MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY

(AUTONOMOUS INSTITUTION)

(Affiliated to JNTU, Hyderabad, Approved by AICTE - Accredited by NBA & NAAC – 'A' grade - ISO 9001:2015 certified)
Maisammaguda, Dhulapally (post via Hakimpet), Secunderabad – 500100, Telangana state, INDIA. Contact number: 040-23792146/64634237, e-mail id: mrcet2004@gmail.com, website: www.mrcet.ac.in

MACHINE DRAWING

1.0 CONVENTIONAL REPRESENTATION

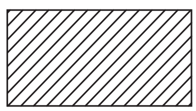
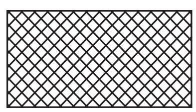
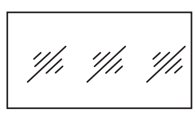
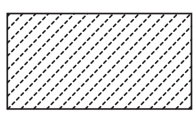
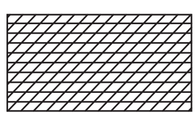
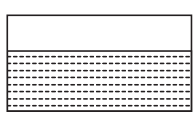
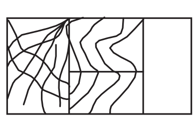
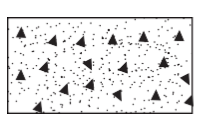
Certain draughting conventions are used to represent materials in section and machine elements in engineering drawings.

Materials:

As a variety of materials are used for machine components in engineering applications, it is preferable to have different conventions of section lining to differentiate between various materials. The recommended conventions in use are shown in Fig.

Machine Components:

When the drawing of a component in its true projection involves a lot of time, its convention may be used to represent the actual component. Figure shows typical examples of conventional representation of various machine components used in engineering drawing.

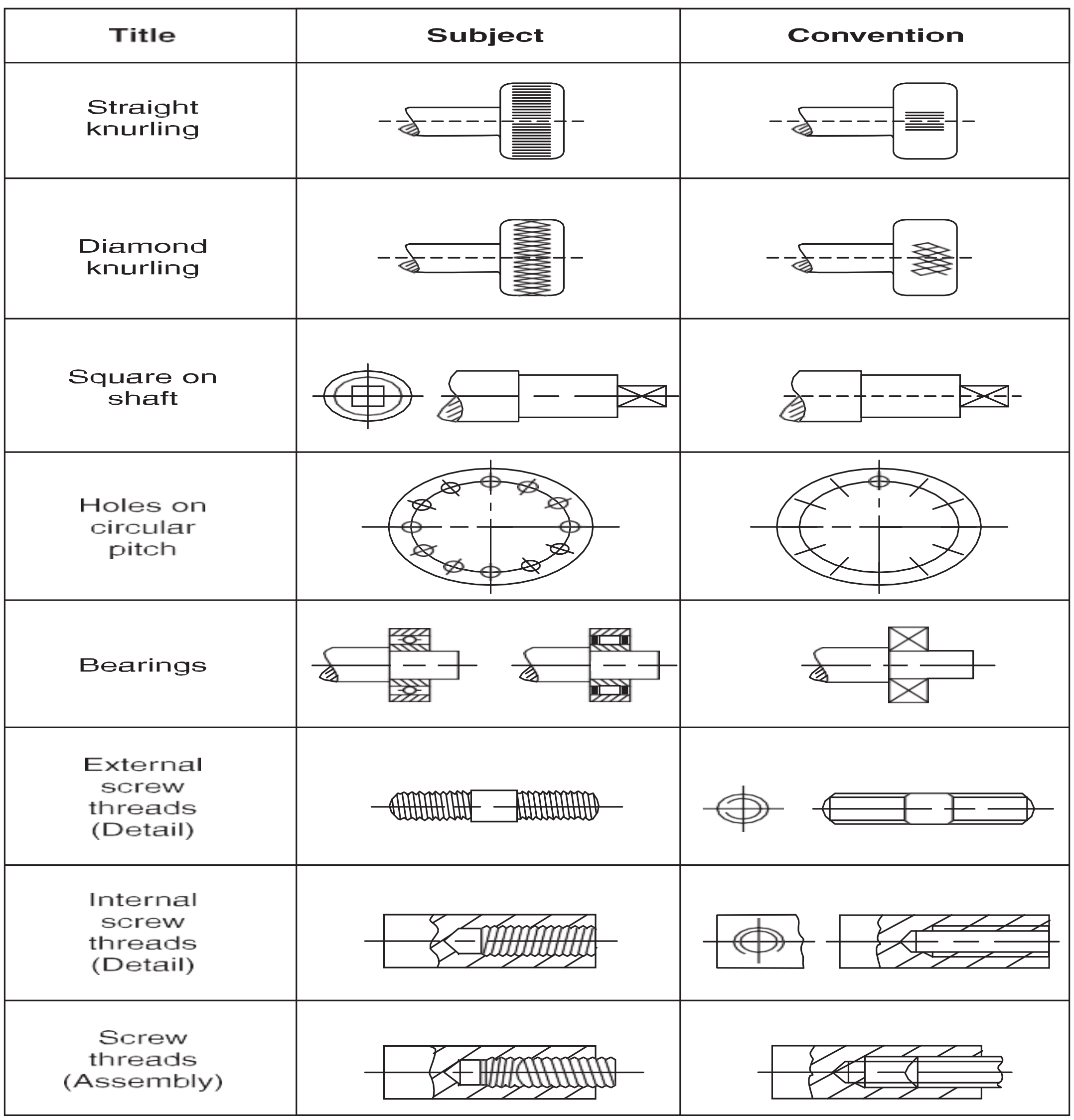
Type	Convention	Material
Metals		Steel, Cast Iron, Copper and its Alloys, Aluminum and its Alloys, etc.
		Lead, Zinc, Tin, White-metal, etc.
Glass		Glass
Packing and Insulating material		Porcelain, Stoneware, Marble, Slate, etc.
		Asbestos, Fiber, Felt, Synthetic resin products, Paper, Cork, Linoleum, Rubber, Leather, Wax, Insulating and Filling materials, etc.
Liquids		Water, Oil, Petrol, Kerosene, etc.
Wood		Wood, Plywood, etc.
Concrete		A mixture of Cement, Sand and Gravel

DIMENSIONS:

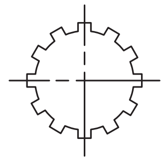
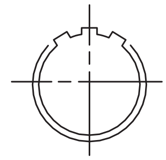
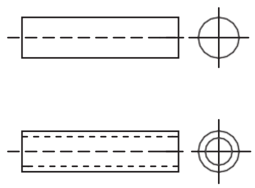
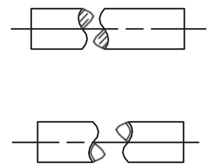
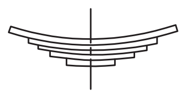
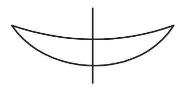
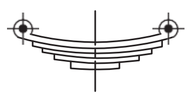
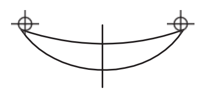
A drawing of a component, in addition to providing complete shape description, must also furnish information regarding the size description. These are provided through the distances between the surfaces, location of holes, nature of surface finish, type of material, etc. The expression of these features on a drawing, using lines, symbols, figures and notes is called dimensioning.

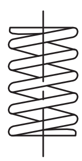
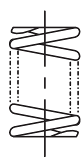
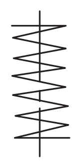
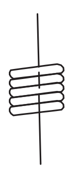
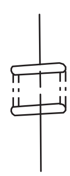
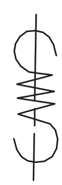
General Principles:

Dimension is a numerical value expressed in appropriate units of measurement and indicated on drawings, using lines, symbols, notes, etc., so that all features are completely defined.

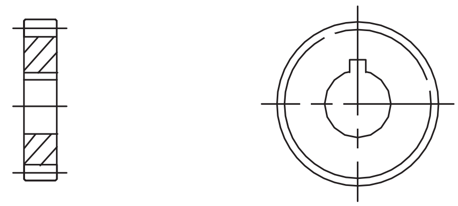
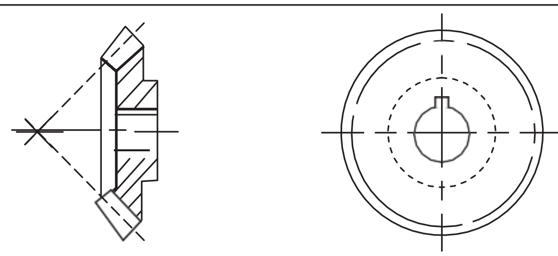
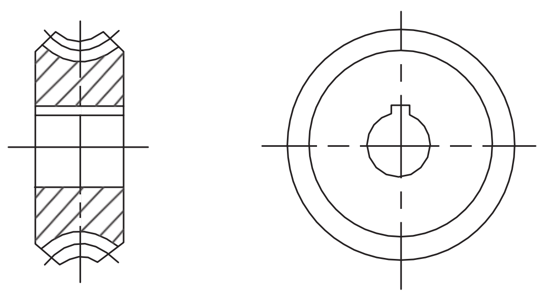
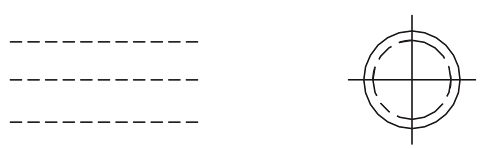


Conventional representation of machine components (Contd.)

Title	Subject	Convention
Splinted shafts		
Interrupted views		
Semi-elliptic leaf spring		
Semi-elliptic leaf spring with eyes		

	Subject	Convention	Diagrammatic Representation
Cylindrical compression spring			
Cylindrical tension spring			

Conventional representation of machine components (Contd.)

Title	Convention
Spur gear	
Bevel gear	
Worm wheel	
Worm	

Conventional representation of machine components

2.0 SCREWED FASTENERS

INTROOUSTION:

A machine element used for holding or joining two or more parts of a machine or structure is known as a fastener. The process of joining the parts is called fastening. The fasteners are of two types : permanent and removable (temporary). Riveting and welding processes are used for fastening permanently. Screwed fasteners such as bolts, studs and nuts in combination, machine screws, set screws, etc., and keys, cotters, couplings, etc., are used for fastening components that require frequent assembly and disassembly.

Screwed fasteners occupy the most prominent place among the removable fasteners. In general, screwed fasteners are used : (i) to hold parts together, (ii) to adjust parts with reference to each other and (iii) to transmit power.

SCREW THREAD NOMENCLATURE:

A screw thread is obtained by cutting a continuous helical groove on a cylindrical surface (external thread). The threaded portion engages with a corresponding threaded hole (internal thread); forming a screwed fastener. Following are the terms that are associated with screw threads shown in Fig.

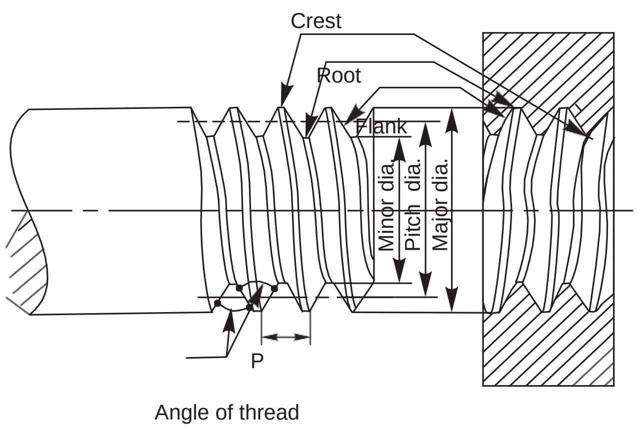


Fig. Screw thread nomenclature

1.Major (nominal) diameter: This is the largest diameter of a screw thread, touching the crests on an external thread or the roots of an internal thread.

2.Minor (core) diameter: This is the smallest diameter of a screw thread, touching the roots or core of an external thread (root or core diameter) or the crests of an internal thread.

3.Pitch diameter: This is the diameter of an imaginary cylinder, passing through the threads at the points where the thread width is equal to the space between the threads.

4.Pitch: It is the distance measured parallel to the axis, between corresponding points on adjacent screw threads.

5.Lead: It is the distance a screw advances axially in one turn.

6.Flank: Flank is the straight portion of the surface, on either side of the screw thread.

7.Crest: It is the peak edge of a screw thread, that connects the adjacent flanks at the top.

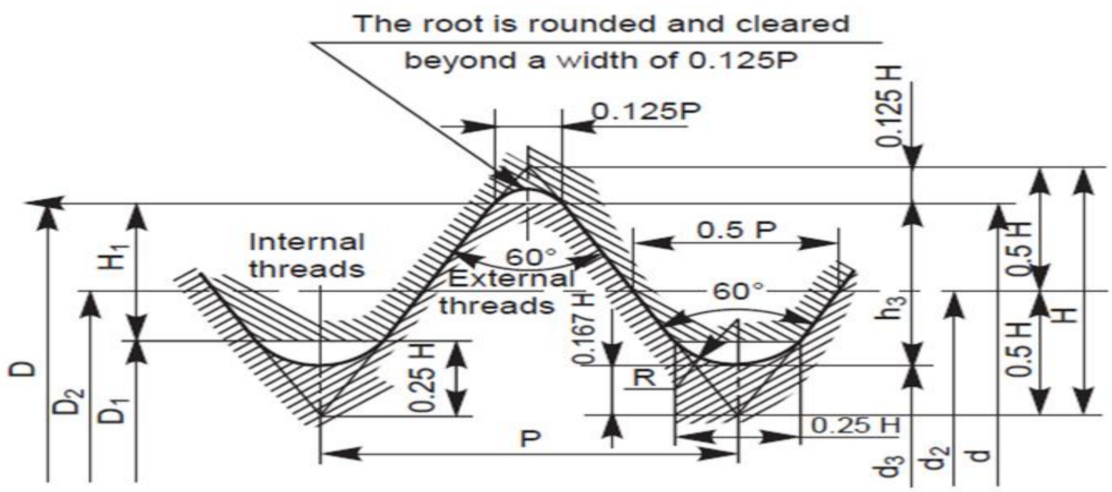
8.Root: It is the bottom edge of the thread that connects the adjacent flanks at the bottom.

9.Thread angle: This is the angle included between the flanks of the thread, measured in an axial plane.

FORMS OF THREADS:

Bureau of Indian Standards (BIS) adapts ISO (International Organization for Standards) metric threads which are adapted by a number of countries apart from India.

The design profiles of external and internal threads are shown in Fig. The following are the relations between the various parameters marked in the figure :



Internal thread diameters	External thread diameters
D - Major diameter	d - Major diameter
D_2 - Pitch diameter	d_2 - Pitch diameter
D_1 - Minor diameter	d_3 - Minor diameter

Metric screw thread

P = Pitch

H = 0.86 P

$D = d$ = Major diameter

$D_2 = d_2 = d - 0.75H$

$D_1 = d_2 - 2(H/2 - H/4) = d - 2H_1$
$= d - 1.08P$

$d_3 = d_2 - 2\,(H/2 - H/6)$
$= d - 1.22P$

$H_1 = (D - D_1)/2 = 5H/8 = 0.54P$

$h_3 = (d - d_3)/2 = 17/24H = 0.61P$

$R = H/6 = 0.14P$

Other Thread Profiles:

Apart from ISO metric screw thread profile, there are other profiles in use to meet various applications. These profiles are shown in Fig. 5.3, the characteristics and applications of which are discussed below :

V-Thread (sharp): This thread profile has a larger contact area, providing more frictional resistance to motion. Hence, it is used where effective positioning is required. It is also used in brass pipe work.

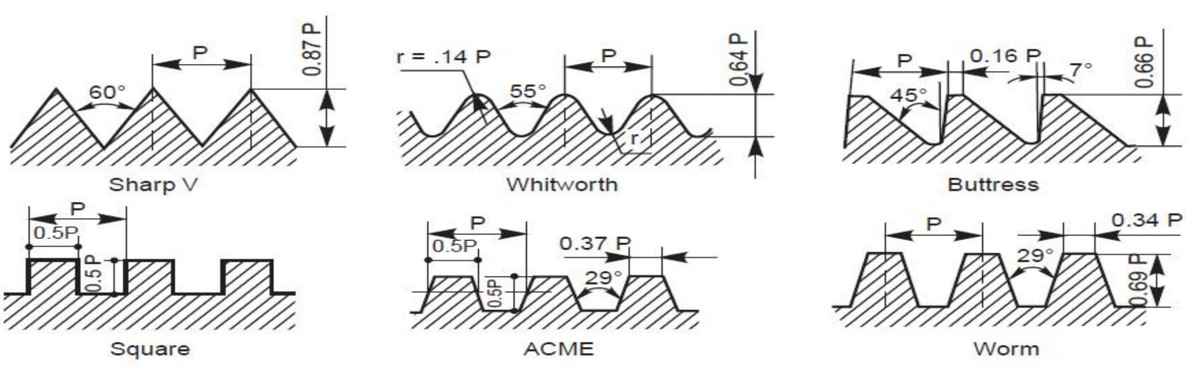
British Standard Whitworth (B.S.W) Thread: This thread form is adopted in Britain in inch units. The profile has rounded ends, making it less liable to damage than sharp V-thread.

Buttress Thread: This thread is a combination of V-and square threads. It exhibits the advantages of square thread, like the ability to transmit power and low frictional resistance, with the strength of the V-thread. It is used where power transmission takes place in one direction only such as screw press, quick acting carpenter's vice, etc.

Square Thread: Square thread is an ideal thread form for power transmission. In this, as the thread flank is at right angle to the axis, the normal force between the threads, acts parallel to the axis, with zero radial component. This enables the nut to transmit very high pressures, as in the case of a screw jack and other similar applications.

ACME Thread: It is a modified form of square thread. It is much stronger than square thread because of the wider base and it is easy to cut. The inclined sides of the thread facilitate quick and easy engagement and disengagement as for example, the split nut with the lead screw of a lathe.

Worm Thread: Worm thread is similar to the ACME thread, but is deeper. It is used on shafts to carry power to worm wheels.



Types of thread profiles

THREAD SERIES:

BIS recommends two thread series: coarse series and fine series, based on the relative values of the pitches. However, it must be noted that the concept of quality is not associated with these terms. For any particular diameter, there is only one largest pitch, called the coarse pitch and the rest are designated as fine pitches.

Table gives the nominal diameter and pitch combinations for coarse and fine series of ISO metric screw threads.

Table :Diameter-pitch combination for ISO metric threads

Nominal diameter		*Pitch*			
First choice	*Second choice*	*Coarse*	*Fine*		
			1	*2*	*3*
2	—	0.4	0.25	—	
—	2.2	0.45	0.25	—	—
2.5	—	0.45	0.35	—	—
3	—	0.5	0.35	—	—
—	3.5	0.6	0.35	—	—
4	—	0.7	0.5	—	—
—	4.5	0.75	0.5	—	—
5	—	0.8	0.5	—	—
6	—	1	0.75	0.5	—
8	—	1.25	1	0.75	—
10	—	1.5	1.25	1	0.75
12	—	1.75	1.5	1.25	—
16	14	2	1.5	1	—
20	18,22	2.5	2	1.5	1
24	27	3	2	1.5	1
30	33	3.5	2	1.5	1
36	39	4	3	2	1.5
42	45	4.5	4	3	2
48	52	5	4	3	2
56	60	5.5	4	3	2
64	68	6	4	3	2
72	76	6	4	3	2
80	85	6	4	3	2
90	95	6	4	3	2
100	—	6	4	3	2
105 to 300	—	—	6	4	3

THREAD DESIGNATION

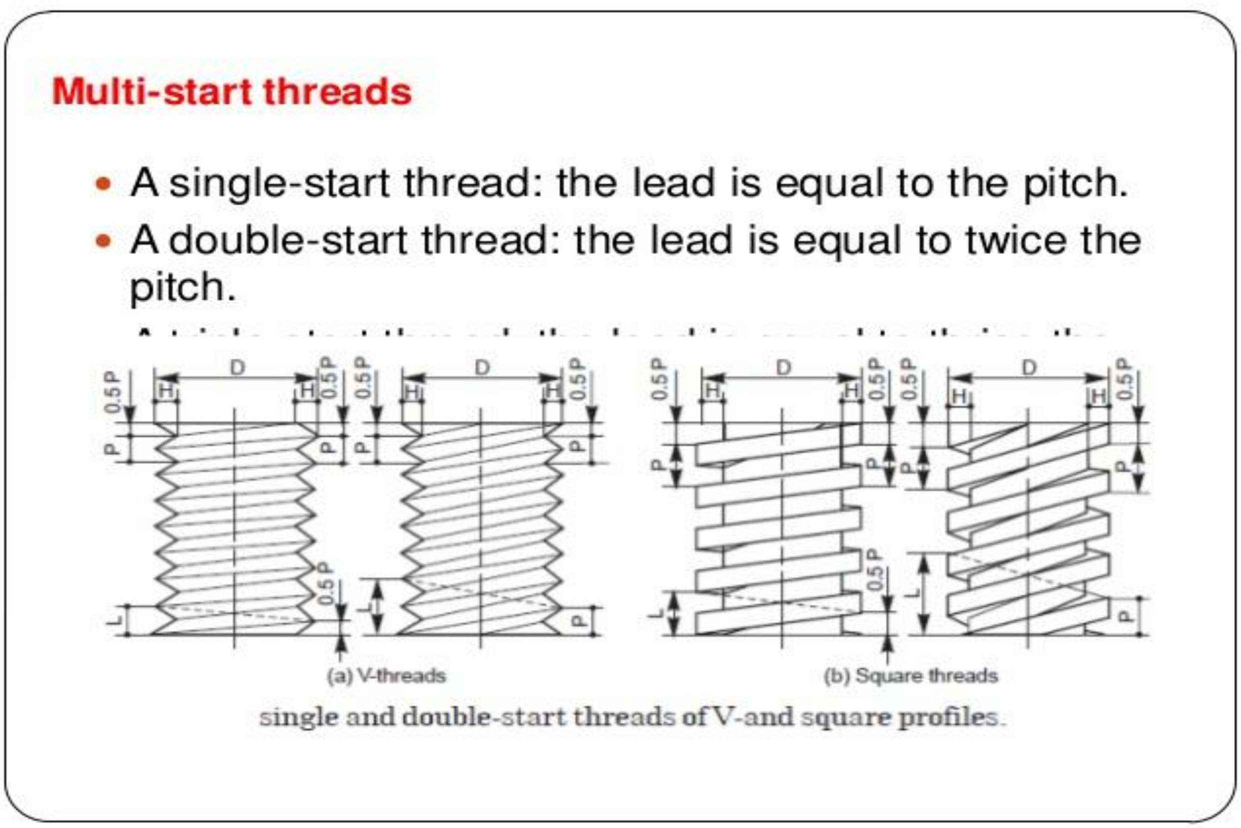
The diameter-pitch combination of an ISO metric screw thread is designated by the letter ‘M’ followed by the value of the nominal diameter and pitch, the two values being separated by the sign ‘×’. For example, a diameter pitch combination of nominal diameter 10 mm and pitch 1.25 mm is designated as M10 × 1.25.

If there is no indication of pitch in the designation, it shall mean the coarse pitch. For example, M 10 means that the nominal diameter of the thread is 10 mm and pitch is 1.5 mm. Following are the other designations, depending on the shape of the thread profile :

SQ 40 × 10 – SQUARE thread of nominal diameter 40 mm and pitch 10 mm ACME 40 × 8 – ACME thread of nominal diameter 40 mm and pitch 8 mm WORM 40 × 10 – WORM thread of nominal diameter 40 mm and pitch 10 mm

MULTI-START THREADS

A single-start thread consists of a single, continuous helical groove for which the lead is equal to the pitch. As the depth of the thread depends on the pitch, greater the lead desired, greater will be the pitch and hence smaller will be the core diameter, reducing the strength of the fastener. To overcome this drawback, multi-start threads are recommended.



single and double-start threads of V-and square profiles.

In multi-start threads, lead may be increased by increasing the number of starts, without increasing the pitch. For a double start thread, lead is equal to twice the pitch and for a triple start thread, lead is equal to thrice the pitch.

In double start threads, two threads are cut separately, starting at points, diametrically opposite to each other. In triple start threads, the starting points are 120° apart on the circumference of the screws.

Multi-start threads are also used wherever quick action is desired, as in fountain pens, automobile starters, arbor press spindles, hydraulic valve spindles, etc.

RIGHT HAND ANO LEFT HAND THREADS

Screw threads may be right hand or left hand, depending on the direction of the helix. A right hand thread is one which advances into the nut, when turned in a clockwise direction and a left hand thread is one which advances into the nut when turned in a counter clockwise direction. An abbreviation LH is used to indicate a left hand thread. Unless otherwise stated, a thread should be considered as a right hand one. Figure illustrates both right and left hand thread forms.

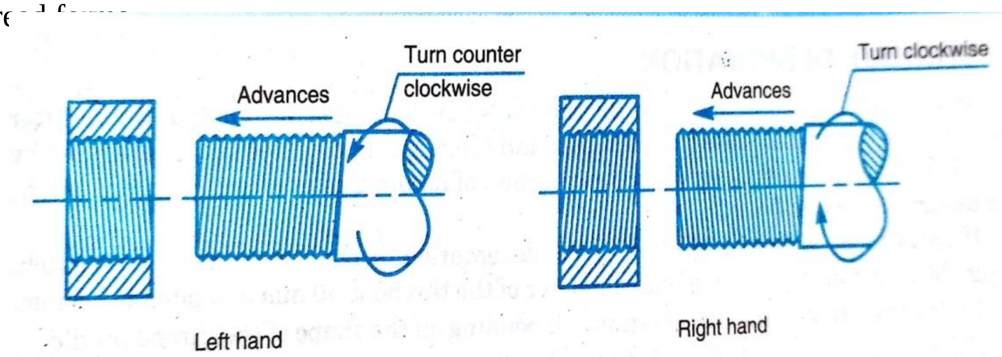
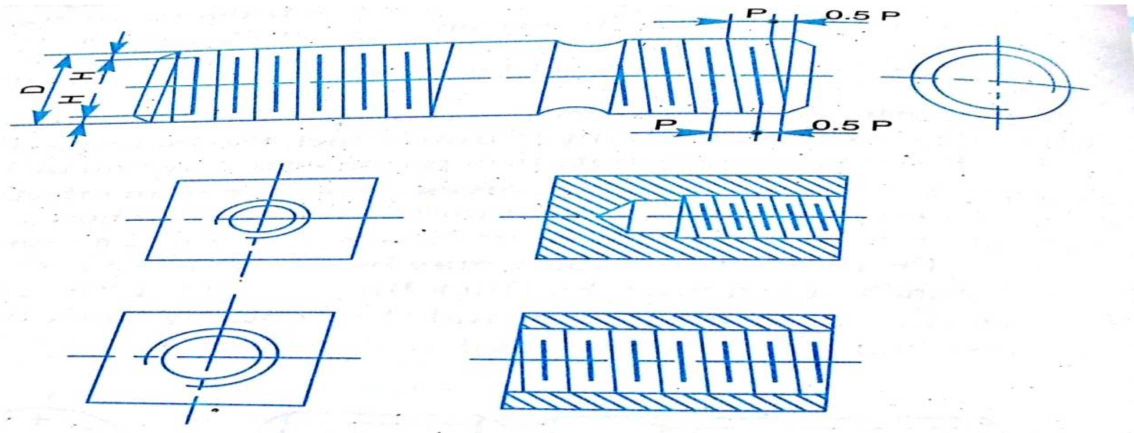


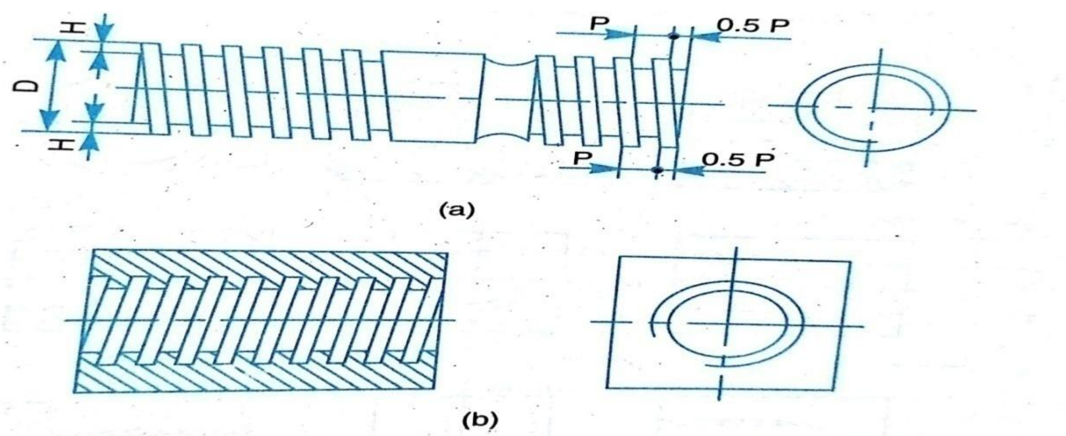
Fig. 5.5 Right hand and left hand threads

V-THREAD & SQUARE THREAD

The simplified representation, though it saves time, is not an effective method to convey thread forms. The schematic representation, used for the purpose is shown in Fig. In practice, the schematic representation is followed for only visible threads, *i.e.,* for external threads and internal threads in section. From the Fig. it may be observed that the crest diameters, both in external and internal threads, are drawn by thick lines. Further, the crests are represented by thin lines, extending upto the major diameter and the roots by thick lines, extending up to the minor diameter, these lines being drawn inclined with a slope equal to half the pitch.



Schematic representation of threaded parts—V-threads



9 Schematic representation of threaded parts--Square threads

BOLTEO JOINT

A bolt and nut in combination Fig. is a fastening device used to hold two

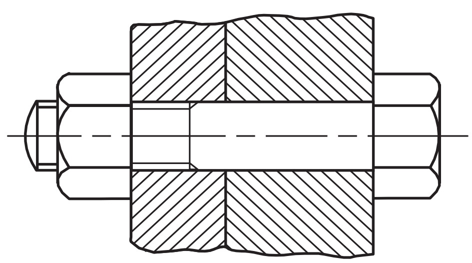


Fig. Bolted joint

parts together. The body of the bolt, called shank is cylindrical in form, the head; square or hexagonal in shape, is formed by forging. Screw threads are cut on the other end of the shank. Nuts in general are square or hexagonal in shape. The nuts with internal threads engage with the corresponding size of the external threads of the bolt. However, there are other forms of nuts used to suit specific requirements. For nuts, hexagonal shape is preferred to the square one, as it is easy to tighten even in a limited Fig. Bolted joint space. This is because, with only one-sixth of a turn, the spanner can be re-introduced in the same position. However, square nuts are used when frequent loosening and tightening is required, for example on job holding devices like vices, tool posts in machines, etc. The sharp corners on the head of bolts and nuts are removed by chamfering.

Methods of Drawing Hexagonal (Bolt Head) Nut:

Drawing hexagonal bolt head or nut, to the exact dimensions is laborious and time consuming. Moreover, as standard bolts and nuts are used, it is not necessary to draw them accurately. The following approximate methods are used to save the draughting time.

Method 1 (Fig.)
Empirical relations :
Major or nominal diameter of bolt = D
Thickness of nut, T = D
Width of nut across flat surfaces, W = 1.5D + 3 mm
Radius of chamfer, R = 1.5D

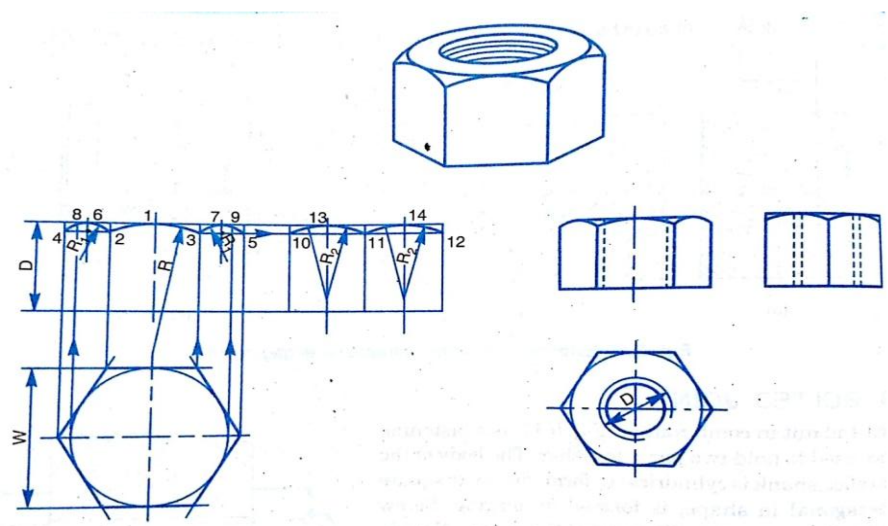


Fig. 5.12 Method of drawing views of a hexagonal nut (Method I)

PROSEOURE:

1. Draw the view from above by drawing a circle of diameter, W and describe a regular hexagon on it, by keeping any two parallel sides of the hexagon, horizontal.

2. Project the view from the front, and the view from side, and mark the height equal to D.

3. With radius R, draw the chamfer arc 2-1-3 passing through the point 1 in the front face.

4. Mark points 4 and 5, lying in-line with 2 and 3.Locate points 8,9 on the top surface, by projecting from the view from above.

5. Draw the chamfers 4–8 and 5–9.

6. Locate points 6 and 7, lying at the middle of the outer two faces.

7. Draw circular arcs passing through the points 4, 6, 2 and 3, 7, 5, after determining the radius R_1 geometrically.

8. Project the view from the side and locate points 10, 11 and 12.

9. Mark points 13 and 14, lying at the middle of the two faces (view from the side).

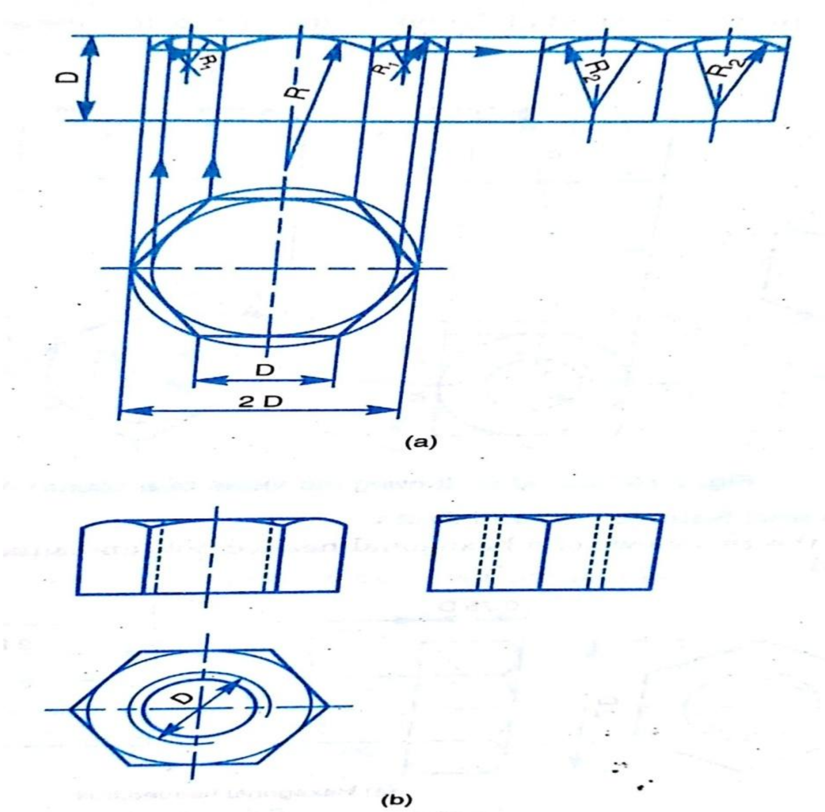
10. Draw circular arcs passing through the points 10, 13, 11 and 11, 14, 12, after determining the radius R_2 geometrically.

It may be noted that in the view from the front, the upper outer corners appear chamfered.
In the view from the side, where only two faces are seen, the corners appear square.

Method 2 (Fig.)
Empirical relations :
Major or nominal diameter of bolt = D
Thickness of nut, T= D
Width of the nut across corners= 2 D
Radius of chamfer arc, R= 1.5 D

Figure illustrates the stages of drawing different views of a hexagonal nut, following the above relations, which are self-explanatory.

The above method may be followed in routine drawing work, as it helps in drawing the views quickly.

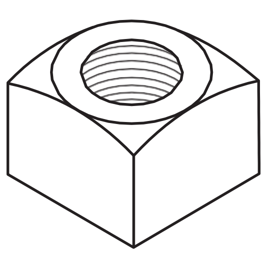


Method of drawing views of a hexagonal nut (Method II)

Method of Drawing Square (Bolt Head) Nut:

A square bolt head and nut may be drawn, showing either across flats or corners. Following relations may be adopted for the purpose:

Major or nominal diameter of bolt = D
Thickness of nut, T = D
Width of the nut across flats, W = 1.5 D + 3 mm
Radius of chamfer arc, R = 2 D



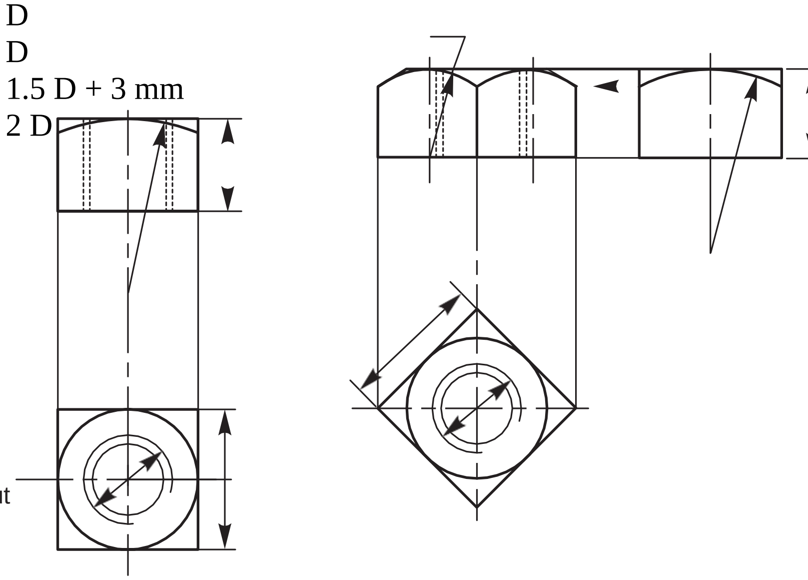
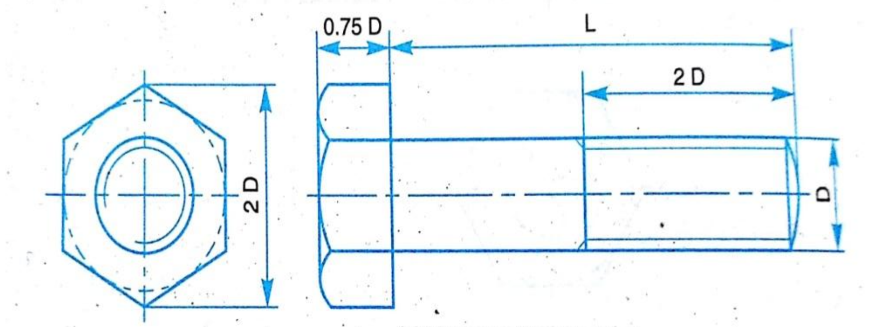


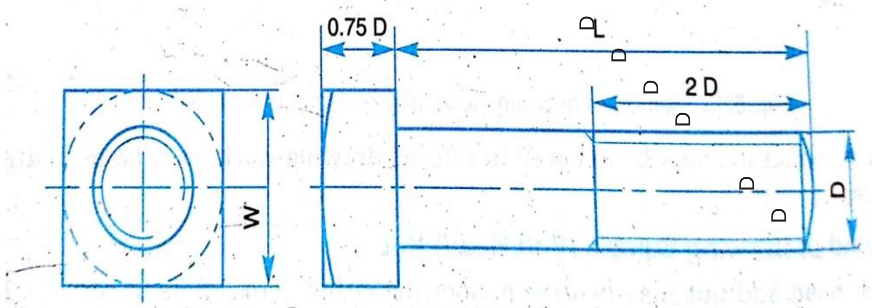
Fig:Method of drawing the views of a square nut

Hexagonal and Square Headed Bolts

Figure shows the two views of a hexagonal headed bolt and square headed bolt, with the proportions marked.



(a) Hexagonal headed bolt



(b) Square headed bolt

Washers:

A washer is a cylindrical piece of metal with a hole to receive the bolt. It is used to give a perfect seating for the nut and to distribute the tightening force uniformly to the parts under the joint. It also prevents the nut from damaging the metal surface under the joint. Figure shows a washer, with the proportions marked.Figure illustrates the views of a hexagonal headed bolt with a nut and a washer in position.

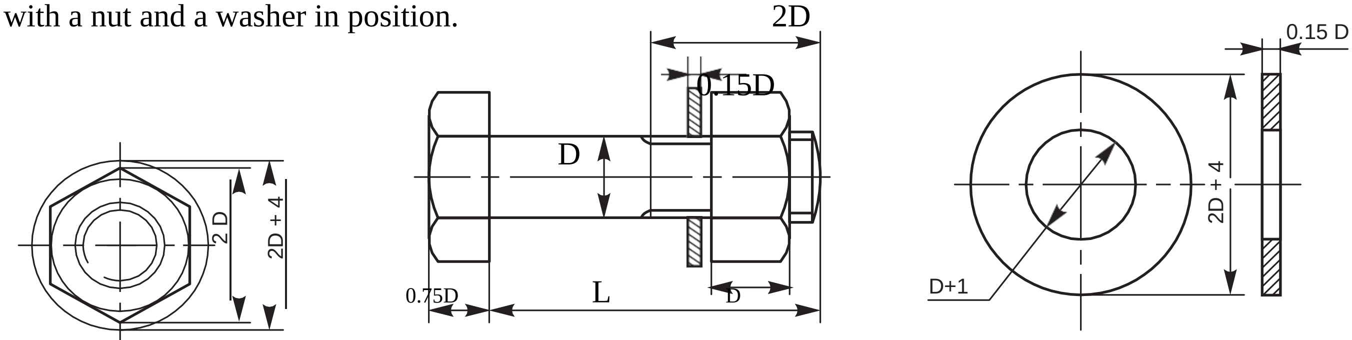


Fig:A hexagonal headed bolt with a nut and a washer in position

Other Forms of Bolts:

Square Headed Bolt with Square Neck: It is provided with a square neck, which fits into a corresponding square hole in the adjacent part, preventing the rotation of the bolt.

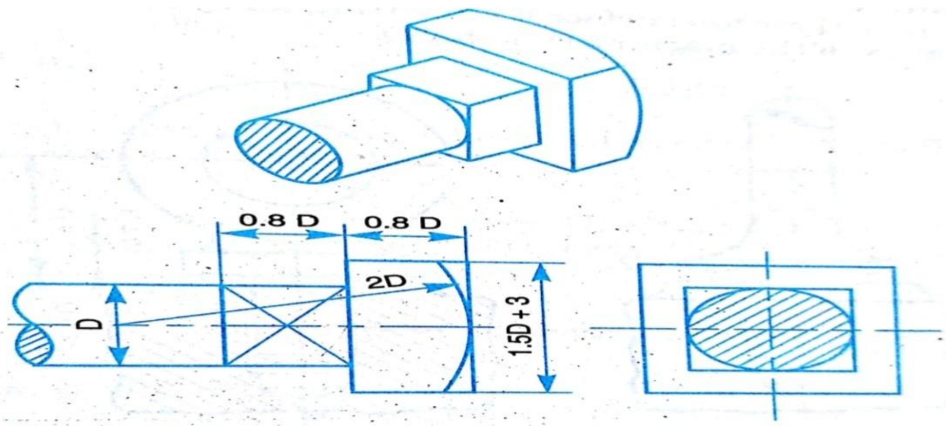


Fig. 5.18 Square headed bolt with square neck

T-Headed Bolt With Square Neck:

In this, a square neck provided below the head, prevents the rotation of the bolt. This type of bolt is used for fixing vices, work pieces, etc., to the machine table having T-slots Fig.

Hook Bolt:

This bolt passes through a hole in one part only, while the other part is gripped by the hook shaped bolt head. It is used where there is no space for making a bolt hole in one of the parts. The square neck prevents the rotation of the bolt Fig.

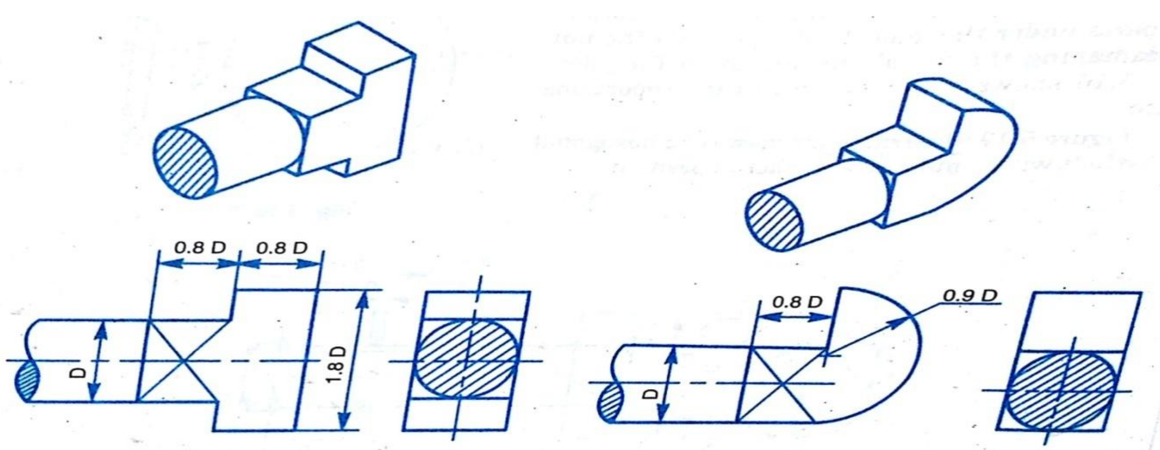
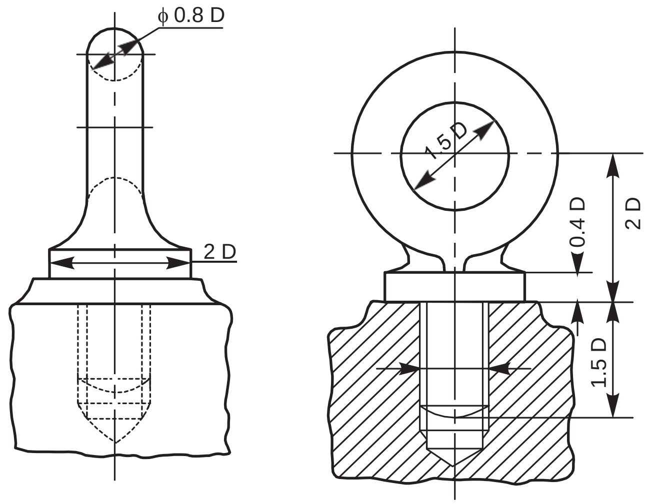


Fig. 5.19 T-headed bolt

Fig. 5.20 Hook bolt

Eye Bolt:

In order to facilitate lifting of heavy machinery, like electric generators, motors, turbines, etc., eye bolts are screwed on to their top surfaces. For fitting an eye bolt, a tapped hole is provided, above the centre of gravity of the machine Fig.



Cap Screws and Machine Screws

Cap screws and machine screws are similar in shape, differing only in their relative sizes. Machine screws are usually smaller in size, compared to cap screws. These are used for fastening two parts, one with clearance hole and the other with tapped hole. The clearance of the unthreaded hole need not be shown on the drawing as its presence is obvious. Figure 5.24 shows different types of cap and machine screws, with proportions marked.

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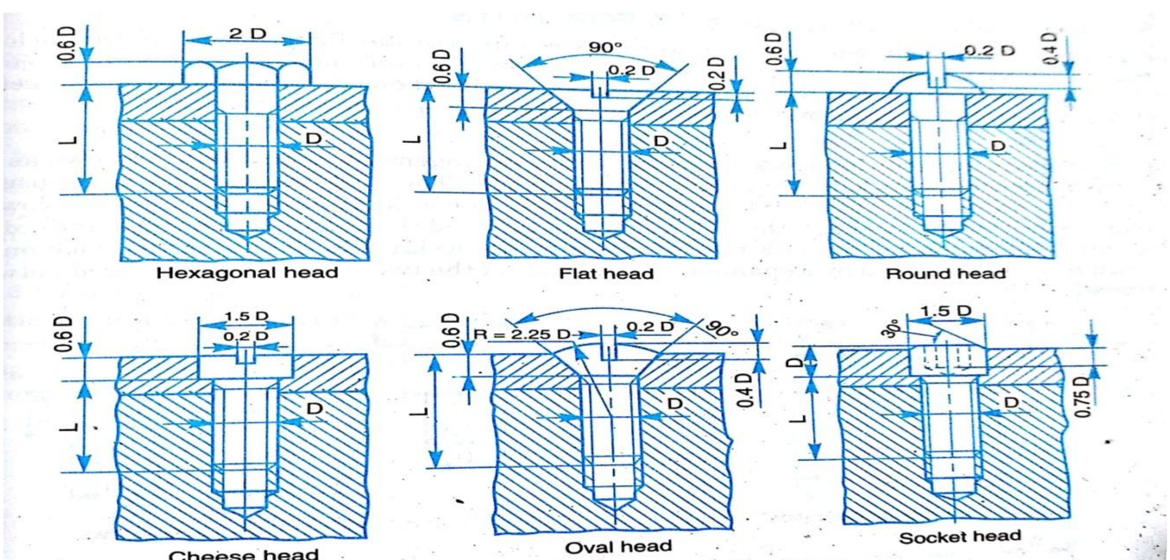

Fig. 5.24 Types of machine and cap screws

The bolted joints, though removable in nature, are required to stay firm without becoming loose, of their own accord. However, the joints used in the moving parts of a machinery, may be subjected to vibrations. This may slacken the joint, leading to serious breakdown. To eliminate the slackening tendency, different arrangements, as discussed further, are used to lock the nuts :

LOCK NUT:

This is the most commonly used locking device. In this arrangement, a second nut, known as lock nut is used in combination with a standard nut Fig. The thickness of a lock nut is usually two-thirds D, where D is the major diameter of the bolt. The lock nut is usually placed below the standard nut. To make the joint, the lock nut is first screwed tightly and then the standard nut is tightened till it touches the lock nut. Afterwards, the locknut is then screwed back on the standard nut, which is held by a spanner. The threads of the two nuts become wedged between the threads of the bolt.

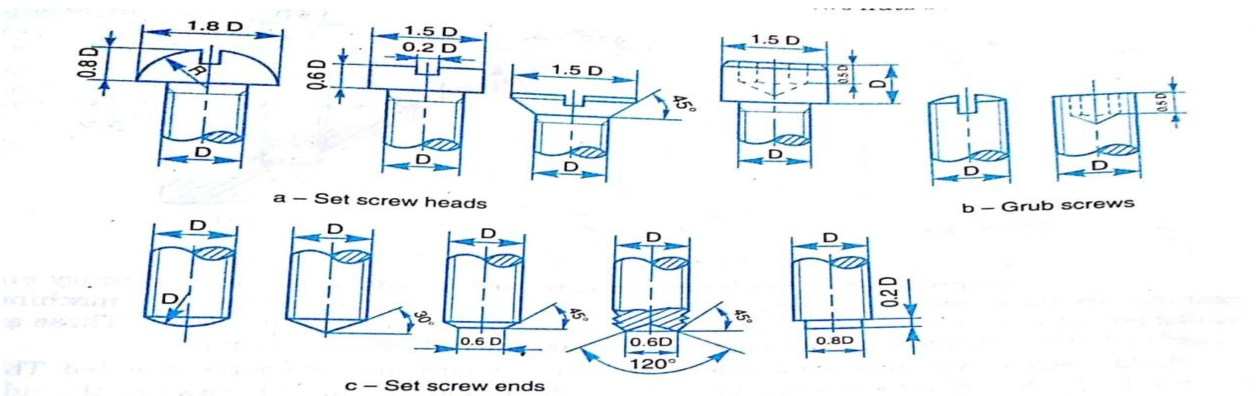

Fig. 5.26

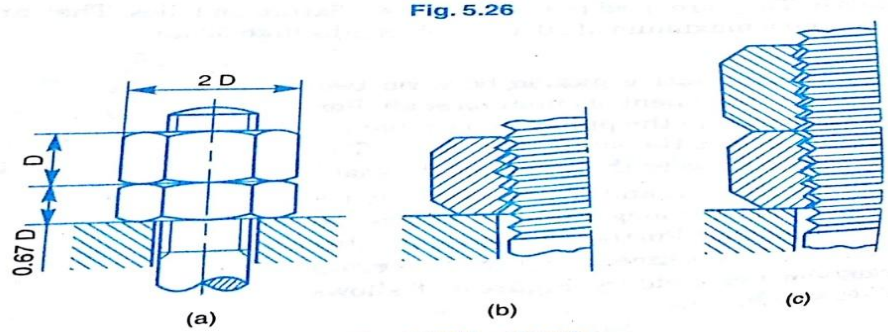

Fig. 5.27 Lock nut

LOCKING BY SPLIT PIN

A split pin, made of steel wire of semi-circular cross-section is used for locking the nut. In this arrangement, the split pin is inserted through a hole in the bolt body and touching just the top surface of the nut. Then, the ends of the pin are split open to prevent it from coming out while in use Fig.

LOCKING BY CASTLE NUT

A castle nut is a hexagonal nut with a cylindrical collar turned on one end. Threads are cut in the nut portion only and six rectangular slots are cut through the collar. A split pin is inserted through a hole in the bolt body after adjusting the nut such that the hole in the bolt body comes in-line with slots. This arrangement is used in automobile works Fig.

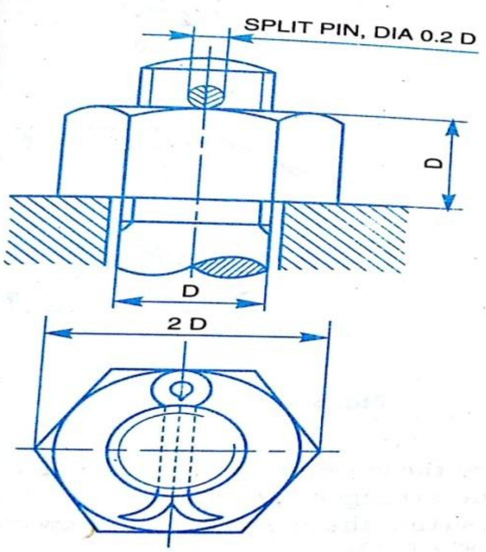

Fig. 5.28 Locking by split pin

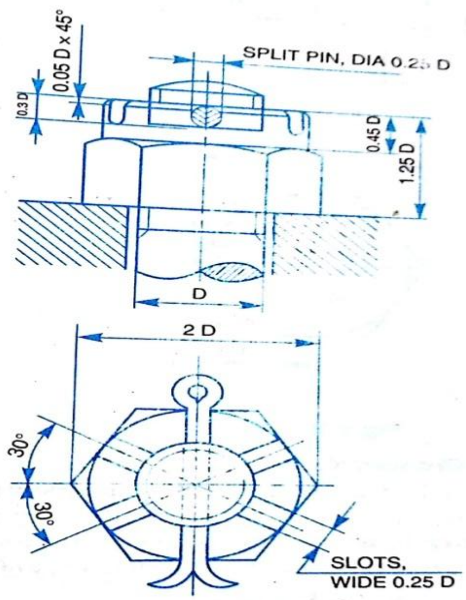

Fig. 5.29 Castle nut

WILE’S LOCK NUT

It is a hexagonal nut with a slot, cut half-way across it. After tightening the nut in the usual manner, a set screw is used from the top of the nut, compressing the two parts. For this purpose, the upper portion of the nut should have a clearance hole and the lower portion tapped Fig.

LOCKING BY SET SCREW

In this arrangement, after the nut is tightened, a set screw in fitted in the part, adjoining the nut, so that it touches one of the flat faces of the nut. The arrangement prevents the loosening tendency of the nut Fig.

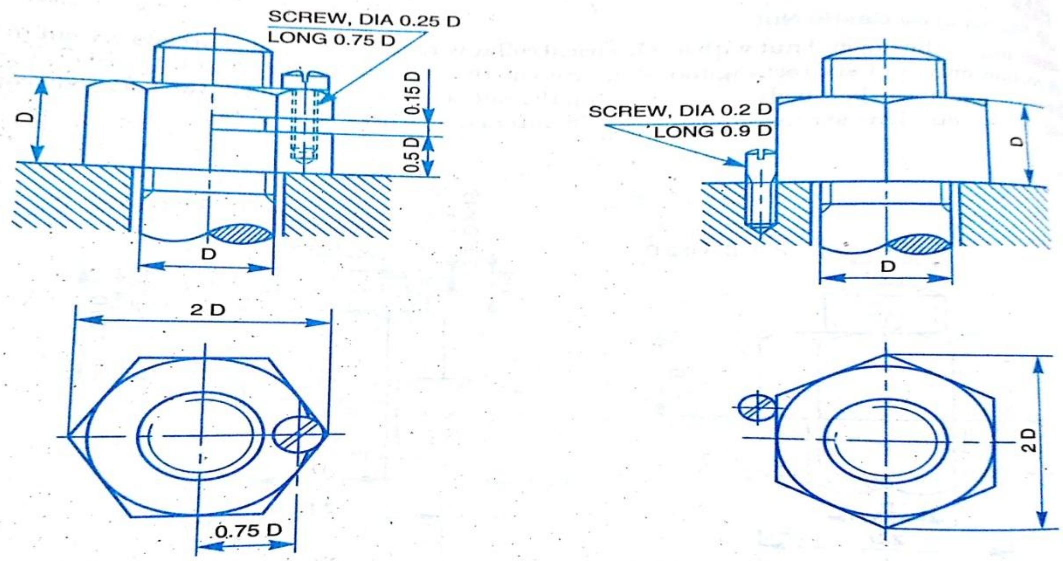

Fig. 5.30 Wile's lock nut

Fig. 5.31 Locking by set screw

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this arrangement, a set screw fitted through the cap and through the … prevents the loosening tendency of the nut, when the pitches of the main nut and the set screw are different Fig. This type of arrangement is used for fitting the propeller blades on turbine shafts.

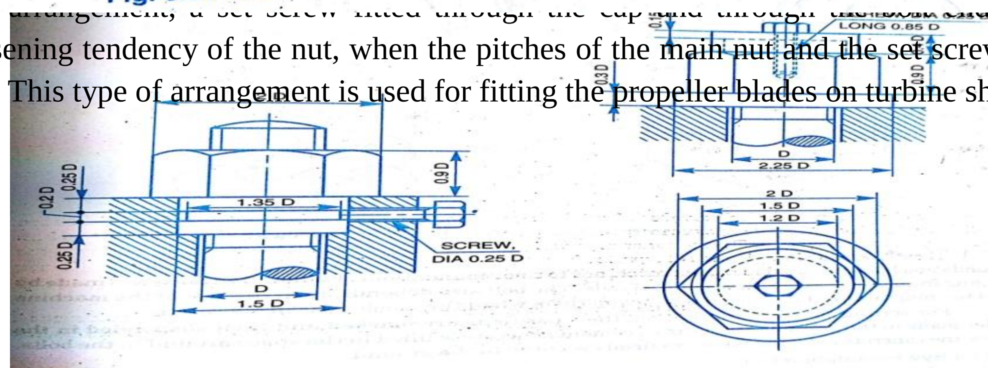


Fig. 5.32 Grooved nut

Fig. 5.33 Locking by screw

LOCKING BY PLATE

A locking plate is grooved such that it fits a hexagonal nut in any position, at intervals of 30° of rotation. It is fixed around the nut, by means of a machine screw, as shown in Fig.

LOCKING BY SPRING WASHER

In this arrangement, a spring washer of either single or double coil is placed under the nut and tightened. The spring force of the washer will be acting upwards on the nut. This force

FOUNDATION BOLTS:

Foundation bolts are used for fixing machines to their foundations. Foundation bolts are made by forging from mild steel or wrought iron rods. The bolt size depends upon the size of the machine and the magnitude of the forces that act on them when the machine is in operation.

For setting the bolts in position, their positions are marked and then suspended in the holes made in the ground. Afterwards, cement concrete is filled in the space around in the bolts. Once the concrete sets; the bolts are firmly secured to the ground.

EYE FOUNDATION BOLT

This is the simplest form of all foundation bolts. In this, one end of the bolt is forged into an eye and a cross piece is fixed in it. Figure shows an eye foundation bolt that is set in concrete.

BENT FOUNDATION BOLT

As the name implies, this bolt is forged in bent form and set in cement concrete. When machines are to be placed on stone beds, the bolts are set in lead. Figure shows a bent foundation bolt that is set first in lead and then in cement concrete, resulting in a firm and stable bolt.

RAG FOUNDATION BOLT

This bolt consists of a tapered body, square or rectangular in cross-section, the tapered edges being grooved. Figure shows a rag foundation bolt that is set first in lead and then in cement concrete.

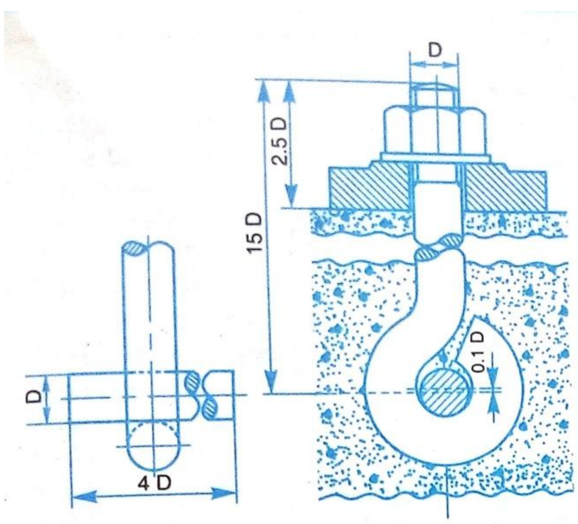


Fig: Eye foundation bolt

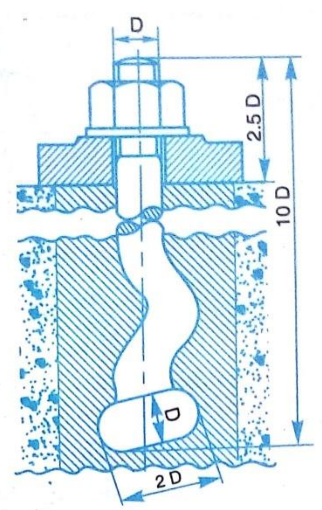


Fig: Bent foundation bolt

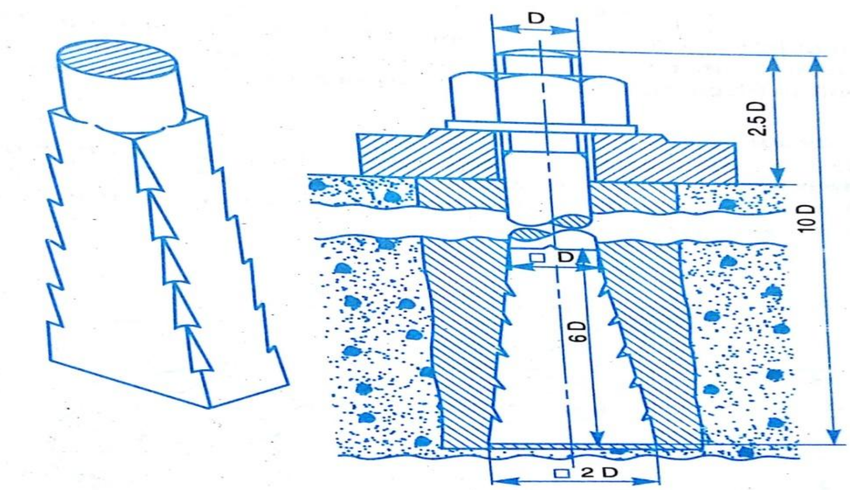


Fig: Rag foundation bolt

LEWIS FOUNDATION BOLT

This is a removable foundation bolt. The body of the bolt is tapered in width on one side. To use this bolt, a pit is produced in cement concrete, by using a (foundation) block. Once the concrete sets-in, the bolt is placed in it so that the tapered bolt surface, bears against the tapered face of the pit. A key is then inserted, bearing against the straight surfaces of the pit and the bolt. This arrangement makes the bolt firm in the bed. However, the bolt may be removed by withdrawing the key. This type of foundation bolt is not commonly used for fixing machines.

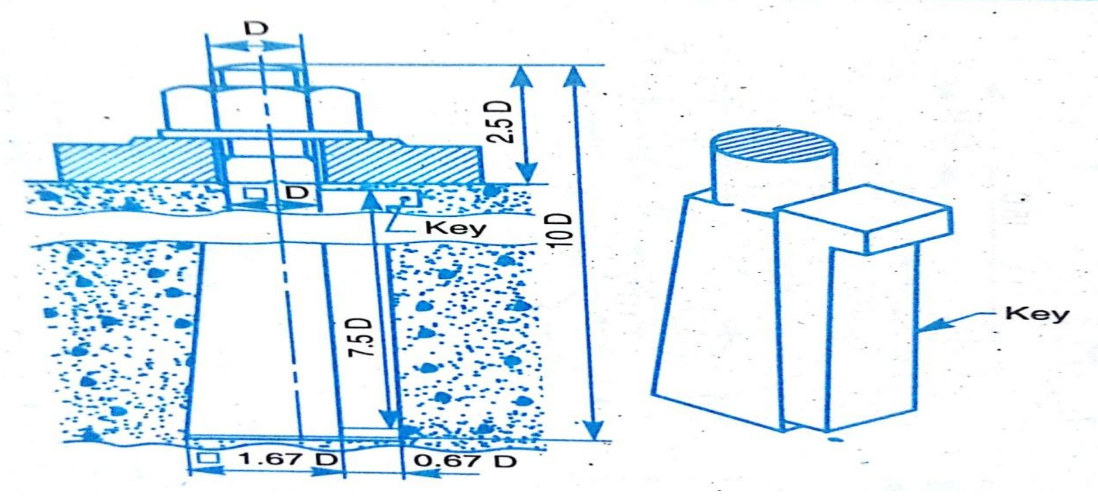


Fig. Lewis foundation bolt

COTTER FOUNDATION BOLT

It is used for fixing heavy machines. It has a rectangular slot at its bottom end, to receive a cotter. For putting the bolts in position, the foundation bed is first made, providing holes for inserting cotters. Figure shows a cotter foundation bolt in position. A cast iron washer (W) placed as shown, provides bearing surface for the cotter (C).

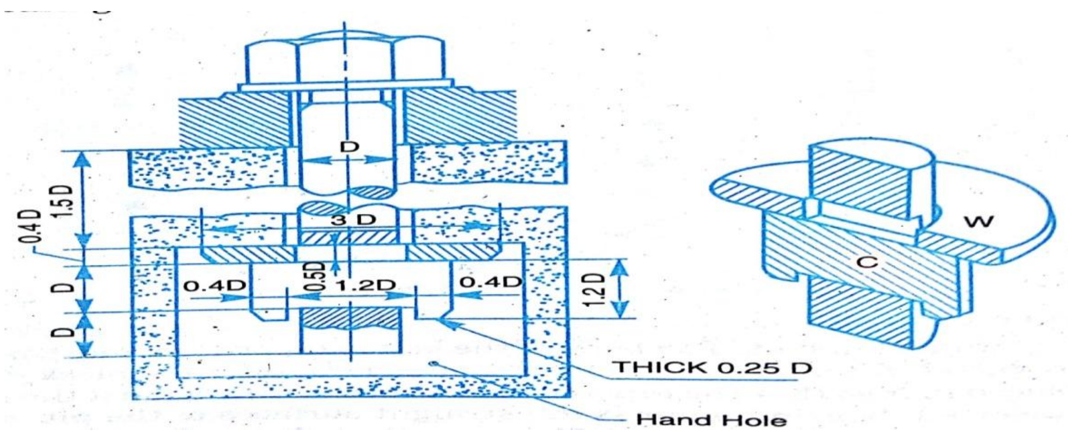


Fig: Cotter foundation bolt

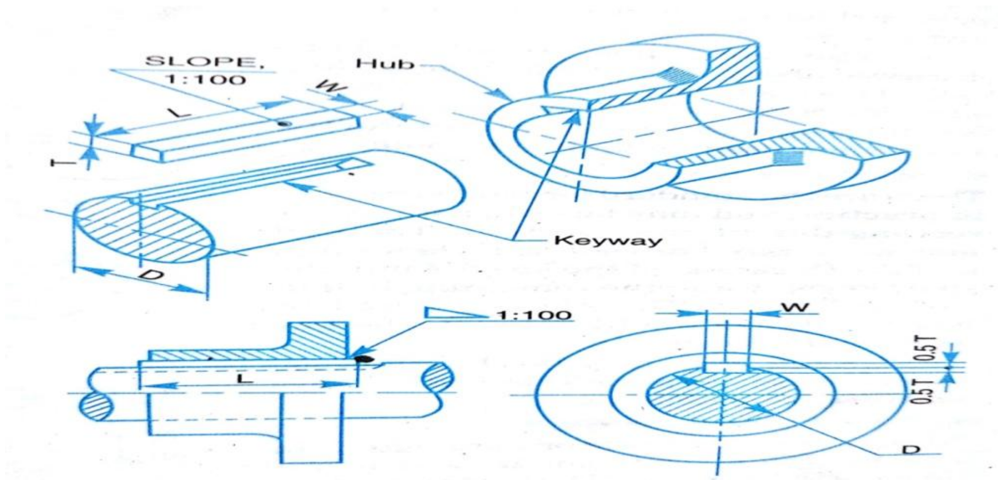
3. KEYS, COTTERS AND PIN JOINTS

INTRODUCTION

Keys, cotters and pin joints discussed in this chapter are some examples of removable (temporary) fasteners. Assembly and removal of these joints are easy as they are simple in shape. The standard proportions of these joints are given in the figures.

KEYS

Keys are machine elements used to prevent relative rotational movement between a shaft and the parts mounted on it, such as pulleys, gears, wheels, couplings, etc. Figure shows the parts of a keyed joint and its assembly.



Hollow Saddle Key

A hollow saddle key has a concave shaped bottom to suit the curved surface of the shaft, on which it is used. A keyway is made in the hub of the mounting, with a tapered bottom surface. When a hollow saddle key is fitted in position, the relative rotation between the shaft and the mounting is prevented due to the friction between the shaft and key.

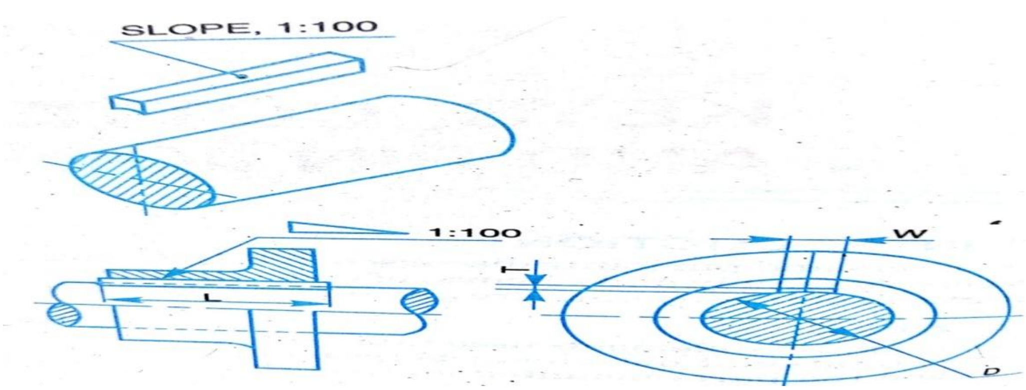


Fig: Hollow saddle key

Flat Saddle Key

It is similar to the hollow saddle key, except that the bottom surface of it is flat. Apart from the tapered keyway in the hub of the mounting, a flat surface provided on the shaft is used to fit this key in position.

Sunk keys may be classified as:

(i)taper keys, (ii) parallel or feather keys and (iii) woodruff keys.

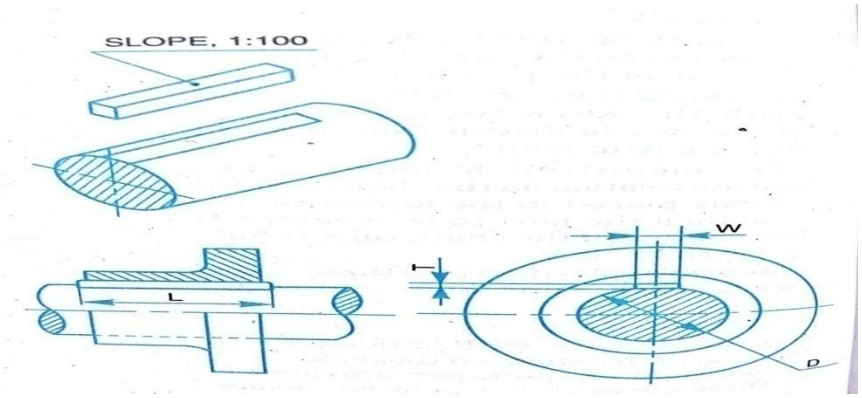


Fig: Flat Saddle Key

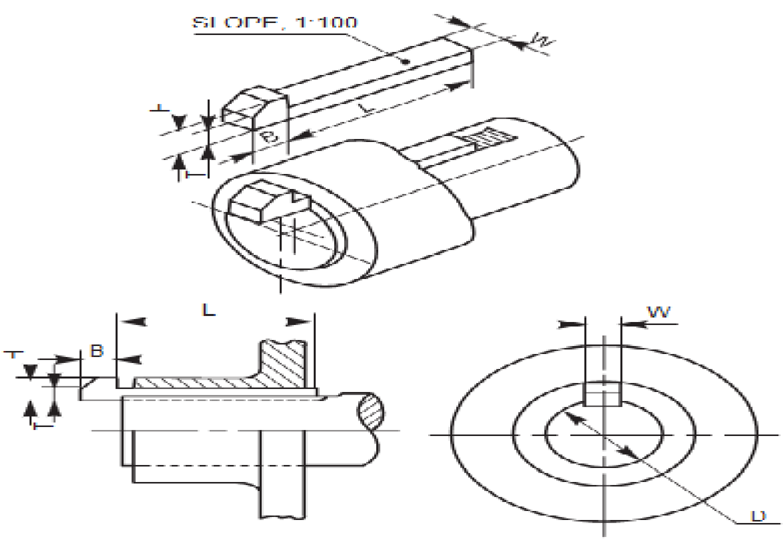


Fig. Key with gib head

Following are the proportions for a gib head:

Width of head, B = 1.5 T If D is the diameter of the shaft, then,

Width of key, W = 0.25 D + 2 mm

Thickness of key, T = 0.67 W (at the thicker end)

Standard taper = 1:100

Height of head, H = 1.75 T

Parallel or Feather Keys

A parallel or feather key is a sunk key, uniform in width and thickness as well. These keys are used when the parts (gears, clutches, etc.)

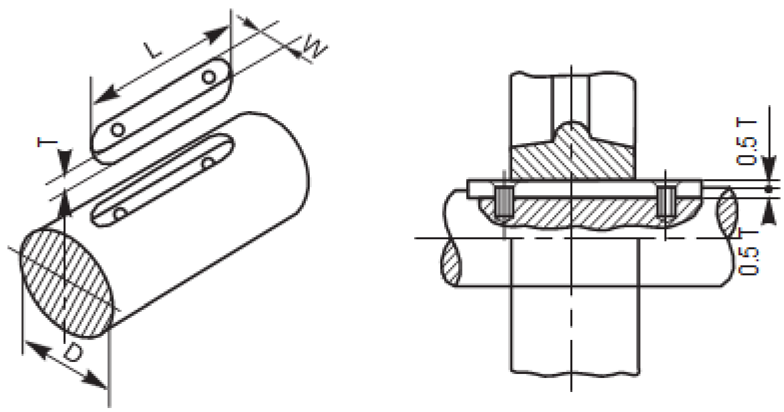
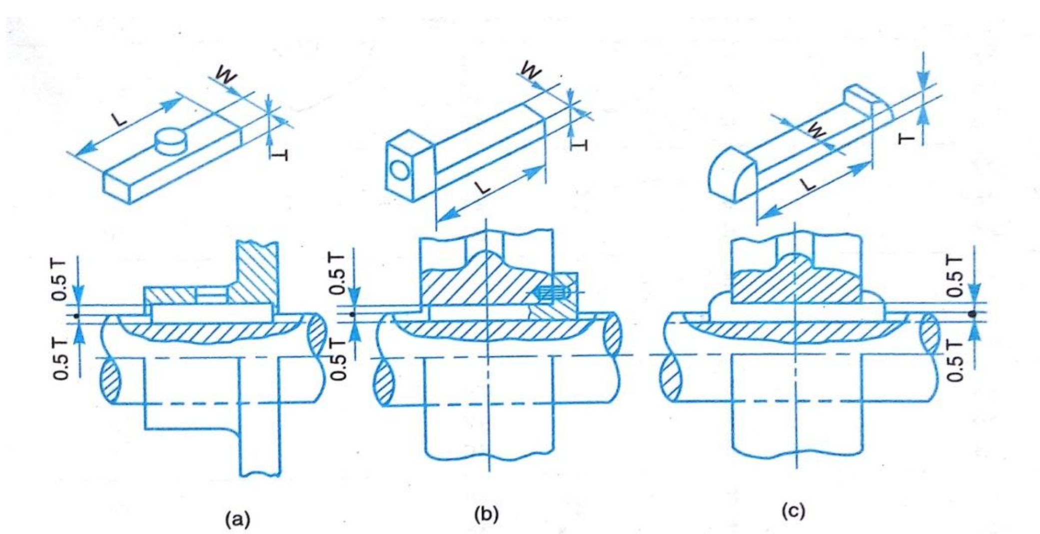


fig: Parallel sunk key

The feather key may be fitted into the keyway provided on the shaft by two or more screws Fig. or into the hub of the mounting Fig. As seen from Fig., these keys are of three types: (i) peg feather key, (ii) single headed feather key and (iii) double headed feather key.



Peg Feather Key:

In this key, a projection known as peg is provided at the middle of the key. The peg fits into a hole in the hub of the sliding member (Fig. *a*). Once placed in a position, the key and the mounting move axially as one unit.

Single Headed Feather Key:

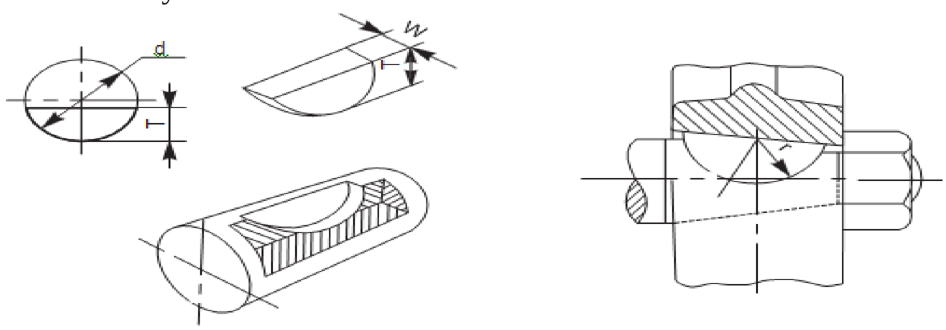
In this, the key is provided with a head at one end. The head is screwed to the hub of the part mounted on the shaft (Fig. *b*).

Double Headed Feather Key:

In this, the key is provided with heads on both ends. These heads prevent the axial movement of the key in the hub. Here too, once placed in position, the key and the mounting move as one unit (Fig. c).

Woodruff Key:

It is a sunk key, in the form of a segment of a circular disc of uniform thickness. As the bottom surface of the key is circular, the keyway in the shaft is in the form of a circular recess to the same curvature as the key.



(a) (b)

Fig: Woodruff Key

If D is the diameter of the shaft,

Thickness of key, W	= 0.25 D
Diameter of key, d	= 3 W
Height of key, T	= 1.35 W
Depth of the keyway in the hub, T1	= 0.5 W + 0.1 mm
Depth of keyway in shaft, T2	= 0.85 W

Round Keys: Round keys are of circular cross-section, usually tapered (1:50) along the length. A round key fits in the hole drilled partly in the shaft and partly in the hub Fig.The mean diameter of the pin may be taken as 0.25 D, where D is shaft diameter. Round keys are generally used for light duty, where the loads are not considerable.

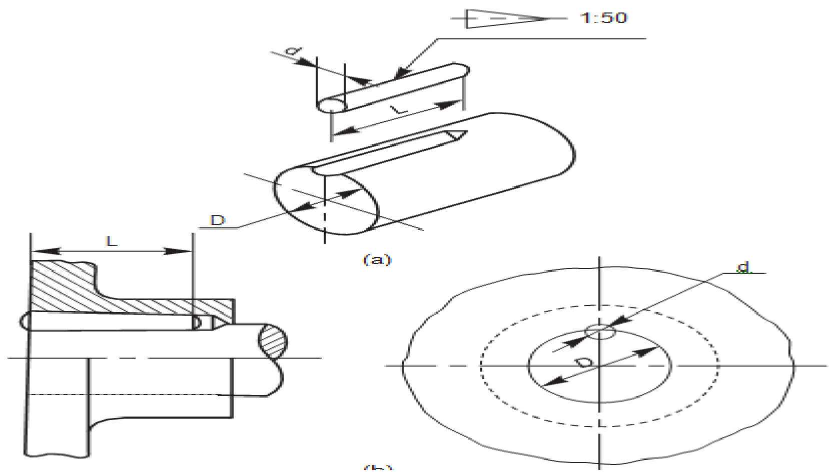


Fig: Round key

COTTER JOINTS:

Cotter joints are used to connect two rods, subjected to tensile or compressive forces along their axes. These joints are not suitable where the members are under rotation. The following are some of the commonly used cotter joints:

Cotter Joint with Sleeve:

This is the simplest of all cotter joints, used for fastening two circular rods. To make the joint, the rods are enlarged at their ends and slots are cut. After keeping the rods butt against each other, a sleeve with slots is placed over them. After aligning the slots properly, two cotters are driven-in through the slots, resulting in the joint Fig

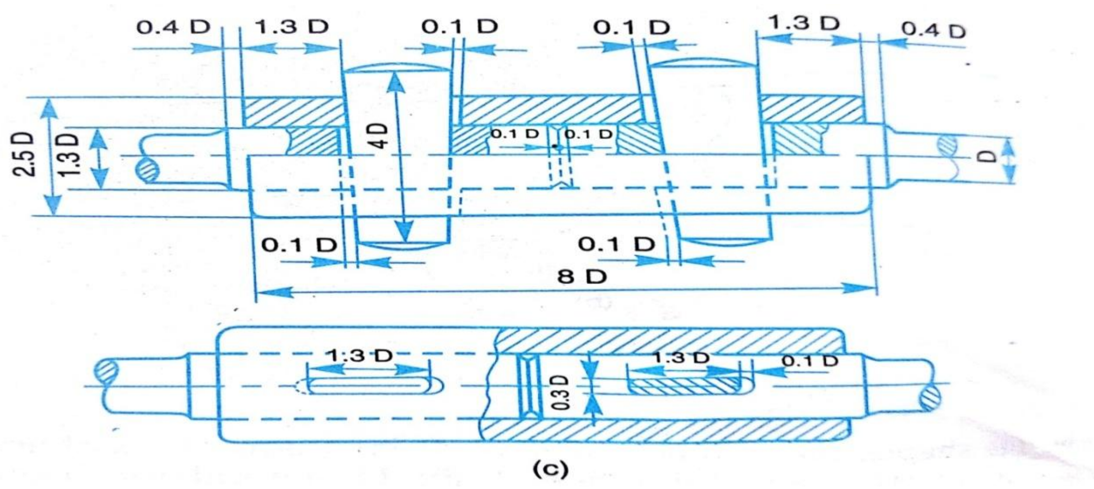
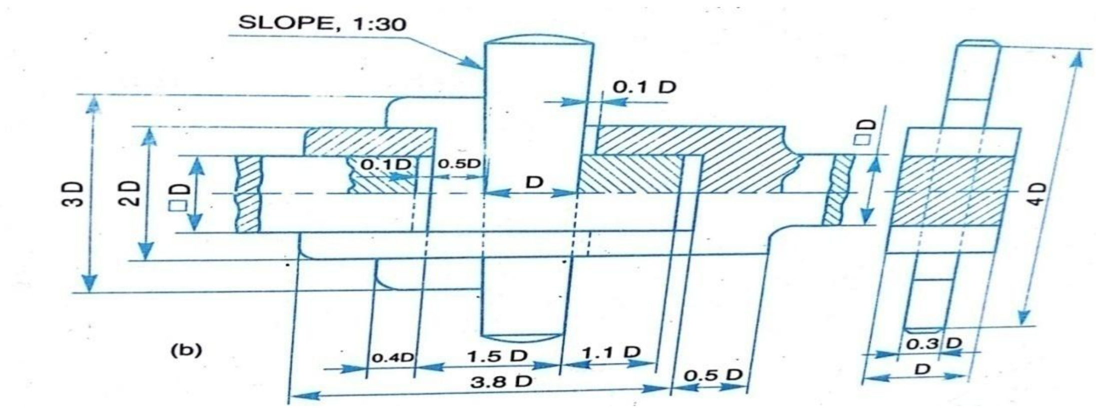


Fig. Cotter joint with sleeve

Cotter Joint with Socket and Spigot Ends

This joint is also used to fasten two circular rods. In this, the rod ends are modified instead of using a sleeve. One end of the rod is formed into a socket and the other into a spigot Fig. and slots are cut. After aligning the socket and spigot ends, a cotter is driven-in through the slots, forming the joint.



Cotter Joint with a Gib

This joint is generally used to connect two rods of square or rectangular cross-section. To make the joint, one end of the rod is formed into a U-fork, into which, the end of the other rod fits in. When a cotter is driven-in, the friction between the cotter and straps of the U-fork, causes the straps to open. This is prevented by the use of a gib.

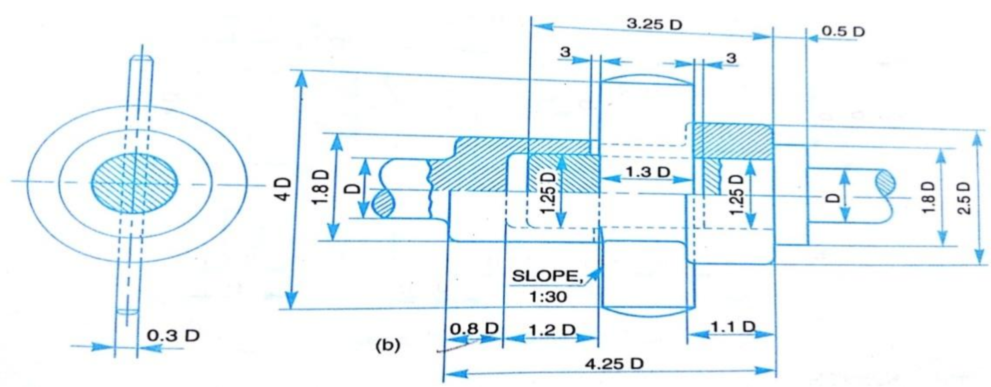


Fig. Cotter joint with a gib

PIN JOINTS: In a pin joint, a pin is used to fasten two rods that are under the action of a tensile force; although the rods may support a compressive force if the joint is guided. Some pin joints such as universal joints, use two pins and are used to transmit power from one rotating shaft to another.

Knuckle Joint:A knuckle joint is a pin joint used to fasten two circular rods. In this joint, one end of the rod is formed into an eye and the other into a fork (double eye). For making the joint, the eye end of the rod is aligned into the fork end of the other and then the pin is inserted through the holes and held in position by means of a collar and a taper pin (Fig). Once the joint is made, the rods are free to swivel about the cylindrical pin.

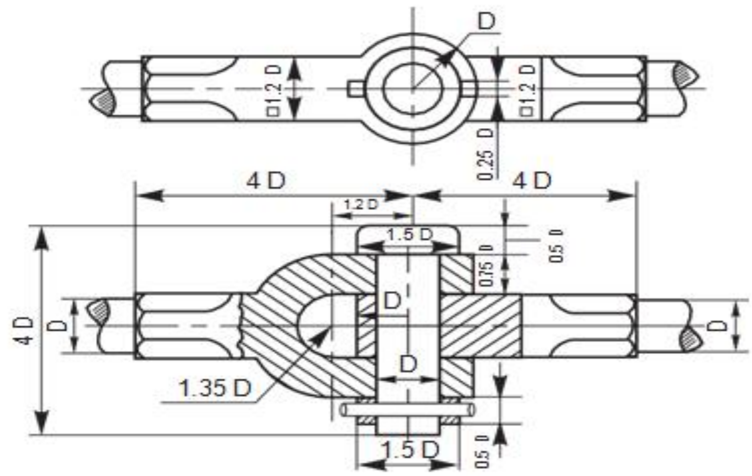


Fig. Knuckle joint

4.SHAFT COUPLINGS

INTRODUCTION

Shaft couplings are used to join or connect two shafts in such a way that when both the shafts rotate, they act as one unit and transmit power from one shaft to the other. Shafts to be connected or coupled may have collinear axes, intersecting axes or parallel axes at a small distance. Based on the requirements, the shaft couplings are classified as: (i) rigid couplings, (ii)flexible couplings, (iii) loose or dis-engaging couplings and (iv) non-aligned couplings.

Rigid Couplings

Rigid shaft couplings are used for connecting shafts having collinear axes. These are further sub-classified into muff or sleeve couplings and flanged couplings.

Sleeve or Muff Couplings

This is the simplest of all couplings. It consists of a sleeve called muff, generally made of cast iron, which is fitted over the ends of the shafts to be connected. After properly aligning the keyways in the shafts and sleeve, a sunk key is driven-in; thus making the coupling. Instead of a single key running the entire length of the sleeve, it is desirable to use two keys, which may be inserted from the outer ends of the sleeve; thus overcoming the possible mis-alignment between the keyways. The following are the types of muff couplings:

Butt-muff Coupling

In this, the ends of the two shafts to be coupled butt against each other, with the sleeve keyed to them, as discussed above .

Half-lap Muff Coupling

In this, the ends of the shafts overlap each other for a short length. The taper provided in the overlap prevents the axial movement of the shafts. Here too, after placing the muff over the overlapping ends of the shafts, a saddle key(s) is(are) used to make the coupling.

Split-muff Coupling

In this, the muff is split into two halves and are recessed. A number of bolts and nuts are used to connect the muff halves and the recesses provided accommodate the bolt heads and nuts.

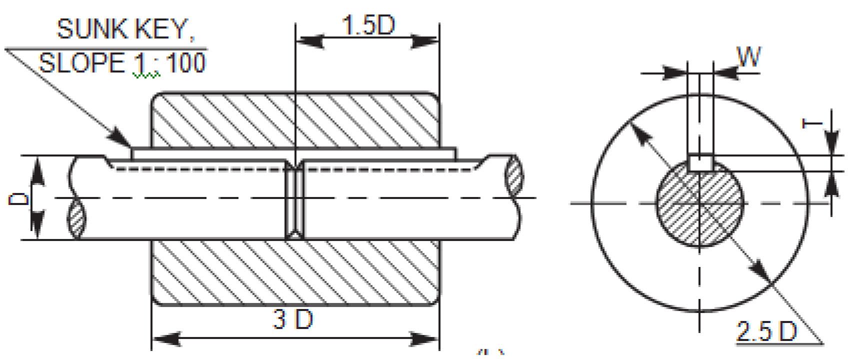


Fig. Butt-muff coupling

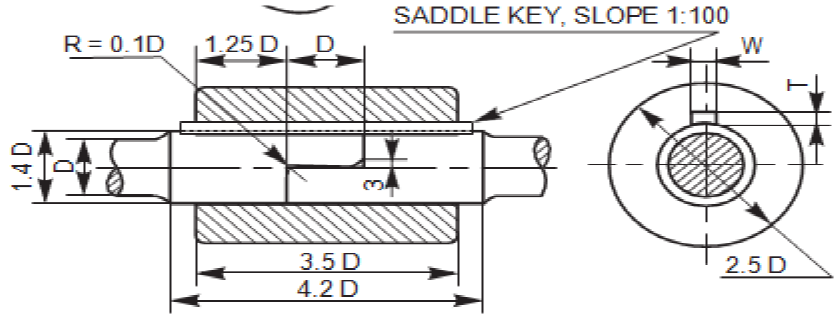


Fig. Half-lap muff coupling

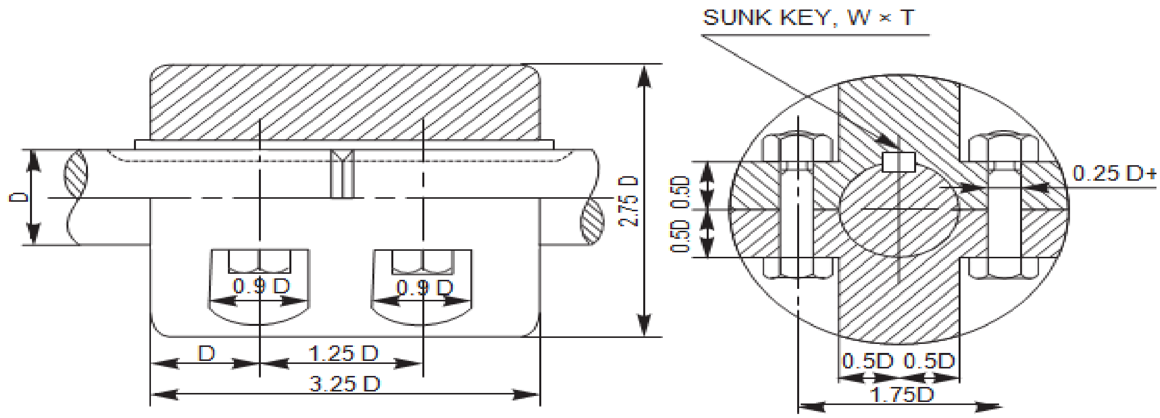


Fig. Split-muff coupling

Flanged Couplings

These are the standard forms of couplings, most extensively used. In a flanged coupling, flanges are either fitted or provided at the ends of shafts. The flanges are fastened together by means of a number of bolts and nuts. The number and size of the bolts depend upon the power to be transmitted and hence, the shaft diameter.

Flanged Coupling with Detachable Flanges

In this, two flanges are keyed, one at the end of each shaft, by means of sunk keys. For ensuring correct alignment, a cylindrical projection may be provided on one flange which fits into the corresponding recess in the other.

Solid Flanged Coupling

Couplings for marine or automotive propeller shafts demand greater strength and reliability. For these applications, flanges are forged integral with the shafts. The flanges are joined together by means of a number of headless taper bolts.

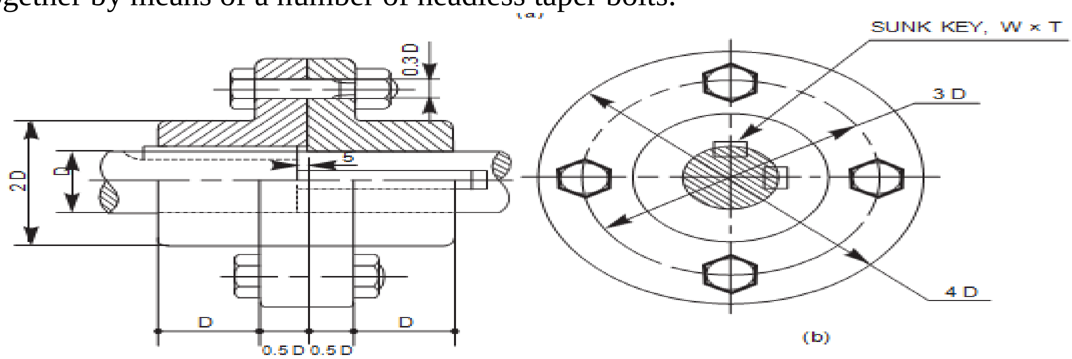


Fig. Flanged coupling

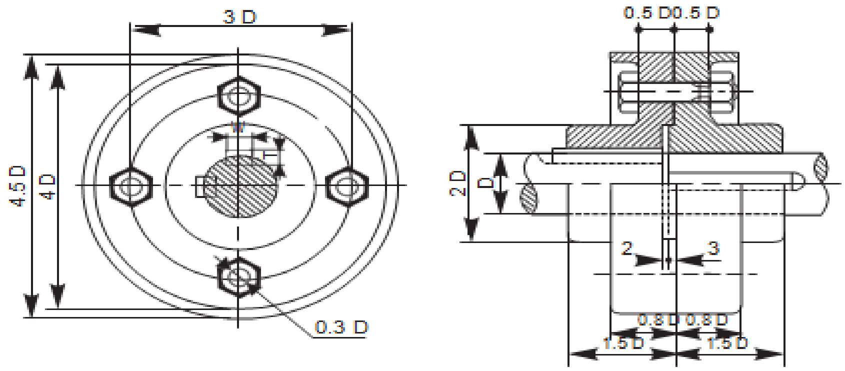


Fig. Protected flanged coupling

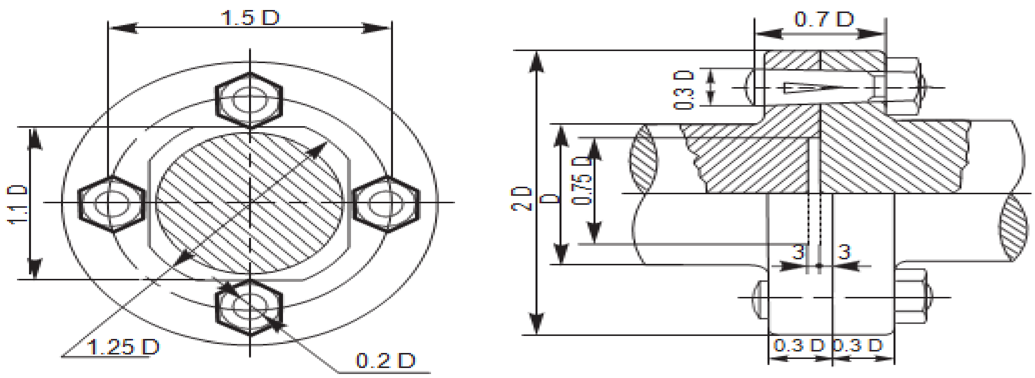


Fig. Solid flanged coupling

Compression Coupling

This consists of a compressible steel sleeve which fits on to the ends of the shafts to be coupled. The sleeve corresponds to the shaft diameter and its outer surface is of double conical form. The sleeve has one through cut longitudinally and five other cuts, equi-spaced, but running alternately from opposite ends to about 85% of its length; making it radially flexible.

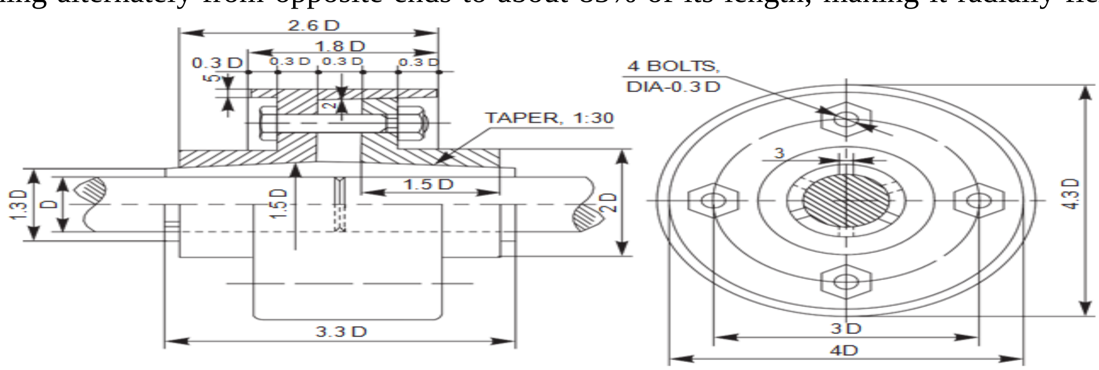


Fig. Compression coupling

Claw Coupling

In this, each flange has a number of identical claws which engage into the corresponding recesses in the flange. One flange is firmly fitted to the driving shaft by means of a taper sunk key. The other one is placed over the driven shaft by two feather keys, so that it can slide freely on it. The sliding flange has a groove on the boss, into which the forked end of a lever fits.

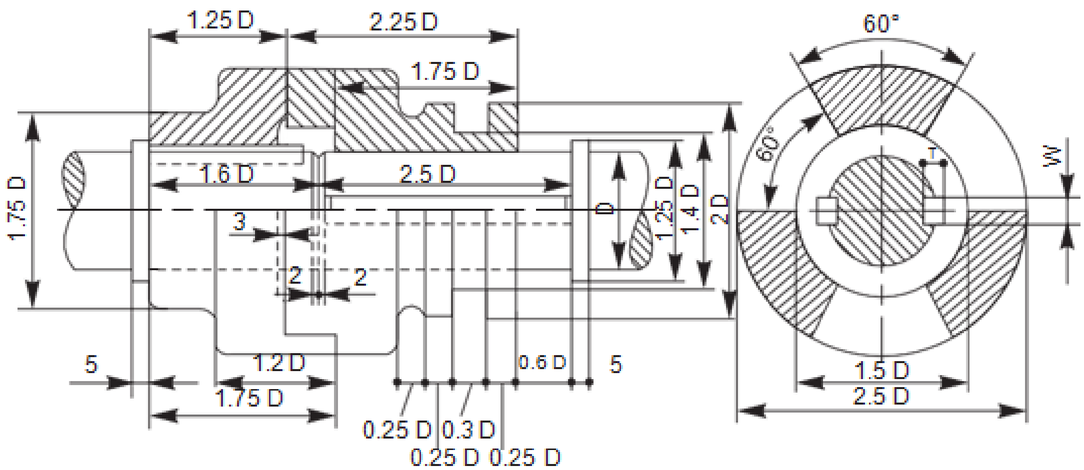


Fig. Claw coupling

Cone Coupling

In this, two shafts may be coupled together by means of two flanges with conical surfaces (on the inside of one and on the outside of the other) by virtue of friction. Here too, one flange is firmly fitted to the driving shaft by means of a taper sunk key, whereas the other slides freely over a feather key fitted to the driven shaft.

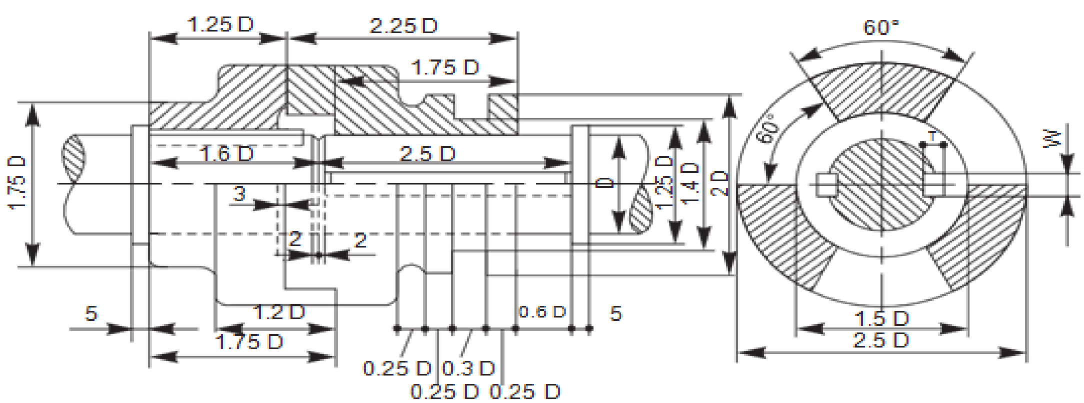


Fig.Cone coupling

Universal Coupling (Hooke's Joint): It is a rigid coupling that connects two shafts, whose axes intersect if extended. It consists of two forks which are keyed to the shafts. The two forks are pin joined to a central block, which has two arms at right angle to each other in the form of a cross.The angle between the shafts may be varied even while the shafts are rotating.

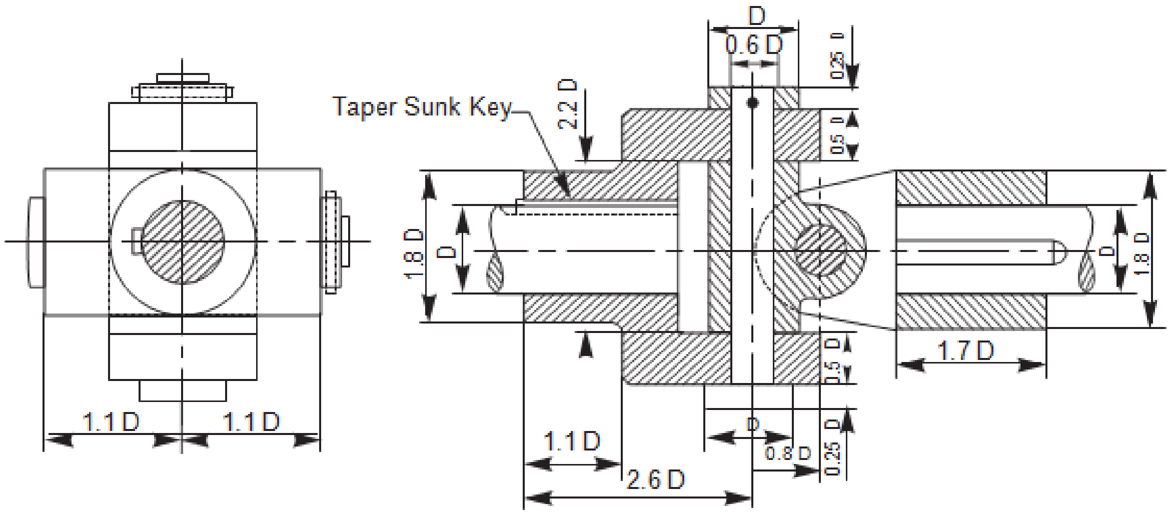


Fig. Universal coupling

Oldham Coupling

It is used to connect two parallel shafts whose axes are at a small distance apart. Two flanges, each having a rectangular slot, are keyed, one on each shaft. The two flanges are positioned such that, the slot in one is at right angle to the slot in the other.

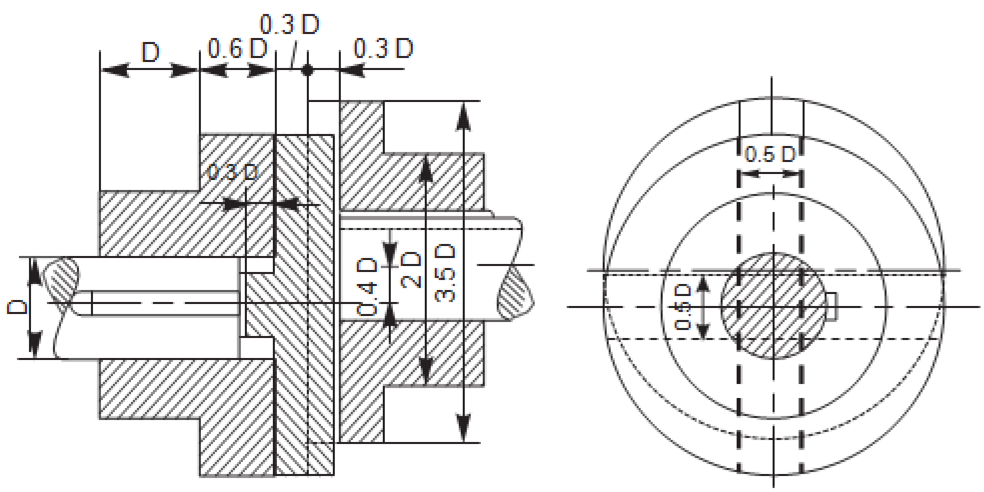


Fig. Oldham coupling

Socket and Spigot Joint

This type of joint is used for underground pipelines of large diameters. In this, one end of a pipe is made into a socket and the other end into a spigot. After placing the spigot end into the socket, the space between them is filled-in, partly by rope (jute or coir) and the remaining by molten lead.

Because of the flexible nature of the joint, it adapts itself to small changes in level due to settlement of earth.

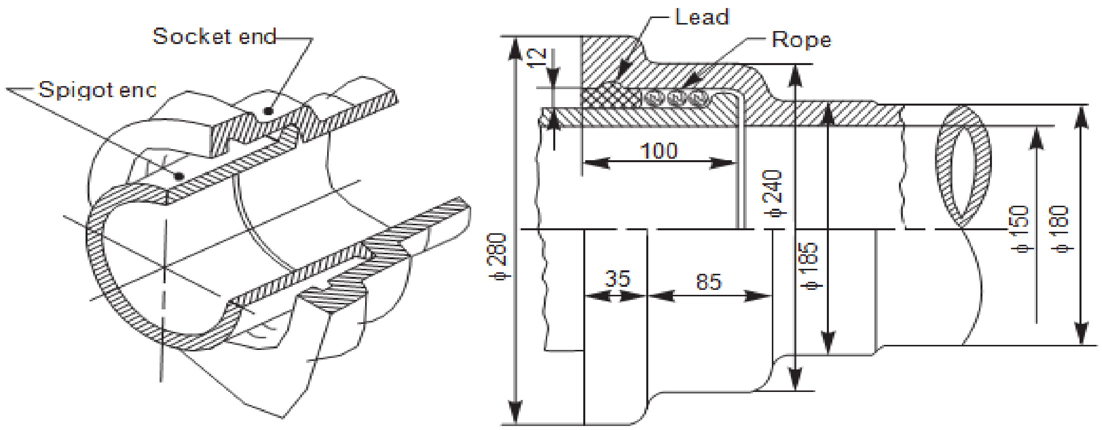


Fig. Socket and spigot joint

5. RIVETTED JOINTS FOR PLATES

INTROOUSTION

Riveted joints are permanent fastenings and riveting is one of the commonly used method of producing rigid and permanent joints. Manufacture of boilers, storage tanks, etc., involve joining of steel sheets, by means of riveted joints. These joints are also used to fasten rolled steel sections in structural works, such as bridge and roof trusses.

Rivet

A rivet is a round rod of circular cross-section. It consists of two parts, viz., head and shank (Fig.(*a*)). Mild steel, wrought iron, copper and aluminum alloys are some of the metals commonly used for rivets. The choice of a particular metal will depend upon the place of application.

Riveting

Riveting is the process of forming a riveted joint. For this, a rivet is first placed in the hole drilled through the two parts to be joined. Then the shank end is made into a rivet head by applying pressure, when it is either in cold or hot condition.

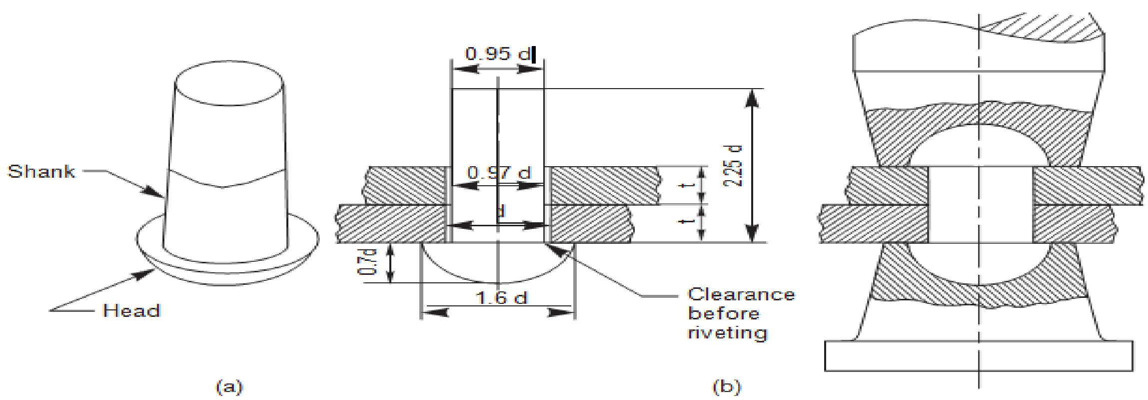


Fig.(*a*) Rivet (*b*) Riveting

RIVET HEADS:

Various forms of rivet heads, used in general engineering works and boiler construction and as recommended by Bureau of Indian Standards, are shown in Fig. The standard proportions are also indicated in the figure.

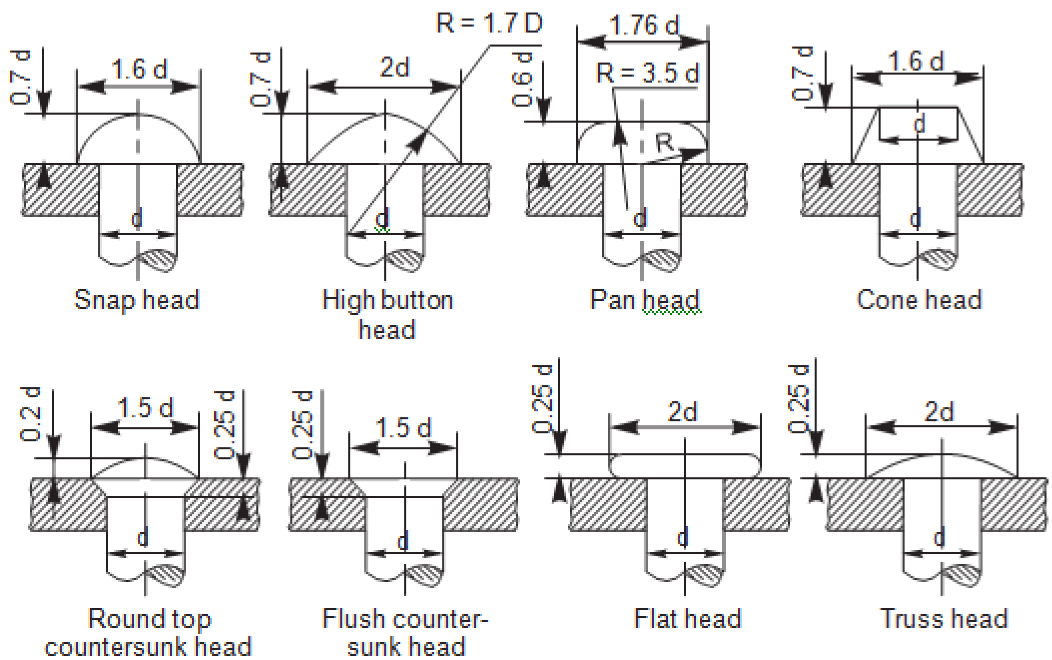


Fig. Types of rivet heads

Diamond Butt Joint:

This is one kind of butt joint made either with a single or double strap. As the name implies, the rivets in this joint are arranged in a diamond shape. Figure shows a double strap diamond butt joint. The joint is generally used to connect tie bars in bridge structures and roof trusses.

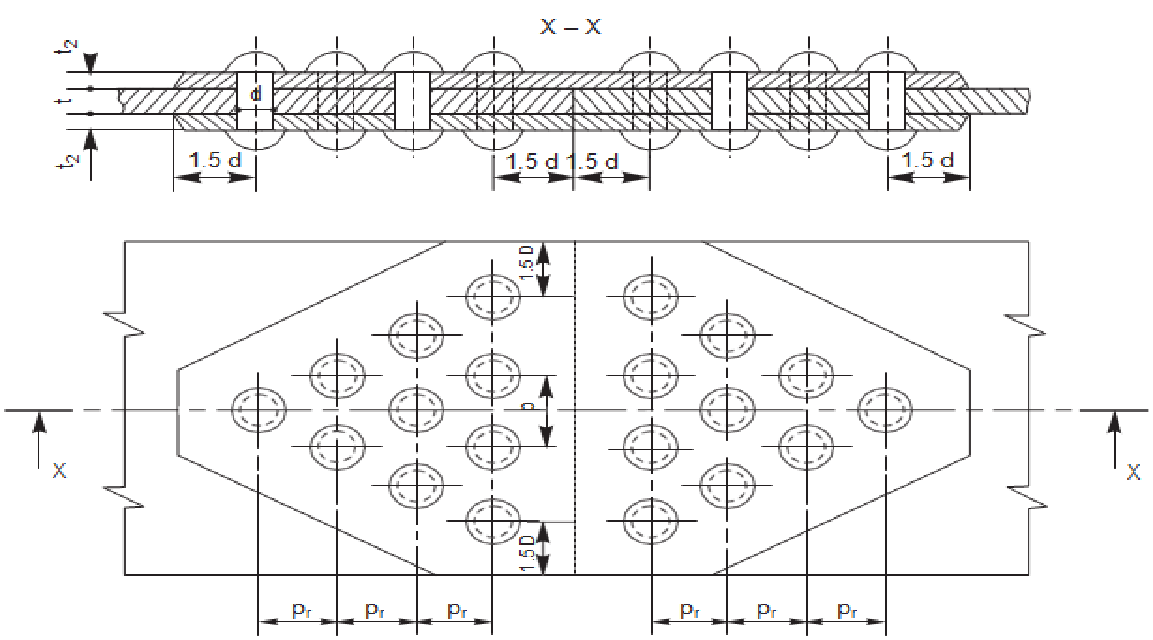


Fig: Double strap diamond butt joint

Lap Joints:

In a lap joint, the plates to be riveted, overlap each other. The plates to be joined are first bevelled at the edges, to an angle of about 80°. Depending upon the number of rows of rivets used in the joint, lap joints are further classified as single riveted lap joint, double riveted lap joint and so on.

In multi-row riveted joints, rows may be arranged either in chain or zig-zag fashion, as shown in Figs. Figure shows a single riveted lap joint. The size of the rivet, *d* is taken as, $d = 6\sqrt{t}$ mm where '*t*' is the thickness of the plates to be joined in millimetres.

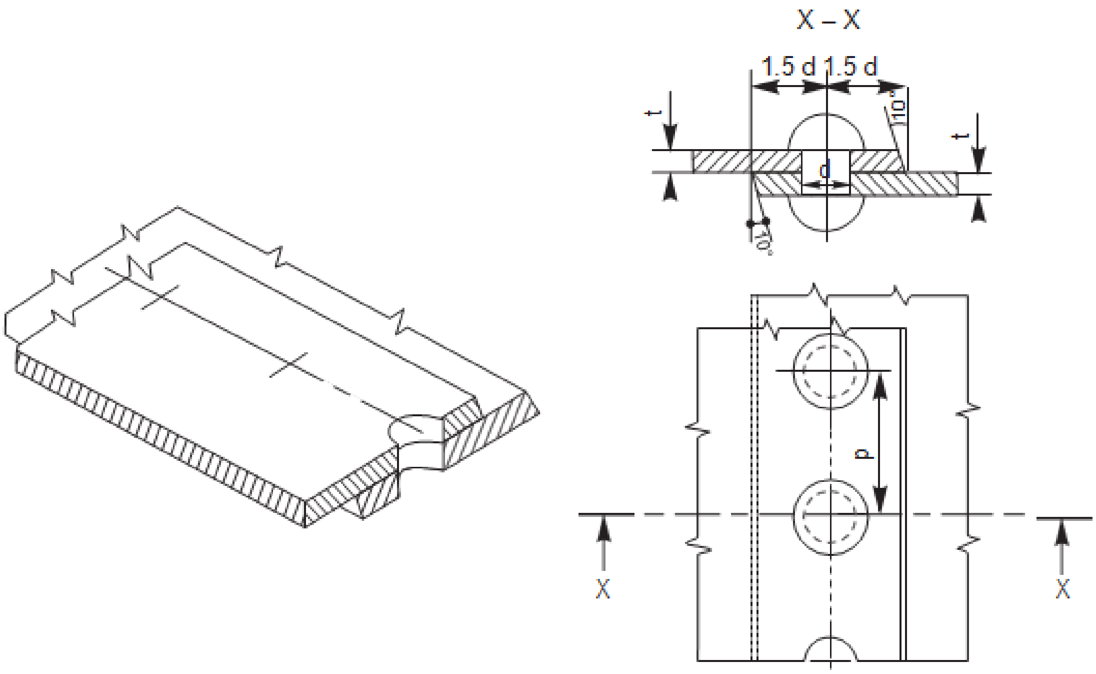


Fig. Single riveted lap joint

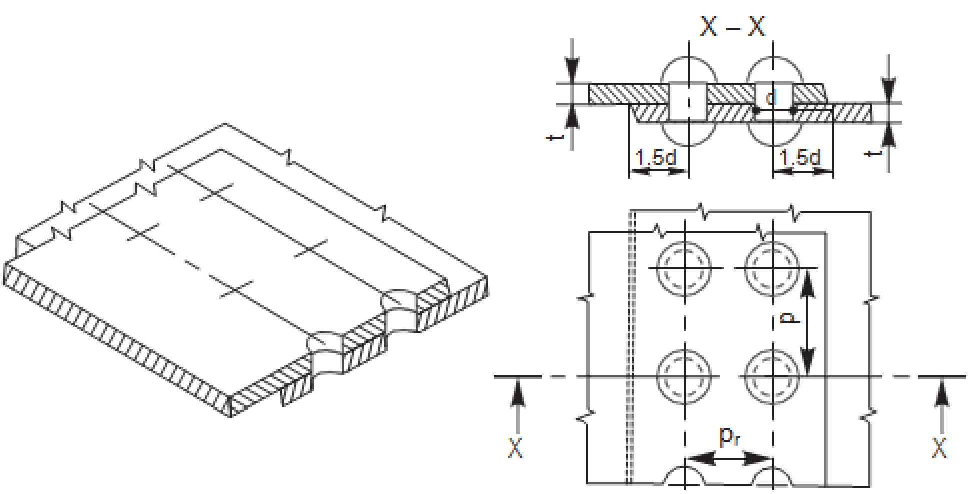


Fig. Double riveted chain lap joint

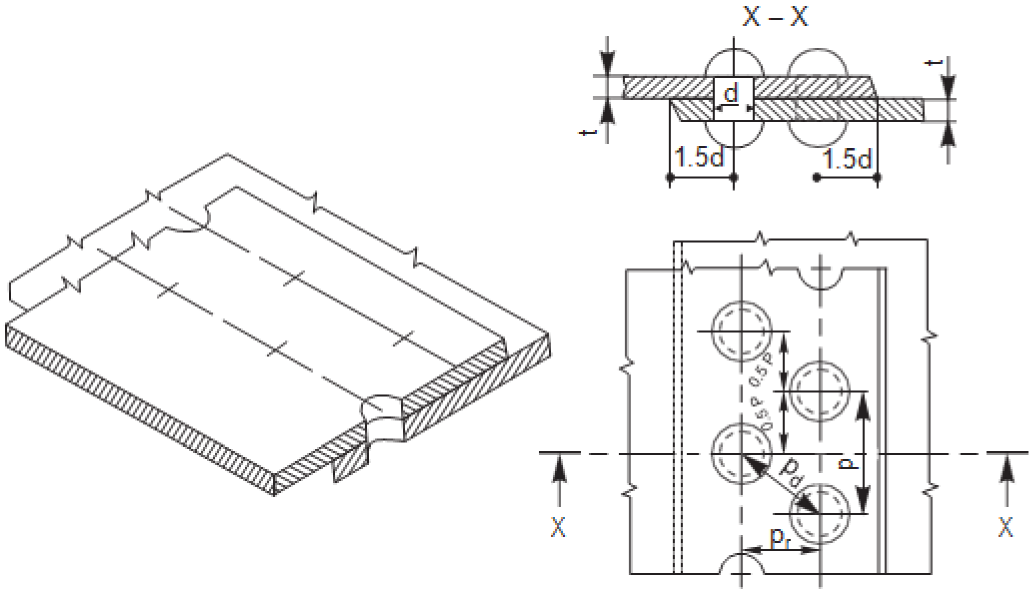


Fig. Double riveted zig-zag lap joint

Butt Joints:

In a butt joint, the plates to be joined, butt against each other, with a cover plate or strap, either on one or both sides of the plates; the latter one being preferred. In this joint, the butting edges of the plates to be joined are square and the outer edges of the cover plate(s) is(are) bevelled.

In a single strap butt joint, the thickness of the strap (cover plate) is given by, t1 = 1.125t If two straps are used, the thickness of each cover plate is given by, t2 = 0.75t

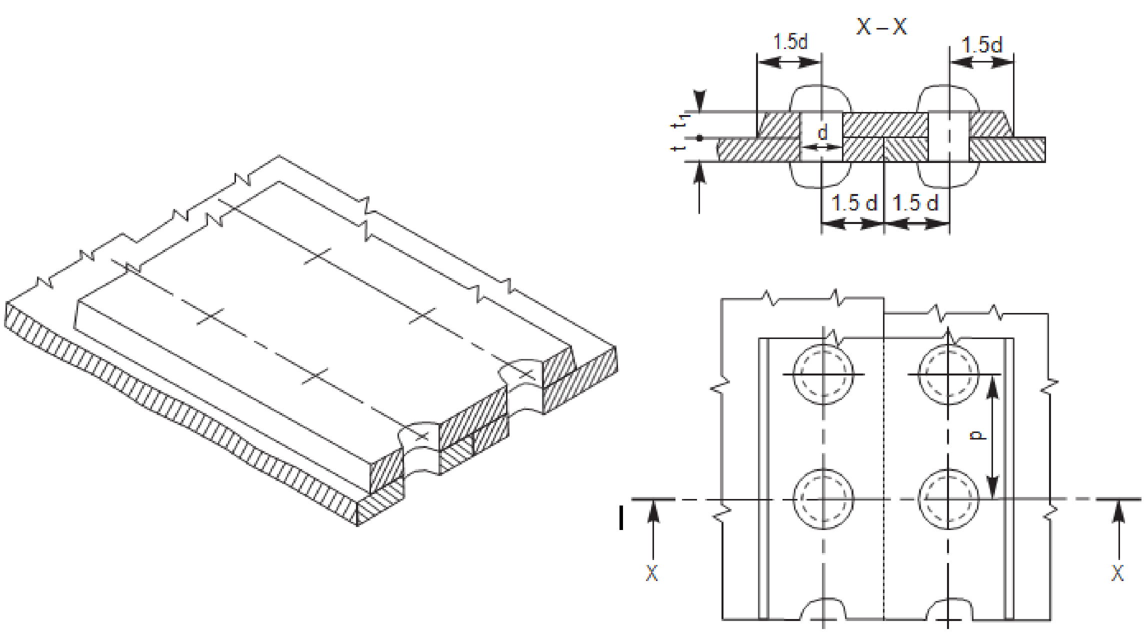


Fig. Single riveted, single strap butt joint

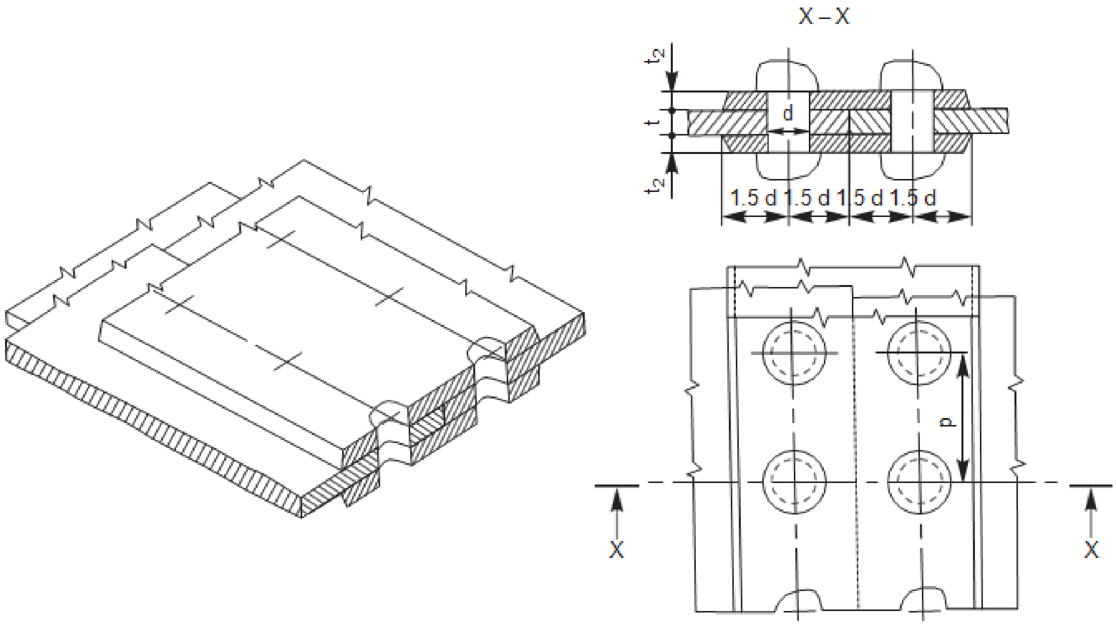


Fig. Single riveted, double strap butt joint

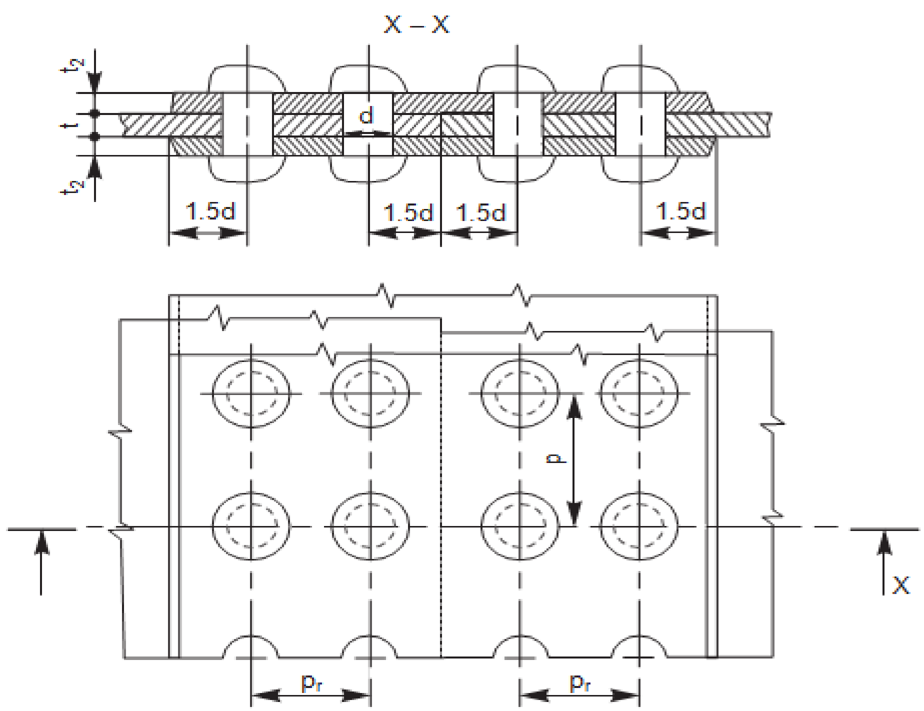


Fig. Double riveted, double strap chain butt joint

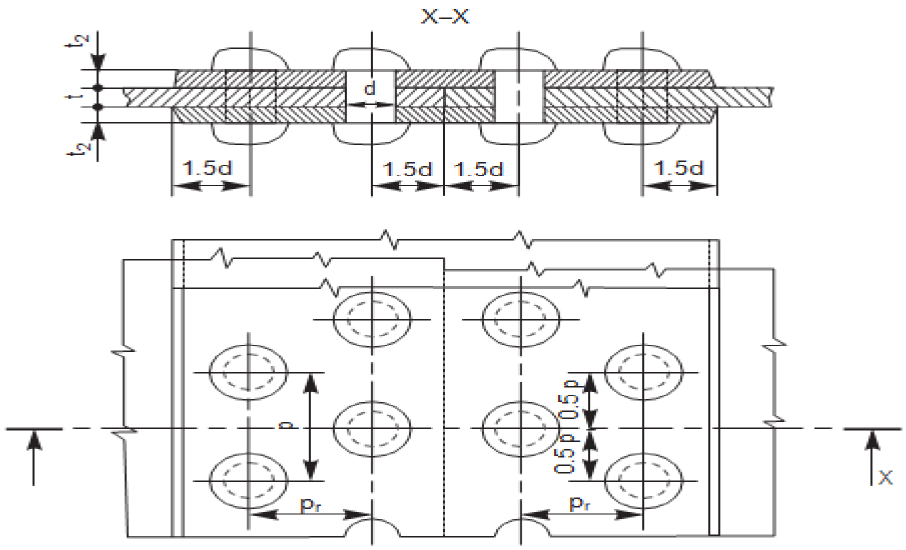


Fig. Double riveted, double strap zig-zag butt joint

Pivot or Foot-step bearing:

This bearing is used to support a vertical shaft under axial load. Further, in this, the shaft is terminated at the bearing. The bottom surface of the shaft rests on the surface of the bearing which is in the form of a disc. The bush fitted in the main body supports the shaft in position and takes care of possible radial loads coming on the shaft.

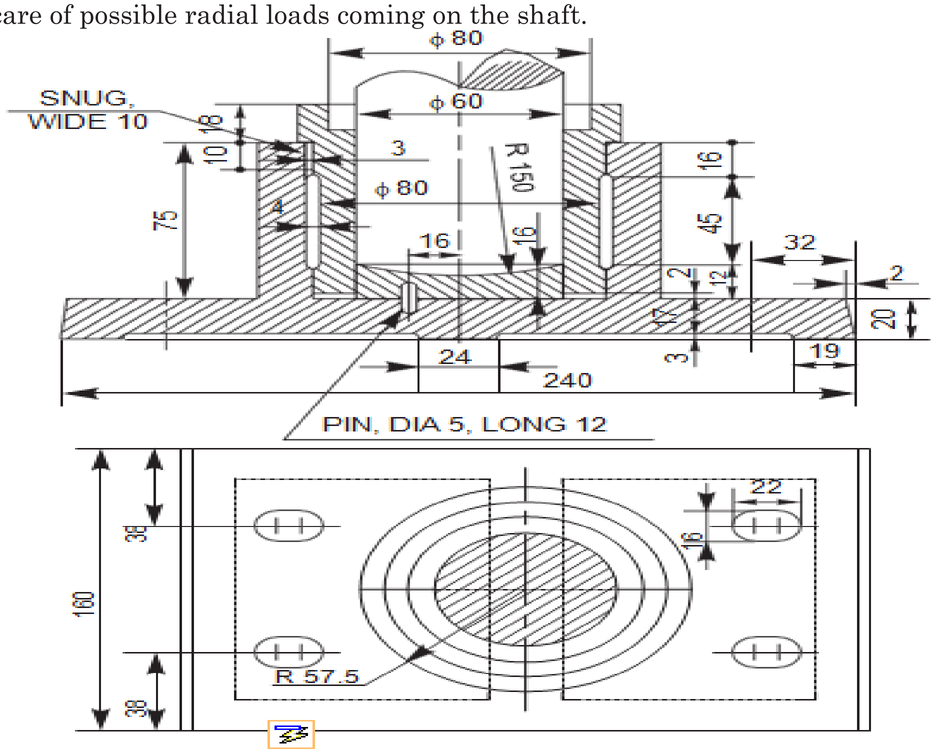


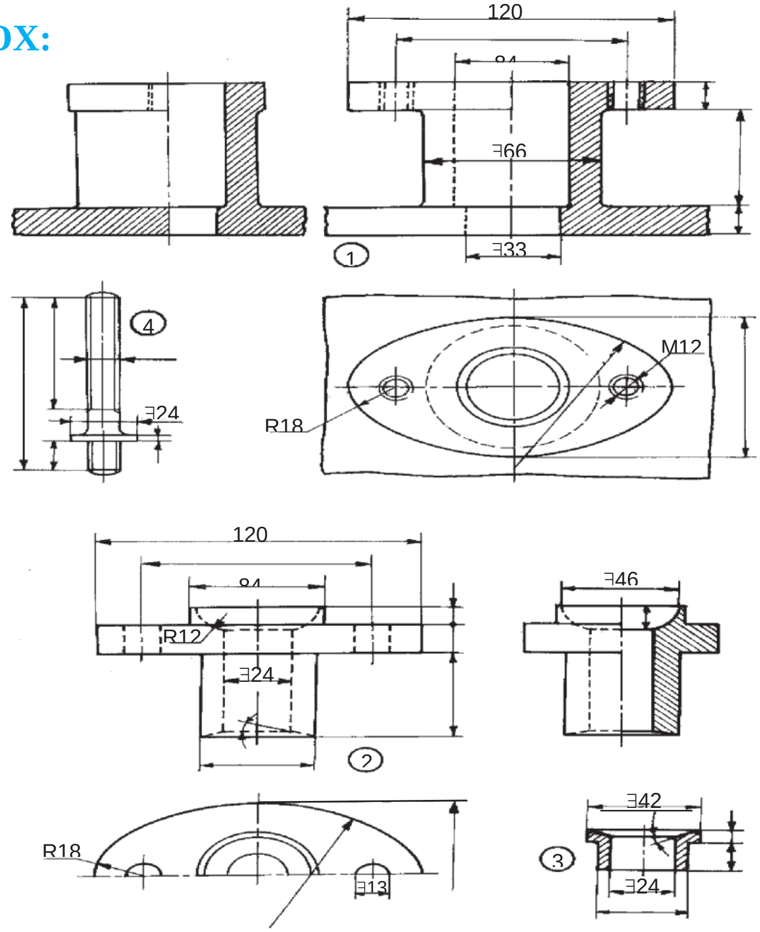
Fig. Foot-step bearing

ASSEMBLY DRAWINGS

a) Engine parts – stuffing box, cross heads, Eccentric, Petrol Engine connecting rod.
b) Other machine parts - Screws jack, Machine Vice, Plummer block, Tailstock.
c) Valves: Steam stop valve, spring loaded safety valve, feed check valve and air cock.

a)ENGINE PARTS:

1)STUFFING BOX:



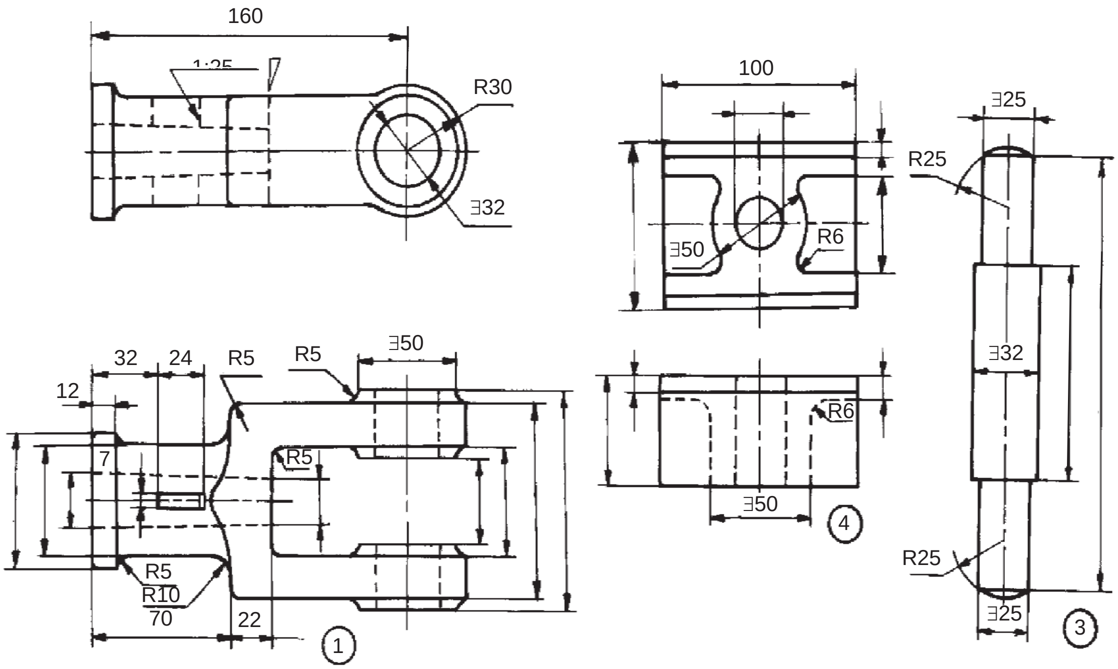
parts list:

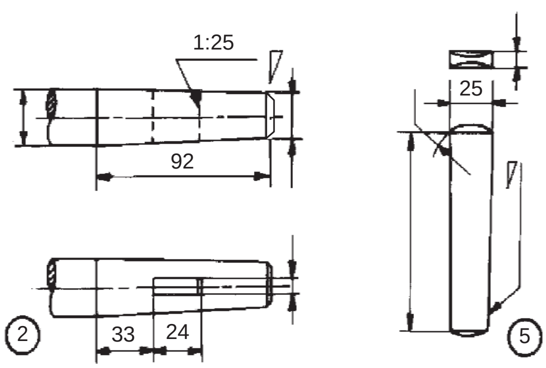
Part No.	Name	Matl	Qty
1	Body	CI	1
2	Gland	Brass	1
3	Bush	Brass	1
4	Stud	MS	2
5	Nut, M12	MS	2

Fig. Stuffing box

2)STEAM ENGINE CROSSHEAD:

Crosshead is used in horizontal steam engines for connecting the piston rod and connecting rod. Figure 18.2 shows the part drawings of a steam engine crosshead. The crosshead, with the help of slide block 4, reciprocates between two guides provided in the engine frame. The gudgeon pin 3, connects the slide blocks with the crosshead block 1. This acts as a pin joint for the connecting rod (not shown in figure). The piston rod 2 is secured to the crosshead block by means of the cotter 5. The assembly ensures reciprocating motion along a straight line for the piston rod and reciprocating cum oscillatory motion for the connecting rod.





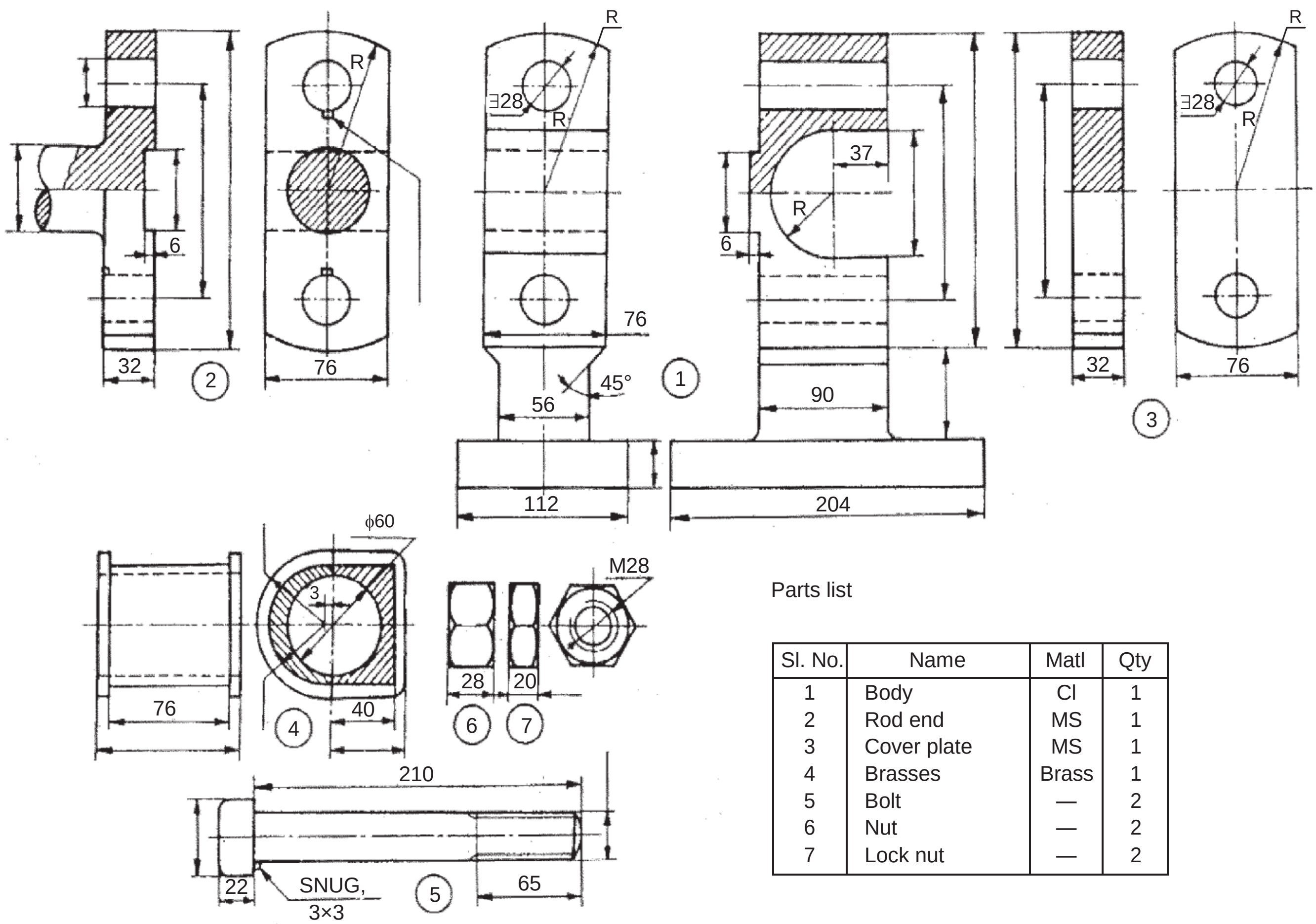
Parts list

Part No.	Name	Matl	Qty
1	Block	CS	1
2	Piston rod	MS	1
3	Gudgeon pin	MS	1
4	Slide block	CI	2
5	Cotter	MS	1

Fig:Steam Engine Crosshead

3)CROSSHEAD:

Figure shows the details of another type of steam engine crosshead. It consists of a body or slide block 1, which slides in-between parallel guides in the frame of the engine. The piston rod end 2 is fitted to the crosshead with the help of bolts 5 and nuts 6 and 7 after placing the brasses 4, and cover plate 3 in position.



Parts list

Sl. No.	Name	Matl	Qty
1	Body	CI	1
2	Rod end	MS	1
3	Cover plate	MS	1
4	Brasses	Brass	1
5	Bolt	—	2
6	Nut	—	2
7	Lock nut	—	2

Fig. Crosshead

4)ECCENTRIC:

It is used to provide a short reciprocating motion, actuated by the rotation of a shaft. Eccentrics are used for operating steam valves, small pump plungers, shaking screens, etc. The components of an eccentric are shown in isometric views Fig. for easy understanding of their shapes. Rotary motion can be converted into a reciprocating motion with an eccentric, but the reverse conversion is not possible due to excessive friction between the sheave and the strap. The crank arrangement, in a slider crank mechanism however, allows conversion in either direction.

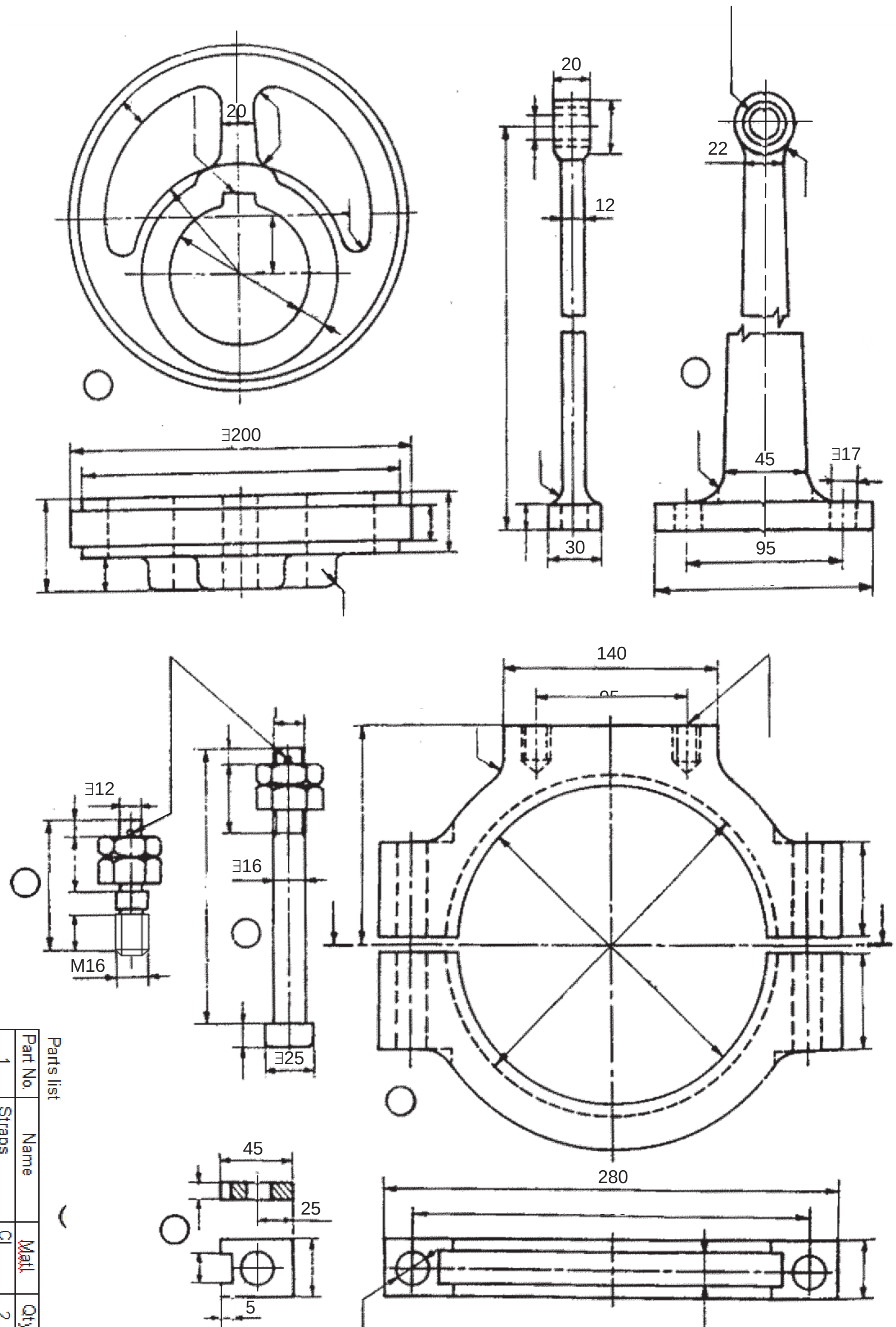
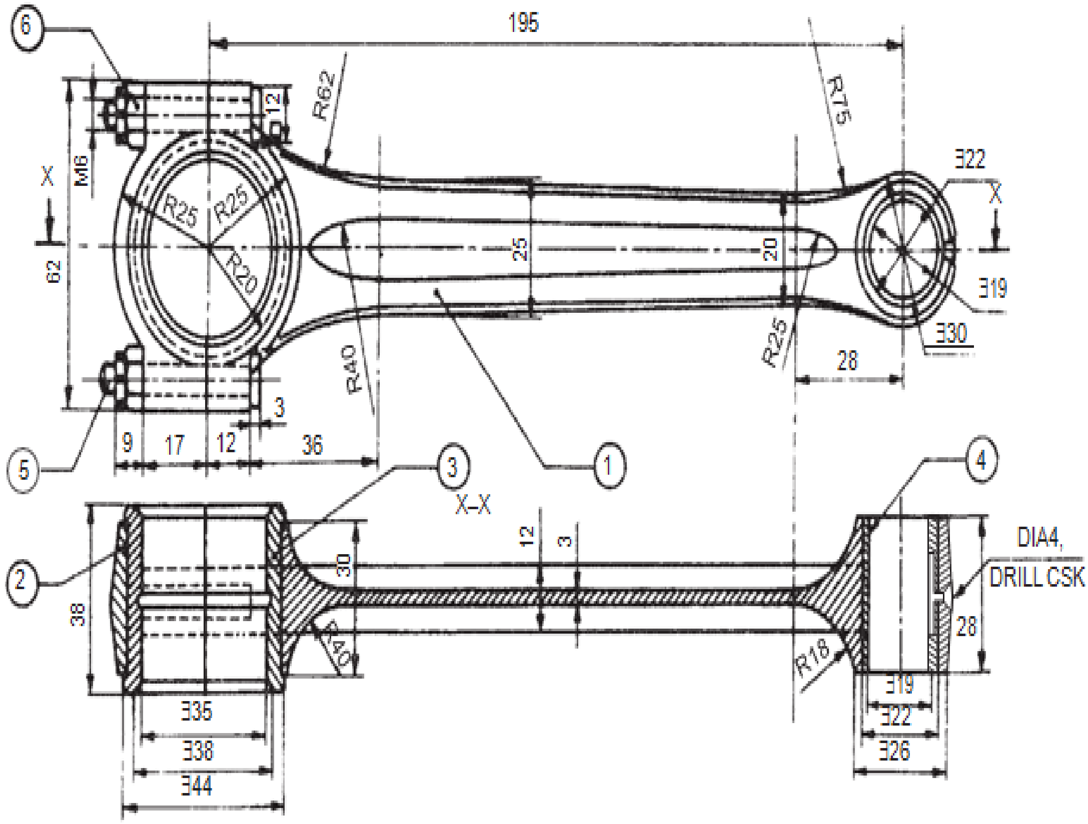


Fig. Details of an eccentric

Parts list

Part No.	Name	Matl	Qty
1	Straps	CI	2
2	Sheave	CI	1
3	Packing strip	Leather	2
4	Strap bolt	MS	2
5	Stud with nut	MS	2
6	Eccentric rod	Forged steel	1

5)PETROL ENGINE CONNECTING ROD:



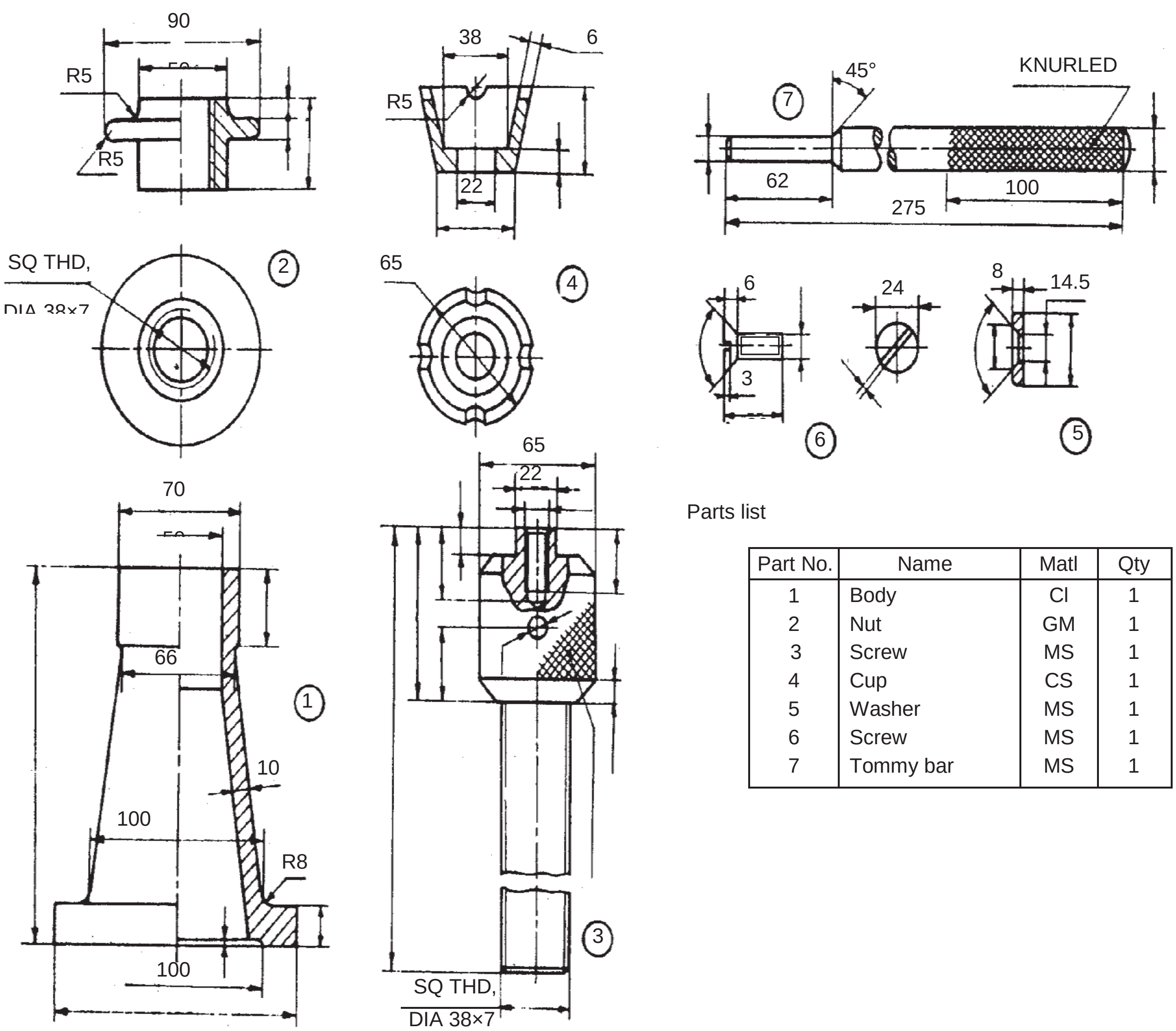
Parts list

Part No.	Name	Matl.	Qty.
1	Rod	FS	1
2	Cap	FS	1
3	Bearing brass	GM	2
4	Bearing bush	P Bronze	1
5	Bolt	MCS	2
6	Nut	MCS	2

Fig. Petrol engine connecting rod

b)OTHER MACHINE PARTS:

1)SCREW JACK: Screw jacks are used for raising heavy loads through very small heights. Figure shows the details of one type of screw jack. In this, the screw 3 works in the nut 2 which is press fitted into the main body 1. The tommy bar 7 is inserted into a hole through the enlarged head of the screw and when this is turned, the screw will move up or down, thereby raising or lowering the load.

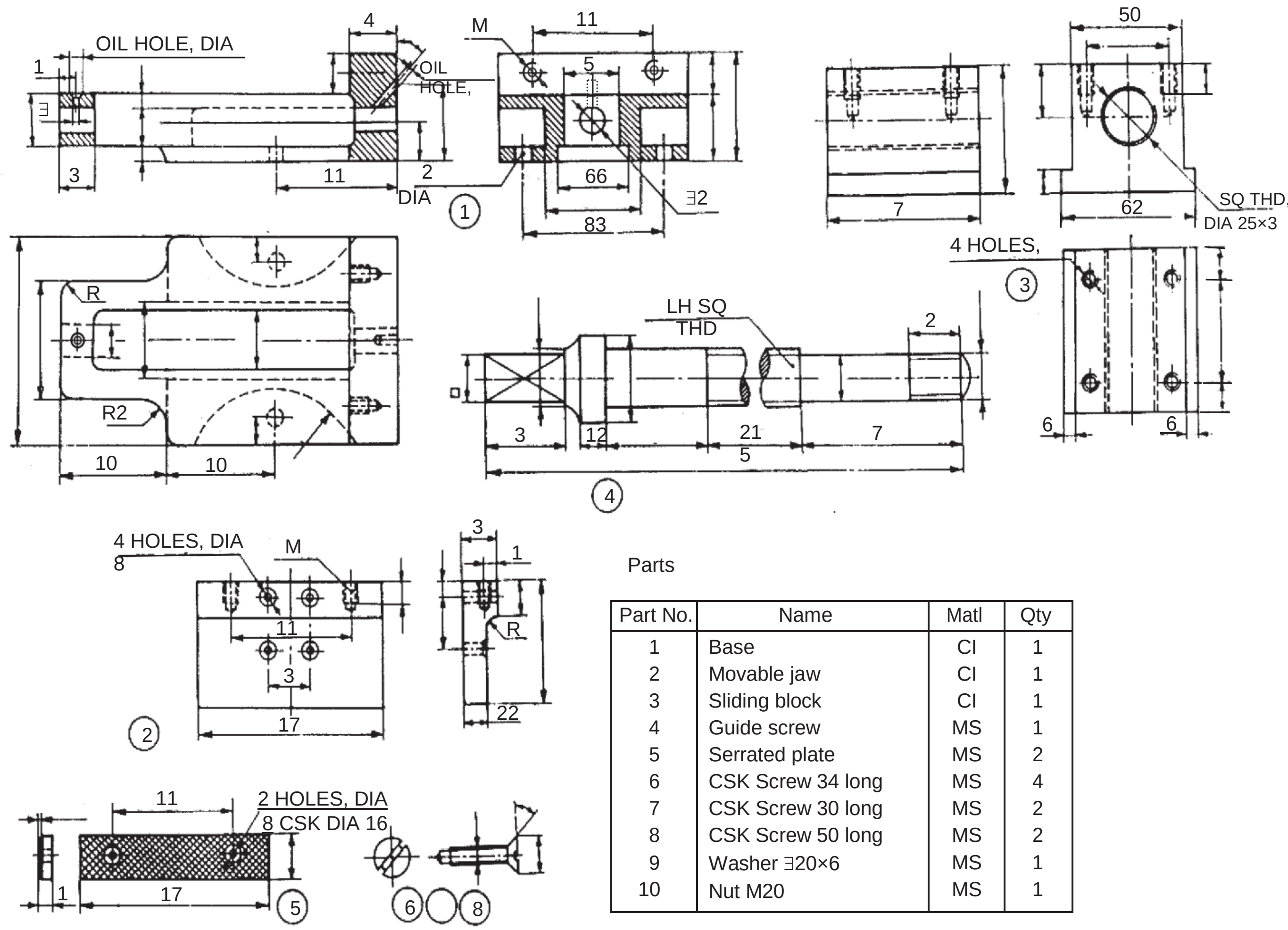


Parts list

Part No.	Name	Matl	Qty
1	Body	CI	1
2	Nut	GM	1
3	Screw	MS	1
4	Cup	CS	1
5	Washer	MS	1
6	Screw	MS	1
7	Tommy bar	MS	1

Fig: Screw jack

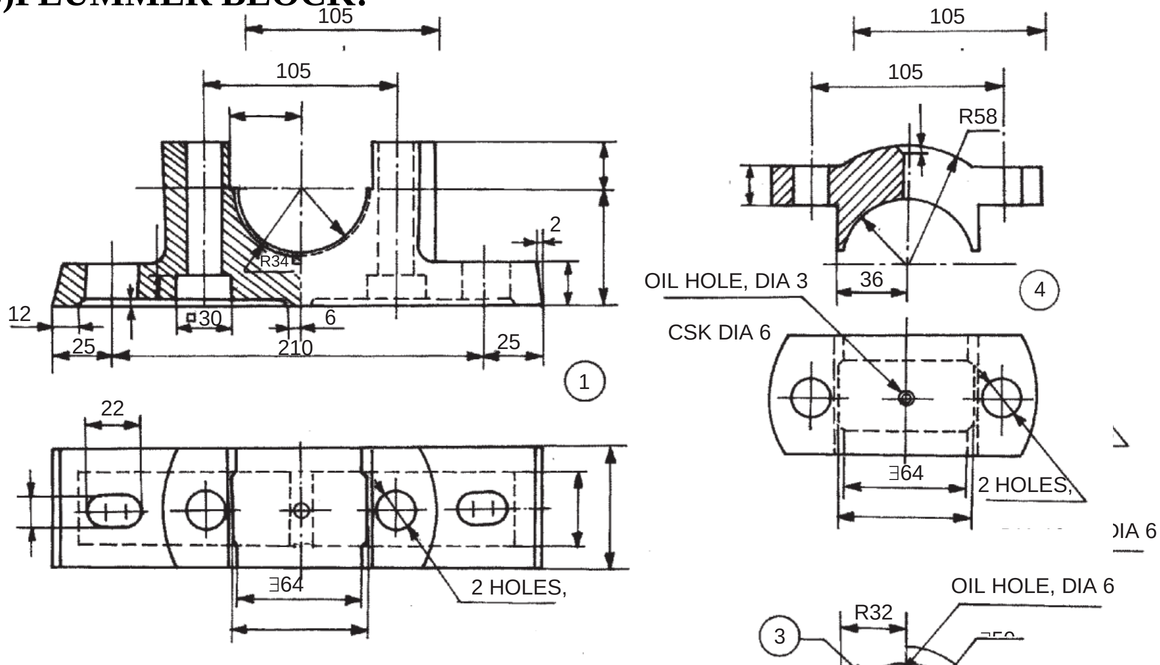
2)MACHINE VICE: The details of a plain machine vice are shown in Fig. It consists of the base 1 which is clamped to the machine table using two T-bolts. The sliding block 3 is fixed in the centre slot of the base by means of the guide screw 4. The movable jaw 2 is fixed to the sliding block with four screws 8 and 7. One of the serrated plates 5 is fixed to the jaw of the base by means of screws 6 and the other to the movable jaw by the screws 7. One end of the guide screw is fixed to the base by means of the washer 9 and nut 10 (not shown in figure). The movable jaw is operated by means of a handle (not shown) which fits onto the square end of the guide screw.



Part No.	Name	Matl	Qty
1	Base	CI	1
2	Movable jaw	CI	1
3	Sliding block	CI	1
4	Guide screw	MS	1
5	Serrated plate	MS	2
6	CSK Screw 34 long	MS	4
7	CSK Screw 30 long	MS	2
8	CSK Screw 50 long	MS	2
9	Washer ∃20×6	MS	1
10	Nut M20	MS	1

Fig. Machine vice

3)PLUMMER BLOCK:



Parts list

Sl. No.	Name	Matl.	Qty.
1	Base	CI	1
2	Bearing brass	Bronze	1
3	Bearing brass	Bronze	1
4	Cap	CI	1
5	Bolt with nuts	MS	2

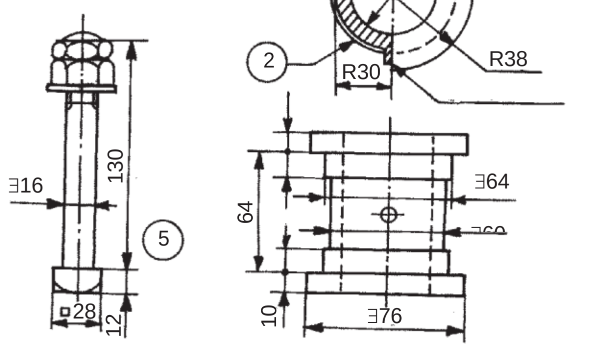
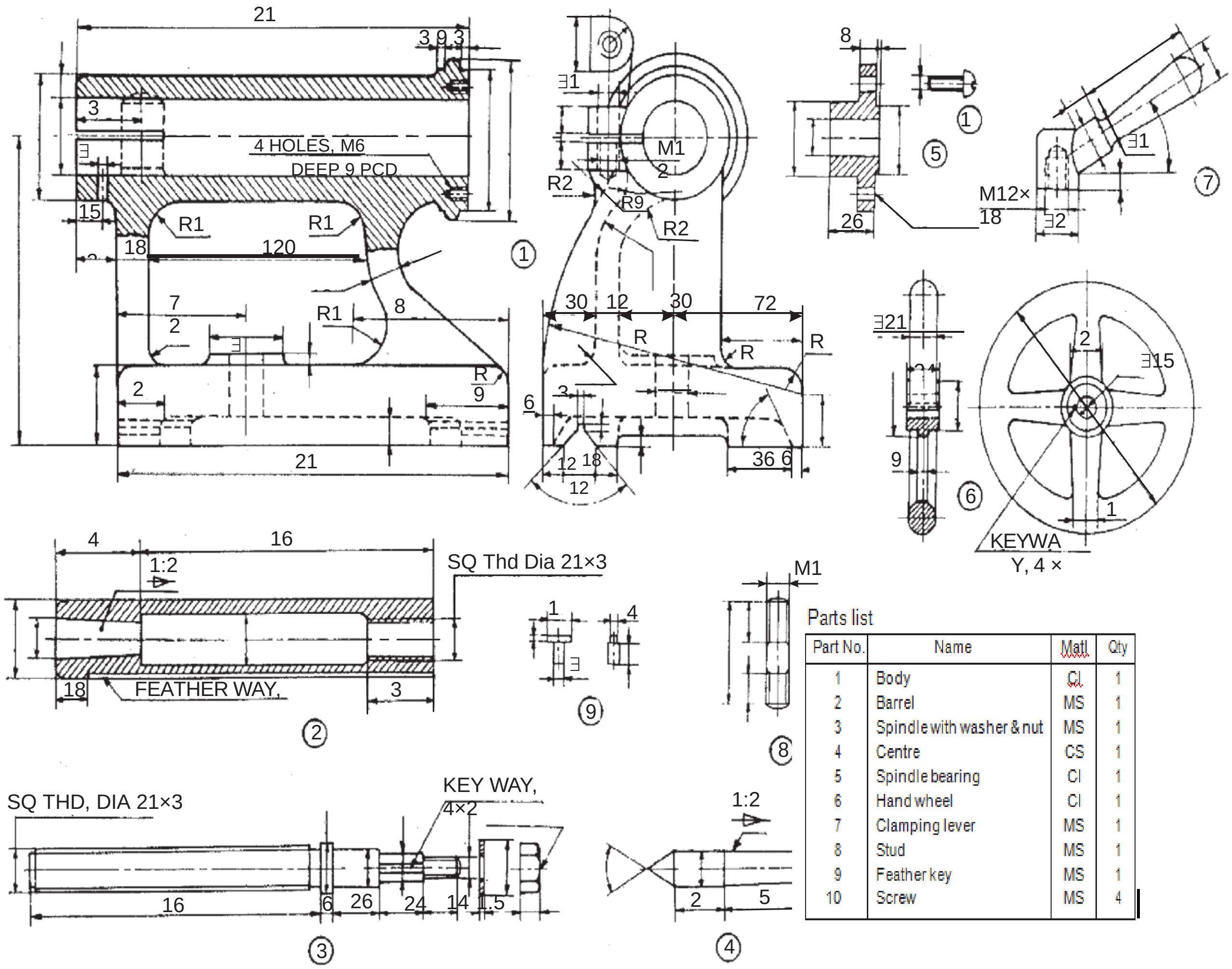


Fig. Plummer block

4) LATHE TAIL-STOCK:



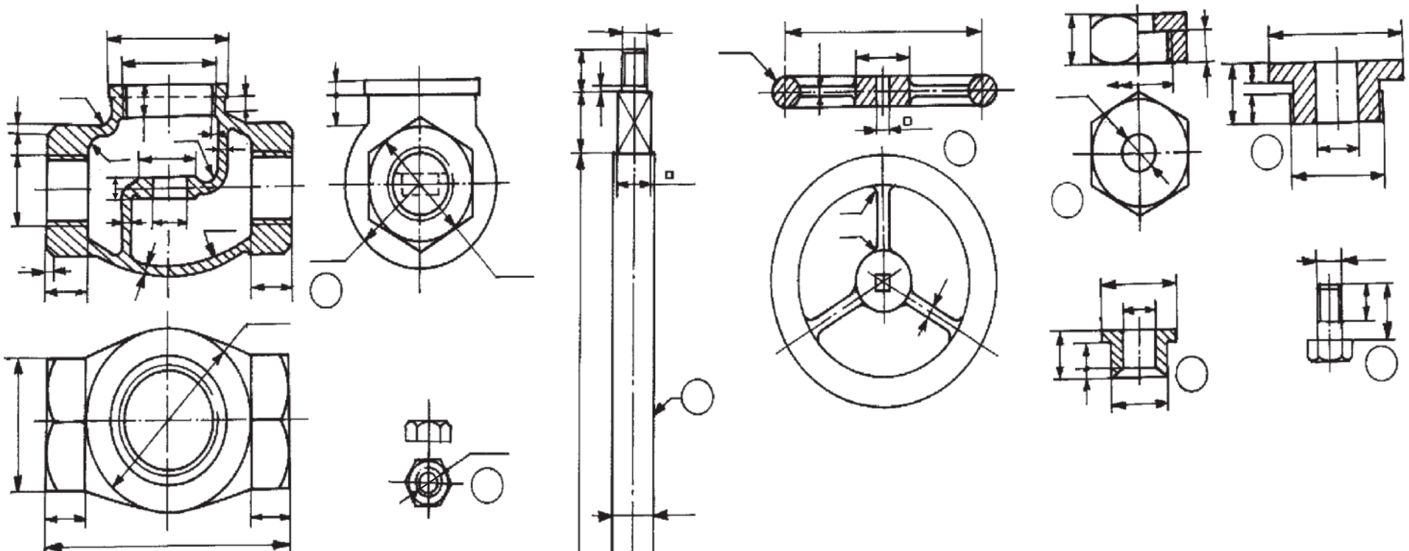
Parts list

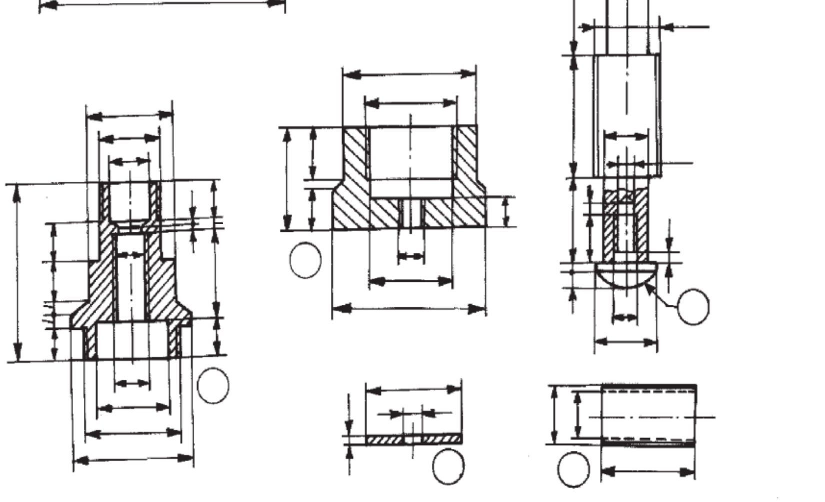
Part No.	Name	Matl	Qty
1	Body	CI	1
2	Barrel	MS	1
3	Spindle with washer & nut	MS	1
4	Centre	CS	1
5	Spindle bearing	CI	1
6	Hand wheel	CI	1
7	Clamping lever	MS	1
8	Stud	MS	1
9	Feather key	MS	1
10	Screw	MS	4

Fig. Lathe tail-stock

C)VALVES:

1)STEAM STOP VALVE:





Sl. No.	Name	Matl.	Qty.
1	Valve body	CI	1
2	Bonnet	Brass	1
3	Gland tightening nut	MS	1
4	Gland	Brass	1
5	Sleeve	MS	1
6	Coller	MS	1
7	Stuffing box packing	Asbestos	1
8	Stem with screw	MS	1
9	Actuating screw end	MS	1
10	Screwed sleeve	Brass	1
11	Valve seat	GM	1
12	Screw	MS	1
13	Hand wheel	CI	1
14	Nut	MS	1

Fig: Steam stop valve

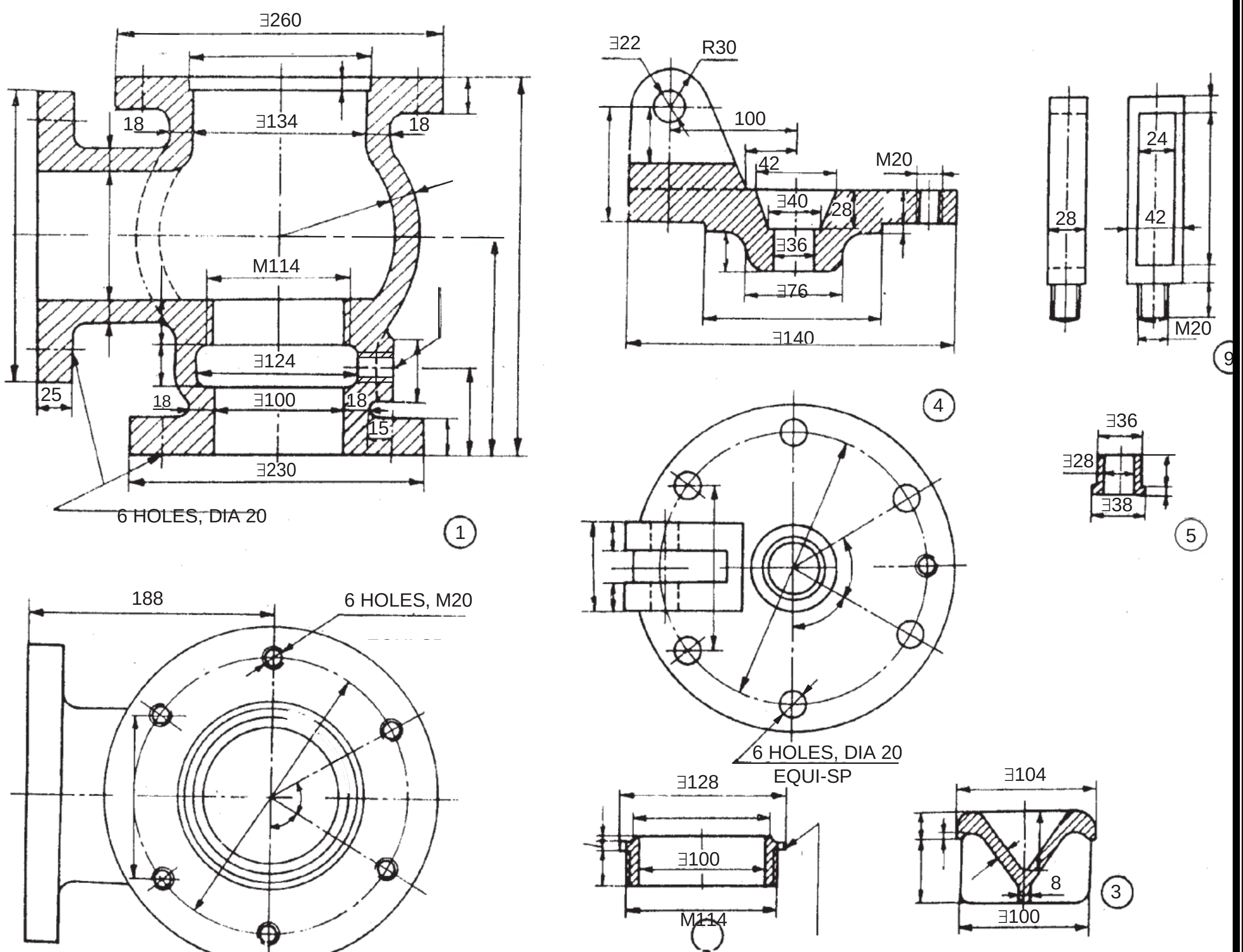
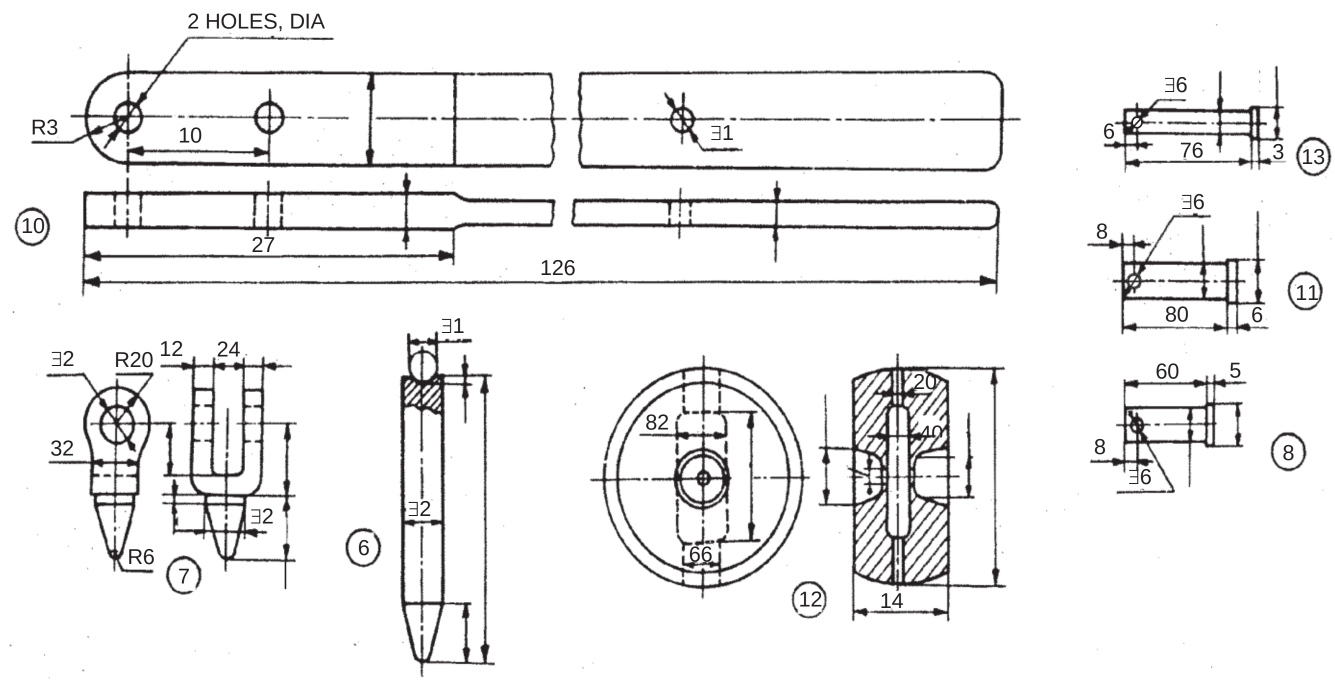


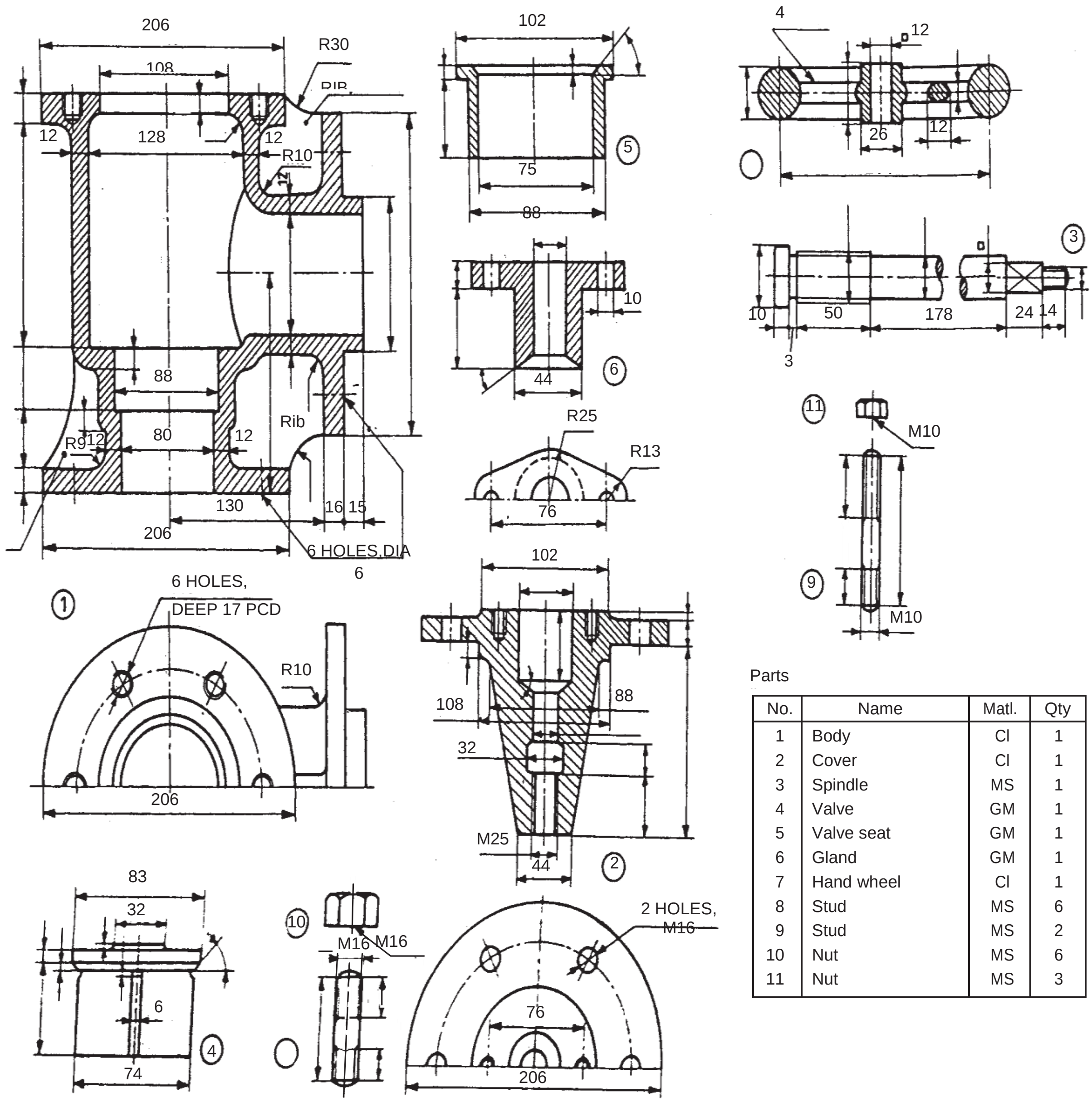
Fig. spring loaded safety valve **(contd.)**



Part No.	Name	Matl	Qty	Part No.	Name	Matl	Qty
1	Body	CI	1	8	Toggle-pin	MS	1
2	Valve seat	GM	1	9	Lever guide	MS	1
3	Valve	GM	1	10	Lever	FS	1
4	Cover	CI	1	11	Fulcrum pin	MS	1
5	Cover bush	Brass	1	12	Weight	CI	1
6	Spindle	MS	1	13	Lever pin	MS	1
7	Toggle	MS	1	14	Stud with nut M20	—	6

Fig. spring loaded safety valve

3)FEED CHECK VALVE: It is used in boilers to regulate the supply of feed water and to maintain the water level. It is fitted close to the boiler shell and in the feed pipe line. Figure shows the details of a feed check valve. The valve prevents water from being returned to the supply line, due to steam pressure in the boiler. Hence, it functions like a non-return valve.

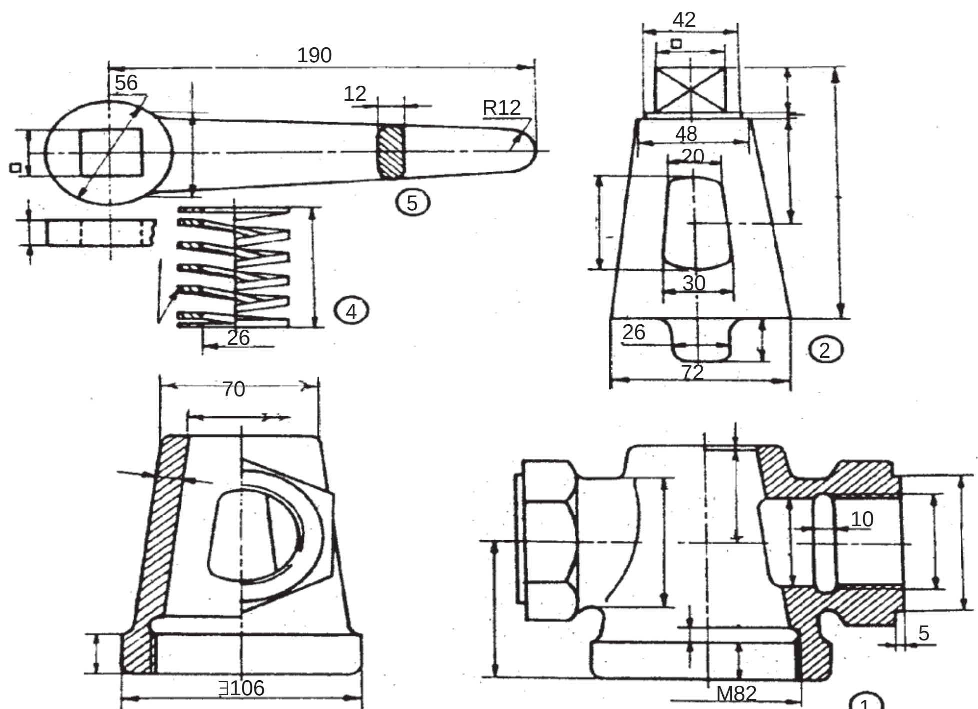


Parts

No.	Name	Matl.	Qty
1	Body	CI	1
2	Cover	CI	1
3	Spindle	MS	1
4	Valve	GM	1
5	Valve seat	GM	1
6	Gland	GM	1
7	Hand wheel	CI	1
8	Stud	MS	6
9	Stud	MS	2
10	Nut	MS	6
11	Nut	MS	3

Fig. Feed check valve

4)AIR COCK: This valve is used to control air or gas supply. The details of an air cock are shown in Fig. It consists of a plug 2 which is inserted into the body 1, from the bottom. The rectangular sectioned spring 4 is placed in position at the bottom of the plug and seated over the screw cap 3. The screw cap is operated to adjust the spring tension. Lever 5 with square hole is used to operate the cock. By a mere 90° turn, the cock is either opened or closed fully.



Parts list

Part No.	Name	Matl	Qty
1	Body	CI	1
2	Plug	CI	1
3	Screw cap	MS	1
4	Spring	Spring S	1
5	Lever	FS	1

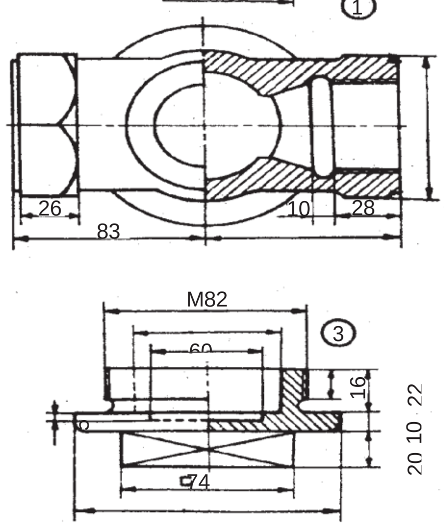


Fig. Air cock