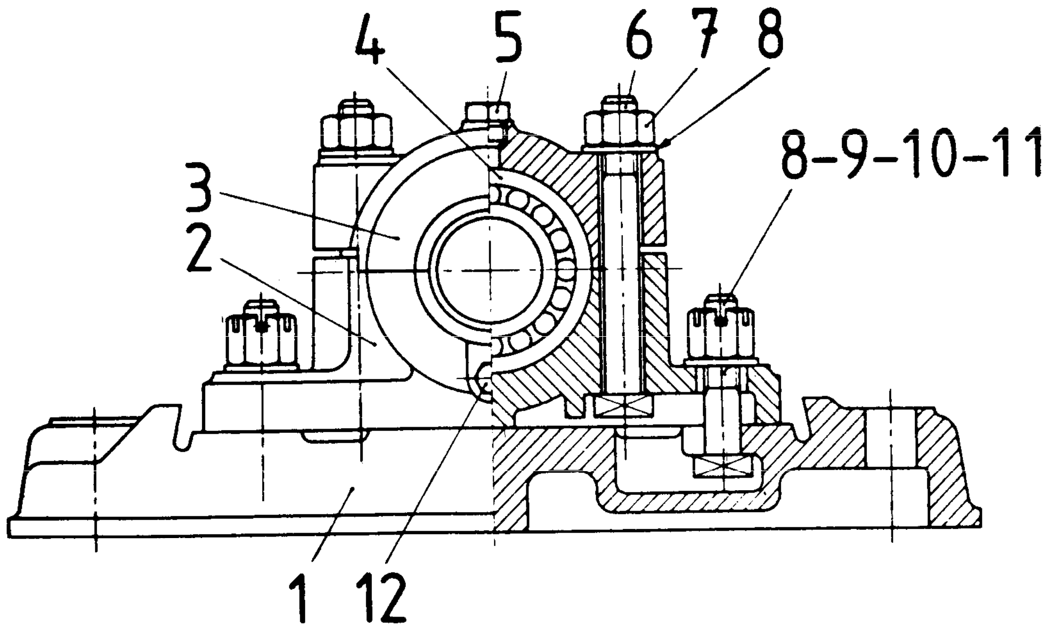


FIG. 2.4

TABLE 2.1 ITEM LIST

Item	*Quantity*	*Description*	*Reference*
1	1	Base	
2	1	Bottom housing	
3	1	Top housing	
4	1	Bearing	
5	1	Filling plug	
6	2	T-bolt	
7	2	Hex nut	
8	4	Washer	
9	2	T-bolt	
10	2	Castle nut	
11	2	Split pin	
12	1	Drain plug	

SECTION 3 PLANNING OF ASSEMBLY DRAWINGS

3.1 Scope – This section covers the requirements of planning of assembly drawings.

3.2 Where a number of drawings are required to detail a complete design, an assembly drawing is necessary. Such a drawing will show the design to a convenient scale, and the drawing or part numbers which are the constituents of the particular assembly are listed in a tabular form as shown in Fig. 2.4 and Table 2.1.

3.3 A method, applicable to general engineering [illegible] a small key plan or elevation or both, conveniently placed near the title block, indicating part of the whole work in thick lines to which the particular drawing sheet refers (*see* Fig. 3.1).

3.4 The general assembly drawing may be broken into further sub-assemblies and parts, determined

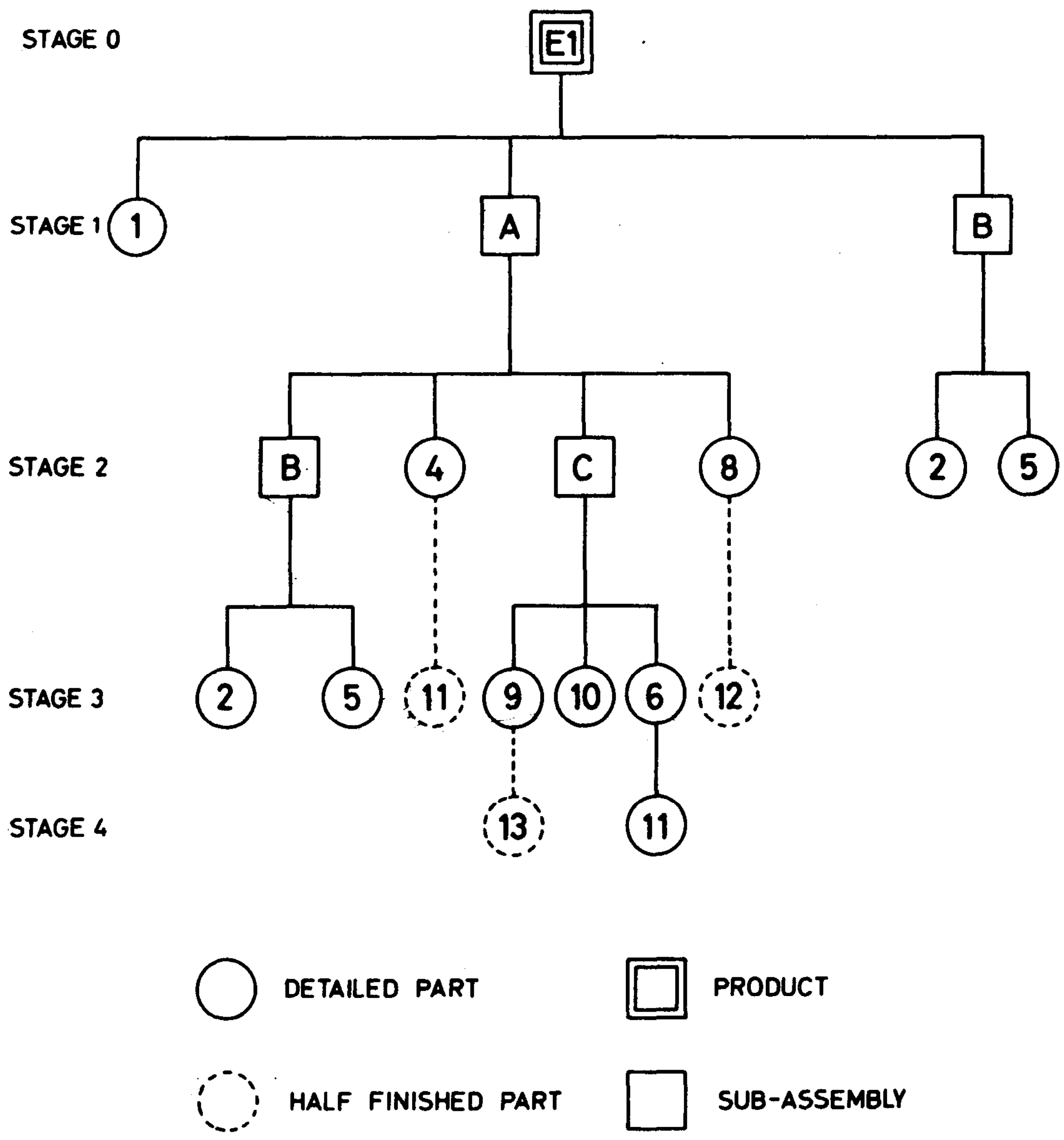
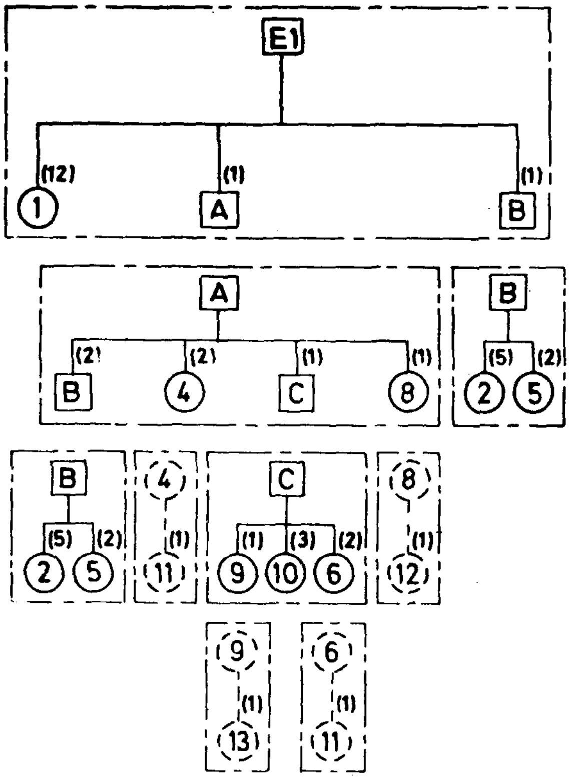


FIG. 3.1

mainly by production requirements. A typical chart showing the breakdown of such assembly drawing is shown in Fig. 3.2.

3.5 In general, the detailed view shown in any assembly drawing should have the same orientation as that shown in the main assembly view.



E1 Consists of	
Object No.	Quantity
1	12
A	1
B	1

A Consists of	
Object No.	Quantity
B	2
4	2
C	1
8	1

B Consists of	
Object No.	Quantity
2	5
5	2

C Consists of	
Object No.	Quantity
9	1
10	3
6	2

4 Consists of	
Object No.	Quantity
11	1

6 Consists of	
Object No.	Quantity
11	1

8 Consists of	
Object No.	Quantity
12	1

9 Consists of	
Object No.	Quantity
13	1

EXPLANATION OF SYMBOLS

□ GROUP PRODUCT

○ COMPOSITE PART

SEMI-FINISHED PRODUCT

( ) INDICATION OF QUANTITY IN THE PARTS LIST

FIG. 3.2

SECTION 4 FOLDING OF DRAWING PRINTS

4.1 Scope -- This section covers two methods of folding of drawing prints.

4.1.1 The first method is intended for drawing prints to be filed or bound, while the second method is intended for prints to be kept individually in filing cabinet.

4.2 Basic Principles – The basic principles in each of the above methods are to ensure that:

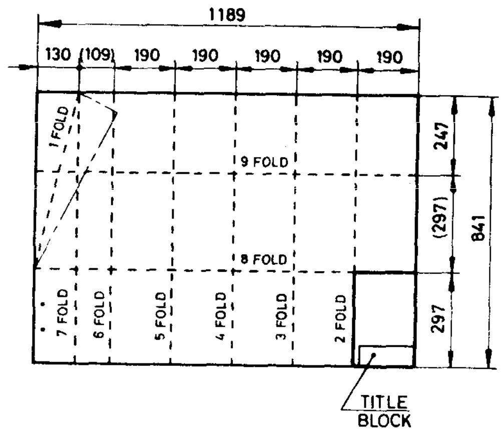
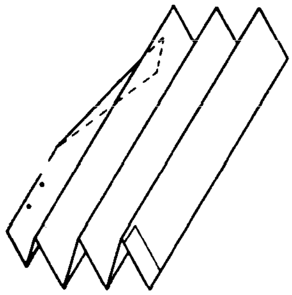
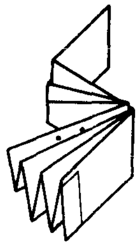
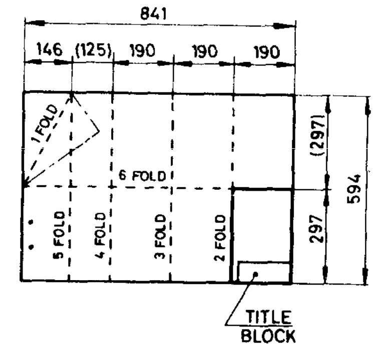
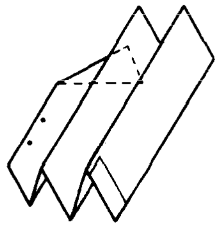
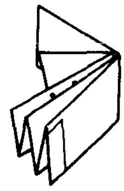
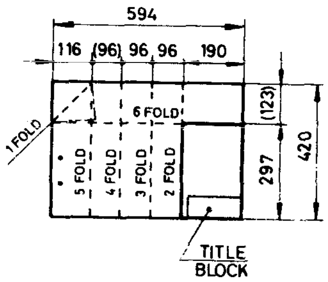
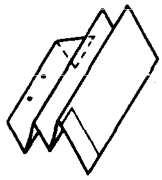
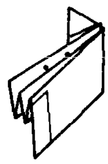
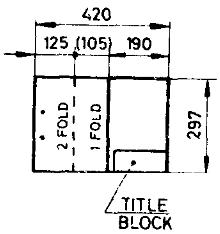
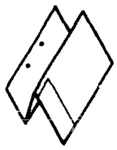
a) all large prints of sizes higher than A4 are folded to A4 sizes;

b) the title blocks of all the folded prints appear in topmost position; and

c) the bottom right corner shall be outermost visible section and shall have a width not less than 190 mm.

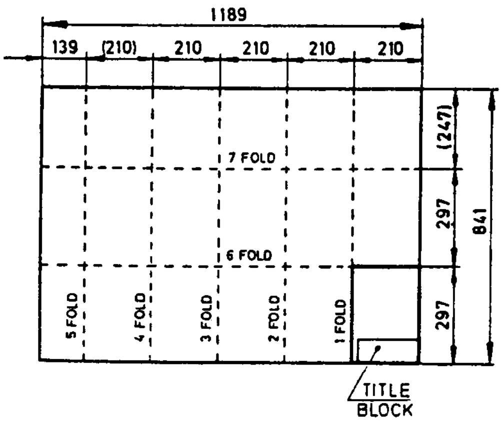
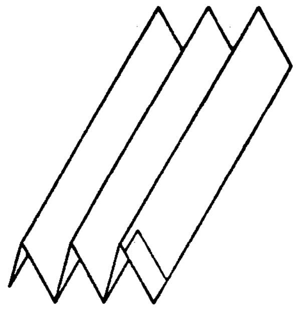
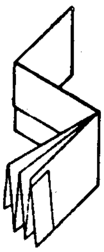
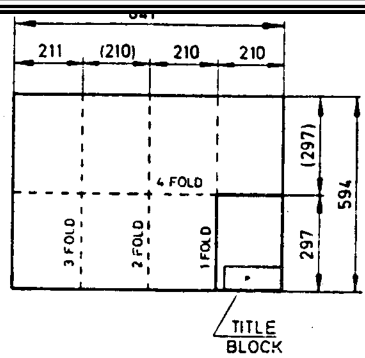
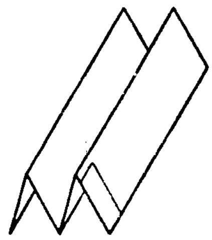
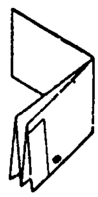
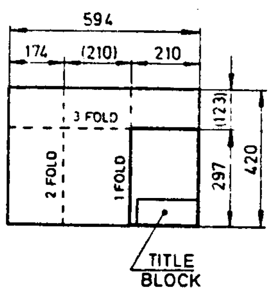
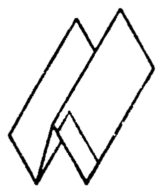
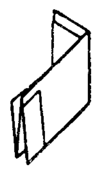
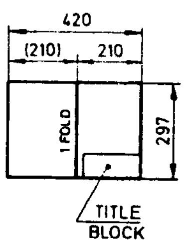
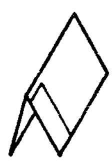
4.3 Depending on the method of folding adopted, suitable folding marks are to be introduced in the tracing sheets as guide.

4.4 Methods of Folding of Drawing Prints – The methods recommended for folding are indicated in Fig. 4.1 and 4.2.

SHEET DESIGNATION	FOLDING DIAGRAM	LENGTHWISE FOLDING	CROSSWISE FOLDING
A0 841 x 1189			
A1 594 x 841			
A2 420 x 594			
A3 297 x 420			—

All dimensions in millimetres.

FIG. 4.1 FOLDING OF PRINTS FOR FILING OR BINDING

SHEET DESIGNATION	FOLDING DIAGRAM	LENGTHWISE FOLDING	CROSSWISE FOLDING
A 0 841 x 1189			
A 1 594 x 841			
A 2 420 x 594			
A 3 297 x 420			—

All dimensions in millimetres.

FIG. 4.2 FOLDING OF PRINTS FOR STORING IN FILING CABINET

SECTION 5 SCALES

5.1 Scope – This section specifies recommended scales and their designation for use on all technical drawings in any field of engineering.

5.2 Definitions

5.2.1 *Scale* – Ratio of the linear dimension of an element of an object as represented in the original drawing to the real linear dimension of the same element of the object itself.

NOTE – The scale of a print may be different from that of the original drawing.

5.2.2 *Full Size* – A scale with the ratio 1:1.

5.2.3 *Enlargement Scale* – A scale where the ratio is larger than 1:1. It is said to be larger as its ratio increases.

5.2.4 *Reduction Scale* – A scale where ratio is smaller than 1:1. It is said to be smaller as its ratio decreases.

5.3 Designation – The complete designation of a scale shall consist of the word 'SCALE' (or its equivalent in the language used on the drawing) followed by the indication of its ratio, as follows:

SCALE 1 : 1 for full size;

SCALE *X* : 1 for enlargement scales;

SCALE 1 : *X* for reduction scales.

If there is no likelihood of misunderstanding, the word SCALE may be omitted.

5.4 Scales for Use on Technical Drawings

Category	*Recommended Scales*		
Enlargement Scales	50:1 5:1	20:1 2:1	10:1
Full size			1:1
Reduction Scales	1:2 1:20 1:200 1:2000	1:5 1:50 1:500 1:5000	1:10 1:100 1:1000 1:10000

5.4.1 The scale to be chosen for a drawing will depend upon the complexity of the object to be depicted and the purpose of the representation.

5.4.2 In all cases, the selected scale shall be large enough to permit easy and clear interpretation of the information depicted.

5.4.3 Details that are too small for complete dimensioning in the main representation shall be shown adjacent to the main representation in a separate detail view (or section) which is drawn to a large scale.

SECTION 6 LINES

6.1 Scope – This section specifies the types of lines, their thickness and application for use in technical drawings.

6.2 Types of Lines

6.2.1 The types of lines and their applications are as given in Table 6.1.

6.2.1.1 It is recommended that only line types as given in Table 6.1 shall be used.

6.2.1.2 Where other types or thicknesses of lines are used for special fields or if the lines specified in Table 6.1 are used for applications other than those detailed in the table, the conventions adopted should be explained by notes on the respective drawing.

6.2.1.3 Typical applications of different types of lines are shown in Fig. 6.1 and 6.2.

6.3 Thicknesses and Proportional Dimensions of Lines

6.3.1 Two thicknesses of lines are used. The ratio of the thick to the thin line shall not be less than 2:1. Grading of lines is in $\sqrt{2}$ increments.

The thickness of lines should be chosen according to the size and the type of the drawing from the following range:

0.18, 0.25, 0.35, 0.5, 0.7, 1, 1.4 and 2 mm.

6.3.2 For all views of one piece to the same scale, the thickness of the lines should be the same.

NOTE – Owing to difficulties in certain methods of recproduction, the line thickness of 0.18 mm should be avoided.

TABLE 6.1

Line	Description	General applications See figures 6.1, 6.2 and other relevant figures
A	Continuous thick	A1 Visible outlines A2 Visible edges
B	Continuous thin (straight or curved)	B1 Imaginary lines of intersection B2 Dimension lines B3 Projection lines B4 Leader lines B5 Hatching B6 Outlines of revolved sections in place B7 Short centre lines
C D[1]	Continuous thin freehand[2] Continuous thin (straight) with zigzags	C1 Limits of partial or interrupted views and sections, if the limit is not a chain thin D1 line (see figures 53 and 54)
E F	Dashed thick[2] Dashed thin	E1 Hidden outlines E2 Hidden edges F1 Hidden outlines F2 Hidden edges
G	Chain thin	G1 Centre lines G2 Lines of symmetry G3 Trajectories
H	Chain thin, thick at ends and changes of direction	H1 Cutting planes
J	Chain thick	J1 Indication of lines or surfaces to which a special requirement applies
K	Chain thin double-dashed	K1 Outlines of adjacent parts K2 Alternative and extreme positions of movable parts K3 Centroidal lines K4 Initial outlines prior to forming (see figure 58) K5 [illegible] (see figure 48)

1) This type of line is suited for production of drawings by machines.

2) Although two alternatives are available, it is recommended that on any one drawing, only one type of line be used.

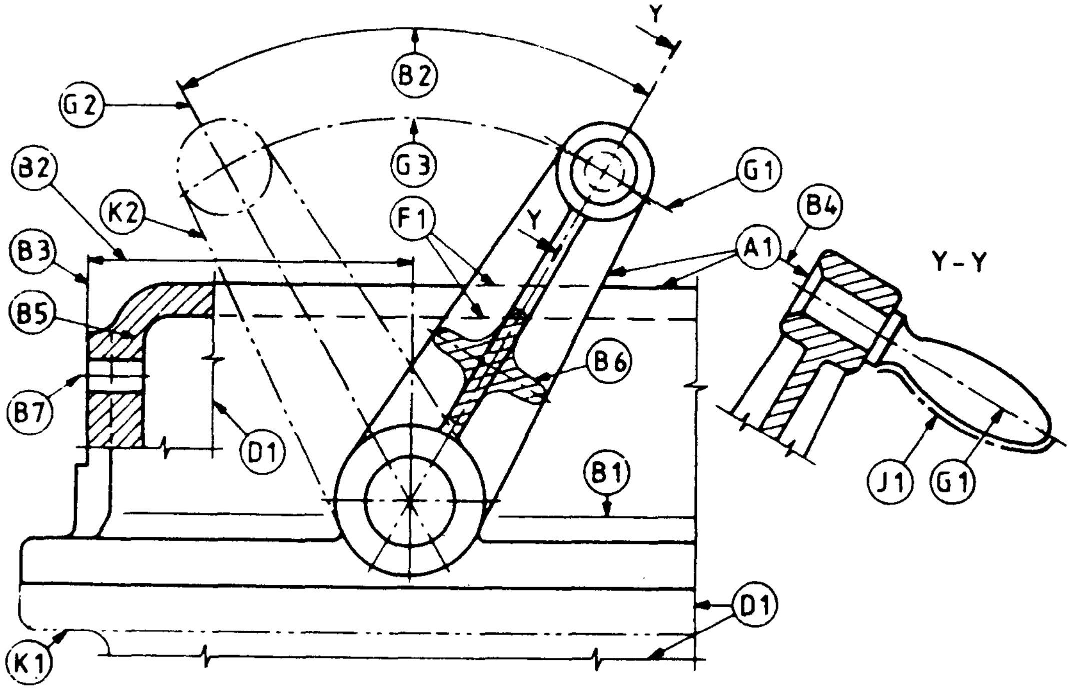


FIG. 6.1

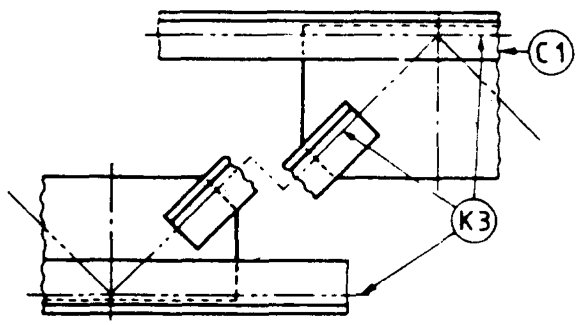


FIG. 6.2

6.4 **Spacing of Lines** – The minimum space between parallel lines, including hatching, should never be less than twice the thickness of the heaviest line. It is recommended that these spaces should never be less than 0.7 mm.

6.5 **Order of Priority of Coinciding Lines** – When two or more lines of different type coincide, the following order of priority should be observed (*see* Fig. 6.3).

a) visible outlines and edges (continuous thick lines, type A);
b) hidden outlines and edges (dashed line, type E or F);
c) cutting planes (chain thin line, thick at ends and changes of cutting planes, type H);
d) centre lines and lines of symmetry (chain thin line, type G);
e) centroidal lines (chain thin double-dashed line, type K);
f) projection lines (continuous thin line, type B).

Adjacent outlines of assembled parts shall coincide, black thin sections excepted (*see* Fig. 9.9).

6.6 **Termination of Leader Lines** – A leader line is a line referring to a feature (dimension, object, outline, etc).

Leader lines should terminate:

– with a dot, if they end within outlines of an object (*see* Fig. 6.4).
– with an arrow head, if they end on the outline of an object (*see* Fig. 6.5).
– without dot or arrowhead, if they end on a dimension line (*see* Fig. 6.6).

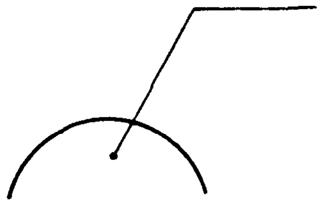


FIG. 6.4

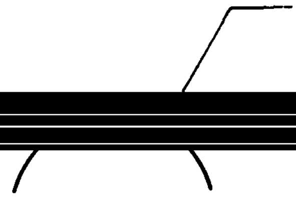


FIG. 6.5

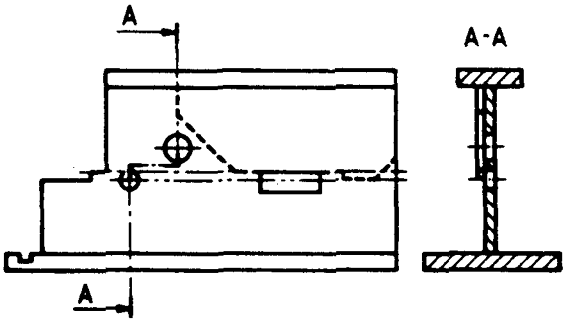


FIG. 6.3

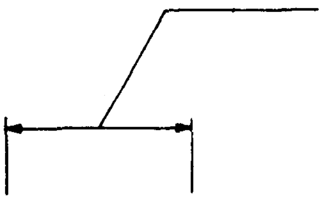


FIG. 6.6

SECTION 7 LETTERING

7.1 Scope – This section specifies the characteristics of lettering used on technical drawings, and associated documents. It concerns primarily letters written with the aid of stencils, but is equally applicable for free hand lettering.

7.2 Dimensions

7.2.1 The height *h* of the capital letter is taken as the base of dimensioning (*see* Tables 7.1 and 7.2).

7.2.2 The two standard ratios for *d/h*, 1/14 and 1/10, are most economical as they result in a minimum number of line thickness as is illustrated in Tables 7.1 and 7.2.

7.2.2.1 Recommended ratios for the height of lower-case letters (without stem or tail), for the space between characters, for the minimum space of the base lines and the minimum space of words are given in Tables 7.1 and 7.2.

7.3 The lettering may be inclined 15° to the right, or may be vertical.

7.4 Recommended Sizes

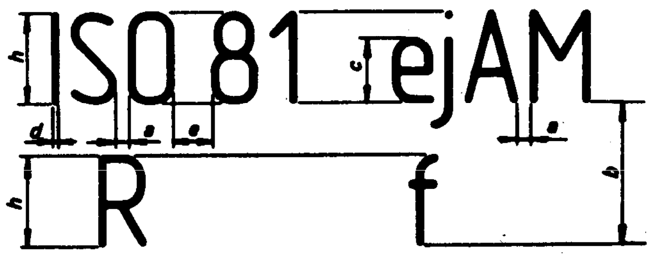


FIG. 7.1

TABLE 7.1

Lettering A ($d = h/14$) — Values in millimetres

Characteristic		Ratio	Dimensions						
Lettering height Height of capitals	*h*	(14/14) *h*	2.5	3.5	5	7	10	14	20
Height of lower-case letters (without stem or tail)	*c*	(10/14) *h*	–	2.5	3.5	5	7	10	14
Spacing between characters	*a*	(2/14) *h*	0.35	0.5	0.7	1	1.4	2	2.8
Minimum spacing of base lines	*b*	(20/14) *h*	3.5	5	7	10	14	20	28
Minimum spacing between words	*e*	(6/14) *h*	1.05	1.5	2.1	3	4.2	6	8.4
Thickness of lines	*d*	(1/14) *h*	0.18	0.25	0.35	0.5	0.7	1	1.4

NOTE – The spacing *a* between two characters may be reduced by half if this gives a better visual effect, as for example LA, TV; it then equals the line thickness *d*.

TABLE 7.2

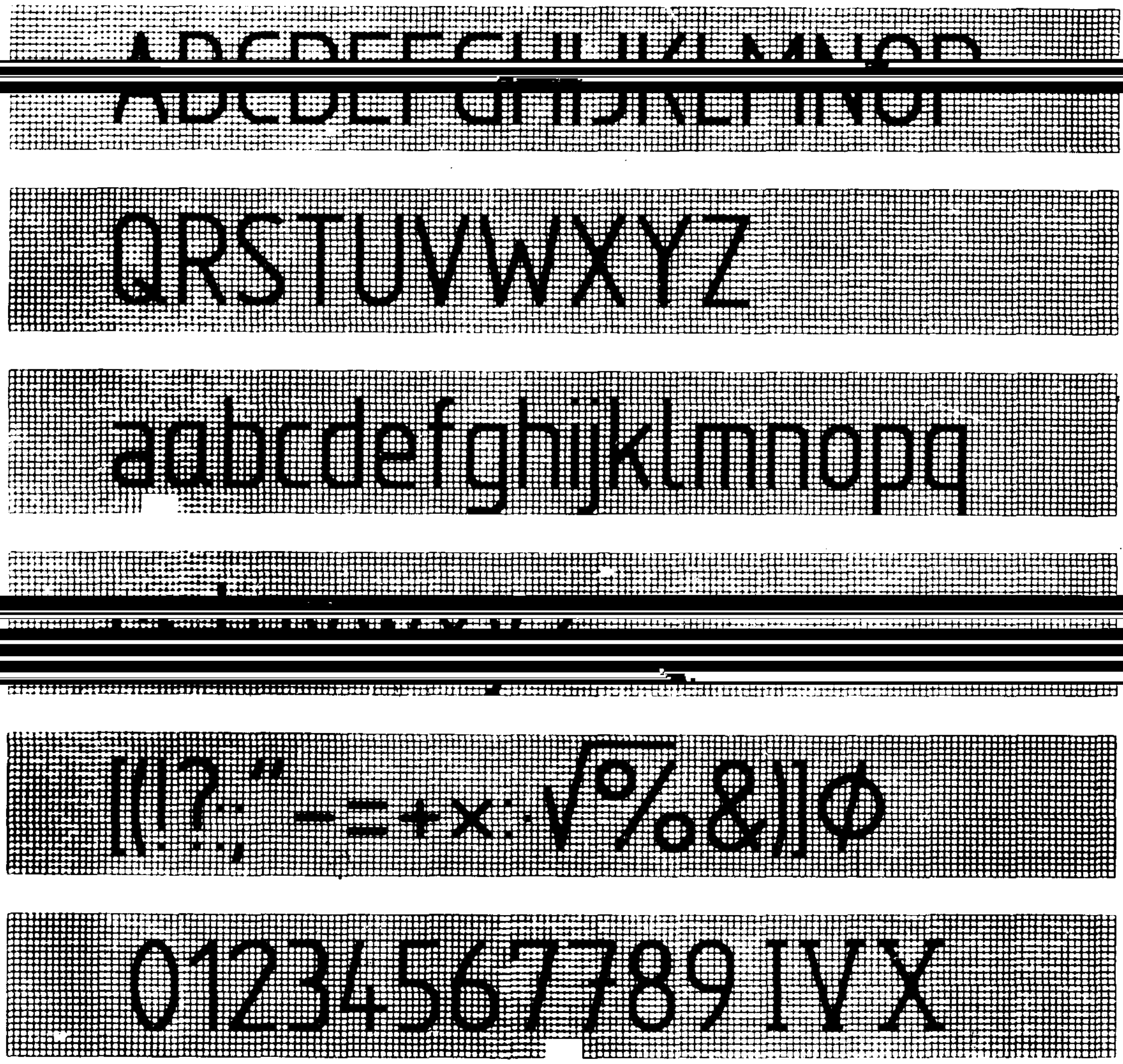
Lettering B (*d* = *h*/10) — **Values in millimetres**

Characteristic		*Ratio*	*Dimensions*						
Lettering height **Height of capitals**	***h***	**(10/10) *h***	**2.5**	**3.5**	**5**	**7**	**10**	**14**	**20**
Height of lower-case letters (without stem or tail)	**c**	**(7/10) *h***	**—**	**2.5**	**3.5**	**5**	**7**	**10**	**14**
Spacing between characters	***a***	**(2/10) *h***	**0.5**	**0.7**	**1**	**1.4**	**2**	**2.8**	**4**
Minimum spacing of base lines	***b***	**(14/10) *h***	**3.5**	**5**	**7**	**10**	**14**	**20**	**28**
Minimum spacing between words	***e***	**(6/10) *h***	**1.5**	**2.1**	**3**	**4.2**	**6**	**8.4**	**12**
Thickness of lines	***d***	**(1/10) *h***	**0.25**	**0.35**	**0.5**	**0.7**	**1**	**1.4**	**2**

NOTE — The spacing *a* between two characters may be reduced by half if this gives a better visual effect, as for example LA, TV; it then equals the line thickness *d*.

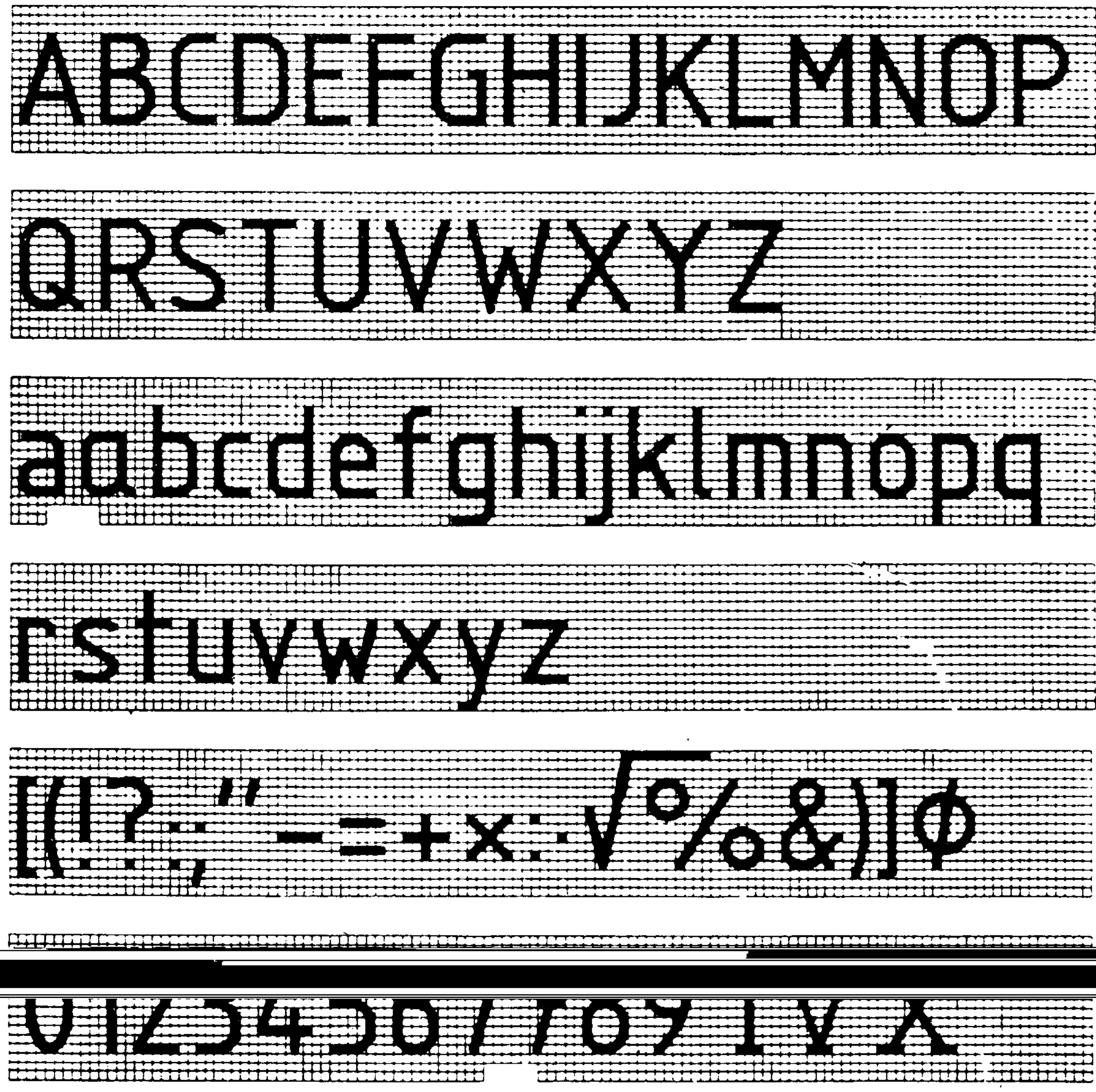
7.5 Specimen

7.5.1 *Lettering A Vertical*



NOTE – To obtain constant line-density, freedom from blotting at intersecting line and ease of writing, the letters shall be formed so that lines cross or meet nearly at right-angles.

7.5.2 *Lettering B Vertical*



NOTE – To obtain constant line-density, freedom from blotting at intersecting line and ease of writing, the letters shall be formed so that lines cross or meet nearly at right-angles.

SECTION 8 GENERAL PRINCIPLES OF PRESENTATION

8.1 Scope – This section specifies the general principles of presentation of technical drawings following the orthographic projection methods.

8.1.1 This section is intended for all kinds of technical drawings (mechanical, electrical, architectural, civil engineering, etc). However, it is recognized that in some specific technical areas, the general rules and conventions cannot adequately cover all the needs of specialized practices, and that additional rules are required which may be specified in separate standards. For these areas, the general principles should however be respected in order to facilitate international exchange of drawings and to ensure the coherence of drawings in a comprehensive system relating to several technical functions.

8.2 Views

8.2.1 *Designation of Views*

View in direction *a* = View from the front

View in direction *b* = View from above

View in direction *c* = View from the left

View in direction *d* = View from the right

View in direction *e* = View from below

View in direction *f* = View from the rear

8.2.1.1 The front view (principle view) having been chosen (*see* 8.2.4), the other customary views make with it and between themselves angles of 90^0 or multiples of 90^0 (*see* Fig. 8.1).

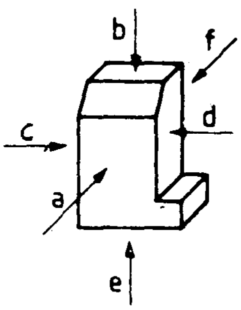


FIG. 8.1

8.2.2 *Relative Position of Views* – Two alternative orthographic projection methods, of equal standing, can be used.

– the first angle projection method, or
– the third angle projection method.

NOTE – For uniformity among the figures given throughout this publication as examples, the relative position of views are those provided by the first angle projection method. It should be understood, however, that each of the two methods could equally have been used without prejudice to the principles established. **However, as a basic requirement, use of first angle projection method is to be followed.**

8.2.2.1 *First angle projection method* – With reference to the front view (a), the other views are arranged as follows (*see* Fig. 8.2):

The view from above (b), is placed underneath.
The view from below (e), is placed above,
The view from the left (c), is placed on the right.
The view from the right (d), is placed on the left.
The view from the rear (f) may be placed on the left, or on the right, as convenient.

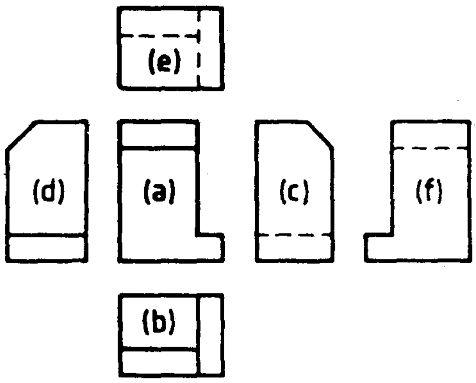


FIG. 8.2

The distinguishing symbol of this method is shown in Fig. 8.3.

FIG. 8.3

8.2.2.2 *Third angle projection method* – With reference to the front view (a), the other views are arranged as follows (*see* Fig. 8.4):

The view from above (b), is placed above.
The view from below (e), is place underneath.
The view from the left (c), is placed on the left.
The view from the right (d), is placed on the right.
The view from the rear (f), may be placed on the left, or on the right, as convenient.

The distinguishing symbol of this method is shown in Fig. 8.5.

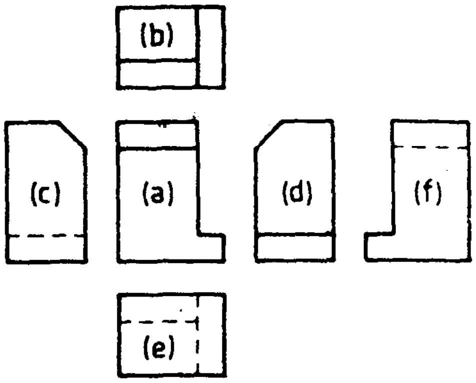


FIG. 8.4

FIG. 8.5

8.2.2.3 *Layout of Views Using Reference Arrows* — In those cases where it is an advantage to position the views not according to the strict pattern of the first or the third angle projection methods, the use of reference arrows permits the various views to be freely positioned.

With the exception of the principal view, each view shall be identified by a capital letter which is repeated near the arrow needed to indicate the direction of viewing for the relevant view.

The designated views may be located irrespective of the principal view. The capital letters identifying the referenced views shall be placed either immediately below or above the relevant views. In any one drawing, the references shall be placed in the same way. No other indication is necessary (*see* Fig. 8.6).

8.2.3 *Indication of Method* — Where one of the methods specified in 8.2.2.1 and 8.2.2.2 is being used, the said method must be indicated on the drawing by means of its distinguishing symbol as shown in Fig. 8.3 or 8.5.

The symbol shall be placed in a space provided for the purpose in the title block of the drawing.

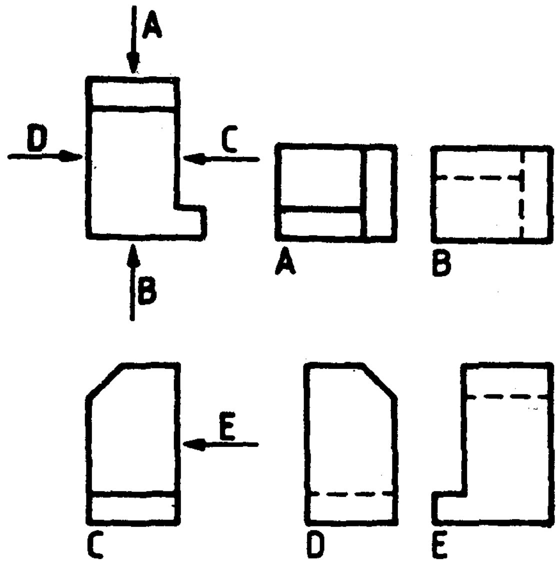


FIG. 8.6

For the layout of views using reference arrows specified in 8.2.2.3, no distinguishing symbol is required.

8.2.4 *Choice of Views*

8.2.4.1 The most informative view of an object shall be used as the front or principal view. Generally, this view shows the part in the functioning position. Parts which can be used in any position should preferably be drawn in the main position of manufacturing or mounting.

8.2.4.2 When other views (including sections) are needed, these shall be selected according to the following princples:

- to limit the number of views and sections to the minimum necessary and sufficient to fully delineate the object without ambiguity,
- to avoid the need for hidden outlines and edges,
- to avoid unnecessary repetition of detail.

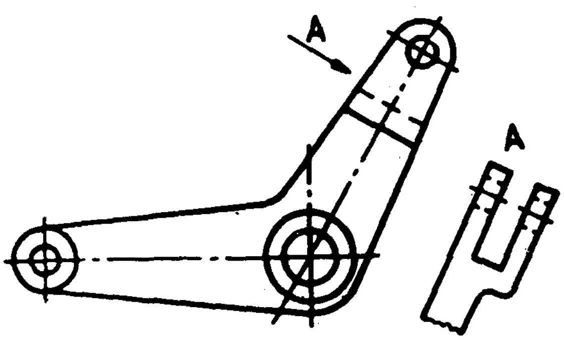


FIG. 8.7

8.2.5 *Special Views*

8.2.5.1 If a direction of viewing different from those shown in 8.2.1 is necessary, or if a view cannot be placed in its correct position using the methods shown in 8.2.2.1 and 8.2.2.2, reference arrows as indicated in 8.2.2.3 shall be used for the relevant view (*see* Fig. 8.7 and 8.8).

8.2.5.2 Whatever the direction of viewing, the capital letters referencing the views shall always be positioned normal to the direction of reading.

8.2.6 *Partial Views* – Partial views may be used where complete views would not improve the information to be given. The partial view shall be cut off by a continuous thin freehand line (type C) or

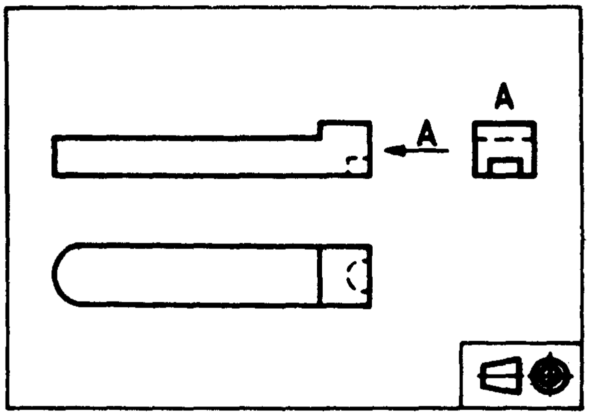


Fig. 8.8

execution of the drawing.

8.2.7 *Local Views*

8.2.7.1 Provided that the presentation is unambiguous, it is permitted to give a local view instead of a complete view for symmetrical items. The local view should be drawn in third angle projection,

8.2.7.2 Local views shall be drawn with continuous thick lines (type A), and shall be connected to the principal view by a centre line (type G). Examples of local views are shown in the Fig. 9.27, 9.28, 9.29 and 9.30.

SECTION 9 SECTIONS AND OTHER CONVENTIONS

9.1 Scope – This section covers the methods of representation of sectional views and other conventions.

9.2 Sections

9.2.1 *Notes on Hatching of Sections*

9.2.1.1 Hatching is generally used to show areas of sections. Allowance must be made for the methods of reproduction that are to be used.

9.2.1.2 The simplest form of hatching is usually adequate for the purpose, and may be based upon continuous thin lines (type B) at a convenient angle, preferably 45^0, to the princpal outlines or lines of symmetry of the sections (*see* Fig. 9.1, 9.2 and 9.3).

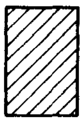


FIG. 9.1

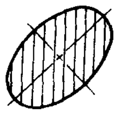


FIG. 9.2

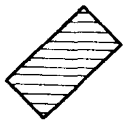


FIG. 9.3

9.2.1.3 Separate areas of a section of the same component shall be hatched in an identical manner. The hatching of adjacent components shall be carried out with different directions or spacings (*see* Fig. 9.4 and 9.5).

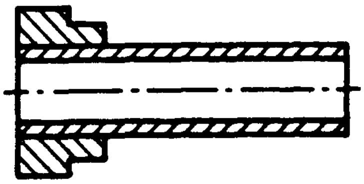


FIG. 9.4

9.2.1.4 Spacing between the hatching lines should be chosen in proportion to the size of the hatched areas, provided that the requirement for minimum spacing are maintained (*see* 6.4).

9.2.1.5 In the case of large areas, the hatching may be limited to a zone following the contour of the hatched area (*see* Fig. 9.5).

9.2.1.6 Where sections of the same part in parallel planes are shown side by side, the hatching shall be identical, but may be offset along the dividing line between the sections if greater clarity is considered necessary (*see* Fig. 9.6).

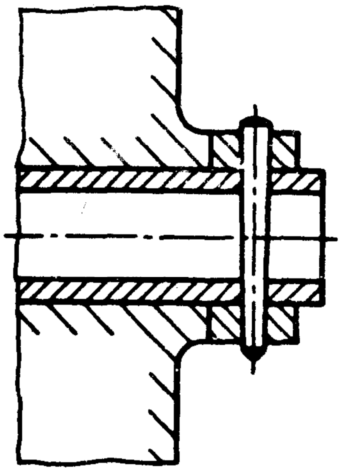


FIG. 9.5

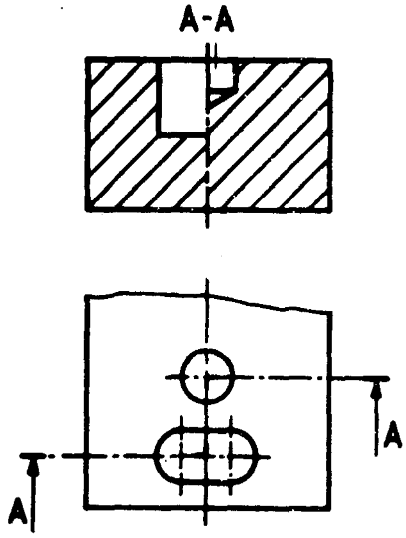


FIG. 9.6

9.2.1.7 Hatching shall be interrupted when it is not possible to place inscriptions outside the hatched area (*see* Fig. 9.7).

9.2.2 *Hatching to Indicate Type of Materials*

9.2.2.1 Hatching may be used to indicate type of materials in sections.

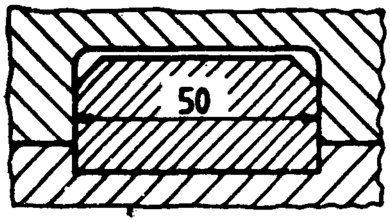


FIG. 9.7

9.2.2.2 If different types of hatching are used to indicate different materials, the meaning of these hatchings shall be clearly defined on the drawing. or by reference to appropriate standards.

9.2.3 *Thin Sections* – Thin sections may be shown entirely black (*see* Fig. 9.8); a space of not less than 0.7 mm must be left between adjacent sections of this type (*see* Fig. 9.9).

FIG. 9.8

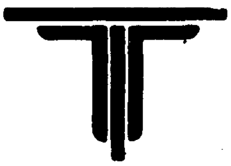


FIG. 9.9

9.2.4 *Notes on Sections*

9.2.4.1 The general rules for the arrangement of views (*see* 8.2.2) apply equally when drawing sections.

9.2.4.2 Where the location of a single cutting plane is obvious, no indication of its position or identification is required (*see* Fig. 9.10 and 9.21).

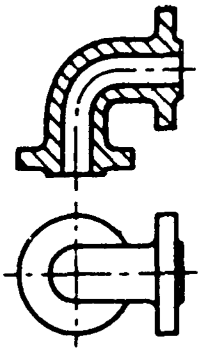


FIG. 9.10

9.2.4.3 Where the location is not obvious, or where it is necessary to distinguish between several cutting planes (*see* Fig. 9.11 to 9.15), the position of the cutting plane(s) shall be indicated by menas of a thin chain line, thick at ends and changes of direction (type H). The cutting plane should be indentified by designations, for example capital letters, and the direction of viewing should be indicated by arrows. The section should be indicated by the relevant designations (*see* Fig. 9.11 to 9.15).

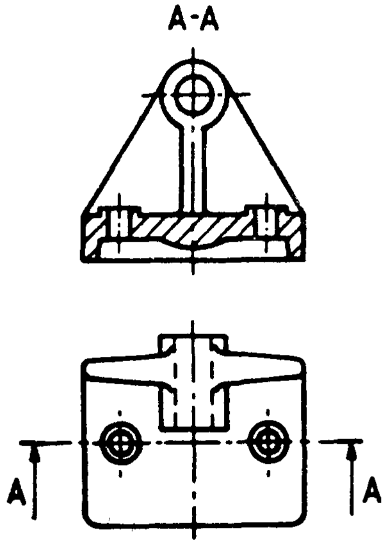


FIG 9.11

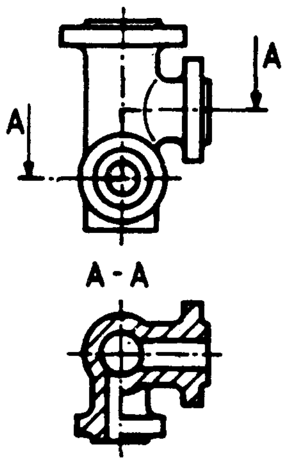


FIG. 9.12

9.2.4.4 The designations on the referenced sections shall be placed either immediately below or above the relevant sections, but in any one drawing the references shall be placed in the same way. No other indication is necessary.

9.2.4.5 In certain cases, the parts located beyond the cutting plane need not be drawn completely.

9.2.4.6 In princple, ribs, fasteners, shafts, spokes of wheels, and the like are not cut in the longitudinal sections, and therefore should not be hatched (*see* Fig. 9.14 and 9.15).

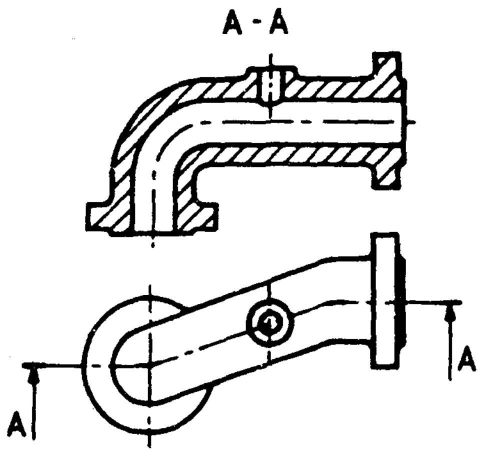


FIG. 9.13

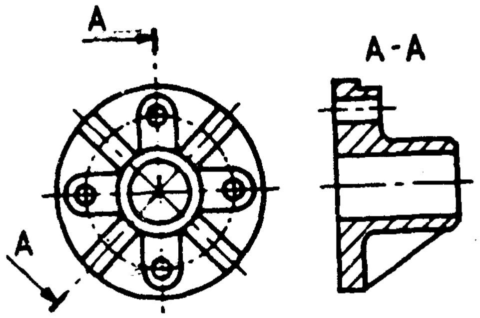


FIG. 9.14

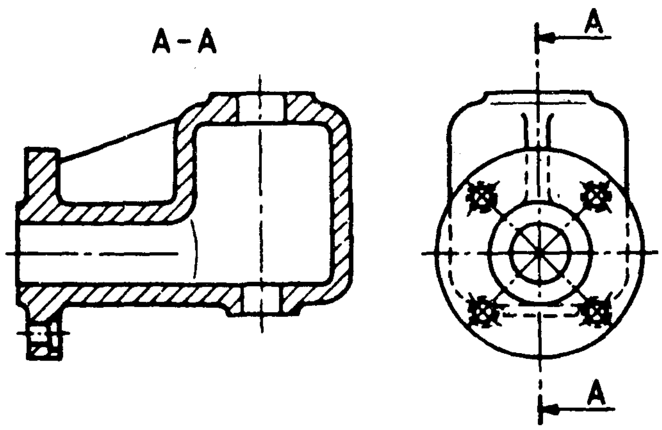


FIG. 9.15

9.2.5 *Cutting Planes (Examples)*

9.2.5.1 Section in one plane (*see* Fig. 9.10 and 9.11);

9.2.5.2 Section in two parallel planes (*see* Fig. 9.12):

9.2.5.3 Section in three contiguous planes (*see* Fig. 9.13):

9.2.5.4 Section in two intersecting planes, one shown revolved into the plane of projection (*see* Fig. 9.14):

9.2.5.5 In the case of parts of revolution containing regularly spaced details that require to be shown in section, but are not situated in the cutting plane, provided that no ambiguity can arise, such details may be depicted by rotating them into the cutting plane (*see* Fig. 9.15) but some indication of having done so is recommended.

9.2.6 *Sections Revolved in the Relevant View or Removed Sections*

9.2.6.1 Cross-sections may be revolved in the relevant view or removed.

9.2.6.2 When revolved in the relevant view, the outline of the section shall be drawn with continuous thin lines (type B) and further identification is not necessary (*see* Fig. 9.16).

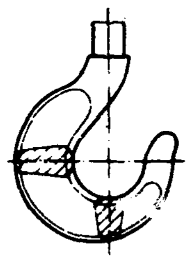


FIG. 9.16

9.2.6.3 When removed, the outline of the section shall be drawn with continuous thick lines (type A). The removed section may be placed:

- either near to and connected with the view by a chain thin line (type G) (*see* Fig. 9.17 A).
- or in a different position and identified in the conventional manner as in 9.2.4 by designation (*see* Fig. 9.17 B).

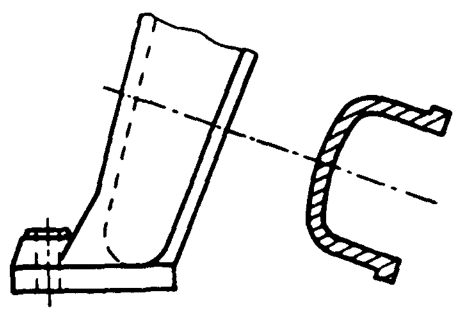


FIG. 9.17 A

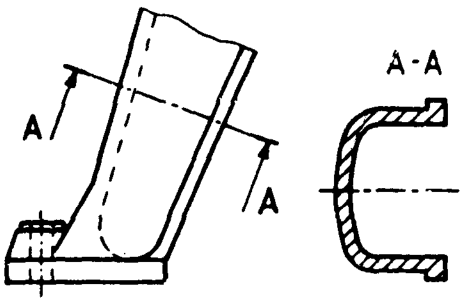


FIG. 9.17 B

9.2.7 *Half Sections* – Symmetrical parts may be drawn half in full view and half in section (*see* Fig. 9.18).

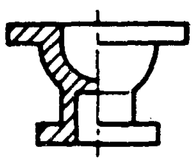


FIG. 9.18

9.2.8 *Local Section* – A local section may be drawn if a complete or half section is not convenient. The local break can be shown by either a continuous thin freehand line (type C) (*see* Fig. 9.19) or by continuous thin straight line with zigzag (type D) (*see* Fig. 6.1).

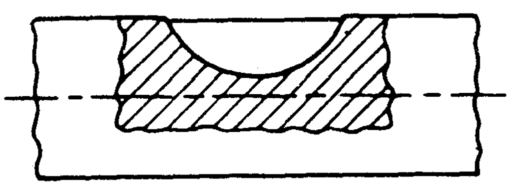


FIG. 9.19

9.2.9 *Arrangement of Successive Sections* – Successive sections may be arranged in a manner similar to the examples shown in Fig. 9.20, 9.21 and 9.22 as convenient for the layout and understanding of the drawing.

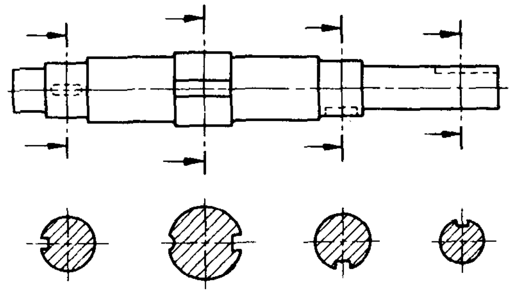


FIG. 9.21

9.3 Other Conventions

9.3.1 *Adjacent Parts* – Where their representation is necessary, parts adjacent to an object shall be drawn with chain thin double dashed lines (type K). The adjacent part shall not hide the princpal part, but may be hidden by the latter (*see* Fig. 9.23).

Adjacent parts in sections shall not be hatched.

9.3.2 *Intersections*

9.3.2.1 *True intersections* – True geometric intersection lines shall be drawn with continuous thick lines (type A) when visible, or with dashed lines (type E or F) when hidden (*see* Fig. 9.24).

9.3.2.2 *Imaginary intersections* – Imaginary intersection lines (such as fillets or rounded corners) may be indicated in a view by means of continuous thin lines (type B), not touching the outlines (*see* Fig. 9.25).

9.3.2.3 *Simplified representation of intersections* – Simplied representations of true geometric or imaginary intersection lines may be applied at intersections:

a) between two cylinders : the curved lines of intersection are replaced by straight lines (*see* Fig. 9.26, 9.27 and 9.29).

b) between a cylinder and a rectangular prism: the displacement of the straight line of intersection is omitted (*see* Fig. 9.28 and 9.30).

As the difference in size between the intersecting parts increases, the simplified representation (*see*

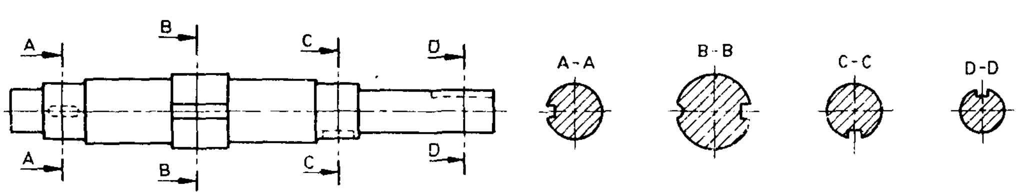


FIG. 9.20

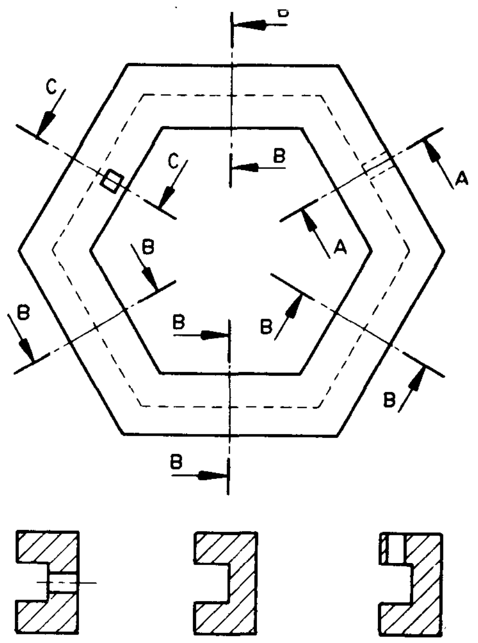


FIG. 9.22

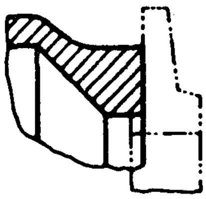


FIG. 9.23

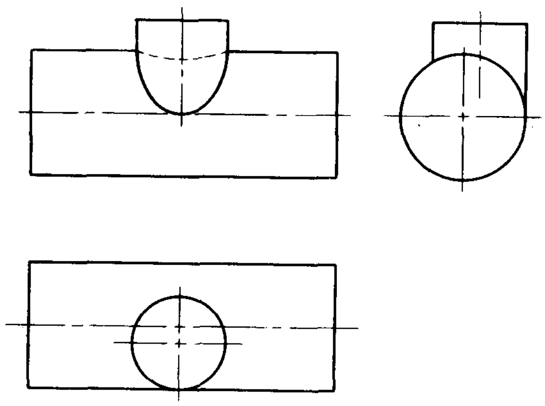


FIG. 9.24

Fig. 9.26 to 9.30) only gives a better approach to a real intersection, provided that the axes of the intersecting parts are both mutually perpendicular and intersect, or nearly so.

NOTE — This simplified representation should be avoided if it affect the comprehensibility of the drawing.

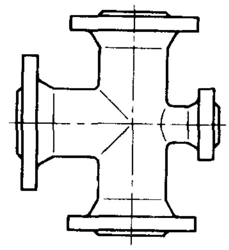


FIG. 9.25

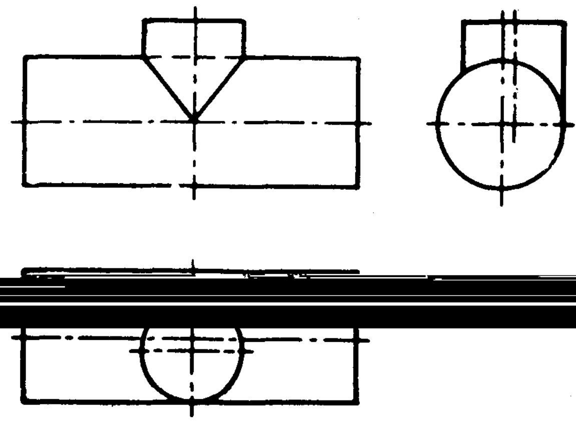


FIG. 9.26

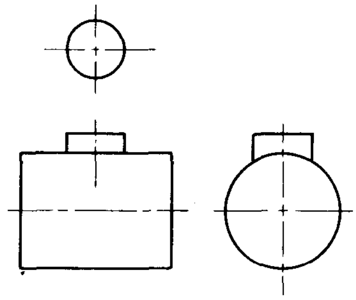


FIG. 9.27

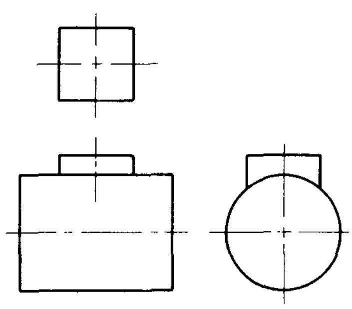


FIG. 9.28

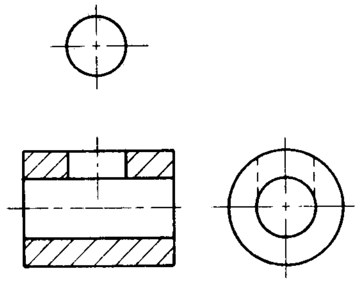


FIG 9.29

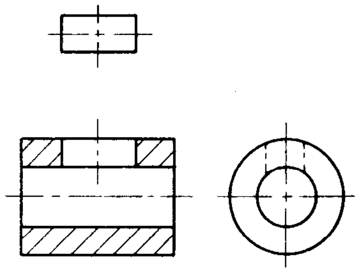


FIG. 9.30

9.3.3 *Conventional Representation of Square Ends and Openings*

9.3.3.1 *Square ends on shafts* – In order to avoid drawing a supplementary view or section, square ends (*see* Fig. 9.31) or tapered square ends on shafts (*see* Fig. 9.32) may be indicated by diagonals [illegible]

9.3.3.2 *Square and rectangular openings* – In order to indicate an opening in a flat part in frontal view, without aid of additional sections, this opening may be shown by drawings its diagonals in continuous thin lines (type B) (*see* Fig. 9.33).

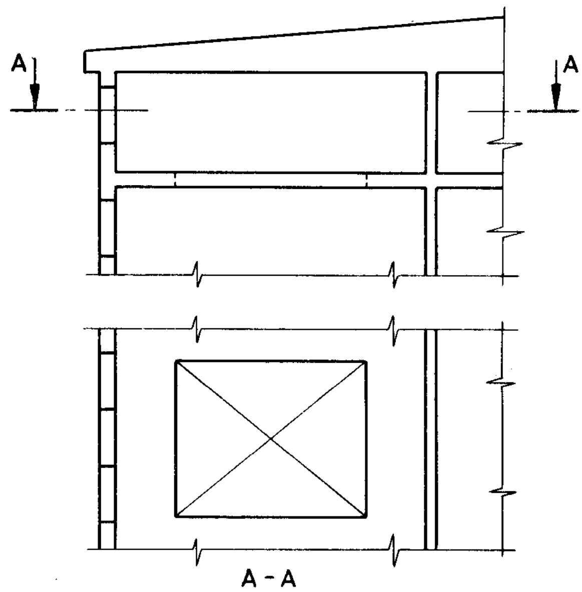


FIG. 9.33

9.3.4 *Parts Located in Front of a Cutting Plane* – If,it is necessary to indicate parts located in front of the cutting plane, these parts are to be represented by chain thin double dashed lines (type K) (*see* Fig. 9.34).

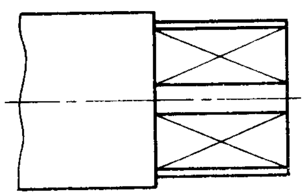


FIG. 9.31

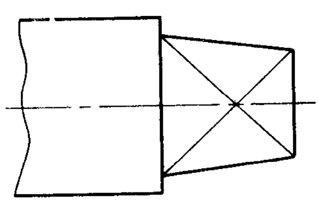


FIG. 9.32

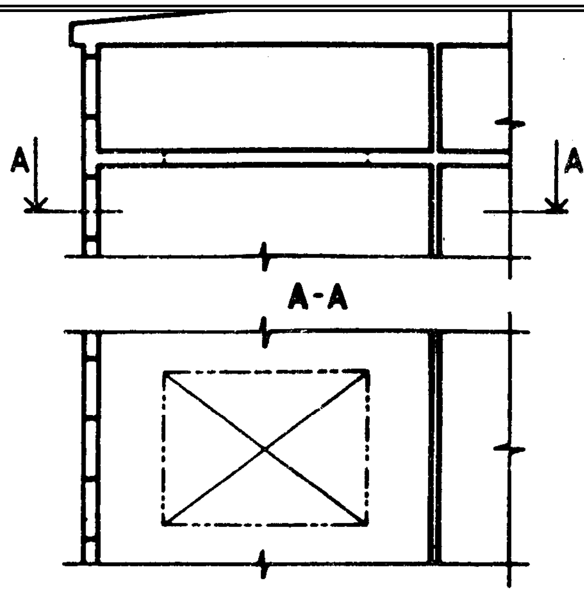


FIG. 9.34

9.3.5 *Views of Symmetrical Parts*

9.3.5.1 To save time and space, symmetrical objects may be drawn as a fraction of the whole (*see* Fig. 9.35 to 9.38).

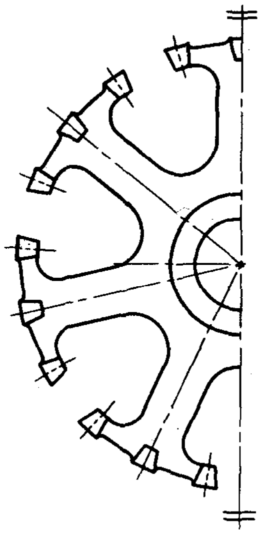


FIG. 9.35

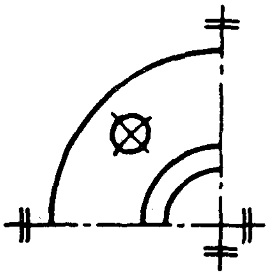


FIG. 9.36

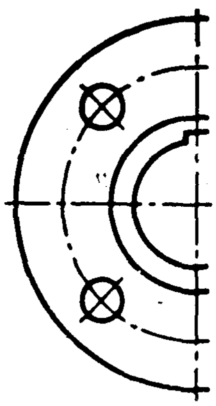


FIG. 9.37

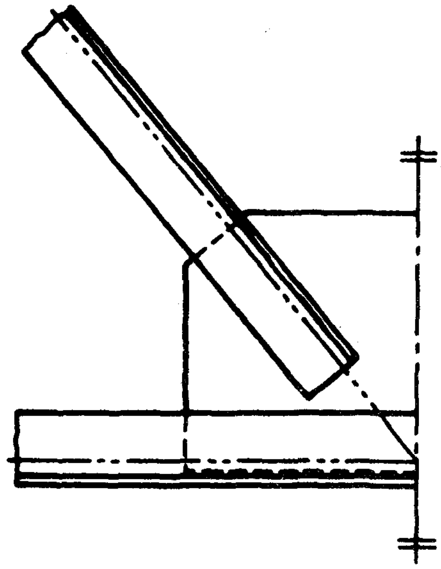


FIG. 9.38

9.3.5.2 The line of symmetry is identified at its ends by two thin short parallel lines drawn at right angles to it (*see* Fig. 9.35, 9.36 and 9.38).

Another method is to show the lines representing the object extending a little beyond the line of symmetry (*see* Fig. 9.37). In this case, the short parallel lines may be omitted.

NOTE – In the application of this practice, it is essential that due care is taken to avoid loss of understanding of the drawing.

9.3.6 *Interrupted Views* – In order to save space, it is permissible to show only those portions of a long object which are sufficient for its definition. The limits of parts retained are shown as for partial views (*see* 8.2.6), and the portions are drawn close to each other (*see* Fig. 9.39 and 9.40).

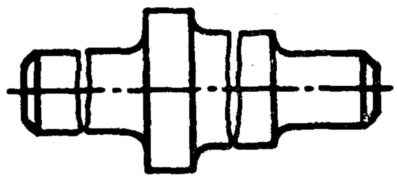


FIG. 9.39

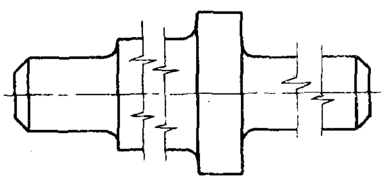


FIG. 9.40

9.3.7 *Simplified Representation of Repetitive Features* – The presentation of repetitive features may be simplified as shown in Fig. 9.41 and 9.42.

NOTE – In all cases, the number and kind of repetitive features should be defined by dimensioning or by a note.

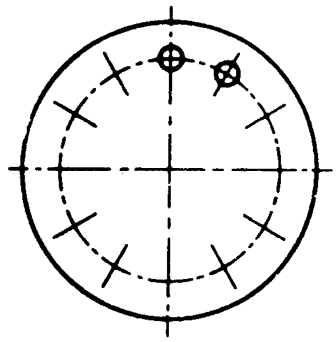


FIG. 9.41

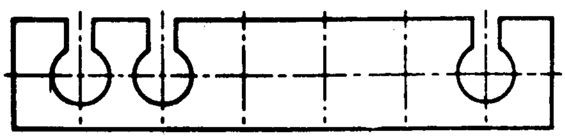


FIG. 9.42

9.3.8 *Elements on a Larger Scale*

9.3.8.1 In cases where the scale is so small that details of the feature cannot be shown or dimensioned, the feature of the part may be framed by a continuous thin line (type B) and identified by a capital letter (*see* Fig. 9.43 A).

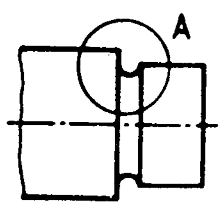


FIG. 9.43 A

9.3.8.2 The relevant feature is then drawn to a stated larger scale accompanied by its identification letter (*see* Fig. 9.43 B).

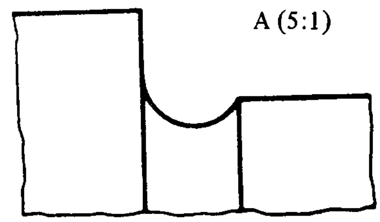


FIG. 9.43 B

9.3.9 *Initial Outlines* – When it is necessary to depict the initial outlines of a part prior to forming, the initial outline shall be indicated by chain thin double dashed lines (type K) (*see* Fig. 9.44).

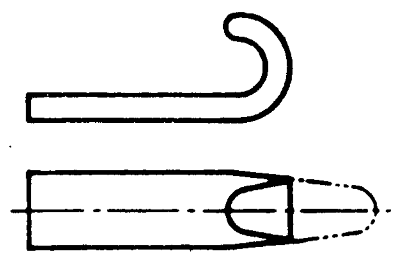


FIG. 9.44

9.3.10 *Use of Colours* – The use of colours on technical drawings is not recommended. If it is essential for clarity to use colours, then their meanings shall be clearly shown on the drawing or in other relevant documents.

9.3.11 *Transparent Objects* – All objects made of transparent material should be drawn as non-transparent.

SECTION 10 CONVENTIONAL REPRESENTATION

10.1 Scope – This section specifies, by means of examples, the rules for representation of threaded parts, springs, gears and common-features on technical drawings.

10.2 Conventional Representation of Threaded Parts – The method of simplified representation of threaded parts is independent of type of screw thread applied. The type of screw thread and its dimensions are to be indicated by means of standard designations.

10.2.1 *Conventional Method of Representation*

10.2.1.1 *Visible screw threads* – For visible screw threads, the crests of threads should be defined by a continuous thick line (type A), and the roots of threads by a continuous thin line (type B) (*see* Fig. 10.1 to 10.4). It is recommended that the space between lines representing the major and minor diametres of the thread be as close as possible to the correct depth of thread, but in all cases this spacing shall not be less than twice the thickness of the thick line or 0.7 mm whichever is larger.

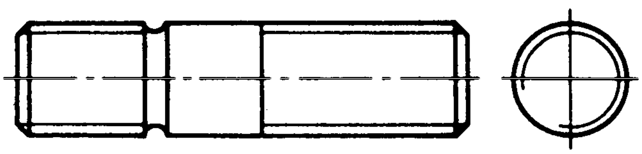


FIG. 10.1

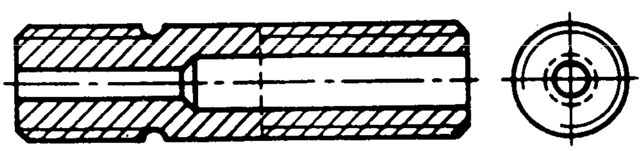


FIG. 10.2

10.2.1.2 *Hidden screw threads* – For hidden screw threads, the crests and the roots should be defined by dashed lines (type E or F, but one type only on the same drawing) (*see* Fig. 10.3 and 10.4).

10.2.1.3 *Sections of threaded parts* – For threaded parts shown in section, hatching should be extended to the line defining the crest of the thread (*see* Fig. 10.2, 10.3 and 10.4).

10.2.1.4 *End view of screw threads* – On an end view of a visible screw thread, the thread roots should be represented by a portion of a circle, drawn with a continuous thin line (type B), of length approximately three-quarters of the circumference (*see* Fig. 10.1, 10.2 and 10.3).

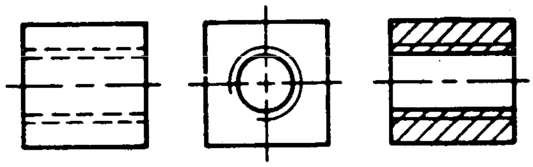


FIG. 10.3

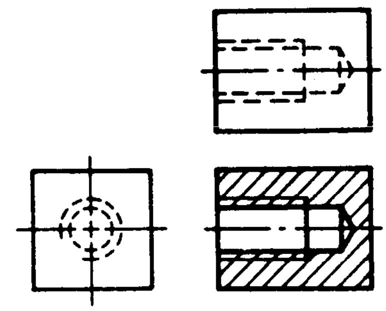


FIG. 10.4

On an end view of a hidden screw thread, the thread roots should be represented by a portion of a circle, drawn with a dashed line (type E or F, but same as that used for the crests and one type only on the same drawing) of the length approximately three-quarters of the circumference (*see* Fig. 10.4).

10.2.1.5 *Limits of useful length of screw threads* – The limit of useful length of a screw thread should be shown by a continuous thick line (type A) or a dashed line (type E or F, but one type on the same drawing) according to whether this limit is visible or hidden. This line should terminate at the line defining the major diameter of the thread (*see* Fig. 10.1, 10.2, 10.4 and 10.6).

10.2.1.6 *Incomplete threads (run-outs)* – Incomplete threads or the limits of useful length are not shown (*see* Fig. 10.1, 10.2, 10.4 and 10.6), except in the case where there is a functional necessity (*see* Fig. 10.5).

10.2.1.7 *Assembled threaded parts* – The above conventions apply to assemblies of threaded parts. However, externally threaded parts should always be shown covering internally threaded parts and should not hidden by them (*see* Fig. 10.5 and 10.6).

10.3 Representation of Springs on Technical Drawings – The rules for representation of springs on technical drawings are specified by examples in the following clauses.

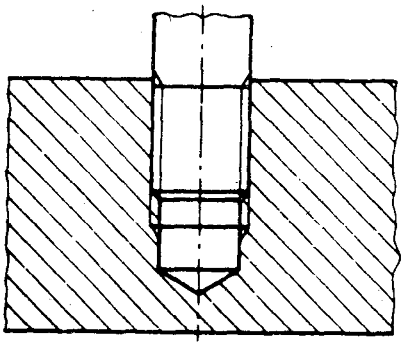


FIG. 10.5

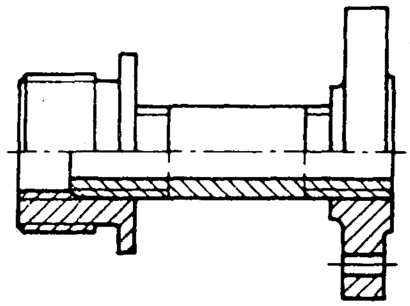
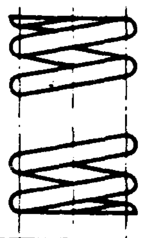
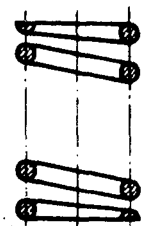
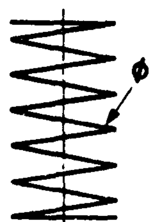
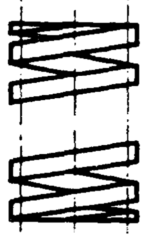
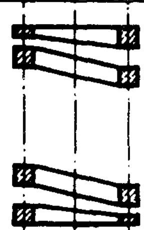
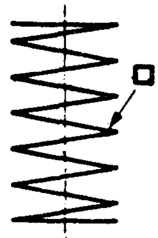
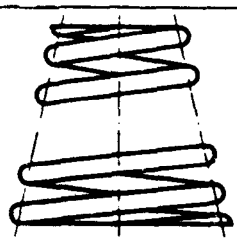
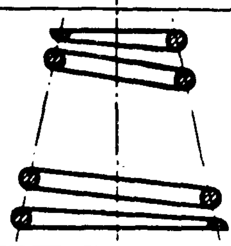
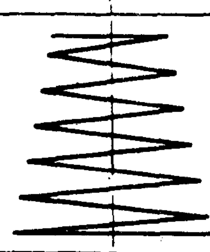
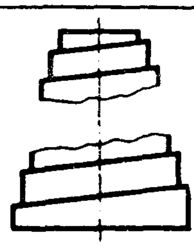
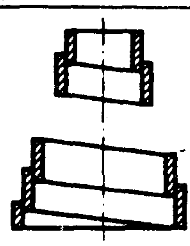


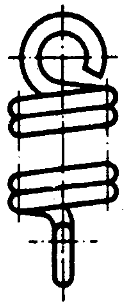
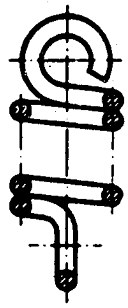
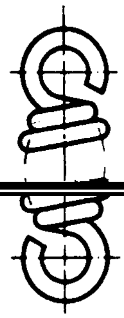
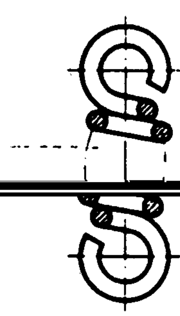
FIG. 10.6

10.3.1 *Cimpression Springs*

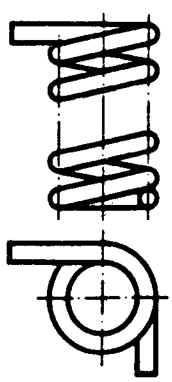
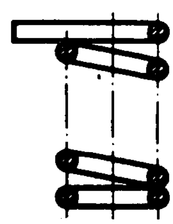
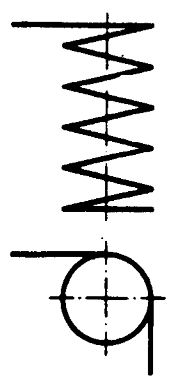
Title	*Representation*		
	view	section	simplified¹⁾
10.3.1.1 Cylindrical helical compression spring of wire of circular cross-section			
10.3.1.2 Cylindrical helical compression spring of wire of rectangular cross-section			
10.3.1.3 Conical helical compression spring of wire of circular cross-section			
10.3.1.4 Conical helical compression spring of wire of rectangular cross-section (volute spring)			

1) If necessary, indicate wound left (or right) hand.
If necessary, the cross-section of the spring material may be indicated in words or by a symbol (*see* **10.3.1.1** and **10.3.1.2**).

10.3.2 *Tension Springs*

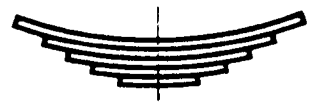
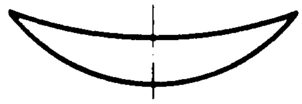
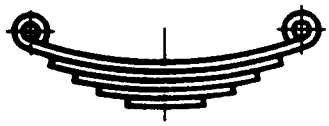
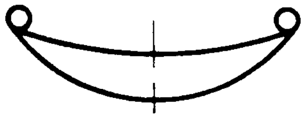
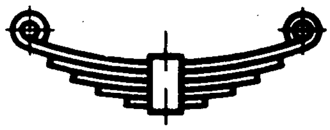
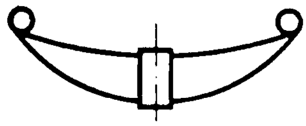
Title	*Representation*		
	view	section	simplified[1)]
10.3.2.1 Cylindrical helical tension spring of wire of circular cross-section			
10.3.2.2 Double-conical helical tension spring of circular cross-section			

10.3.3 *Torsion Springs*

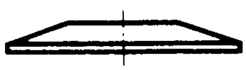
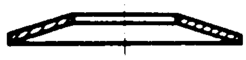
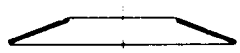
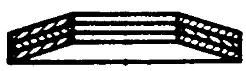
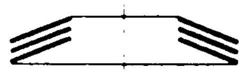
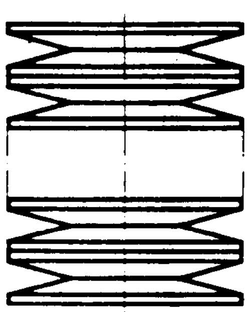
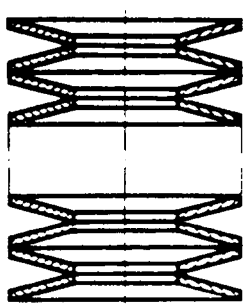
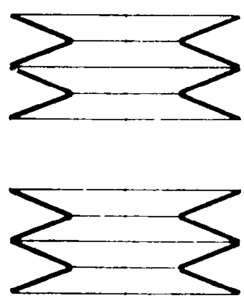
Title	*Representation*		
	view	section	simplified[1)]
10.3.3.1 Cylindrical helical torsion spring of wire of circular cross-section (Wound right hand)			

1) If necessary, indicate wound left (or right) hand.
If necessary the cross-section of spring material may be indicated in words or by symbol (*see* **10.3.1.1** and **10.3.1.2**)

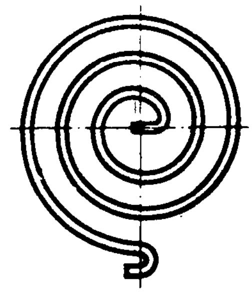
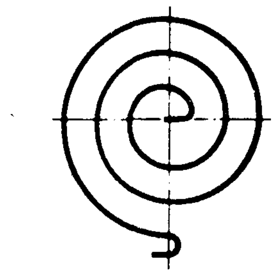
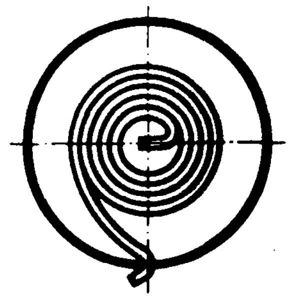
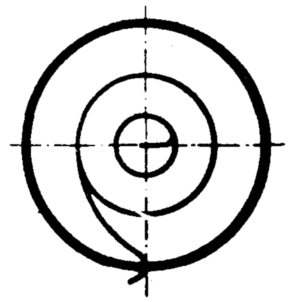
10.3.4 *Leaf Springs*

Title	*Representation*	
	view	simplified
10.3.4.1 Semi-elliptic leaf spring (multi-elliptic spring shown)		
10.3.4.2 Semi-elliptic leaf spring with eyelets		
[illegible]		
10.3.4.4 Semi-elliptic leaf spring with eyelets and centre band		

10.3.5 *Cup Springs*

Title	*Representation*		
	view	section	simplified
10.3.5.1 Cup spring			
10.3.5.2 Multi-cup spring (cups placed in the same direction)			
10.3.5.3 Multi-cup spring (successive cups alternating in direction)			

10.3.6 *Spiral Springs*

Title	Representation	
	view	simplified
10.3.6.1 Spiral spring		
10.3.6.2 Spiral spring (the spring is wound by rotating the box)		

10.4 Conventional Representation of Gears on Technical Drawings – This clause deals with the conventional representation of toothed portion of gears including worm gearing and chain wheels. It is applicable to detail drawings and assembly drawings. As a fundamental principle, a gear is represented (except in axial section) as a solid part without teeth, but with the addition of the pitch surface in a thin long chain line.

10.4.1 *Detail Drawings (Individual Gears)*

10.4.1.1 *Contours and edges* – Represent the contours and the edges of each gear (*see* Fig. 10.7, 10.8 and 10.9), as if they were:

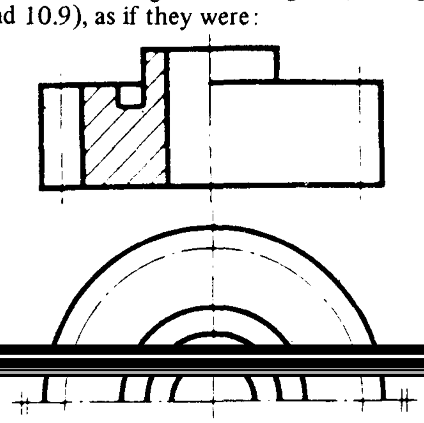


FIG. 10.7

a) in an unsectioned view, a solid gear bounded by the tip surface.

b) in an axial section, a spur gear having two diametrically opposed teeth, represented unsectioned, even in the case of a gear that does not have spur teeth or that has an odd number of teeth.

10.4.1.2 *Pitch surface* – Draw the pitch surface with a thin, long chain line, even in concealed portions and sectional views, and represent it:

a) in a projection normal to the axis, by its pitch circle (external pitch circle in the case of a bevel gear and the median pitch circle in the case of a worm wheel) (*see* Fig. 10.7, 10.8 and 10.9).

b) in a projection parallel to the axis, by its apparent contour, extending the line beyond the gear contour on each side (*see* Fig. 10.7, 10.8 and 10.9).

10.4.1.3 *Root surface* – As a general rule, do not represent the root surface except in sectional views. However, if it seems helpful to show it also on [illegible] thin continuous line (*see* Fig. 10.10, 10.11 and 10.12).

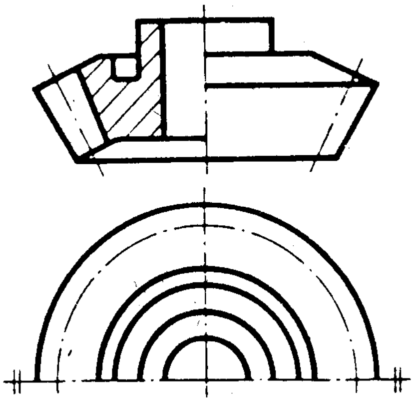


FIG. 10.8

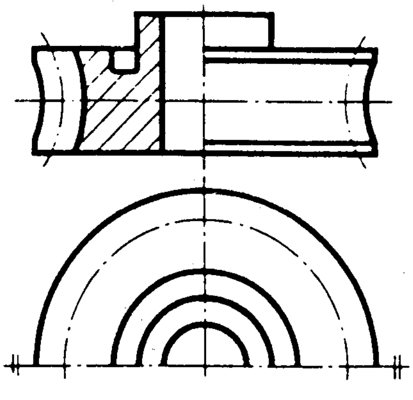


FIG. 10.9

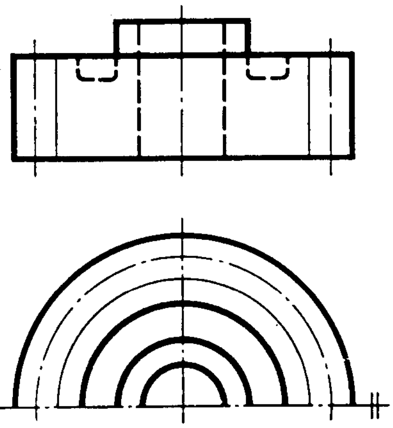


FIG. 10.10

10.4.1.4 *Teeth* – Specify the teeth profile either by reference to a standard or by a drawing to a suitable scale.

If it is essential to show one or two teeth on the drawing itself (either to define the ends of a toothed portion or rack, or in order to specify the position of the teeth in relation to a given axial plane), draw them as thick continuous lines (*see* Fig. 10.11 and 10.12).

It is necessary to indicate the direction of the teeth of a gear or rack on the view of the tooth

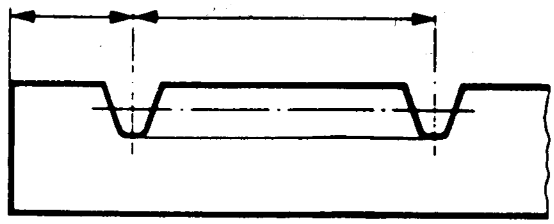


FIG. 10.11

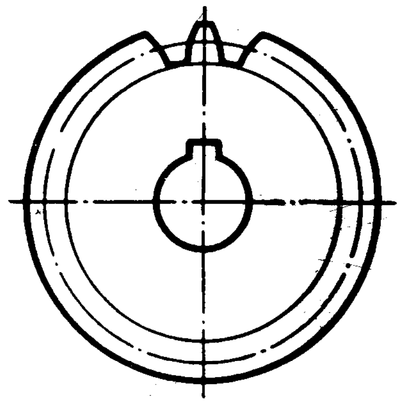
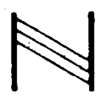
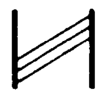
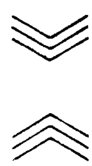
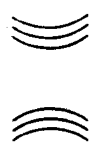


FIG. 10.12

surface in a projection parallel to the gear axes, three thin continuous lines of the corresponding form and direction should be shown (*see* Table 10.1 and Fig. 10.13).

TABLE 10.1

Tooth System	*Symbol*
Helical to the right	
Helical to the left	
Double helical	
Spiral	

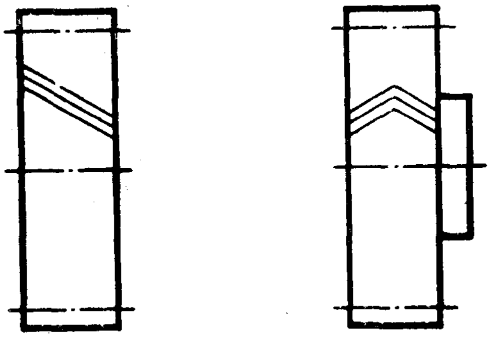


FIG. 10.13

NOTE – If mating gears are represented, the direction of the teeth should be shown on one gear only.

10.4.2 *Assembly Drawings (Gear Pairs)*

10.4.2.1 *External engagement of cylindrical gears* (*see* Fig. 10.14).

10.4.2.2 *Internal engagement of cylindrical gears*

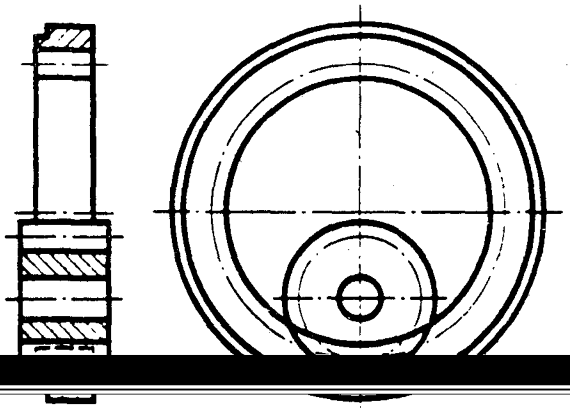


FIG. 10.15

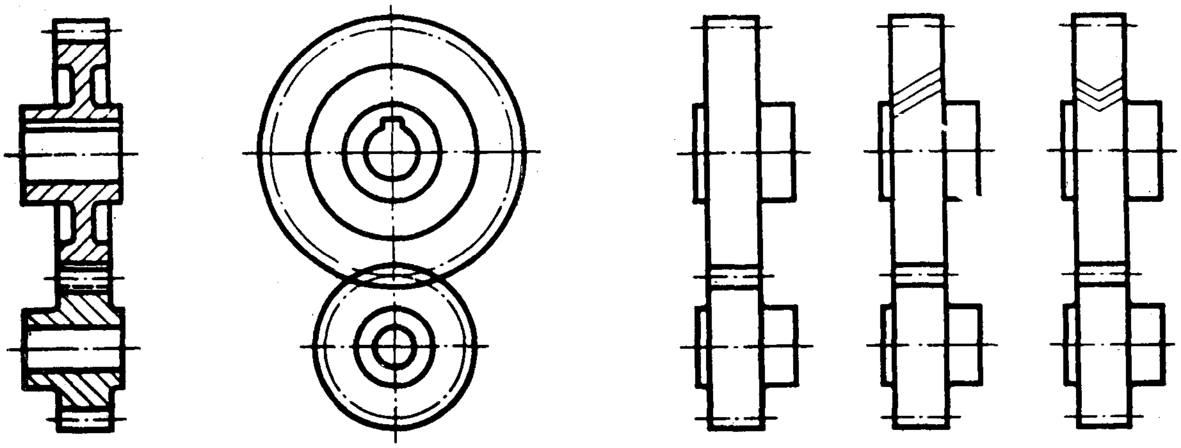


FIG. 10.14

10.4.2.3 *Engagement of pinion with rack*

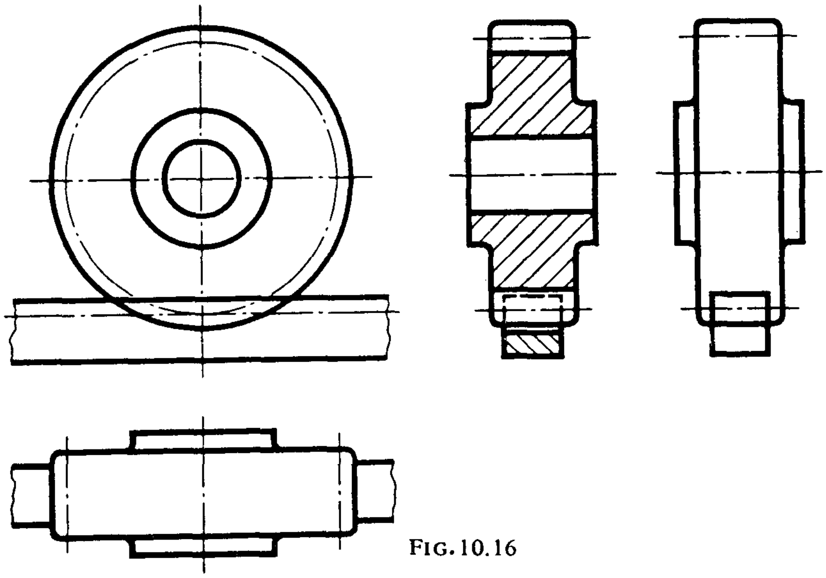


FIG. 10.16

10.4.2.4 *Engagement of bevel gears, axis intersection at any angle*

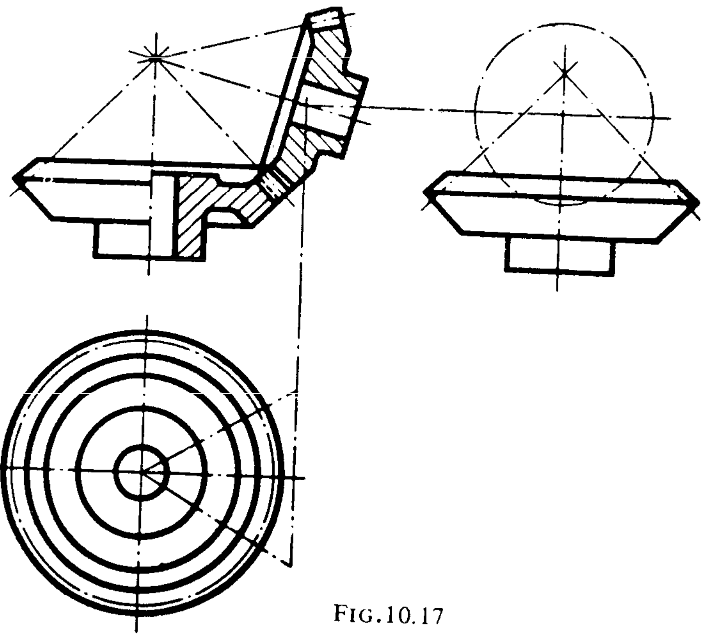


FIG. 10.17

10.4.2.5 *Engagement with cylindrical worm, in cross-section*

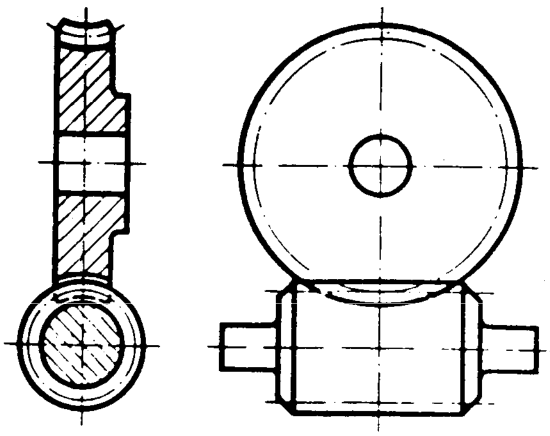


FIG. 10.18

10.4.2.6 *Chain wheels*

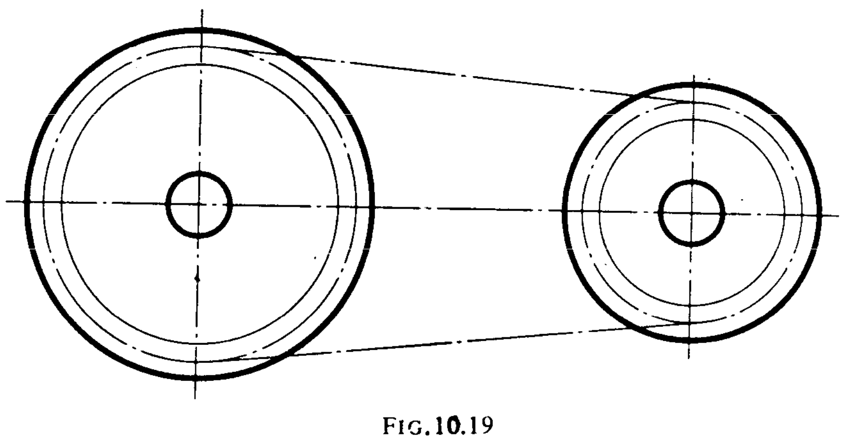
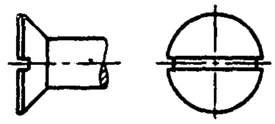
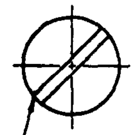
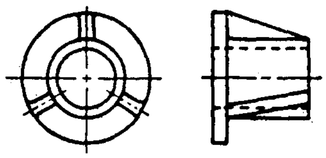
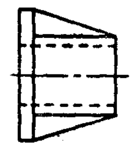
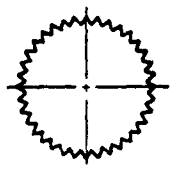
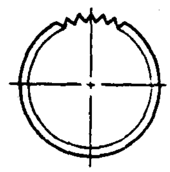
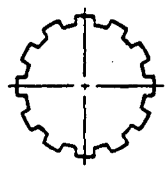
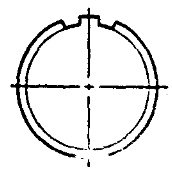
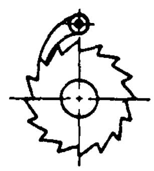
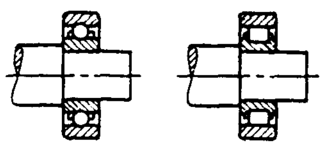
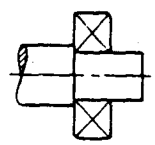
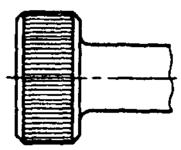
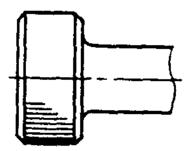
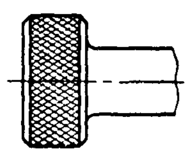
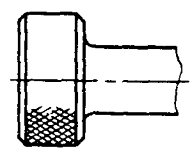
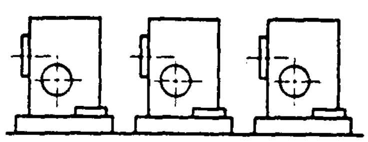
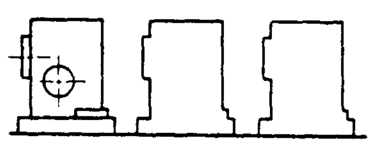


FIG. 10.19

TABLE 10.2 CONVENTIONAL REPRESENTATION OF COMMON FEATURES

TITLE	ACTUAL PROJECTION/SECTION	CONVENTION
SLOTTED HEAD		 TO BE DRAWN AT 45°
RADIAL RIBS		
SERRATED SHAFT		
SPLINED SHAFT		
RATCHET AND PINION		
BEARINGS		
STRAIGHT KNURLING		
DIAMOND KNURLING		
REPEATED PARTS		

SECTION 11 GENERAL PRINCIPLES OF DIMENSIONING ON TECHNICAL DRAWINGS

11.1 Scope and Field of Application

11.1.1 This section establishes the general principles of dimensioning applicable in all fields (that is mechanical, electrical, civil engineering, architecture, etc). It is possible that in some specific technical areas, the general rules and conventions will not cover all the needs of specialized practices adequately. In such cases additional rules may be laid down in standards specific to these areas. However, the general principles of this section shall be followed to facilitate the international exchange of drawings and to ensure the coherence of drawings in a comprehensive system relating to several technical fields.

11.1.2 The figures as shown in this section, merely illustrate the text and are not intended to reflect actual usage. The figures are consequently simplified to indicate only the relevant general principles applicable in any technical field.

11.2 General Principles

11.2.1 *Definitions* – For the purpose of this section, the following definitions apply.

[illegible] expressed in appropriate units of measurement and indicated graphically on technical drawings with lines, symbols and notes.

Dimensions are classified according to the following types:

a) *Functional dimension* – A dimension that is essential to the function of the piece or space (*see F* in Fig. 11.1).

b) *Non-functional dimension* – A dimension that is not essential to the function of the piece or space (*see NF* in Fig. 11.1).

c) *Auxiliary dimension* – A dimension given for information purposes only. It does not govern production or inspection operations and is derived from other values shown on the drawing or in related documents. An auxiliary dimension is given in parentheses and no tolerance applies to it (*see AUX* in Fig. 11.1).

11.2.1.2 *Feature* – An individual characteristic such as flat surface, a cylindrical surface, two parallel surfaces, a shoulder, a screw thread, a slot, a profile, etc.

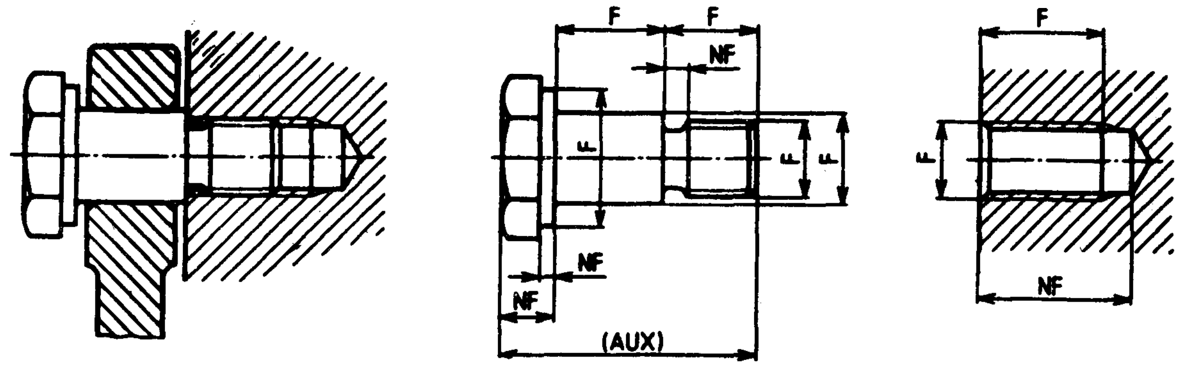
11.2.1.3 *End product* – The complete part ready for assembly or service or a configuration produced from a drawing specification. An end product may also be a part ready for further processing (for example, the product of a foundry or forge) or a configuration needing further processing.

11.2.2 *Application*

11.2.2.1 All dimensional information [illegible] completely shall be shown directly on a drawing unless this information is specified in associated documentation.

11.2.2.2 Each feature shall be dimensioned once only on a drawing.

11.2.2.3 Dimensions shall be placed on the view or section that most clearly shows the corresponding features.



a) Design requirement b) Shoulder screw c) Threaded hole

FIG 11.1 FUNCTIONAL, NON-FUNCTIONAL AND AUXILIARY DIMENSIONS

11.2.2.4 Each drawings shall use the same unit (for example, millimetres) for all dimensions but without showing the unit symbol. In order to avoid misinterpretation, the predominant unit symbol on a drawing may be shown in a note.

Where other units have to be shown as part of the drawing specification (for example, N·m for torque or kPa for pressure), the appropriate unit symbol shall be shown with the value.

11.2.2.5 No more dimensions than are necessary to define a part or an end product shall be shown on a drawing. No feature of a part or an end product shall be defined by more than one dimension in any one direction. Exception may, however, be made:

a) where it is necessary to give additional dimensions at intermediate stages of production (for example, the size of a feature prior to carburizing and finishing);

b) where the addition of an auxiliary dimension would be advantageous.

11.2.2.6 Production processes or inspection methods should not be specified unless they are essential to ensure satisfactory functioning or interchangeability.

11.2.2.7 Functional dimensions should be shown directly on the drawing wherever possible (*see* Fig. 11.2).

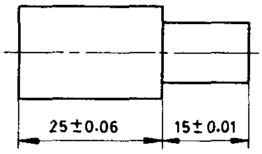


FIG.11.2 FUNCTIONAL DIMENSIONING

Occasionally indirect functional dimensioning is justified or necessary. In such cases, care must be exercised so that the effect of directly shown functional dimensioning is maintained. Figure 11.3 shows the effect of acceptable indirect functional dimensioning that maintains the dimensional requirements established by Fig. 11.2.

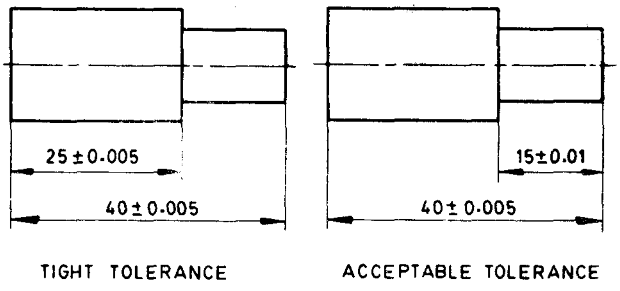


FIG.11.3 INDIRECT FUNCTIONAL DIMENSIONING

11.2.2.8 The non-functional dimensions should be placed in a way which is most convenient for production and inspection.

11.3 Method of Dimensioning

11.3.1 *Elements of Dimensioning* – The elements of dimensioning include the projection line, dimension line, leader line, dimension line termination, the origin indication, and the dimension iteself. The various elements of dimensioning are illustrated in Fig. 11.4 and 11.5.

11.3.2 *Projection Lines, Dimension Lines and Leader Lines* – Projection lines, dimension lines and leader lines are drawn as thin continuous lines as shown in Section 6 and as illustrated in Fig. 11.4 and 11.5.

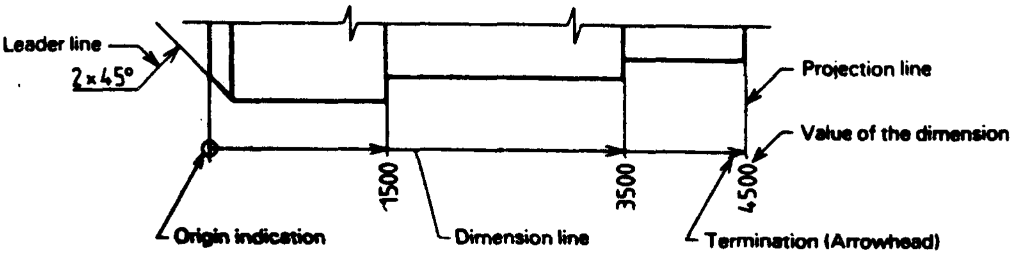


FIG. 11.4

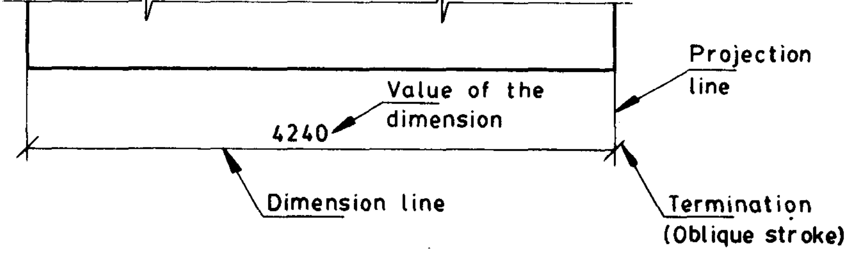


FIG. 11.5

11.3.2.1 Projection lines shall extend slightly beyond the respective dimension line (*see* Fig. 11.4 and 11.5).

11.3.2.2 Projection lines should be drawn perpendicular to the feature being dimensioned. Where necessary, however, they may be drawn obliquely, but parallel to each other (*see* Fig. 11.6).

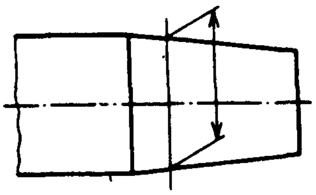


FIG.11.6

11.3.2.3 Intersecting construction and projection lines shall extend slightly beyond their point of intersection (*see* Fig. 11.7).

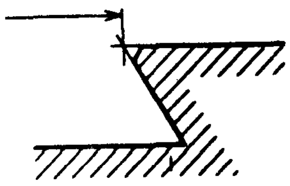


FIG.11.7

11.3.2.4 In general, projection lines and dimension lines should not cross other lines unless this is unavoidable (*see* Fig. 11.8).

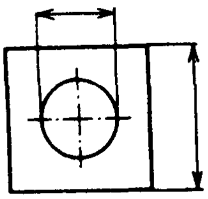


FIG.11.8

11.3.2.5 A dimension line shall be shown unbroken where the feature to which it refers is shown broken (*see* Fig. 11.9), except as indicated in 11.3.4.1, method 2.

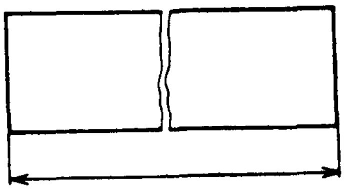


FIG.11.9

11.3.2.6 Intersecting projection and dimension lines should be avoided. Where unavoidable, however, neither line shall be shown with a break (*see* Fig. 11.10).

11.3.2.7 A centreline or the outline of a part shall not be used as a dimension line but may be used in place of a projection line (*see* Fig. 11.10).

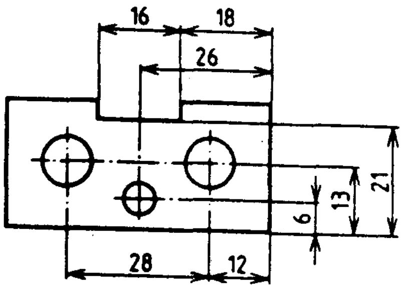


FIG.11.10

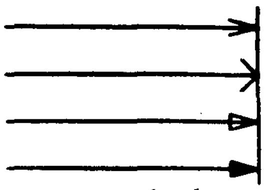
11.3.3 *Terminations and Origin Indication* — Dimension lines shall show distinct terminations (that is either arrowheads or oblique strokes), or, where applicable, an origin indication.

11.3.3.1 Two dimension line terminations (*see* Fig. 11.11) and an origin indication (*see* Fig. 11.12) are specified in this section. They are:

a) the arrowhead, drawn as short lines forming barbs at any convenient included angle between 15° and 90°. The arrowhead may be open, closed, or closed and filled in [*see* Fig. 11.11 (a)]

b) the oblique stroke, drawn as a short line inclined at 45° [*see* Fig. 11.11 (b)];

c) the origin indication, drawn as a small open circle of approximately 3 mm in diameter (*see* Fig. 11.12).



a) Arrowheads

b) Oblique Stroke

FIG.11.11

FIG.11.12

11.3.3.2 The size of the terminations shall be proportionate to the size of drawing on which they are used but not larger than is necessary to read the drawing.

11.3.3.3 One style of arrowhead termination only shall be used on a single drawing. However, where space is too small for an arrowhead, the oblique stroke or a dot may be substituted (*see* Fig. 11.24).

11.3.3.4 Arrowhead terminations shall be shown within the limits of the dimension line where space is available (*see* Fig. 11.13). Where space is limited, the arrowhead termination may be shown outside the intended limits of the dimension line that is extended for that purpose (*see* Fig. 11.14).

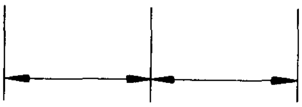


FIG. 11.13

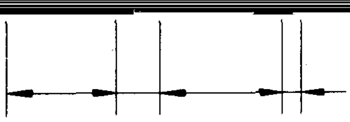


FIG. 11.14

11.3.3.5 Only one arrowhead termination, with its point on the arc end of the dimension line, shall be used where a radius is dimensioned (*see* Fig. 11.15). The arrowhead termination may be either on the inside or on the outside of the feature outline (or its projection line) depending upon the size of the feature.

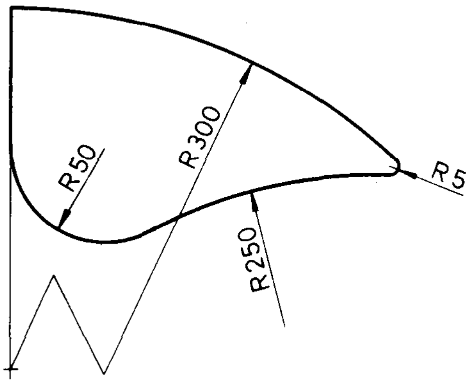


FIG. 11.15

11.3.4 *Indicating Dimensional Values on Drawings*

a) Dimensional values shall be shown on drawings in characters of sufficient size to ensure complete legibility on the original drawing as well as on reproductions made from microfilms.

b) They shall be placed in such a way that they are not crossed or separated by any other line on the drawing.

11.3.4.1 Values shall be indicated on a drawing according to one of the following two methods. Only one method should be used on any one drawing.

Method 1

a) Dimensional values shall be placed parallel to their dimension lines and preferably near the middle, above and clear of the dimension line (*see* Fig. 11.16).

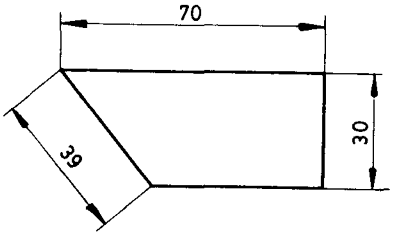


FIG. 11.16

b) An exception may be made where superimposed running dimensions are used (*see* 11.4.2.4). However, values shall be indicated so that they may be read from the bottom or from the right hand side of the drawing. Values on oblique dimension lines shall be oriented as shown in Fig. 11.17.

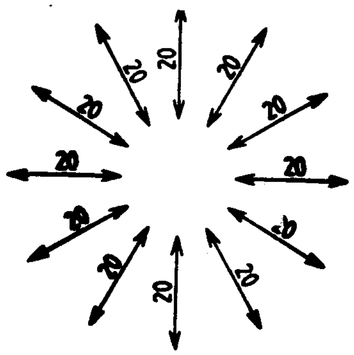


FIG. 11.17

c) Angular dimensional values may be oriented either as in Fig. 11.18 or Fig. 11.19.

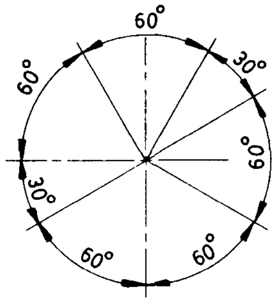


FIG. 11.18

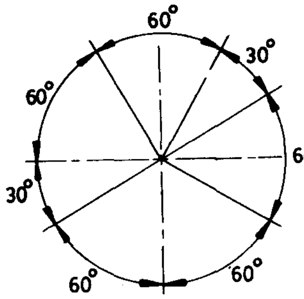


FIG. 11.19

Method 2

a) **Dimensional values shall be indicated so that they may be read from the bottom of the drawing sheet. Non-horizontal dimension lines are interrupted, preferably near the middle so that the value may be inserted (*see* Fig. 11.20 and 11.21).**

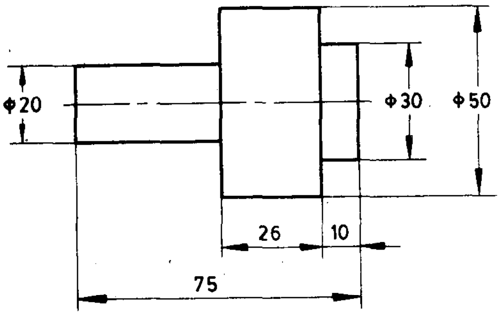


FIG. 11.20

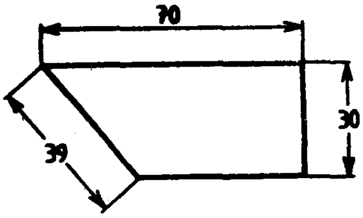


FIG. 11.21

b) Angular dimensional values may be oriented either as in Fig. 11.19 or 11.22.

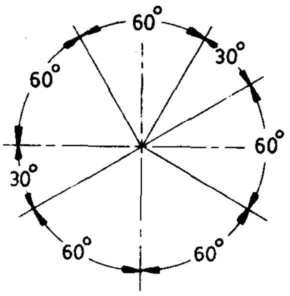


FIG. 11.22

11.3.4.2 The positioning of dimensional values frequently needs adapting to different situations. Therefore, for example, values may be:

a) **closer to a termination to avoid having to follow a long dimension line where only part of the dimension line needs to be shown (*see* Fig. 11.23)**

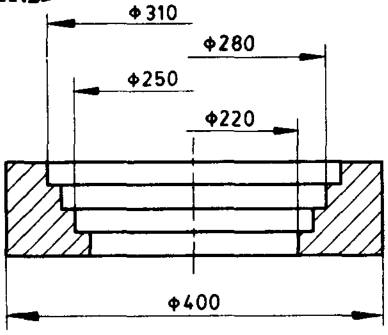


FIG. 11.23

b) above the extension of the dimension line beyond one of the terminations if space is limited (*see* Fig. 11.24).

c) at the end of a leader line which terminates on a dimension line that is too short for dimensional value to be indicated in the usual way (*see* Fig. 11.24).

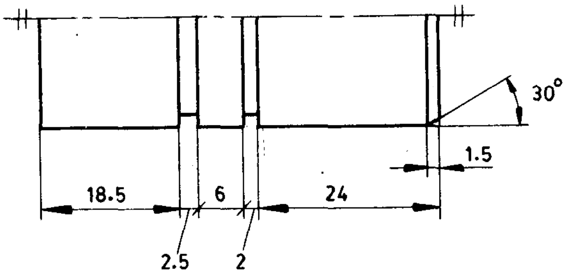


FIG. 11.24

d) above a horizontal extension of a dimension line where space does not allow placement at the interruption of a non-horizontal dimension line (*see* Fig. 11.25).

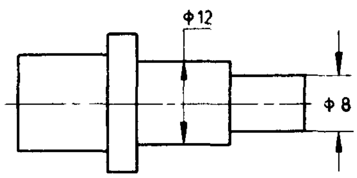


FIG. 11.25

11.3.4.3 Values for dimensions out-of-scale (except where break lines are used) shall be underlined with a straight thick line (*see* Fig. 11.26).

NOTE – Dimensions out-of-scale can result from a feature size modification where the modication does not warrant an extensive drawing revision to correct the feature scale.

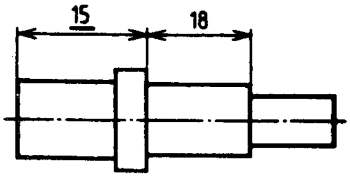


FIG. 11.26

11.3.4.4 The following indications are used with dimensions to show applicable shape identification and to improve drawing interpretation. The diameter and square symbols may be omitted where the shape is clearly indicated. The applicable indication (symbol) shall precede the value for dimension (*see* Fig. 11.27 to 11.31).

ϕ : Diameter	Sϕ : Spherical diameter
R: Radius	SR : Spherical radius
□: Square	

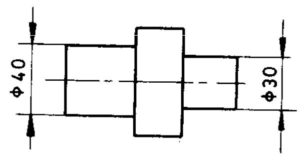


FIG. 11.27

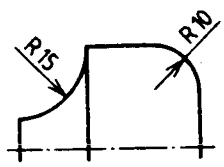


FIG. 11.28

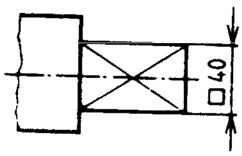


FIG. 11.29

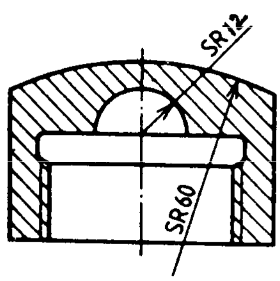


FIG. 11.30

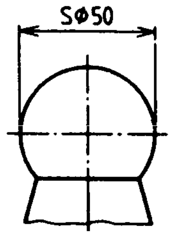


FIG. 11.31

11.4 Arrangement and Indication of Dimensions – The arrangement of dimensioning on a drawing shall indicate clearly the design purpose. Generally, the arrangement of dimensions is the result of a combination of various design requirements.

11.4.1 *Chain Dimensioning* – Chains of single dimensions (*see* Fig. 11.32) should be used only where the possible accumulation of tolerances does not impinge on the functional requirements of the part. Any termination may be used for chain dimensoining except the 90° arrowhead [*see* Fig. 11.11 (a)].

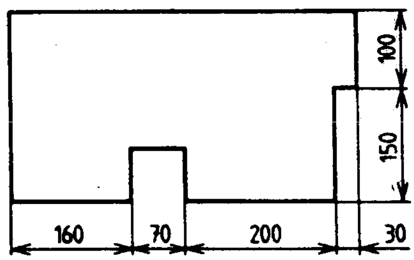


FIG. 11.32

11.4.2 *Dimensioning From a Common Feature*

11.4.2.1 This method of dimensioning is used where a number of dimensions of the same direction relate to a common origin.

11.4.2.2 Dimensioning from a common feature may be executed as parallel dimensioning or as superimposed running dimensioning.

11.4.2.3 Parallel dimensioning is the placement of a number of single dimension lines parallel one to another and spaced out so that the dimensional value can easily be added in (*see* Fig. 11.33 and 11.41).

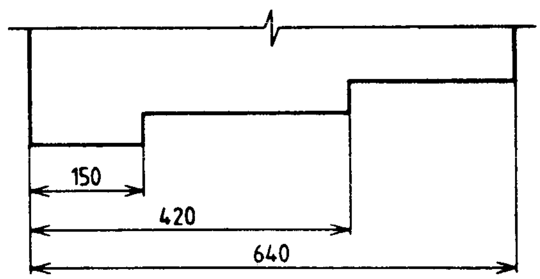


FIG. 11.33

11.4.2.4 Superimposed running dimensioning is simplified parallel dimensioning and may be used where there are space limitations and where no legibility problems would occur (*see* Fig. 11.34 and 11.35).

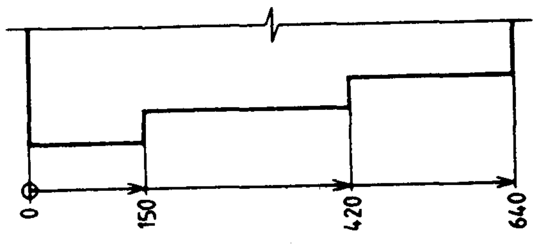


FIG. 11.34

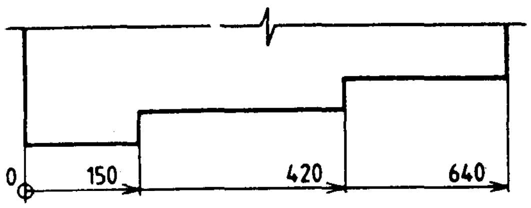


FIG. 11.35

The origin indication (*see* Fig. 11.12) is placed appropriately and the opposite ends of each dimension line shall be terminated only with an arrowhead.

Dimensional values may be placed, where there is no risk of confusion, either:

- near the arrowhead, in line with the corresponding projection line (*see* Fig. 11.34), or
- near the arrowhead, above and clear of the dimension line (*see* Fig. 11.35).

11.4.2.5 It may be advantageous to use superimposed running dimensioning in two directions. In such a case, the origins may be as shown in Fig. 11.36.

11.4.3 *Dimensioning by Coordinates*

11.4.3.1 It may be useful, instead of dimensioning as shown in Fig. 11.36, to tabulate dimensional values as shown in Fig. 11.37.

11.4.3.2 Coordinates for intersections in grids on block plans (site plans) are indicated as shown in Fig. 11.38.

Coordinates for arbitrary points of reference without a grid shall appear adjacent to each point (*see* Fig. 11.39) or in tabular form (*see* Fig. 11.40).

11.4.4 *Combined Dimensioning* – Single dimensions, chain dimensioning and dimensioning from a common feature may be combined on a drawing, if necessary (*see* Fig. 11.41 and 11.42).

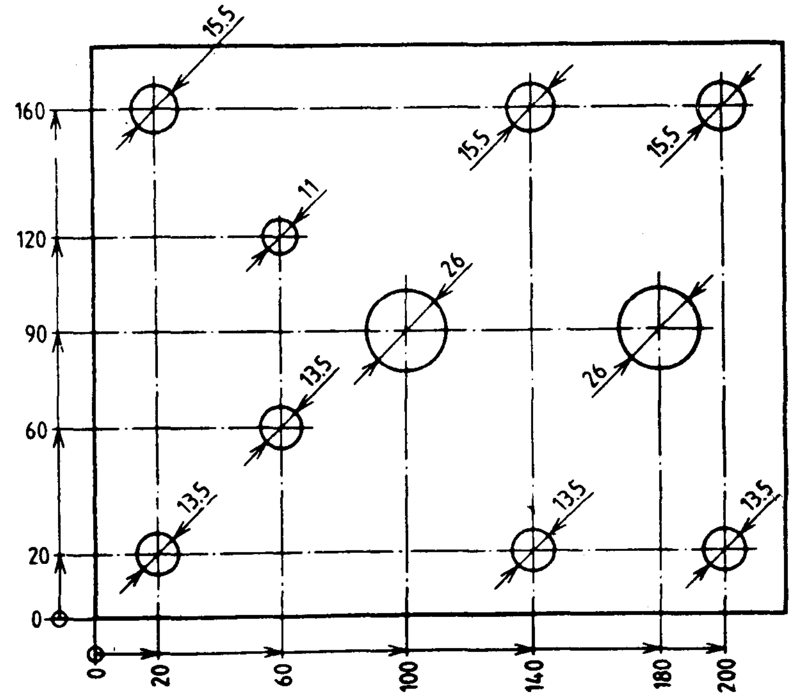
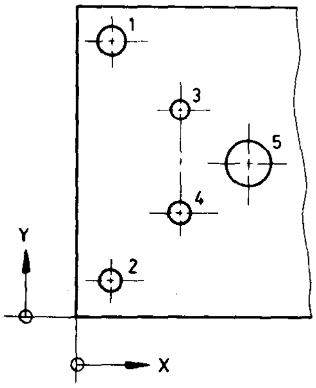


FIG. 11.36



	X	Y	Φ
1	20	160	15.5
2	20	20	13.5
3	60	120	11
4	60	60	13.5
5	100	90	26
6			
7			
8			

FIG. 11.37

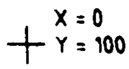


FIG. 11.38

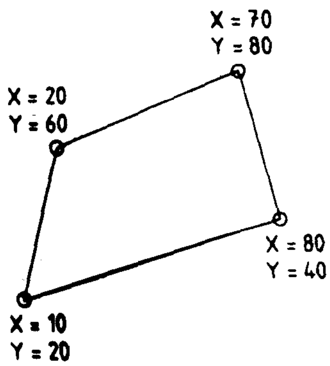
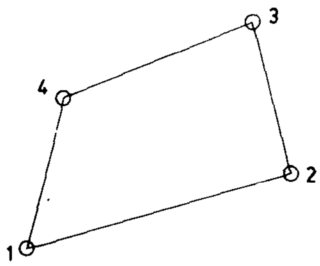


FIG. 11.39



	X	Y
1	10	20
2	80	40
3	70	80
4	20	60

FIG. 11.40

11.5 Special Indications

11.5.1 *Chords, Arcs, Angles and Radii*

11.5.1.1 The dimensioning of chords, arcs and angles shall be as shown in Fig. 11.43.

11.5.1.2 Where the centre of an arc falls outside the limits of the space available, the dimension line of the radius shall be broken or interrupted according to whether or not it is necessary to locate the centre (*see* Fig. 11.15).

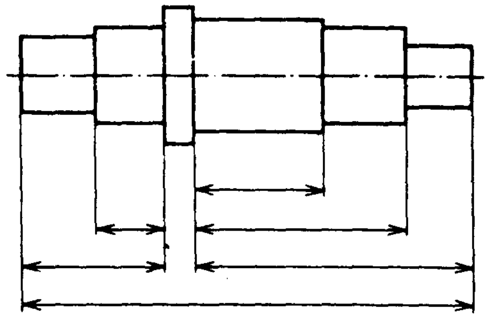


FIG. 11.41

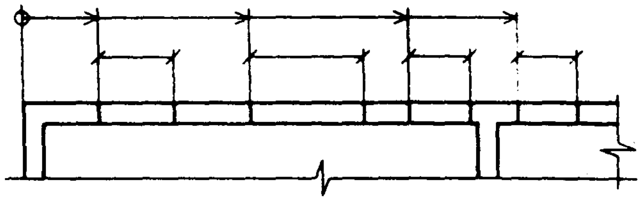


FIG. 11.42

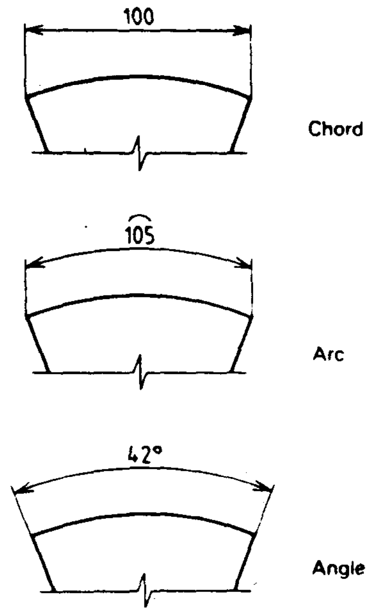


FIG. 11.43

11.5.1.3 Where the size of the radius can be derived from other dimensions, it shall be indicated with a radius arrow and the symbol *R* without an indication of the value (*see* Fig. 11.44).

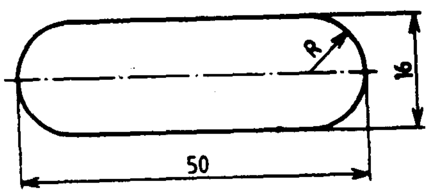


FIG. 11.44

11.5.2 *Equidistant Features* – Where equidistant features or uniformly arranged elements are part of the drawing specification, dimensioning may be simplified as follows.

11.5.2.1 Linear spacings may be dimensioned as shown in Fig. 11.45. If there is any possibility of confusion between the length of the space and the number of spacings, one space shall be dimensioned as shown in Fig. 11.46.

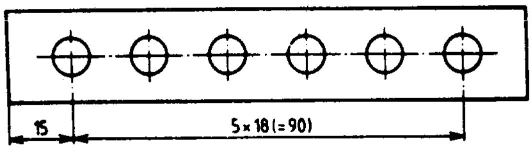


FIG. 11.45

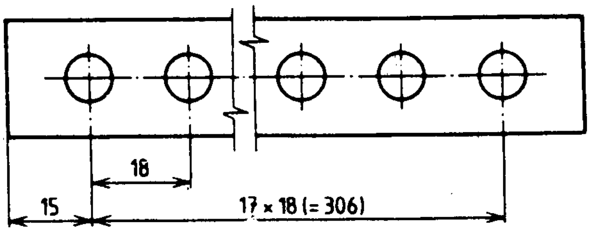


FIG. 11.46

11.5.2.2 Angular spacings of holes and other features may be dimensioned as shown in Fig. 11.47.

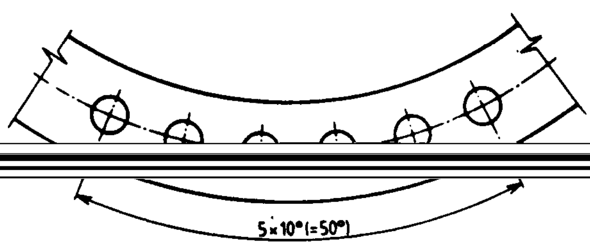


FIG. 11.47

11.5.2.3 The angles of the spacings may be omitted if their number is evident without confusion (*see* Fig. 11.48).

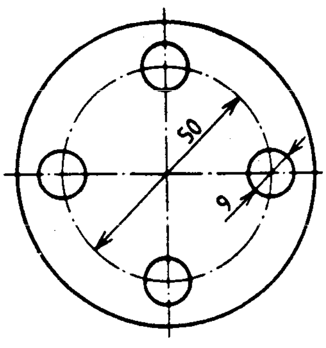


FIG. 11.48

11.5.2.4 Circular spacings may be dimensioned indirectly by giving the number of elements as shown in Fig. 11.49.

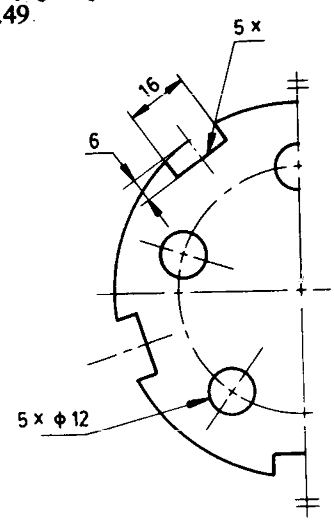
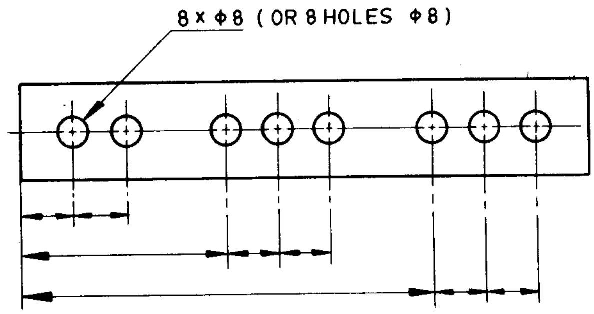


FIG. 11.49

11.5.3 *Repeated Features* – If it is possible to define a quantity of elements of the same size so as to avoid repeating the same dimensional value, they may be given as shown in Fig. 11.50 and 11.51.



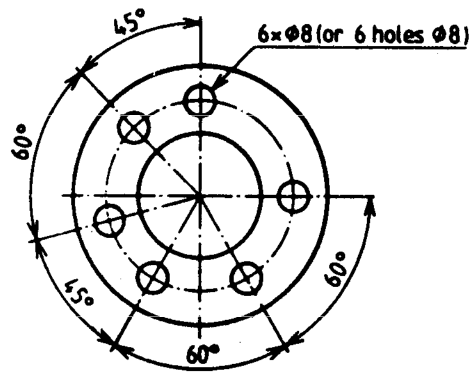


FIG. 11.51

11.5.4 *Chamfers and Countersinks*

11.5.4.1 Chamfers shall be dimensioned as shown in Fig. 11.52. Where the chamfer angle is 45°, the indications may be simplified as shown in Fig. 11.53 and 11.54.

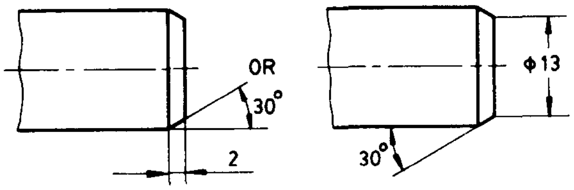


FIG. 11.52 CHAMFERS DIMENSIONED

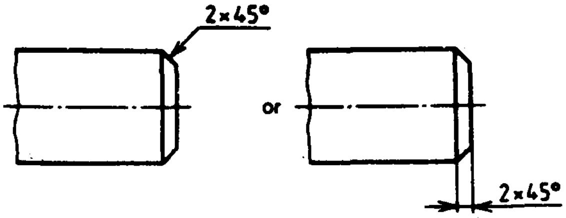


FIG. 11.53 45° CHAMFERS SIMPLIFIED

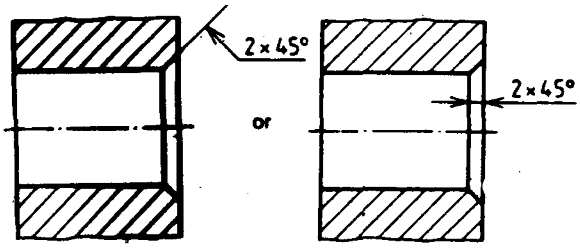


FIG. 11.54 INTERNAL CHAMFERS

11.5.4.2 Countersinks are dimensioned by showing either the required diametral dimension at the surface and the included angle, or the depth and the included angle (*see* Fig. 11.55).

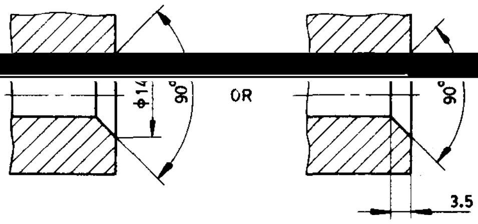


FIG. 11.55 COUNTERSINKS

11.5.5 *Other Indications*

11.5.5.1 Where necessary, in order to avoid repeating the same dimensional value or to avoid long leader lines, reference letters may be used in connection with an explanatory table or note (*see* Fig. 11.56). Leader lines may be omitted.

11.5.5.2 In partially drawn views and partial sections of symetrical parts, the dimension lines that need to cross the axis of symmetry are shown extended sightly beyond the axis of symmetry; the second termination is then omitted (*see* Fig. 11.57).

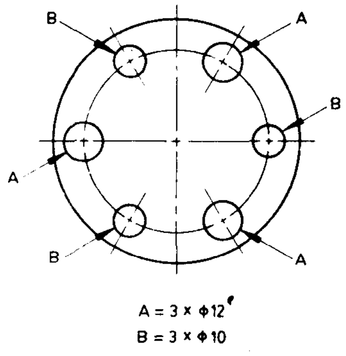


FIG. 11.56

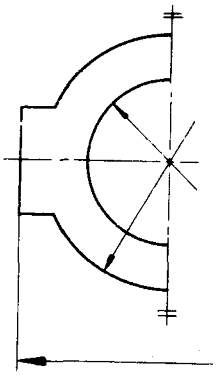


FIG. 11.57

11.5.5.3 Where several parts are drawn and dimensioned in an assembly, the groups of dimensions related to each part should be kept as separate as possible (*see* Fig. 11.58).

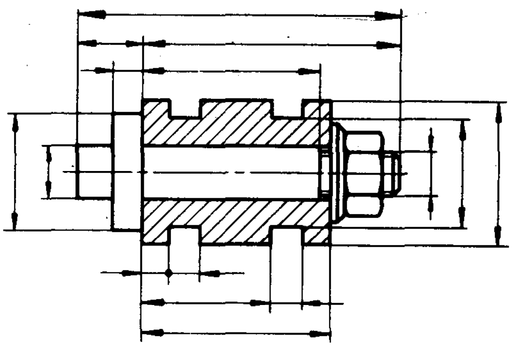


FIG. 11.58 DIMENSIONING AN ASSEMBLY

a limited area or length of a surface to indicate a special condition. In such instances, the area or length and its location are indicated by a long thick chain line, drawn adjacent and parallel to the surface and at a short distance from it.

11.5.5.5 If special requirement is applied to an element of revolution, the indication shall be shown on one side only (*see* Fig. 11.59).

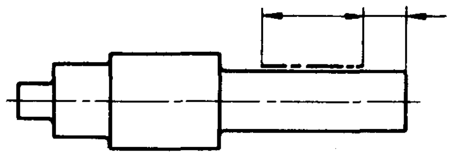


FIG. 11.59

11.5.5.6 Where the location and extent of the special requirement requires identification, the appropriate dimensioning is necessary. However, where the drawing clearly shows the extent of the indication, dimensioning is not necessary (*see* Fig. 11.60).

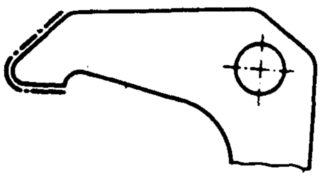


FIG. 11.60

11.6 Indication of Levels

11.6.1 *General* – Levels shall be expressed in appropriate units from a predetermined base-zero level.

11.6.2 *Levels on Vertical Views and Sections*

11.6.2.1 The predetermined base-zero level on vertical views and sections shall be indicated with a closed arrowhead with barbs at an included angle of 90°. The arrowhead shall point to a horizontal line, shall be half filled in, and shall be connected to a horizontal leader line by means of a short thin line (*see* Fig. 11.61).

11.6.2.2 If it is required to indicate the altitude of the base-zero level, the base-zero level symbol is modified to include 0.000 directly above and the actual altitude directly below the horizontal leader line (*see* Fig. 11.62).

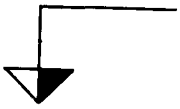


FIG. 11.61

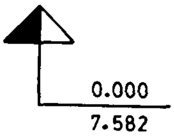


FIG. 11.62

11.6.2.3 Subsequent levels are indicated in vertical views and sections with an arrowhead with barbs at an included angle of 90° pointing to the respective level and attached to a short thin vertical line. The vertical line is connected at right angles to a horizontal leader line above which is placed the appropriate level dimension (*see* Fig. 11.63).

11.6.3 *Levels on Horizontal (Plan) Views and Sections*

11.6.3.1 The numerical value of the level for a point (a specific location) shall be placed above the leader line that is connected to an *X*. The *X* is used to indicate the exact position of a particular point (*see* Fig. 11.64).

11.6.3.2 If the specific location point is defined by two intersecting outlines, the *X* shall be replaced with a circle and the numerical value of the elevation shall be located above the leader line that is extended from the circle on the same side of the outline as the surface associated with the elevation (*see* Fig. 11.65).

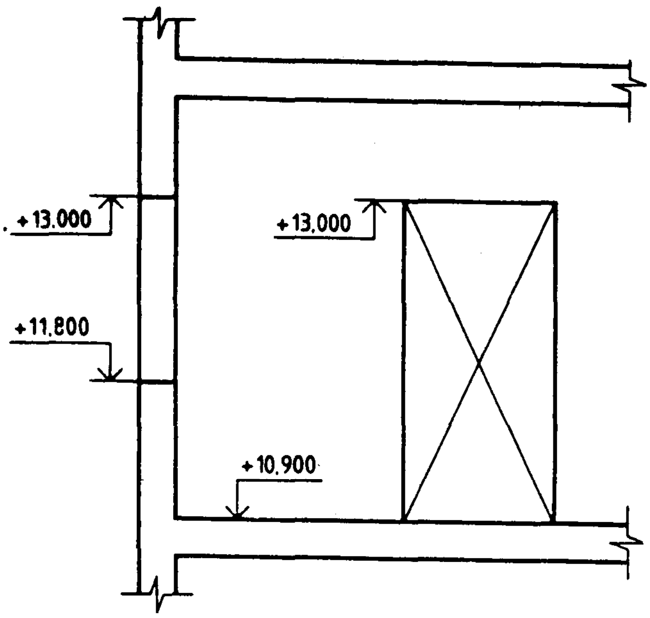


FIG. 11.63

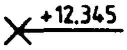


FIG. 11.64

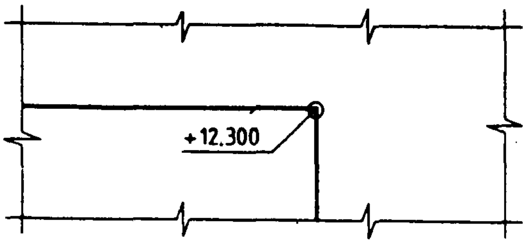


FIG. 11.65

11.6.3.3 The numerical value of an elevation of an outline shall be located adjacent to it and on the same side of it as the surface associated with the elevation (*see* Fig. 11.66).

11.6.4 *Levels on Site Layout*

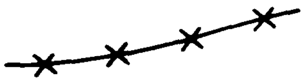
11.6.4.1 Levels on ground preparation drawings and site plans shall be given as follows:

Original ground level to be used	+ 0.000 (underlined)
New ground level	+ 0.000
Original ground level no longer valid	(+0.000)

11.6.4.2 Levels for contour lines shall be located on the upper side of the countour line and shall be given as follows:

Contour line

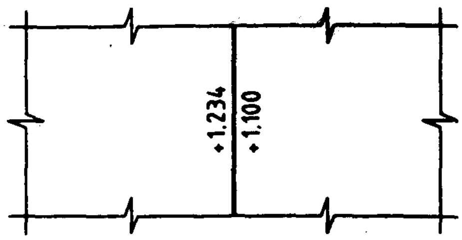
Original contour line no longer valid



11.6.4.3 Elevation datum to be used when setting out dimensions shall be shown as follows:

⊕ FIX +0.000

Example



Meaning

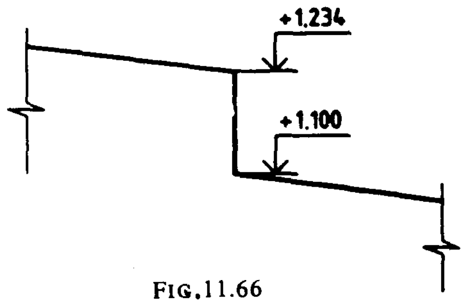


FIG.11.66

SECTION 12 INDICATION OF LINEAR AND ANGULAR TOLERANCES ON TECHNICAL DRAWING

12.1 Scope – This section specifies the indication of tolerances for linear and angular dimensions on technical drawings. Indicating such tolerances does not necessarily imply the use of any particular method of production, measurement or gauging.

12.2 Units

12.2.1 Units of the deviations shall be expressed in the same unit as the basic size.

12.2.2 If two deviations relating to the same dimension have to be shown, both shall be expressed to the same number of decimal places (*see* Fig. 12.2), except if one of the deviations is zero (*see* Fig. 12.5).

12.3 Indication of the Components of a Linear Dimension

12.3.1 *ISO Symbols* – The components of the toleranced dimension shall be indicated in the following order:

a) the basic size, and

b) the tolerance symbol.

12.3.1.1 If, in addition to the symbols (*see* Fig. 12.1), it is necessary to express the values of the deviations (*see* Fig. 12.2) or the limits of size (*see* Fig. 12.3), the additional information shall be shown [illegible]

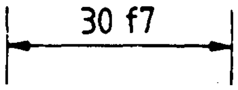


FIG. 12.1

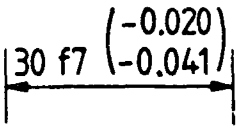


FIG. 12.2

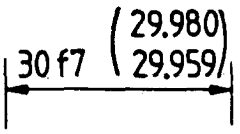


FIG. 12.3

12.3.2 *Permissible Deviations* – The components of the toleranced dimension shall be indicated in the following order (*see* Fig. 12.4 to 12.6):

a) the basic size, and
b) the values of the deviations.

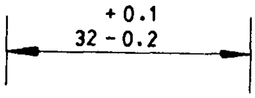


FIG. 12.4

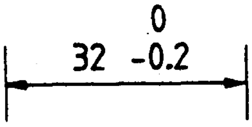


FIG. 12.5

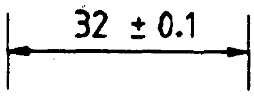


FIG. 12.6

12.3.2.1 If one of the two deviations is zero, this should be expressed by the digit zero (*see* Fig. 12.5).

12.3.2.2 If the tolerance is symmetrical in relation to the basic size, the value of the deviations [illegible] sign ± (*see* Fig. 12.6).

12.3.3 *Limits of Size* – The limits of size may be indicated by an upper and lower dimension (*see* Fig. 12.7).

12.3.4 *Limits of Size in One Direction* – If a dimension needs to be limited in one direction only, this should be indicated by adding "min" or "max" to the dimension (*see* Fig. 12.8).

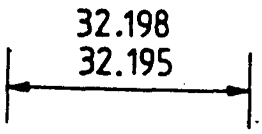


FIG. 12.7

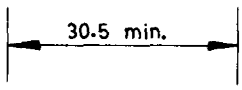


FIG. 12.8

12.4 Order of Indication of Deviations and Limits of Size – The upper deviation or the upper limit of size shall be written in the upper position and the lower deviation or the lower limit of size in the lower position, irrespective of whether a hole or a shaft is toleranced.

12.5 Indication of Tolerances on Drawings of Assembled Parts

12.5.1 *ISO Symbols*

12.5.1.1 The tolerance symbol for the hole shall be placed before that for the shaft (*see* Fig. 12.9) or above it (*see* Fig. 12.10), the symbols being preceded by the basic size indicated once only.

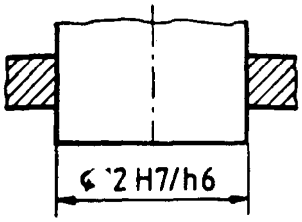


FIG. 12.9

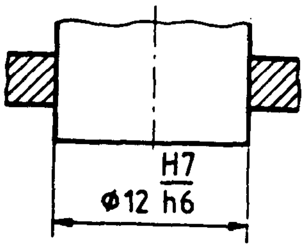


FIG. 12.10

12.5.1.2 If it is also necessary to specify the numerical values of the deviations, they should be written in brackets (*see* Fig. 12.11).

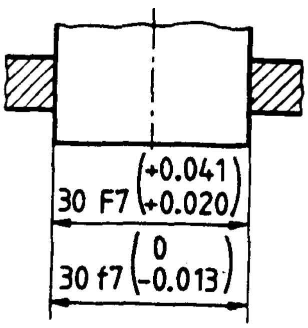


FIG. 12.11

For the sake of simplicity, dimensioning with only one dimension line may be used (*see* Fig. 12.12).

12.5.2 *Values by Digits* – The dimension for each of the components of the assembled parts shall be preceded by the name (*see* Fig. 12.12) or item reference (*see* Fig. 12.13) of the components, the dimension for the hole being placed in both cases above that for the shaft.

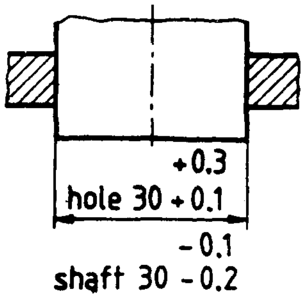


FIG. 12.12

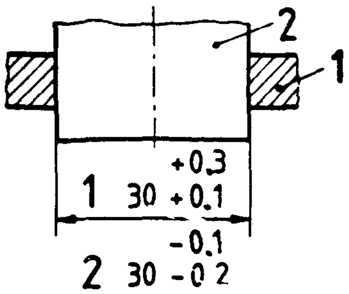


FIG. 12.13

12.6 Indication of Tolerances on Angular Dimensions – The rules given for the indication of tolerances on linear dimensions are equally applicable to angular dimensions (*see* Fig. 12.16 and 12.17), except that the units of the basic angle and the fractions thereof, as well as the deviations, shall always be indicated, (*see* Fig. 12.14 to 12.17). If the angular deviation is expressed in either minutes of a degree or seconds of a minute of a degree, the value of the minute or second shall be preceded by 0° or 0° 0′ as applicable.

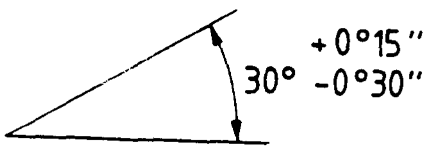


FIG. 12.14

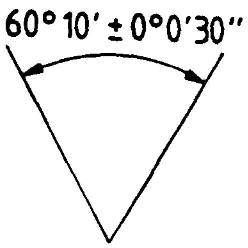


FIG. 12.15

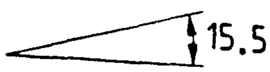


FIG 12.16

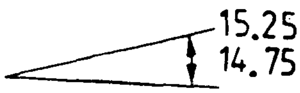


FIG. 12.17

SECTION 13 METHODS OF DIMENSIONING AND TOLERANCING CONES

13.1 Scope – This section specifies methods of dimensioning and tolerancing cones on drawings.

13.2 Definitions and Symbols

13.2.1 *Taper* – The ratio of the difference in the diameters of two sections of a cone to their distance.

Thus taper $C = \frac{D - d}{L} = 2 \tan \frac{\alpha}{2}$

(*see* Fig. 13.1).

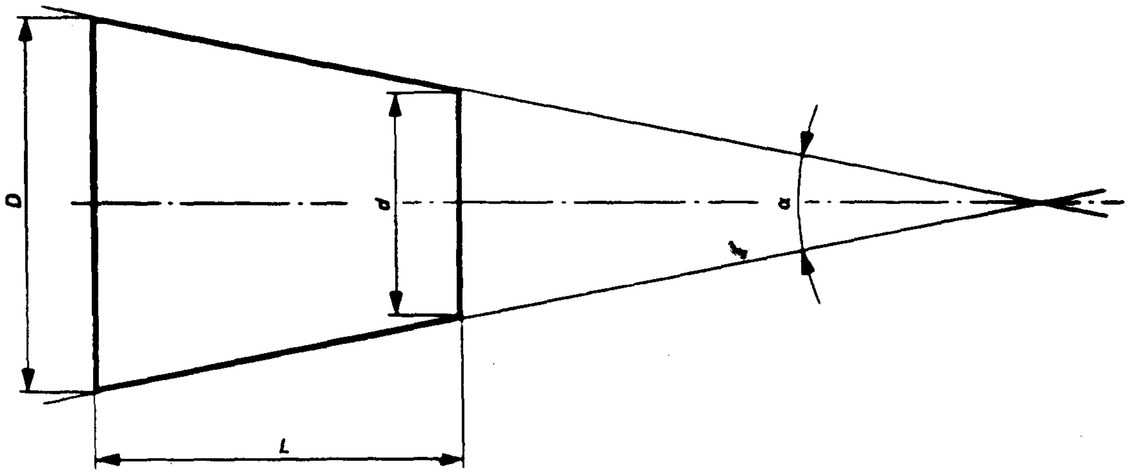


FIG. 13.1

13.2.2 The following symbol indicates a taper and, correctly oriented, may be used to show the direction of the taper (*see* below).

NOTE – Taper (as defined above) shall not be confused with slope.

Slope, which is not the subject of this guide, is the inclination of the line representing the inclined surface of a wedge expressed as the ratio of the differences in the heights at right angles to the base line, at a specified distance apart, to that distance.

Thus slope $= \frac{H - h}{L} = \tan \beta$ (*see* Fig. 13.2).

If necessary the following symbol for slope may be used to show the direction of the slope :

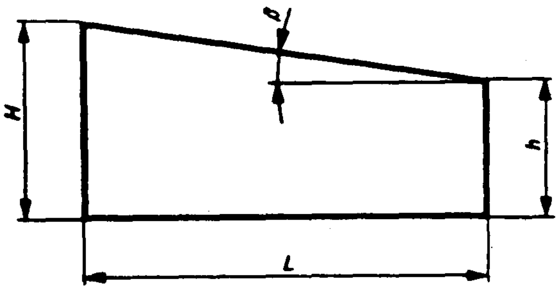


FIG. 13.2

13.3 Dimensioning

13.3.1 The following dimensions may be used, in different combinations, to define the size, form and position of cones:

a) the taper, specified either by the included angle or as a ratio, for example:
   - 0.3 rad
   - 35^0
   - 1:5
   - 0.2:1
   - 20 % (*see* Fig. 13.10)

b) the diameter at the larger end;

c) the diameter at the smaller end;

d) the diameter at a selected cross-section, this cross-section may be within or outside the cone;

e) the dimension locating a cross-section at which the diameter is specified;

f) the length of the cone.

Figures 13.3 to 13.6 show some typical combinations of dimensions.

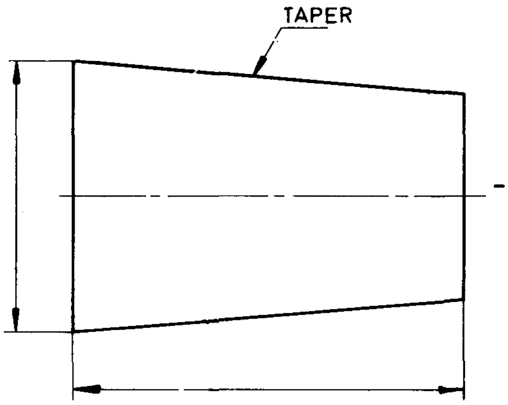


FIG.13.3

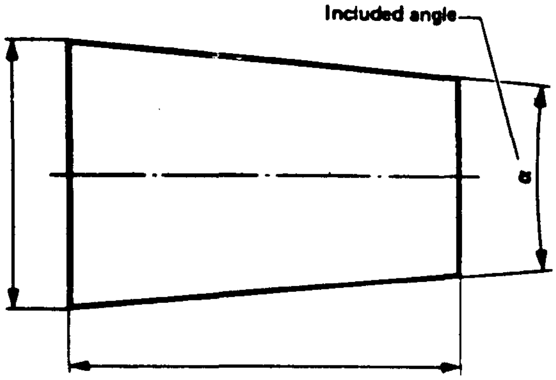


FIG.13.4

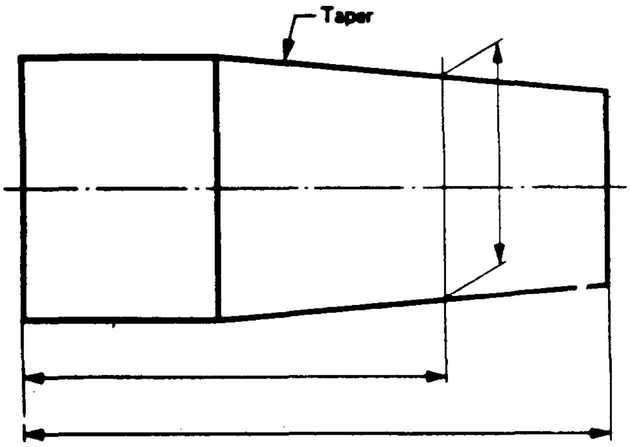


FIG.13.5

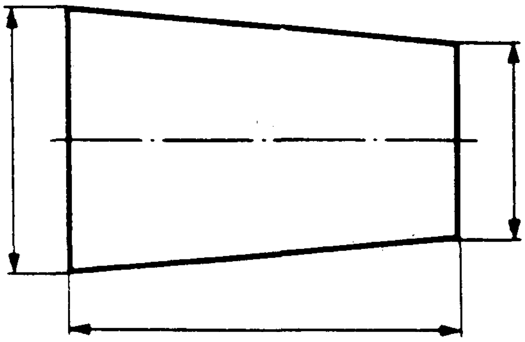


FIG.13.6

13.3.2 No more of these dimensions than are necessary shall be specified. However, additional dimensions may be given as "auxiliary" dimensions in brackets for information, for example half the included angle.

13.3.3 When a taper of standardized series is concerned (in particular morse or metric taper) the tapered feature may be designated by specifying the standard series and appropriate number.

13.4 Tolerancing

13.4.1 *General*

13.4.1.1 There are two methods of specifying the accuracy of cones, namely, basic taper method and toleranced taper method. In this publication, only basic taper method has been explained.

13.4.1.2 On the right-hand side of the figures, the tolerance zones are shown.

13.4.1.3 It should be noted that errors of form may exist, provided that every part of the surface lies inside the tolerance zone. In practice it may not be permitted to absorb the whole of the tolerance zone by errors of form. When restrictions in this regard are necessary this shall be indicated by appropriate tolerances of form.

13.4.1.4 The datum dimensions (which may be linear or angular) and the toleranced sizes define the tolerance zone within which the conical surface shall be contained.

13.4.1.5 A datum dimension (enclosed in a frame) is a dimension which defines the exact location of a point, line, plane or conical surface, the real position of which is controlled by means other than by direct tolerancing of this dimension.

13.4.1.6 It may be used to define the exact position of a cross section of a cone at which the diameter is allowed to vary within specified limits. It may also be used to define the exact diameter of a cross section of a cone, the position of which is

13.4.1.7 It should be noted that where the method of dimensioning shown in Fig. 13.8 and 13.9 is used, either the diameter or the position will be a datum dimension (enclosed in a frame).

13.4.1.8 The choice of the tolerancing method and of the values of the tolerances depends on the functional requirements.

13.4.2 *Basic Taper Method*

13.4.2.1 In this method the tolerances limit the variation of penetration of mating surfaces each profiles of the same taper corresponding to the maximum and minimum material conditions.

13.4.2.2 The tolerance zone limiting the cone is established by a tolerance either on diameter or on position.

By convention the prescribed or resulting tolerances of the diameter of the feature applies at all cross sections throughout its length (*see* Fig. 13.7 to 13.9).

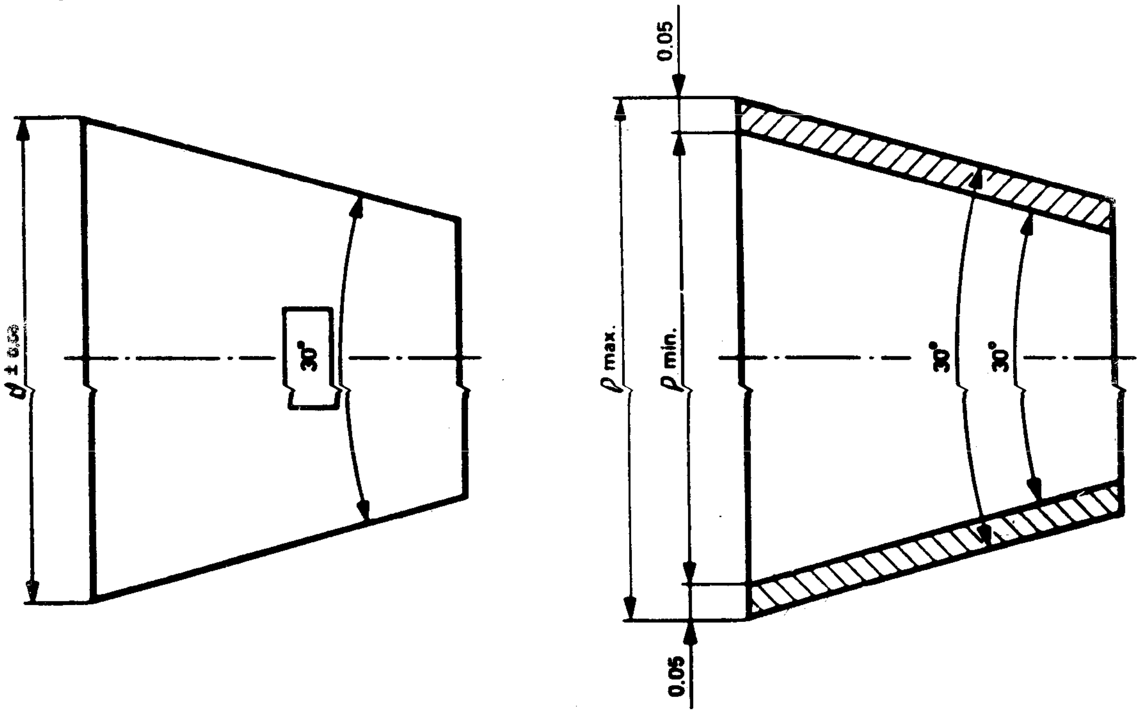


FIG. 13.7

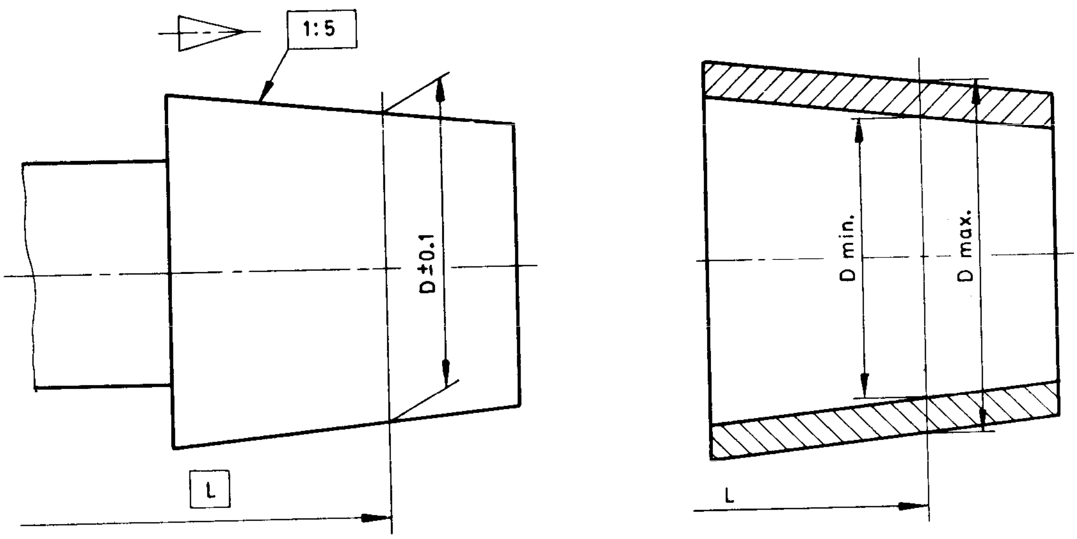


FIG. 13.8

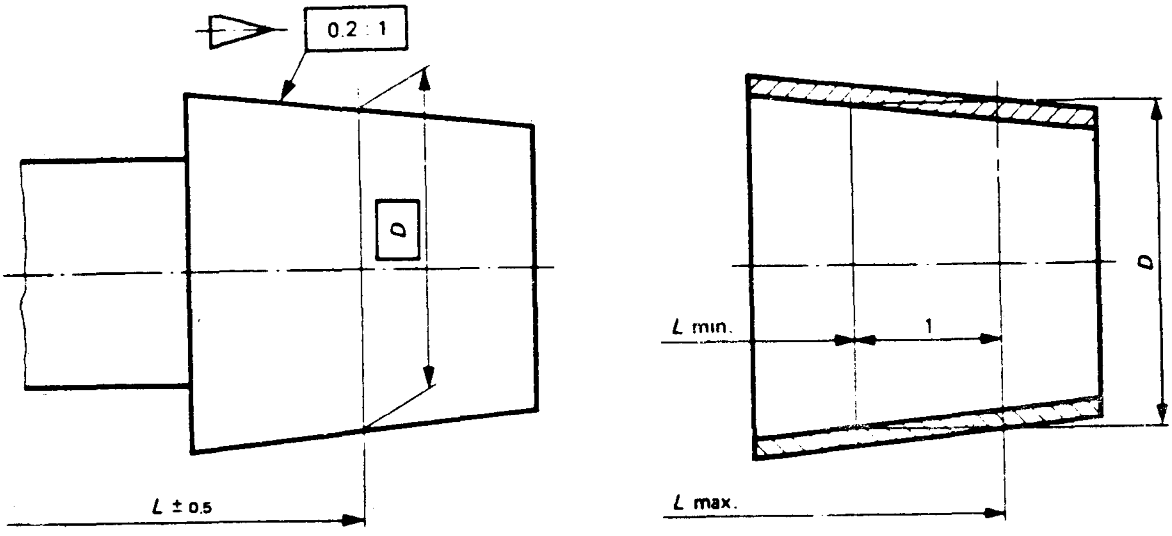


FIG. 13.9

13.4.2.3 The surface of cone may lie anywhere within the tolerance zone (*see also* 13.4.1.3).

13.4.2.4 Figure 13.7 illustrates a cone dimensioned by the basic taper method and where the size at one end of the feature is specified by a toleranced dimension.

13.4.2.5 Figure 13.8 illustrates a cone dimensioned by the basic taper method and where the size is controlled by a toleranced dimension at a cross section located by a datum dimension enclosed in a frame.

13.4.2.6 Figure 13.9 illustrates a cone dimensioned by the basic taper method and where the diameter of a cross-section is a datum dimension. This cross-section is located within specified limits in

13.4.2.7 The basic taper method according to Fig. 13.7, 13.8 or 13.9 may not be suitable for use in cases where the variation in taper, arising from the necessary tolerances on diameter or position would not be acceptable. This may be overcome by the use of Fig. 13.10.

13.4.2.8 Where it is necessary to apply restrictive conditions limiting the effective variation of the taper within the tolerance zone, the following methods shall be used:

a) By a reference to a written note specifying the permissible limit of the actual taper;
b) By indicating a restrictive angularity tolerance to the generating lines with respect to the axis (*see* Fig. 13.10).

NOTE – The tolerance zone for angularity (including straightness) may lie anywhere within the tolerance zone

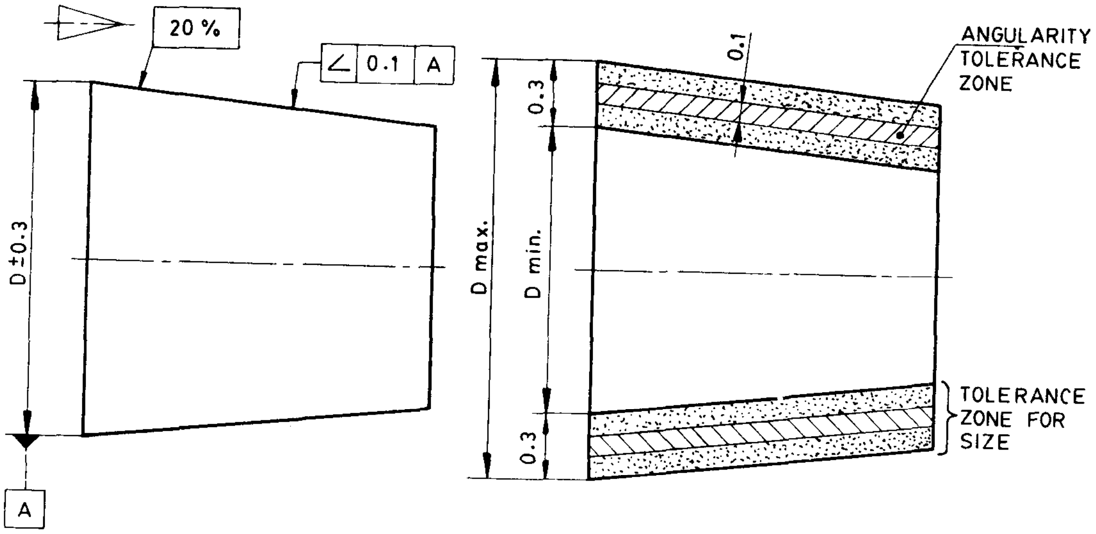


FIG. 13.10

SECTION 14 METHOD OF INDICATING SURFACE TEXTURE ON TECHNICAL DRAWINGS

14.1 Scope – This section specifies the symbols and additional indications of surface texture to be indicated on technical drawings.

14.2 Symbols used for Indication of Surface Texture

14.2.1 The basic symbol consists of two legs of unequal length inclined at approximately 60° to the line representing the considered surface, as shown in Fig. 14.1.

14.2.1.1 This symbol alone has no meaning except as in 14.4.4 and 14.4.7.

14.2.2 If the removal of material by machining is required, a bar is added to the basic symbol, as shown in Fig. 14.2.

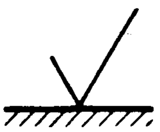


FIG. 14.1

FIG. 14.2

14.2.3 If the removal of material is not permitted, a circle is added to the basic symbol, as shown in Fig. 14.3.

14.2.4 The symbol in Fig. 14.3 may also be used in a drawing relating to a production process to indicate that a surface is to be left in the state resulting from a preceding manufacturing process, whether this state was achieved by removal of material or otherwise.

14.2.4.1 In this case none of the indications given in 14.3 are added to the symbol.

14.2.5 When special surface characteristics have to be indicated, a line is added to the longer arm of any of the above symbols, as shown in Fig. 14.4.

FIG. 14.3

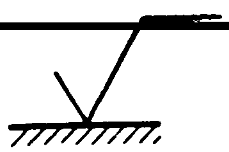


FIG. 14.4

14.3 Indications Added to the Symbols

14.3.1 *Indication of Surface Roughness*

14.3.1.1 The value or values defining the principal criterion of roughness are added to the symbols given in Fig. 14.1, 14.2 and 14.3, as shown in Fig. 14.5, 14.6 and 14.7.

14.3.1.2 A surface texture specified:

- as in Fig. 14.5 may be obtained by any production methods.
- as in Fig. 14.6 shall be obtained by removal of material by machining, and
- as in Fig. 14.7 shall be obtained without removal of material.

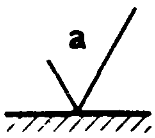


FIG. 14.5

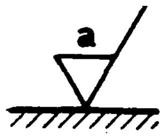


FIG. 14.6

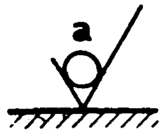


FIG. 14.7

14.3.1.3 When only one value is specified it represents the maximum permissible value of surface roughness.

14.3.1.4 If it is necessary to impose maximum and minimum limits of the principal criterion of surface roughness, both values shall be shown as in Fig. 14.8 with the maximum limit (a_1) above the minimum limit (a_2).

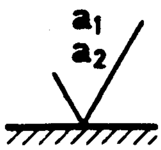


FIG. 14.8

14.3.1.5 The principal criterion of roughness, R_a may be indicated by the corresponding roughness grade number shown in Table 14.1.

14.3.2 *Indication of Special Surface Texture Characteristics*

14.3.2.1 In certain circumstances, for functional reasons, it may be necessary to specify additional special requirements concerning surface texture.

14.3.2.2 If it is required that the final surface texture be produced by one particular production method, this method shall be indicated in plain language on an extension of the longer arm of the symbol given in Fig. 14.4 as shown in Fig. 14.9.

TABLE 14.1

Roughness Values R_a µm (1)	*Roughness Grade Numbers* (2)
50	N 12
25	N 11
12.5	N 10
6.3	N 9
3.2	N 8
1.6	N 7
0.8	N 6
0.4	N 5
0.2	N 4
0.1	N 3
0.05	N 2
0.025	N 1

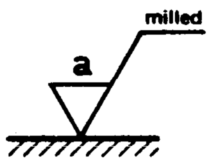


FIG. 14.9

14.3.2.3 Also on this extension line shall be given any indications relating to treatment or coatings.

Unless otherwise stated, the numerical value of the roughness applies to the surface texture after treatment or coating.

If it is necessary to define surface texture both before and after treatment, this shall be explained in a suitable note or in accordance with Fig. 14.10.

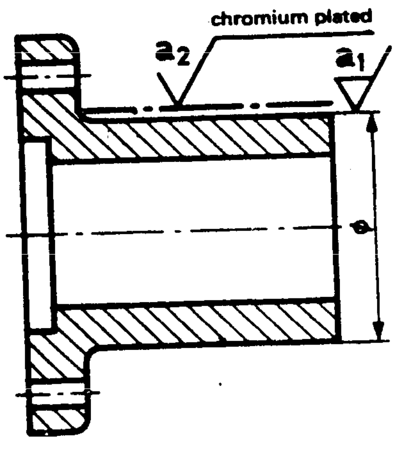


FIG. 14.10

14.3.2.4 If it is necessary to indicate the sampling length, it shall be selected from the series given in IS:3073-1967 'Assessment of surface roughness', and be stated adjacent to the symbol as shown in Fig. 14.11.

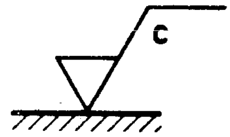


FIG. 14.11

14.3.2.5 If it is necessary to control the direction of lay, it is specified by a symbol (*see* **14.3.3**) added to the surface texture symbol as shown in Fig. 14.12.

NOTE – The direction of lay is the direction of the predominant surface pattern, ordinarily determined by the production method employed.

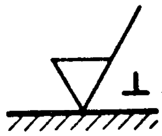


FIG. 14.12

14.3.3 *Symbols for the Direction of Lay* – The series of symbols shown in Table 14.2 specifies the common directions of lay.

14.3.4 *Indication of Machining Allowance* – Where it is necessary to specify the value of the machining allowance, this shall be indicated on the left of the symbols as shown in Fig. 14.13. This value shall be expressed in millimetres according to the general system used for dimensioning the drawing.

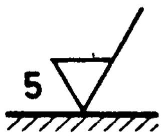
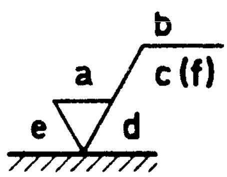


FIG. 14.13

14.3.5 *Position of the Specifications of the Surface Texture in the Symbol* – The specifications of surface texture shall be placed relative to the symbol as shown in Fig. 14.14.



a = Roughness value *Ra* in micrometres
or
= Roughness grade number N1 to N12.

b = Production method, treatment or coating
c = Sampling length
d = Direction of lay
e = Machining allowance
f = Other roughness values (in brackets).

FIG. 14.14

14.4 Indications on Drawings

14.4.1 In confirmity with Section 11, the symbol, as well as the inscriptions, shall be oriented so that they may be read from the bottom or the right hand side of the drawing (*see* Fig. 14.15).

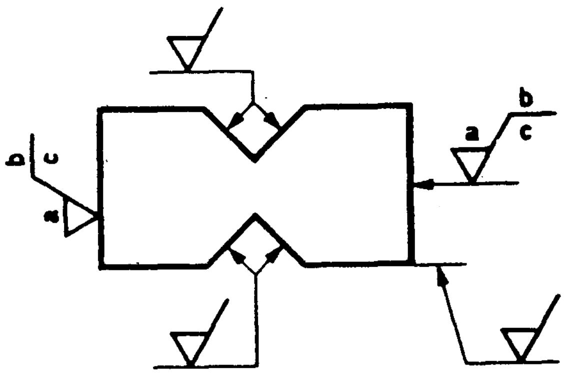


FIG. 14.15

14.4.1.1 If it is not practicable to adopt tnis general rule, the symbol may be drawn in any position, but only provided that it does not carry any indications of special surface texture characteristics or of machining allowances. Nevertheless, in such cases the inscription defining the value of the principal criterion of roughness (if present) shall always be written in conformity with the general rule (*see* Fig. 14.16).

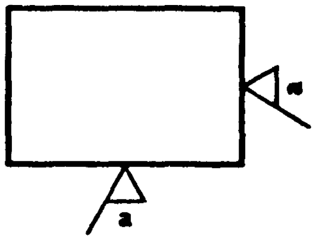


FIG. 14.16

14.4.1.2 If necessary, the symbol may be connected to the surface by a leader line terminating in an arrow.

14.4.1.3 The symbol or the arrow shall point from outside the material of the piece, either to the line representing the surface, or to an extension of it (*see* Fig. 14.15).

14.4.2 In accordance with the general principles of dimensioning, the symbol is only used once for a given surface and, if possible, on the view which carries the dimension defining the size or position of the surface (*see* Fig. 14.17).

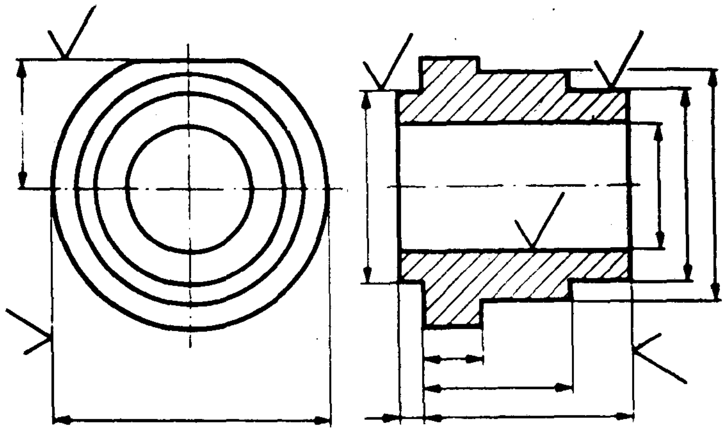


FIG. 14.17

14.4.3 If the same texture is required on all the surfaces of a part, it is specified:

- either by a note near a view of the part (Fig. 14.18), near the title block, or in the space devoted to general notes;
- or following the part number on the drawing (Fig. 14.19).

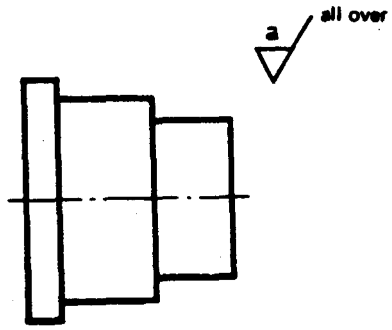


FIG. 14.18

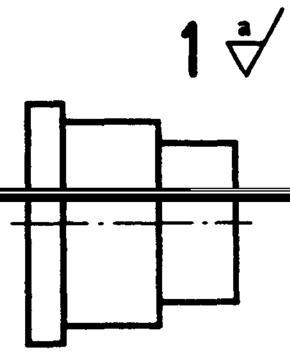
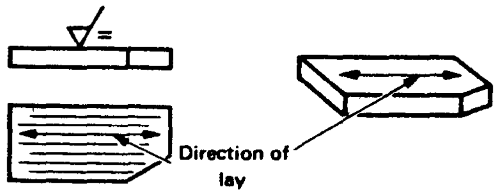
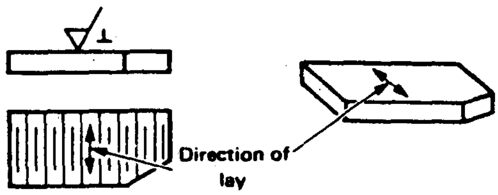
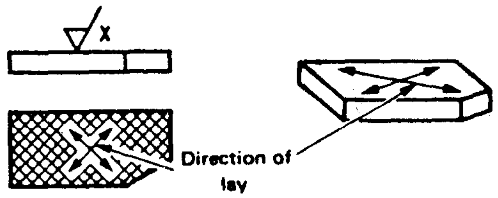
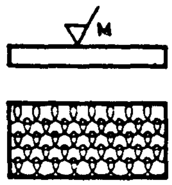
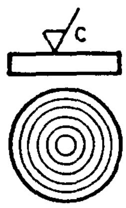
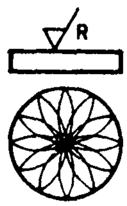


FIG. 14.19

TABLE 14.2

Symbol	*Interpretation*	
=	Parallel to the plane of projection of the view in which the symbol is used	
⊥	Perpendicular to the plane of projection of the view in which the symbol is used	
X	Crossed in two slant directions relative to the plane of projection of the view in which the symbol is used	
M	Multi-directional	
C	Approximately circular relative to the centre of the surface to which the symbol is applied	
R	Approximately radial relative to the centre of the surface to which the symbol is applied	

NOTE – Should it be necessary to specify a direction of lay not clearly defined by these symbols then this must be achieved by a suitable note on the drawing.

14.4.4 If the same surface texture is required on the majority of the surfaces of a part, it is specified as in 14.4.3 with the addition of :

- the notation "except where otherwise stated" (Fig. 14.20).
- or a basic symbol (in brackets) without any other indication (Fig. 14.21).

[redacted]

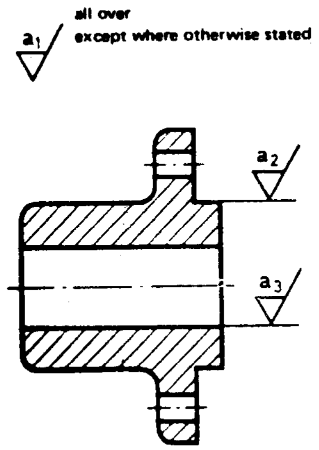


FIG. 14.20

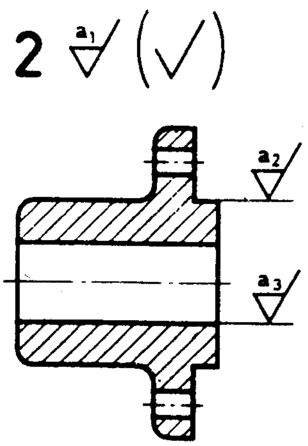


FIG. 14.21

14.4.5 The symbols for the surface textures which are exceptions to the general symbol are indicated on the corresponding surfaces.

14.4.6 To avoid the necessity of repeating a complicated specification a number of times, or where space is limited, a simplified specification may be used on the surface, provided that its meaning is explained near the drawing of the part, near the title block or in the space devoted to general notes (*see* Fig. 14.23).

14.4.7 If the same surface texture is required on a large number of surfaces of the part, one of the

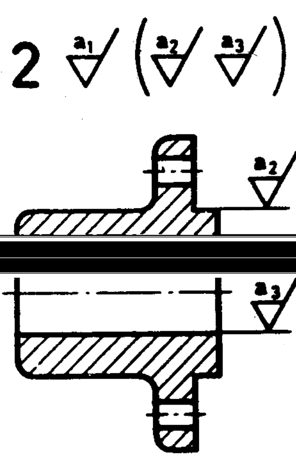


FIG. 14.22

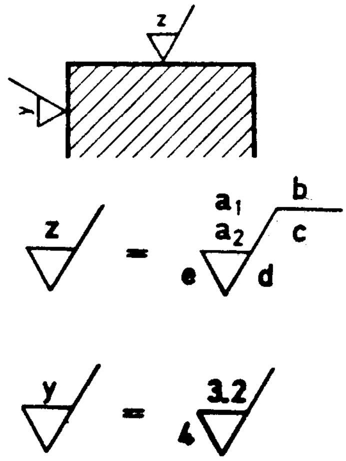


FIG. 14.23

symbols shown in Fig. 14.1, 14.2 or 14.3 may be used on the appropriate surfaces and its meaning given on the drawing, for example, as shown in Fig. 14.24, 14.25 and 14.26.

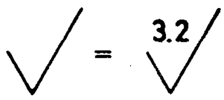


FIG. 14.24

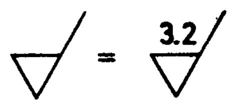


FIG. 14.25

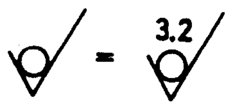


FIG. 14.26

14.5 Important Notes

14.5.1 Only give indications of the roughness, method of production or machining allowance in so far as this is necessary to ensure fitness for purpose and only for those surfaces which require it.

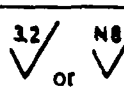
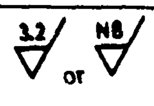
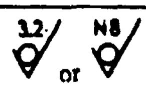
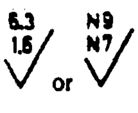
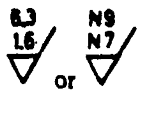
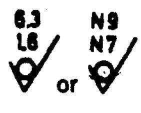
14.5.2 The specification of surface texture is unnecessary whenever the ordinary manufacturing processes by themselves ensure an acceptable surface finish.

14.6 Synoptic Tables

14.6.1 *Symbols with No Inscription*

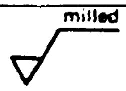
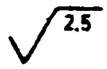
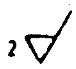
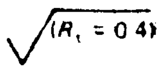
	Symbol	*Meaning*
14.6.1.1		Basic symbol. It may only be used alone when its meaning is explained by a note.
14.6.1.2		A machined surface with no indication of any other detail.
14.6.1.3		A surface from which the removal of material is prohibited. This symbol may also be used in a drawing relating to a production process to indicate that a surface is to be left in the state resulting from a preceding manufacturing process, whether this state was achieved by removal of material or otherwise.

14.6.2 *Symbols with indication of the Principal Criterion of Roughness,* R_a

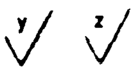
	Symbol			*Meaning*
	Removal of Material by machining is			
	optional	*obligatory*	*prohibited*	
14.6.2.1				A surface with a maximum surface roughness value R_a of 3.2 µm
14.6.2.2				A surface with a maximum surface roughness value R_a of 6.3 µm and a minimum of 1.6 µm

14.6.3 *Symbols with Additional Indications*

(May be used singly, in combination or combined with an appropriate symbol from **14.6.2**).

	Symbol	*Meaning*
14.6.3.1		Production method: milled.
14.6.3.2		Sampling length: 2.5 mm
14.6.3.3		Direction of lay: perpendicular to the plane of projection of the view.
14.6.3.4		Machining allowance: 2 mm
14.6.3.5		Indication (in brackets) of a criterion of roughness other than that used for R_a for example $R_t = 0.4\ \mu m$

14.6.4 *Simplified Symbols*

	Symbol	*Meaning*
14.6.4.1		A note indicates the meaning of the symbol.
14.6.4.2		A note indicates the meaning of the symbols.

NOTE — The surface texture values, production method, sampling length, direction of lay and machining allowance quoted are typical values and are only given as examples.

SECTION 15 TECHNICAL DRAWINGS FOR STRUCTURAL METAL WORK

15.1 Scope — This section specifies complementary [illegible] and dimensioning (Section 11), necessary for assembly and detail drawings concerning:

- structural metal work consisting of plates and sheets, profile sections and compound elements (including bridges, frameworks, pilings) etc);
- lifting and transport appliances;
- storage tanks and pressure vessels;
- lifts, moving stairways and conveyor belts;
- etc.

15.2 Representation of Holes, Bolts and Rivets

15.2.1 Representation on Projection Planes Normal to Their Axes

15.2.1.1 In order to represent holes, bolts and rivets on projection planes normal to their axes, the following symbols, represented in thick lines, shall be used (Table 15.1 and 15.2).

15.2.1.2 The symbol for holes shall be without a dot in the centre.

TABLE 15.1

Hole	Symbol for hole			
	without countersinking	countersunk on near side	countersunk on far side	countersunk on both sides
drilled in the workshop				
drilled on site				

TABLE 15.2

Bolt or Rivet	*Symbol for bolt or rivet to fit in Hole*			*Symbol for rivet to fit in Hole Countersunk on Both Sides*
	Without Countersinking	Countersunk on Near Side	Countersunk on Far Side	
Fitted in the workshop				
Fitted on site				
Fitted on site and hole drilled on site				

NOTE – To distinguish bolts from rivets, the designation of bolts shall always begin with a prefix showing the type of screw thread. (Example : the designation for a bolt with metric screw thread is M 12 x 50, whilst that for a rivet is ϕ 12 x 50).

15.2.2 *Representation on Projection Planes Parallel to Their Axes* — In order to represent holes, bolts and rivets on projection planes parallel to their axes, the symbols of the following representations shall be adopted (Tables 15.3 and 15.4). Only the horizontal dash of these symbols shall be represented in thin line, while all other parts shall be represented in thick line.

TABLE 15.3

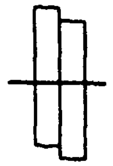
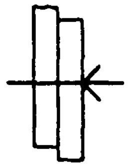
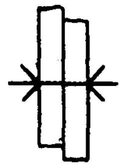
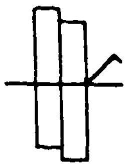
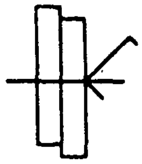
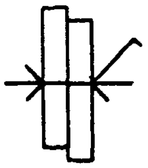
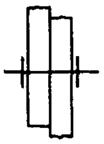
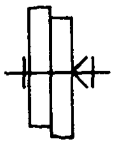
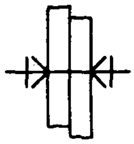
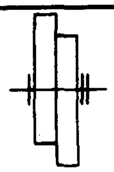
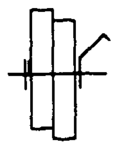
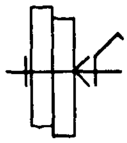
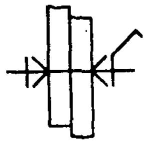
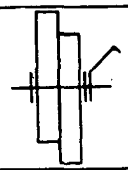
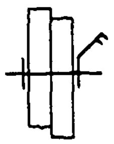
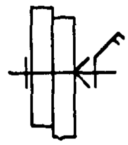
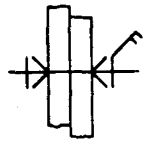
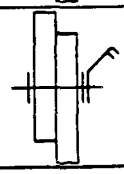
Hole	*Symbol for Hole*		
	Without Countersinking	Countersunk on One Side Only	Countersunk on Both Sides
Drilled in the Workshop			
Drilled on Site			

TABLE 15.4

Bolt or rivet	Symbol for bolt or rivet to fit in hole		Symbol for rivet to fit in hole countersunk on both sides	Symbol for bolt with designated nut position
	without countersinking	countersunk on one side only		
fitted in the workshop				
fitted on site				
fitted on site and hole drilled on site				

NOTE — To distinguish bolts from rivets, the designation of bolts shall always begin with a prefix showing the type of screw thread. (Example : the designation for a bolt with metric screw thread is M 12 X 50, whilst that for a rivet is ϕ 12 X 50.)

15.2.3 *Dimensioning and Designation*

NOTE – Because, in practice, the dimension lines and the projection lines are drawn with the same drawing instrument, a short thin line, drawn at 45° to the dimension line, has been used to represent the terminations of dimension lines.

15.2.3.1 The projection lines shall be separated from the symbols of holes, bolts and rivets on projection planes parallel to their axes (*see* Fig. 15.1).

15.2.3.2 The diameter of holes shall be indicated at the side of the symbol (*see* Fig. 15.3).

15.2.3.3 To indicate the characteristics of bolts and rivets the designation shall be given in accordance with national standards or other specifications in use (*see* Fig. 15.2).

15.2.3.4 The designation of holes, bolts and rivets, when referred to groups of identical elements, can be restricted to one exterior element (*see* Fig. 15.2).

In this case the designation shall be preceded by the number of holes, bolts, rivets constituting the group (*see* Fig. 15.2 and 15.3).

[illegible] as shown in Fig. 15.5 and 15.6.

15.3 **Dimensioning of Chamfers** – Chamfers shall be defined by means of linear dimensions as shown in Fig. 15.4 A and 15.4 B.

15.4 **Dimensioning and Lengths of Arcs** – At the side of the developed lengths of arcs, the bending radius to which these lengths refer shall be indicated in brackets (external fibre, centroidal fibre, etc) as shown in Fig. 15.5 and 15.6.

15.5 Designation of Bars, Profile Sections, Plates and Sheets

15.5.1 *Bars and Profile Sections* – Symbols and dimensions indicated in Table 15.5 shall be applied. The designation on drawing shall be adapted to the position of bar or profile section (*see* Fig. 15.1, 15.5, 15.6 and 15.7).

15.5.2 *Plates and Sheets* – Plates and sheets shall be designated by their thickness followed by the overall finished dimensions of the enclosing rectangle (*see* Fig. 15.7, 15.8 and 15.9).

15.6 Dimensioning of Gusset Plates

15.6.1 The reference system for dimensioning a gusset shall be made up by at least two converging centroidal lines with a defined angular position. Their [illegible] holes referred to the above mentioned centroidal lines, the overall dimensions and the minimum distance between the edges of the gusset plates and [illegible]

15.6.2 The inclination of axes of structural shapes and bars shall be indicated at the two short sides of a right angle triangle (system of the triangle), preferably with the values of the real distances of the reference points (or with conventional values, referred to 100, indicated in brackets) (*see* Fig. 15.8 and 15.9).

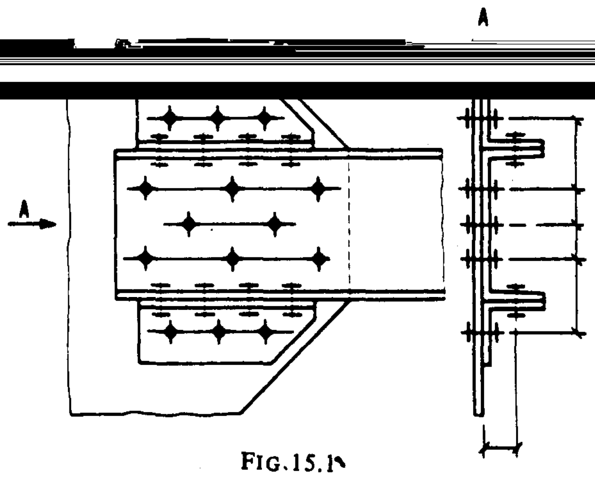


FIG. 15.1

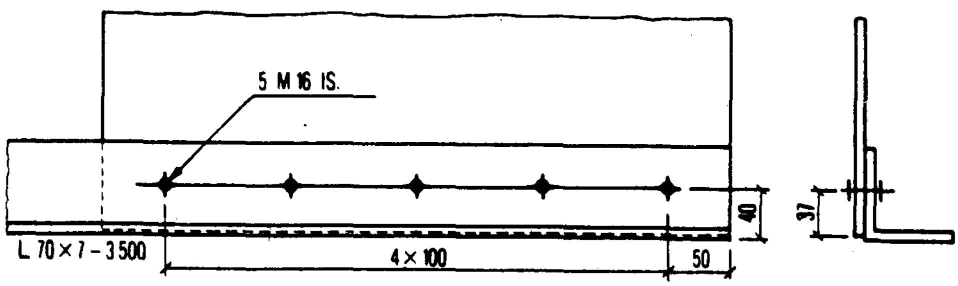


FIG. 15.2

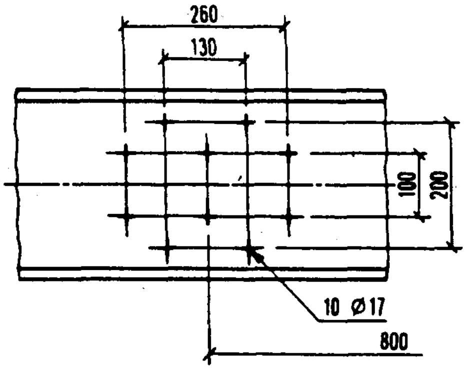


FIG. 15.3

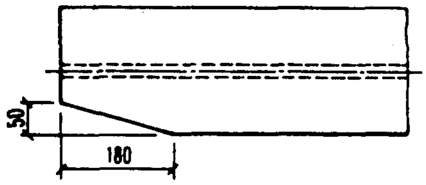


FIG 15.4 A

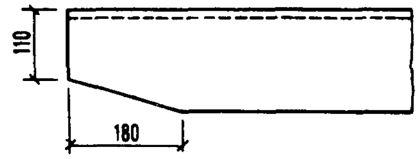


FIG. 15.4 B

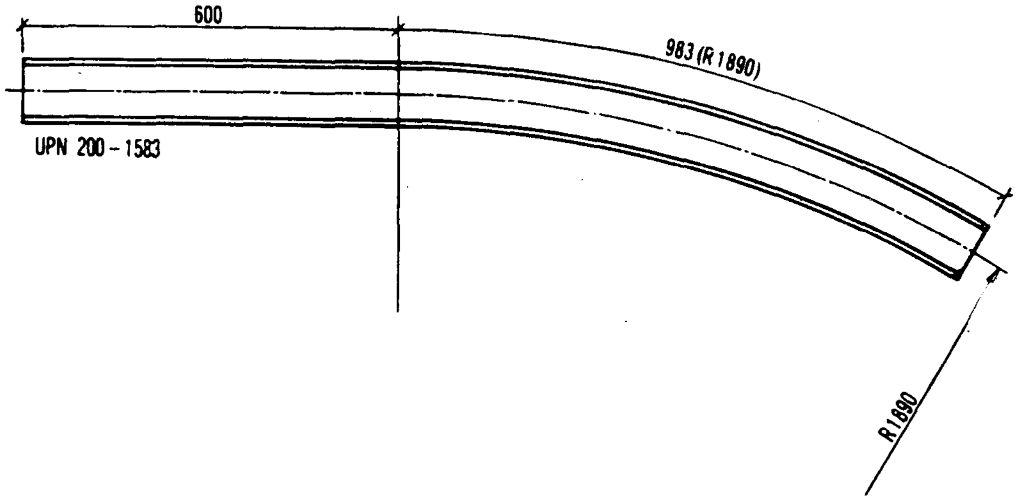


FIG 15.5

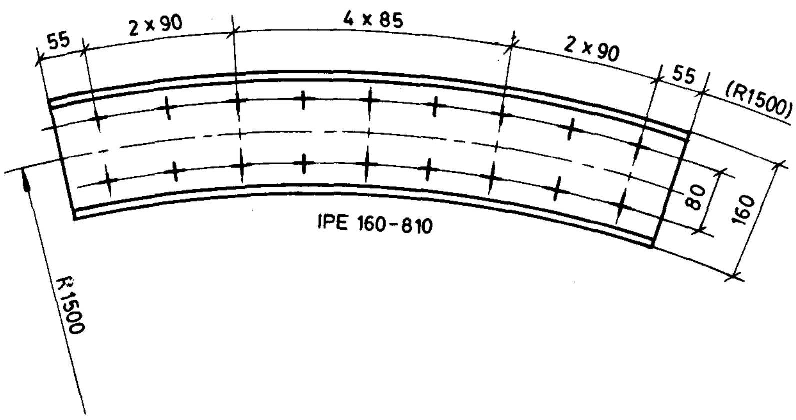
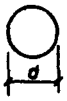
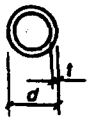
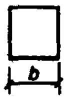
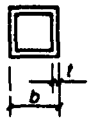
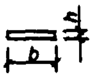
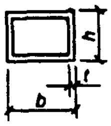
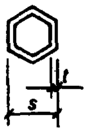
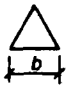
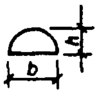


FIG. 15.6

TABLE 15.5

Description	*Designation*		*Signification of dimensions*
	Symbol	Dimensions	
Circular solid section	Ø	*d*	
Tube		*d* x *t*	
Square solid section	□	*b*	
Square hollow section		*b* x *t*	
Rectangular solid section	▭	*b* x *h*	
Rectangular hollow section		*b* x *h* x *t*	
Hexagonal solid section	⬡	*s*	
Hexagonal hollow section		*s* x *t*	
Triangular solid section	△	*b*	
Semi-circular solid section	◠	*b* x *h*	

(Continued)

TABLE 15.5 *(Concluded)*

Description	*Designation*		*Signification of dimensions*
	Symbol	Dimensions	
Angle section	L		
T-section	T		
I-beam section	I		
Channel section	[	If there are no National Standards or other relevant standards, profile section dimensions shall be indicated by means of their particular characteristics preceded by the symbol.	
Z-section	˥	(Example : L 80 × 60 × 7 – 500)	
Rail section			
Bulb angle section			
Bulb flat			

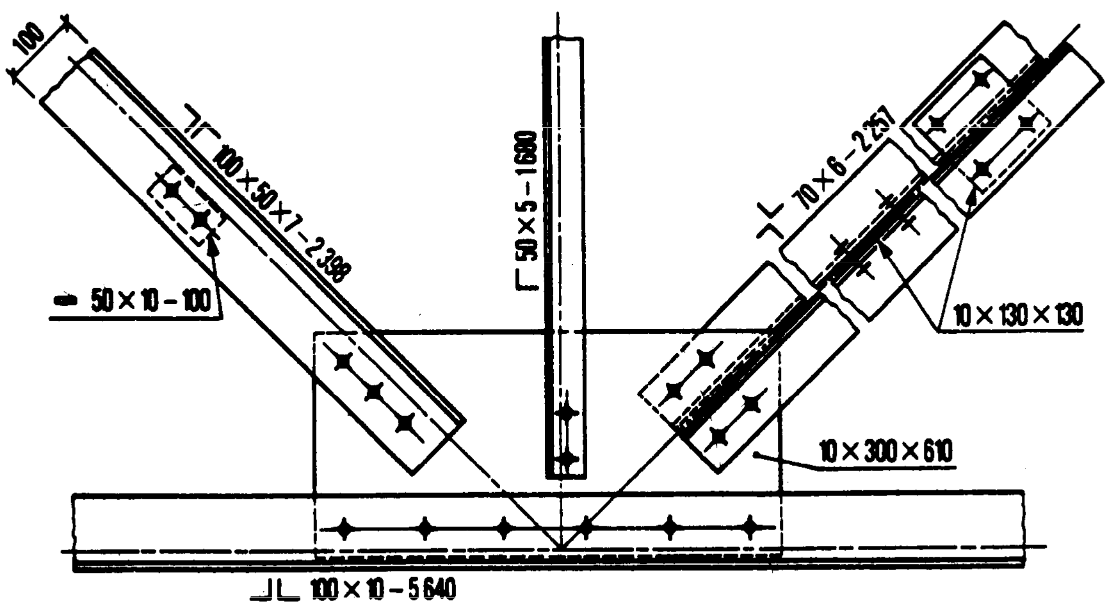


FIG. 15.7

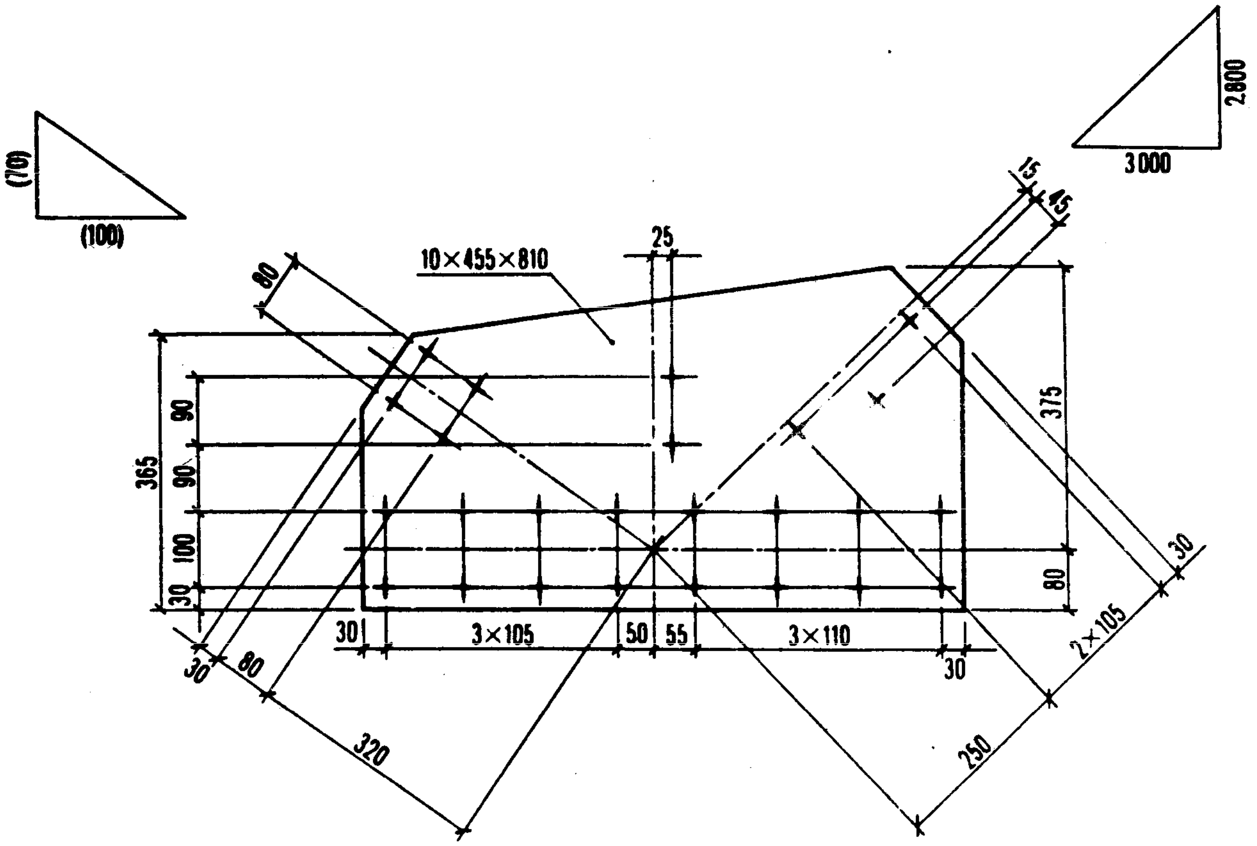


FIG.15.8

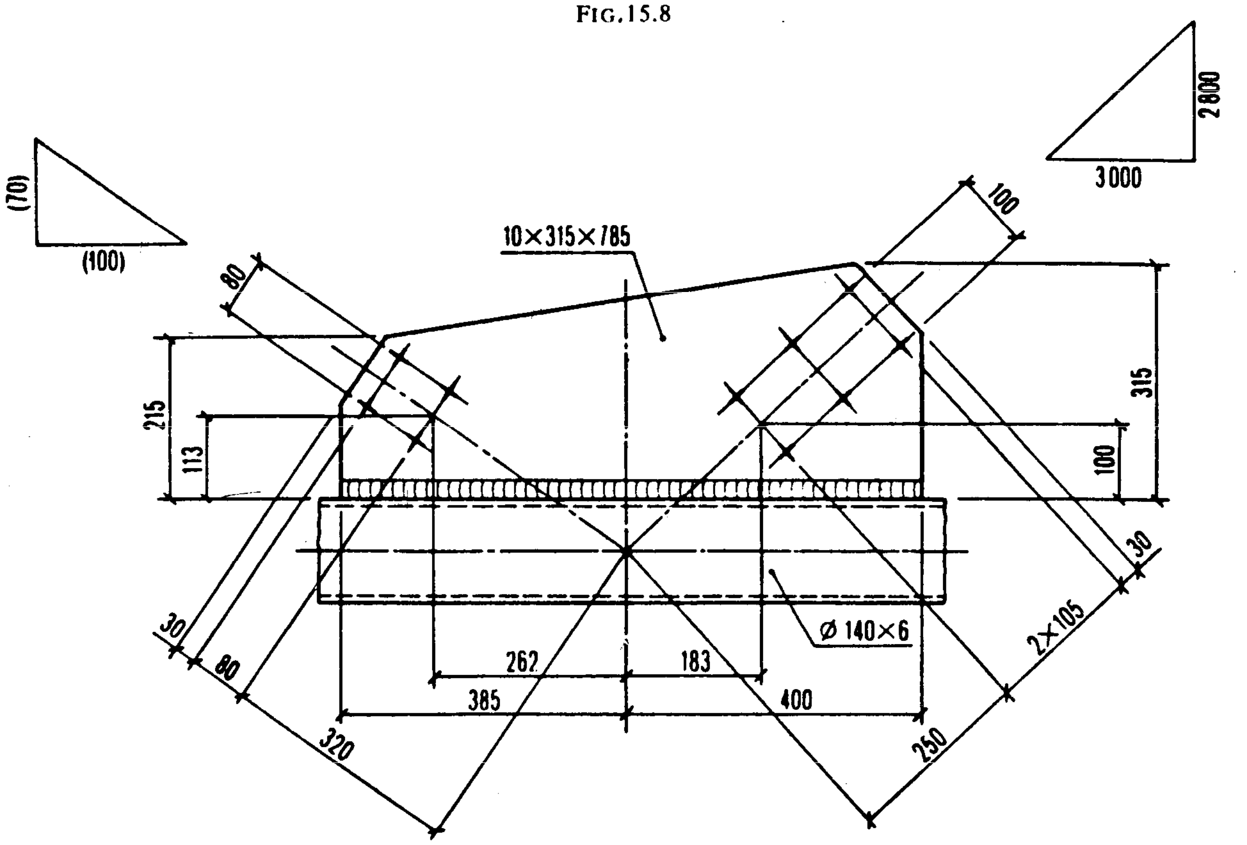


FIG.15.9

15.7 Diagrammatic Representation

15.7.1 Structural metal work can be represented diagrammatically indicating by continuous thick lines the centroidal lines of the intersecting elements.

15.7.2 In this case, the values of the distances between the reference points of the centroidal lines shall be indicated directly on the represented elements (*see* Fig. 15.10).

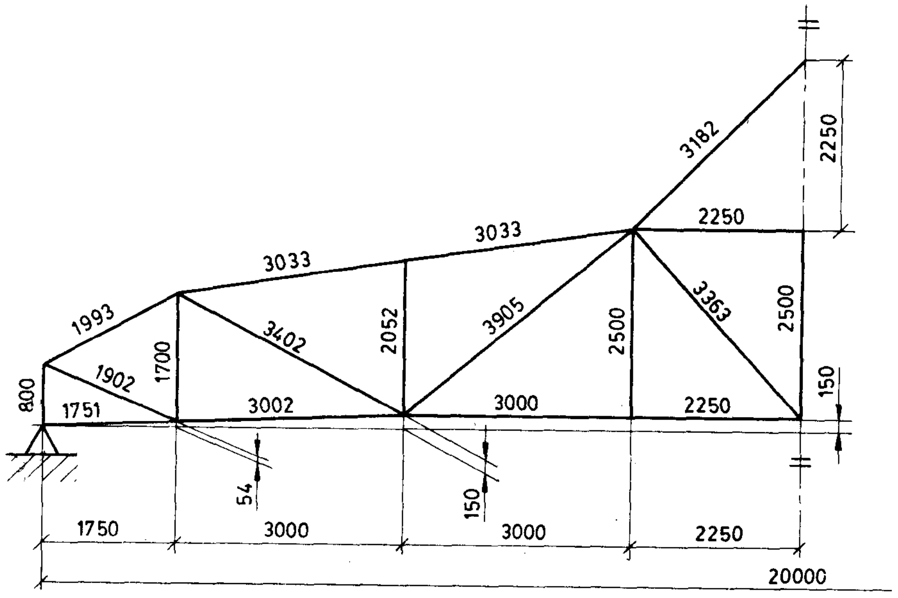


FIG. 15.10

SECTION 16 SYMBOLIC REPRESENTATION OF WELDS ON TECHNICAL DRAWINGS

16.1 Scope – This section prescribes the rules to be applied for the symbolic representation of welds on drawings.

16.2 Symbols

16.2.1 *Elementary Symbols*

16.2.1.1 The various categories of welds are characterized by a symbol which, in general, is similar to the shape of the welds to be made.

16.2.1.2 The symbol shall not be taken to prejudge the process to be employed.

16.2.1.3 The elementary symbols are shown in Table 16.1.

16.2.2 *Combination of Elementary Symbols*

16.2.2.1 When required, combination of elementary symbols can be used. Typical examples are given in Table 16.4.

16.2.3 *Supplementary Symbols*

16.2.3.1 Elementary symbols may be completed by a symbol characterizing the shape of the external surface of the weld.

16.2.3.2 The recommended supplementary symbols are given in Table 16.2.

16.2.3.3 The absence of a supplementary symbol means that the shape of the weld surface does not need to be indicated precisely.

16.2.3.4 Examples of combinations of elementary and supplementary symbols are given in Table 16.3.

NOTE – Though it is not forbidden to associate several symbols, it is better to represent the weld on a separate sketch, when symbolization becomes too difficult.

16.2.3.5 Table 16.3 gives example of application of supplementary symbols.

16.3 Position of the Symbols on Drawings

16.3.1 *General* – The symbols covered by these rules form only part of a complete method of representation (Fig. 16.1), which comprises in addition to the symbol (3) itself.

- an arrow line (1) per joint (*see* Fig. 16.2 and 16.3)
- a dual reference line consisting of two parallel lines; one continuous and one dashed (2) exception (*see* Note 1); and
- a certain number of dimensions and conventional signs.

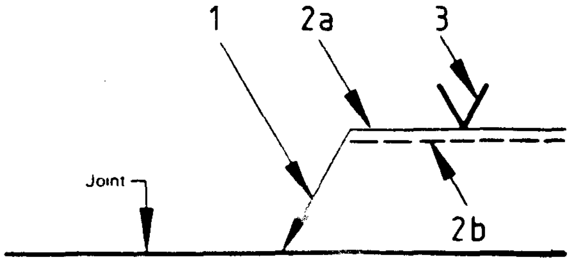


FIG. 16.1 METHOD OF REPRESENTATION

NOTE 1 – The dashed line can be drawn either above or beneath the continuous line (*see also* **16.3.5**).

For symetrical welds, the dashed line is unnecessary and should be omitted.

NOTE 2 – The thickness of lines for arrow line, reference line, symbol and lettering shall be in accordance with the thickness of line for dimensioning according to Section 6 and 7 respectively.

The purpose of the following rules is to define the location of welds by specifying:

- the position of the arrow line;
- the position of the reference line; and
- the position of the symbol.

16.3.2 *Relation Between the Arrow Line and the Joint* – The examples given in Fig. 16.2 and 16.3 explain the meaning of the terms:

- "arrow side" of the joint, and
- "other side" of the joint.

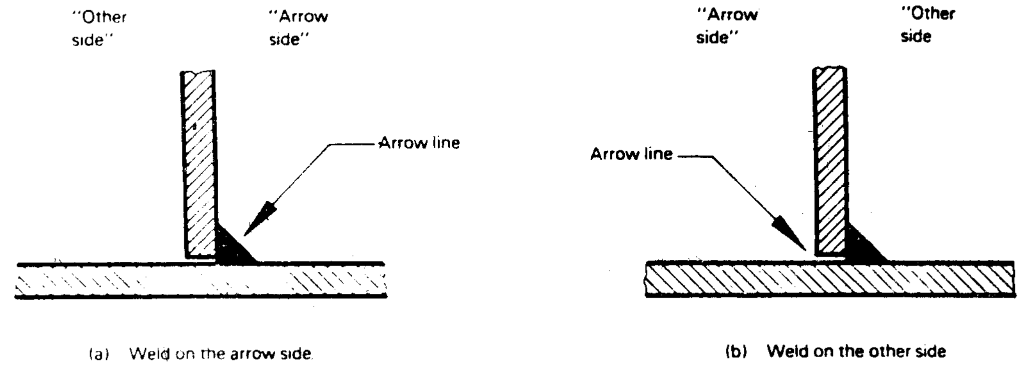


FIG. 16.2 T-JOINT WITH ONE FILLET WELD

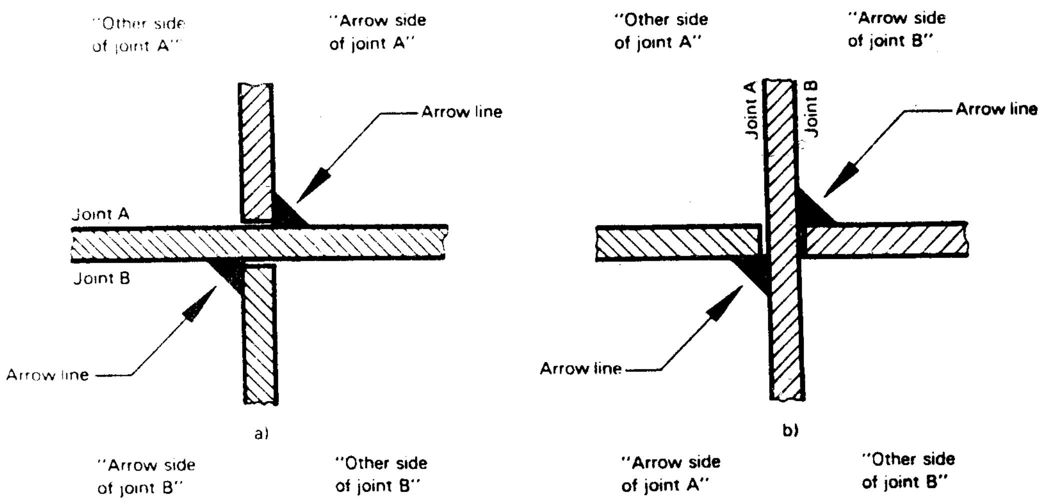


FIG. 16.3 CRUCIFORM JOINT WITH TWO FILLET WELDS

NOTE : The position of the arrow in these sketches is chosen for purposes of clarity. Normally, it would be placed immediately adjacent to the joint.

16.3.3 *Position of the Arrow Line* – The position of the arrow line with respect to the weld is generally of no special significance (*see* Fig. 16.4 A and 16.4 B). However, in the case of welds of types 4, 6 and 8 (*see* Table 16.1); the arrow line shall point towards the plate which is prepared (*see* Fig. 16.4 C and 16.4 D).

The arrow line

– joins one end of the continuous reference line such that it forms an angle with it,

– shall be completed by an arrow head.

16.3.4 *Position of the Reference Line* – The reference line shall preferably be drawn parallel to the bottom edge of the drawing, or if it is not possible then perpendicular.

16.3.5 *Position of the Symbol with Regard to the Reference Line* – The symbol is to be placed either above or beneath the reference line in accordance with the following regulation:

– the symbol is placed on the continuous line side of the reference line if the weld (weld face) is on the arrow side of the joint (*see* Fig. 16.5 a).

– the symbol is placed on the dashed line side if the weld (weld face) is on the other side of the joint (*see* Fig. 16.5 b).

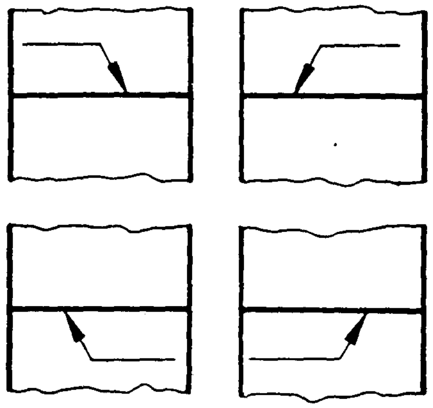


FIG. 16.4 A

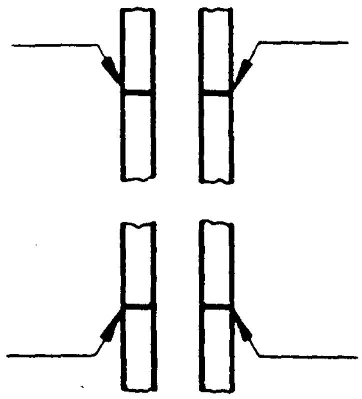


FIG. 16.4 B

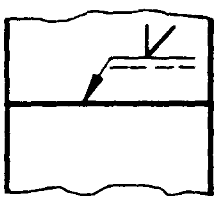


FIG. 16.4 C

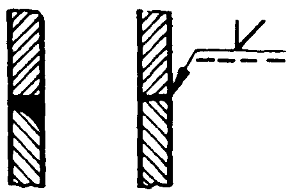
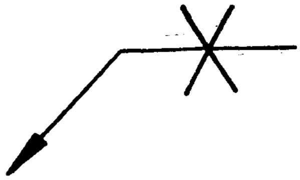


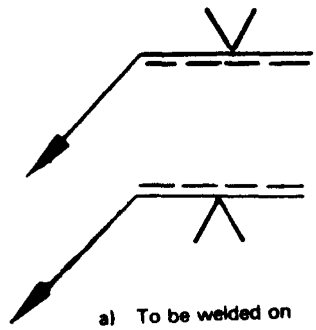
FIG. 16.4 D

FIG. 16.4 POSITION OF THE ARROW LINE

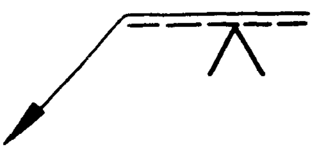
NOTE – In the case of spot welds made by projection welding, the projection surface is to be considered as the external surface of the weld.

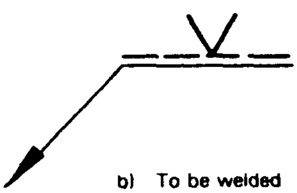


For symmetrical welds only



a) To be welded on the arrow side





b) To be welded on the other side

FIG. 16.5

FIG. 16.5 POSITION OF THE SYMBOL ACCORDING TO THE REFERENCE LINE

16.4 Dimensioning of Welds

16.4.1 *General Rules*

16.4.1.1 Each weld symbol may be accompanied by a certain number of dimensions.

16.4.1.2 These dimensions are written as follows, in accordance with Fig. 16.6:

a) The main dimensions relative to the cross-section are written on the left-hand side (that means before) of the symbol.

b) Longitudinal dimensions are written on the right-hand side (that means after) of the symbol.

16.4.1.3 The method of indicating the main dimensions is defined in table 16.5. The rules for setting down these dimensions are also given in this table.

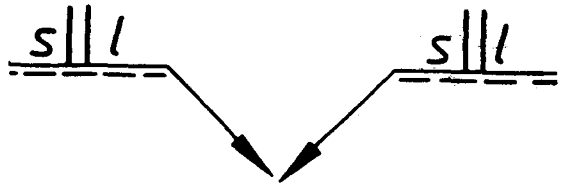


FIG. 16.6 EXAMPLES OF THE PRINCIPLE

16.4.1.4 Other dimensions of less importance may be indicated, if necessary.

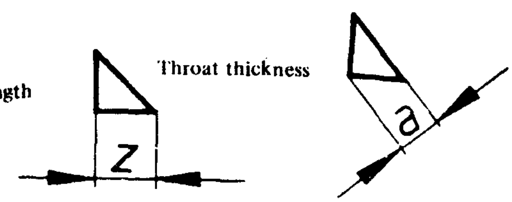
16.4.2 *Main Dimensions to be Shown*

16.4.2.1 The dimension that locates the weld in relation to the edge of the sheet shall not appear in the symbolisation but on the drawing.

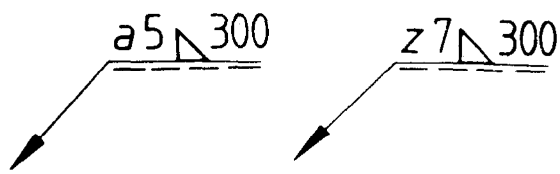
16.4.2.2 The absence of any indication following the symbol signifies that the weld is to be continuous over the whole length of the workpiece.

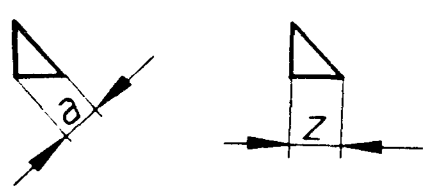
16.4.2.3 In the absence of any indication to the contrary, butt welds are to have complete penetration.

16.4.2.4 For the fillet welds, there are two methods to indicate dimensions (*see* Fig. 16.7). Therefore, the letters *a* or *z* shall always be placed in front of the value of the corresponding dimension.



16.4.2.5 In the case of plug or slot welds with bevelled edges, it is the dimension at the bottom of the hole which shall be taken into consideration.

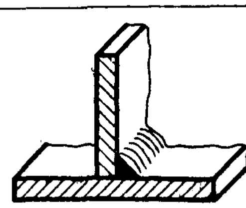




$$z = a\sqrt{2}$$

FIG. 16.7 METHODS OF INDICATING DIMENSIONS FOR FILLET WELDS

TABLE 16.1

No.	Designation	Illustration	Symbol
1	Butt weld between plates with raised edges [1]; edge flanged weld /USA/ (the raised edges being melted down completely)		
2	Square butt weld		
3	Single-V butt weld		
4	Single-bevel butt weld		
5	Single-V butt weld with broad root face		
6	Single-bevel butt weld with broad root face		
7	Single-U butt weld (parallel or sloping sides)		
8	Single-J butt weld		
9	Backing run; back or backing weld /USA/		
10	Fillet weld		

1) Butt welds between plates with raised edges (symbol 1) not completely penetrated are symbolized as square butt welds (symbol 2) with the weld thicknesses shown (*see* Table 16.5).

(Continued)

TABLE 16.1 - *(Concluded)*

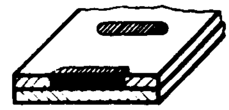
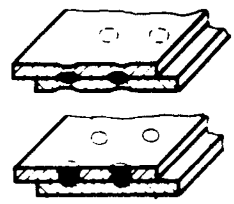
No.	*Designation*	*Illustration*	*Symbol*
11	Plug weld; plug or slot weld /USA/		⊓
12	Spot weld		○

TABLE 16.4 EXAMPLES OF COMBINATION OF ELEMENTARY SYMBOLS

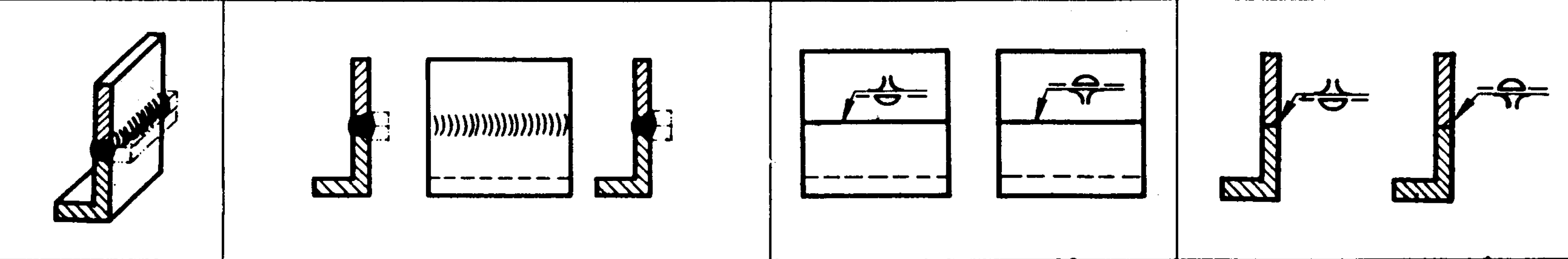
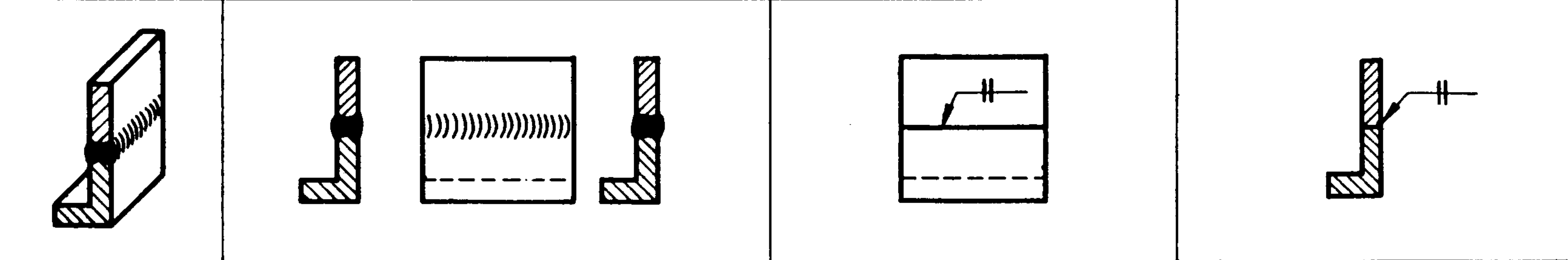
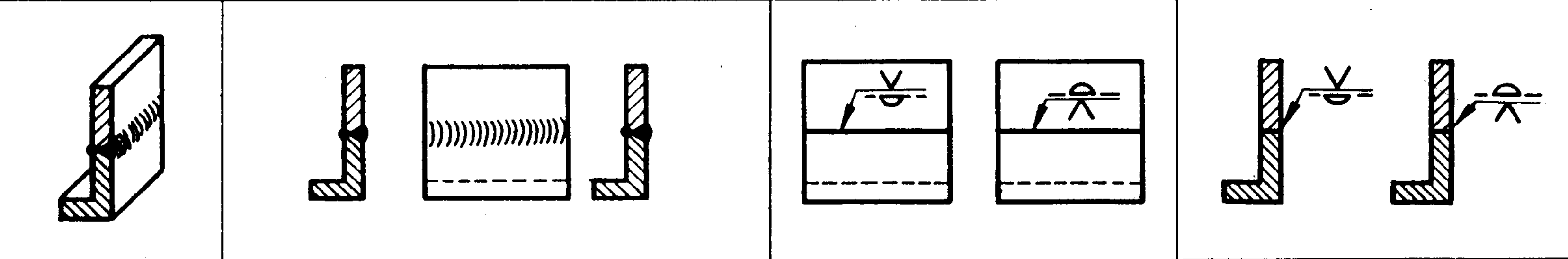
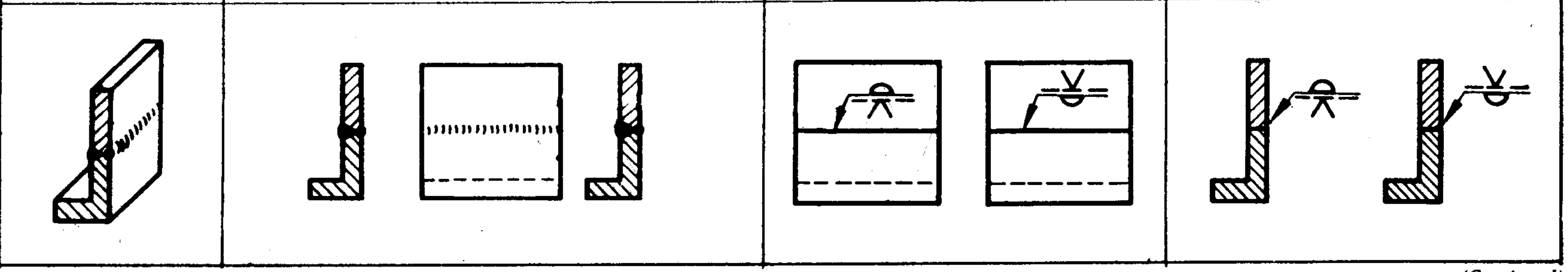
No.	Designation Symbol (Numbers refer to Table 16.1)	Illustration	Representation	Symbolization either	Symbolization or
1	Butt weld between plates with raised edges 1 and backing run 9 1-9				
2	Square butt weld 2 welded from both sides 2-2				
3	Single-V butt weld 3 and backing run 9 3-9				
4					

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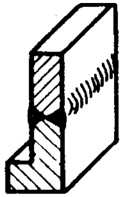
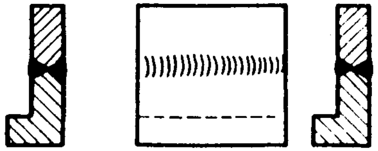
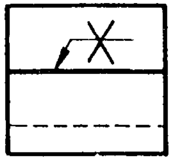
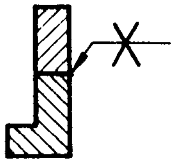
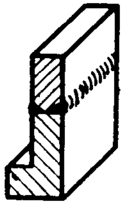
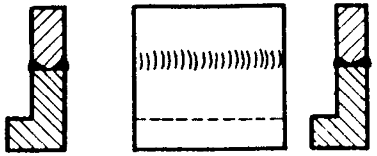
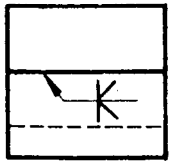
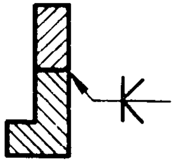
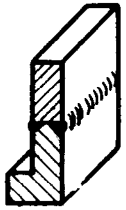
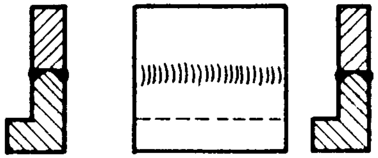
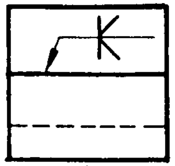
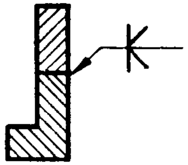
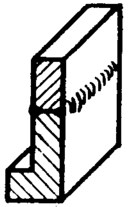
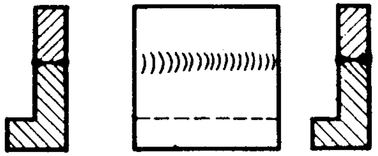
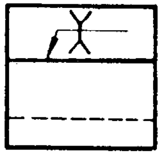
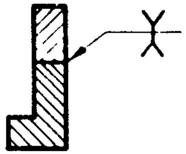
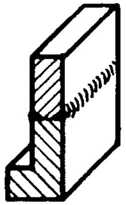
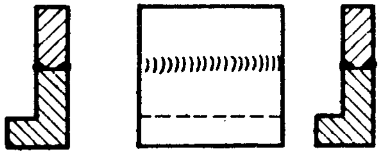
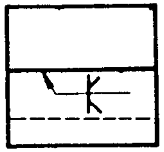
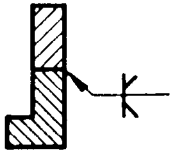
TABLE 16.4 *(Continued)*

No.	Designation Symbol (Numbers refer to Table 16.1)	Illustration	Representation 	Symbolization	
				either	or
5	Double-V butt weld V 3 (X weld) 3-3				
6	Double-bevel butt weld 4 (K weld)				
7	4-4				
8	Double-V butt weld with broad root face Y 5 5-5				
9	Double-bevel butt weld with broad root face 6 6-6				

(Continued)

TABLE 16.4

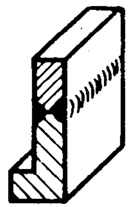
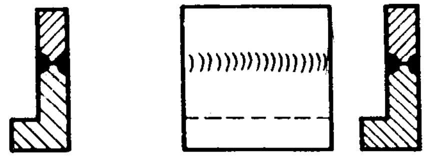
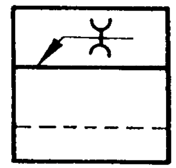
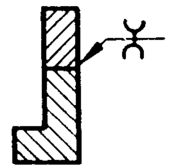
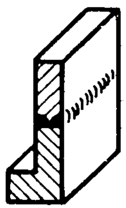
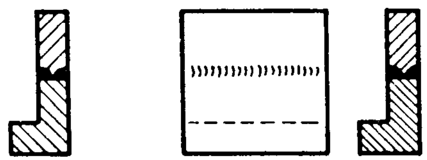
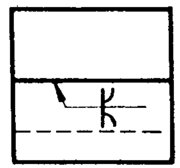
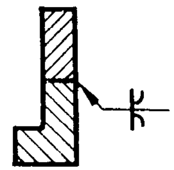
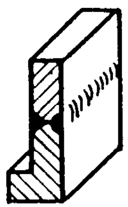
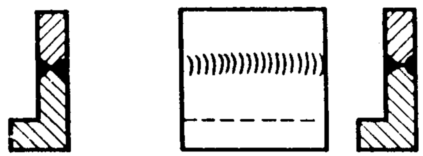
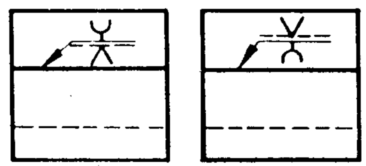
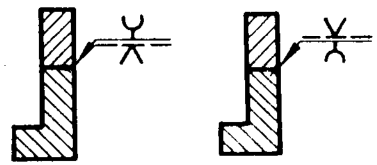
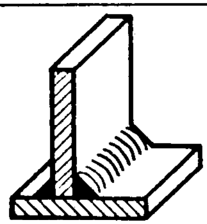
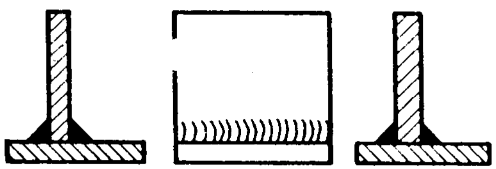
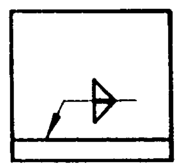
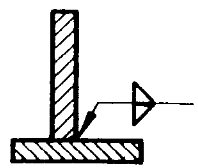
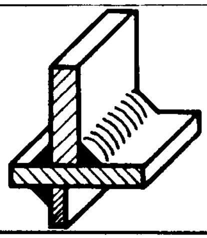
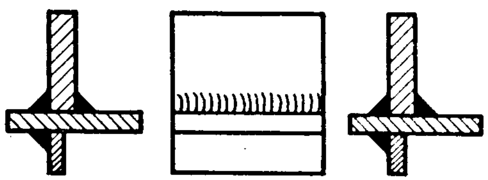
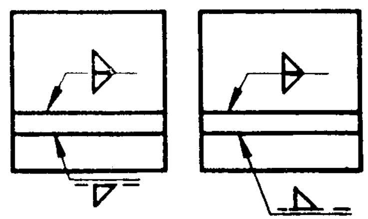
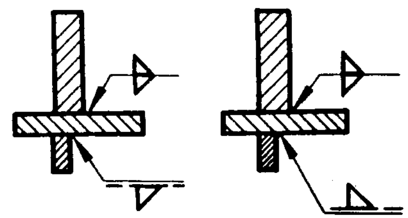
No.	Designation Symbol (Number refer to Table 16.1)	Illustration	Representation 	Symbolization: either	Symbolization: or
10	Double-U butt weld  7 7-7				
11	Double-J butt weld  8 8-8				
12	Single-V butt weld  3 and single-U butt weld  7 3-7				
13	Fillet weld  10				
14	and fillet weld  10 10-10				

TABLE 16.5 PLAIN DIMENSIONS

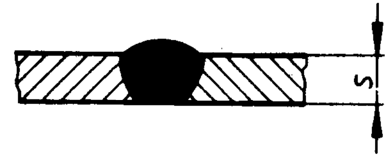
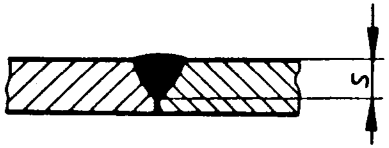
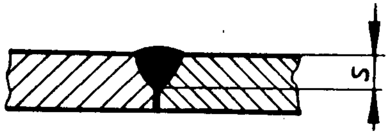
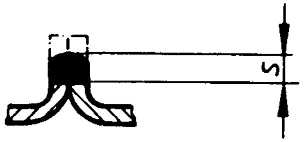
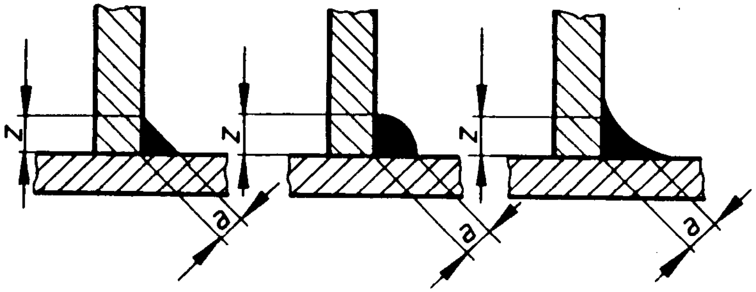
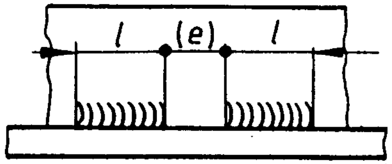
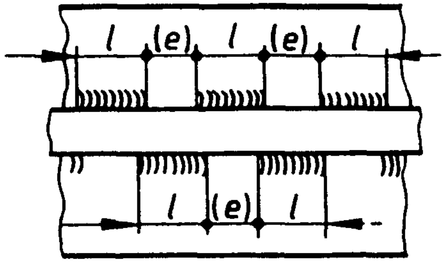
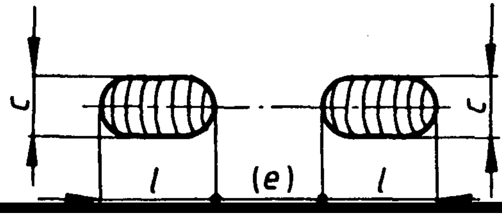
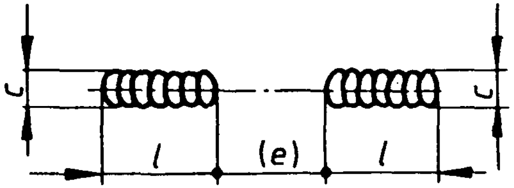
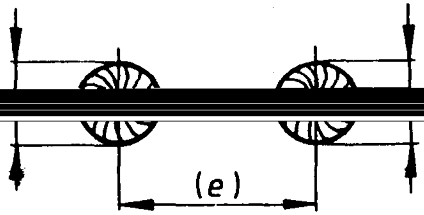
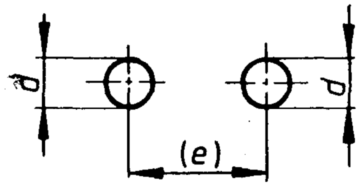
No.	*Designation of Welds*	*Definition*		*Inscription*
1	Butt weld		*s* : minimum distance from the surface of the part to the bottom of the penetration, which cannot be greater than the thickness of the thinner part.	V see 16.4.2.2 and 16.4.2.3
				s || see 16.4.2.2
				s Y see 16.4.2.2
2	Butt weld between plates with raised edges		*s* : minimum distance from the external surface of the weld to the bottom of the penetration.	s || see 16.4.2.2 and foot note (1) to Table 16.1
3	Continuous fillet weld		*a* : height of the largest isosceles triangle that can be inscribed in the section. *z* : side of the largest isosceles triangle that can be inscribed in the section.	a ◺ z ◺ see 16.4.2.2 and 16.4.2.4
4	Intermittent fillet weld		*l* : length of weld (without end craters). *(e)* : distance between adjacent weld elements. *n* : number of weld elements. *a*, *z* } (see No. 3)	a ◺ n × l (e) z ◺ n × l (e) see 16.4.2.4

TABLE 16.5 *(Concluded)*

No.	*Designation of Welds*	*Definition*		*Inscription*
5	Staggered intermittent fillet weld		l, (e), n } (see No. 4) a, z } (see No. 3)	$a \triangleright n \times l$ (e) / a $n \times l$ (e) $z \triangleright n \times l$ (e) / z $n \times l$ (e) see 16.4.2.4
6	Plug or slot weld		l, (e), n } (see No. 4) c : width of slot	$c \sqcap n \times l\ (e)$ see 16.4.2.5
7	Seam weld		l, (e), n } (see No. 4) c : width of weld	$c \ominus n \times l\ (e)$
			n : (see No. 4) d : diameter of hole	
9	Spot weld		n : (see No. 4) (e) : spacing d : diameter of spot	$d \bigcirc n \times (e)$

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SP : 46-1988

SECTION 17 DRAWING PRACTICE FOR ISOMETRIC PROJECTION

17. Scope – This section lays down the principles of isometric projection.

17.1 The isometric projection is used in the preparation of such drawings in which the essential features are required to be shown otherwise in three views.

17.2 Drafting Aids

17.2.1 Drafting aids for drawing in isometric

Drafting machines, isometric grid (*see* Fig. 17.4).

17.2.2 For the preparation of drawings in pipework construction it is also customary to use computer-controlled curve plotters. When a drafting machine is used without a grid, it is advisable to work with the following detent settings:

A Vertical
B at angle α (-30° to the horizontal)
C at angle β ($+30^\circ$ to the horizontal)

The lines in the isometric grid are arranged as indicated under *A*, *B* and *C*.

NOTE – When it is used for pipework and fittings

17.3 Representation Without a Grid – The representation of a cube and of circles in three views is shown in Fig. 17.1. Dimensioning examples are shown in Fig. 17.2 and 17.3

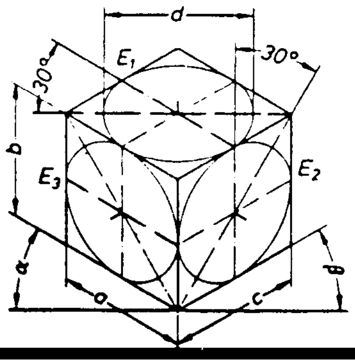


FIG. 17.1

Ratio of sides $a : b : c = 1 : 1 : 1$

$\alpha = 30^\circ$

$\beta = 30^\circ$

Ratio of edges : diameter $d = 1 : 0{\cdot}82$

Ellipse E_1...major axis horizontal

Ellipse E_2...major axis at right angles to 30°

Ellipse E_3...major axis at right angles to 30°

Ratio of the axes with all ellipses $1 : 1{\cdot}7$

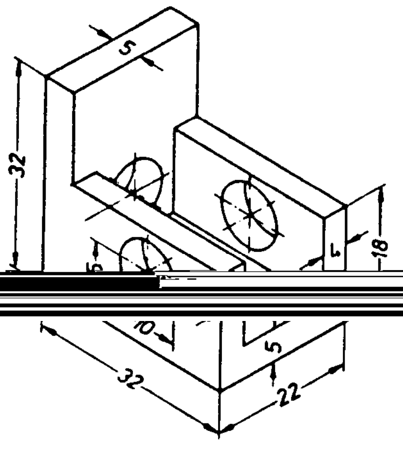


FIG. 17.2

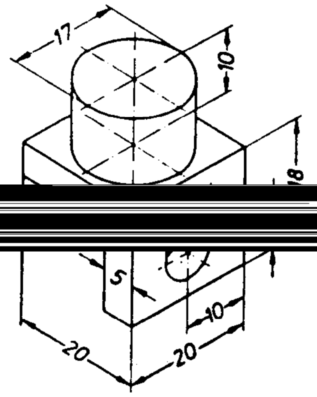


FIG. 17.3

17.4 Representation Using a Grid – Figure 17.4 shows the representation of a component on an isometric grid.

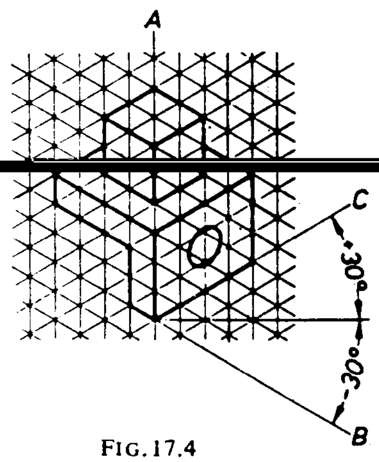


FIG. 17.4

17.5 Co-ordinates

17.5.1 For the purpose of standardizing calculations and manufacturing processes, it is desirable to define the principal directions of the co-ordinates.

17.5.2 The positive direction of the *Z*-axis is the direction in which a right hand thread screw would move if turned by its positive *X*-axis towards the positive *Y*-axis.

17.5.3 All co-ordinate values taken from the origin in the direction of the arrow are positive and those in the opposite direction are negative (*see* Fig. 17.5).

17.5.4 The directions of the co-ordinates *X*, *Y*, *Z* are called the principal directions and the areas enclosed by them are called the principal planes.

17.6 Representation in the System of Co-ordinates – In order to provide an unambiguous representation of lines (for example, pipe bends) in isometric projection, it is necessary to show the principal planes by hatching. The planes of the side view (co-ordinates *Y*, *Z*) and front view (co-ordinates *X*, *Z*) should be hatched vertically and the planes of the top view (co-ordinates *X*, *Y*) should be hatched at – 30° (*See* Fig. 17.6).

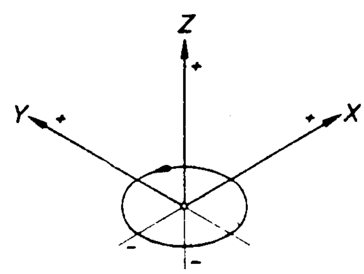


FIG. 17.5

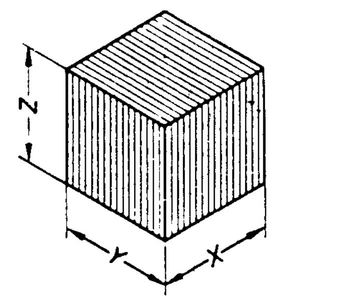


FIG. 17.6

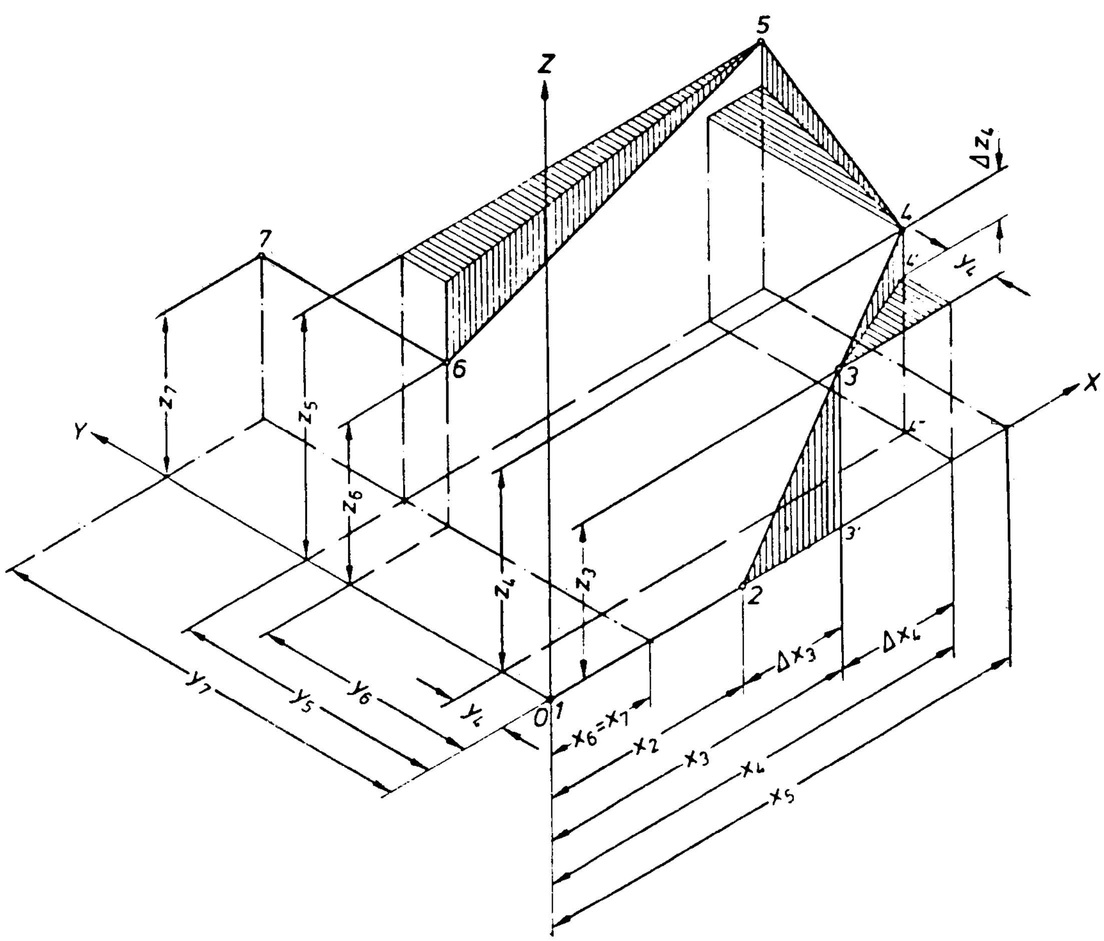


FIG. 17.7

Figure 17.7 shows a bent pipe in isometric projection in the co-ordinate system.

dimensioning is point Z1 (p_1) with co-ordinates $x_1 = 0, y_1 = 0, z_1 = 0$.

17.6.2 The section 1-2 lies on the X co-ordinate and has co-ordinates $x_2 = +50$, $y_2 = 0$ and $z_2 = 0$.

17.6.3 Section 2-3 lies in the principal plane X, Z and has dimension x_3 and z_3 and co-ordinates $x_3 = +75$, $y_3 = 0$ and $z_3 = +34$. The vertical hatching (*see* Fig. 17.6) shows clearly that the plane of bending of the pipe lies in the principal plane X, Z.

17.6.4 Although in the representation, section 3-4 is a continuation of 2-3, point 4 is outside the principal plane X, Z, and has dimensions x_4, y_4 and z_4; their co-ordinates are $x_4 = +104$, $y_4 = +12$ and $z_4 = +45$. To show the three-dimensional bending clearly in the representation it is necessary to project the co-ordinate point 4 together with point 4′ onto the corresponding principal planes and to use hatching as shown in Fig. 17.6. Sections 4-5 and 5-6 are represented in a similar manner whilst Section 6-7 lies in the direction of the Y co-ordinate.

17.7 Dimensioning in the Co-ordinate System – Co-ordinate dimensioning is useful for mechanical calculation of developed lengths, for bending and twisting angles using data processing and for programme-controlled machine tools. The co-ordinates can have positive and negative values (in accordance with Fig. 17.5).

17.7.1 The co-ordinate values for the bent pipe run shown in Fig. 17.7 are given in Table 17.1.

17.8 Representation of Auxiliary Views – Auxiliary views are necessary when edges of solids or surfaces lie in the viewing direction of the isometric projection. It is advisable to represent the auxiliary view in orthographic projection (*see* Fig. 17.8).

TABLE 17.1 CO-ORDINATE VALUES FOR BENT PIPE RUN

P_1	$x_1 = 0$	$y_1 = 0$	$z_1 = 0$
P_2	$x_2 = +50$	$y_2 = 0$	$z_2 = 0$
P_3	$x_3 = +75$	$y_3 = 0$	$z_3 = +34$
P_4	$x_4 = +104$	$y_4 = +12$	$z_4 = +45$
P_5	$x_5 = +118$	$y_5 = +62$	$z_5 = +54$
P_6	$x_6 = +26$	$y_6 = +52$	$z_6 = +36$
P_7	$x_7 = +26$	$y_7 = +100$	$z_7 = +36$

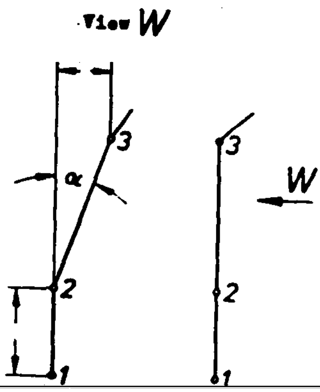


FIG. 17.8 AUXILIARY VIEW IN ORTHOGRAPHIC PROJECTION

17.9 Example of Drawing – Figure 17.9 shows a drawing of a bent pipe in isometric projection with co-ordinate values.

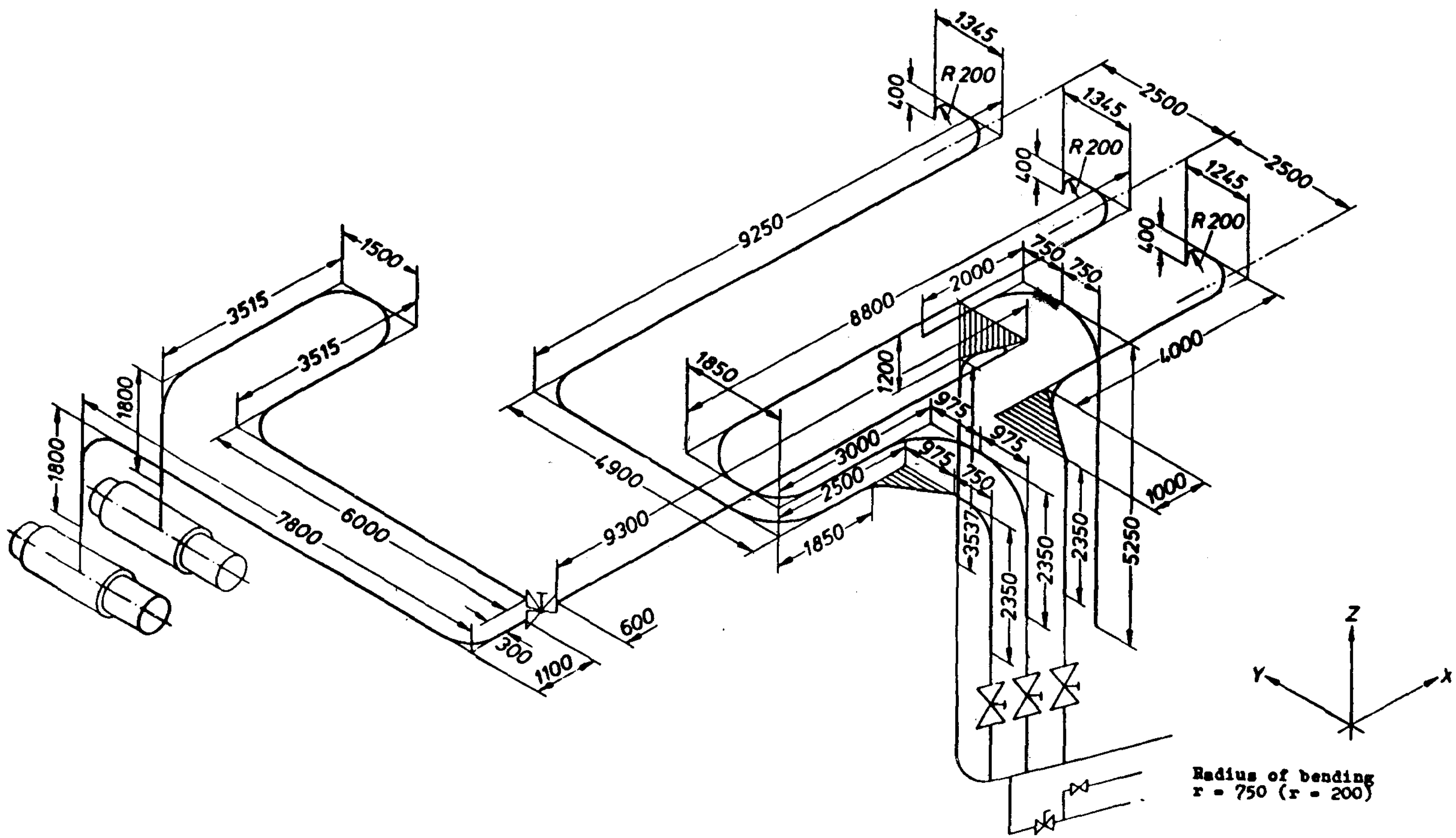


FIG. 17.9 PIPE LAYOUT SHOWN IN ISOMETRIC PROJECTION (EXAMPLE)

SECTION 18 EXAMPLES OF INDICATION AND INTERPRETATION OF GEOMETRICAL TOLERANCING SYMBOLS AND CHARACTERISTICS

18.1 Scope – This section incorporates the examples of indication and interpretation of geometrical tolerancing symbols and characteristics.

18.2 Form tolerances limit the deviations of an individual feature from its ideal geometrical form.

18.3 Orientation, location and run-out tolerances limit the deviations of the mutual orientation and/or location of two or more features. For functional reasons one or more features may be indicated as a datum. If necessary, a geometrical tolerance should be specified to the datum feature in order to ensure that the datum feature is sufficiently exact for its purpose.

18.4 The geometrical tolerance applies always to the whole extent of toleranced feature unless otherwise specified, for example, 0.02/50 indicates that a tolerance of 0.02 is permitted for an extent of 50 at any place on the toleranced feature.

18.5 When a geometrical tolerance applies to an axis or a median plane, then the arrow of the leader line terminates at the dimension line (*see* Fig. 18.4).

18.6 When a geometrical tolerance applies to a line or surface itself, then the leader line with its arrow terminating on the contour of the the feature has to be clearly separated from the dimension line (*see* Fig. 18.5).

18.7 The same method of indication is used for the datum triangle.

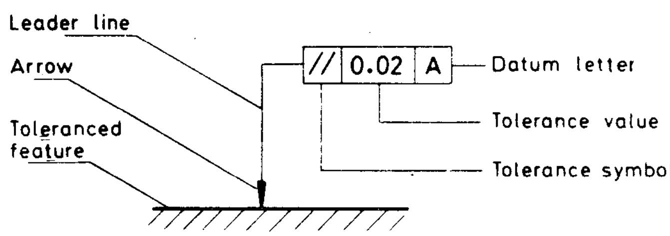


FIG. 18.1

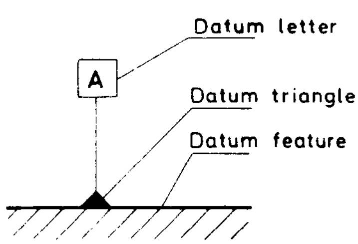


FIG. 18.2

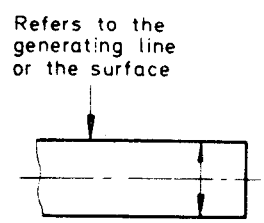


FIG. 18.5

FIG. 18.3

FIG. 18.6

FIG 18.7

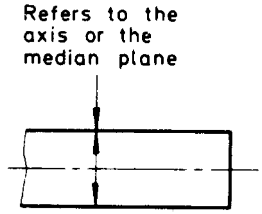


FIG. 18.4

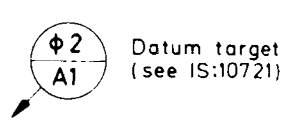
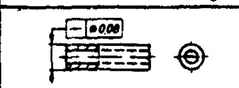
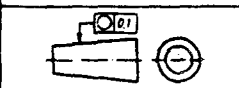
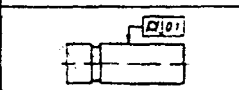
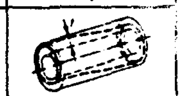
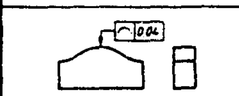
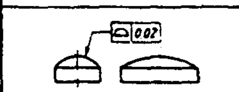
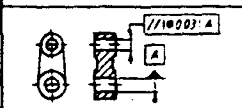
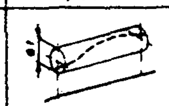
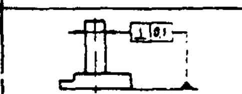
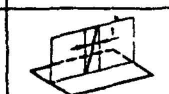
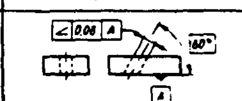
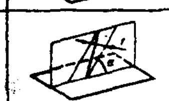
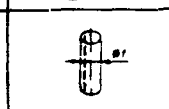
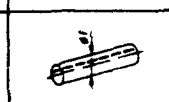
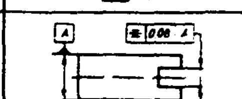
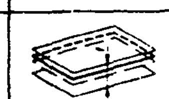
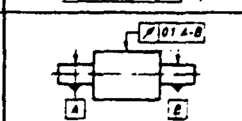
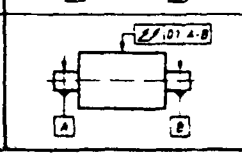
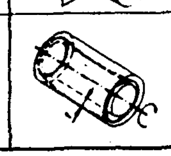


FIG. 18.8

TABLE 18.1

Values in millimetres

Symbols and Toleranced Characteristics				Examples of Indication and Interpretation		
				Indication on the drawing	Tolerance zone	Interpretation
Single features	Form tolerances	⏤	**Straightness**			The axis of the cylinder, to which the tolerance frame is connected, shall be contained in a cylindrical zone of diameter 0,08.
Single features	Form tolerances	⏥	**Flatness**			The surface shall be contained between two parallel planes 0,08 apart.
Single features	Form tolerances	○	**Circularity**			The circumference of each cross-section shall be contained between two co-planar concentric circles 0,1 apart.
Single features	Form tolerances	⌭	**Cylindricity**			The considered surface shall be contained between two coaxial cylinders 0,1 apart.
Single or related features	Form tolerances	⌒	**Profile of any line**			In each section parallel to the plane of projection, the considered profile shall be contained between two lines enveloping circles of diameter 0,04, the centres of which are situated on a line having the true geometrical profile.
Single or related features	Form tolerances	⌓	**Profile of any surface**			The considered surface shall be contained between two surfaces enveloping spheres of diameter 0,02, the centres of which are situated on a surface having the true geometrical form.
Related features	Orientation tolerances	//	**Parallelism** of a line (axis) with reference to a datum line			The toleranced axis shall be contained in a cylindrical zone of diameter 0,03, parallel to the datum axis A (datum line).
Related features	Orientation tolerances	⊥	**Perpendicularity** of a line (axis) with reference to a datum surface			The axis of the cylinder, to which the tolerance frame is connected, shall be contained between two parallel planes 0,1 apart, perpendicular to the datum surface.
Related features	Orientation tolerances	∠	**Angularity** of a line (axis) with reference to a datum surface			The axis of the hole shall be contained between two parallel planes 0,08 apart which are inclined at 60° to the surface A (datum surface).
Related features	Location tolerances	⌖	**Position** of a line			The axis of the hole shall be contained within a cylindrical zone of diameter 0,08, the axis of which is in the theoretically exact position of the considered line, with reference to the surfaces A and B (datum planes).
Related features	Location tolerances	◎	**Coaxiality** of an axis			The axis of the cylinder, to which the tolerance frame is connected, shall be contained in a cylindrical zone of diameter 0,08 coaxial with the datum axis A-B.
Related features	Location tolerances	⌯	**Symmetry** of a median plane			The median plane of the slot shall be contained between two parallel planes which are 0,08 apart and symmetrically disposed about the median plane with respect to the datum feature A.
Related features	Run-out tolerances	↗	**Circular run-out** radial			The radial run-out shall not be greater than 0,1 in any plane of measurement during one revolution about the datum axis A-B.
Related features	Run-out tolerances	⌰	**Total run-out** radial			The total radial run-out shall not be greater than 0,1 at any point on the specified surface during several revolutions about the datum axis A-B, and with relative axial movement between part and measuring instrument. The movement shall be guided along a line having a theoretically perfect form of the contour and being in correct position to the datum axis.

SECTION 19 ABBREVIATIONS

19.1 Scope – This section covers such of the abbreviations which are recommended for use in general engineering drawings. Abbreviations already covered in specific subjects, such as units and quantities, tolerancing, gears, fluid power, electrical and electronics are not dealt in this section.

19.2 Table 19.1 lists some of the common abbreviations recommended. Abbreviations are the same both for singular and plural usage. Only capital letters are used for abbreviations to ensure maintenance of legibility bearing in mind reproduction and reduction processes. Abbreviations which have already been standardized nationally/internationally using lower case letters should, however, be written according to the corresponding standard.

19.2.1 When using abbreviations and symbols in engineering drawings, the following points are to be borne in mind.

a) They should be used sparingly only when space saving in a drawing is essential.

b) Short words such as 'day', 'unit', 'time', etc, should preferably be written in full, even when an abbreviation has been standardized.

c) Periods (full stop symbol) are not to be used except where the abbreviation marks a word (for example, No.; FIG.)

d) For hyphenated words, abbreviations are to be with the hyphen.

e) Sometimes one and the same letter symbol may represent more than one term or quantity. Hence it is advisible not to use such symbols to mean two different terms in one and the same drawing. If it becomes unavoidable, the symbols may be provided with suitable subscript.

TABLE 19.1 RECOMMENDED ABBREVIATIONS

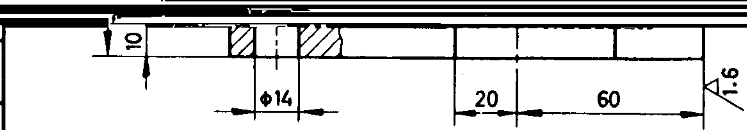
Term	*Abbreviation*	*Term*	*Abbreviation*
Across corners	A/C	Ground level	GL
Across flats	A/F	Haxagon/Hexagonal	HEX
Alteration	ALT	Horizontal	HORZ
Approved	APPD	Hydraulic	HYD
Approximate	APPROX	Head	HD
Arrangement	ARRGT	Indian Standard	IS
Assembly	ASSY	Inspection/ed	INSP
Auxiliary	AUX	Inside diameter	ID
Bearing	BRG	Insulation	INSUL
Cast iron	CI	Internal	INT
Centres	CRS	Left hand	LH
Centre line	CL	Long	LG
Centre of gravity	CG	Machine/machinery	M/C
Centre-to-centre	C/C	Manufacture/ing	MFG
Chamfered	CHMED	Material	MATL
Checked	CHKD	Maximum	max.
Cheese head	CH HD	Mechanical	MECH
Continued	CONTD	Minimum	min.
Constant	CONST	Miscellaneous	MISC
Counterbore	C'BORE	Modification	MOD
Countersunk	CSK	Nominal	NOM
Countersunk head	CSK HD	North	N
Cylinder/cylindrical	CYL	Number	NO.
Diameter (in a note)	DIA	Opposite	OPP
Dimension	DIM	Outside diameter	OD
Drawing	DRG	Pitch circle diameter	PCD
East	E	Quantity	QTY
etcetera	etc	Radius (in a note)	RAD
External	EXT	Reference	REF
Figure	FIG.	Required	REQD
General	GEN	Right hand	RH

(Continued)

TABLE 19.1 *(Concluded)*

Term	*Abbreviation*	*Term*	*Abbreviation*
Round	RD	Thick	THK
Screw/Screwed	SCR	Thread (in a note)	THD
Serial number	SL NO.	Through (in a note)	THRU
Sheet	SH	Tolerance	TOL
Sketch	SK	Typical	TYP
South	S	Undercut (in a note)	U/C
Specification	SPEC	Weight	WT
Spotface	SF	West	W
Standard	STD	With reference to/	
Symmetrical (in a note)	SYM	With respect to (in a note)	WRT
Temperature (in a note)	TEMP		

As in the Original Standard, this Page is Intentionally Left Blank



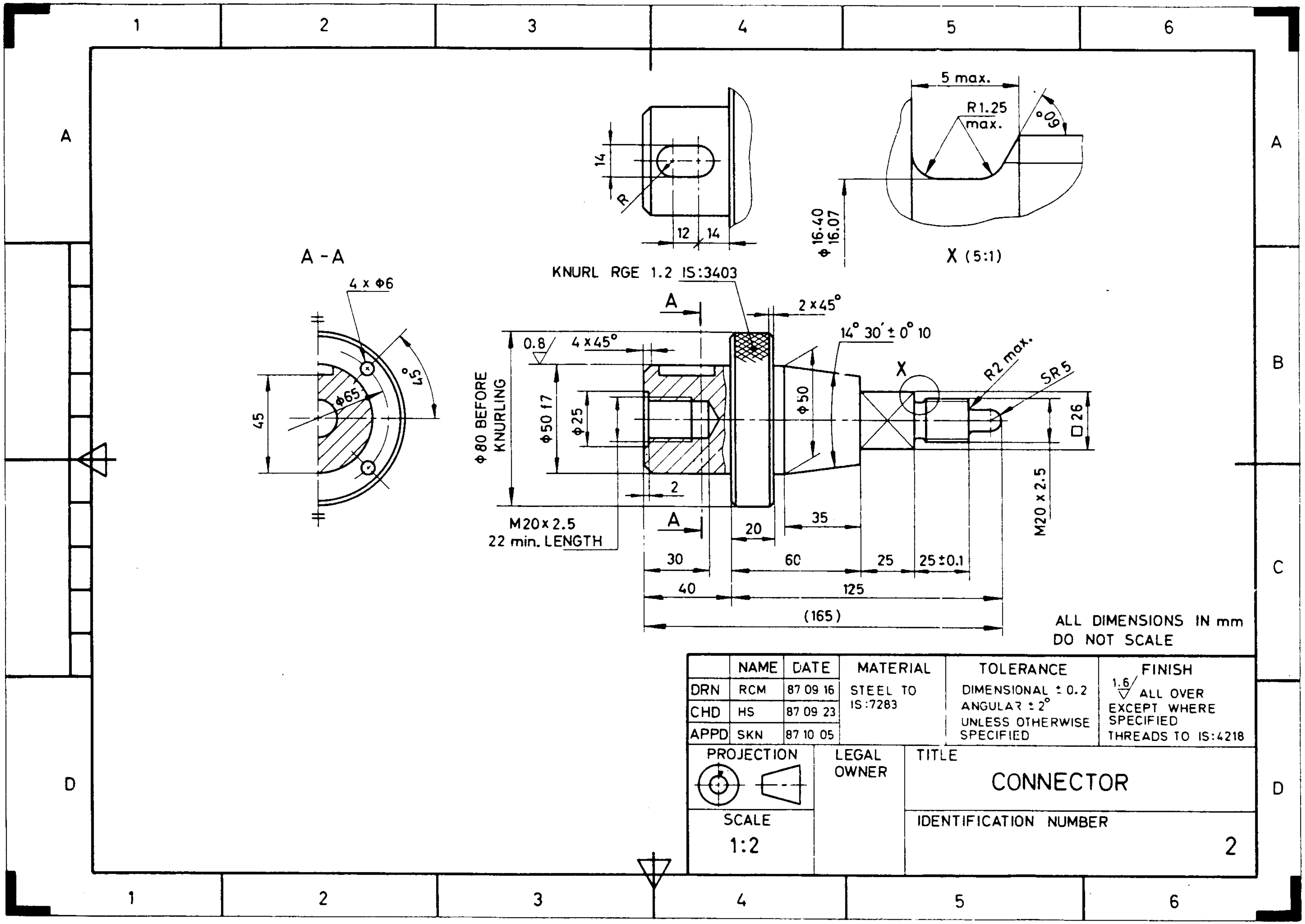
ALL DIMENSIONS IN mm
DO NOT SCALE

	NAME	DATE	MATERIAL	TOLERANCE	FINISH
DRN	RCM	87 08 21	MALLEABLE CAST IRON TO IS:2107	CAST DIM ± 1.5	AS CAST EXCEPT WHERE SPECIFIED
CHD	HS	87 08 25		MACHINED DIM ± 0.2	
APPD	SKN	87 08 31		ANGULAR DIM ± 0° 30′	THREADS TO IS:4218

PROJECTION	LEGAL OWNER	TITLE
		SWIVEL BRACKET
SCALE 1:2		IDENTIFICATION NUMBER 1

E E F F

1 2 3 4


A - A
4 x Φ6
Φ65
45°
45
KNURL RGE 1.2 IS:3403
2 x 45°
14° 30′ ± 0° 10
0.8
4 x 45°
Φ 80 BEFORE KNURLING
Φ 50 f7
Φ 25
Φ 50
X
R2 max.
SR 5
□ 26
M20 x 2.5
M20 x 2.5
22 min. LENGTH
2
20
35
30
60
25
25 ± 0.1
40
125
(165)
14
R
12
14
5 max.
R 1.25 max.
60°
Φ 16.40
16.07
X (5:1)
ALL DIMENSIONS IN mm
DO NOT SCALE
NAME
DATE
DRN RCM 87 09 16
CHD HS 87 09 23
APPD SKN 87 10 05
MATERIAL
STEEL TO IS:7283
TOLERANCE
DIMENSIONAL ± 0.2
ANGULAR ± 2°
UNLESS OTHERWISE SPECIFIED
FINISH
1.6
ALL OVER EXCEPT WHERE SPECIFIED
THREADS TO IS:4218
PROJECTION
LEGAL OWNER
TITLE
CONNECTOR
SCALE
1:2
IDENTIFICATION NUMBER
2

APPENDIX B
SYSTEMS OF LIMITS AND FITS

B-1. General – For the sake of simplicity, and in view of the particular importance of cylindrical parts with circular parts with circular section, only limits and fits are referred to explicitly. It should be clearly understood however that recommendations for this type of component apply equally well to other plain parts or components; in particular, the general term 'hole' or 'shaft' can be taken as referring to the space containing or contained by two parallel faces (or tangent planes) of any part, such as the width of a slot, the thickness of the key, etc.

B-2. Reference Temperature – The standard reference temperature is 20°C for industrial measurements and, consequently, for dimensions defined by the system (*see* **B-5**).

B-3. Tolerances of Parts – Due mainly to the inevitable inaccuracy of manufacturing methods, a part cannot be made precisely to a given dimensions but, in order to meet its purpose, it is sufficient that it should be made so as to lie within two permissible limits of size, the difference of which is the tolerance.

B-3.1 For the sake of convenience, a basic size is ascribed to the part and each of the two limits is defined by its deviation from basic size. The magnitude and sign of the deviation are obtained by subtracting the basic size from the limit in question.

B-3.2 Figure B-1 which illustrates these definitions, is in practice replaced by a schematic diagram similar to Fig. B-2 for the sake of simplicity. In this simplified schematic diagram, the axis of the part, which is not represented, always lies, by convention, below the diagram. (in the example illustrated, the two deviations of the shaft are negative and those of the hole positive).

B-4. Fits – When two parts are to be assembled, the relation resulting from the difference between their sizes before assembly is called a fit.

B-4.1 Depending upon the respective positions of the tolerance zones of the hole or the shaft, the fit may be a clearance fit, a transition fit (that is such that the assembly may have either a clearance or an interference), or an interference fit.

B-4.2 Figure B-1 shows a clearance fit, and Fig. B-3 shows the schematic diagram of tolerance zone in various cases.

B-5. Fit System – Two of the most commonly used methods of applying are the hole-basis system and the shaft-basis system which are shown in Fig. B-4.

B-6. Symbols for Tolerances and Deviations and Symbols for Fits – In order to satisfy the usual requirements both of individual parts and of fits, the System provides, for any given basic size, a whole range of tolerances together with a whole range of deviations defining the position of these tolerances with respect to the line of zero deviation, called the

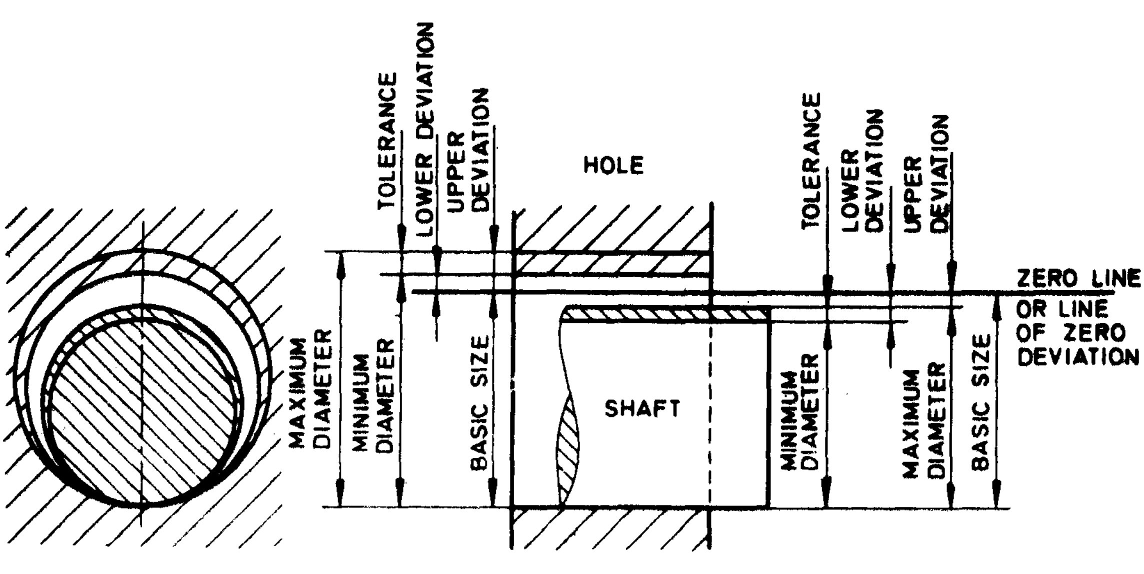


FIG. B-1 DIAGRAM ILLUSTRATING BASIC SIZE DEVIATIONS AND TOLERANCES

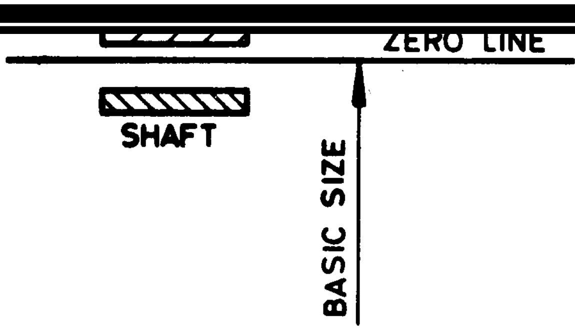


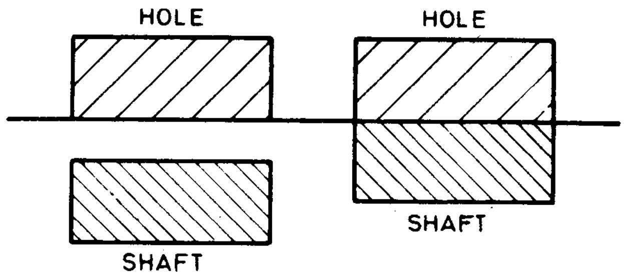
FIG. B-2 SIMPLIFIED SCHEMATIC DIAGRAM OF CLEARANCE FIT

symbol, called the grade.

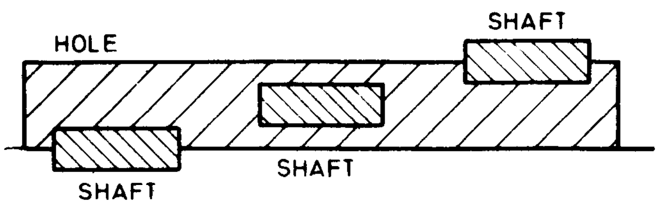
B-6.2 The position of the tolerance zone with respect to the zero line, which is a function of the basic size, is indicated by a letter symbol (in some cases, two letters), a capital letter for holes, a small letter for shafts (*see* Fig. B-5).

B-6.3 The toleranced size is thus defined by its basic value followed by a 'symbol' composed of the letter (in some cases, two letters) and a number.

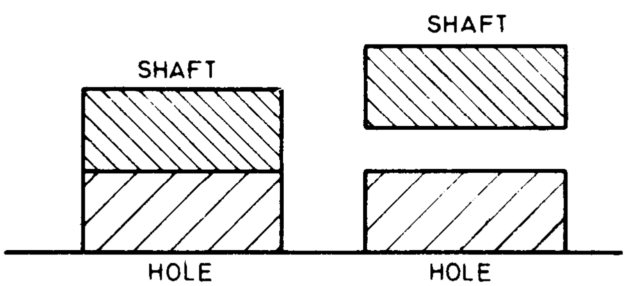
Examples: 45 g7.



Schematic Representation of
Clearance Fit



Schematic Representation of
Transition Fit



Schematic Representation of
Interference Fit

FIG. B-3

B-6.4 A fit is indicated by the basic size common to both components, followed by symbol corresponding to each component, the hole being quoted first.

Example: 45 H8/g7 (possibly 45 H8-g7 or 45 H8/g7).

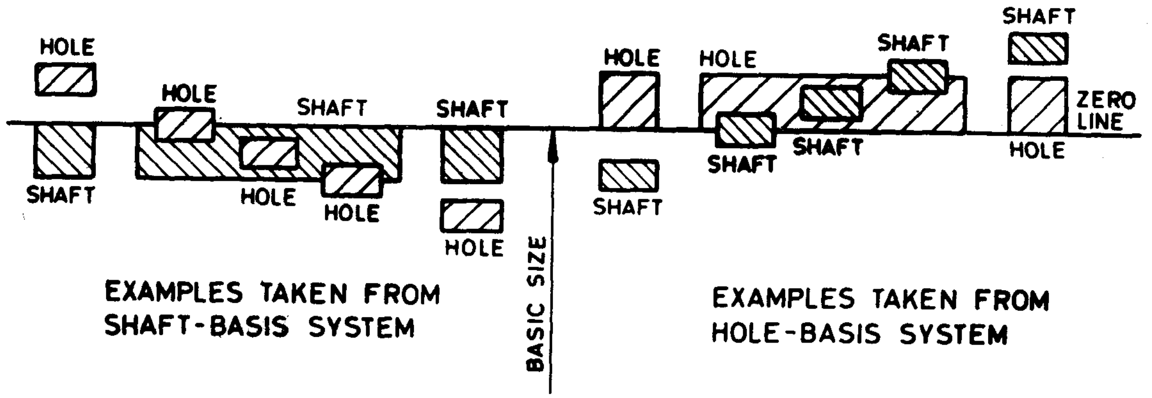


FIG. B-4 EXAMPLES ILLUSTRATING THE SHAFT BASIS AND HOLE BASIS SYSTEM

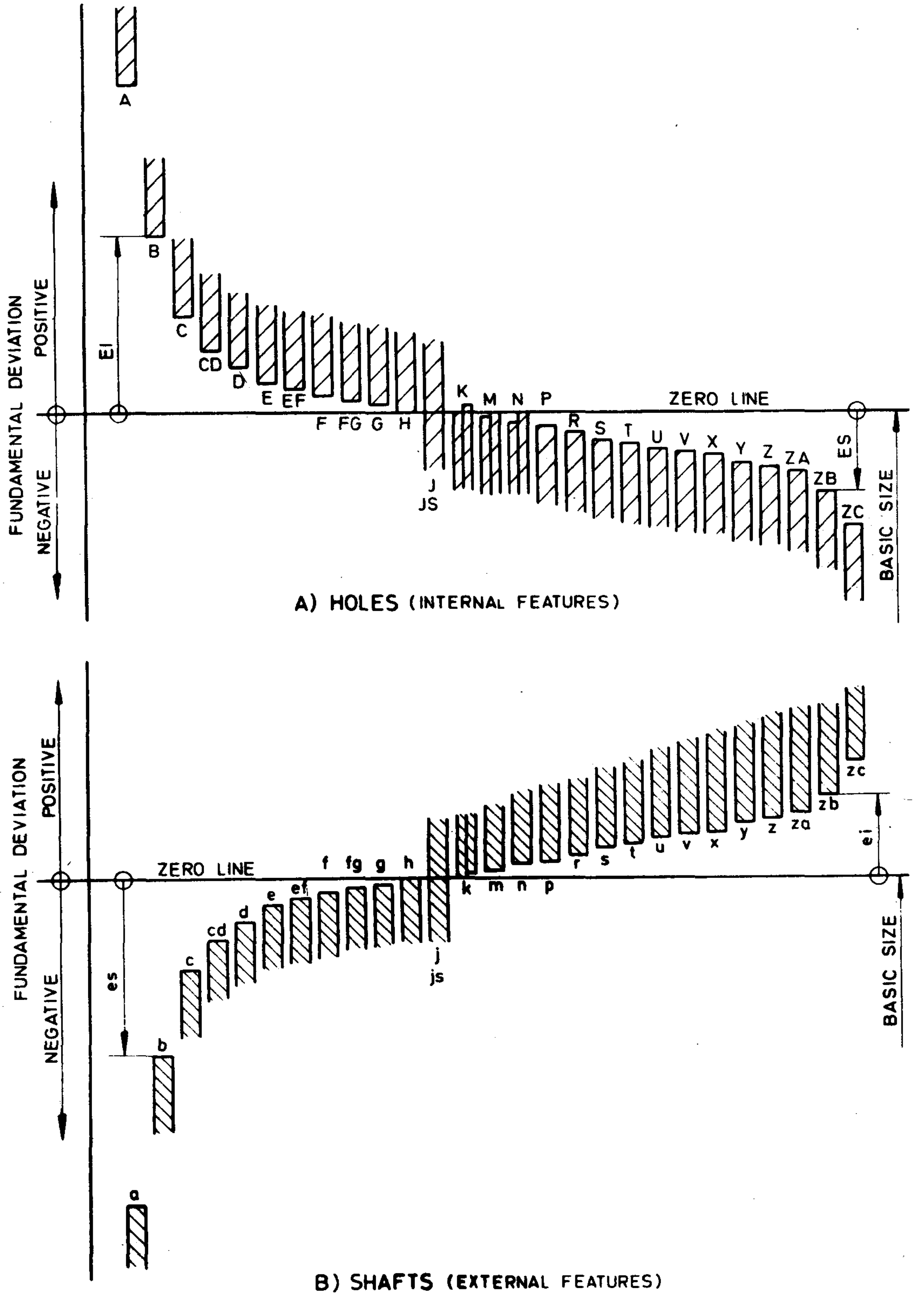

A
B
C
CD
D
E
EF
F FG G H
J
JS
K M N P
R S T U V X Y Z ZA ZB ZC
ZERO LINE
EI
ES
FUNDAMENTAL DEVIATION
POSITIVE
NEGATIVE
BASIC SIZE
A) HOLES (INTERNAL FEATURES)
ZERO LINE
a b c cd d e ef f fg g h
j
js
k m n p r s t u v x y z za zb zc
es
ei
FUNDAMENTAL DEVIATION
POSITIVE
NEGATIVE
BASIC SIZE
B) SHAFTS (EXTERNAL FEATURES)

FIG. B-5

APPENDIX C

GUIDE FOR SELECTION OF FITS

C-1. General This guide gives recommendations for the selection of fits in engineering problems concerned with the mating of a shaft and a hole. These recommendations are also applicable to non-cylindrical fits.

C-1.1 This guide gives the representative usage of various classes and grades of fit. These examples are only of an illustrative character and they do not specify any design details.

C-2. Systems of Fits

C-2.1 The hole basis system is the system of fits in which design size of the hole is the basic size and the allowance is applied to the shaft (*see* Fig C-1). In the shaft basis system the design size of the shaft is the basic size and the allowance is applied to the hole.

[illegible]

product, the manufacturing methods, the condition of the raw material, etc.

C-2.1.2 The hole basis system is the extensively used system. This is because a hole is more diffcult to produce than a shaft due to the fixed character of hole producing tools. The shaft basis system should only be used where it will convey unquestionable economic advantages, that is where it is necessary to be able to mount several parts with holes having different deviations on a single shaft of drawn steel bar without machining the latter.

C-2.1.3 The designers should decide on the adoption of either system to secure general interchargeability. A shaft dimension to a certain class of fit with a hole in the hole basis system differs from the shaft giving the same fit in the shaft basis system.

C-3. Classification of Fits

C-3.1 The system of fits may be broadly classified as clearance fit, transition fit and interference fit.

C-3.1.1 Clearance fit results in a positive [illegible]

hole H.

C-3.1.2 Transition fit may result in either a clearance fit or interference fit depending on the actual value of the individual tolerances of the mating components. Shafts js to n produce transition fit with the basic hole H.

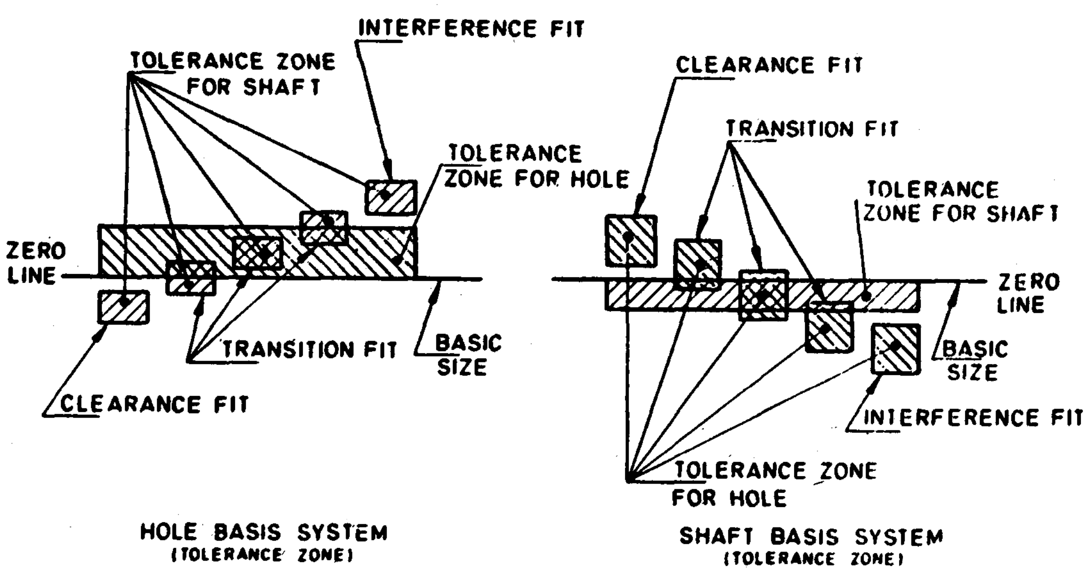


FIG. C-1 EXAMPLE ILLUSTRATING HOLE BASIS AND SHAFT BASIS SYSTEMS

C-3.1.3 Interference fit results in a positive interference over the whole range of tolerance. Shafts p to u produce interference fit with the basic hole H.

C-3.1.4 Tolerances and deviations for both holes and shafts offer a wide range of fits of which many of the possible combinations may not be of practical use. Majority of common engineering requirements may be satisfied on the basis of a restricted selection of tolerance grades resulting in economy and ease of standardization, yet leading to universally applicable and recommended fits. The commonly used fits are given in Table C-4.

C-4. Choice of Fits and Tolerances

C-4.1 *Fits* – Fits may be selected on the hole basis system or the shaft basis system. The choice of fits considerably depends on the material of mating parts, workmanship, length of engagement, bearing load, speed, type of lubrication, temperature, humidity, surface finish, etc.

C-4.2 *Tolerances* – in order to obtain the most economic manufacture consistent with satisfactory quality, it is recommended that as wide a tolerance shall be provided as is possible. In the allocation of tolerances to the hole and the shaft members of a fit, it is generally advisable to give a larger tolerance to the hole than to the shaft due to the fact that hole is more difficult to produce than a shaft. The exception is in the case of very large sizes where the effects of temeprature play a large role.

C-4.2.1 The tolerances chosen shall be the largest compatible with the conditions of use the hole being the more difficult member to machine, may often be allocated a tolerance one grade coarser than that of the shaft (for example H8-f7).

C-5. Recommendations

C-5.1 Recommendations for selection of tolerance zones for general purposes are given in Table C-1.

Wherever possible the tolerance zones shall be chosen from the corresponding symbols for shafts and holes as indicated in Table C-1. The first choice shall preferably be made from the symbols enclosed in the frames.

TABLE C-1 SELECTION OF TOLERANCE ZONES

(*Clause C-5.1*)

For Shafts

						g5	h5	js5	k5	m5	n5	p5	r5	s5	t5	
					f6	g6	h6	js6	k6	m6	n6	p6	r6	s6	t6	
				e7	f7		h7	js7	k7	m7	n7	p7	r7	s7	t7	u7
			d8	e8	f8		h8									
			d9	e9			h9									
			d10													
a11	b11	c11					h11									

For Holes

						G6	H6	Js6	K6	M6	N6	P6	R6	S6	T6
					F7	G7	H7	Js7	K7	M7	N7	P7	R7	S7	T7
				E8	F8		H8	Js8	K8	M8	N8	P8	R8		
			D9	E9	F9		H9								
			D10	E10			H10								
A11	B11	C11	D11				H11								

NOTE – Deviation js and Js may be replaced by the corresponding deviations j and J.

Nominal Size Rang																																		
Over 80 up to 100	+93 +71	+73 +51	+59	+45	+25	+11	0	0	0	0	−12	−36	−72	−120	−170 −390	−220 −440	−380 −600	−58 −93	−38 −73	−24	−10	+10	+17·5	+35	+54	+87	+220	+47	+90	+159	+260	+390 +170	+440 +220	+600 +380
Over 100 up to 120	+101 +79	+76 +54	+37	+23	+3	−11	−22	−35	−87	−220	−34	−71	−126	−207	−180 −400	−240 −460	−410 −630	−66 −101	−41 −76	−59	−45	−25	−17·5	0	0	0	0	+12	+36	+72	+120	+400 +180	+460 +240	+630 +410
Over 120 up to 140	+117 +92	+88 +63													−200 −450	−260 −510	−460 −710	−77 −117	−48 −88													+450 +200	+510 +260	+710 +460
Over 140 up to 160	+125 +100	+90 +65	+68 +43	+52 +27	+28 +3	+12·5 −12·5	0 −25	0 −40	0 −100	0 −250	−14 −39	−43 −83	−85 −148	−145 −245	−210 −460	−280 −530	−520 −770	−85 −125	−50 −90	−28 −68	−12 −52	+12 −28	+20 −20	+40 0	+63 0	+100 0	+250 0	+54 +14	+106 +43	+185 +85	+305 +145	+460 +210	+530 +280	+770 +520
Over 160 up to 180	+133 +108	+93 +68													−230 −480	−310 −560	−580 −830	−93 −133	−53 −93													+480 +230	+560 +310	+830 +580
Over 180 up to 200	+151 +122	+106 +77													−240 −530	−340 −630	−660 −950	−105 −151	−60 −106													+530 +240	+630 +340	+950 +660
Over 200 up to 225	+159 +130	+109 +80	+79 +50	+60 +31	+33 +4	+14·5 −14·5	0 −29	0 −46	0 −115	0 −290	−15 −44	−50 −96	−100 −172	−170 −285	−260 −550	−380 −670	−740 −1 030	−113 −159	−63 −109	−33 −79	−14 −60	+13 −33	+23 −23	+46 0	+72 0	+115 0	+290 0	+61 +15	+122 +50	+215 +100	+355 +170	+550 +260	+670 +380	+1 030 +740
Over 225 up to 250	+169 +140	+113 +84													−280 −570	−420 −710	−820 −1 110	−123 −169	−67 −113													+570 +280	+710 +420	+1 110 +820
Over 250 up to 280	+190 +158	+126 +94	+88	+66	+36	+16	0	0	0	0	−17	−56	−110	−190	−300 −620	480 800	−920 −1 240	−138 −190	−74 −126	−36	−14	+16	+26	+52	+81	+130	+320	+69	+137	+240	+400	+620 +300	+800 +480	+1 240 +920
Over 280 up to 315	+202 +170	+130 +98	+56	+34	+4	−16	−32	−52	−130	−320	−49	−108	−191	−320	−330 −650	540 860	−1 050 −1 370	−150 −202	−78 −130	−88	−66	−36	−26	0	0	0	0	+17	+56	+110	+190	+650 +330	+860 +540	+1 370 +1 050
Over 315 up to 355	+226 +190	+144 +108	+98	+73	+40	+18	0	0	0	0	−18	−62	−125	−210	−360 −720	600 960	−1 200 −1 560	−169 −226	−87 −144	−41	−16	+17	+28·5	+57	+89	+140	+360	+75	+151	+265	+440	+720 +360	+960 +600	+1 560 +1 200
Over 355 up to 400	+244 +208	+150 +114	+62	+37	+4	−18	−36	−57	−140	−360	−54	−119	−214	−350	−400 −760	680 1 040	−1 350 −1 710	−187 −244	−93 −150	−98	−73	−40	−28·5	0	0	0	0	+18	+69	+125	+210	+760 +400	+1 040 +610	+1 710 +1 350
Over 400 up to 450	+272 +232	+166 +126	+108	+80	+45	+20	0	0	0	0	−20	−68	−135	−230	−440 −840	760 1 160	−1 500 −1 900	−209 −272	−103 −166	−45	−17	+18	+31·5	+63	+97	+155	+400	+83	+165	+290	+480	+840 +440	+1 160 +760	+1 900 +1 500
Over 450 up to 500	+292 +252	+172 +132	+68	+40	+5	−20	−40	−63	−155	−400	−60	−131	−232	−385	−480 −880	840 1 240	−1 650 −2 050	−229 −292	−109 −172	−108	−80	−45	−31·5	0	0	0	0	+20	+68	+135	+230	+880 +480	+1 240 +840	+2 050 +1 650

TABLE C-3 RECOMMENDED FITS (CLEARANCE AND INTERFERENCE FITS)—DIMENSIONS IN μm

Nominal Size Range, mm	H7 s6	S7 h6	H7 r6	R7 h6	H7 p6	P7 h6	H7 n6	N7 h6	H7 h6	K7 h6	Js7 h6	H7 h6	H8 h7	H8 h9	H11 h9	H11 h11	H7 js6
From 1 up to 3	−4 −20	−8 −24	0 −16	−4 −20	+4 −12	0 −16	+6 −10	+2 −14	+10 −6	+6 −10	+11 −5	+16 0	+24 0	+39 0	+85 0	+120 0	+13 +3
Over 3 up to 6	−7 −27	−7 −27	−3 −23	−3 −23	0 −20	0 −20	+4 −16	+4 −16	+11 −9	+11 −9	+14 −6	+20 0	+30 0	+48 0	+105 0	+150 0	+16 +4
Over 6 up to 10	−8 −32	−8 −32	−4 −28	−4 −28	0 −24	0 −24	+5 −19	+5 −19	+14 −10	+14 −10	+16·5 −7·5	+24 0	+37 0	+58 0	+126 0	+180 0	+19·5 +4·5
Over 10 up to 14	−10	−10	−5	−5	0	0	+6	+6	+17	+17	+20	+29	+45	+70	+153	+220	+23·5
Over 14 up to 18	−39	−39	−34	−34	−29	−29	−23	−23	−12	−12	−9	0	0	0	0	0	+5·5
Over 18 up to 24	−14	−14	−7	−7	−1	−1	+6	+6	+19	+19	+23·5	[illegible]	[illegible]	+85	+182	+260	+27·5
Over 24 up to 30	−48	−48	−41	−41	−35	−35	−28	−28	−15	−15	−10·5	0	0	0	0	0	+6·5
Over 30 up to 40	−18	−18	−9	−9	−1	−1	+8	+8	+25	+23	+28·5	+41	+64	+101	+222	+320	+33
Over 40 up to 50	−59	−59	−50	−50	−42	−42	−33	−33	−18	−18	−12·5	0	0	0	0	0	+8
Over 50 up to 65	−23 −72	−23 −72	−11 −60	−11 −60	−2	−2	+10	+10	+28	+28	+34	+49	+76	+120	+264	+380	+39·5
Over 65 up to 80	−29 −78	−29 −78	−13 −62	−13 −62	−51	−51	−39	−39	−21	−21	−15	0	0	0	0		+9·5
Over 80 up to 100	−36 −93	−36 −93	−16 −73	−16 −73	−2	−2	+12	+12	+32	+32	+39·5	+57	+89	+141	+307	+440	+46
Over 100 up to 120	−44 −101	−44 −101	−19 −76	−19 −76	−59	−59	−45	−45	−25	−25	−17·5	0	0	0	0	0	+11
Over 120 up to 140	−52 −117	−52 −117	−23 −88	−23 −88													
Over 140 up to 160	−60 −125	−60 −125	−25 −90	−25 −90	−3 −68	−3 −68	+13 −52	+13 −52	+37 −28	+37 −28	+45 −20	+65 0	+103 0	+163 0	+350 0	+500 0	+52·5 +12·5
Over 160 up to 180	−68 −133	−68 −133	−28 −93	−28 −93													
Over 180 up to 200	−76 −151	−76 −151	−31 −106	−31 −106													
Over 200 up to 225	−84 +159	−84 −159	−34 −109	−34 −109	−4 −79	−4 −79	+15 −60	+15 −60	+42 −33	+42 −33	+52 −23	+75 0	+118 0	+187 0	+405 0	+580 0	+60·5 +14·5
Over 225 up to 250	−94 −169	−94 −169	−38 −113	−38 −113													
Over 250 up to 280	−106 −190	−106 −190	−42 −126	−42 −126	−4	−4	+18	+18	+48	+48	+58	+34	+113	+211	+450	+640	+68
Over 280 up to 315	−118 −202	−118 −202	−46 −130	−40 −130	−88	−88	−66	−66	−36	−36	−26	0	0	0	0	0	+16
Over 315 up to 355	−133 −226	−133 −226	−51 −144	−51 −144	−5	−5	+20	+20	+53	+53	+64·5	+93	+146	+229	+500	+720	+75
Over 355 up to 400	−151 −244	−151 −244	−57 −150	−57 −150	−98	−98	−73	−73	−40	−40	−28·5	0	0	0	0	0	+18
Over 400 up to 450	−169 −272	−169 −272	−63 −166	−63 −166	−5	−5	+23	+23	+58	+58	+71·5	+103	+160	+252	+555	+800	+83
Over 450 up to 500	−189 −292	−189 −292	−69 −172	−69 −172	−108	−108	−80	−80	−45	−45	−31·5	0	0	0	0	0	+20

Nominal Size Range, mm	G7H7 h6g6	H7 f7	F8 h6	H8 f7	F8 h9	H8 e8	E8 h9	H8 d9	H9 d9	D10 h9	H11 d9	D10 h11	C11 h9	C11 H11 h11 c11	B11 h11	H11 b11	A11H11 h11 a11
From 1 up to 3	+18 +2	+26 +6	+26 +6	+30 +6	+45 +6	+42 +14	+64 +14	+59 +20	+70 +20	+85 +20	+105 +20	+120 +20	+145 +60	+180 +60	+206 +140	+260 +140	+390 +270
Over 3 up to 6	+24 +4	+34 +10	+36 +10	+40 +10	+58 +10	+56 +20	+80 +20	+78 +30	+90 +30	+108 +30	+135 +30	+153 +30	+175 +70	+220 +70	+223 +140	+290 +140	+420 +270
Over 6 up to 10	+29 +5	+43 +13	+44 +13	+50 +13	+71 +13	+69 +25	+97 +25	+98 +40	+112 +40	+134 +40	+166 +40	+188 +40	+206 +80	+260 +80	+249 +150	+330 +150	+460 +280
Over 10 up to 14	+35	+52	+54	+61	+86	+86	+118	+120	+136	+163	+203	+230	+248	+315	+271	+370	+510
Over 14 up to 18	+6	+16	+16	+16	+16	+32	+32	+50	+50	+50	+50	+50	+95	+95	+150	+150	+290
Over 18 up to 24	+41	+62	+66	+74	+105	+106	+144	+150	+169	+201	+247	+279	+292	+370	+293	+420	+560
Over 24 up to 30	+7	+20	+20	+20	+20	+40	+40	+65	+65	+65	+65	+65	+110	+110	+160	+160	+300
Over 30 up to 40	+50	+75	+80	+89	+126	+128	+174	+181	+204	+242	+302	+340	+342 +120	+440 +120	+306 +170	+490 +170	+630 +310
Over 40 up to 50	+9	+25	+25	+25	+25	+50	+50	+80	+80	+80	+80	+80	+352 +130	+450 +130	+356 +180	+500 +180	+640 +320
Over 50 up to 65	+59	+90	+95	+106	+150	+152	+208	+220	+248	+294	+364	+410	+404 +140	+520 +140	+399 +190	+570 +190	+720 +340
Over 65 up to 80	+10	+30	+30	+30	+30	+60	+60	+100	+100	+100	+100	+100	+414 +150	+530 +150	+409 +200	+580 +200	+740 +360
Over 80 up to 100	+69	+106	+112	+125	+177	+180	+246	+261	+294	+347	+427	+480	+477 +170	+610 +170	+462 +220	+660 +220	+820 +380
Over 100 up to 120	+12	+36	+36	+36	+36	+72	+72	+120	+120	+120	+120	+120	+487 +180	+620 +180	+482 +240	+680 +240	+850 +410
Over 120 up to 140													+550 +200	+700 +200	+535 +260	+760 +260	+900 +460
Over 140 up to 160	+79 +14	+123 +43	+131 +43	+146 +43	+206 +43	+211 +85	+285 +85	+308 +145	+345 +145	+405 +145	+495 +145	+555 +145	+560 +210	+710 +210	+555 +280	+780 +280	+1 020 +520
Over 160 up to 180													+580 +230	+730 +230	+585 +310	+810 +310	+1 080 +580
Over 180 up to 200													+645 +240	+820 +240	+659 +340	+920 +340	+1 240 +660
Over 200 up to 225	+90 +15	+142 +50	+151 +50	+168 +50	+237 +50	+244 +100	+330 +100	+357 +170	+400 +170	+470 +170	+575 +170	+645 +170	+665 +260	+840 +260	+699 +380	+960 +380	+1 320 +740
Over 225 up to 250													+685 +280	+860 +280	+739 +420	+1 000 +420	+1 400 +820
Over 250 up to 280	+101	+160	+169	+189	+267	+272	+370	+401	+450	+530	+640	+720	+750 +300	+940 +300	+832 +480	+1 120 +480	+1 560 +920
Over 280 up to 315	+17	+56	+56	+56	+56	+110	+110	+190	+190	+190	+190	+190	+780 +330	+970 +330	+892 +540	+1 180 +540	+1 530 +1 050
Over 315 up to 355	+111	+176	+187	+208	+291	+303	+405	+439	+490	+580	+710	+800	+860 +350	+1 080 +360	+996 +600	+1 320 +600	+1 920 +1 200
Over 355 up to 400	+18	+62	+62	+62	+62	+125	+125	+210	+210	+210	+210	+210	+900 +400	+1 120 +400	+1076 +680	+1 400 +680	+2 070 +1 350
Over 400 up to 450	+123	+194	+205	+228	+320	+329	+445	+482	+540	+635	+785	+880	+995 +440	+1 240 +440	+1200 +760	+1 560 +760	+2 390 +1 500
Over 450 up to 500	+20	+68	+68	+68	+68	+135	+135	+230	+230	+230	+230	+230	+1035 +480	+1 280 +480	+1280 +840	+1 640 +840	+2 450 +1 650

C-5.2 Limits for the tolerance zones enclosed in the frames in Tables C-1 are given in Table C-2.

C-5.3 Dimensions for the fits chosen from the tolerance zones enclosed in the frames in Table C-1 are given in Table C-3.

TABLE C-4 COMMONLY USED FITS

(*Clause* C-3.1.4)

I For Holes

Type of Fit	*Class of Shaft*	*With Holes*					*Remakrs*
		*H6**	*H7*	*H8*	*H9*	*H11*	
Clearance	a — b	–	–	–	–	a11 , b11	Large clearance fit and widely used
	c	–	–	–	–	c11	Slack running fit
	d	–	d8*	d8*,d9,d10	d8*, d9, d10	d9	Loose running fit
	e	e7*	e8	e8, e9*			Easy running fit
	f	f6*	f7	f7, f8*			Normal running fit
	g	g5*	g6	–			Close running fit or sliding fit, also spigot and location fit
	h	h5*	h6	h7,h8*,h9		h11	Precision sliding fit. Also fine spigot and location fit.
Transition	js	js5*	js6	js7*			Push fit for very accurate location with easy assembly and disassembly
	k	k5*	k6	k7*			Light keying fit (true transition) for keyed shafts, non-running locked pins, etc.
	m	m5*	m6*	m7*			Medium keying fit
	n	n5*	n6	n7*			Heavy keying fit (for tight assembly mating surfaces)
Interference	p	p5*	p6	p7*			Light press fit with easy dismantling for non-ferrous parts. Standard press fit with easy dismantling for ferrous and non-ferrous parts assembly
	r	r5*	r6	r7*			Medium drive fit with easy dismentling for ferrous parts assembly Light drive fit with easy dismentling for non-ferrous parts assembly
	s	s5*	s6	s7*			Heavy drive fit for ferrous parts permanent or semi-permanent assembly standard press fit for non-ferrous parts
	t	t5*	t6*	t7*			Force fit on ferrous parts for permanent assembly

* Second preference fits.

(Continued)

TABLE C-4 *(Concluded)*

II For Shafts								
Type of Fit	*Class of Holes*	*With Shafts*						*Remakrs*
		*h5**	*h6*	*h7*	*h8**	*h9*	*h11*	
Clea…	A						A11	Large clearance fit widely used
	B						B11	
	C						C11	Slack running fit
	[illegible]							[illegible]
	E		E8*		E8*	E9		Easy running fit
	F		F7*		F8	F8*		Normal running fit
	G	G6*	G7					Close running fit or sliding fit, also spigot and location fit
	H	H6*	H7	H8	H8	H8, H9	H11	Precision sliding fit. Also fine spigot and location fit.
Tran…ion	Js	Js6*	Js7	Js8*				Push fit for very accurate location with easy assembly and disassembly
	K	K6*	K7	K8*				Light keying fit (true transition) for keyed shafts, non-running locked pins, etc.
	M	M6*	M7*	M8*				Medium keying fit
	N	N6*	N7	N8*				Heavy keying fit (for tight assembly of mating surfaces)
Interference	P	P6*	P7					Light press fit with easy dismantling for non-ferrous parts. Standard press fit with easy dismantling for ferrous and non-ferrous parts assembly
	R	R6*	R7					Medium drive fit with easy dismentling for ferrous parts assembly Light drive fit with easy dismantling for non-ferrous parts assembly
	S	S6*	S7					Heavy drive fit for ferrous parts permanent or semi-permanent assembly standard press fit for non-ferrous parts
	T	T6*	T7					Force fit on ferrous parts for permanent assembly

* Second preference fits.

APPENDIX D

GENERAL TOLERANCES FOR LINEAR AND ANGULAR DIMENSIONS

D-1 General — Specifies the permissible machining [illegible] tolerance indications.

D-1.1 This standard is applicable for all machining processes with chips like turning, milling, etc, and without chips like drawing, printing, embossing, pipe bending, etc. and is not applicable for production [illegible] flame cutting, etc.

D-2 Deviations

D-2.1 *Linear Dimensions* — Shall be as given in Table D-1.

TABLE D-1 DEVIATIONS FOR LINEAR DIMENSIONS

(All dimensions in millimetres)

Class of Deviation	*Range of Nominal Dimensions*												
	Above	*0.5*	*3*	*6*	*30*	*120*	*315*	*1000*	*2000*	*4000*	*8000*	*12000*	*16000*
	Up to and including	*3*	*6*	*30*	*120*	*315*	*1000*	*2000*	*4000*	*8000*	*12000*	*16000*	*20000*
Fine		± 0.05	± 0.05	± 0.1	± 0.15	± 0.2	± 0.3	± 0.5	± 0.8	–	–	–	–
Medium		± 0.1	± 0.1	± 0.2	± 0.3	± 0.5	± 0.8	± 1.2	± 2	± 3	± 4	± 5	± 6
Coarse		–	± 0.2	± 0.5	± 0.8	± 1.2	± 2	± 3	± 4	± 5	± 6	± 7	± 8
Extra coarse		–	± 0.5	± 1	± 1.5	± 2	± 3	± 4	± 6	± 8	± 10	± 12	± 12

D-2.2 *Radii and Chamfer* — Shall be as given in Table D-2.

TABLE D-2 DEVIATIONS FOR RADII AND CHAMFERS

(All dimensions in millimetres)

Class of Deviation	*Range of Nominal Dimensions*					
	Above	*0.5*	*3*	*6*	*30*	*120*
	Up to and including	*3*	*6*	*30*	*120*	*315*
Fine and medium		± 0.2	± 0.5	± 1	± 2	± 4
Coarse and extra coarse		± 0.2	± 1	± 2	± 4	± 8

D-2.3 *Angular Dimensions* – Shall be as given in Table D-3.

TABLE D-3 DEVIATIONS FOR ANGULAR DIMENSIONS

(All dimensions in millimetres)

Class of Deviation	*Permissible Variations on Length of Shorter Side of Angle*							
	Upto 10		*Over 10 to 50*		*Over 50 to 120*		*Over 120*	
	Degree	mm per 100 mm	Degree	mm per 100 mm	Degree	mm per 100 mm	Degree	mm per 100 mm
Fine and medium	$\pm 1^{0}$	±1.8	$\pm 30'$	±0.9	±20	±0.6	$\pm 10'$	±0.3
Coarse	$\pm 1^{0}30'$	±2.6	$\pm 50'$	±1.5	±25	±0.7	$\pm 15'$	±0.4
Extra coarse	$\pm 3^{0}$	±5.1	$\pm 2^{0}$	±3.5	$\pm 1^{0}$	+1.8	$\pm 30'$	±0.9

D-3. Indications in Drawings – In the space provided for the purpose of drawings or otherwise, two methods of indications are suggested:

a) Class of deviation required shall be indicated, for example, Medium IS:2102, Coarse IS:2102, etc.

b) The values of the permissible variations to be shown in general note for dimensions without tolerance indications.

ALPHABETICAL INDEX

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INDIAN STANDARDS REFERRED

IS: 813-1986	Scheme of symbols for welding
IS: 919 (Part 1)-1963	Recommendation for limits and fits for engineering : Part 1 General engineering
IS:1076 (Part 1)-1985 ISO 3-1973	Preferred numbers : Part 1 Series of preferred numbers
IS: 1076 (Part 2)-1985 ISO 17-1973	Preferred numbers : Part 2 Guide to the use of preferred numbers and series of preferred numbers
IS: 1076 (Part 3)-1985 ISO 497-1973	Preferred numbers : Part 3 Guide to the choice of series of preferred numbers and series containing more rounded values of preferred numbers
IS: 2102 (Part 1)-1980	General tolerances for dimensions and form and position : Part 1 General tolerances for linear and angular dimensions
IS: 2709-1982	Guide for selection of fits
IS: 3073-1967	Assessment of surface roughness
IS: 3403-1981	Dimensions for knurls
IS: 4218 (Part 1)-1976	ISO metric screw threads : Part 1 Basic and design profiles
IS: 4218 (Part 2)-1976	ISO metric screw threads : Part 2 Diameter pitch combination
IS: 4218 (Part 3)-1974	ISO metric screw threads : Part 3 Basic dimensions for design profile
IS: 4218 (Part 4)-1976	ISO metric screw threads : Part 4 Tolerancing system
IS: 4218 (Part 5)-1979	ISO metric screw threads : Part 5 Tolerances
IS: 4218 (Part 6)-1978	ISO metric screw threads : Part 6 Limits of sizes for commercial bolts and nuts
IS: 7283-1974	Hot rolled bars for production of bright bars
IS: 8000 (Part 1)-1985 ISO 1101-1983	Geometrical tolerancing on technical drawings : Part 1 Tolerances of form, orientation, location and run-out and appropriate geometrical definitions
IS: 8000 (Part 2)-1976	Geometrical tolerancing on technical drawings : Part 2 Maximum material principles
IS: 8000 (Part 3)-1985 ISO 1660-1982	Geometrical tolerancing on technical drawings : Part 3 Dimensioning and tolerancing of profiles
IS: 8000 (Part 4)1976	Geometrical tolerancing on technical drawings : Part 4 Practical examples of indication on drawings
IS: 9609 (Part 1)-1983 ISO 3098/1-1974	Lettering on technical drawings : Part 1 English characters
IS: 9609 (Part 2)-1985 ISO 3098/2-1984	Lettering on technical drawings : Part 2 Greek characters
IS: 10164-1985 ISO 6428-1982	Requirements to execute technical drawings for microcopying
IS: 10711-1983 ISO 5457-1980	Sizes of drawing sheet
IS: 10712-1983 ISO 6433-1981	Presentation of item references on technical drawings
IS: 10713-1983 ISO 5455-1979	Scales for use on technical drawings
IS: 10714-1983 ISO 6433-1981	General principles of presentation on technical drawings
IS: 10715-1983 ISO 6410-1981	Presentation of threaded parts on technical drawings
IS: 10716-1983 ISO 2162-1973	Rules for presentation of springs on technical drawings

IS: 10717-1983 ISO 2203-1973	Conventional representation of gears on technical drawings
IS: 10718-1983 ISO 3040-1974	Method of dimensioning and tolerancing cones on technical drawings
IS: 10719-1983 ISO 1302-1978	Method of indicating surface texture on technical drawings
IS: 10720-1983 ISO 5261-1981	Technical drawings for structural metal work
IS: 10721-1985 ISO 5459-1981	Datum and datum systems for geometrical tolerancing on technical drawings
IS: 10990-1984	Code of practice for industrial piping diagram
IS: 11065 (Part 1)-1984	Drawing practice for axonometric projection : Part 1 Isometric projection
IS: 11065 (Part 2)-1985	Drawing practice for axonometric projection : Part 2 Dimetric projection
IS: 11663-1986	Conventional representation of common features
IS: 11664-1986	Folding of drawing punts
IS: 11665-1985 ISO 7200-1984	Technical drawings – Title blocks
IS: 11666-1985 ISO 7573-1983	Technical drawings – Item lists
IS: 11667-1985 ISO 406-1982	Technical drawings – Linear and angular tolerancing – Indications on drawings
IS: 11669-1986 ISO 129-1985	General principles of dimensioning on technical drawings
IS: 11670-1986	Abbreviations for use in technical drawings