MACHINE DRAWING
PART-A

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VKR VNB & AGK COLLEGE OF ENGINEERING

II Year - II Semester **MACHINE DRAWING**

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Course Objective: The student will acquire knowledge of fastening arrangements such as welding, riveting the different styles of attachment for shaft. The student also is enabled to prepare the assembly of various machine or engine components and miscellaneous machine components.

Machine Drawing Conventions :

Need for drawing conventions – introduction to IS conventions

a) Conventional representation of materials, common machine elements and parts such asscrews, nuts, bolts, keys, gears, webs, ribs.

b) Types of sections – selection of section planes and drawing of sections and auxiliary sectional views. Parts not usually sectioned.

c) Methods of dimensioning, general rules for sizes and placement of dimensions for holes, centers, curved and tapered features.

d) Title boxes, their size, location and details - common abbreviations & their liberal usage

e) Types of Drawings – working drawings for machine parts.

PART-A

I. Drawing of Machine Elements and simple parts

Objective: To provide basic understanding and drawing practice of various joint, simple mechanical parts

Selection of Views, additional views for the following machine elements and parts with every drawing proportions.

a) Popular forms of Screw threads, bolts, nuts, stud bolts, tap bolts, set screws.

b) Keys, cotter joints and knuckle joint.

c) Riveted joints for plates

d) Shaft coupling, spigot and socket pipe joint.

e) Journal, pivot and collar and foot step bearings

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PART-B

II. Assembly Drawings:

Objective: The student will be able to draw the assembly from the individual part drawing.

Drawings of assembled views for the part drawings of the following using conventions and easy drawing proportions.

a) Engine parts –Gear pump, Fuel pump Petrol Engine connecting rod, piston assembly.

b) Other machine parts - Screws jacks, Machine Vices Plummer block, Tailstock.

c) Valves: spring loaded safety valve, feed check valve and air cock, Control valves

NOTE : First angle projection to be adopted. The student should be able to provide working drawings of actual parts. End semester examination for 70 Marks, Part A- 20 Marks (Answer two questions out of Three), Part B- 50 Marks (Assembly Drawing).

Text Books:

1. Machine Drawing – N.Siddeswar, K.Kannaiah & V.V.S.Sastry - TMH
2. Machine Drawing –K.L.Narayana, P.Kannaiah & K. Venkata Reddy / New Age/ Publishers

References:

1. Machine Drawing – P.S.Gill,
2. Machine Drawing – Luzzader
3. Machine Drawing – Rajput
4. Machine Drawing – N.D. Junnarkar, Pearson
5. Machine Drawing – Ajeeth Singh, McGraw Hill
6. Machine Drawing – KC John, PHI
7. Machine Drawing – B Battacharya, Oxford
8. Machine Drawing – Gowtham and Gowtham, Pearson

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For the subject having design and / or drawing, (such as Engineering Graphics, Engineering Drawing, Machine Drawing) and estimation, the distribution shall be **30 marks** for **internal evaluation** (**20 marks** for continuous Assessment (**day–to–day work**) and **10 marks for internal tests**) and **70 marks for end examination**.

There shall be two internal tests in a Semester for **10 marks** each and final marks can be calculated with **80% weightage** for better of the two tests and **20% weightage** for other test and these are to be added to the marks obtained in day to day work.

SHEET 1

CONVENTIONAL REPRESENTATION

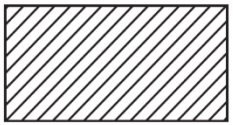
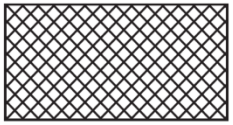
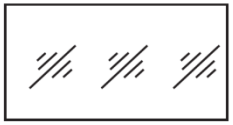
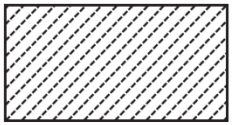
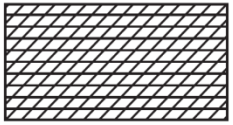
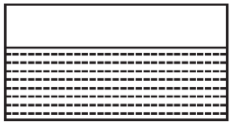
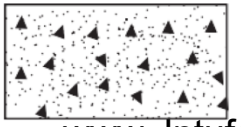
Materials:

- 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.

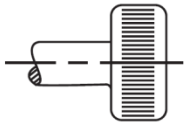
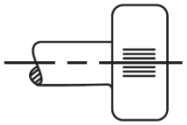
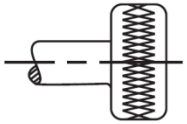
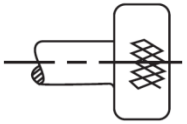
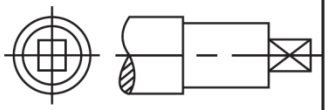
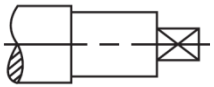
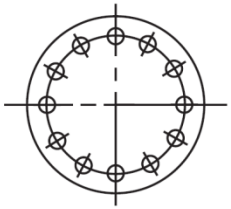
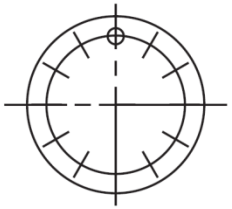
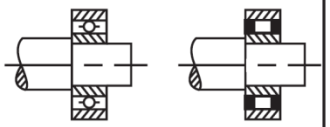
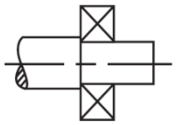
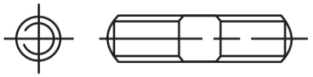
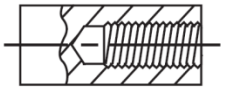
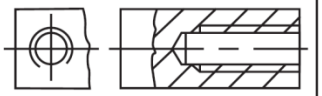
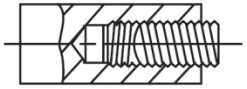
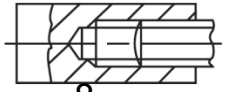
Machine Components:

- 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.

Conventional representation of materials

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

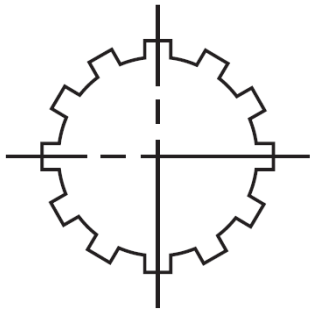
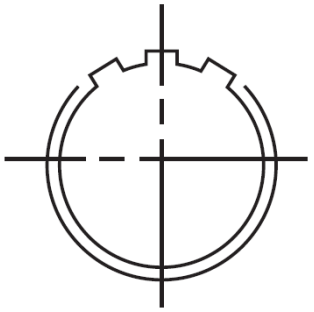
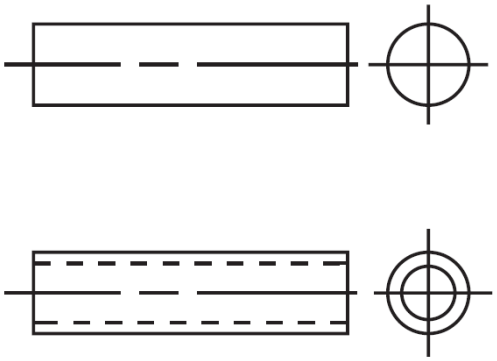
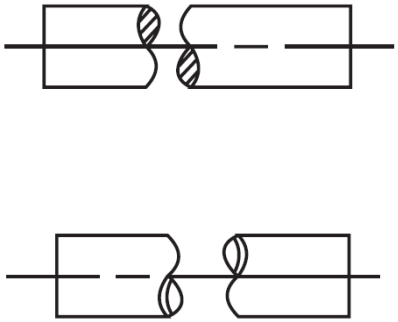
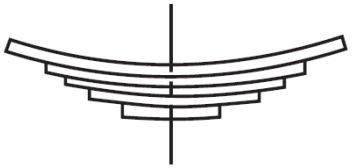
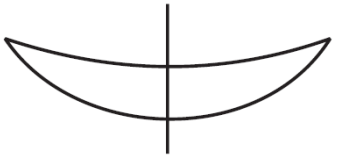
Conventional representation of machine components

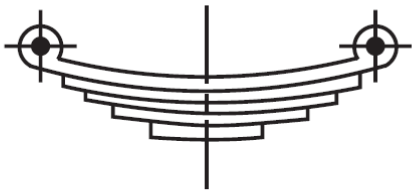
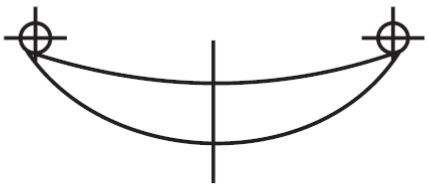
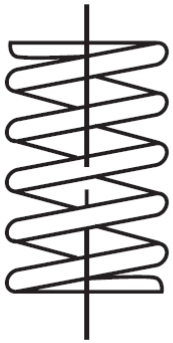
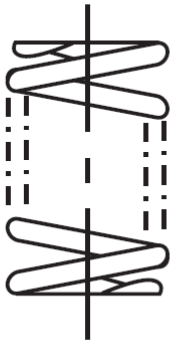
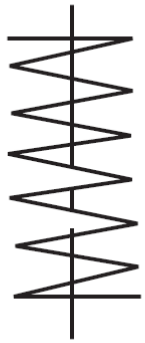
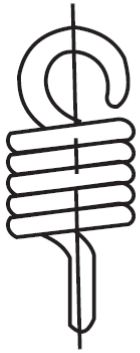
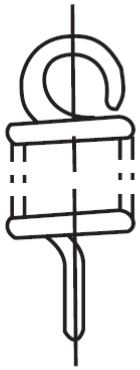
Title	Subject	Convention
Straight knurling		
Diamond knurling		
Square on shaft		
Holes on circular pitch		
Bearings		
External screw threads (Detail)		
Internal screw threads (Detail)		
Screw threads (Assembly)		

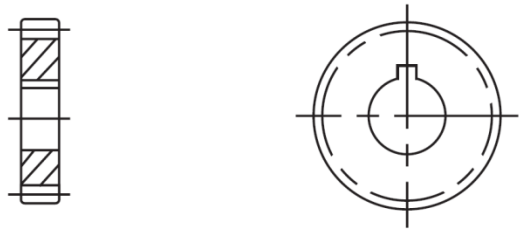
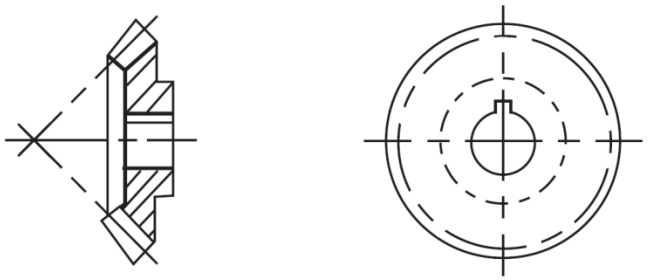
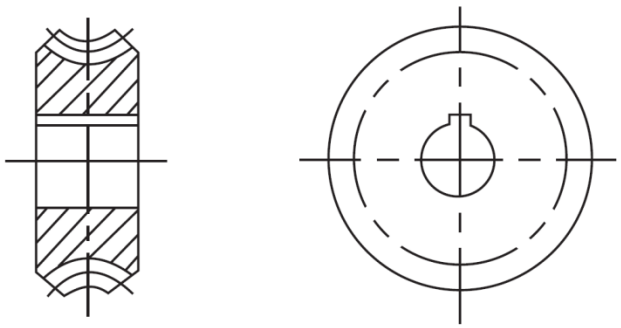
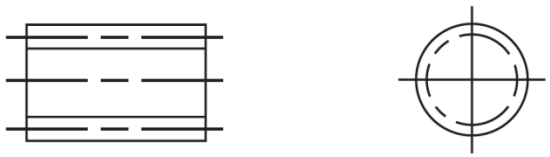
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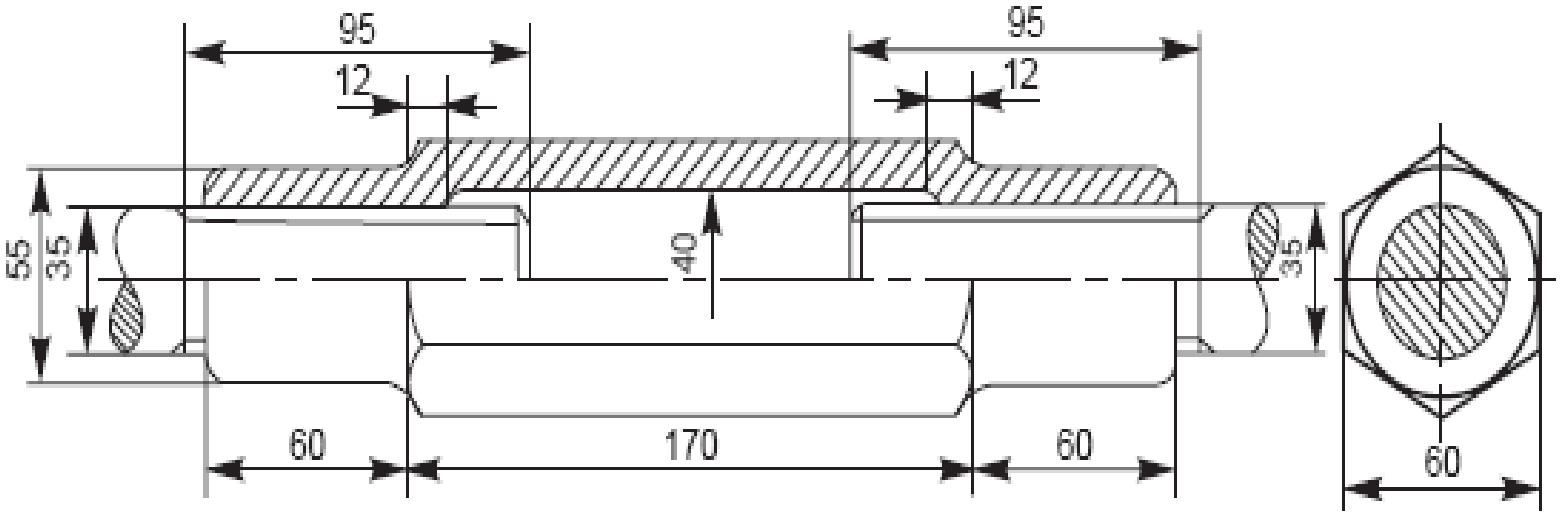
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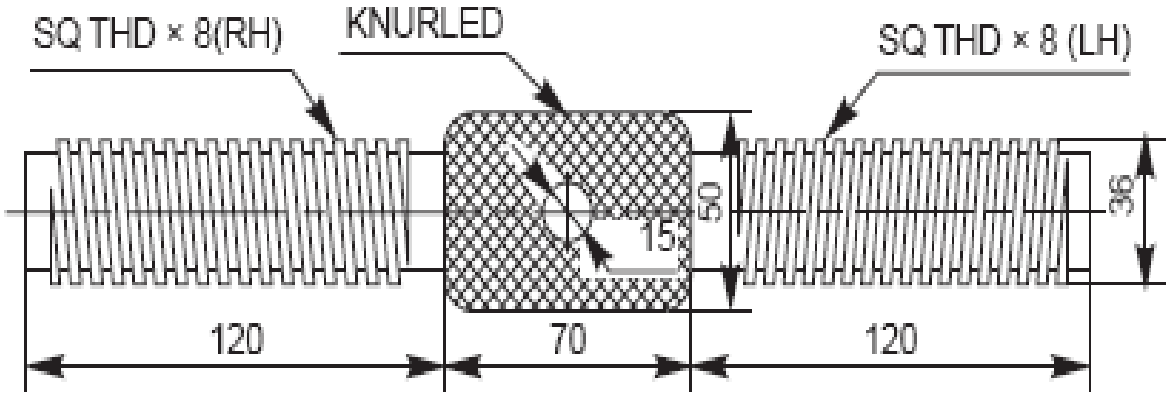
Title	Subject	Convention
Splined shafts		
Interrupted views		
Semi-elliptic leaf spring		

Semi-elliptic leaf spring with eyes			
	Subject	Convention	Diagrammatic Representation
Cylindrical compression spring			
Cylindrical tension spring			

Title	Convention
Spur gear	
Bevel gear	
Worm wheel	
Worm	



(a) Adjustable joint for round rods



(b) Coupler for railway coaches

Fig. 5.6

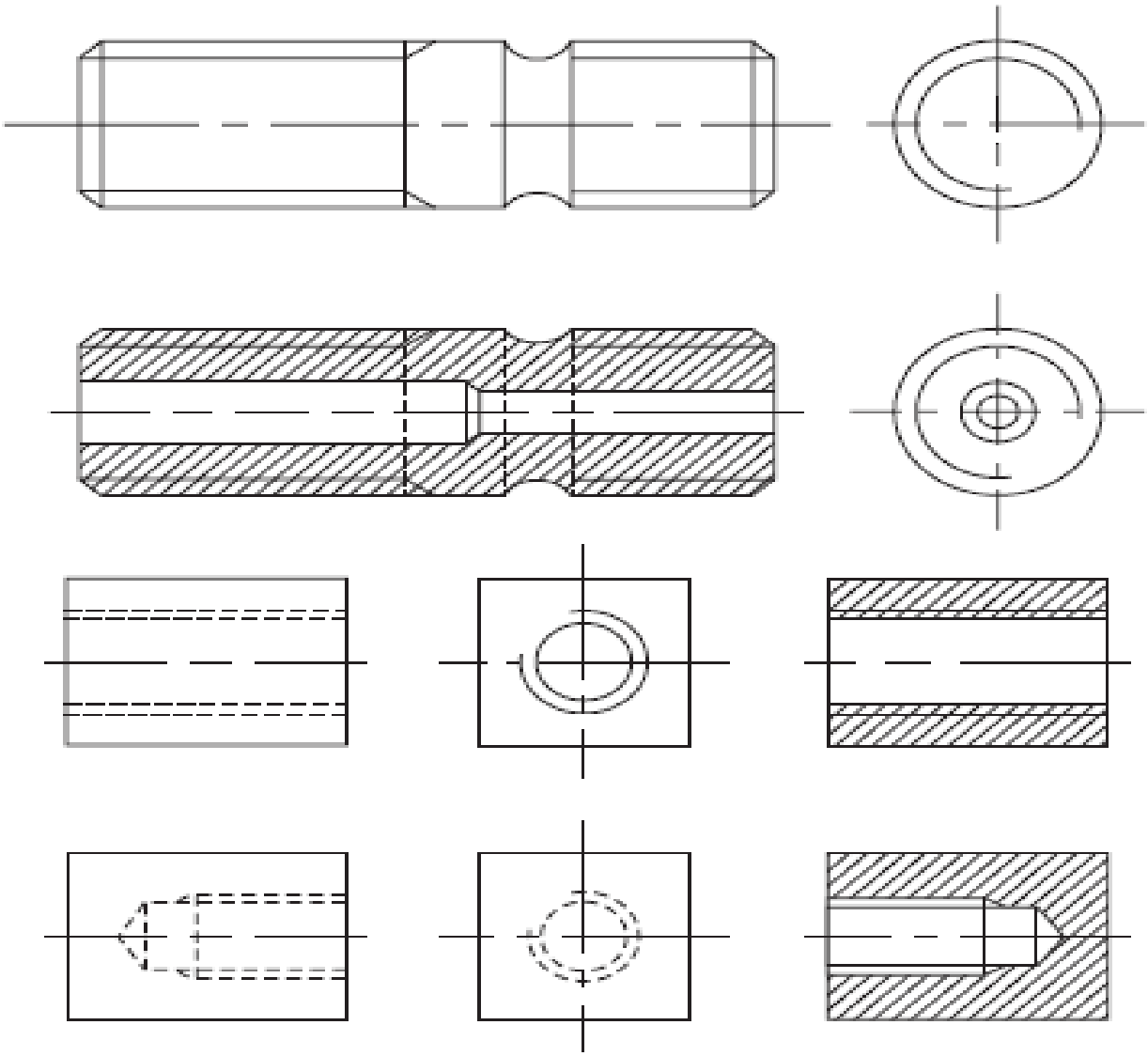
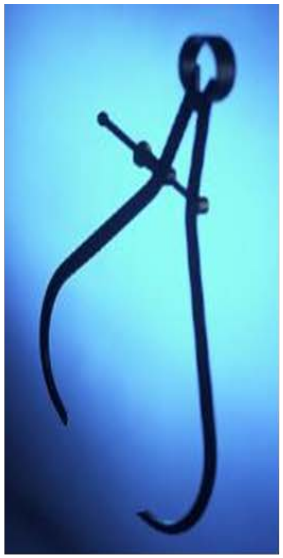


Fig. 5.7 Conventional representation of threads

SHEET 2

Screw Threads and Threaded Fasteners

Screw Thread Uses



Adjusters



Fasteners



Transfer Power



Mechanical Advantage

SCREWED FASTENERS

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 dissemble

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 NOMINCLATURE

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.

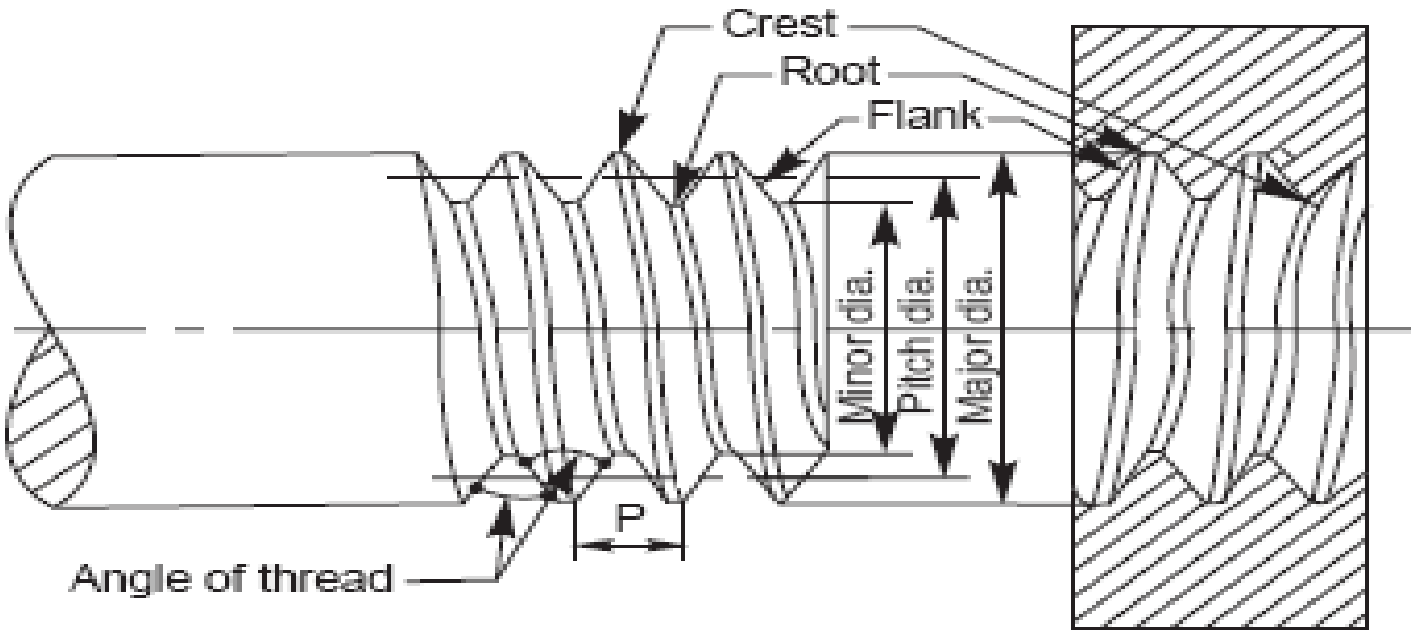
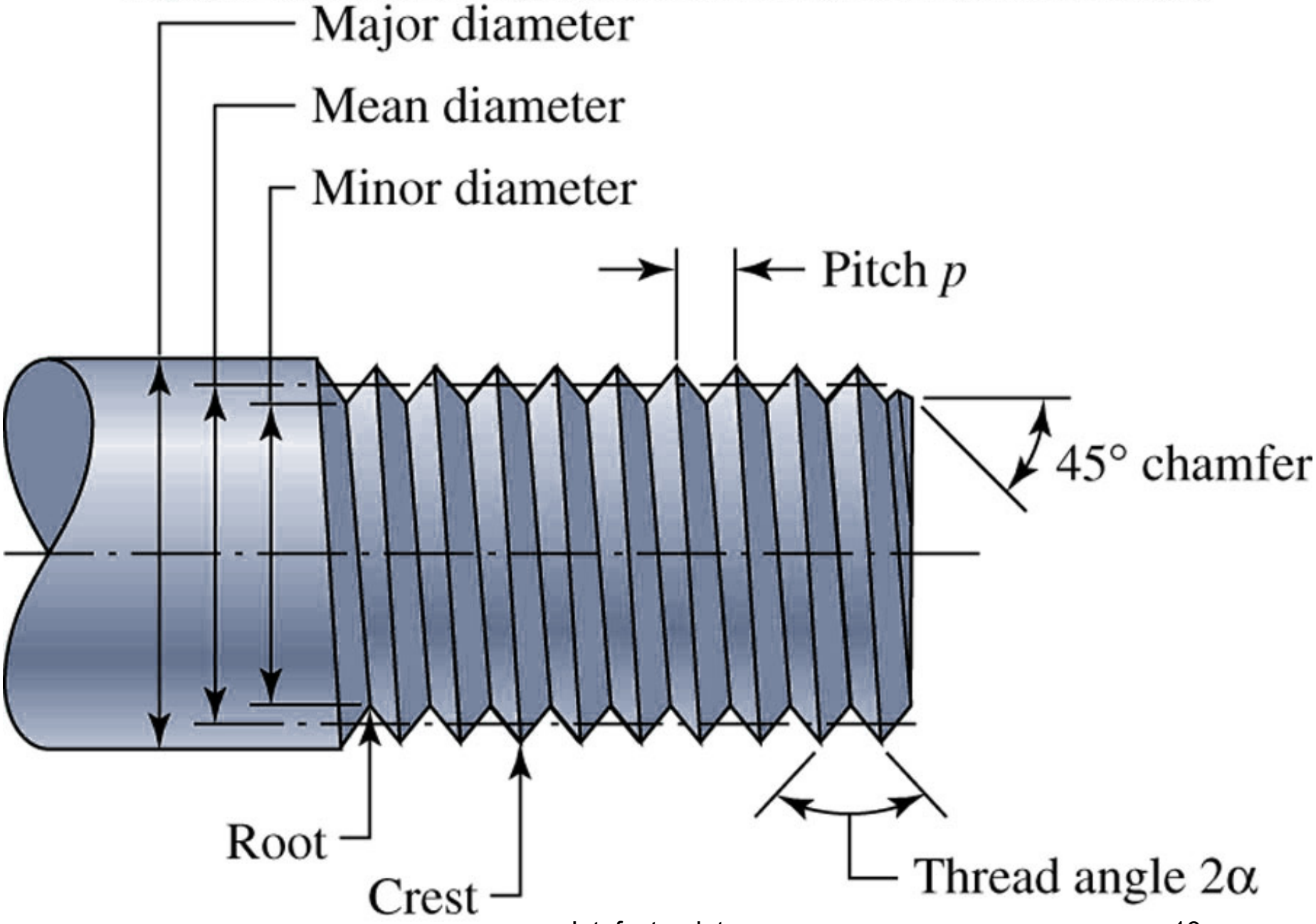


Fig. 5.1 Screw thread nomenclature

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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.

THREAD PROFILES

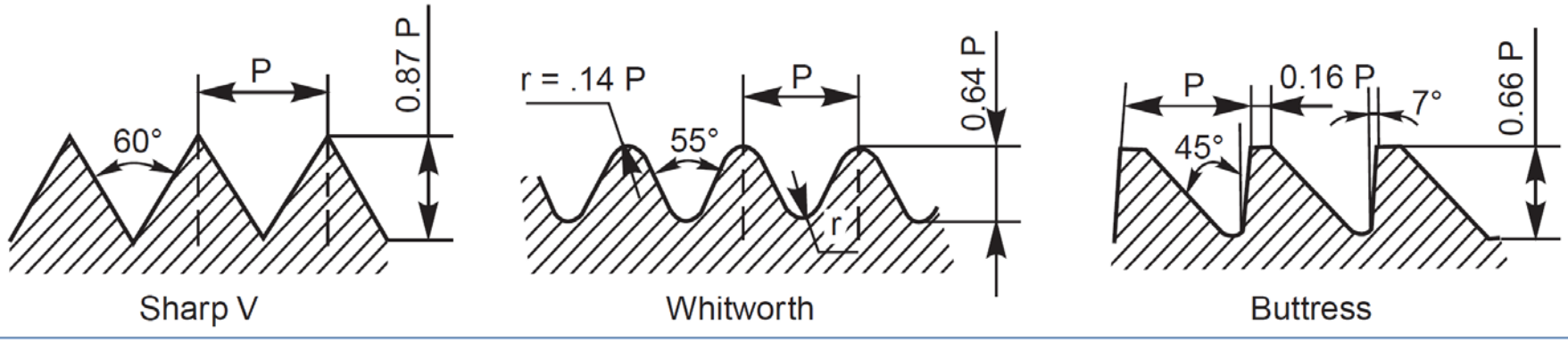


Fig. 5.3 Types of thread profiles

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.

Whitworth 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. It is also called as British Standard Whitworth (B.S.W) 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.

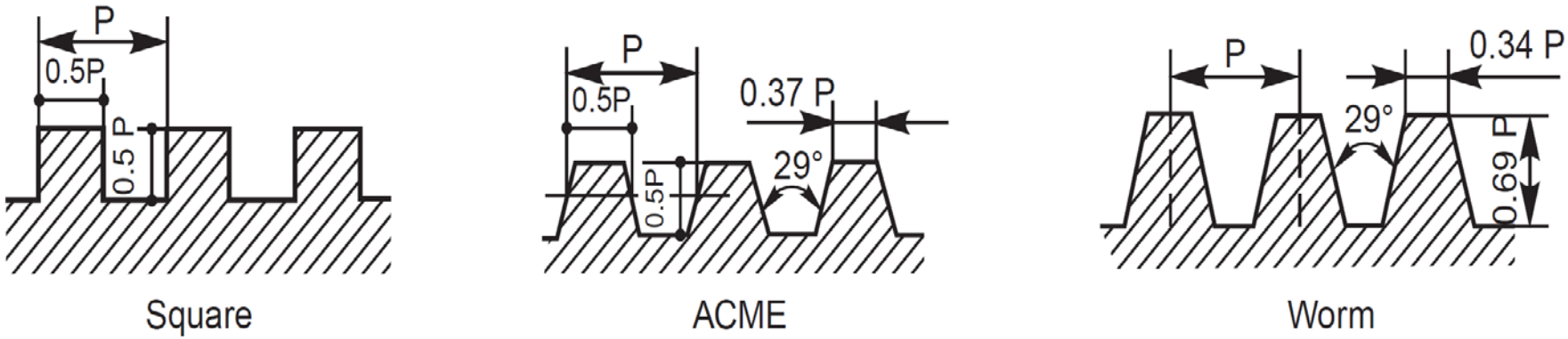


Fig. 5.3 Types of thread profiles

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.

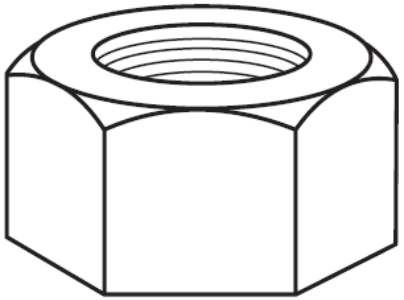
ACME Thread

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.

Hexagonal Nut



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

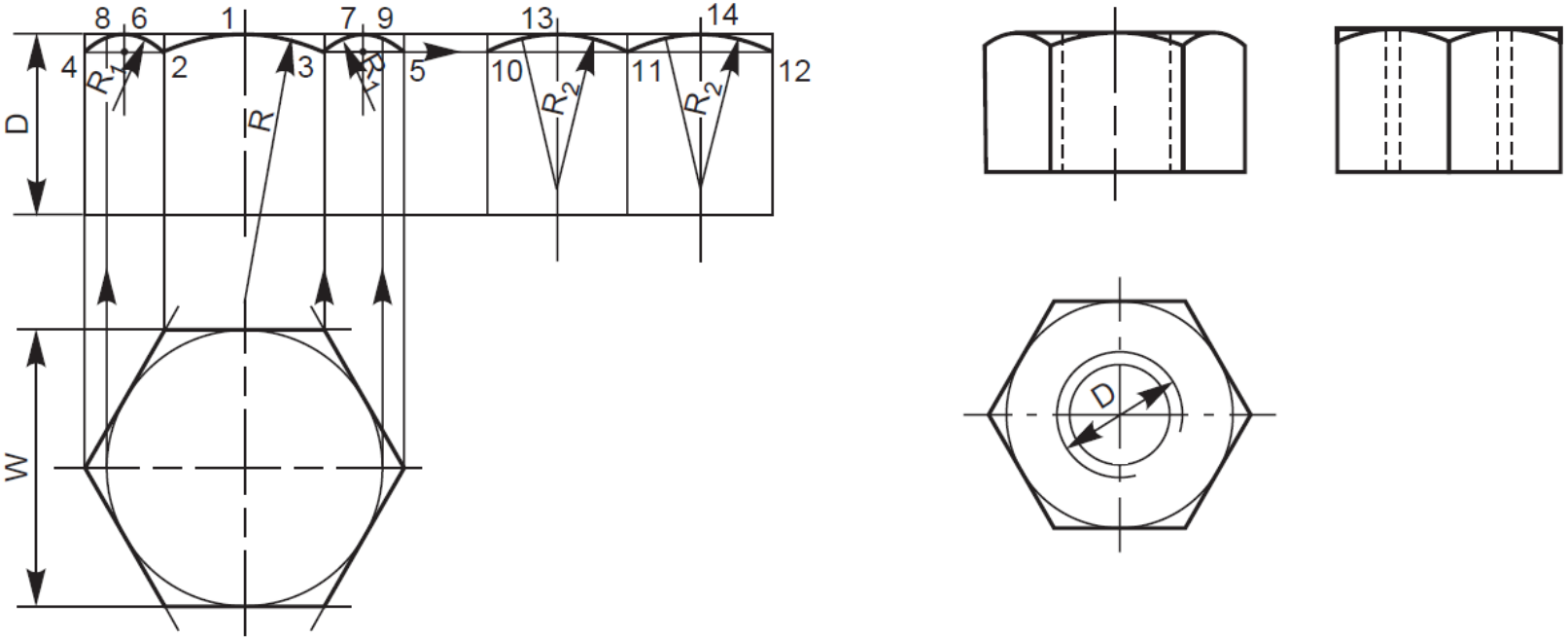


Fig. 5.12 Method of drawing views of a hexagonal nut (Method I)

Procedure:

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.
5. Locate points 8,9 on the top surface, by projecting from the view from above.
6. Draw the chamfers 4–8 and 5–9.
7. Locate points 6 and 7, lying at the middle of the outer two faces.
8. Draw circular arcs passing through the points 4, 6, 2 and 3, 7, 5, after determining the radius R_1 geometrically.
9. Project the view from the side and locate points 10, 11 and 12.
10. Mark points 13 and 14, lying at the middle of the two faces (view from the side).
11. 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.

Square Nut

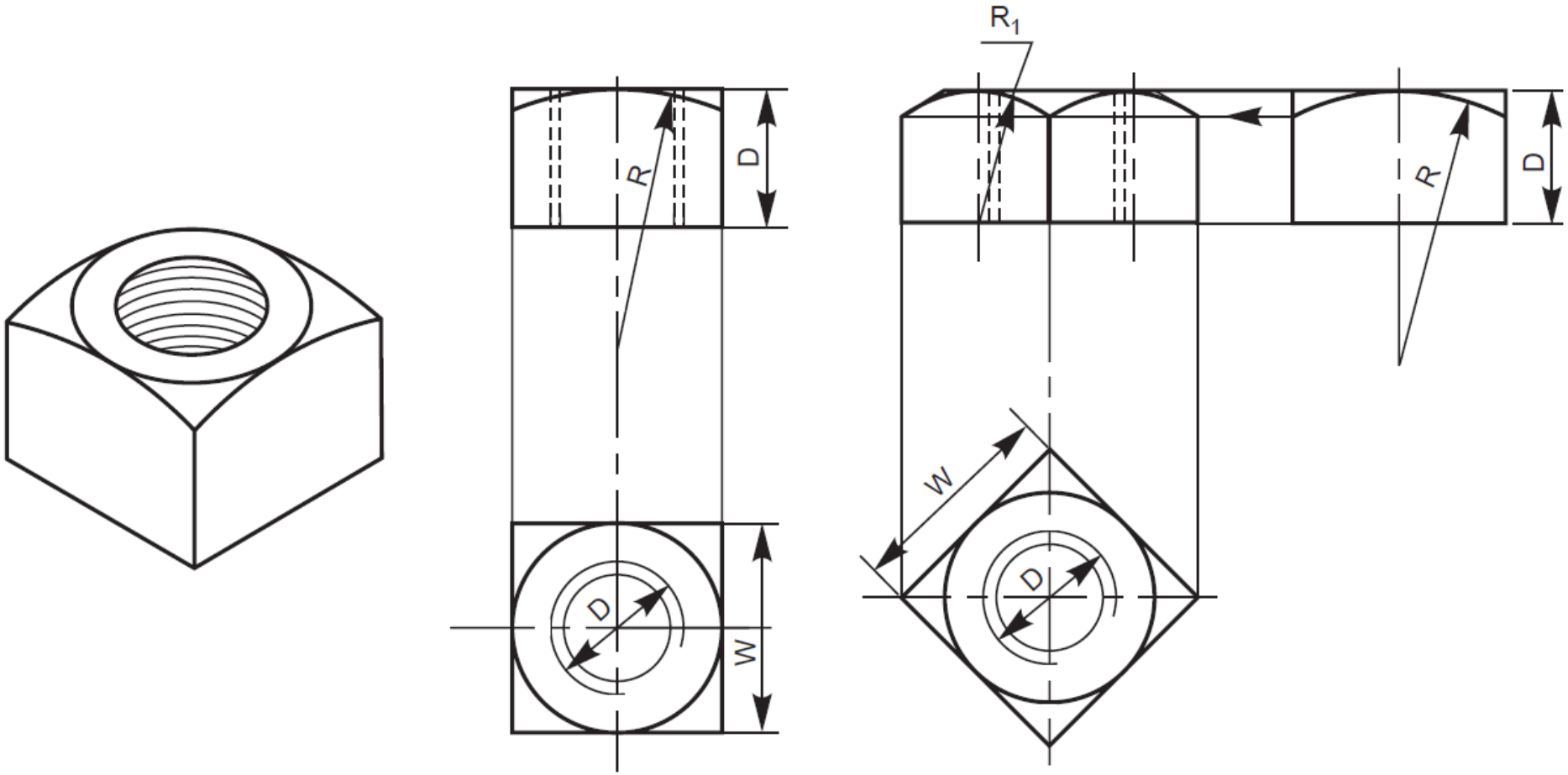


Fig.5.14 Method of drawing the views of a square nut

Major or nominal diameter of bolt = D

Thickness of nut, T = D

Width of the nut across flats, W = 1.5 D + 3 mm

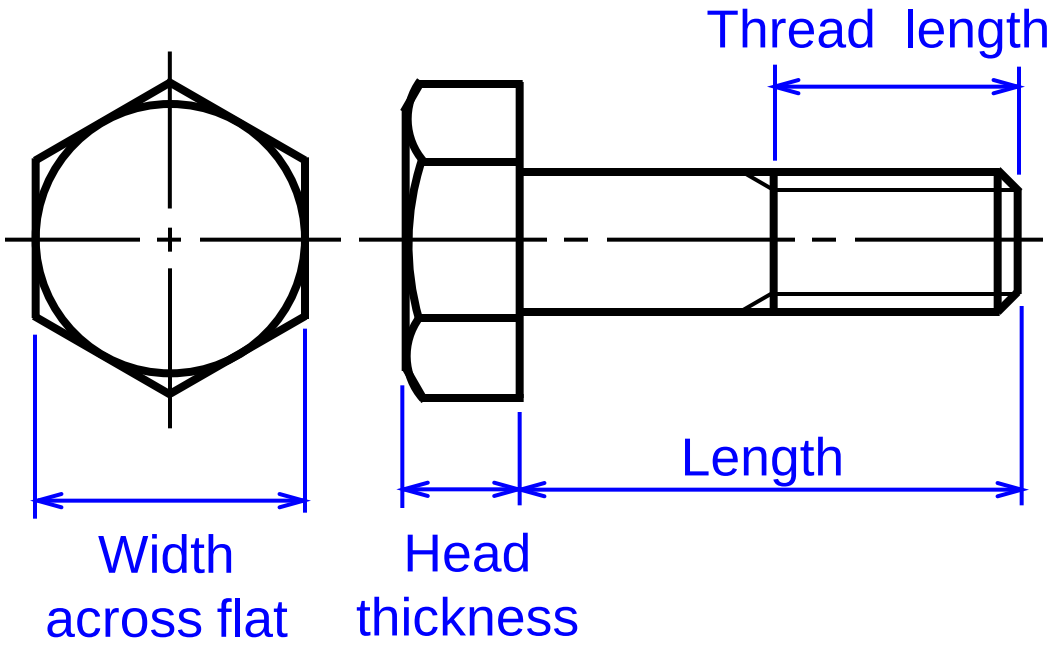
Radius of chamfer arc, R = 2 D

BOLT : Terminology

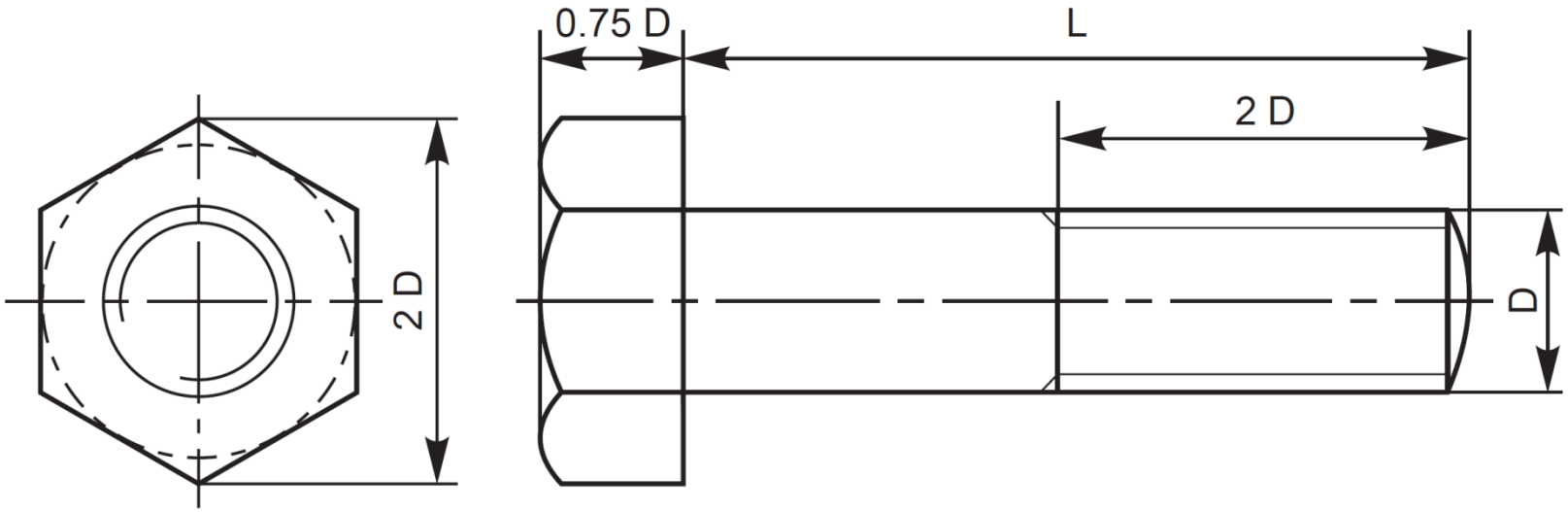
Bolt is a threaded cylinder with a head.



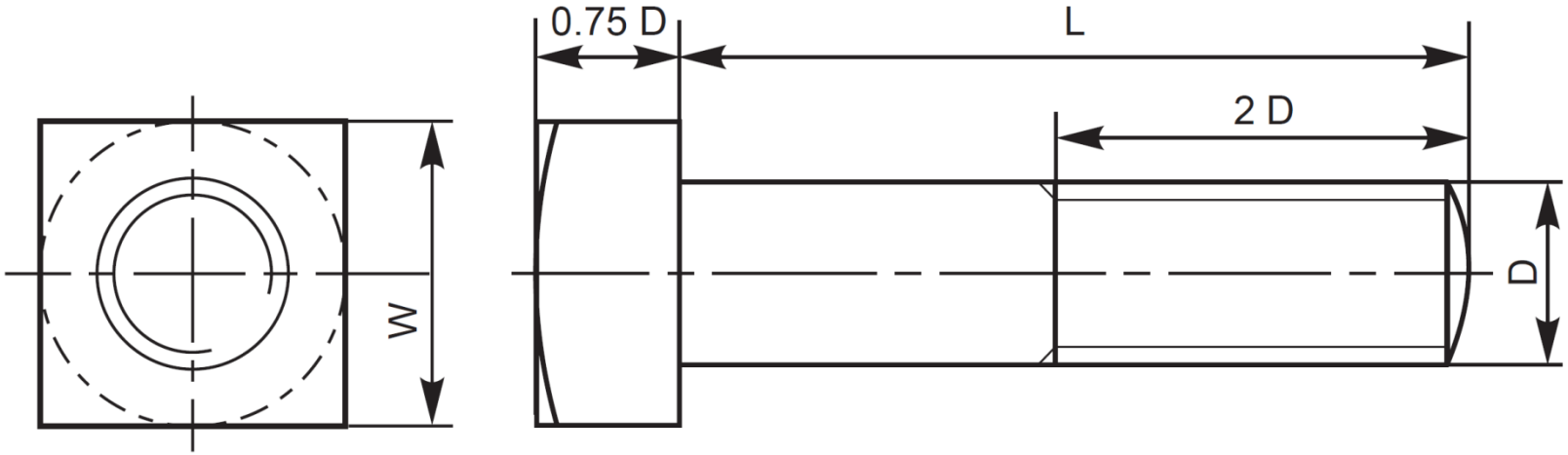
Hexagonal head bolt and nut



HEXAGONAL & SQUARE HEADED BOLT



(a) Hexagonal headed bolt



(b) Square headed bolt

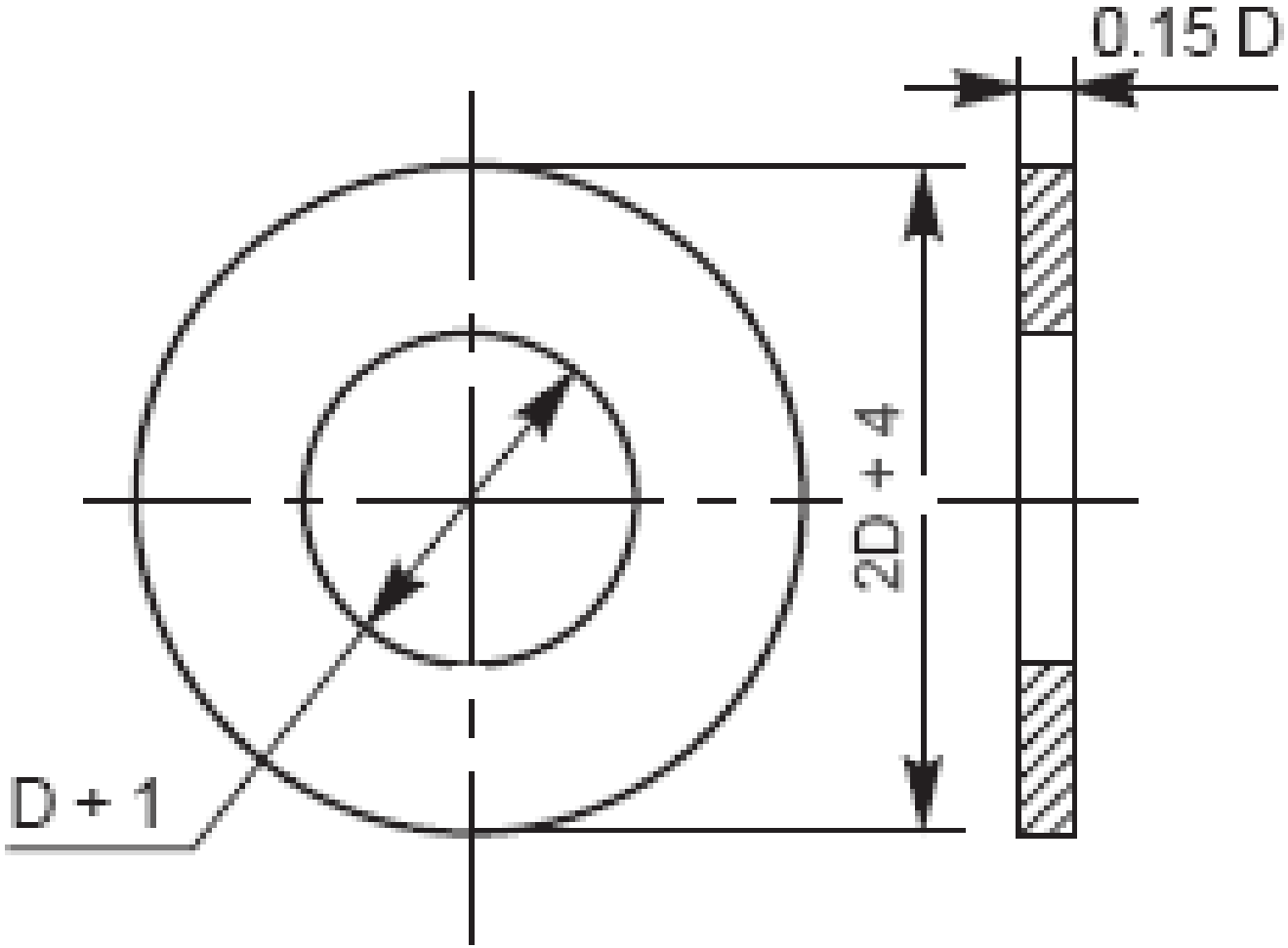


Fig. 5.16 Washer

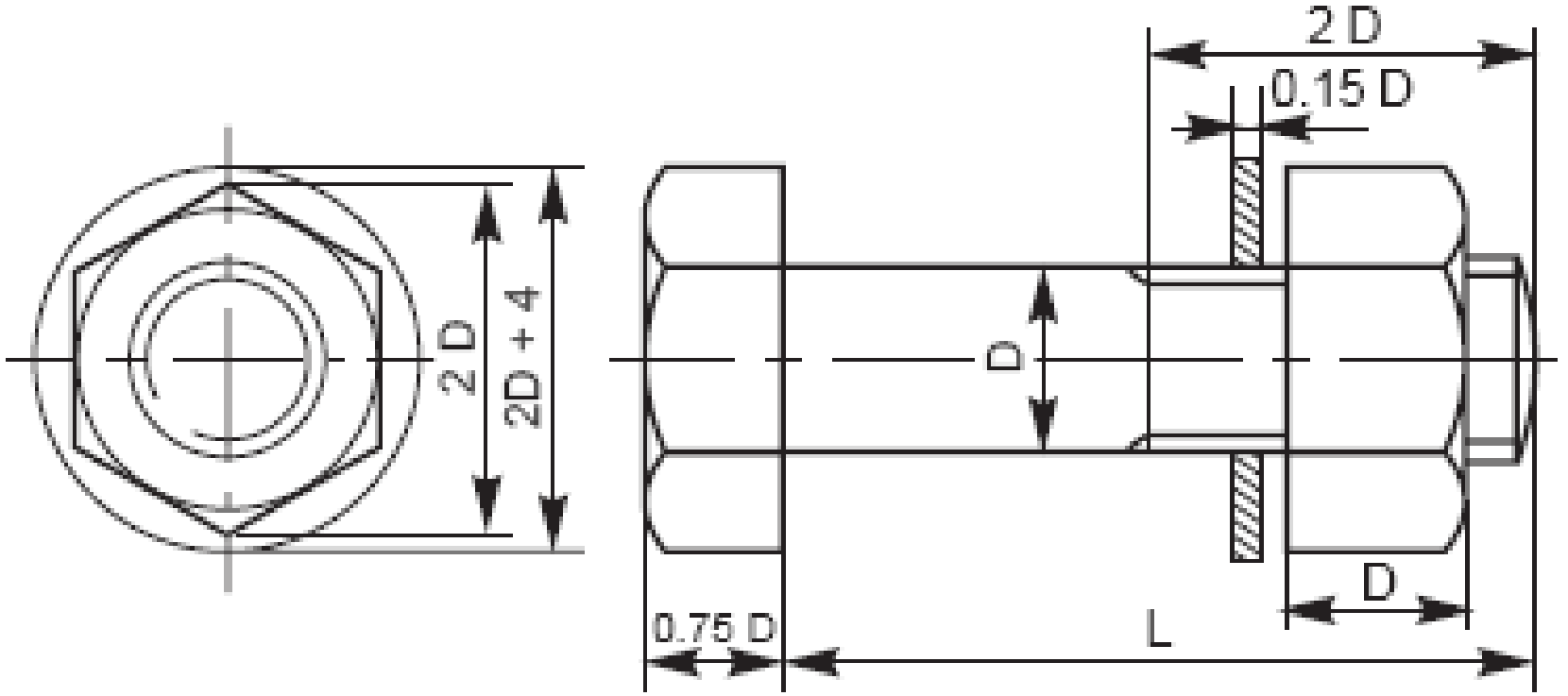


Fig. 5.17 A hexagonal headed bolt with a nut and a washer in position

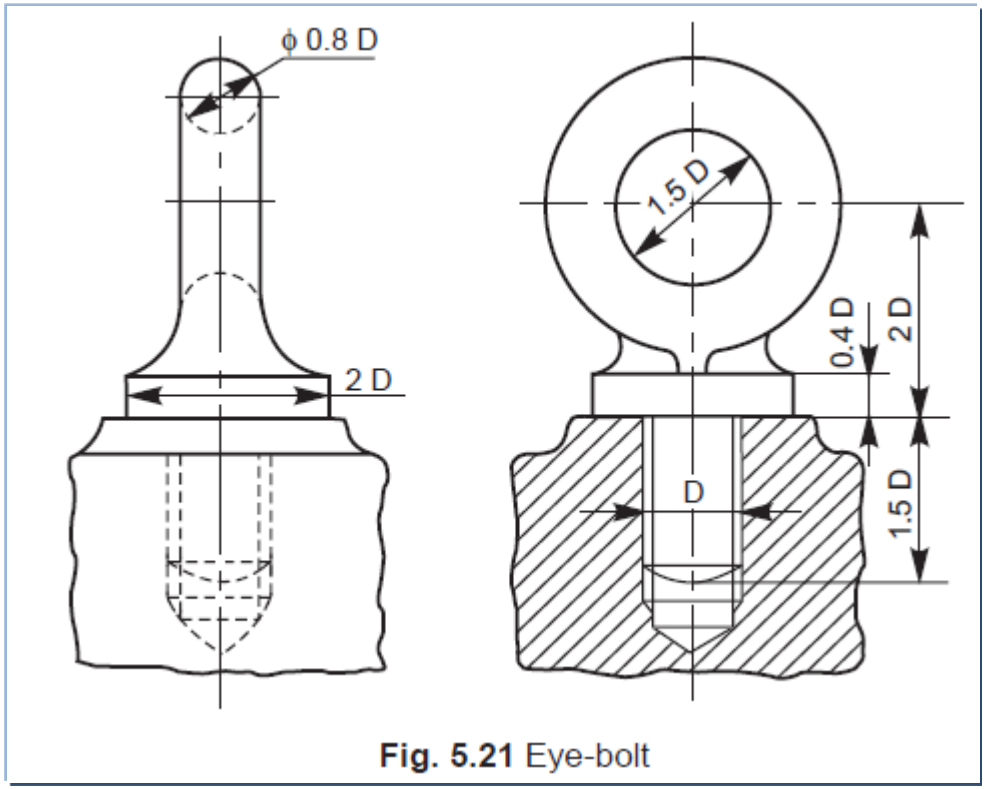


Fig. 5.21 Eye-bolt

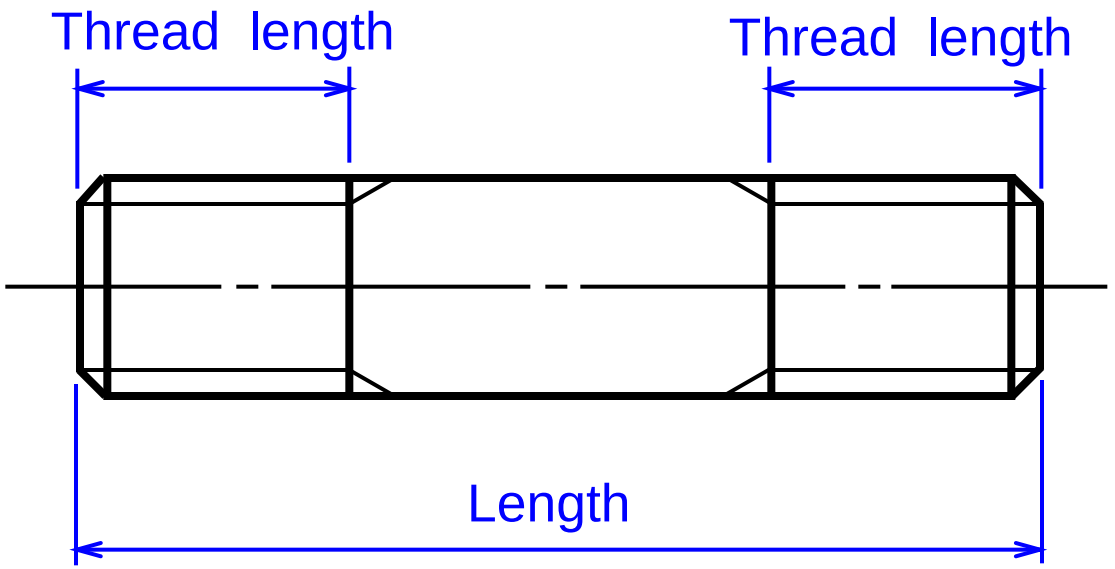
In order to facilitate lifting of heavy machinery, like electric generators, motors, turbines, etc., eye bolts are screwed on to their top surfaces. For fitting an eye bolt, a tapped hole is provided, above the centre of gravity of the machine (Fig. 5.21).

STUD : Terminology

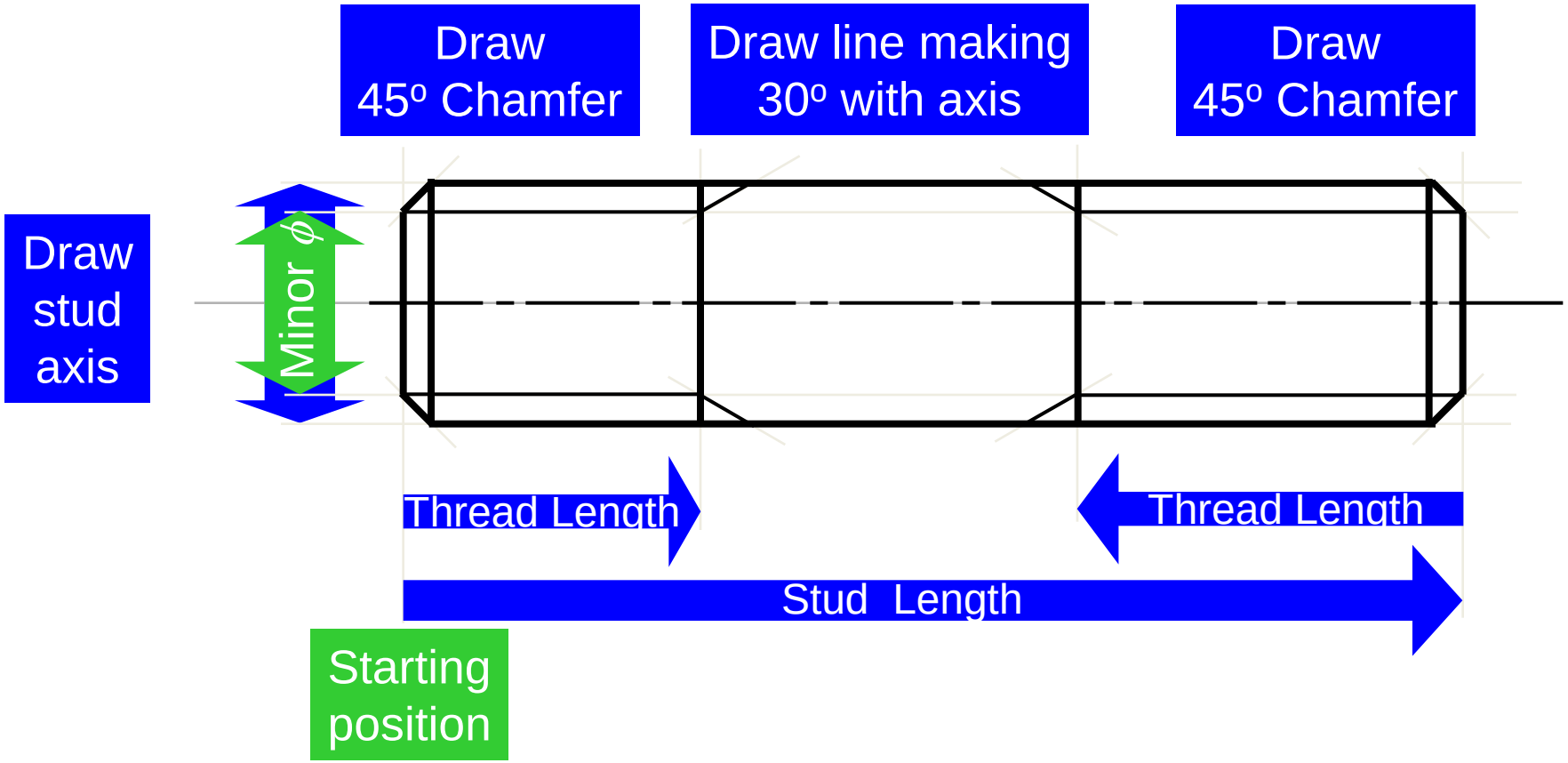
Stud is a *headless* bolt, threaded at both ends.



Drawing representation



STUD : Drawing steps



Stud Bolt or Stud

- It consists of cylindrical shank with threads cut on both the ends (Fig. 5.22*a*). It is used where there is no place for accommodating the bolt head or when one of the parts to be joined is too thick to use an ordinary bolt.

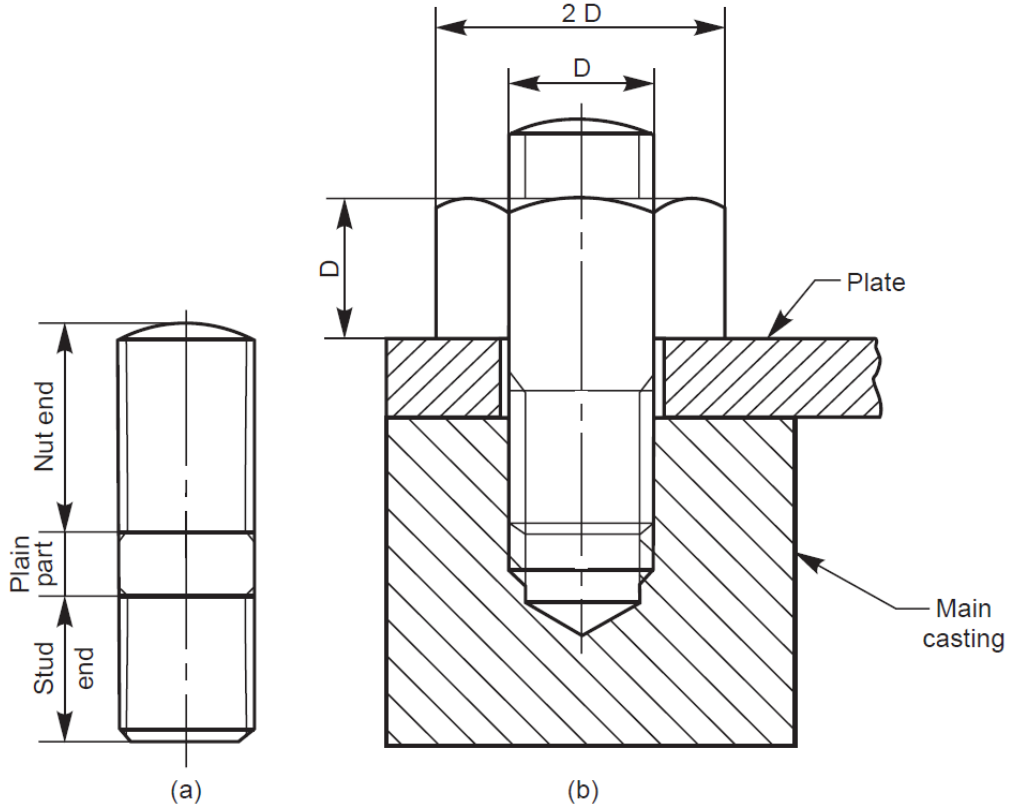
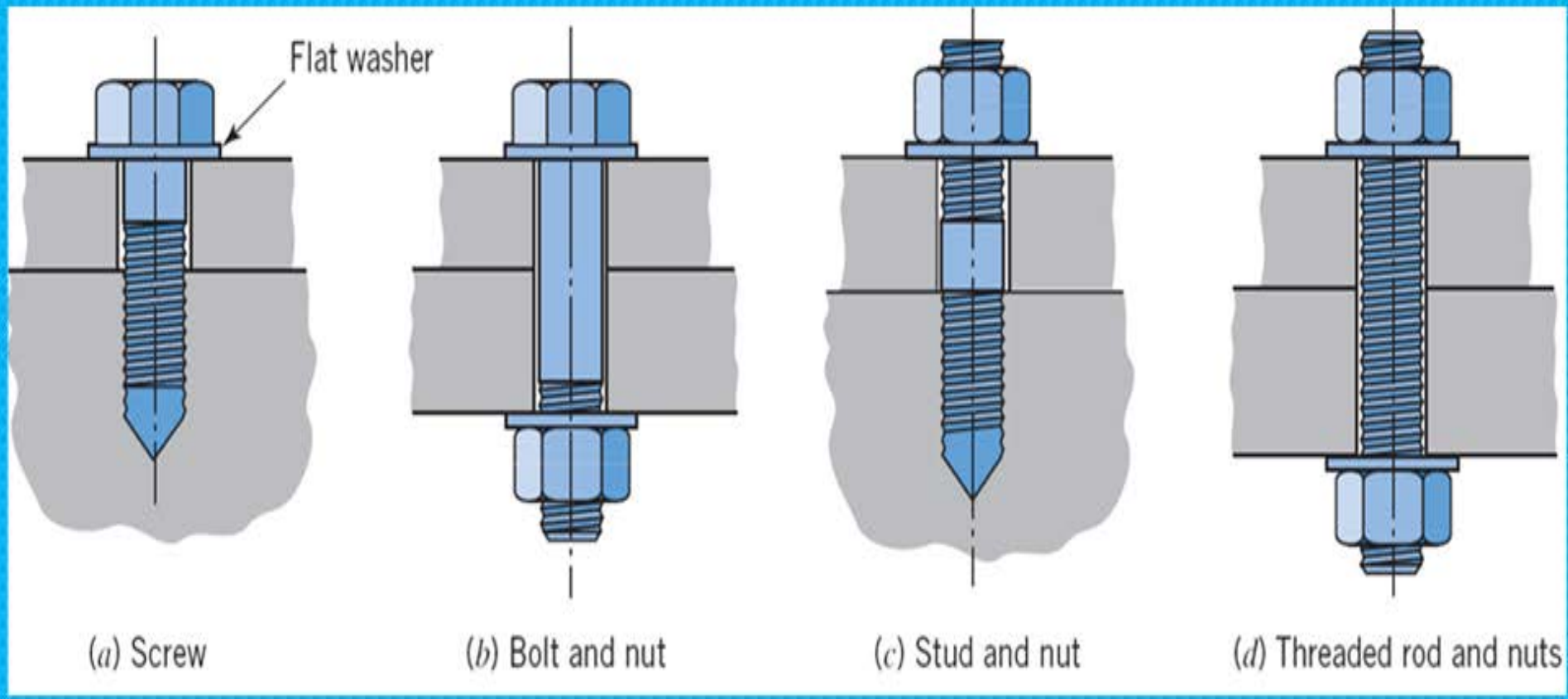


Fig. 5.22 (*a*)–Stud, (*b*)–Stud joint

- The stud is first screwed into one of the two parts to be joined, usually the thicker one.
- A stud driver, in the form of a thick hexagonal nut with a blind threaded hole is used for the purpose.
- After placing the second part over the stud, a nut is screwed-on over the nut end.
- It is usual to provide in the second part, a hole which is slightly larger than the stud nominal diameter. Figure 5.22*b* shows a stud joint.


Flat washer
(a) Screw
(b) Bolt and nut
(c) Stud and nut
(d) Threaded rod and nuts

Other Forms of Nuts

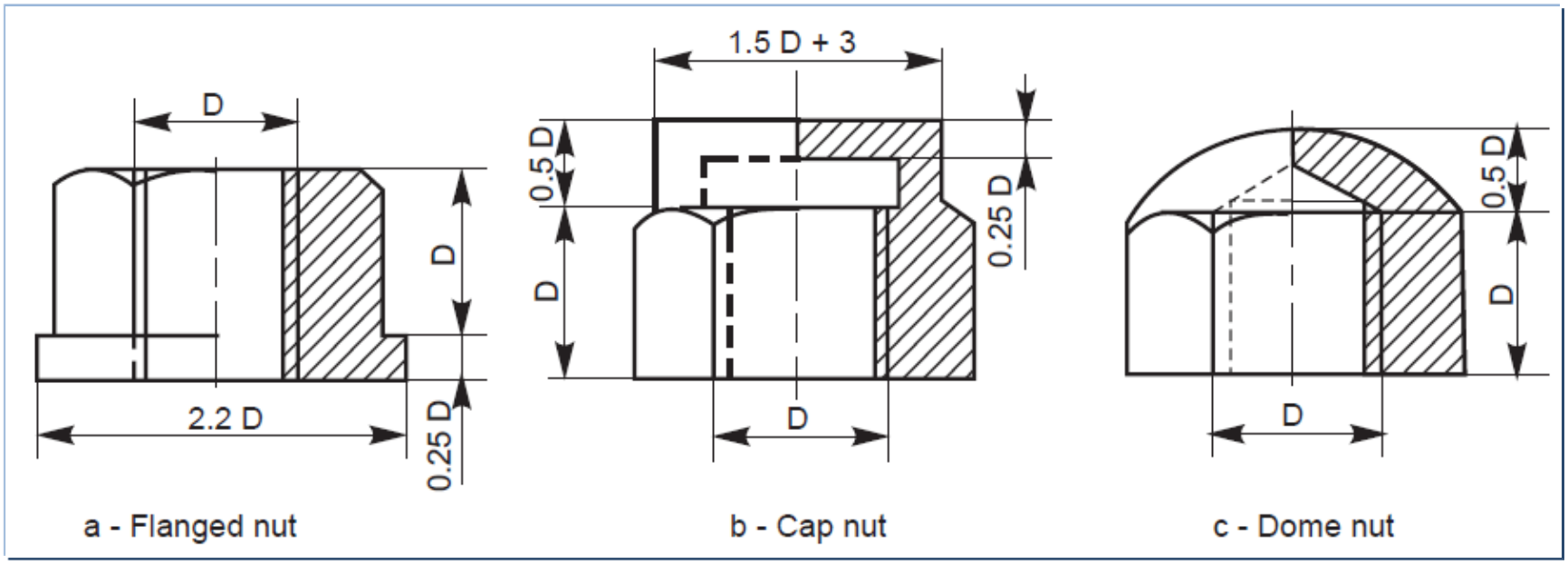


Figure 5.23

Flanged Nut: This is a hexagonal nut with a collar or flange, provided integral with it. This permits the use of a bolt in a comparatively large size hole (Fig. 5.23*a*).

Cap Nut: It is a hexagonal nut with a cylindrical cap at the top. This design protects the end of the bolt from corrosion and also prevents leakage through the threads. Cap nuts are used in smoke boxes or locomotive and steam pipe connections (Fig. 5.23*b*).

Dome Nut: It is another form of a cap nut, having a spherical dome at the top (Fig. 5.23*c*).

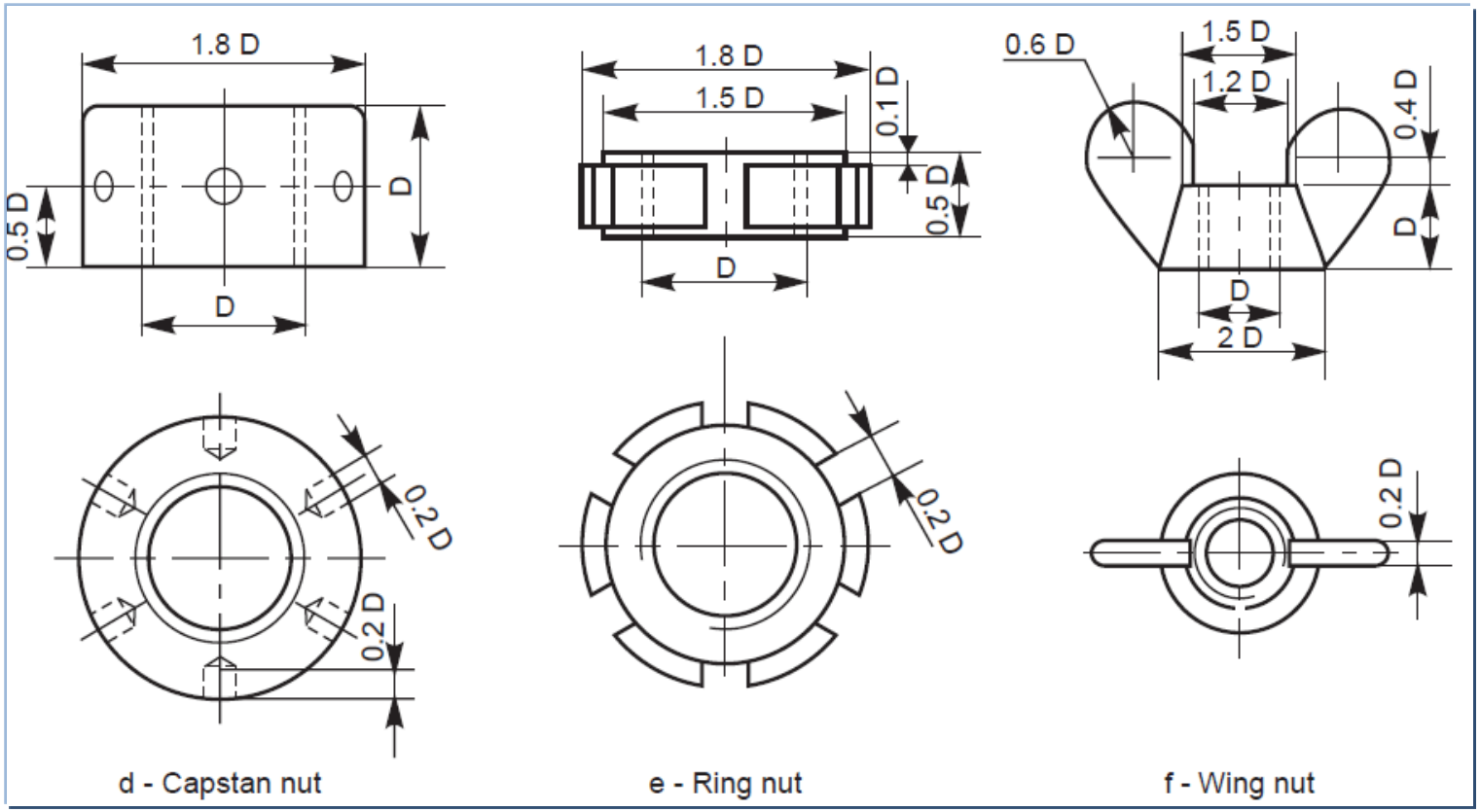


Figure 5.23

Capstan Nut: This nut is cylindrical in shape, with holes drilled laterally in the curved surface. A tommy bar may be used in the holes for turning the nut (Fig. 5.23*d*). Holes may also be drilled in the upper flat face of the nut.

Ring Nut: This nut is in the form of a ring, with slots in the curved surface, running parallel to the axis. A special C-spanner is used to operate the nut. These nuts are used on large screws, where the use of ordinary spanner is inconvenient (Fig. 5.23*e*).

Wing Nut: This nut is used when frequent removal is required, such as inspection covers, lids, etc. It is operated by the thumb (Fig. 5.23*f*).

LOCK NUTS

- The bolted joints, though removable in nature are required to stay firm without becoming loose.
- The joints used in moving parts of a machinery may be subjected to vibrations. This may slacken the joint , leading to serious break down.
- To eliminate the slackening tendency, different arrangements are used to lock the nuts.

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 legs of the split pin are opened out to prevent it from coming out while in use.

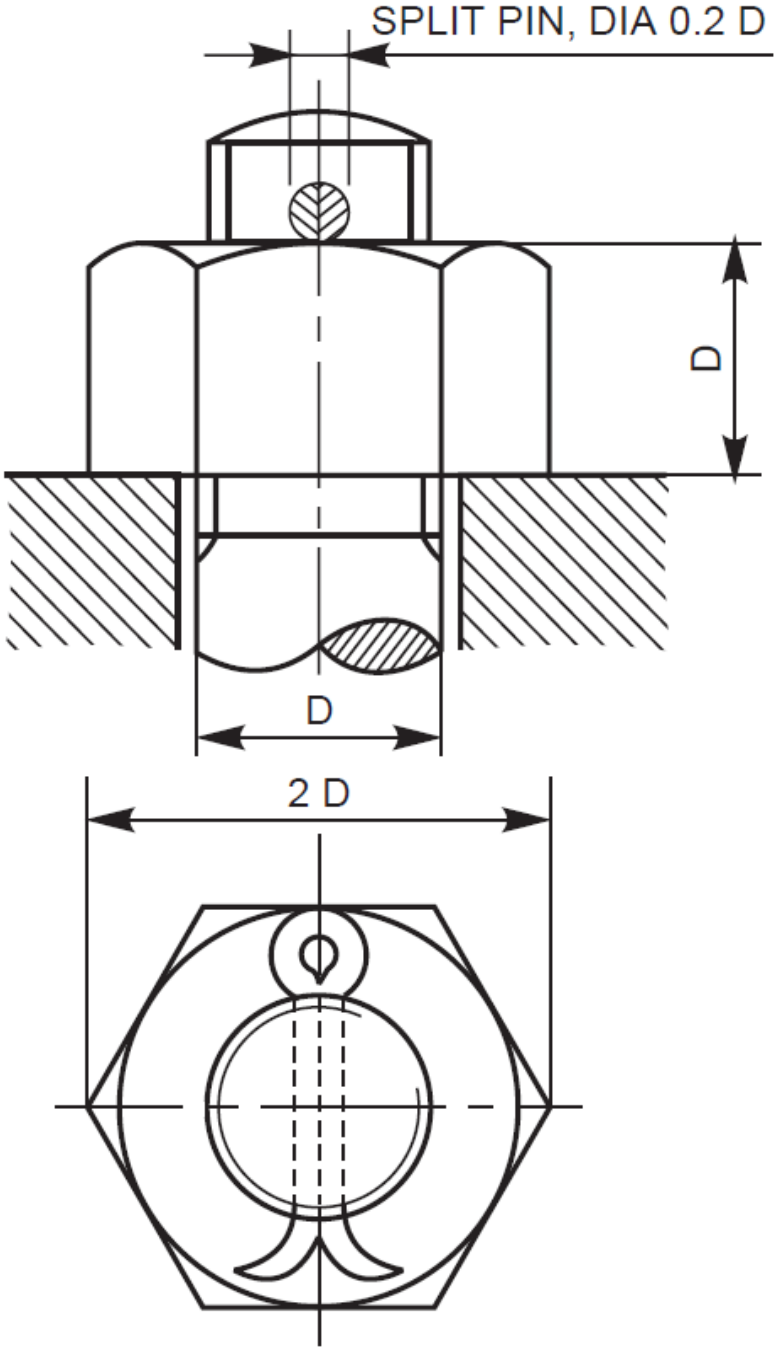
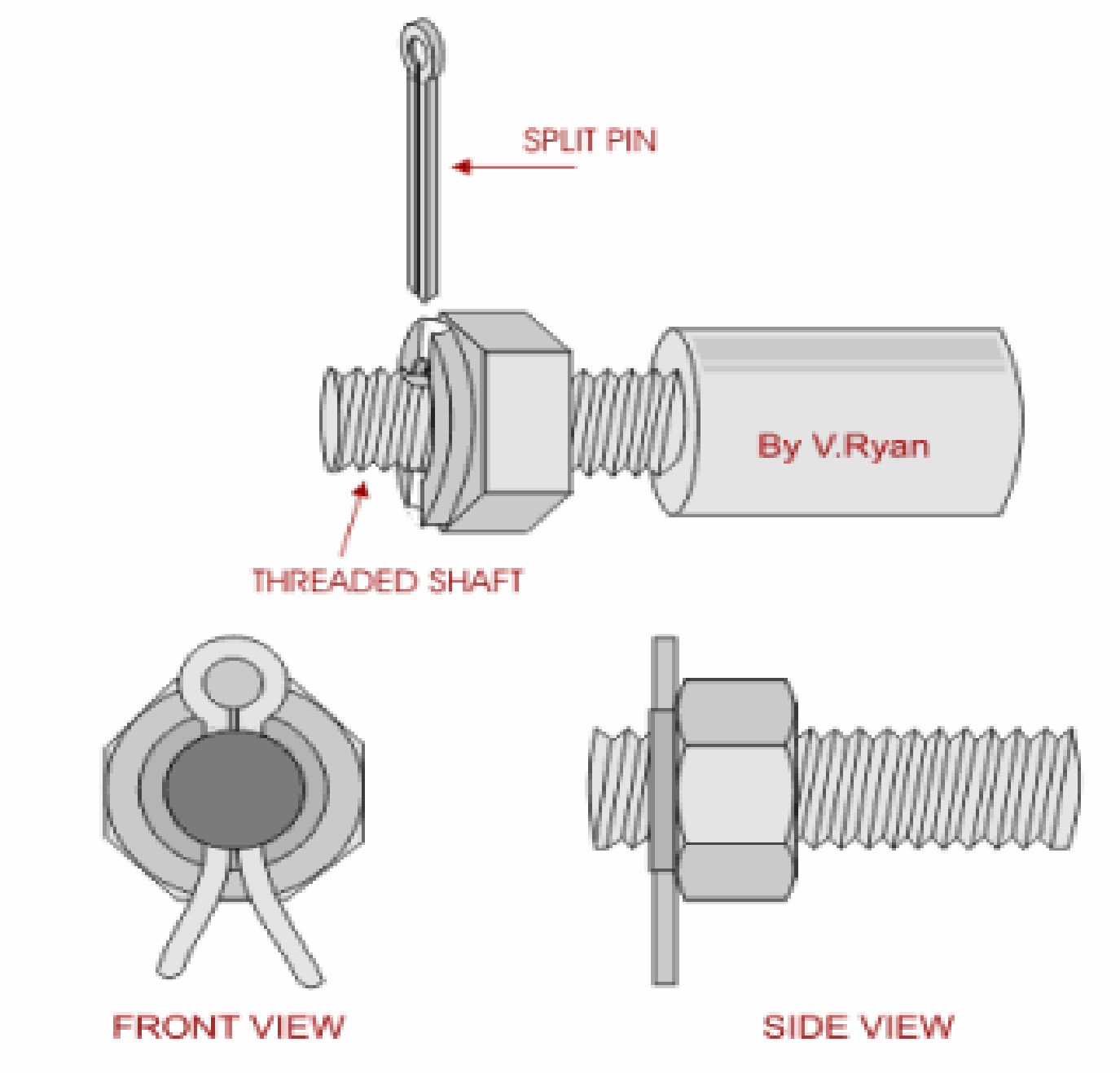


Fig. 5.28 Locking by split pin

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SPLIT PIN
By V.Ryan
THREADED SHAFT
FRONT VIEW
SIDE VIEW


SPLIT PIN LOCKING
HFS - 502

CASTLE NUT

- A castle nut is a hexagonal nut with a cylindrical collar at one end
- 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 the slots
- Castle nuts are widely used in automobiles and Locomotive engines.

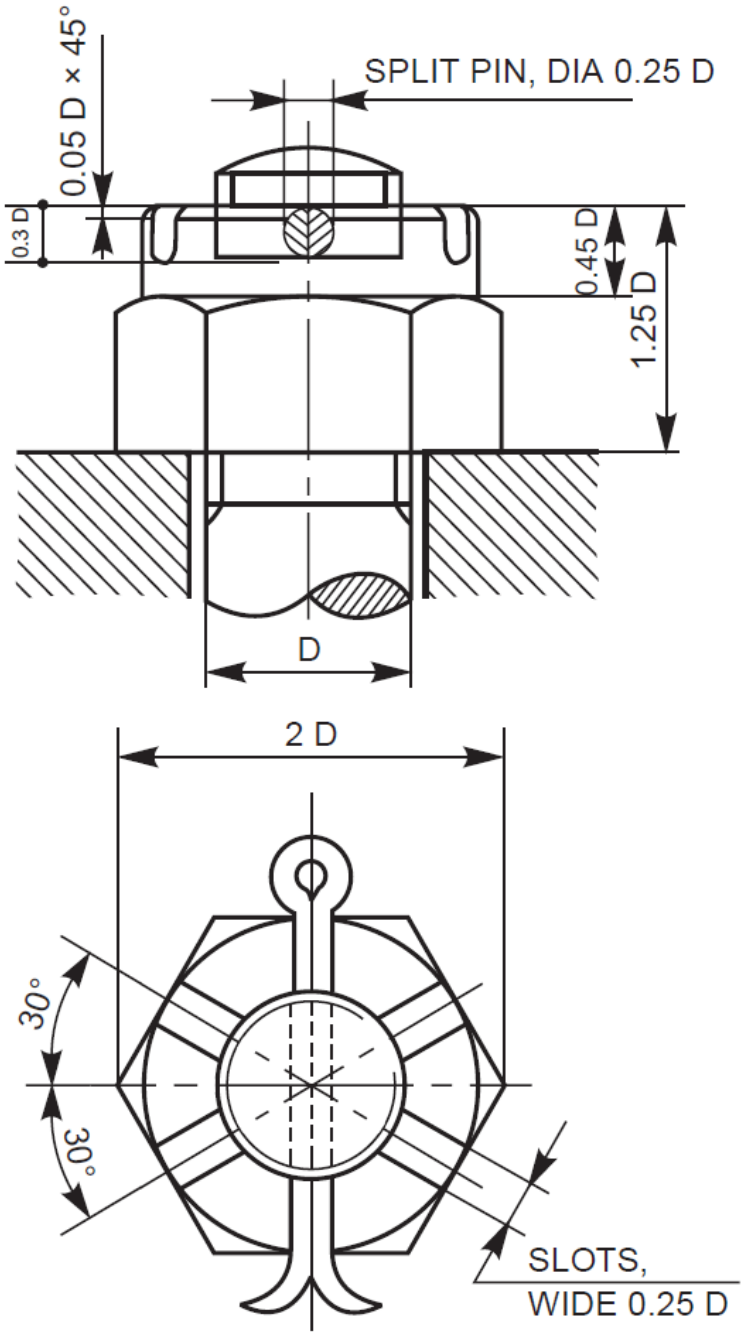
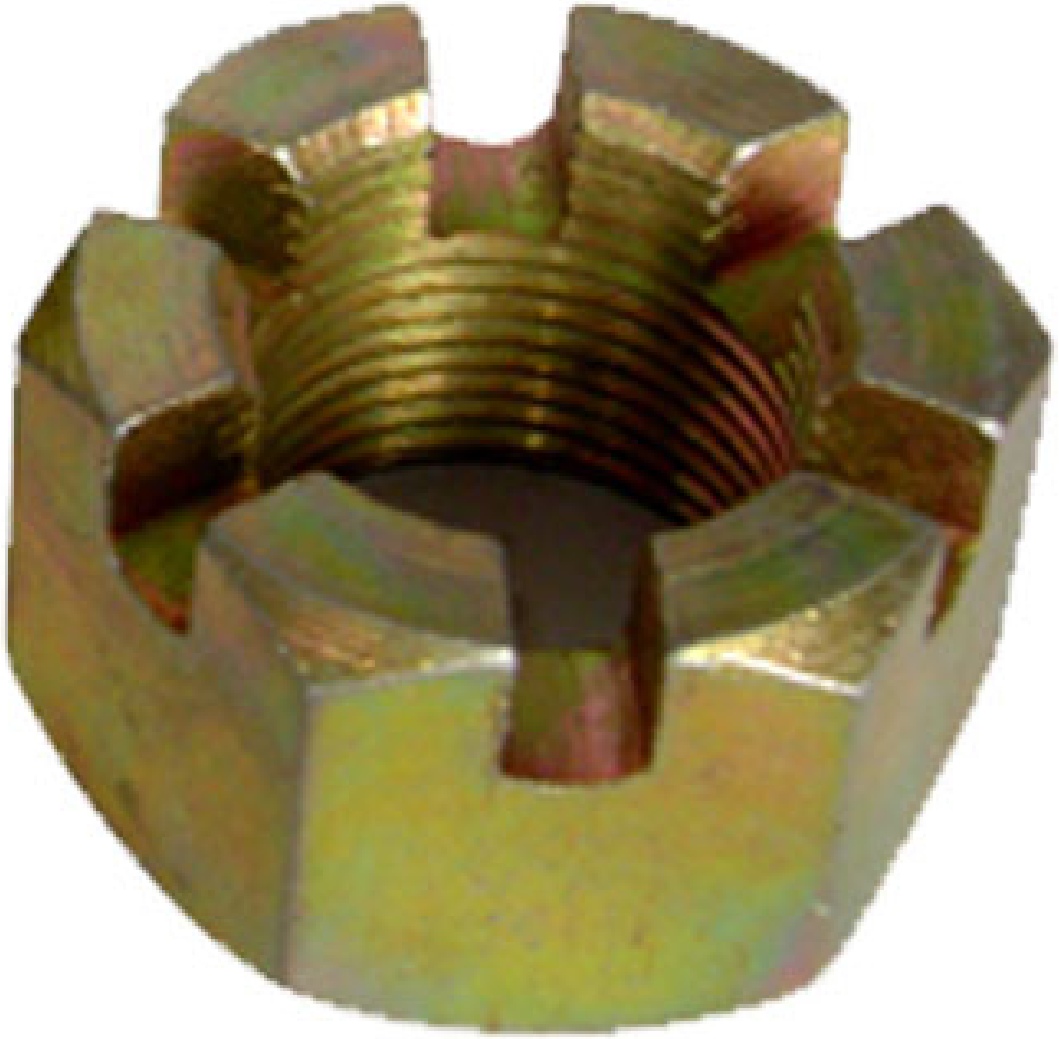


Fig. 5.29 Castle nut

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cotter pin installation

WILE'S LOCK NUT

- It is a hexagonal nut with a slot, cut half-way across it.

- After tightening the nut in usual manner, a set screw is used from the top of the nut, compressing two parts.

- For this purpose the upper portion of the nut should have a clearance hole and the lower portion tapered.

- On tightening the set screw, the upper part of the nut presses against the lower, resulting an increase in gripping force in the nut and the bolt threads.

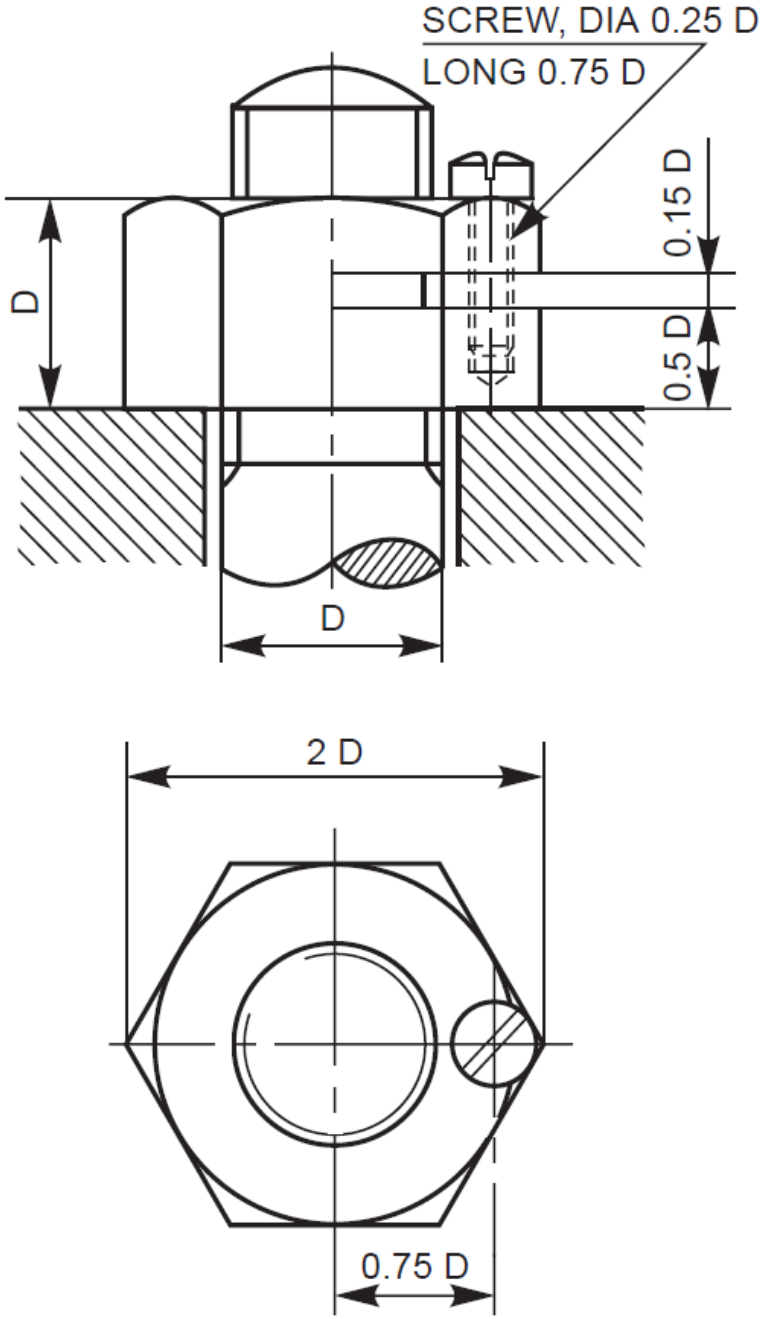


Fig. 5.30 Wile's lock nut

Locking by set screw

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

- The arrangement prevents the loosening of the nut.

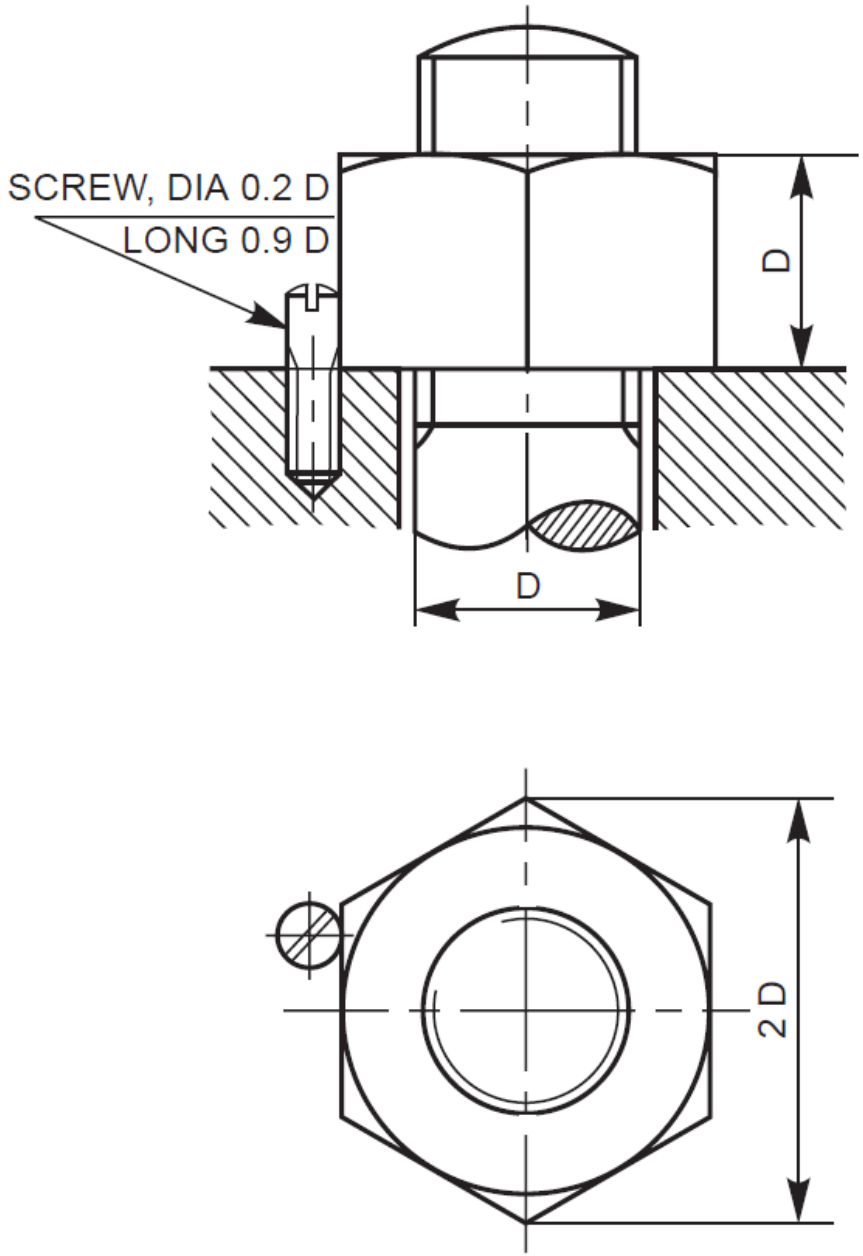


Fig. 5.31 Locking by set screw

GROOVED NUT

- In this nut, a cylindrical grooved collar is made at the bottom surface of the hexagonal nut.
- The collar fits into the hole of the adjoining piece.
- In this arrangement, after tightening the nut, a set screw is inserted from one end in such away that it fits into the groove of the collar, preventing the loosening tendency of the nut.

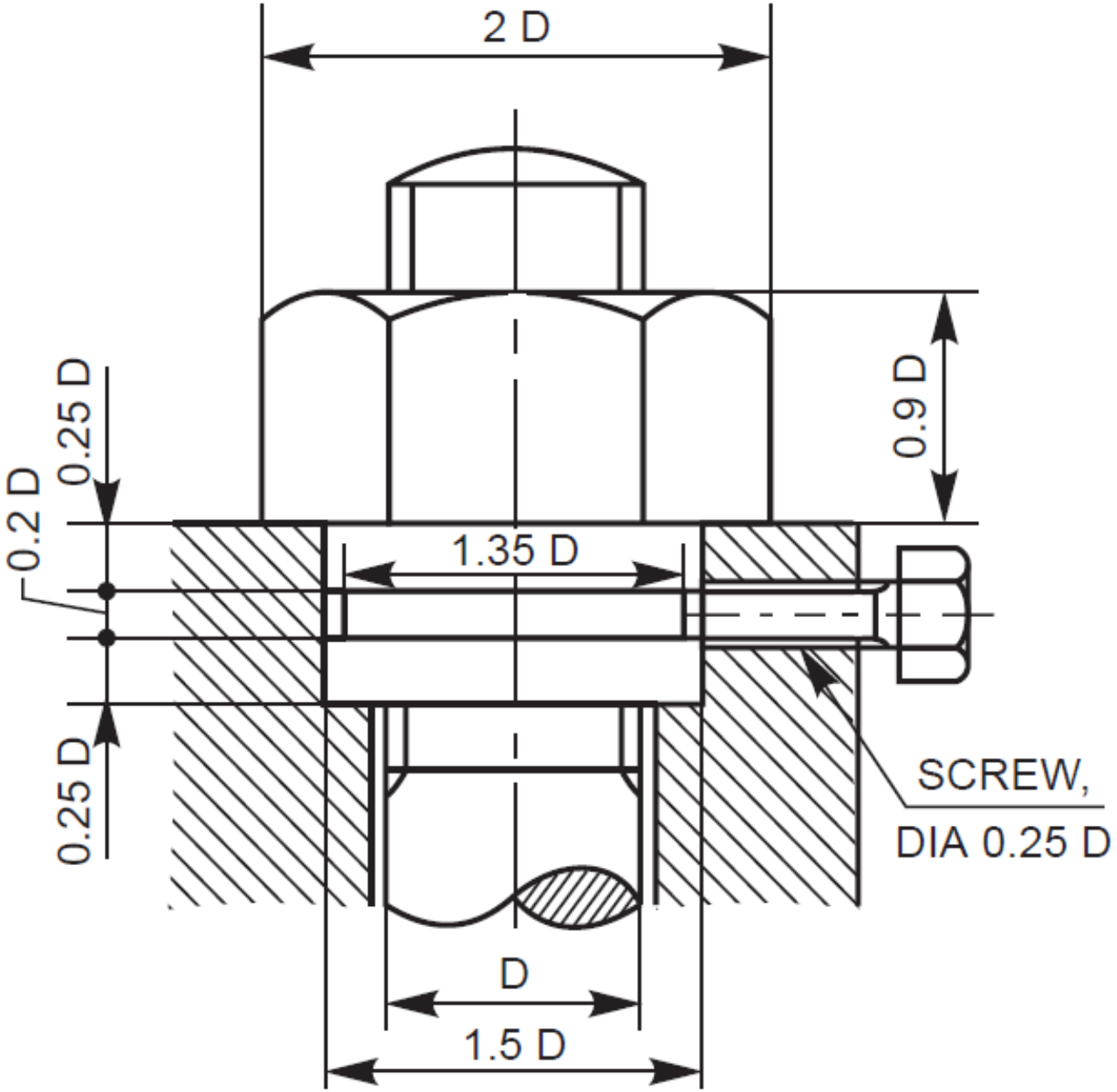


Fig. 5.32 Grooved nut

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FOUNDATION BOLTS

❖Foundation bolts are used to fix machines to their foundations.

❖Foundation bolts are made by forging from mild steel or wrought iron rods.

❖The size of the bolt depends on size of the machine and the forces acting on them when the machine is in use.

1. Eye foundation bolt

- This is the simplest form of all bolts.
- In this one end of the bolt is forged into an eye
- A mild steel bar passes through the eye of the bolt at right angles to its axis by which the bolt is fixed in the foundation.

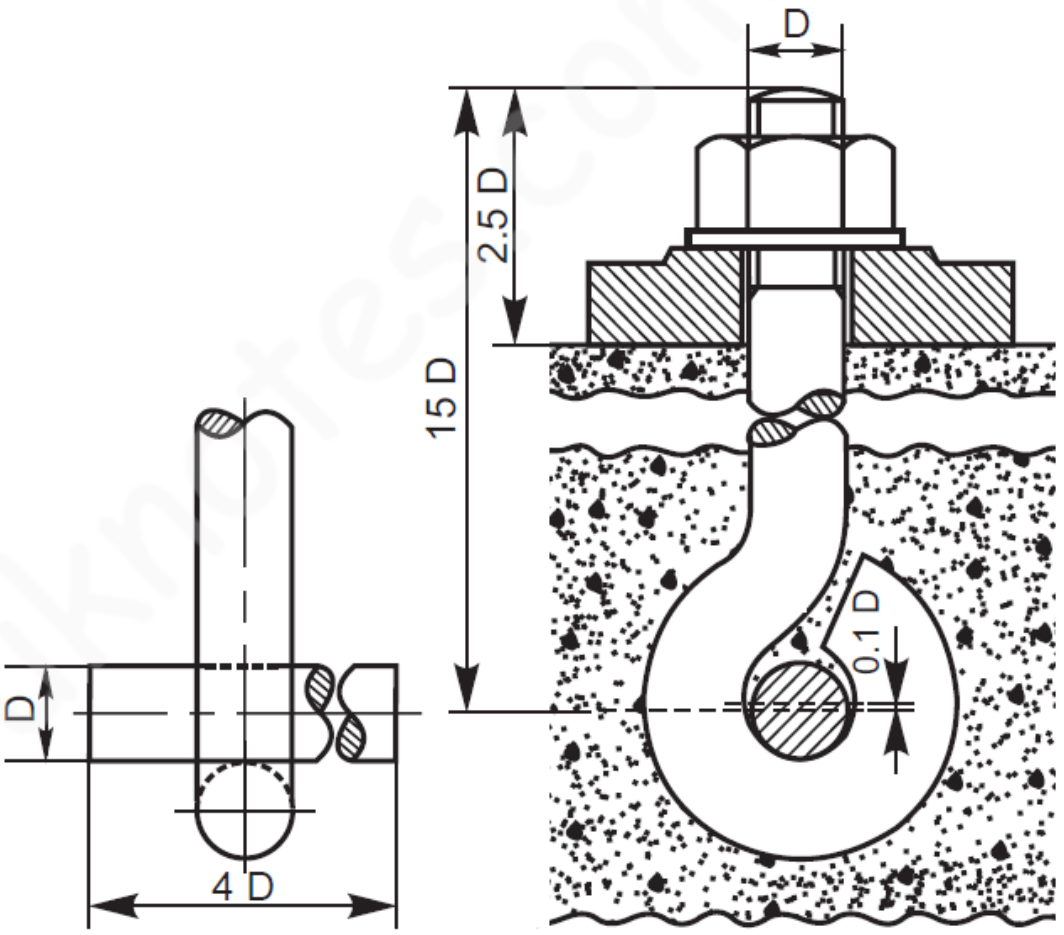


Fig. 5.36 Eye foundation bolt

2. BENT FOUNDATION BOLT

- It is a simple foundation bolt made from mild steel or wrought iron bar in a curved/ bent form.
- If the machines are to placed on stone beds bent foundation bolts are first set in lead and then in cement concrete.
- As shown in the figure the end of the bolt is rounded of twice the diameter.

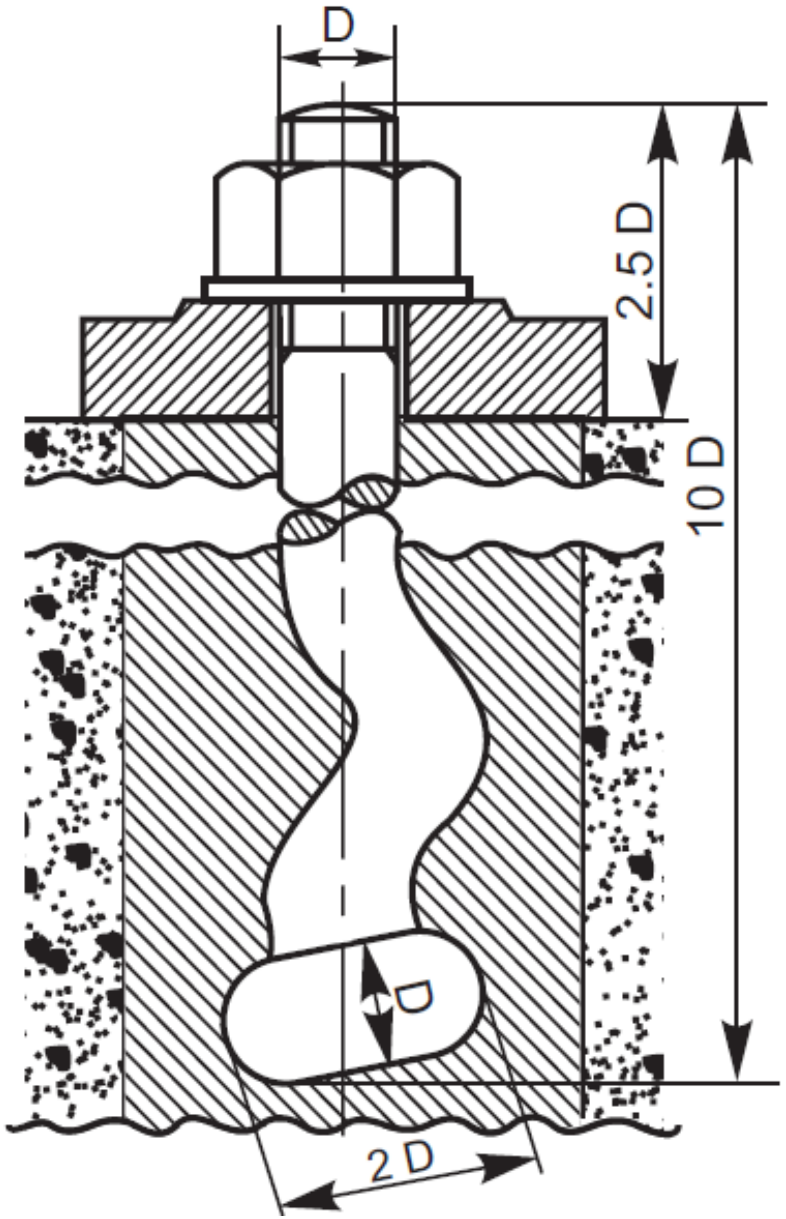


Fig. 5.37 Bent foundation bolt

3. RAG FOUNDATION BOLT

- Rag bolt is used for fixing the heavy machines to stone or concrete foundation.

- It consists of tapered body, square or rectangular cross section, the tapered edges being grooved.

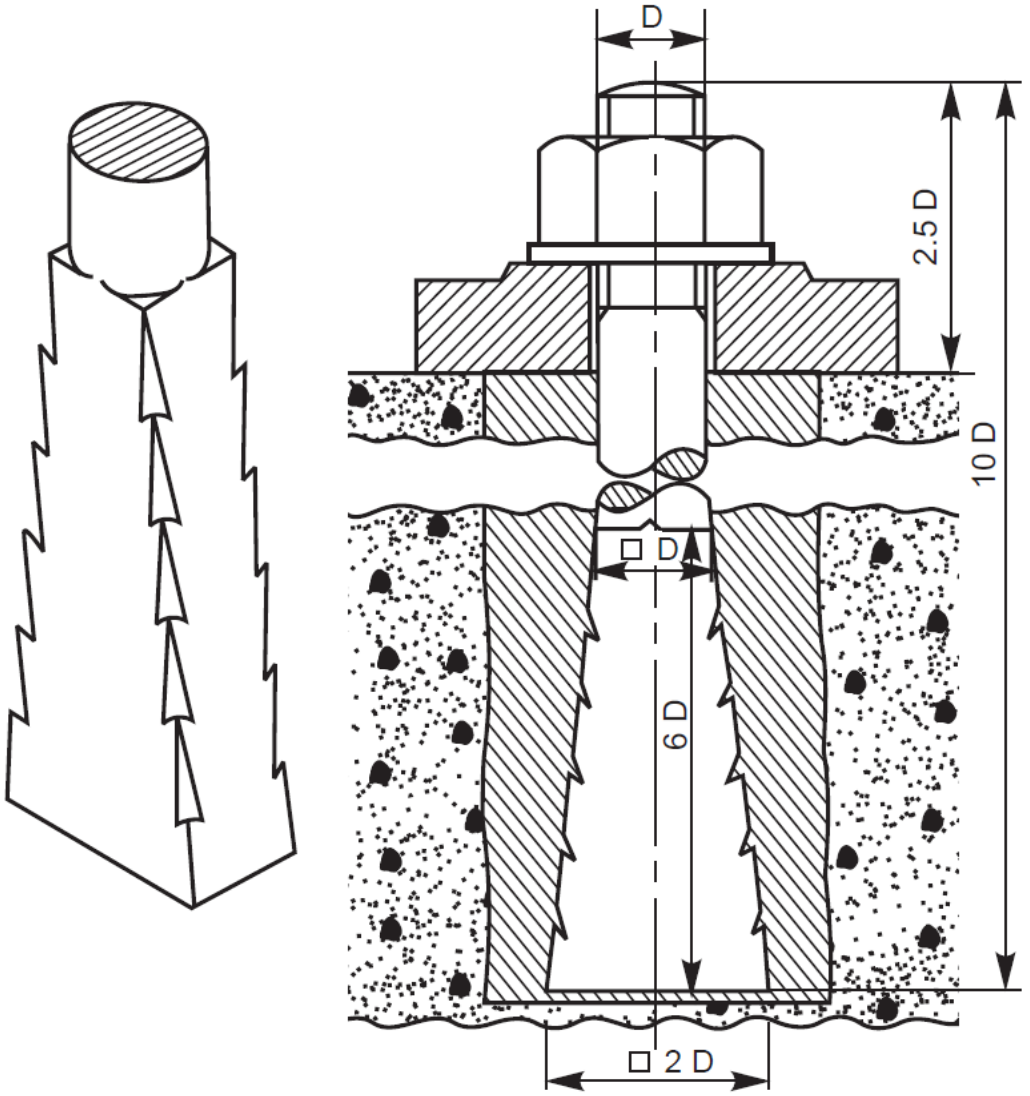


Fig. 5.38 Rag foundation bolt

4. LEWIS FOUNDATION BOLT

- It is used for temporary foundation
- In this bolt one side is formed straight and other is tapered.
- It is fixed along with a key which is inserted with the straight side in the foundation.
- The bolt can be easily removed by simply drawing the key.
- This bolt is advantageous for lifting huge stones

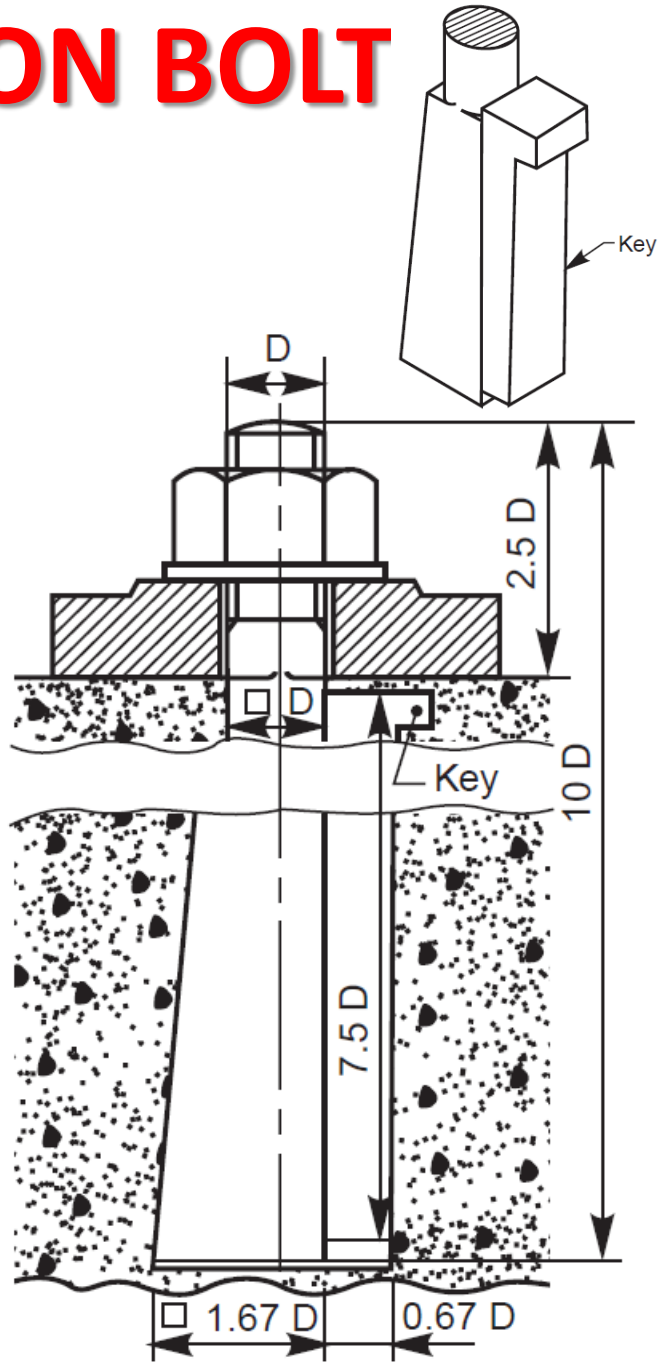
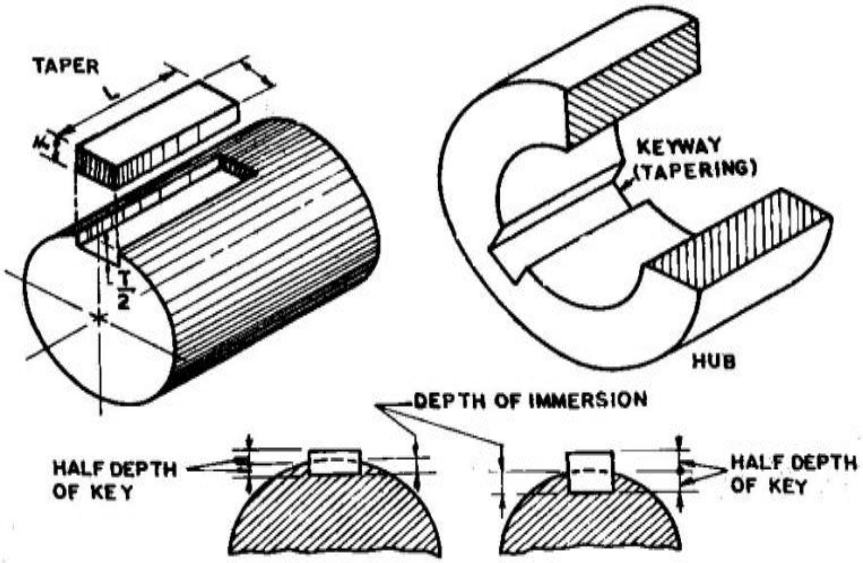


Fig. 5.39 Lewis foundation bolt

SHEET 3

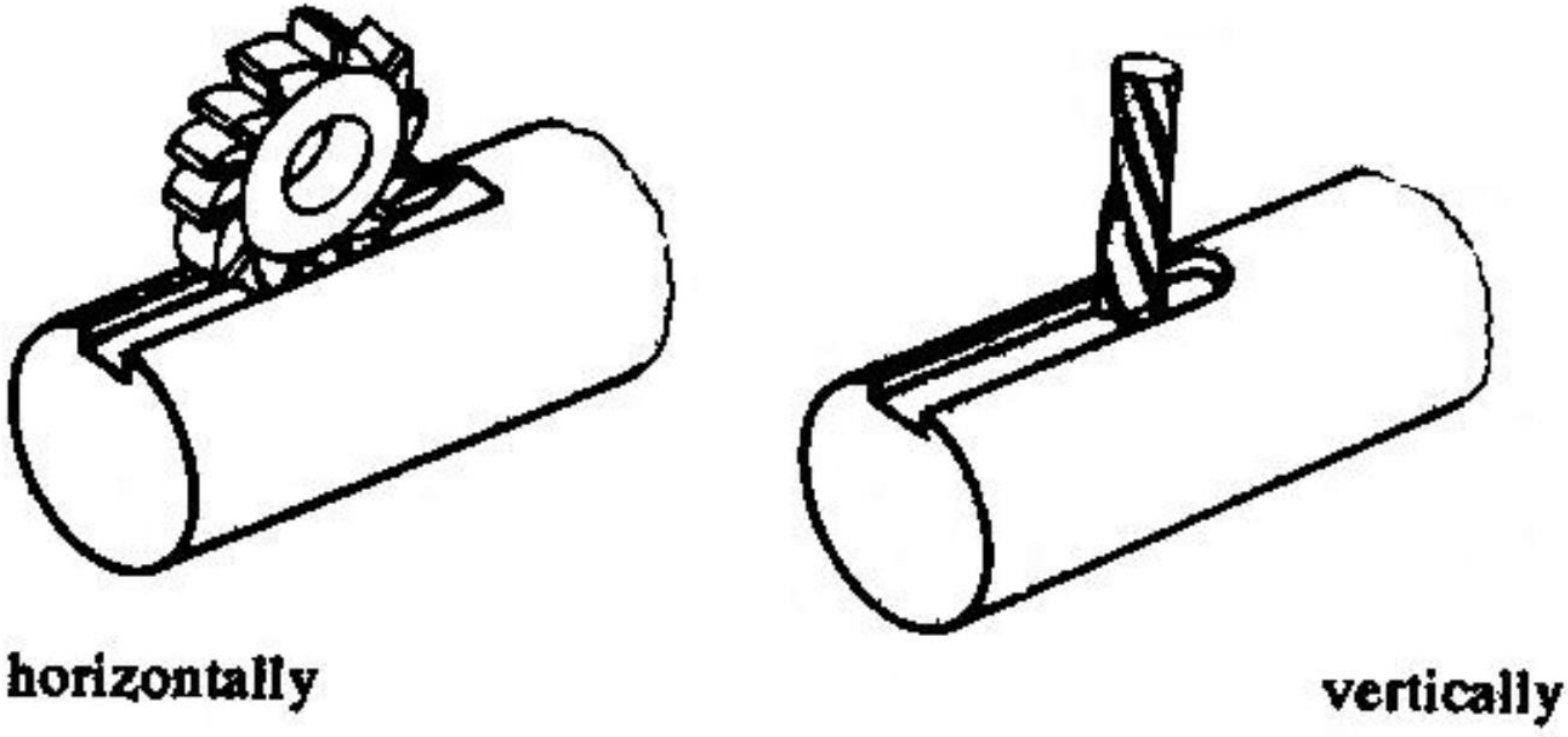
Keys and Cotter Joints

Keys



- A key is the piece inserted in an axial direction between a shaft and hub of the mounted machine element such as pulley or gear to prevent relative rotation may allow sliding movement along the shaft if required.
- Keys are temporary fastening and are always made of mild steel because they are subjected to shearing and compressive stresses caused by the torque they transmit.
- A keyway is the groove cut in the shaft or hub to accommodate a key. Key ways can be milled horizontally or vertically.

Keyways milled



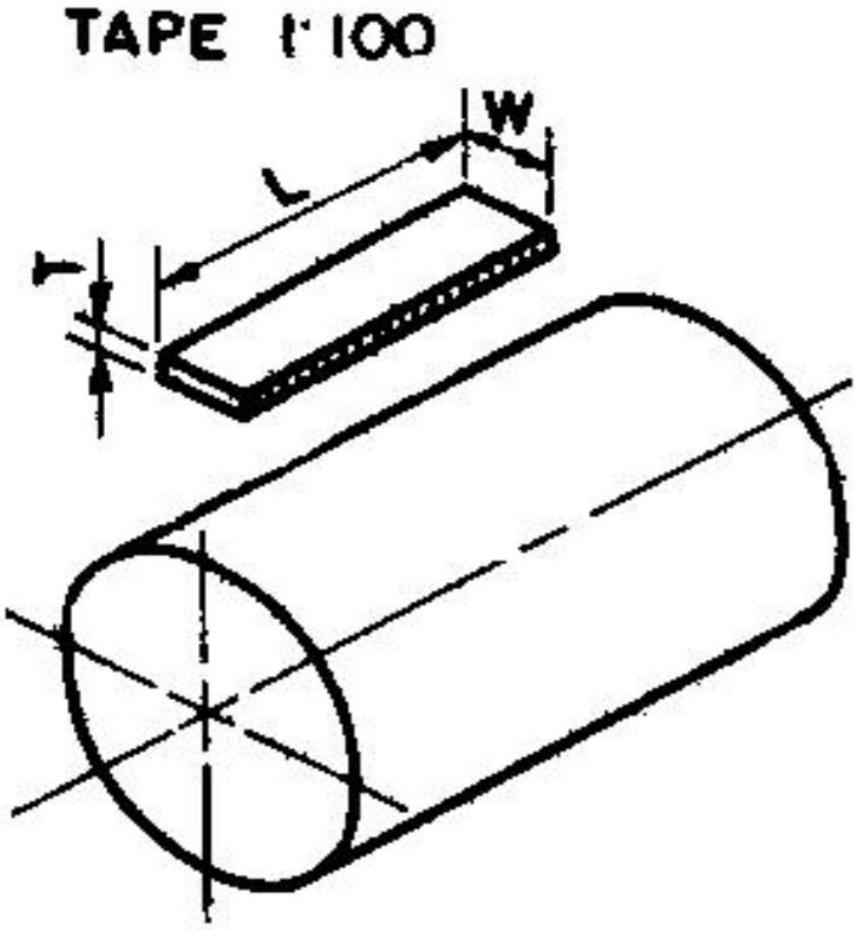
Classification of keys

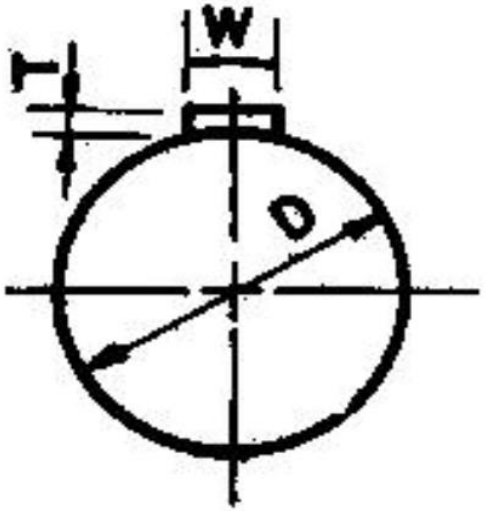
- Saddle keys
  - » Hollow saddle key
  - » Flat saddle key
- Sunk keys
  - » Taper sunk keys
  - » Parallel sunk keys
  - » Feather keys
  - – Woodruff key (adjustable key)
- Round keys
  - » Parallel pin
  - » Taper pin

Hollow saddle key

–this key has curved underside so that it can be placed on the curved surface of the shaft. The keyway is cut in the mating piece (hub) only.

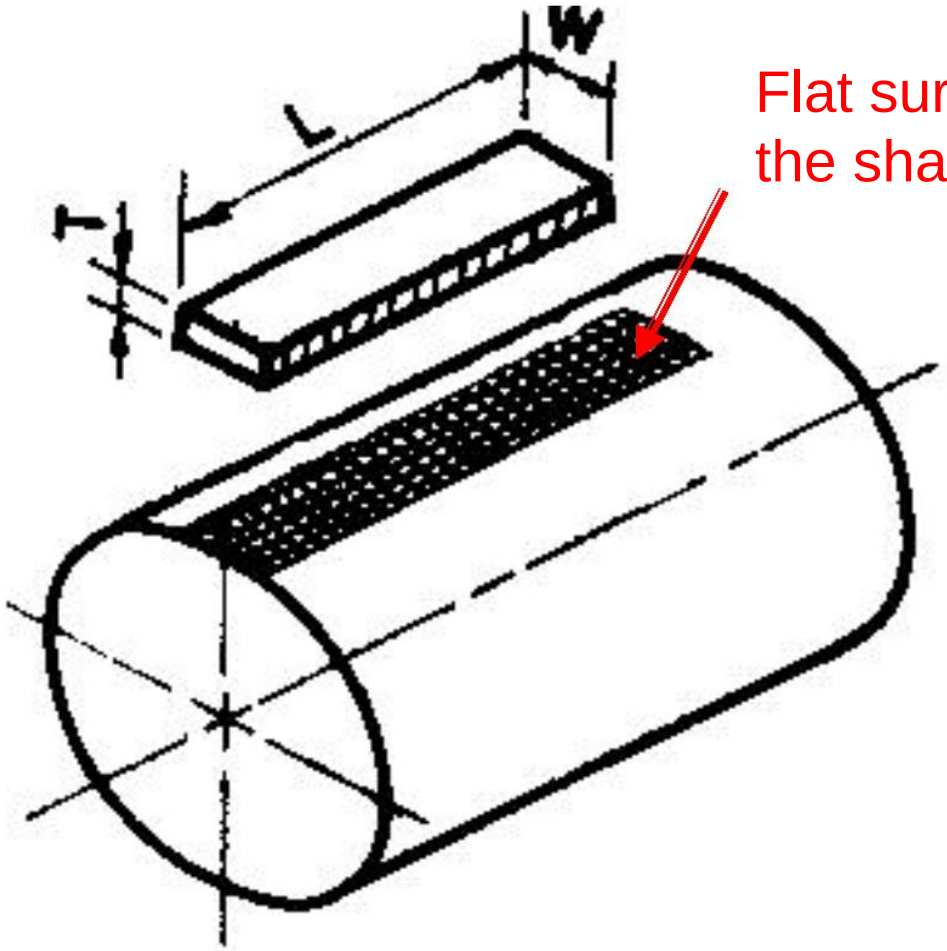
Saddle key are taper keys and are sunk into the hub only
Taper prevents axial movement along the shaft



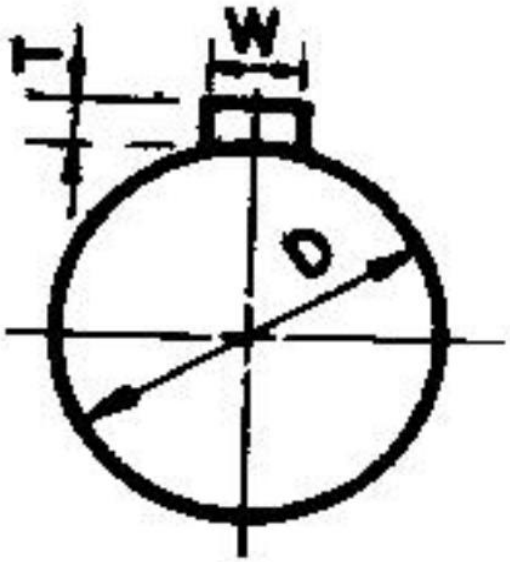


Saddle key is suitable for light duty, since they rely on a friction drive alone and are liable to slip on the shaft under load

Flat saddle key



Flat surface on the shaft



Let D = diameter of the shaft

Width of the key, W = D/4

Nominal thickness at large end , T = W/3 = D/12

Length of the key , L = D to 1.5D

Taper on the top surface = 1:100

holding force is comparative large than the hollow saddle key

Sunk keys

- Sunk keys are sunk in the shaft and the hub. These keys are suitable for heavy duty since they rely on positive drive.
  - Taper sunk keys:
    - This is the standard form of the key and may be either of rectangular or square cross-section. The key is sunk in the shaft to a depth of half its nominal thickness when measured at the side.
      - » Rectangular cross-section

        let D = diameter of the shaft

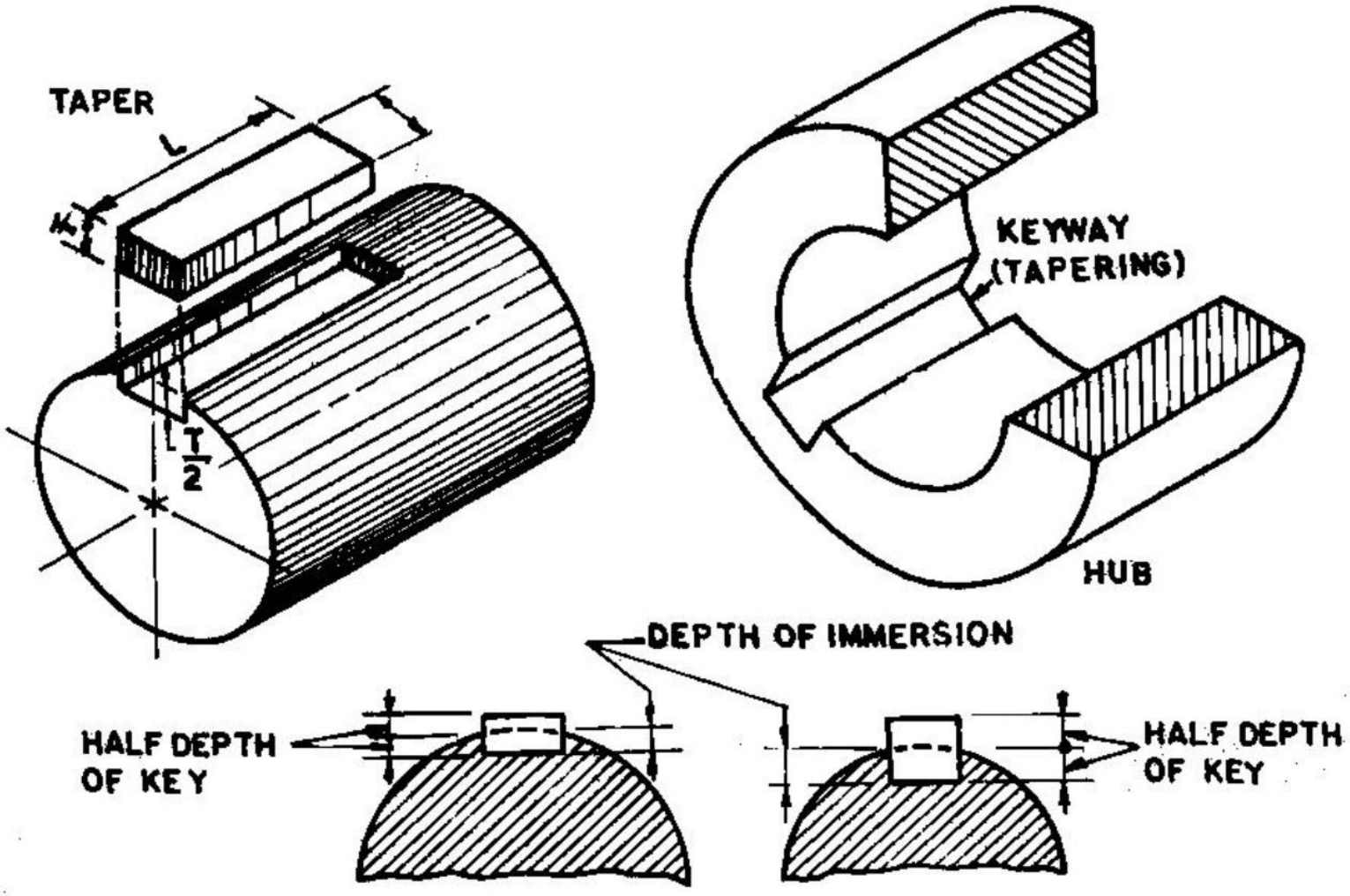
        width of the key W = D/4

        nominal thickness T = (2/3)W = (1/6)D

        » Square cross-section:

        T = W

Sunk taper key

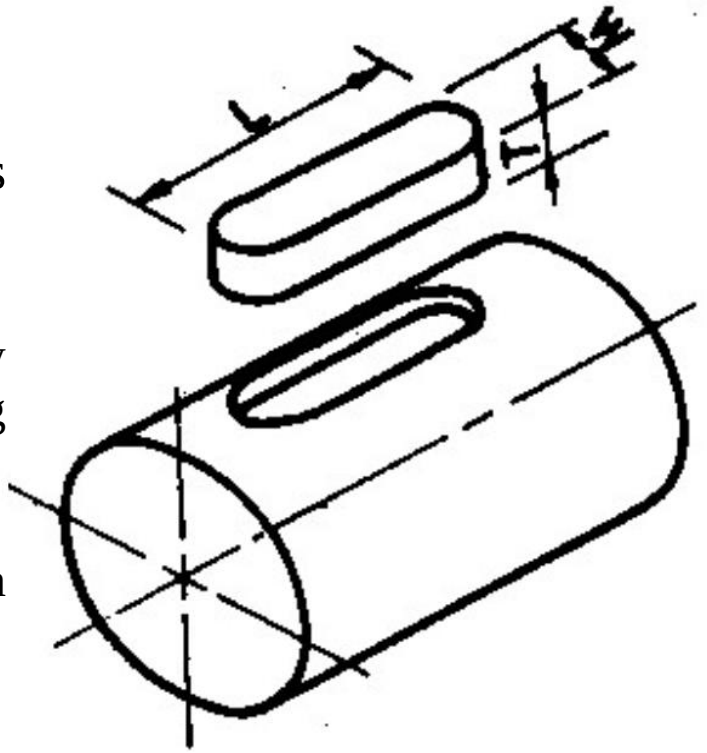


Parallel sunk key

It is uniform in width and thickness throughout.

It is thus taper less and is used where the pulley or other mating piece is required to slide along the shaft.

It may be rectangular or square cross-section and their ends may be squared or rounded.

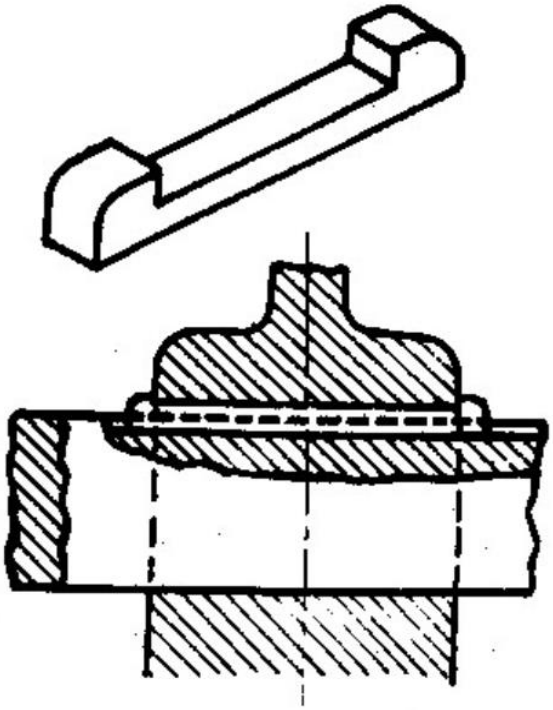


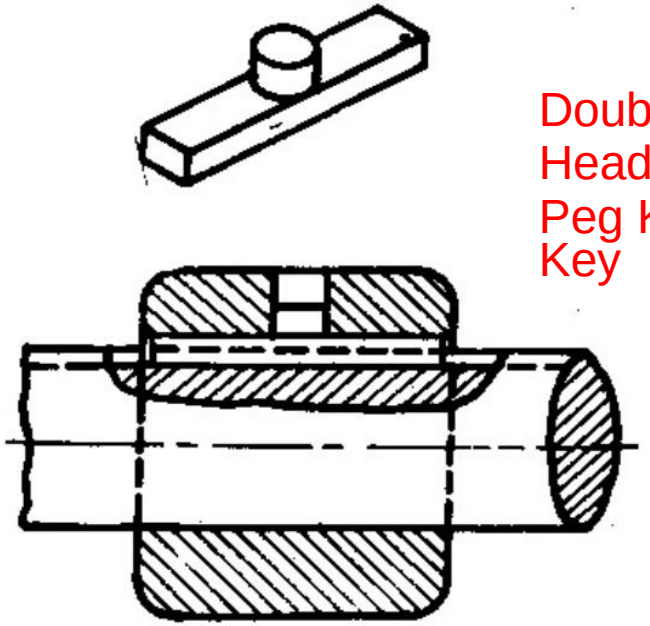
Feather keys

It is a key attached to one member of a pair

It is a particular kind of parallel key that permits axial moment

A feather key is secured either to the shaft or to the hub, the key being a sliding fit in the keyway of the machine element on which it moves.





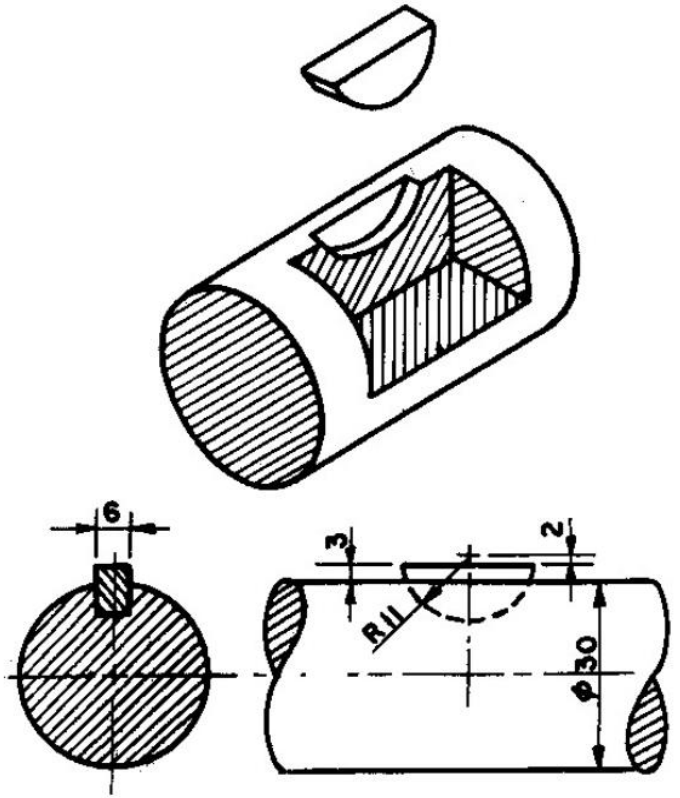
Double Headed Peg Key
Key

Woodruff keys

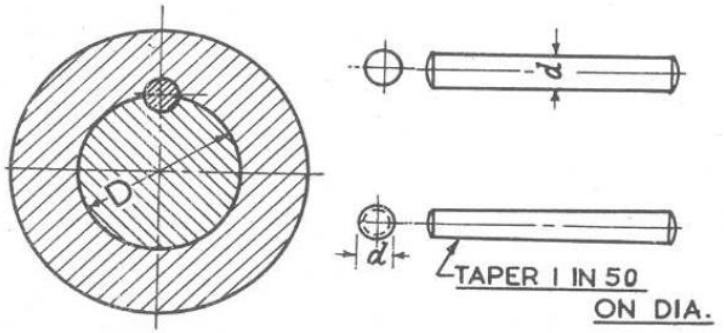
The key fits into a semi-circular keyway in the shaft and the top of the key fits into a plain rectangular key way in the hub of the wheel.

Since the key and the key seat bear the same radius , it has the advantage of adjusting itself to any taper of the slot of the hub or boss of wheel

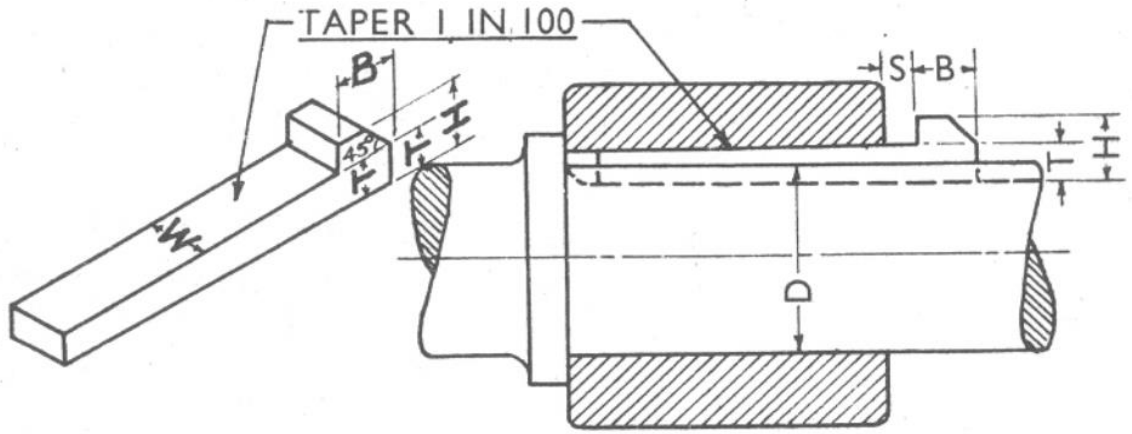
Used in feed gear box of lathe, other machine tools and in automobiles



Round key or Pin Key:

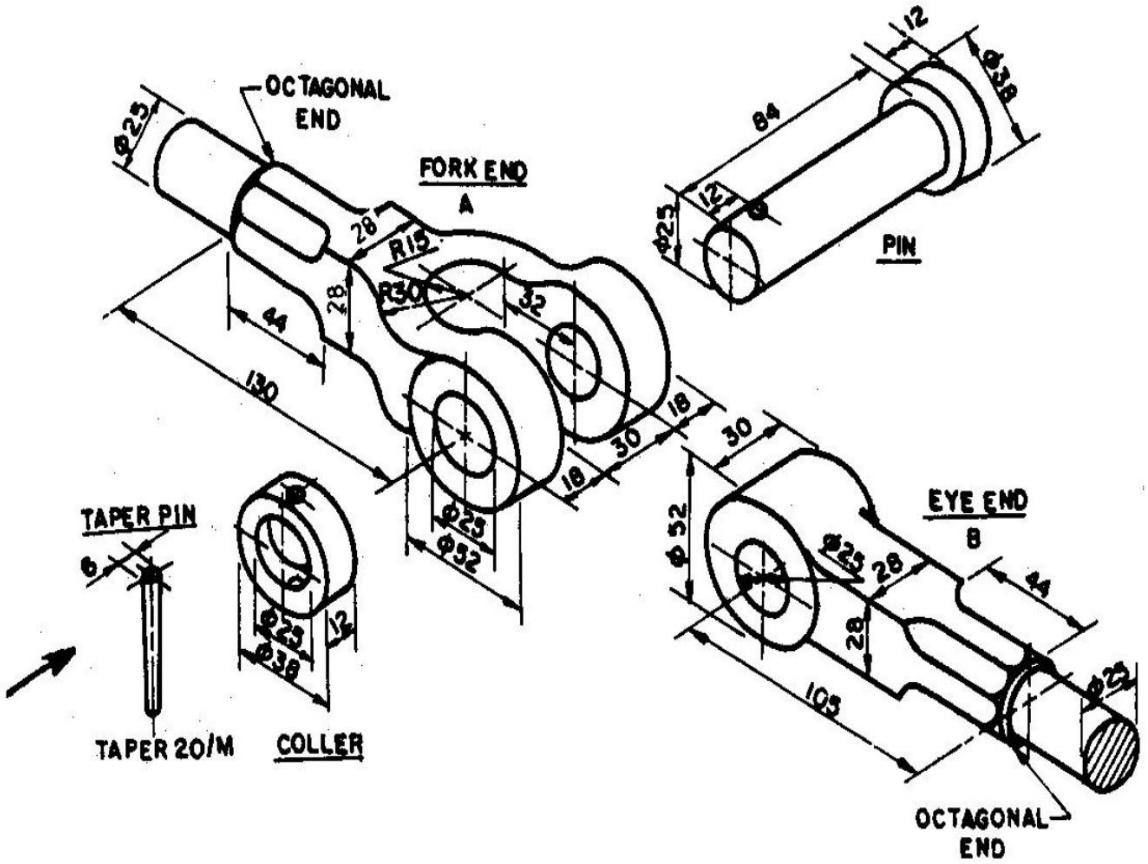


(i) ROUND KEY (ii) TAPER PIN



Key with gib-head

Joints::: **Knuckle joint**



Two or more rods subjected to tensile and compressive forces are fastened together

Their axes are not in alignments but meet in a point

The joint allows a small angular moment of one rod relative to another

It can be easily connected and disconnected

Applications: Elevator chains, valve rods, etc

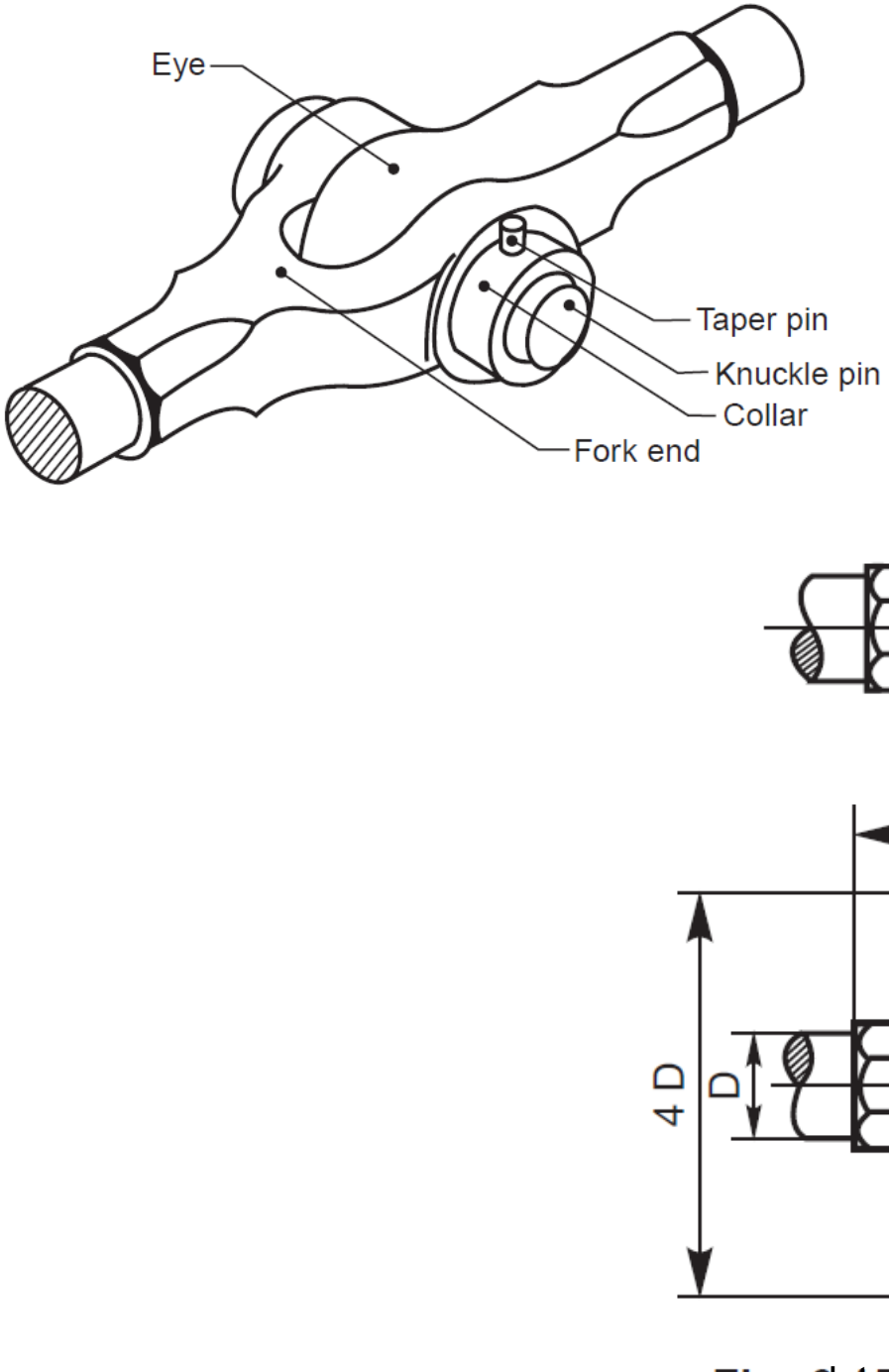
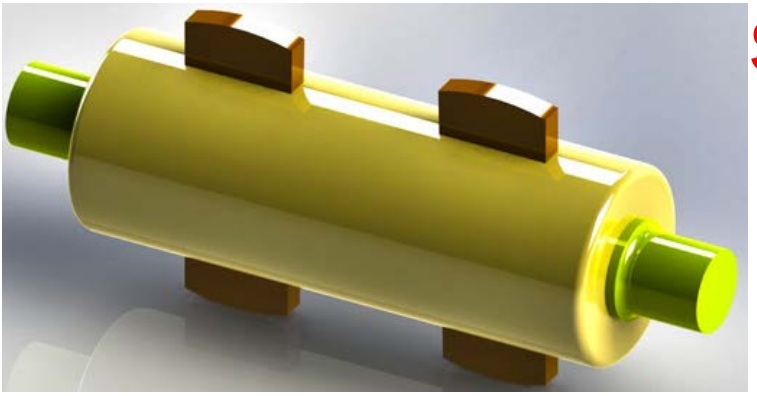


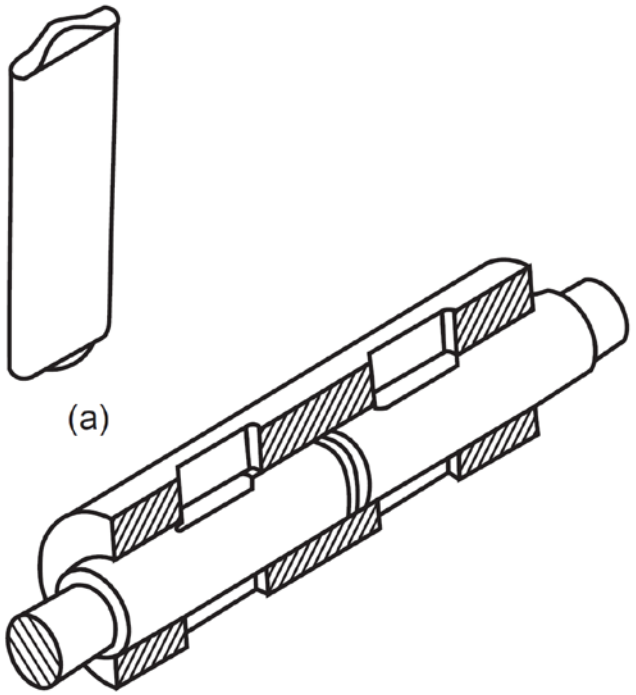
Fig. 6.15 Knuckle joint

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Sleeve and cotter joint (for circular rods)

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.



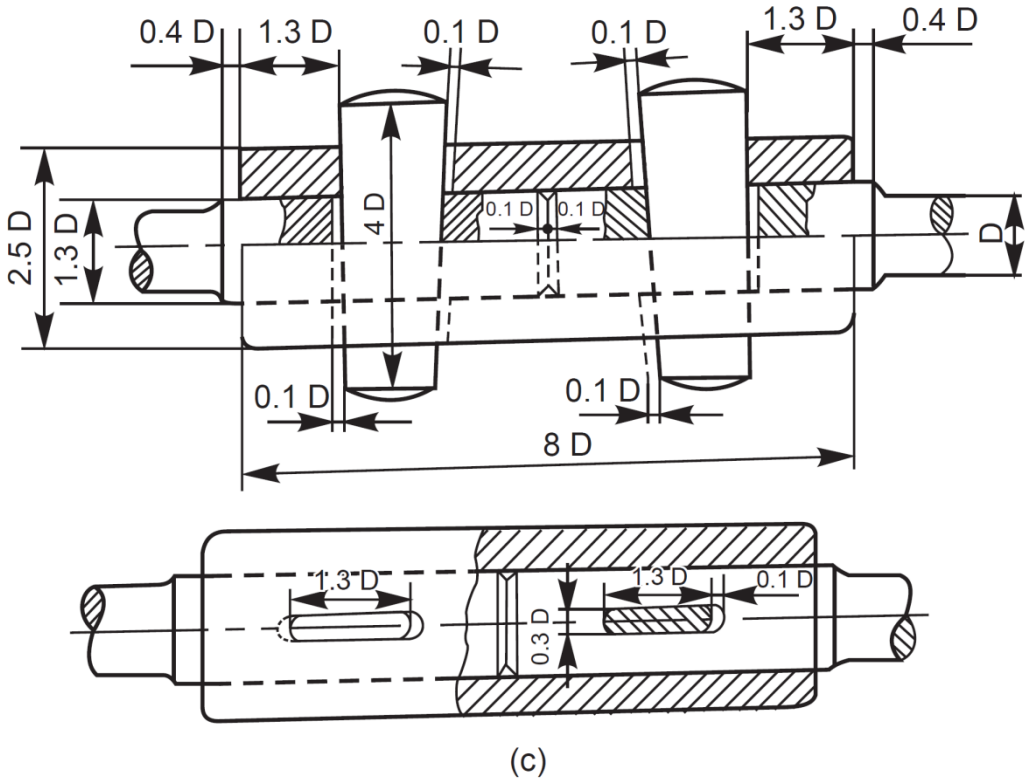


Fig. 6.12 Cotter joint with sleeve

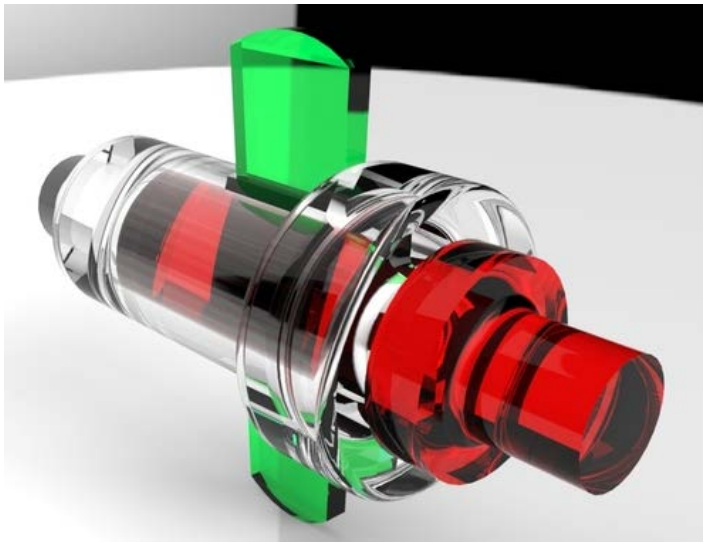
This is the simplest of all cotter joints, used for fastening two circular rods. To make the joint, the rods are enlarged at their ends and slots are cut. After keeping the rods butt against each other, a sleeve with slots is placed over them. After aligning the slots properly, two cotters are driven-in through the slots, resulting in the joint (Fig. 6.12). The rod ends are enlarged to take care of the weakening effect caused by the slots.

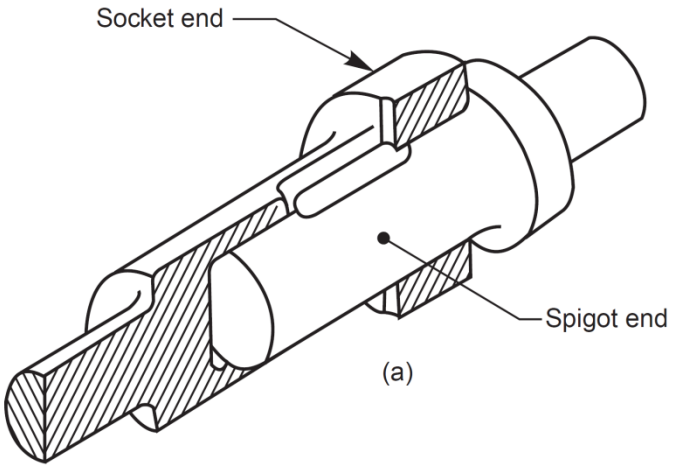
The slots in the rods and sleeve are made slightly wider than the width of cotter. The relative positions of the slots are such, that when a cotter is driven into its position, it permits wedging action and pulls the rod into the sleeve.

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Cotter joints with socket and spigot ends

for circular bars





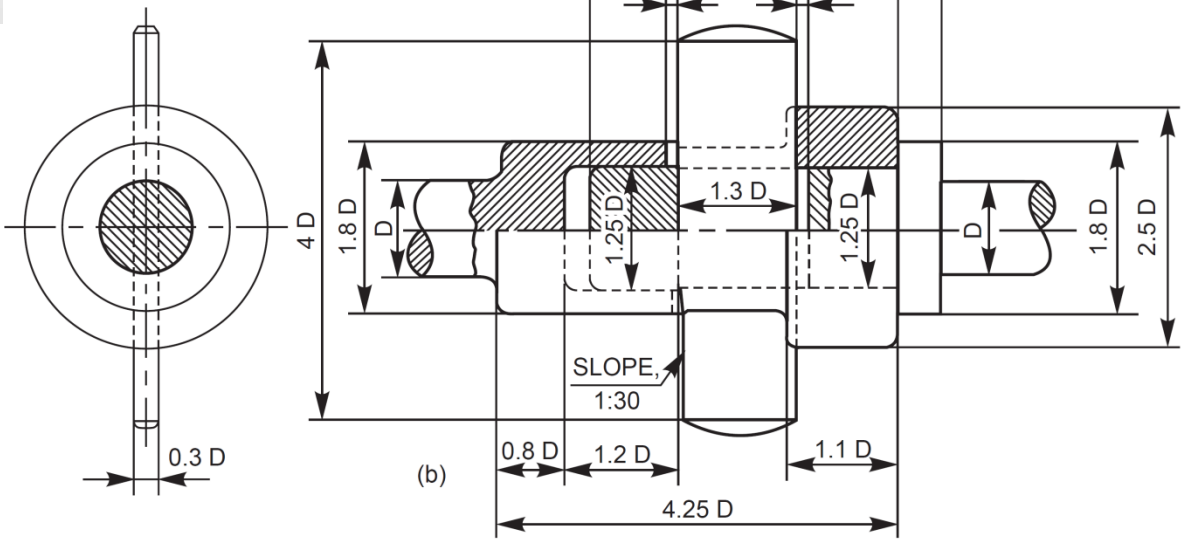
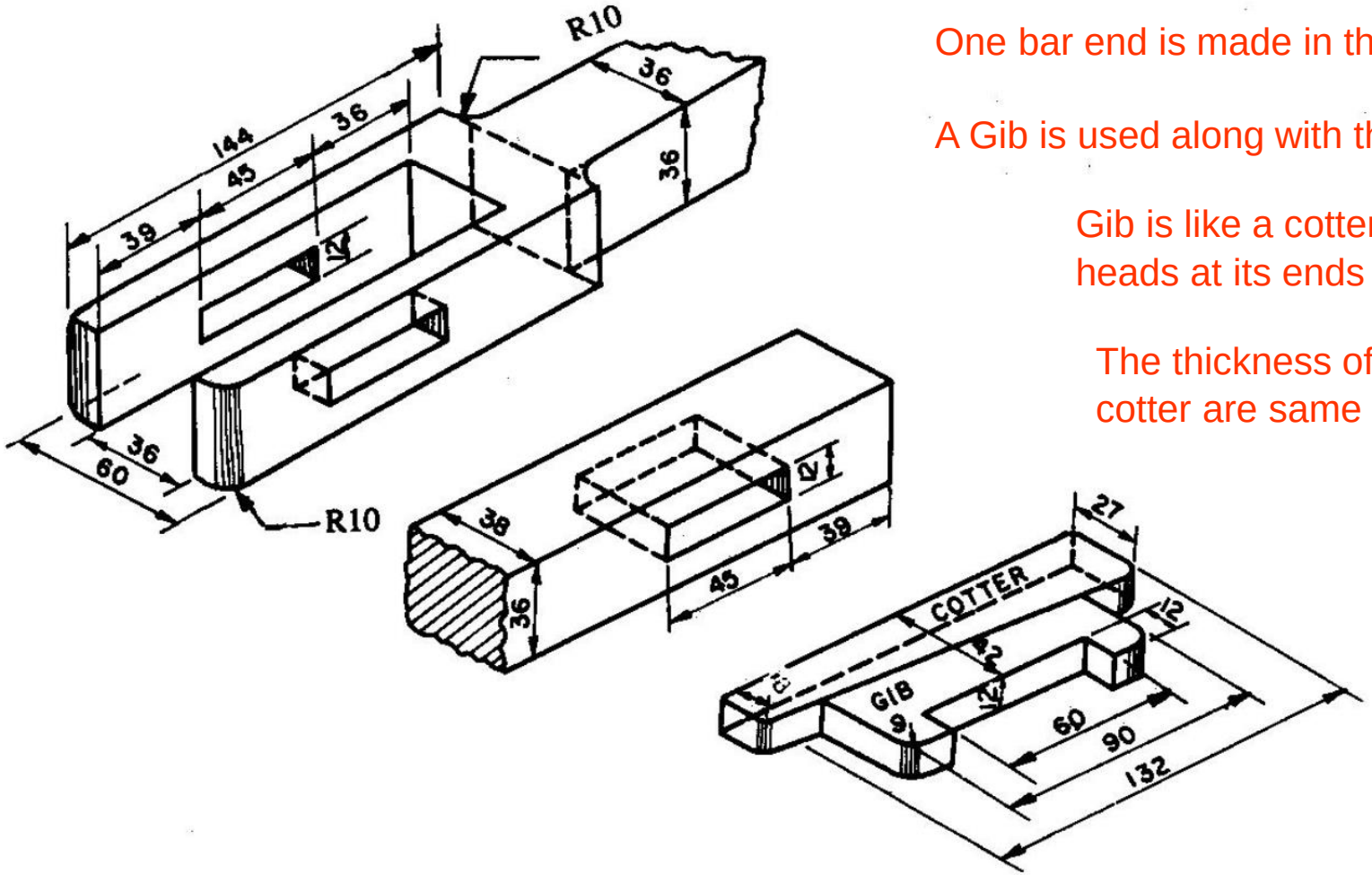


Fig. 6.13 Cotter joint with socket and spigot ends

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. 6.13) and slots are cut. After aligning the socket and spigot ends, a cotter is driven-in through the slots, forming the joint.

Gib and cotter joint for rectangular rods



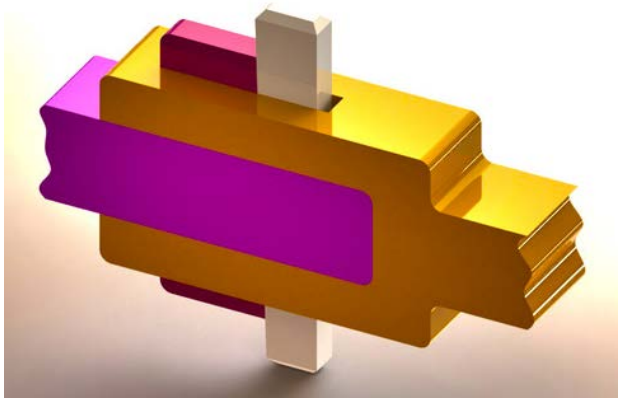
One bar end is made in the form of a strap

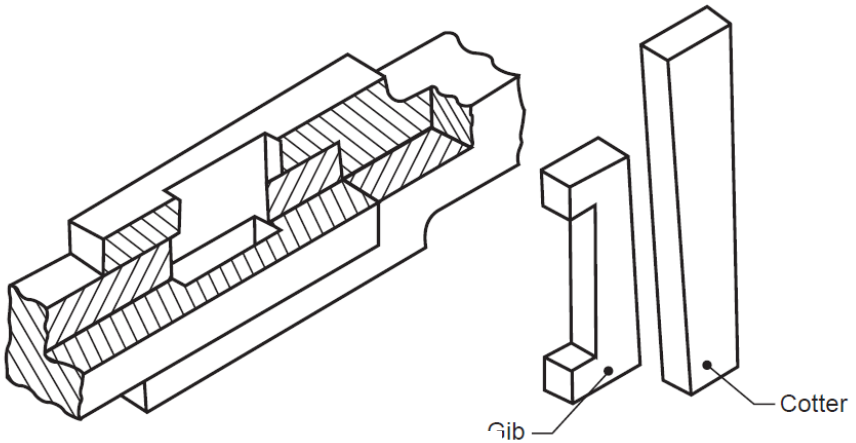
A Gib is used along with the cotter.

Gib is like a cotter but with two gib heads at its ends .

The thickness of the gib and cotter are same

Gib and cotter joint or rectangular





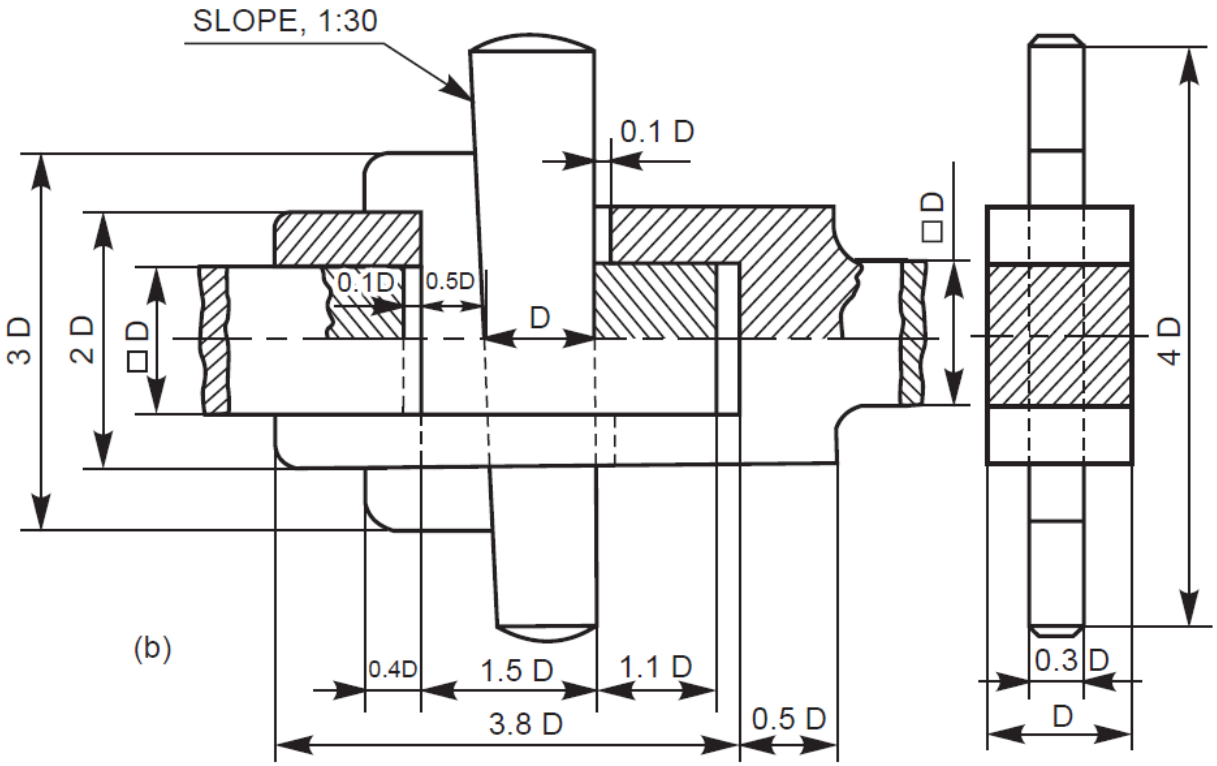


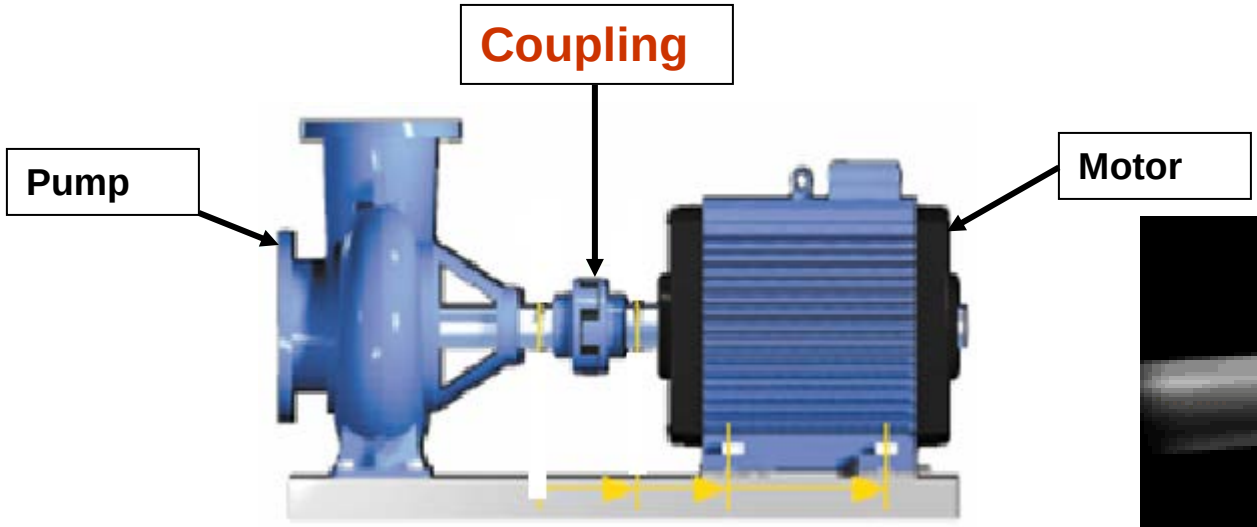
Fig. 6.14 Gib and cotter joint

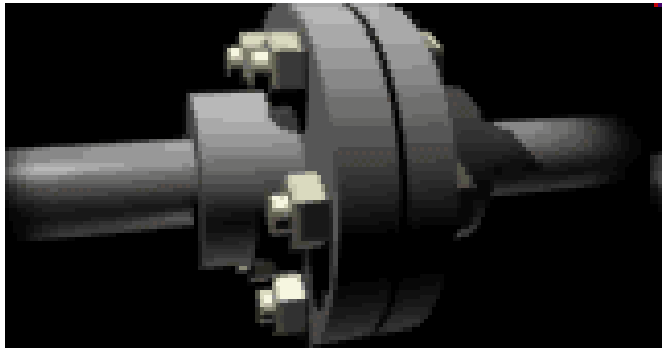
SHEET 4

Shaft Couplings

Couplings

Coupling is a device used to connect two shafts together at their ends for the purpose of transmitting power





Uses of coupling

- To provide connection of shafts of units made separately
- To allow misalignment of the shafts or to introduce mechanical flexibility.
- To reduce the transmission of shock loads
- To introduce protection against overloads.
- To alter the vibration characteristics

Types of coupling

- **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 Coupling*
  - Butt-Muff Coupling
  - Half lap Muff Coupling
  - Split Muff Coupling
- *Flanged Coupling*
  - Flanged Coupling with Detachable Flanges
  - Solid Flanged Coupling

Flexible Couplings:

- Perfect alignment of two shafts is impossible to achieve and difficult to maintain, because of inevitable bearing wear and other reasons.
- To overcome the trouble, flexible couplings are employed. These permit relative rotation or variation in the alignment of shaft axes within certain limits. The following are the types of flexible couplings:
  - Bushed Pin Type Flanged Coupling
  - Compression Coupling

Dis-engaging Couplings:

- Disengaging couplings are used when power transmission from one shaft to another is intermittent. With this, the shafts can be engaged or disengaged as and when required, even during rotation.
- A dis-engaging coupling in general consists of one part firmly fixed to the driving shaft and another one mounted with provision for sliding over the driven shaft.
- The part that is mounted on the driven shaft, can be made to slide at will to engage or disengage from the rotating driving shaft.
- The following are the examples of dis-engaging couplings.
    - Claw Coupling
    - Cone Coupling

Non-Aligned Couplings

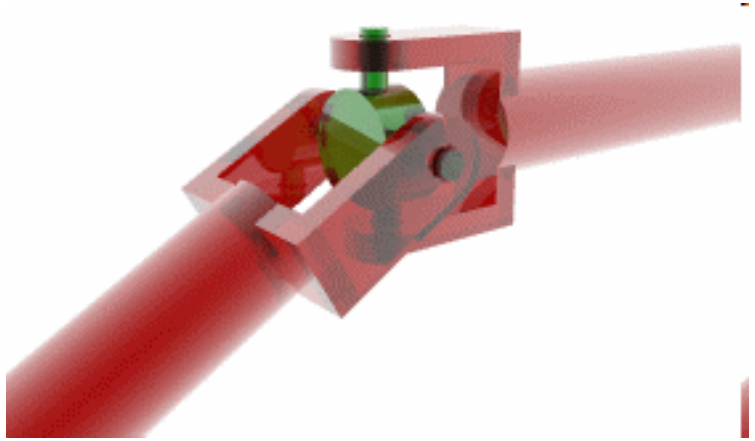
- Non-aligned couplings are used to transmit power between two shafts which are not coaxial.
- The following are the examples of non-aligned couplings:
    - Universal Coupling (Hook's Joint)
    - Oldham Coupling



Rigid coupling

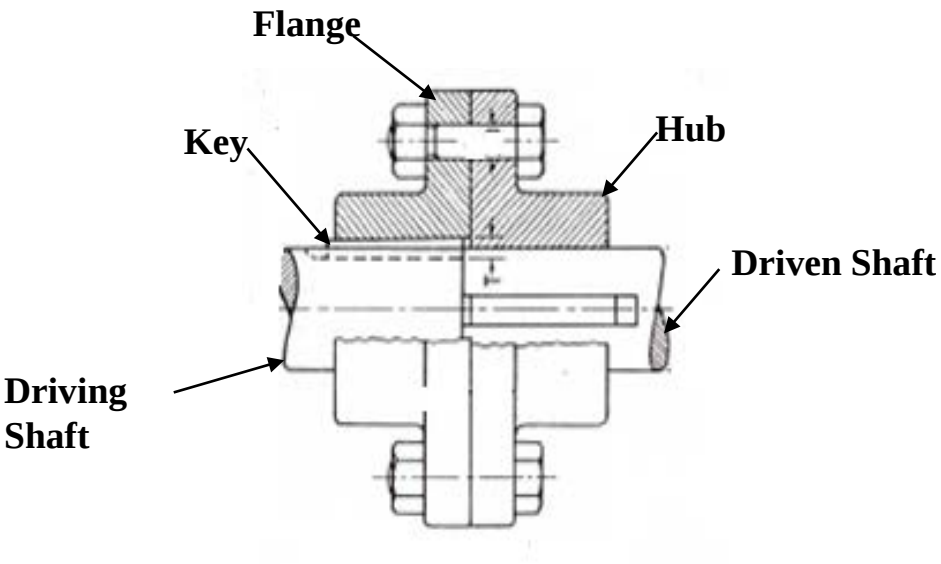


Flexible coupling



Universal coupling

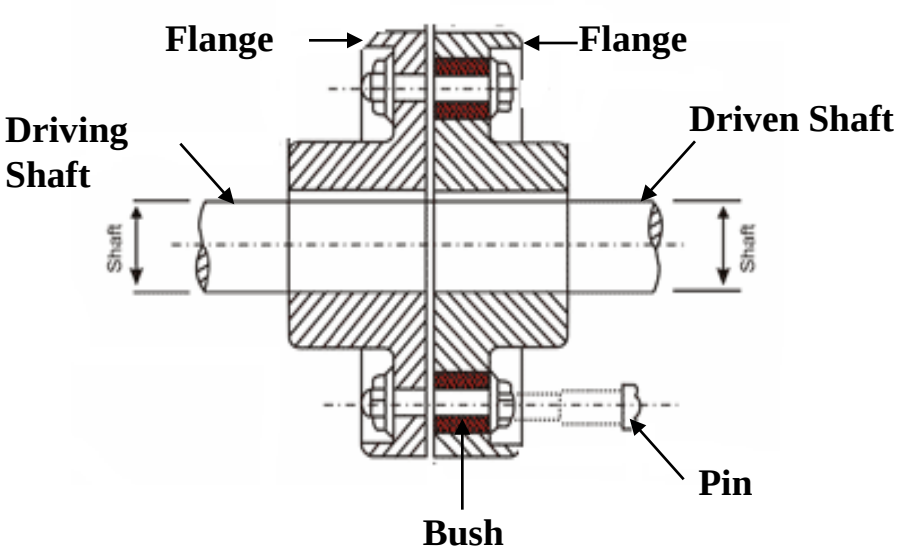
Rigid coupling



Flanged Coupling

- Rigid couplings are used when precise shaft alignment is required
- Simple in design and are more rugged
- Generally able to transmit more power than flexible couplings
- Shaft misalignments cannot be compensated

Flexible Coupling



- A flexible coupling permits with in certain limits, relative rotation and variation in the alignment of shafts
- Pins (Bolts) covered by rubber washer or bush is used connect flanges with nuts
- The rubber washers or bushes act as a shock absorbers and insulators.

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 (Fig.7.1).

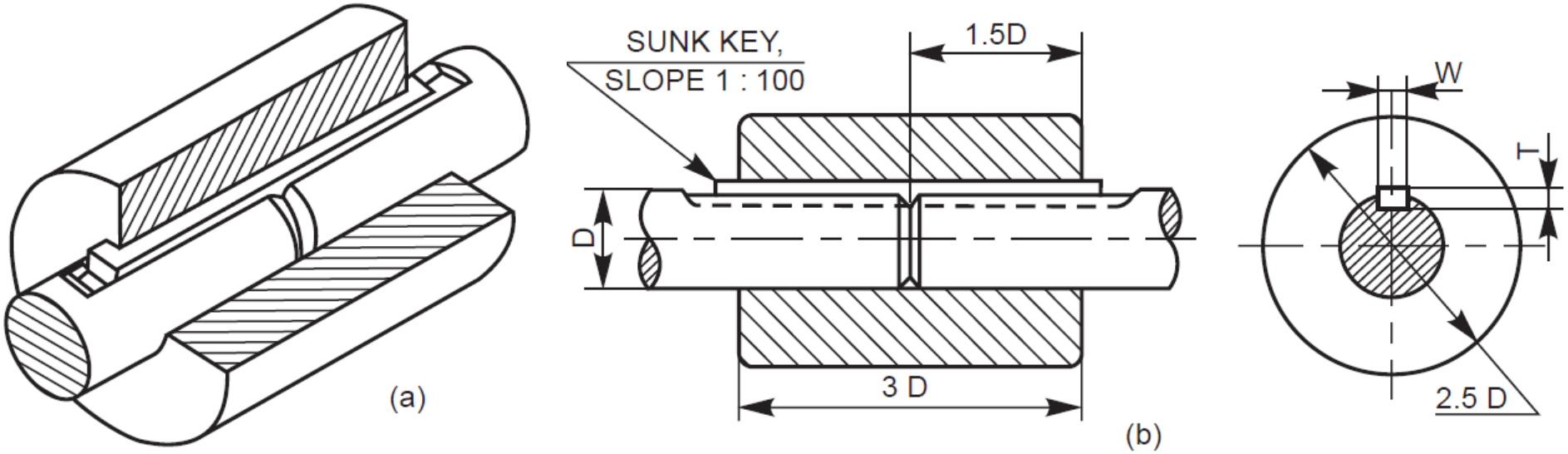
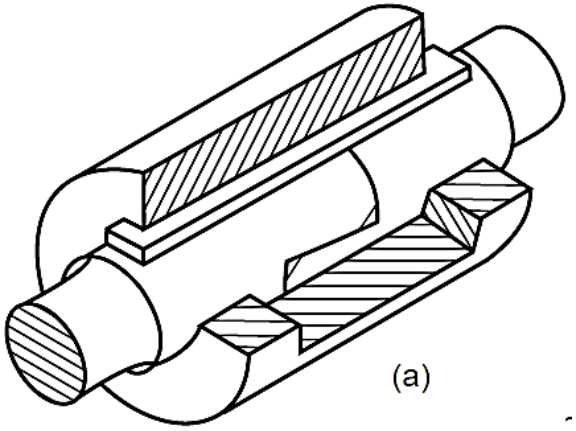


Fig. 7.1 Butt-muff coupling

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 (Fig. 7.2).



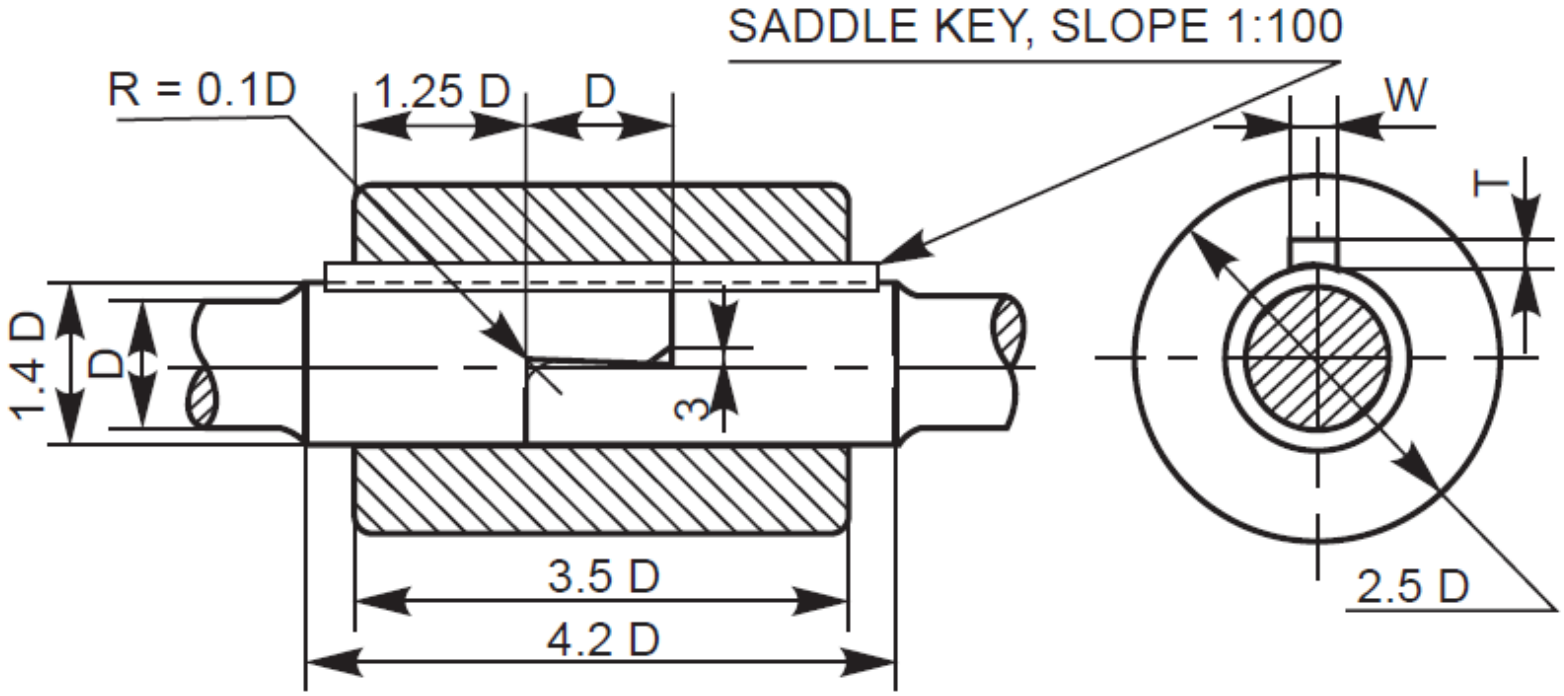


Fig. 7.2 Half-lap muff coupling

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.
- For making the coupling, a sunk key is first placed in position and then the muff halves are joined by bolts and nuts (Fig. 7.3).
- This type of coupling is used for heavy duty work, since both the key and friction grip transmit the power (torque).

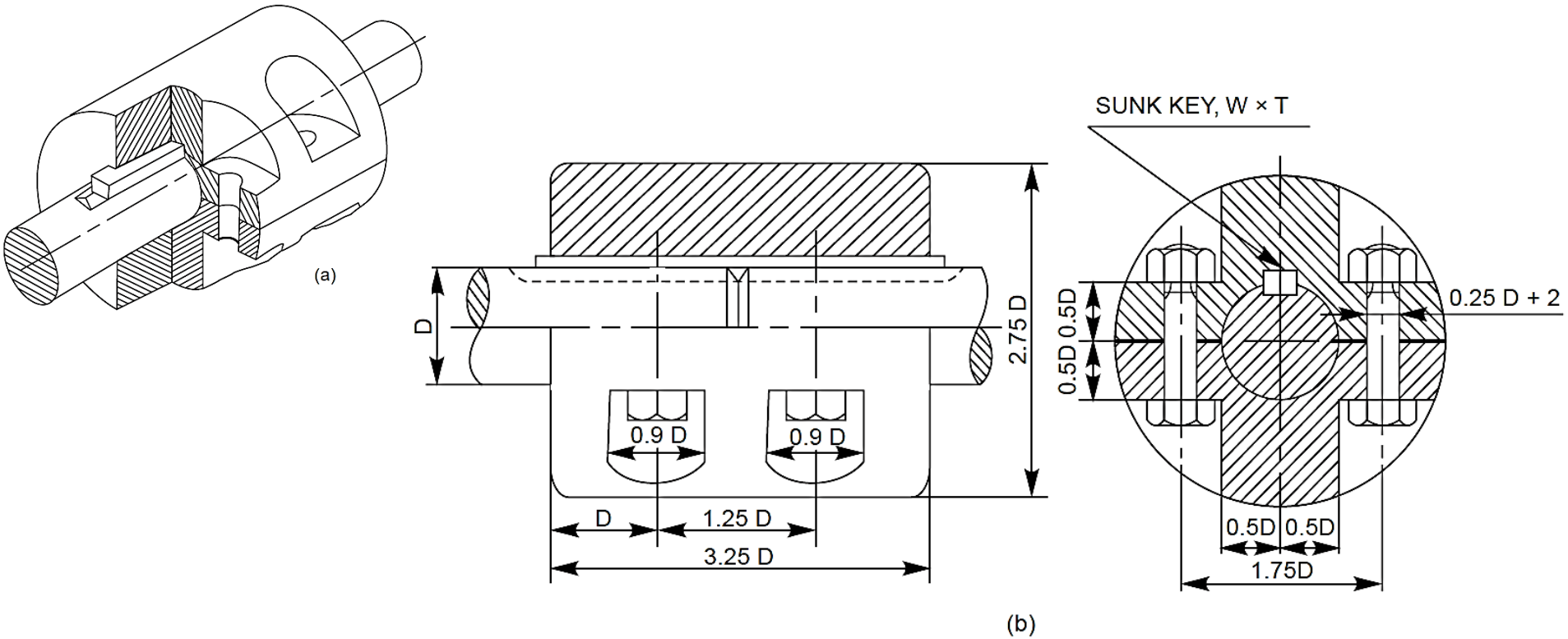
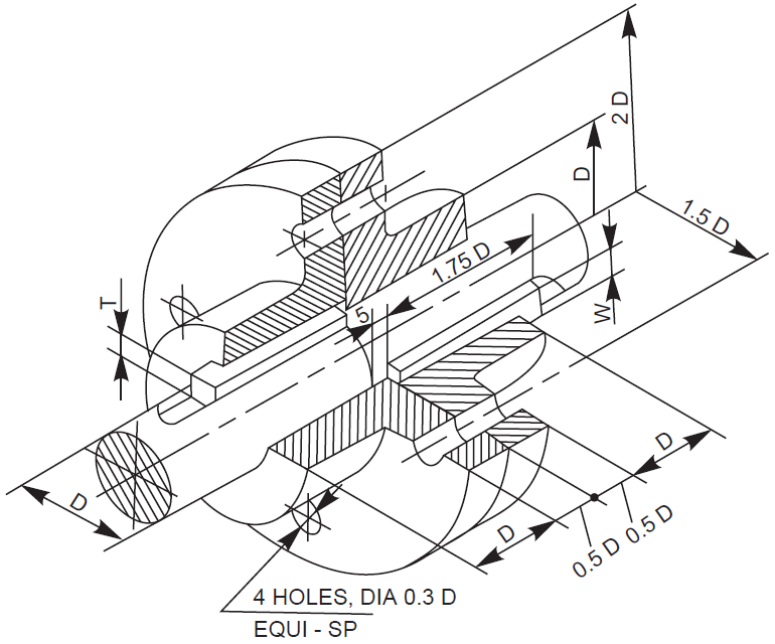


Fig. 7.3 Split-muff coupling

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- In this, two flanges are keyed, one at the end of each shaft, by means of sunk keys (Fig. 7.4). For ensuring correct alignment, a cylindrical projection may be provided on one flange which fits into the corresponding recess in the other.



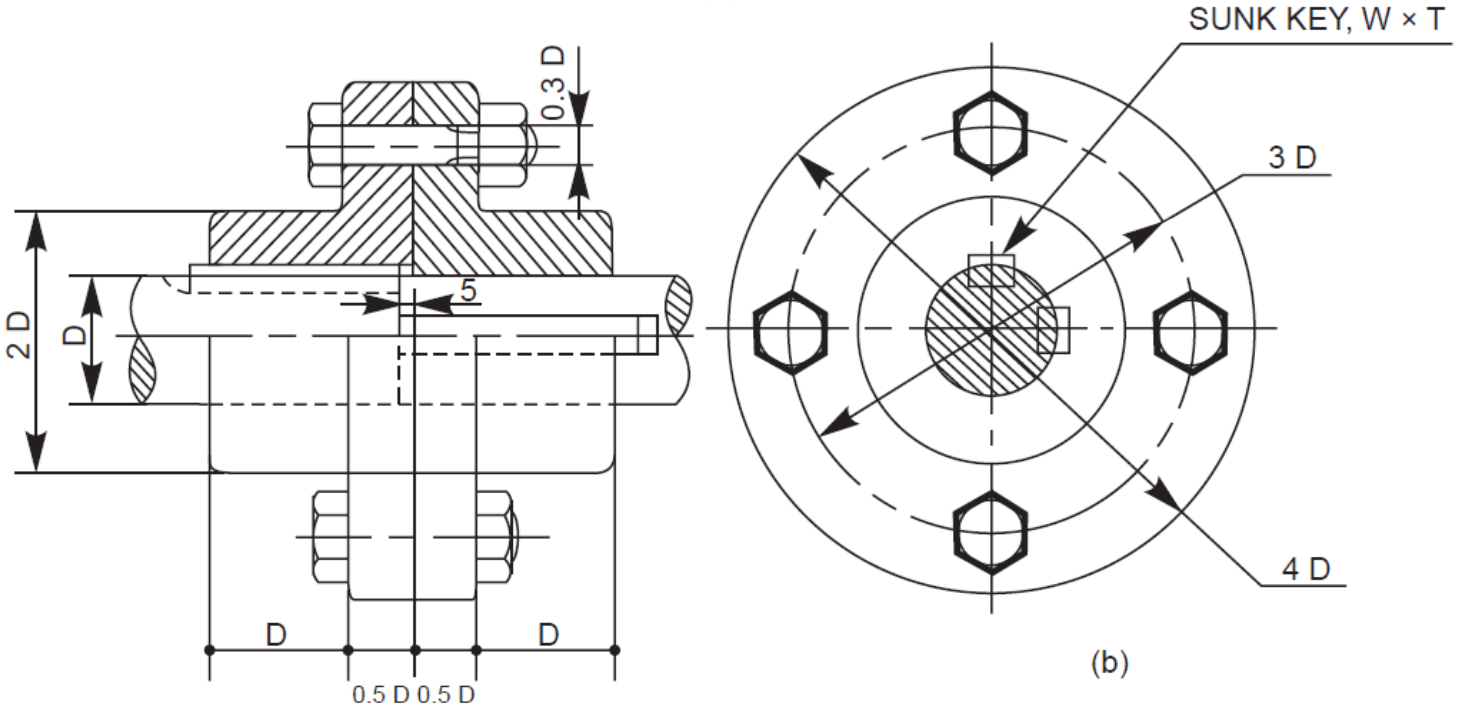


Fig. 7.4 Flanged coupling

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- In the previous design shown in figure 7.4, the bolt heads and nuts are exposed and liable to cause injury to the workman. Hence, as a protection, the bolt heads and nuts may be covered by providing an annular projection on each flange. A flanged coupling, using these flanges is called a protected flanged coupling (Fig. 7.5).

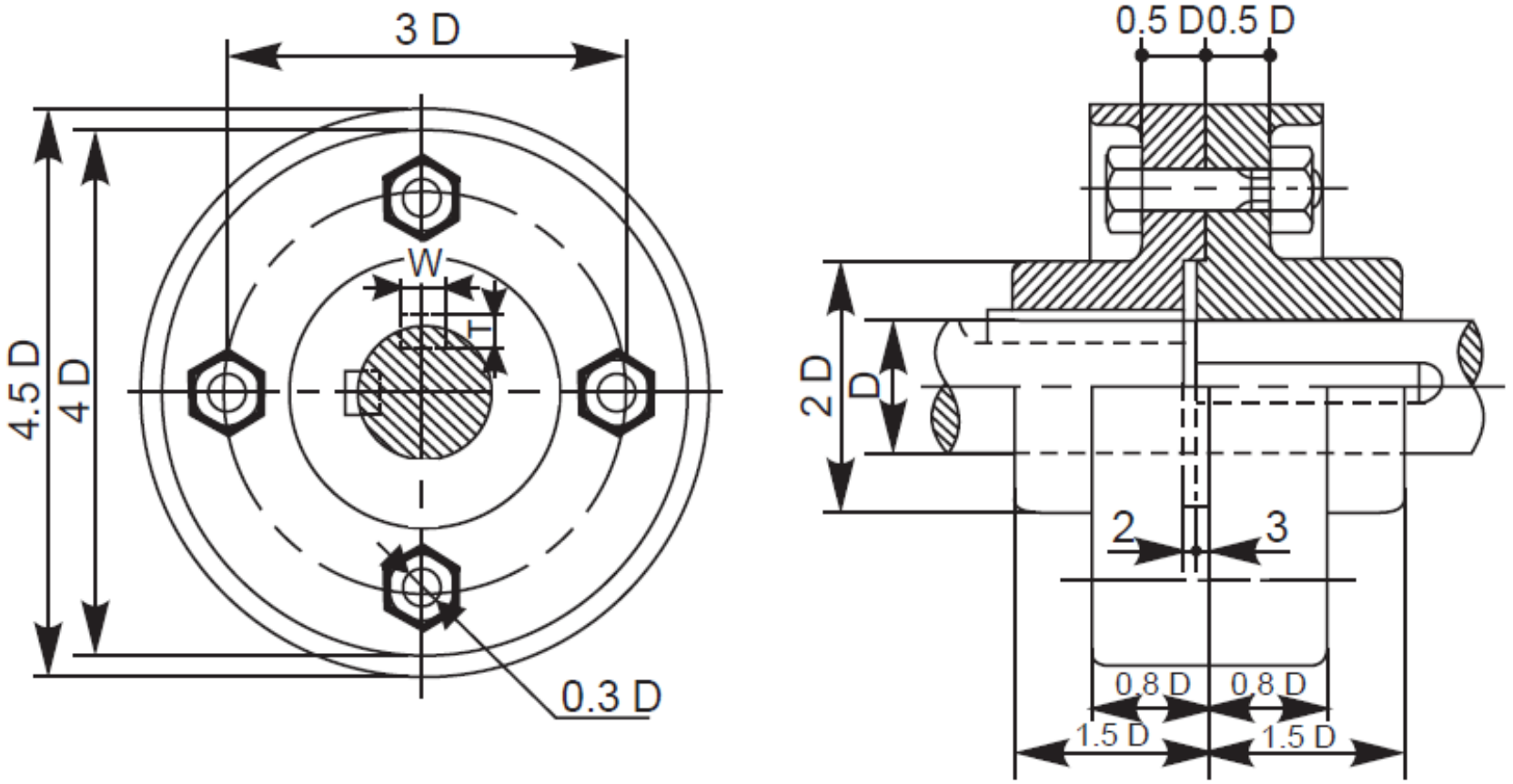


Fig. 7.5 Protected flanged coupling

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. 7.6).

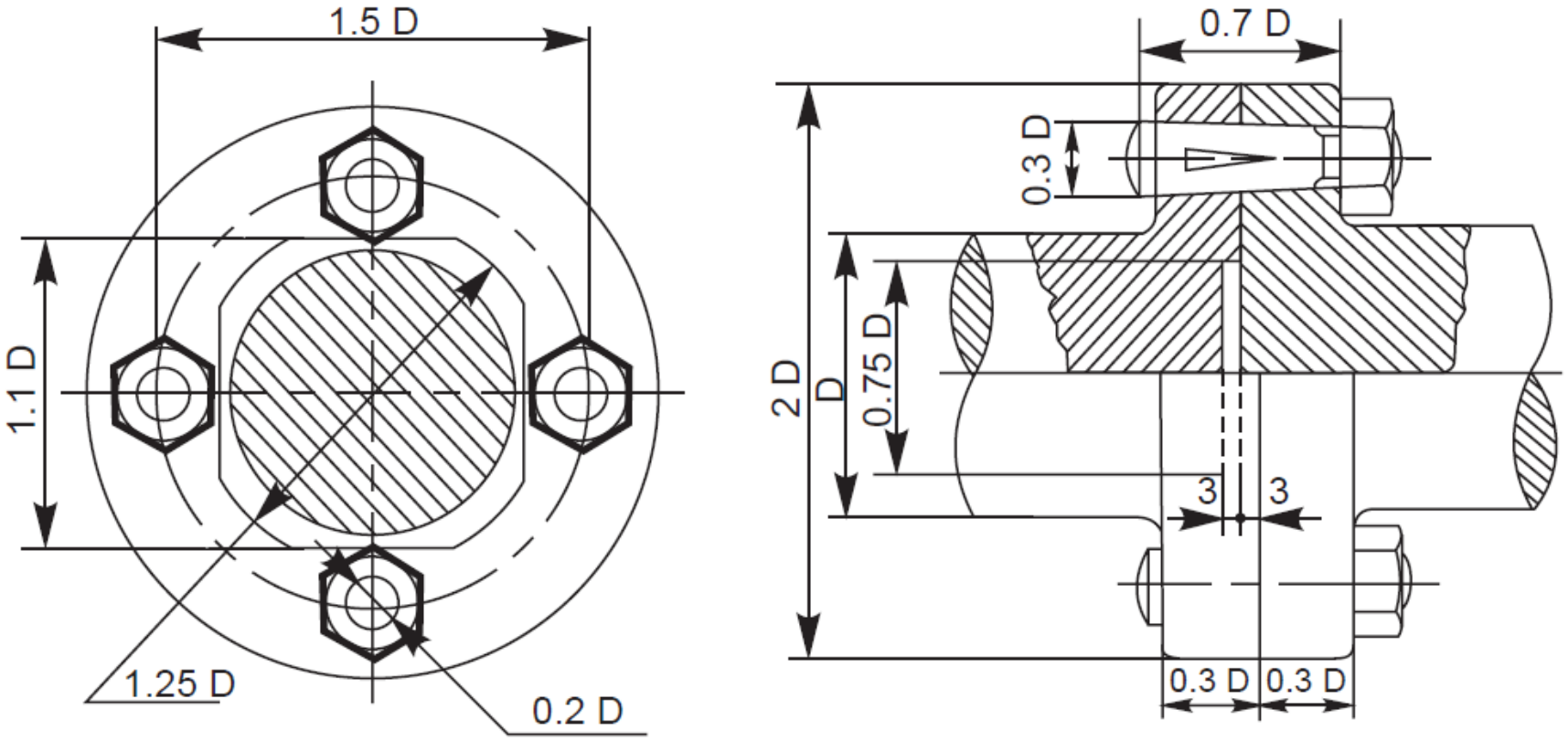


Fig. 7.6 Solid flanged coupling

- It is the modified version of a protected flanged coupling. In this, bolts are replaced by bushed pins. The smaller ends of the pins are rigidly fastened by nuts to one of the flanges, while the enlarged ends are covered with flexible material like leather or rubber bushes, in the other flange (Fig. 7.7).
- The flexible medium takes care of mis-alignment, if any, and acts as a shock absorber. These couplings are used to connect prime mover or an electric motor and a centrifugal pump.

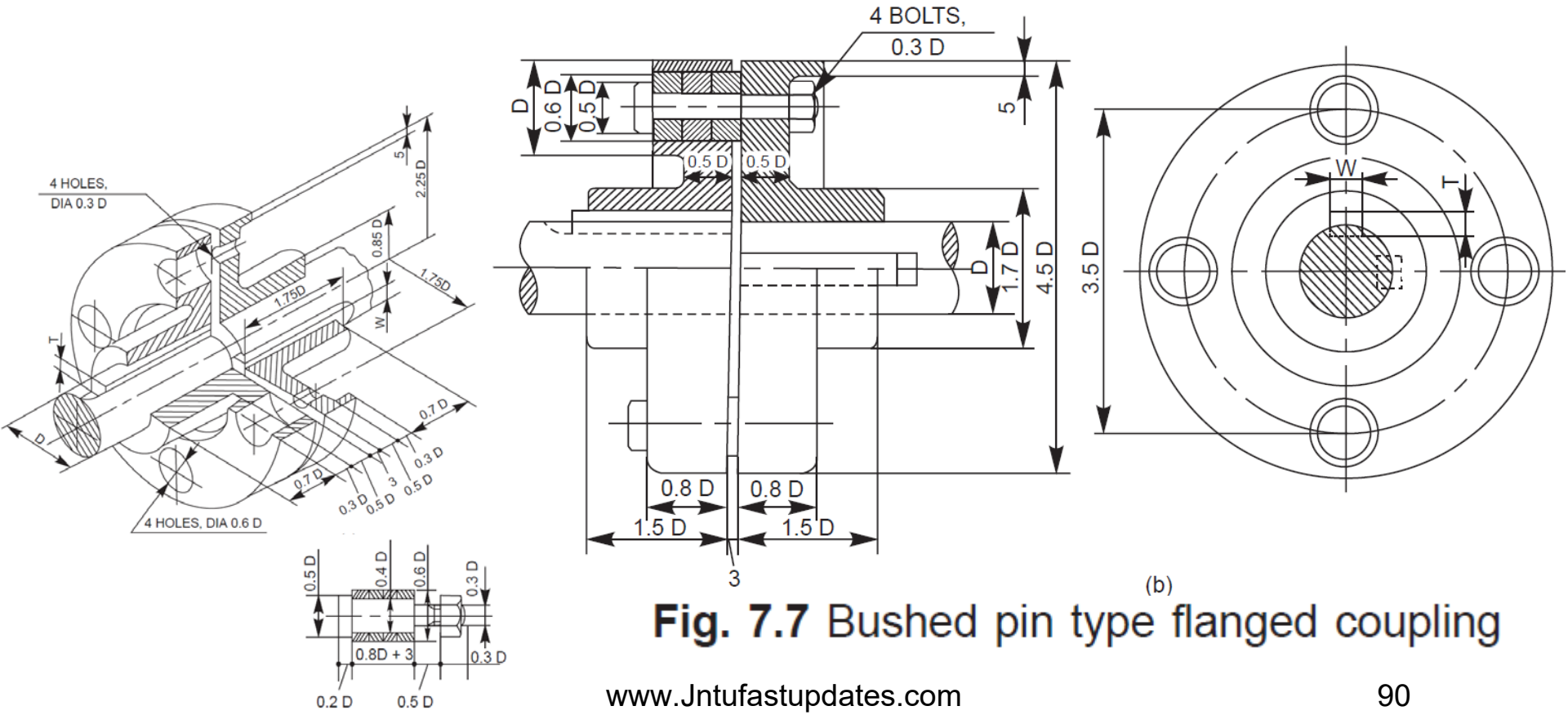
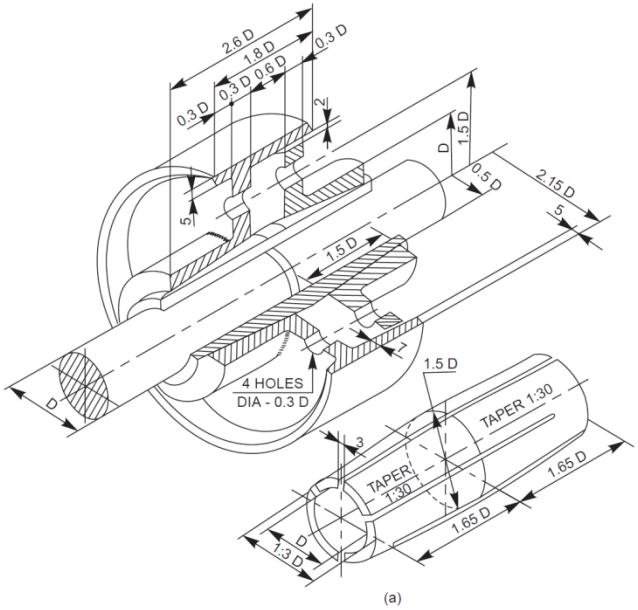


Fig. 7.7 Bushed pin type flanged coupling



- 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.
- The two flanges used have conical bores and are drawn towards each other by means of a number of bolts and nuts, making the sleeve firmly compressed onto the shafts.

Here, the friction between the shafts and sleeve assists power transmission and the bolts do not take any load. Because of the presence of flexible sleeve, the coupling takes care of both axial and angular mis-alignment of shafts (Fig. 7.8).

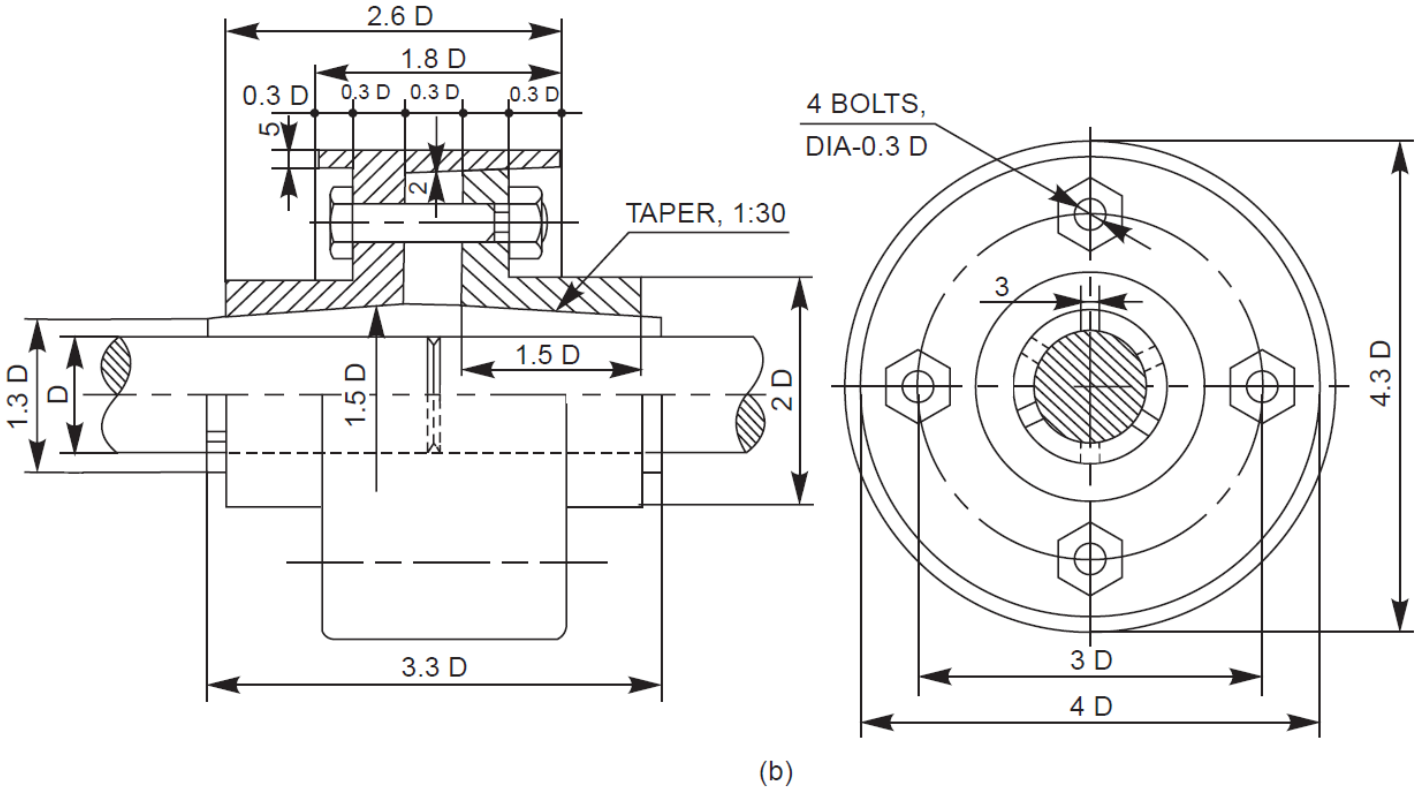
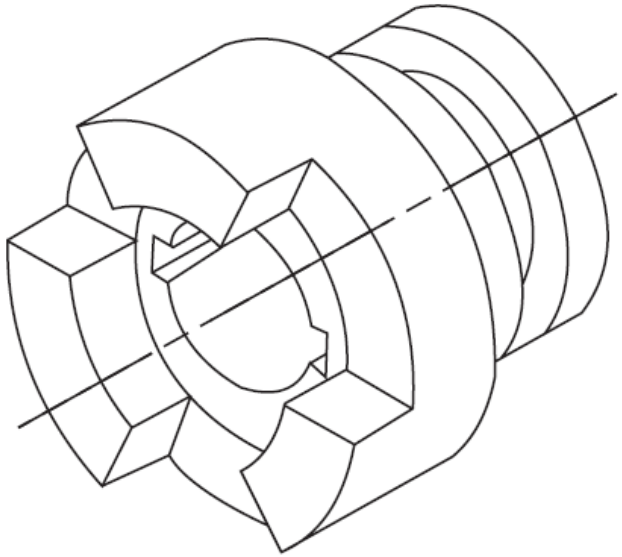


Fig. 7.8 Compression coupling

- 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. By operating the lever, the sliding flange may be moved so as to engage with or disengage from the fixed flange (Fig. 7.9). This type of coupling is generally used on slow speed shafts.



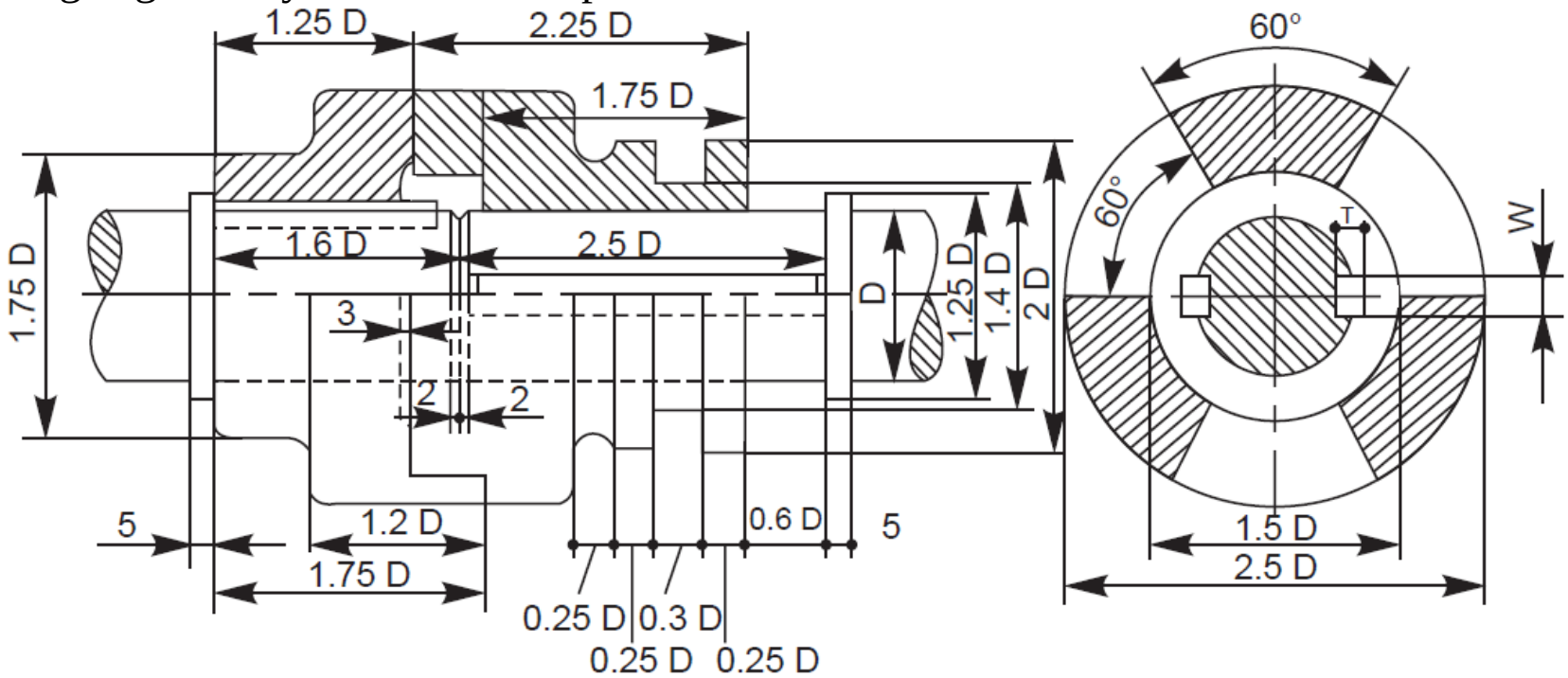


Fig. 7.9 Claw coupling

- 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.
- The sliding flange may be moved by means of a forked lever fitted into the groove provided on it. (Fig. 7.10).

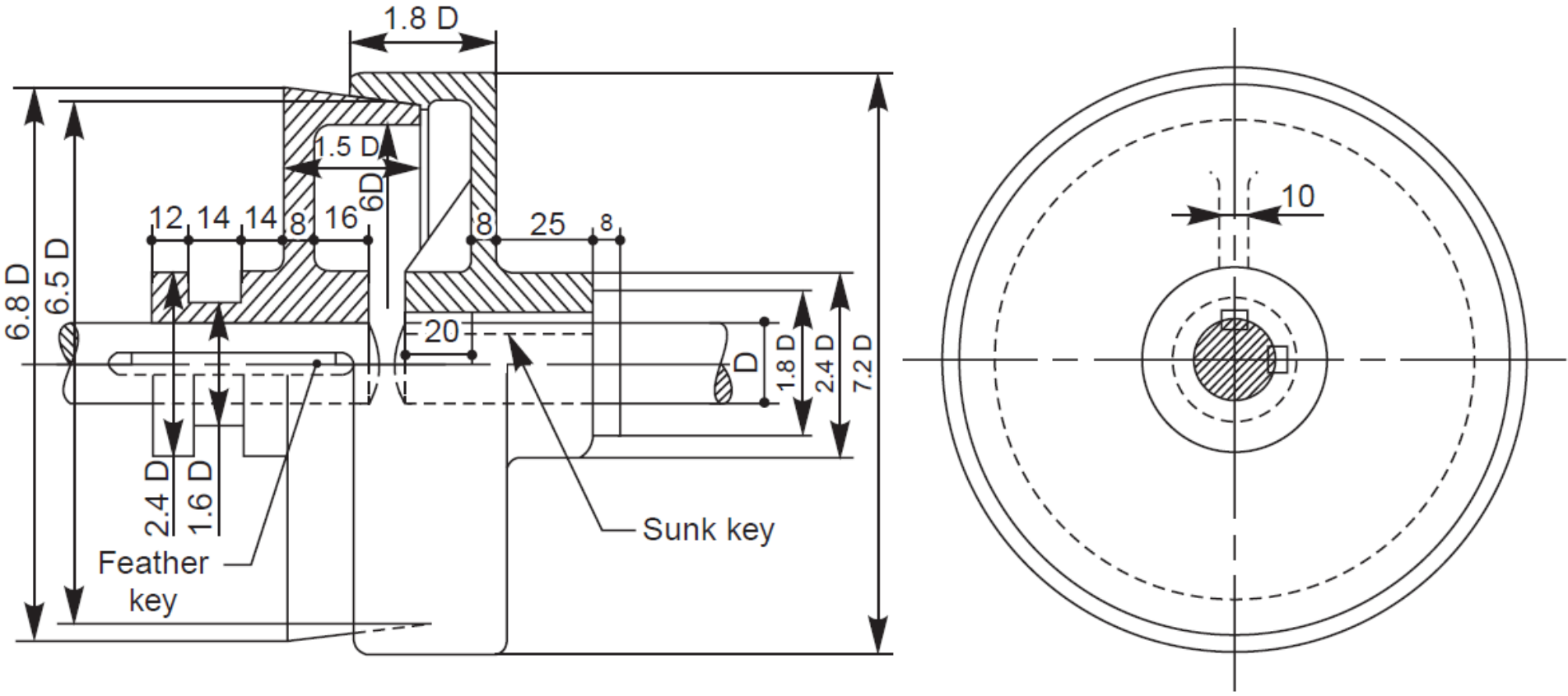
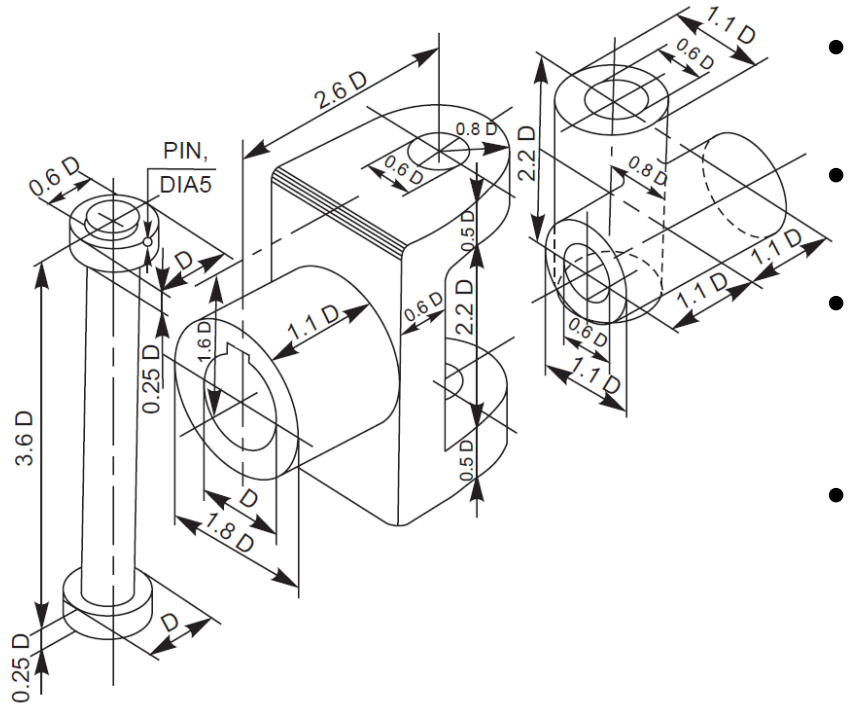
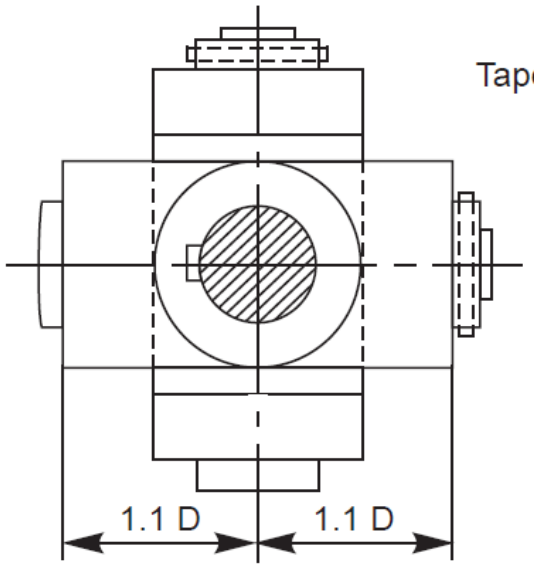


Fig. 7.10 Cone coupling

- 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 (Fig. 7.11).
- The angle between the shafts may be varied even while the shafts are rotating.





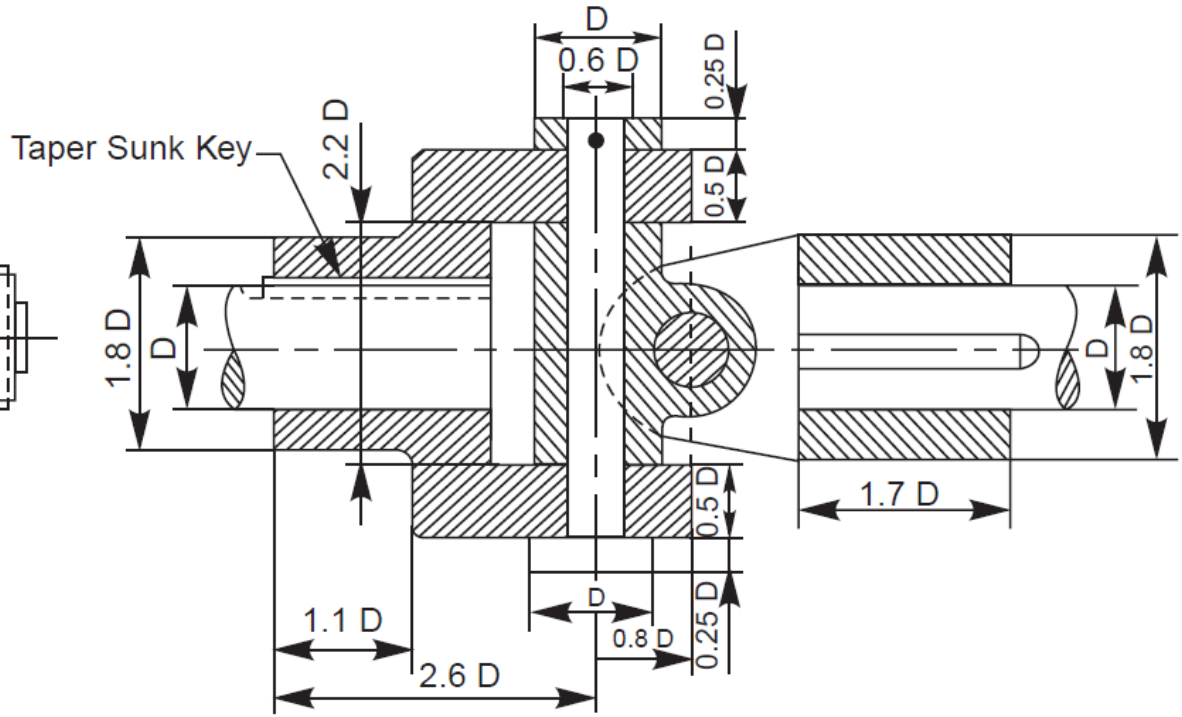


Fig. 7.11 Universal coupling

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- 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.
- To make the coupling, a circular disc with two rectangular projections on either side and at right angle to each other, is placed between the two flanges.
- During motion, the central disc, while turning, slides in the slots of the flanges. Power transmission takes place between the shafts, because of the positive connection between the flanges and the central disc (Fig. 7.12).

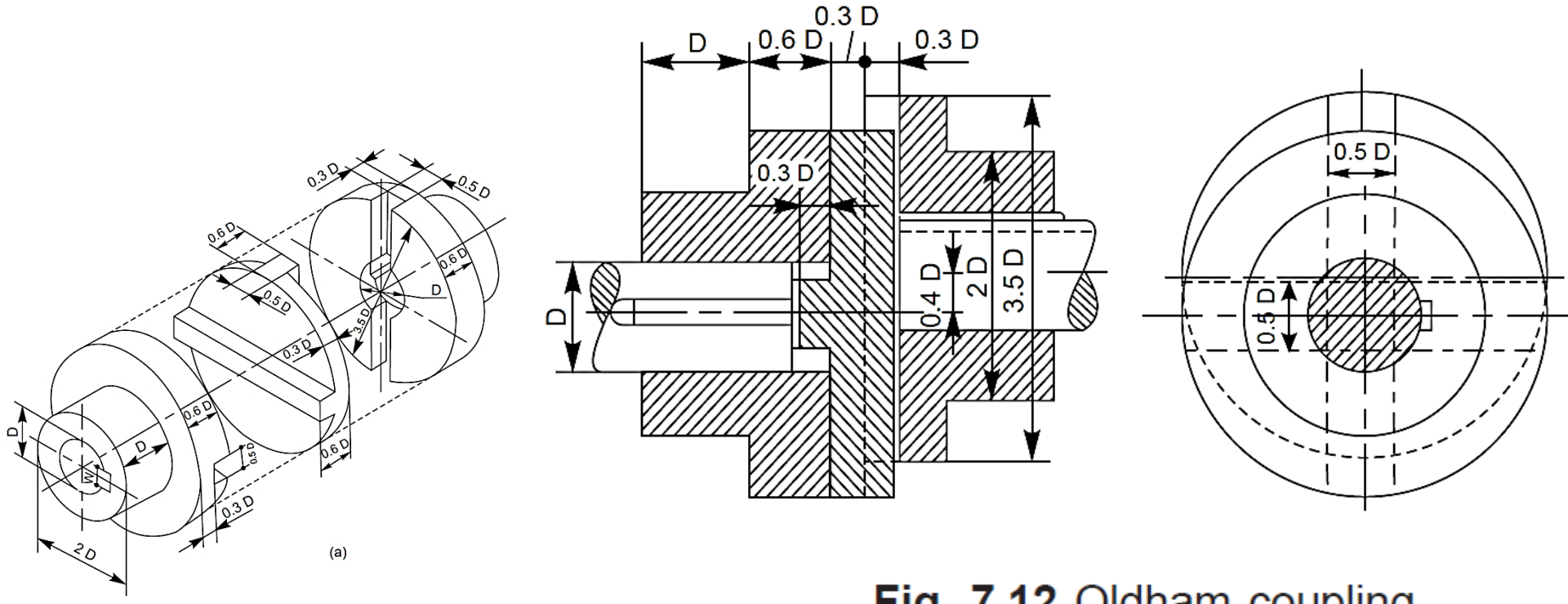


Fig. 7.12 Oldham coupling

Advantages and Limitations

Advantages

- Torsionally stiff
- No lubrication or maintenance
- Good vibration damping and shock absorbing qualities
- Less expensive than metallic couplings
- More misalignment allowable than most metallic couplings

Limitations

- Sensitive to chemicals and high temperatures
- Usually not torsionally stiff enough for positive displacement
- Larger in outside diameter than metallic coupling
- Difficult to balance as an assembly

SHEET 5

RIVETED JOINTS

RIVETED JOINTS

RIVET

A rivet is a round rod of circular cross-section. It consists of two parts, viz., head and shank (Fig. 10.1 (*a*)). Mild steel, wrought iron, copper and aluminium 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.

- Pressure may be applied to form the second rivet head, either by direct hammering or through hydraulic or pneumatic means. While forming the rivet head, the shank will bulge uniformly. Hence, a certain amount of clearance between the hole and shank must be provided before riveting (Fig. 10.1 (*b*)).
- Hot riveting produces better results when compared to cold riveting. This is because, after hot riveting, the contraction in the shank length tends to pull the parts together, making a tight joint.

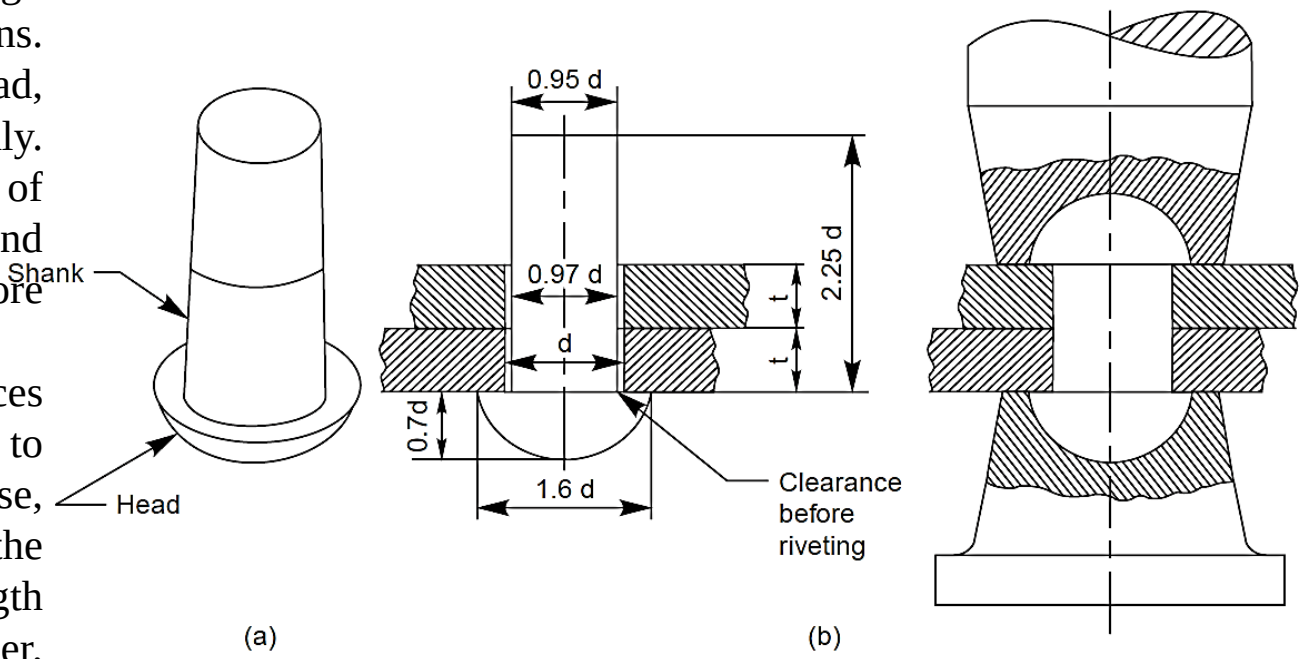


Fig. 10.1 (*a*) Rivet (*b*) Riveting

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Caulking and Fullering

Riveted joints must be made air tight in applications such as boilers and other pressure vessels. Caulking or fullering is done to make the riveted joints air tight.

Caulking

The outer edges of the plates used in boiler and other pressure vessels are bevelled. To produce air tight riveted joints, these bevelled edges of the plates are caulked. Caulking is an operation in which the outer bevelled edges of the plates are hammered and driven-in by a caulking tool. The caulking tool is in the form of a blunt edged chisel (Fig. 10.2*a*).

Fullering

Similar to caulking, fullering is also used to produce air tight joints. Unlike the caulking tool, the width of the fullering tool is equal to the width of the bevelled edges of the plates (Fig. 10.2 (*b*)). Caulking and fullering operations are carried out effectively by applying pneumatic pressure.

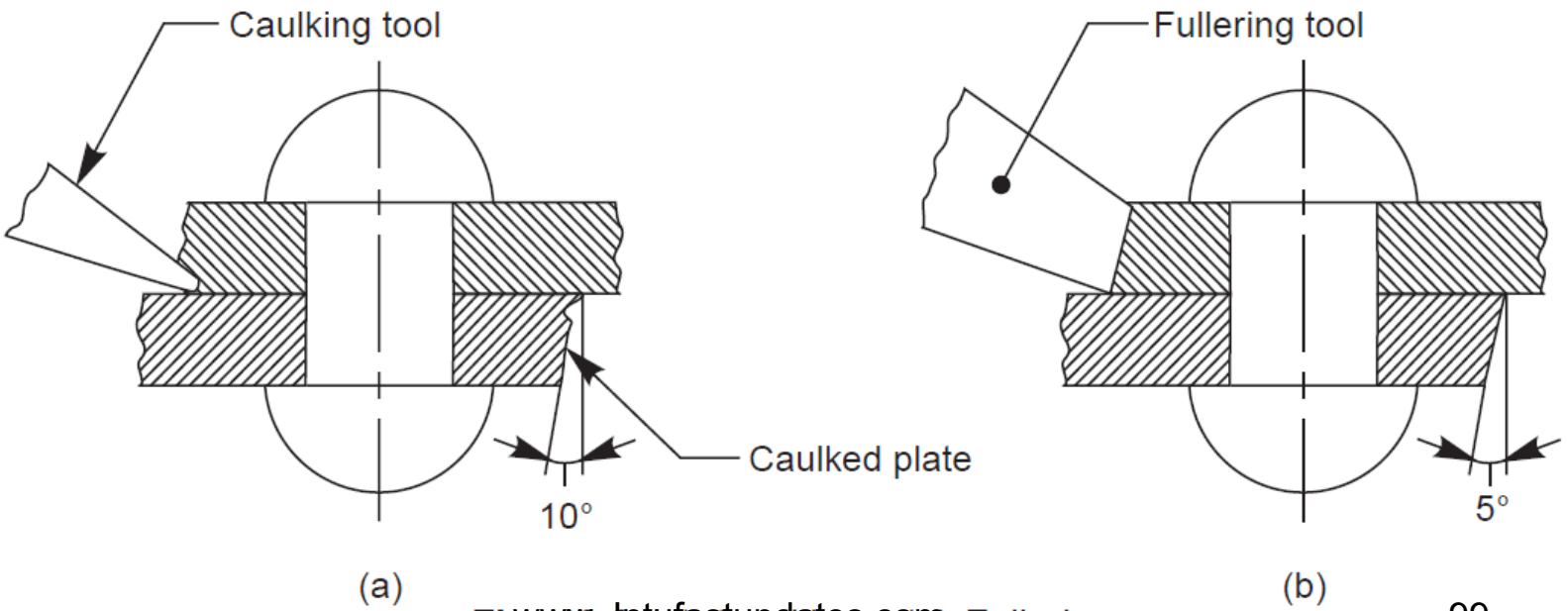


Fig. 10.2 (*a*) Caulking (*b*) Fullering

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Definitions

Pitch: It is the distance between the centres of the adjacent rivets in the same row. It is denoted by '*p*' and usually taken as 3*d*, where *d* is the rivet diameter.

Margin: It is the distance from the edge of the plate to the centre of the nearest rivet. It is usually taken as 1.5*d*, where *d* is the rivet diameter. It is denoted by '*m*'.

Chain Riveting: If the rivets are used along a number of rows such that the rivets in the adjacent rows are placed directly opposite to each other, it is known as chain riveting (Fig. 10.10).

Zig-Zag Riveting: In a multi-row riveting, if the rivets in the adjacent rows are staggered and are placed in between those of the previous row, it is known as zig-zag riveting (Fig. 10.11).

Row Pitch: It is the distance between two adjacent rows of rivets. It is denoted by 'p_r' and is given by, $p_r = 0.8p$, for chain riveting $p_r = 0.6p$, for zig-zag riveting.

Diagonal Pitch: This term is usually associated with zig-zag riveting and is denoted by 'p_d'. It is the distance between the centre of a rivet in a row to the next rivet in the adjacent row.

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. 10.3. The standard proportions are also indicated in the figure.

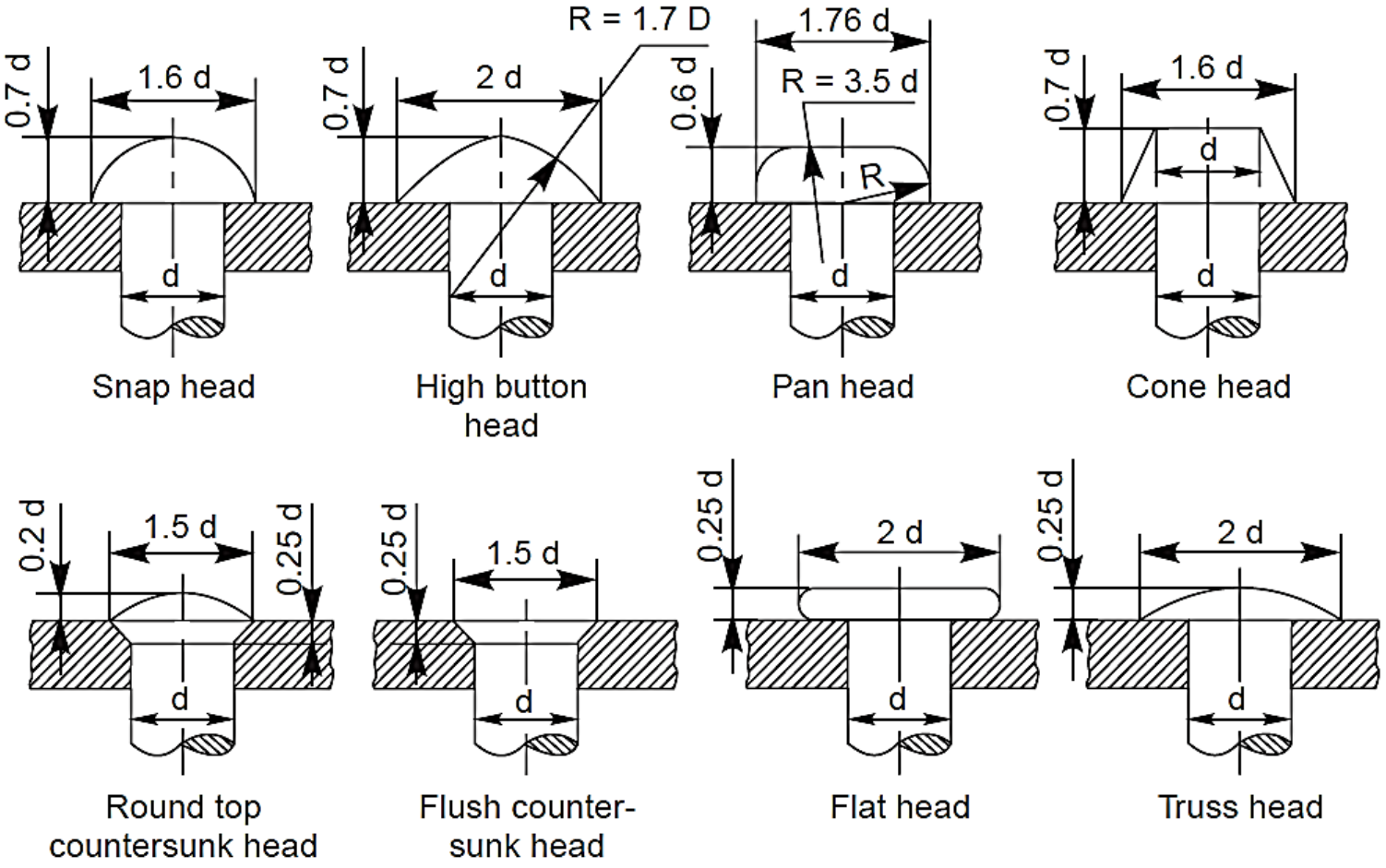
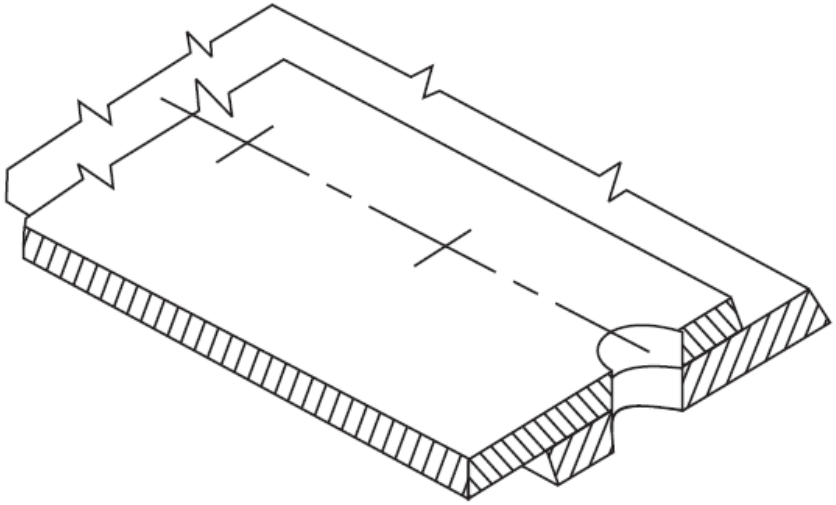
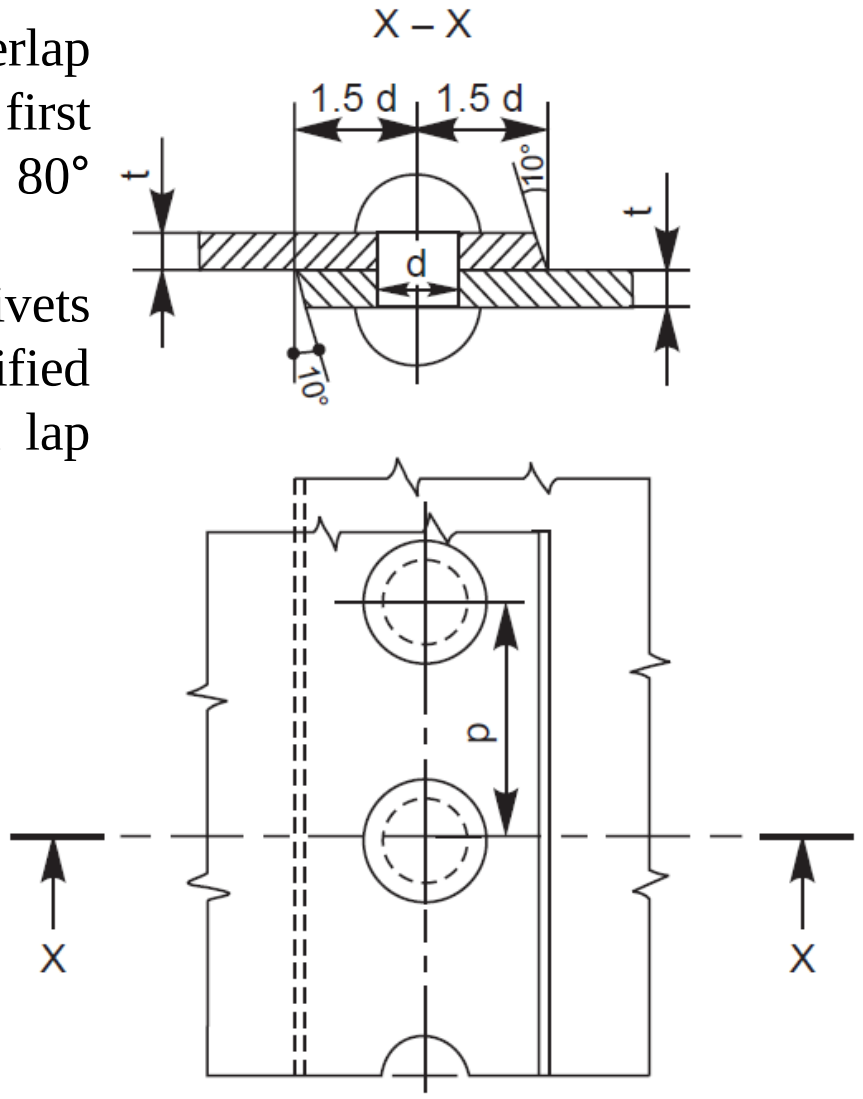


Fig. 10.3 Types of rivet heads

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° (Fig. 10.9).
- 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.





The size of the rivet, *d* is taken as, $d = 6t$ mm where '*t*' is the thickness of the plates to be joined in millimetres.

Fig. 10.9 Single riveted lap joint

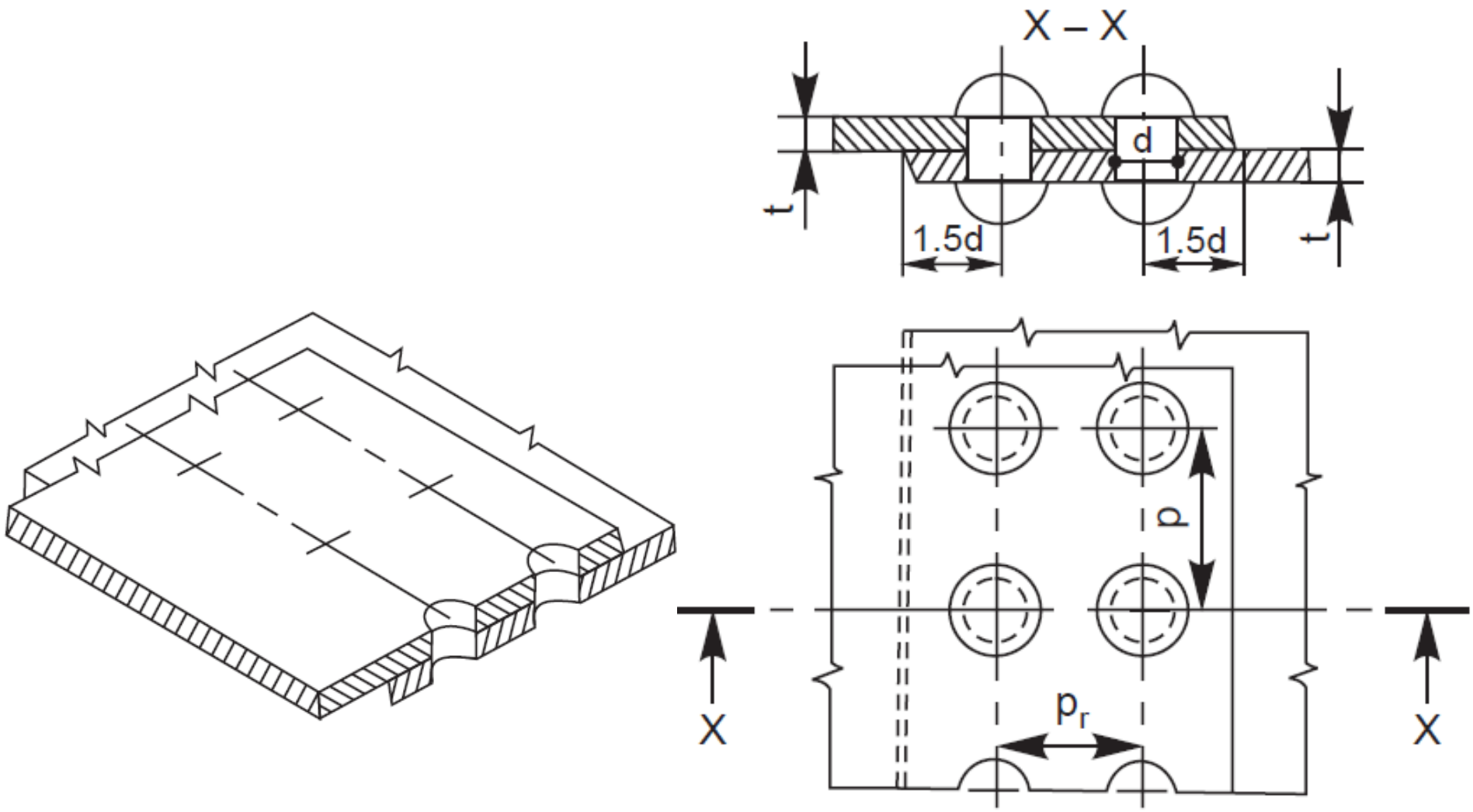


Fig. 10.10 Double riveted chain lap joint

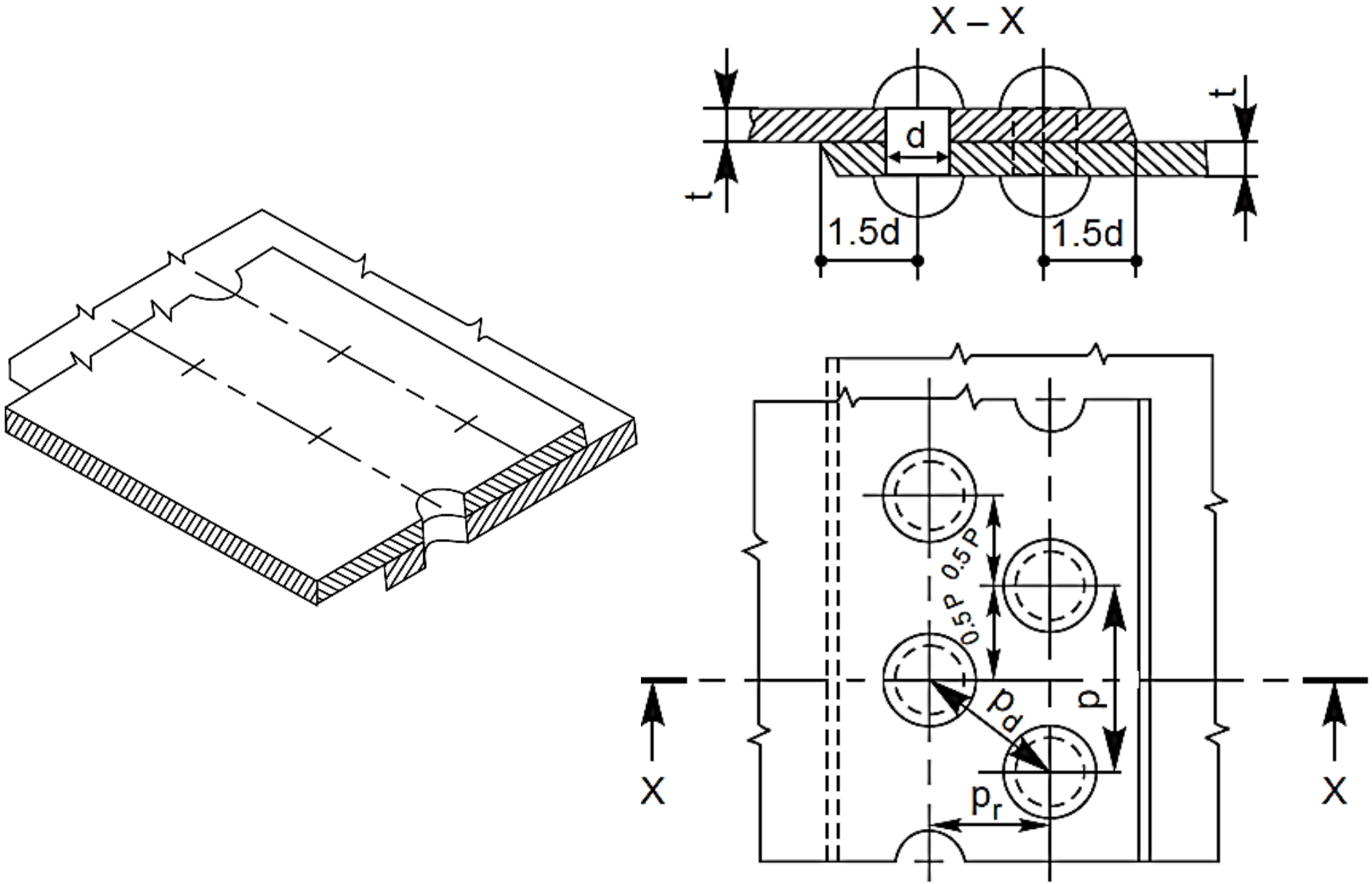
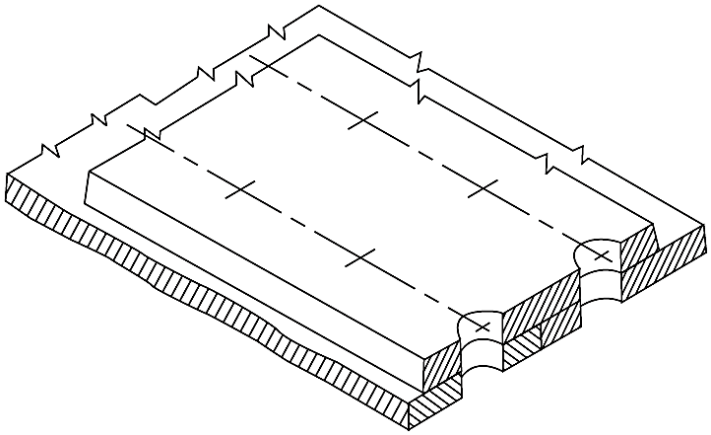
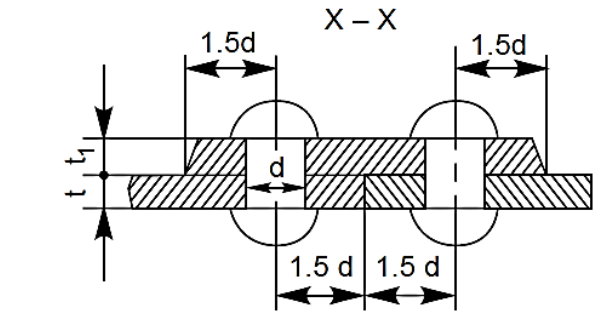


Fig. 10.11 Double riveted zig-zag lap joint

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. These joints are generally used for joining thick plates, and are much stronger than lap joints.
- In a single strap butt joint, the thickness of the strap (cover plate) is given by, $t_1 = 1.125t$
- If two straps are used, the thickness of each cover plate is given by, $t_2 = 0.75t$





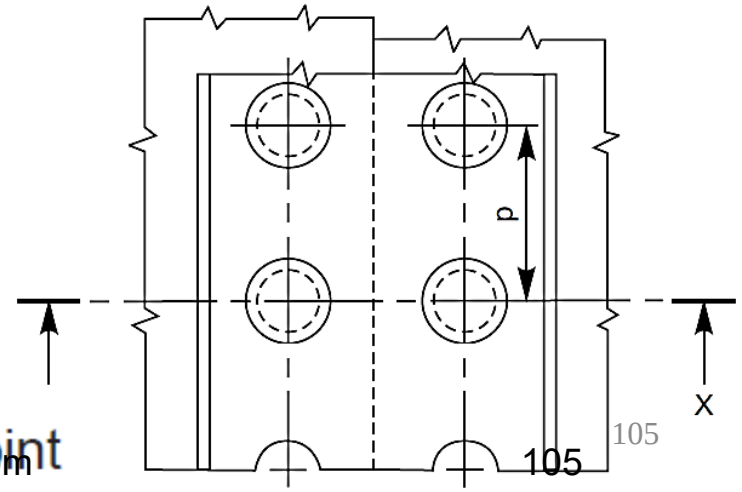


Fig. 10.12 Single riveted, single strap butt joint

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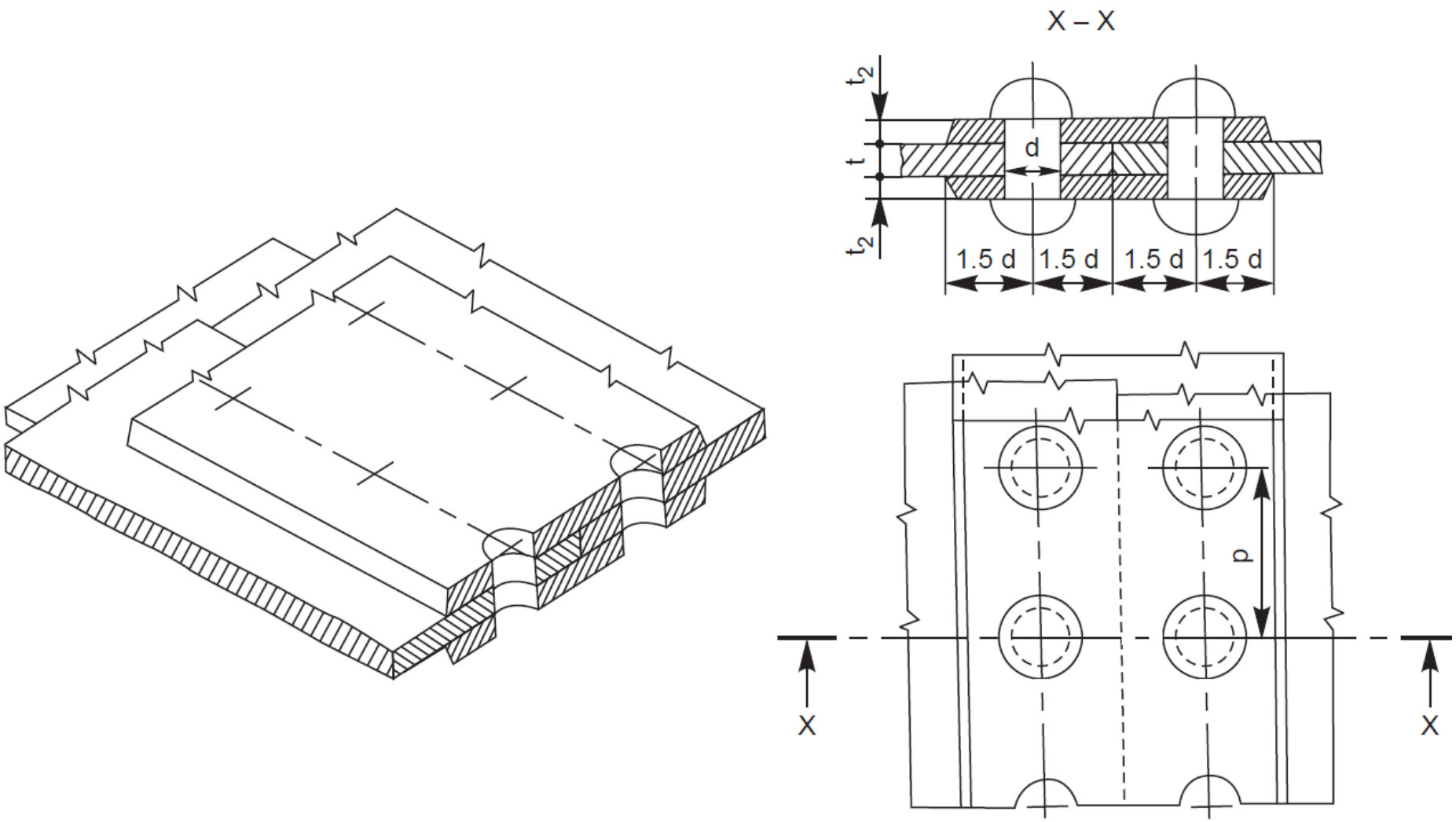


Fig. 10.13 Single riveted, double strap butt joint

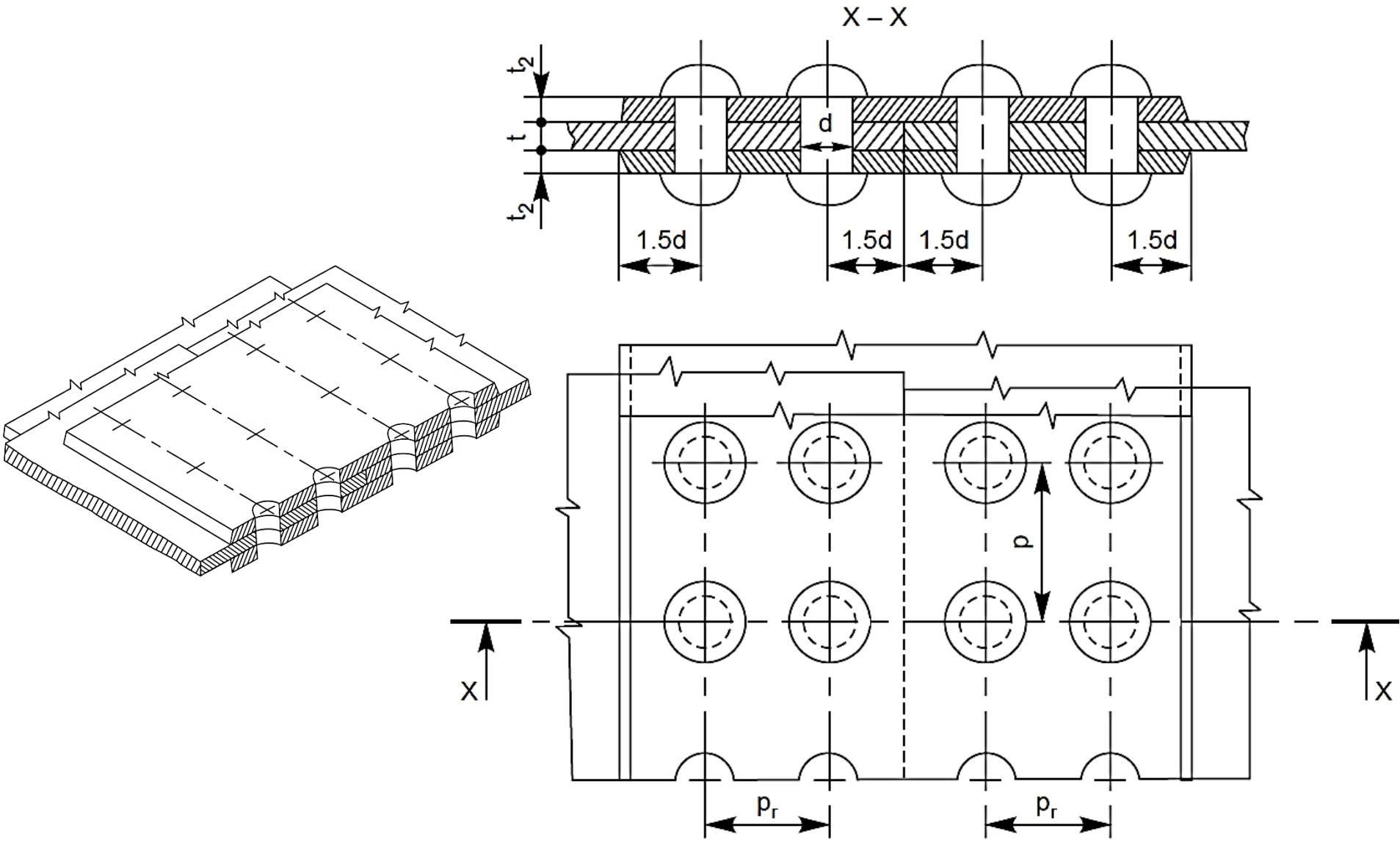


Fig. 10.14 Double riveted, double strap chain butt joint

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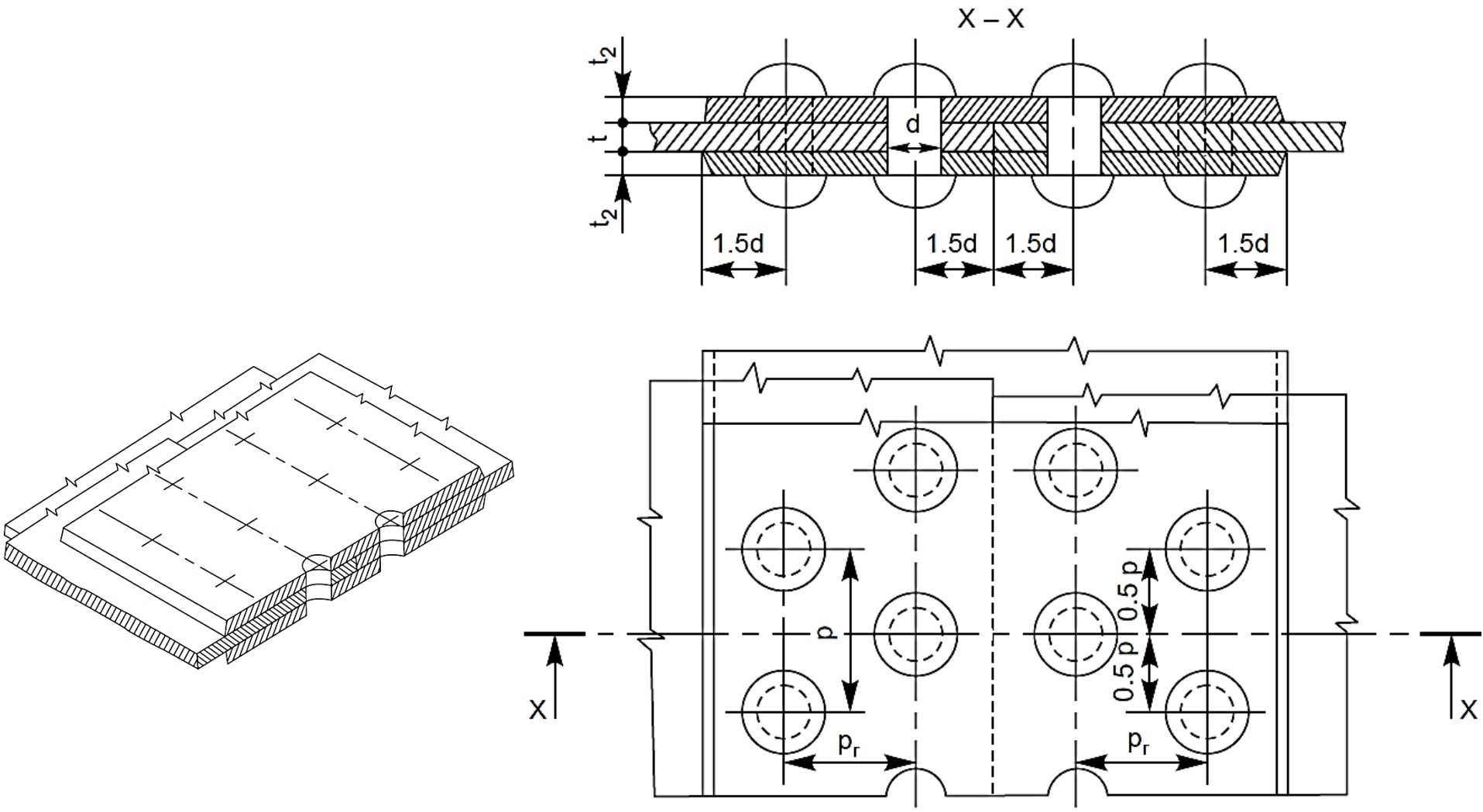


Fig. 10.15 Double riveted, double strap zig-zag butt joint

SHEET 6

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Bearings

- Bearings are supports for shafts, providing stability, and free and smooth rotation.
- The importance of bearings may be understood from the supporting requirement of machine tool spindles, engine crankshafts, transmission or line shafts in workshops, etc.
- Bearings are broadly classified into two categories: sliding contact bearings and rolling contact bearings or antifriction bearings.

1. Sliding contact bearings:

- Sliding contact bearings are those in which the rotating shaft has a sliding contact with the bearing and the friction is relatively high. Hence, these bearings require more lubrication.
- According to the direction in which the bearing is loaded, these bearings are further classified as: journal bearings and thrust bearings.

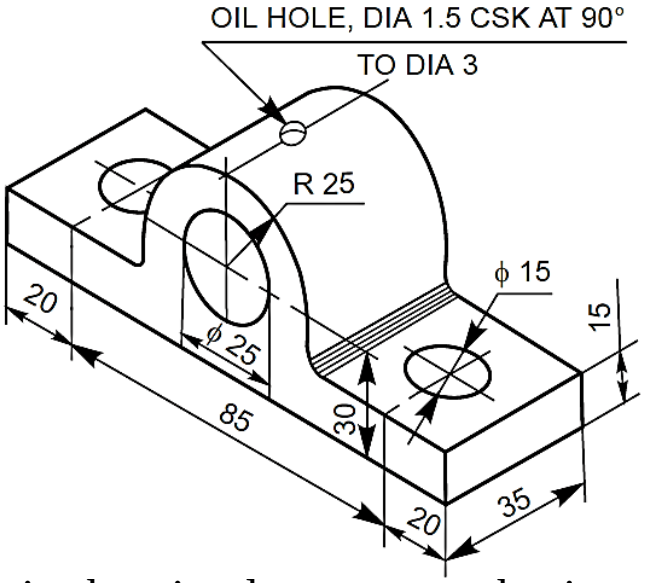
i. Journal bearings
   - Solid Journal bearing
   - Bushed Journal bearing
   - Pedestal bearing or Plummer block

ii. Thrust bearings
   - Pivot or foot-step bearing
   - Collar thrust bearings

2. Rolling Contact (Anti-friction) bearings

- Radial bearings
- Thrust bearings

Solid Journal Bearing



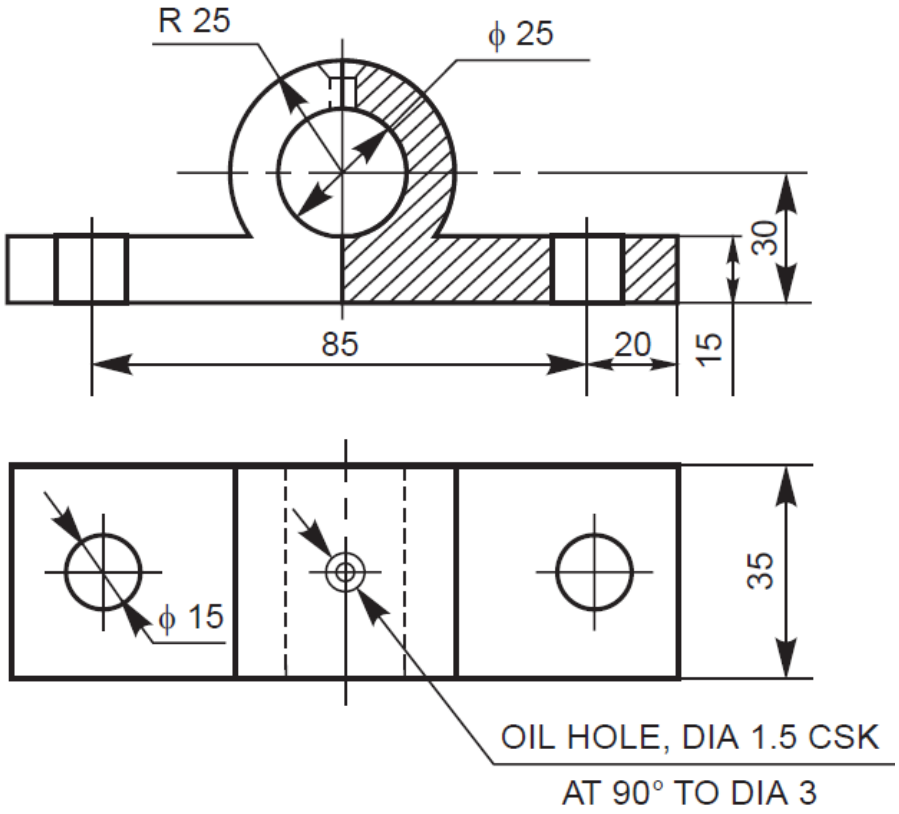


Fig. 12.2 Solid journal bearing

This is the simplest among the journal bearings, and usually made of cast iron. This consists of a cylindrical block with a rectangular base. The hole in the cylindrical block supports the shaft and the holes in the base are used for bolting down the bearing. A hole provided at the top of the body is used for introducing lubricant into the bearing (Fig. 12.2).

The drawback of this bearing is the absence of provision for adjustment in case of wear and hence it has to be discorded. Hence, this is used when the load on the bearing is small and the wear is immaterial.

Bushed Journal Bearing

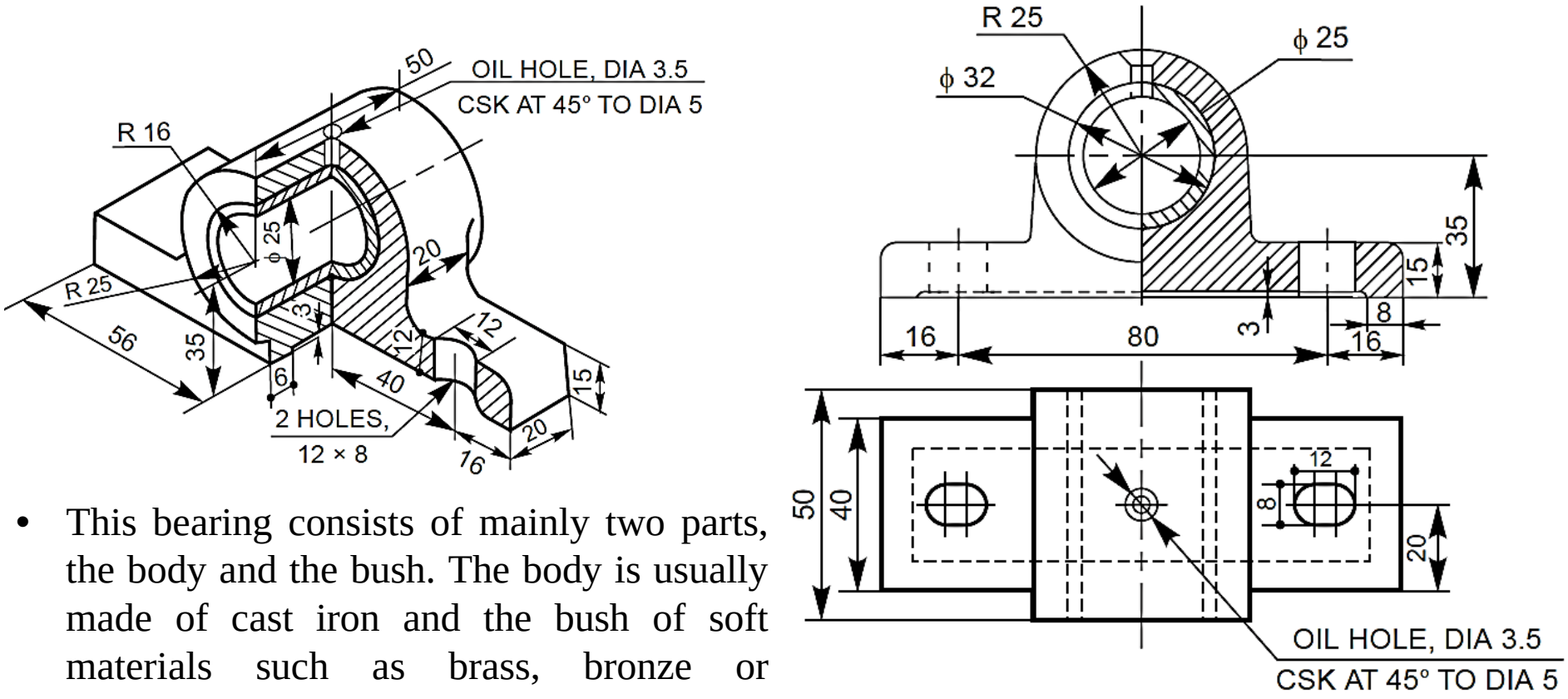
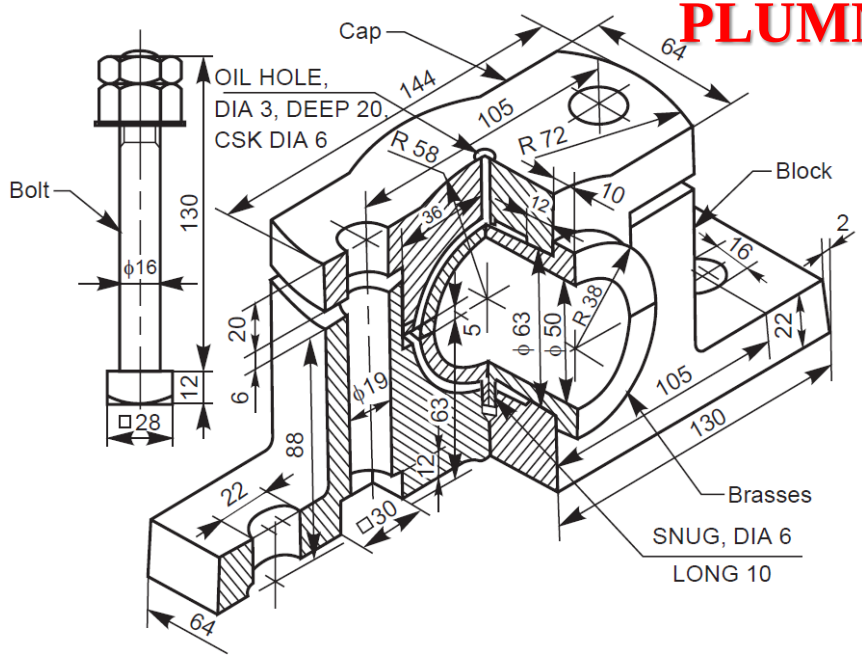


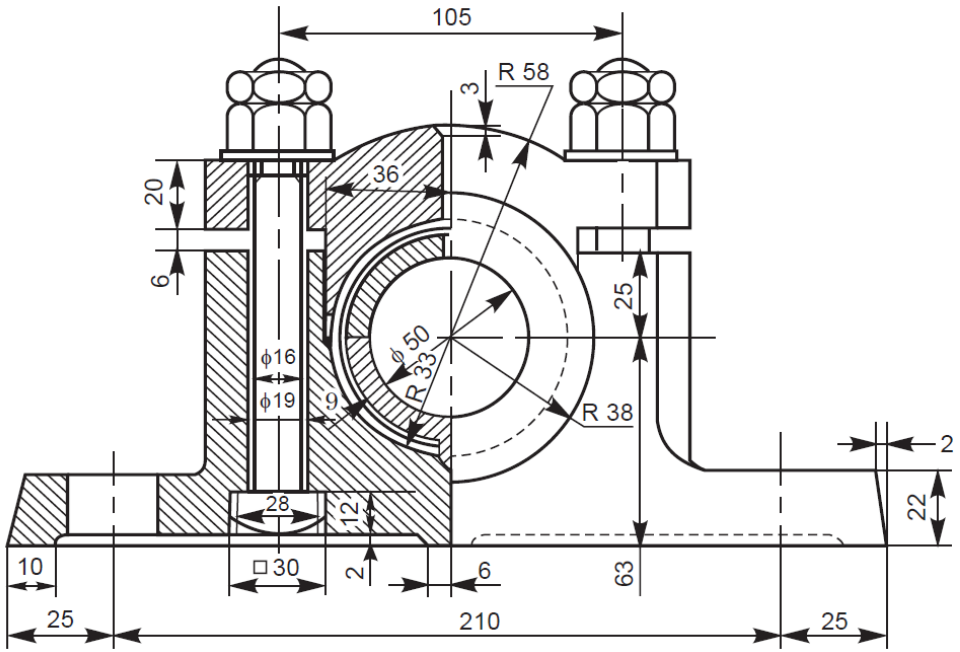
Fig. 12.3 Bushed journal bearing

- This bearing consists of mainly two parts, the body and the bush. The body is usually made of cast iron and the bush of soft materials such as brass, bronze or gunmetal.
- The bush is press fitted in the body; preventing relative axial and rotary motion. With this arrangement, to renew the bearing, it is only necessary to renew the bush.
- The oil hole provided at the top of the body and running through the bush is used to introduce the lubricant (Fig. 12.3).

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PLUMMER BLOCK OR PEDASTAL BEARING





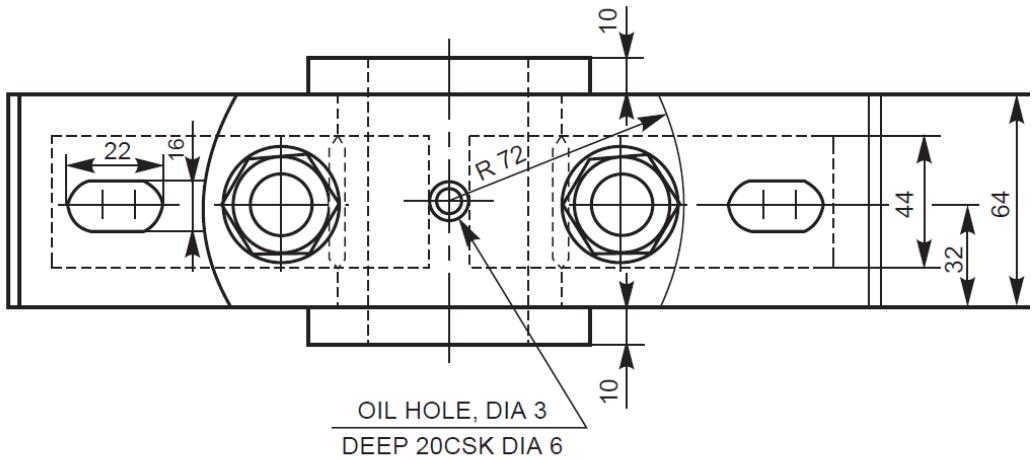
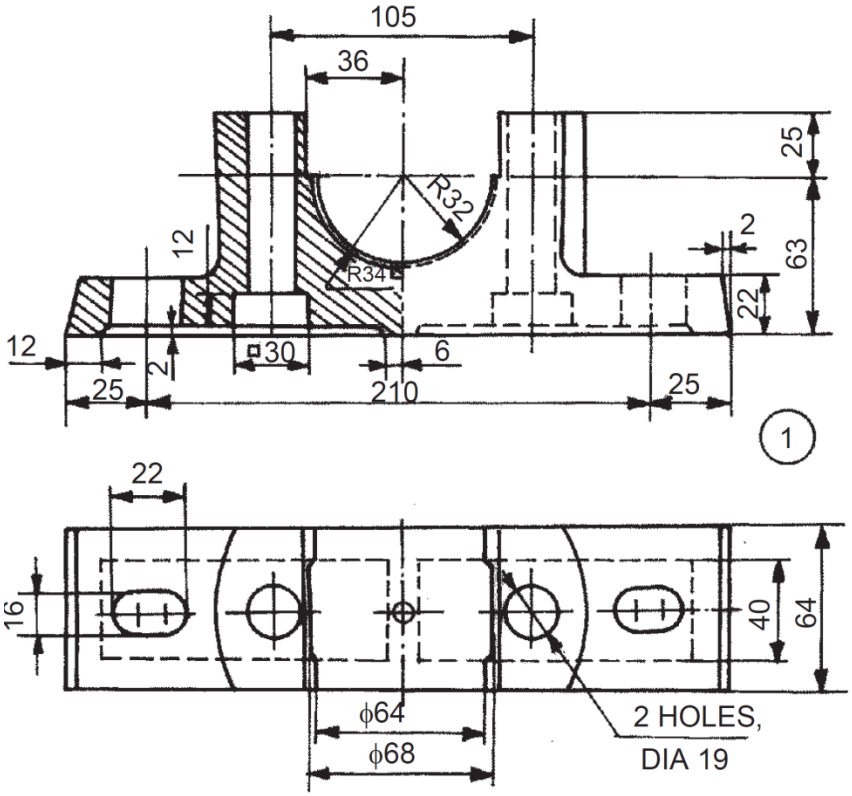
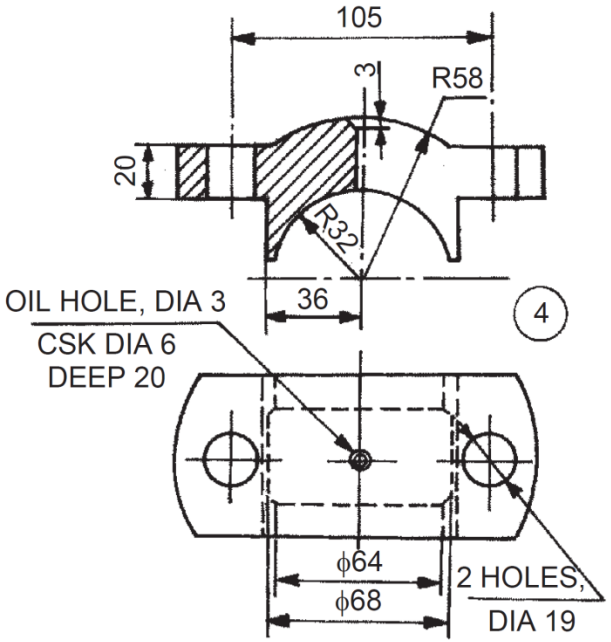
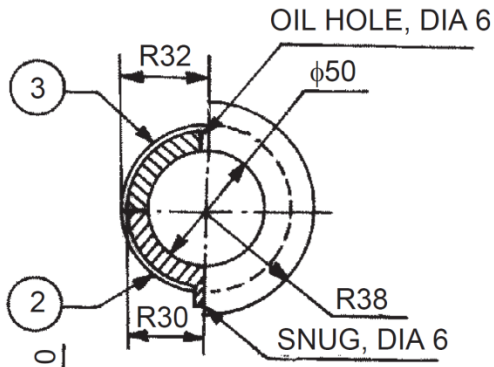


Fig. 12.4 Plummer block

- This bearing is used for long shafts, requiring intermediate support, especially when the shaft cannot be introduced in the bearing end-wise.
- It consists of a pedastal or base, a cap and a bush, split into two halves, called ‘bearing brasses’. The split parts used in the assembly, facilitate easy assembly and periodical replacement of the worn-out brasses.
- After placing the journal on the lower half of the bush, kept in the base, the upper half of the bush is placed and the cap is then fixed to the pedastal, by means of two bolts (Fig. 12.4).
- Flanges are provided at either end of the bush, to prevent its axial motion. The rotary motion of the bush is prevented by a snug provided at the bottom of the lower brass, fitting into a corresponding hole in the base.

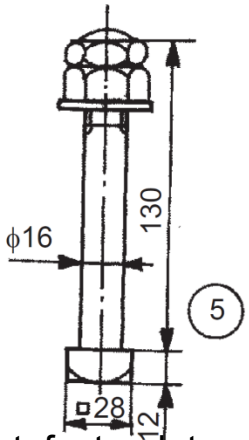


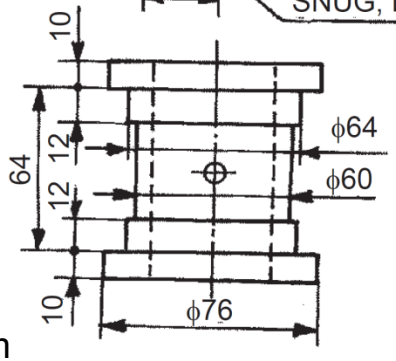




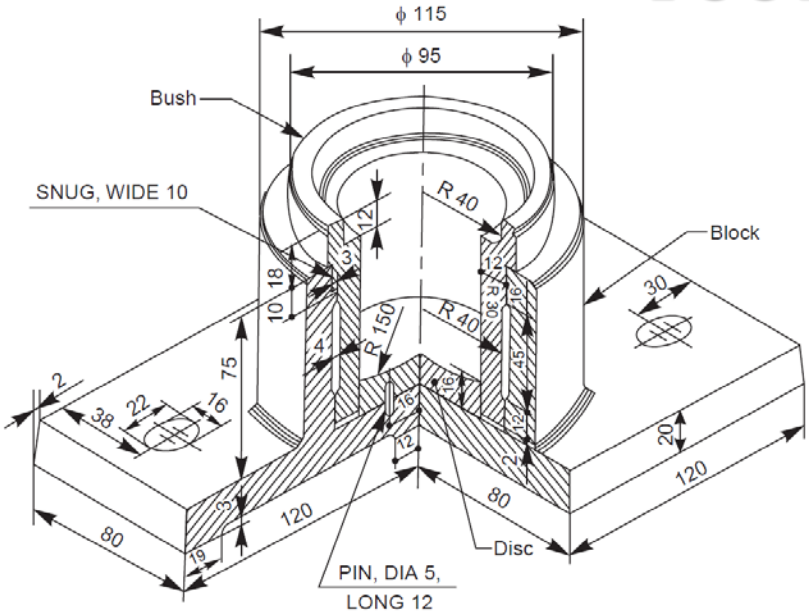
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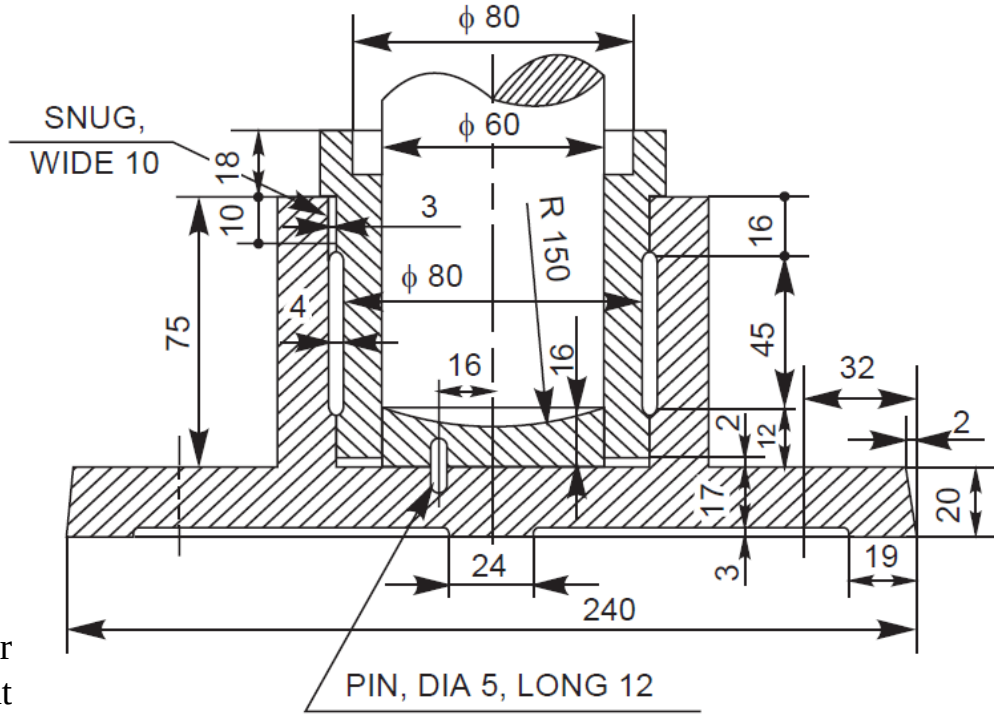
Sl. No.	Name	Matl.	Qty.
1	Base	CI	1
2	Bearing brass	Bronze	1
3	Bearing brass	Bronze	1
4	Cap	CI	1
5	Bolt with nuts	MS	2





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.
- The disc is prevented from rotation by a pin inserted through the body and away from the centre.
- The bush is also prevented from rotation by a snug, provided at its neck, below the collar (Fig. 12.9).
- The space between the shaft and the collar, serves as an oil cup for lubricating the bearing.
- The bush and the body are recessed to reduce the amount of machining. The base of the body is also recessed to serve the same purpose.

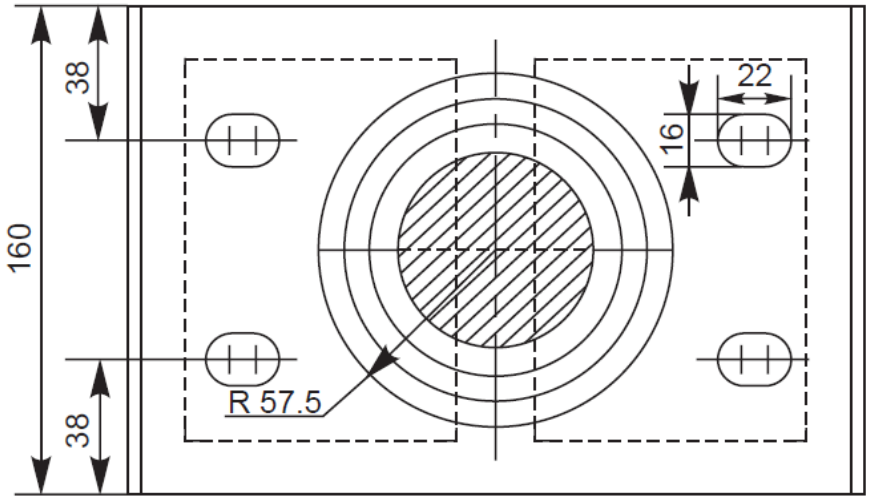
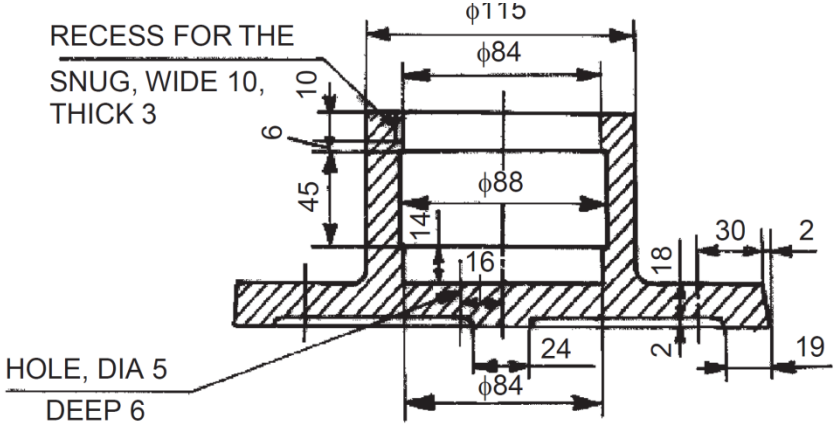
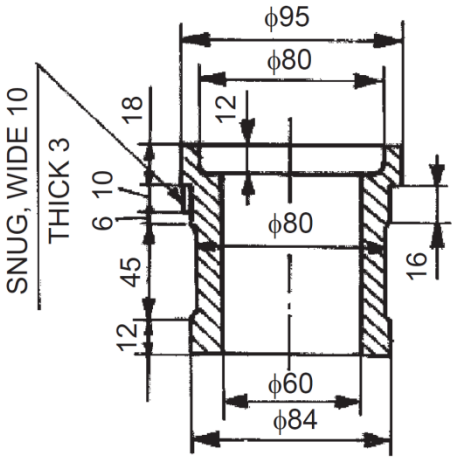


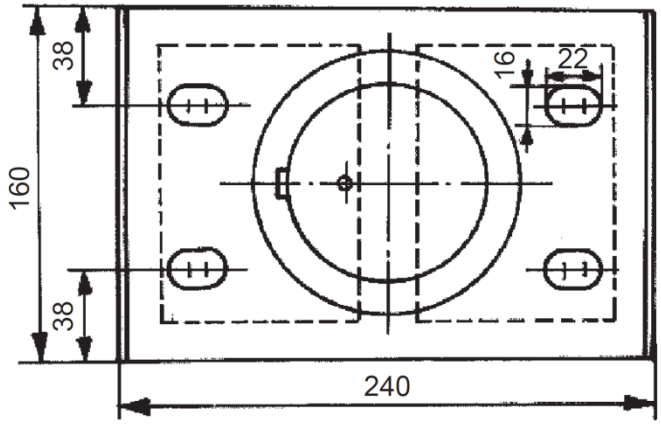
Fig. 12.9 Foot-step bearing

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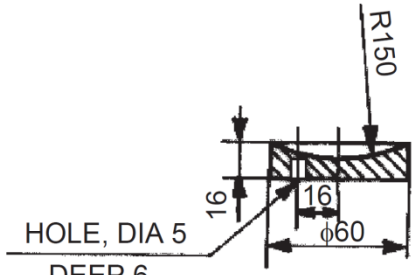




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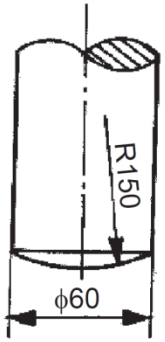
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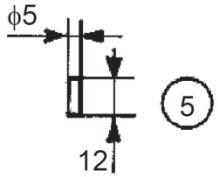
3

Parts list

Sl. No.	Name	Matl.	Qty.
1	Body	Cast iron	1
2	Bush	Brass	1
3	Disc	P Bronze	1
4	Shaft	Mild steel	1
5	Pin	Mild steel	1



4



5