CHAPTER 10. JOINTS

10.1 Detachable and Permanent Joints

The joints of parts in apparatus, assemblies and machines vary in designated purpose, design form, and technology of manufacture.

Joints are classified into detachable and permanent.

Detachable joints are the joints, recurrent assembly and disassembly of which cause no damage to their parts. Among such kind of joints are: threaded, keyed, splined, pinned, splint-pinned joints, etc.

Permanent joints are not designed for disassembly, hence, it damages the parts of a joint. Among permanent joints are: welded, soldered, adhesive, riveted joints, etc.

Detachable joints are also divided into movable and fixed ones.

The movable detachable joints are the joints, in which one part may move relative to another, e.g. a joint of a movable nut with a screw of a lathe carriage.

The fixed detachable joints are the joints, the parts of which cannot move relative to each other, e.g. a joint by means of a screw or a bolt and a nut.

10.2 Thread Representation and Designation

Thread is a surface made by a spiral movement of a plane contour along a cylindrical or conical surface. By such a movement, the plane contour produces a screw protrusion of a corresponding profile, limited by the screw's cylindrical or conical surfaces.

Threads are classified according to the following (Fig.10.1):

The threaded surface's form (cylindrical, conical);

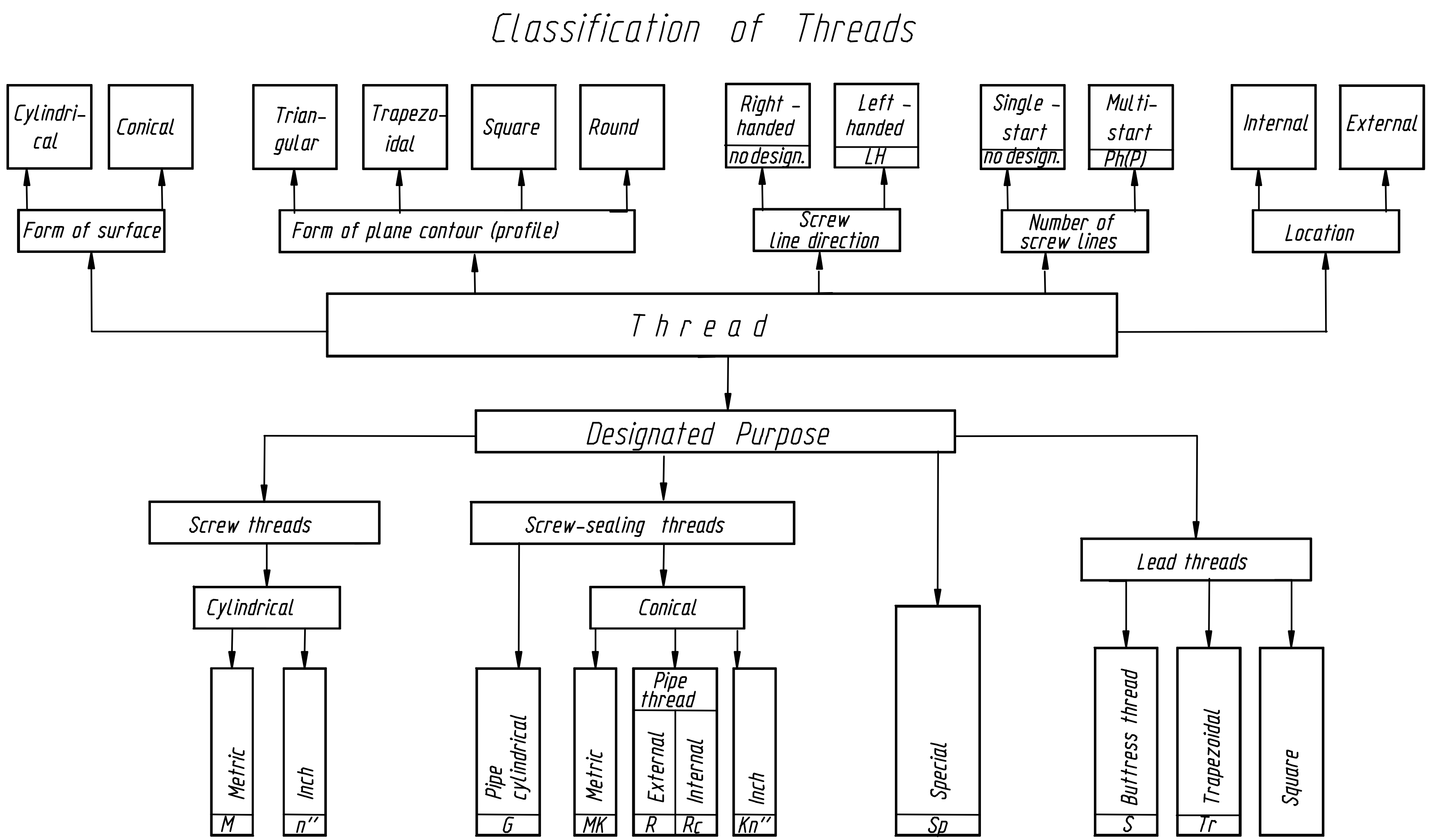
The profile form (triangular, square or flat, trapezoidal, round, etc.);

The screw direction (right-hand and left-hand);

The number of the thread starts (single-start and multistart);

The thread's location on a shank surface or in a hole (external and internal);

The designated purpose (screw, screw-sealing, leading, special threads, etc.).



Classification of Threads
Cylindri-cal
Conical
Trian-gular
Trapezo-idal
Square
Round
Right - handed
no design.
Left - handed
LH
Single - start
no design.
Multi-start
Ph(P)
Internal
External
Form of surface
Form of plane contour (profile)
Screw line direction
Number of screw lines
Location
Thread
Designated Purpose
Screw threads
Screw-sealing threads
Lead threads
Cylindrical
Conical
Metric
M
Inch
n''
Pipe cylindrical
G
Metric
MK
Pipe thread
External
R
Internal
Rc
Inch
Kn''
Special
Sp
Buttress thread
S
Trapezoidal
Tr
Square

Fig.10.1

All threads are divided into two groups: *standard* and *non-standard*. Parameters of the standard threads (profile, pitch and diameter) are specified by standards. Parameters of non-standard threads do not correspond to any standards.

A Thread type depends on its profile, i.e. the contour obtained in the cutting plane, which passes through the thread axis.

If the screw motion is made by a point, the spatial curve produced by it is referred to as a screw line (Fig.10.2, a).

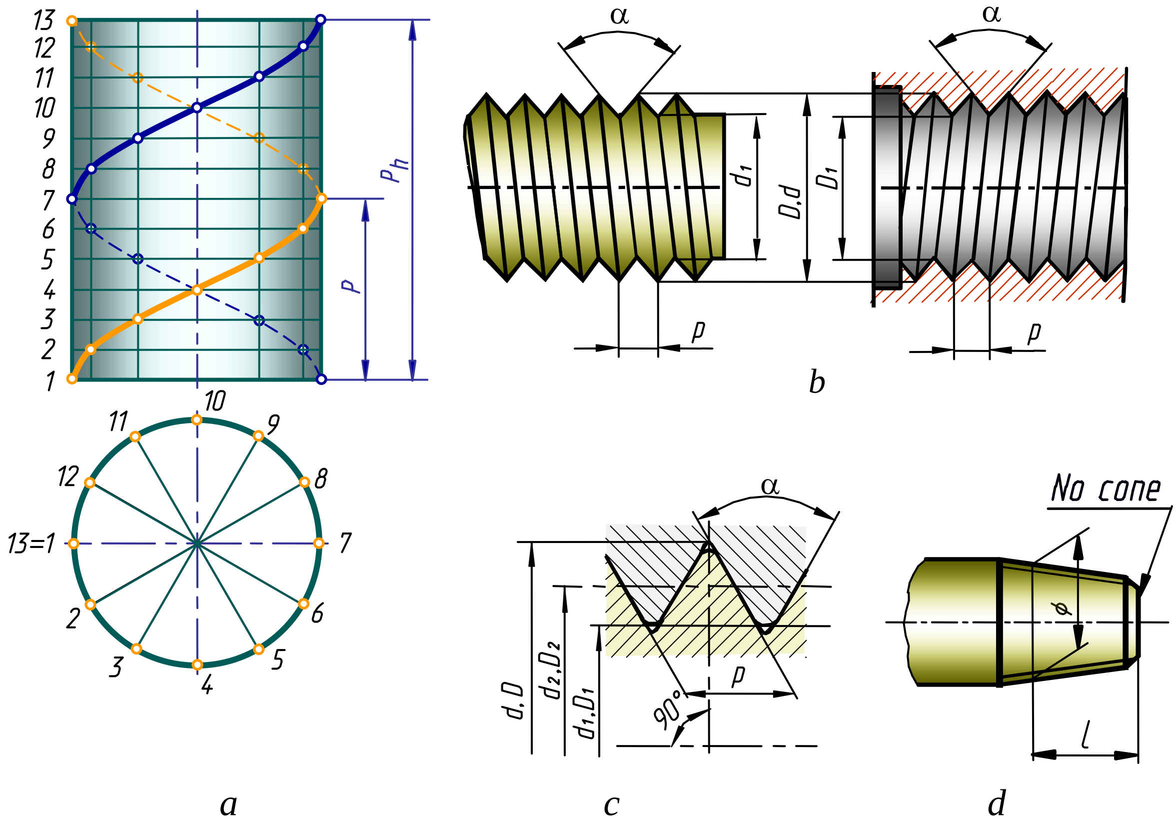


Fig.10.2

The principal parameters of thread:

the external (nominal) *diameter of thread d,D* - diameter of an imaginary cylinder or cone, described around the vertices of the external thread or the root of internal thread;

the internal diameter of thread d_1,D_1 - diameter of an imaginary cylinder or cone, described around the root of external thread or the vertices of internal thread;

the thread profile - the contour of a thread cut by a plane, which passes through its axis (for example, Fig.10.2, b, c shows the triangular profile);

the angle α - is the angle contained by the adjacent lateral profile sides;

the thread pitch P - the distance (parallel to the thread axis) between two of the same name lateral sides of the profile;

the thread lead P_h - the distance (parallel to the thread axis) between the nearest lateral profile sides of the same name, belonging to one screw surface. The axis travel of a screw or a nut per one revolution is equal to one lead of a thread.

A lead of a single-start thread is equal to a thread pitch, a lead of a multistart thread is equal to the product of the pitch P by the number of starts n: $P_h = n \times P$

All the diameters of the conical threads are specified in the principal plane. The principal plane is the plane of a reference section, perpendicular to the thread axis and positioned at the given distance *l* from the cone *base* (Fig.10.2, d). The pitch of the conical thread is the projection of a line-segment, connecting the neighbouring vertices of the thread profile, onto the axis.

Depending on the screw direction there are right-handed or left-handed threads. The right-handed thread is produced by the contour, which rotates clockwise and travels along the axis away from the viewer. The left-handed thread is produced by the contour, which rotates counter-clockwise and travels along the axis away from the viewer.

The screw thread is designed for the fixed fastening of parts. Both, metric and inch threads can be used as the screw threads.

The screw-sealing threads are designed mostly for the close, hermetically sealed fastening of parts. The pipe and conical threads belong to the screw-sealing threads.

The lead threads are applied to transmit the axis power and the motion of lead screw of lathes, hoisting apparatus, etc. The trapezoidal, buttress, square and round threads can be applied as the lead ones. They may be single-start and multistart.

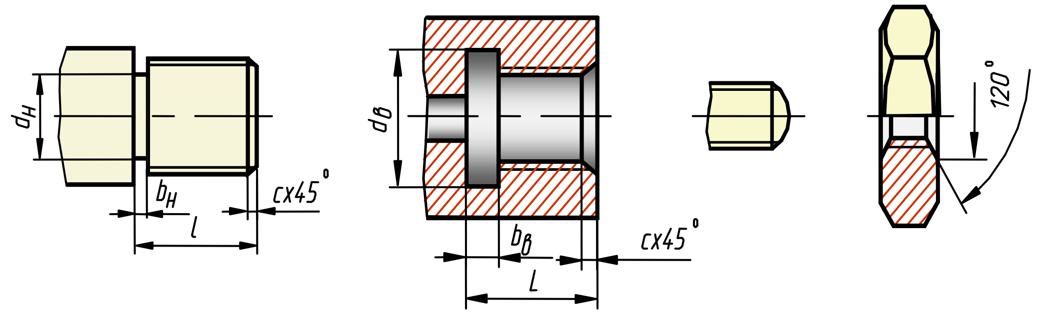
Designing and Technological Elements of Threads

The external thread is cut by special machines or by threading tools, thread milling cutters and threading dies. The internal thread is usually cut by threading tools or screw taps. Dies and taps are applied for thread cutting on a previously prepared detail blank or in a hole.

Thread tapers are the areas with an incomplete, evenly reduced profile. The taper is a non-operational part of thread, and it must be considered when determining the length of a threaded detail part.

When an internal thread is cut, the material is first drilled a little deeper than is actually required. The diameter of the hole is the same as the root diameter of the thread and is called the tapping diameter. The screw thread is then cut with a tap, but the tap cannot reach right to the bottom of the hole and some of the *tapping hole* is left.

To obtain the complete thread of a screw body or of a hole, the thread turning is made.



a *b* *c* *d*

Fig.10.3

Thread turning is a ring groove on a screw body (its diameter d_e is smaller than the internal diameter of the thread being cut, Fig.10.3, a) or a ring recessing in a hole (its diameter is larger than the external thread diameter, Fig.10.3, b), which are produced for the threading tool to escape.

An important designing element of the threaded parts is *chamfer* - an edge of a cylindrical or conical screw body or hole, cut in the way of a truncated cone (Fig.10.3, c).

Drawing Screw Threads

Drawing a screw thread properly is a tedious business. There are conventions for drawing threads which make life very much easier.

The thread body is represented by continuous thick lines along the external diameter of the thread and by continuous thin lines along the internal diameter (Fig.10.4). On the representations obtained by projecting onto a plane, parallel to the body axis, a continuous thin line (equal to the thread length minus taper) is drawn along the internal thread diameter. On the representations obtained by projecting onto a plane, perpendicular to the body axis, an arc is passed along the internal thread diameter. The arc is drawn 3/4 of the circle, broken at any place. The line specifying the thread boundary is drawn at the end of the complete thread profile (in front of the tapering). It is a continuous base-line, passed up to the line of the external thread diameter (Fig.10.4, a). If the thread is represented as invisible, its boundary is drawn with short dashes up to the line of external diameter(Fig.10.4, c, d).

The thread hole is represented by continuous thick lines along the internal diameter of the thread and by continuous thin lines along the external diameter (Fig.10.4).

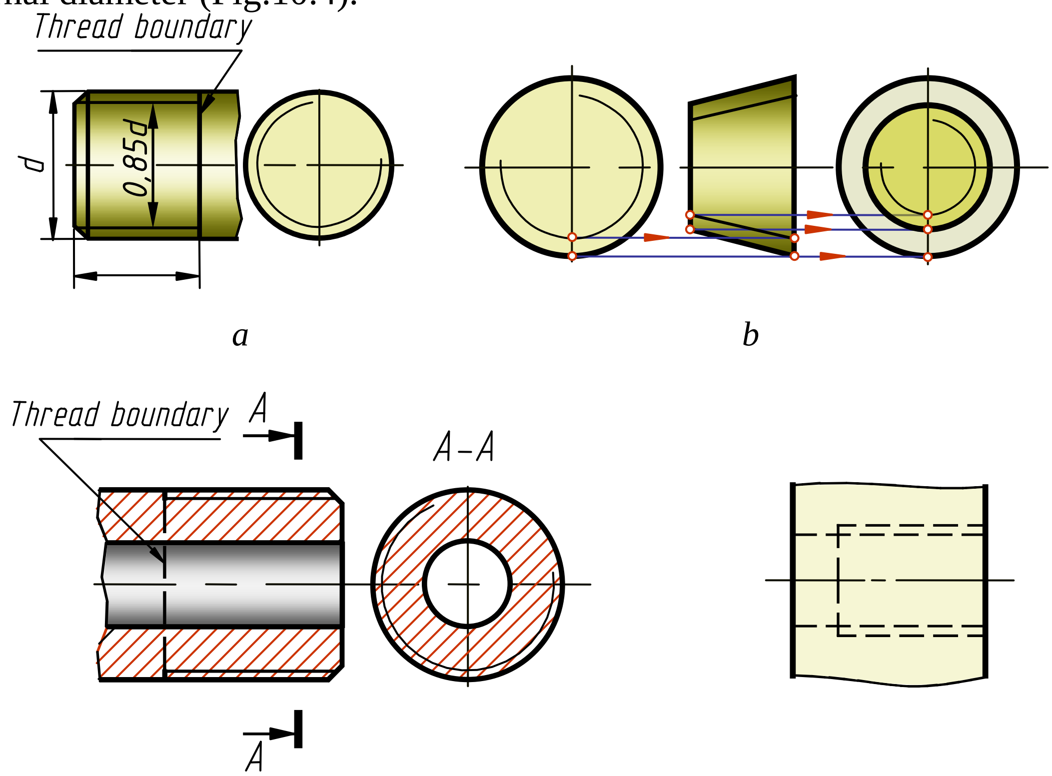


Fig.10.4

On the representations obtained by projecting onto a plane, perpendicular to the hole axis, an arc is passed along the external thread diameter. The arc is drawn 3/4 of the circle, broken at any place. The line of the thread boundary in the hole is drawn with a continuous base-line, passed up to the line of the external thread diameter (Fig.10.5, b).

The cross-hatching lines on sectional views and sections are passed up to the lines of the external diameter of the screw body, and up to the lines of the internal diameter of the hole, i.e. in both cases cross-hatching is drawn up to the continuous base-lines (Fig.10.4 and 10.5).

If the thread hole is represented as invisible, the thread is drawn with parallel hatching lines of similar thickness. The thread of a hole on a sectional view is more pictorial. The continuous thin line of the thread is passed at a distance of 0.8 mm minimum and the pitch value maximum, from the continuous base-line (approx. 0.85d).

The chamfers of no designated purpose are not represented on the above projection (Fig.10.4, a and 10.5, a). The continuous thin line of the screw body thread must intersect the line of the chamfer’s boundary (Fig.10.4, a).

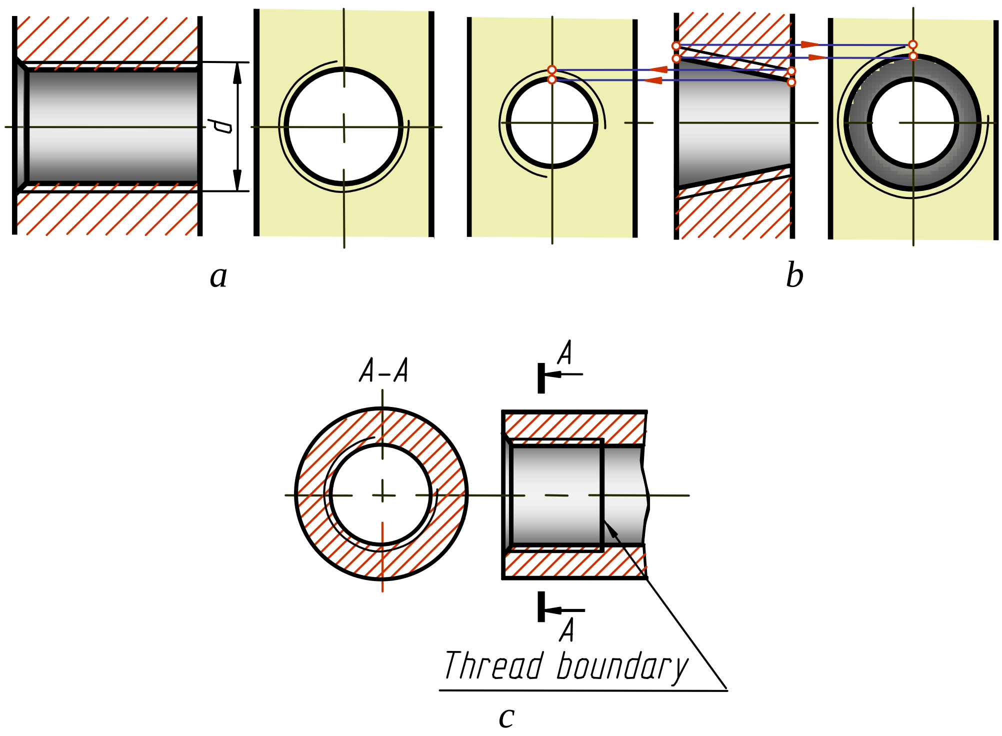


Fig.10.5

The taper is not considered when dimensioning the thread of a shank or a hole (Fig.10.6, a, b). If it is necessary, proceed as shown in Fig.10.6, c, d.

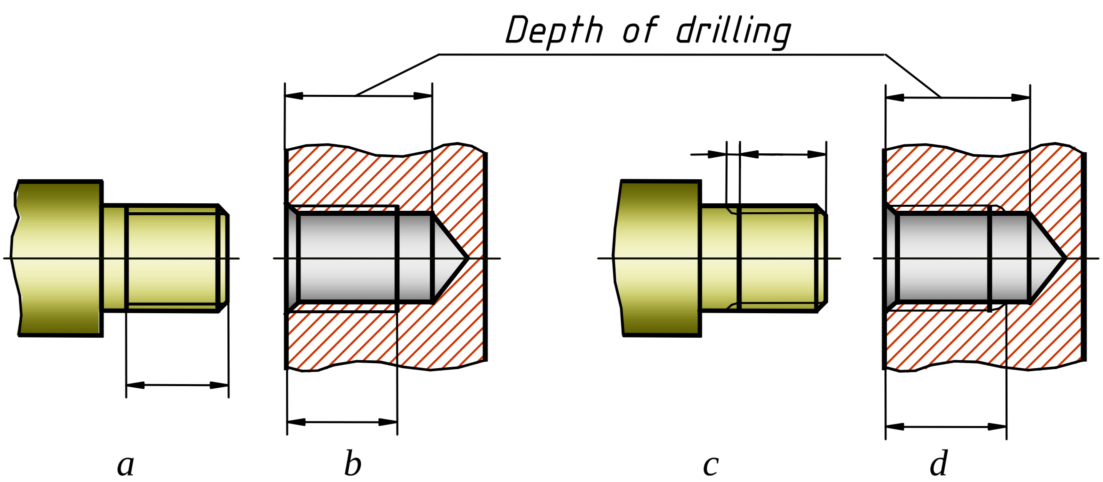
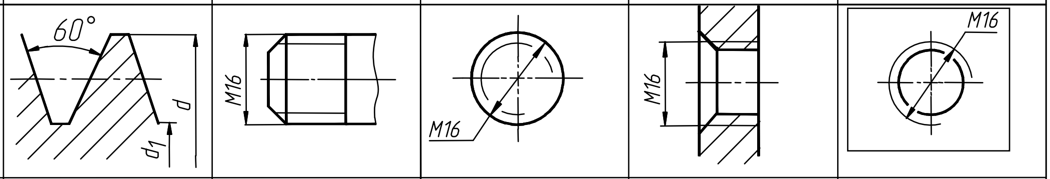
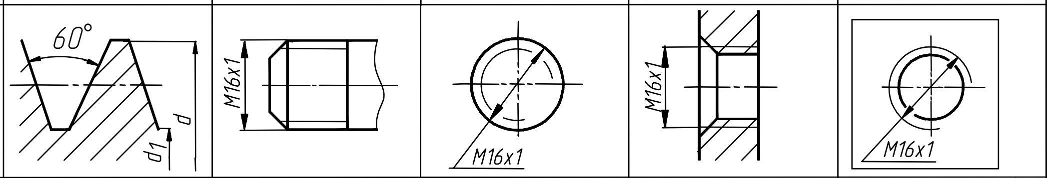
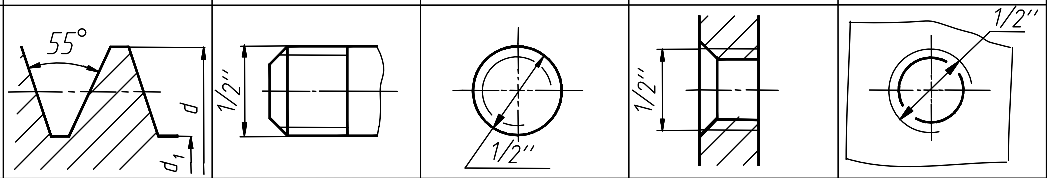
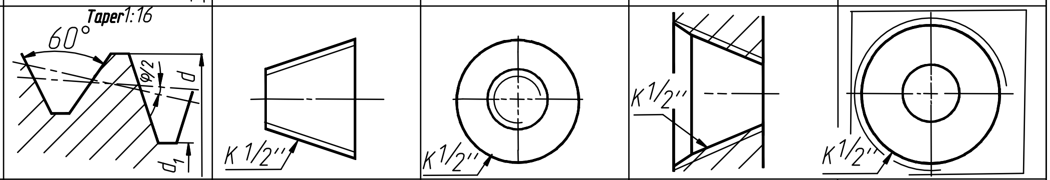
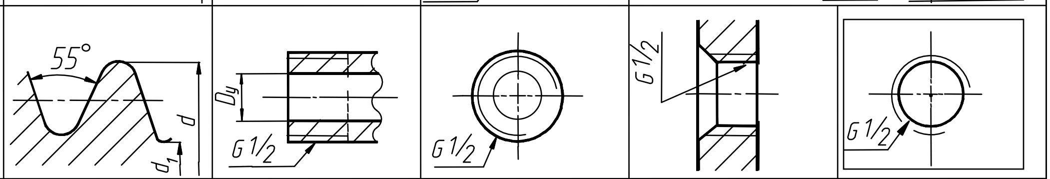
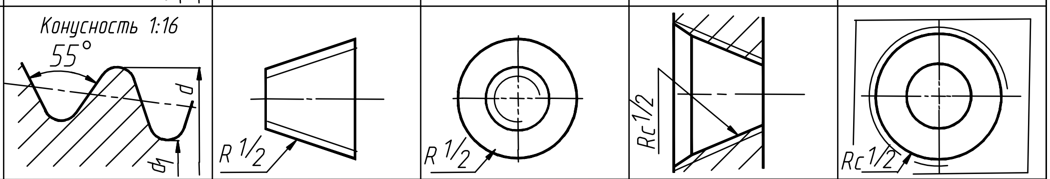
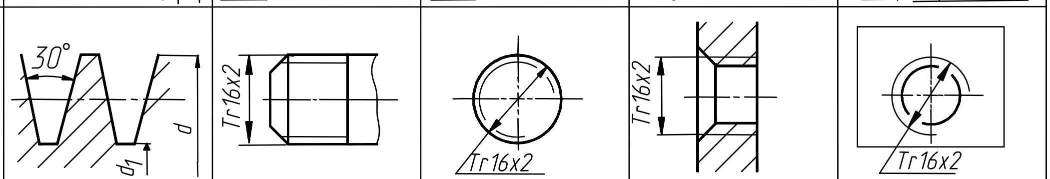
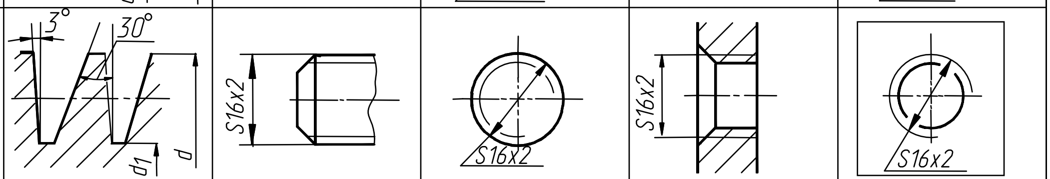
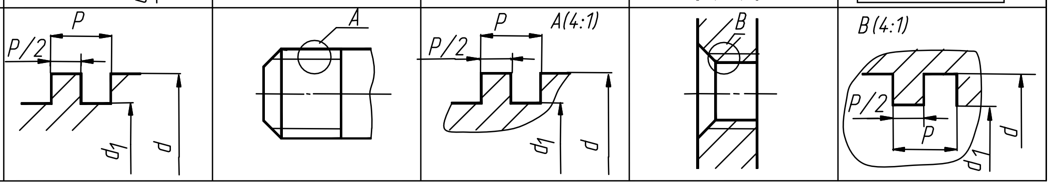


Fig.10.6

A blind threaded hole is called a *seat*. The seat ends with a cone, obtained by drilling (the sharpened end of a drill is of a conical form). Unless otherwise required, the thread is drawn to the bottom of the hole (Fig.10.7, a), the conical seat end is not shown (Fig.10.7, b).

Table 10.1

Type of Thread	Profile of Thread	Conventional Representations of Thread			
		External Thread		Internal Thread	
		On plane parallel to thread axis	On plane perpendicular to thread axis	Sectional View	View (no sectional)
Metric (coarse pitch)					
Metric (fine pitch)					
Cylindrical (inch)					
Conical (inch)					
Pipe Cilindrical					
Pipe Conical					
Trapezoidal					
Buttress					
Square					

When drawing on the plane parallel to the thread axis, the thread of the hole of a threaded joint is shown only in the part not covered by the shank thread (Fig.10.8, a, b).

One of the methods of representation of thread with a non-standard profile is shown in Fig.10.9 (with all necessary dimensions and extreme tolerances, dimensions are in letters). The additional data (number of starts, whether the thread is left-handed, etc.) is presented if necessary, accompanied with the word “Thread”. Table 10.1 provides conventional representations of thread of different types according to standards.

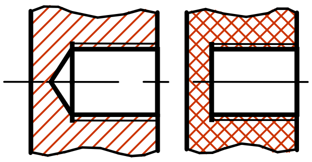
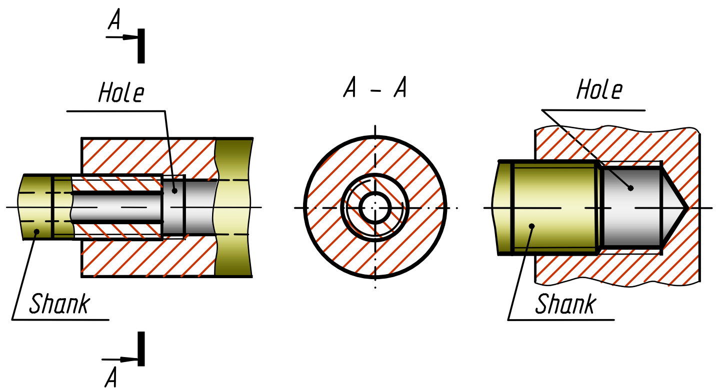


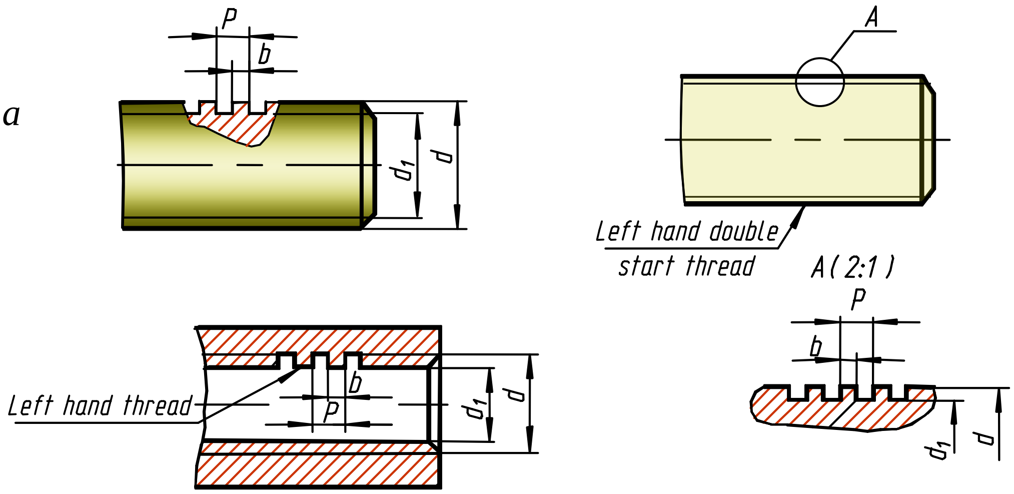
Fig.10.7



a b

Fig.10.8

a



b c

Fig.10.9

Thread Designations

Metric thread has a triangular profile with the vertex angle of 60° (Fig.10.10). The profile and the basic dimensions of metric thread, also the diameters and pitches, are specified by standards. Metric threads for diameters from 1 to 600 mm are divided into two types: coarse pitch thread (diameters 1-68 mm) and fine pitch thread (diameters 1-600 mm). Starting from 6 mm, several pitches are specified for each diameter of fine thread, Table 10.2.

The conventional designation of the coarse pitch thread includes the letter M, presenting the thread profile and the nominal (external) diameter of thread in millimetres. For example, M56 indicates that the thread is metric, coarse pitch, nominal diameter 56 mm.

The designation of fine pitch thread additionally includes the pitch dimension in millimetres, e.g. *M56×3*.

If it a right-hand thread, it is not shown in the convention. If it is a left-hand one, it is designated by letters LH, e.g. *M56×3LH*.

Table 10.2

External diameter of thread	Thread Pitch	
	Coarse	Fine
6	1	0.75; 0.5
8	1.25	1; 0.75; 0.5
10	1.5	1.25; 1; 0.75; 0.5
12	1.75	1.5; 1.25; 1; 0.75; 0.5
14	2	1.5; 1.25; 1; 0.759; 0.5
16	2	1.5; 1; 0.75; 0.5
18	2.5	2; 1.5; 1; 0.75; 0.5
20	2.5	2; 1.5; 1; 0.75; 0.5
22	2.5	2; 1.5; 1; 0.75; 0.5
24	3	2; 1.5; 1; 0.75
27	3	2; 1.5; 1; 0.75
30	3.5	3; 2; 1.5; 1; 0.75

Conventional representations of standard threads are supplemented by designations to indicate their complete characteristics. Designations of all threads except conical and pipe cylindrical, refer to the external diameter and are printed on the extension and dimension lines (Fig.10.10).

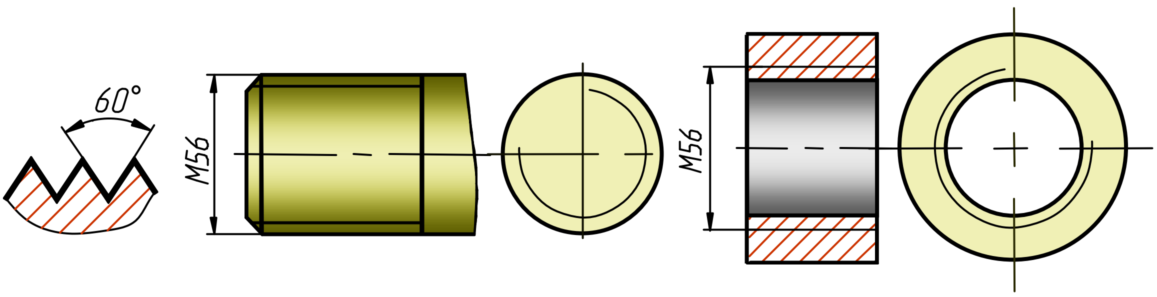


Fig.10.10

The designations of conical and pipe cylindrical threads are shown on the shelves of the extension lines passed from the thread representation (Fig.10.11 and 10.12).

Metric thread may be completed as multistart. Below is an example of the designation of a multistart metric thread:

M24×6(P2) - three - start metric thread with the nominal diameter 24 mm, the pitch 2 mm, the lead 6mm.

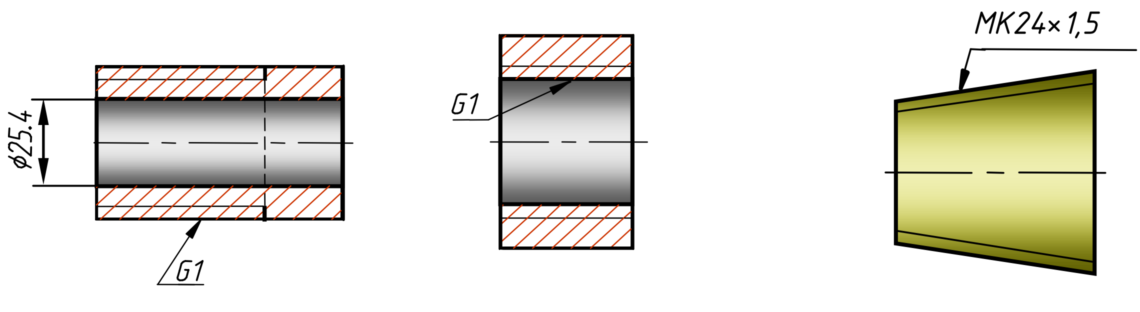
Inch (Whitworth) thread is standardised for fastening parts but, as a rule, is applied for manufacture of spare parts.

The profile of the inch thread is an isosceles triangle with the angle $\alpha=55°$.

The diameter is measured in inches, one inch (1″) is equal to 25.4 mm. Inch thread is evaluated in terms of the number of thread wraps (or threads of a screw) per an inch of its length.

When designating the inch thread, only its external diameter is shown (in inches). For example: inch thread of diameter d=1/2″ is designated 1/2″.

The Pipe cylindrical thread has a triangular profile with the angle $\alpha=55°$ and rounded-off crests and roots. Each size of the thread is evaluated in terms of a certain integrate number of pitches per one inch of its length, i.e. per 25.4 mm. The profiles of external and internal threads completely coincide, which guarantees hermetic sealing of threaded joints. Such a thread is applied in pipe joints, also in joining of an internal cylindrical thread with an external conical one. This thread's designation contains the letter *G*, specifying thread type and size. The size of thread is equal to the internal diameter of the pipe, on which this thread is cut. The external diameter is equal to the internal one of this pipe plus two dimensions of thickness of its wall. For example: *G1* reads that it is a pipe cylindrical thread cut on a pipe with the internal diameter 25.4 mm (i.e. 1 inch). The external diameter is 33.249 mm (Fig.10.11, a).



a b c

Fig.10.11

Designation of the thread in Fig.10.11, b reads: a pipe cylindrical thread of a hole into which a pipe of the internal diameter 25.4 mm (1inch) is screwed. Designation of the left-handed thread is completed with the letters *LH* placed after the thread dimension. Example: *GI1/2LH* – a pipe cylindrical thread, size *11/2″*, left-handed.

A metric conical thread with the angle α=60°, angle of taper 1:16 (the inclination angle of generatrices to the geometric axis of the cone 1°47′24″) and a nominal diameter from 6 to 60 mm is applied for the conical threaded joints and joints of the external conic thread with the internal cylindrical thread.

Designation: *MK24×1.5* (Fig.10.11, c)
For the left-handed thread: *MK24×1.5LH*
For the joints of the external conic thread with the internal cylindrical one:

M/MK24×1.5

Inch conical thread has a triangular profile with the angle α=60°. It is cut on the conical surfaces of parts with the angle of taper 1:16. Its designation is K and the conventional diameter in inches, e.g. *K11/2″*.

A pipe conical thread has a triangular profile with the angle α=55° and rounded-off crest. It is cut on the conical surfaces of parts with the angle of taper 1:16. Its dimensions on the principal plane correspond to the dimensions of the pipe cylindrical thread.

Its designation is: *R* - for the external thread, R_c - for the internal one, and the thread's size (conventional diameter in inches), e.g. *R1 1/2″* - a pipe external conical thread with the conventional diameter *1 1/2″* (Fig.10.12).

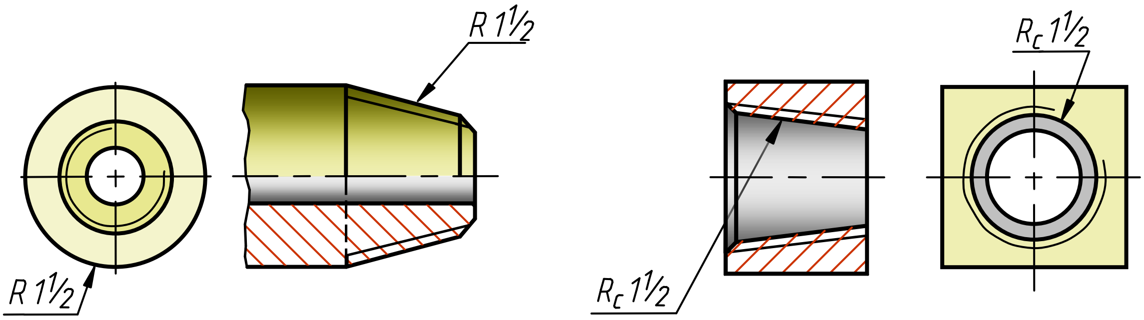


Fig.10.12

A trapezoidal single-start thread has the profile of an isosceles trapezoid with the angle, contained by the lateral sides, 30° (Fig.10.13, a). Each diameter is specified, as a rule, with three pitches. Designation: *Tr*, external diameter and pitch, e.g. *Tr 32 × 6* (Fig.10.13, b).

Designation of a *multistart trapezoidal thread*: *Tr*, nominal external thread diameter, numeric lead value, and in brackets the letter P for pitch and numeric pitch value. There is the sign x between the nominal diameter and the lead value, e.g. *Tr20×4(P2).* The letters LH are added for the left-handed thread: *Tr80×40(P10)LH*, *Tr32×6LH* (Fig.10.13, c).

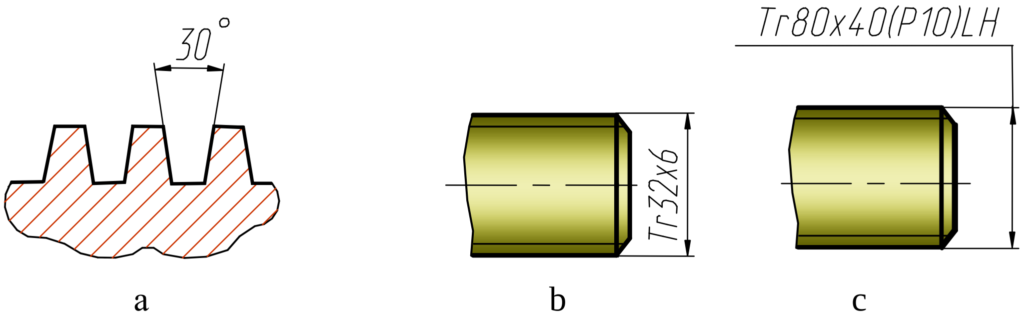


Fig.10.13

Buttress thread: profile of non-isosceles trapezoid with the angle of a working side 3°, non-working - 30° (Fig.10.14, a). The profile roots are rounded-off. Both, trapezoidal and buttress threads may have different pitches for one diameter.

Designation: *S*, nominal external diameter and pitch, e.g. *S50×8*. For the left-handed thread the letters *LH* are added: *S50×8LH*.

Designation for multistart thread: *S*, nominal external diameter, lead value and letter *P* in brackets with the pitch value, e.g. *S50×24(P8)* (Fig.10.14, c).

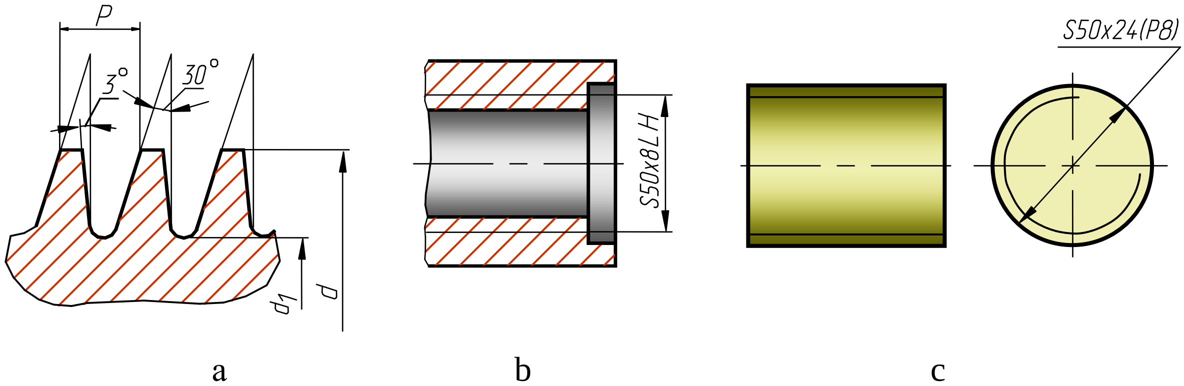


Fig.10.14

The *square thread* is applied to prevent self-unscrewing under loading. As the profile of this thread is not standardised, all data necessary for its manufacture must be shown on a drawing (Fig.10.15).

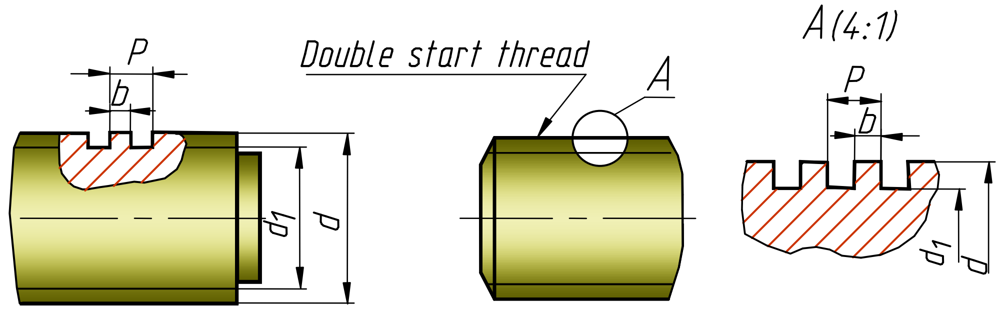


Fig.10.15

There are also the other types of standard threads for special purposes. Special threads are of two types:

1) with the standard profile and non-standard sizes of pitch or diameter. Designations of such threads include the letters *Sp* which means «special», the profile, dimensions of external diameter and pitch. Example: *SpM60*x*3.5* - special metric thread with the external diameter 60mm and fine non-standard pitch 3.5 mm

2) with non-standard profile. The profile of these threads is drawn to an increased scale as an extension element, and all dimensions and other data are placed on it. A square thread, for example, belongs to non-standard threads (Fig.10.15).

Table 10.1 presents designations of threads of different types.

Dimensions of Design and Technological Elements of Threads

Design and technological elements of threads (chamfers, tapers, tapping holes, turnings) are specified by concrete forms and dimensions. For most standardised threads they are determined in accordance with a thread pitch.

Turnings (grooves and recessings) are usually drawn simplified, but the drawing must be completed with an extension element. Fig.10.17 and 10.18 show an example of a representation of a turning, type 1, for the external and internal threads (dimensions in letters).

Conical chamfers on bodies and in holes with metric thread are shaped as a truncated cone with a crest angle 90° (Fig.10.16).

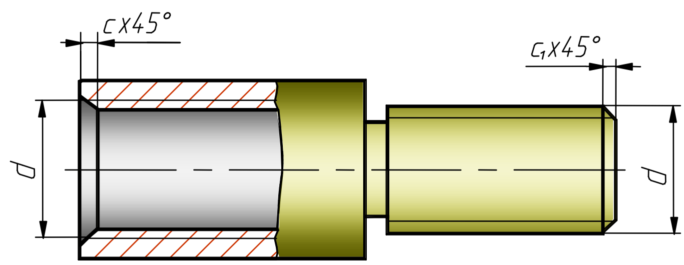


Fig.10.16

The designing and technological elements are often represented according to dimension relationships, but conforming to the standard regulations.

Thus, the following relationships are used for the metric thread with the pitch P (Fig.10.17 and 10.18):

The width of turnings for the metric thread with the pitch *P* is assumed to be equal to the length of the corresponding tapping hole, i.e. $b_e \approx 3P$ and $b_i \approx 4P$ (Fig.10.3, a, b). The diameter d_e of the external turning is drawn a bit shorter than the internal thread diameter d_i, likewise the diameter d_i of the internal turning - a bit longer than the external thread diameter.

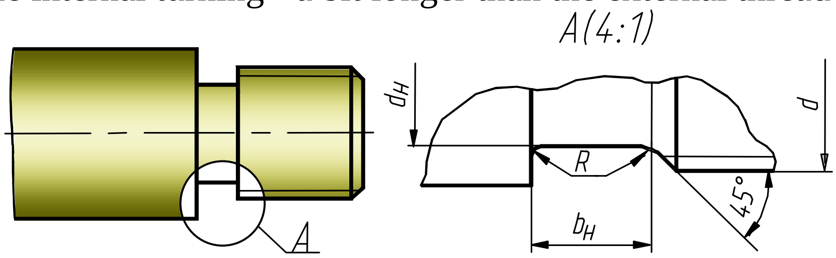


Fig.10.17

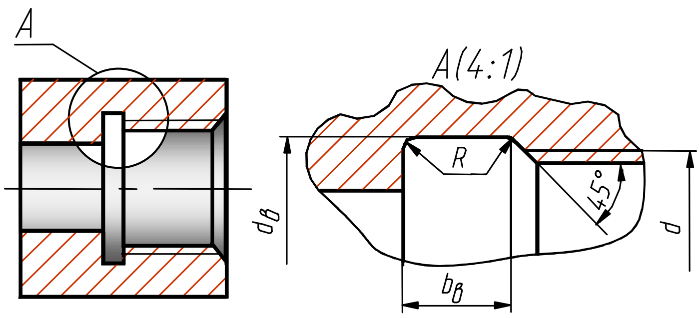


Fig.10.18

10.3 Threaded Products and Joints

Threaded joints are widely used in engineering. Usually they are divided into two types:

a) joints obtained by direct screwing of the parts being joined;

b) joints obtained by means of special joining details, such as bolts, screws, studs, fittings, etc.

The most wide spread threaded products are bolts, screws, studs, nuts and the like. All the products are standardised.

Bolts. A bolt is a cylindrical body with a head and a threaded end for a nut. Bolt heads are different in shape. According to the accuracy of manufacture, the bolts are classified as bolts of a normal, long and coarse accuracy rate.

The most frequently used bolts are the ones with a hexagonal head.

The hexagon bolts may have metric thread with the coarse or fine pitch. Fig. 10.19 presents three variants of representation of such a bolt:

* without a hole in shank or head;
* with a body hole for a pin;
* with two head holes for a wire lock.

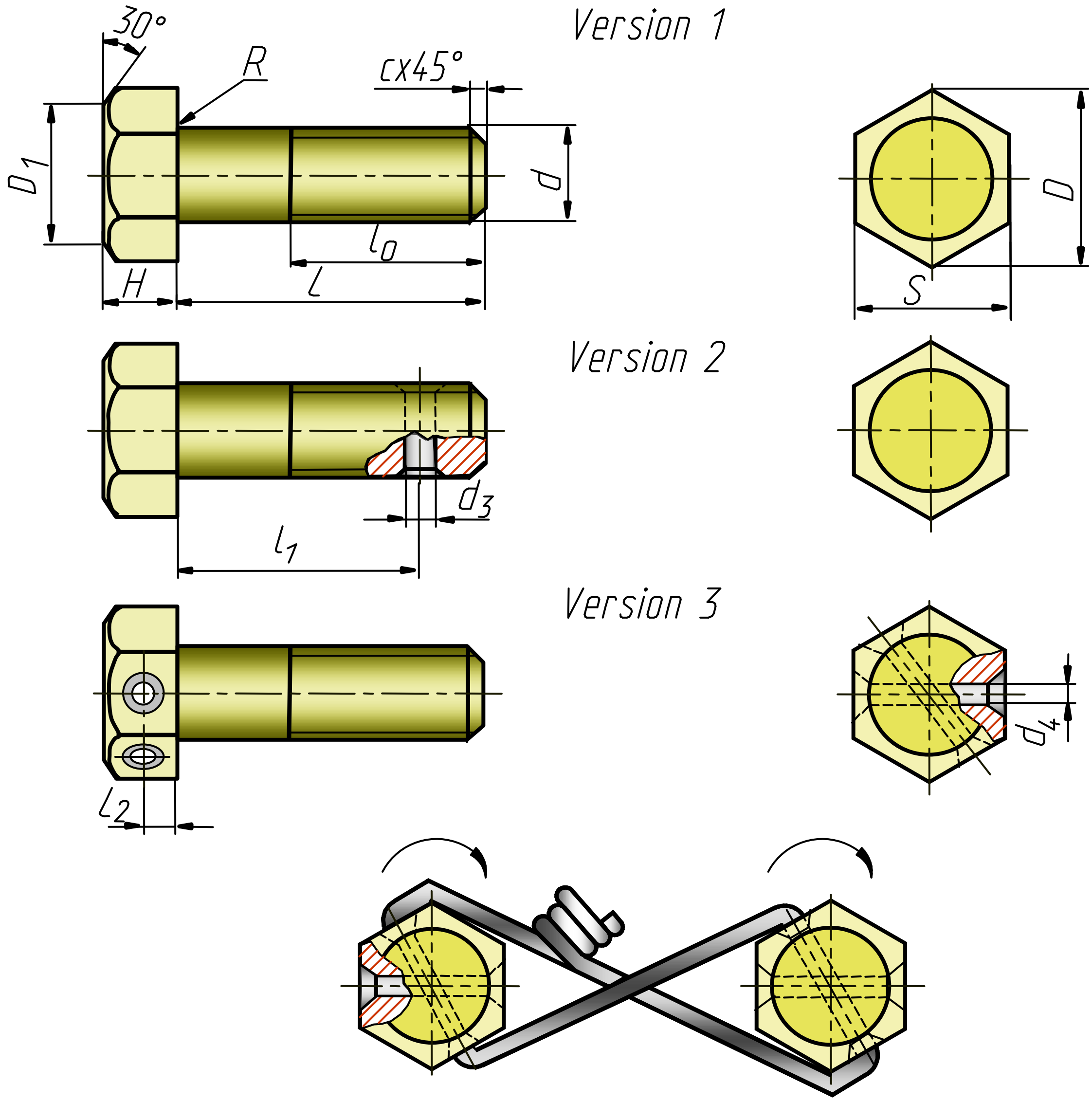


Fig.10.19

To strengthen the bolt, the so-called, fillet is produced - rounding-off of the radius *R*. The term ‘length of bolt’ means the length of the shank, dimension *l*. To avoid the thread’s face and to simplify screwing a nut on, the threaded bolt end is usually turned to a cone (the chamfer is removed).

An example of a bolt designation:

Bolt *M10×50* is a bolt of version I (the version is not to be shown in designations) with the metric thread of the diameter d=10 mm, with a coarse pitch (which is not to be shown in designations) and the bolt length l=50mm.

Screws. A screw is a cylindrical body with a head and a threaded end. Screws are divided into fastening and set screws (forcing, adjusting, etc). Fastening screws are classified as the screws for metal and those for wood or plastics (wood screws).

Fastening screws for metal work pieces are widely used in machine building (Fig.10.20). They are:

- round-head screw;
- button-head screw;
- countersunk screw;
- semicounter-sunk screw;

Round-head screws have one version of manufacture - with a straight slot.

Button-head, countersunk and semicounter-sunk screws have two versions of manufacture - with a straight and Philips slot.

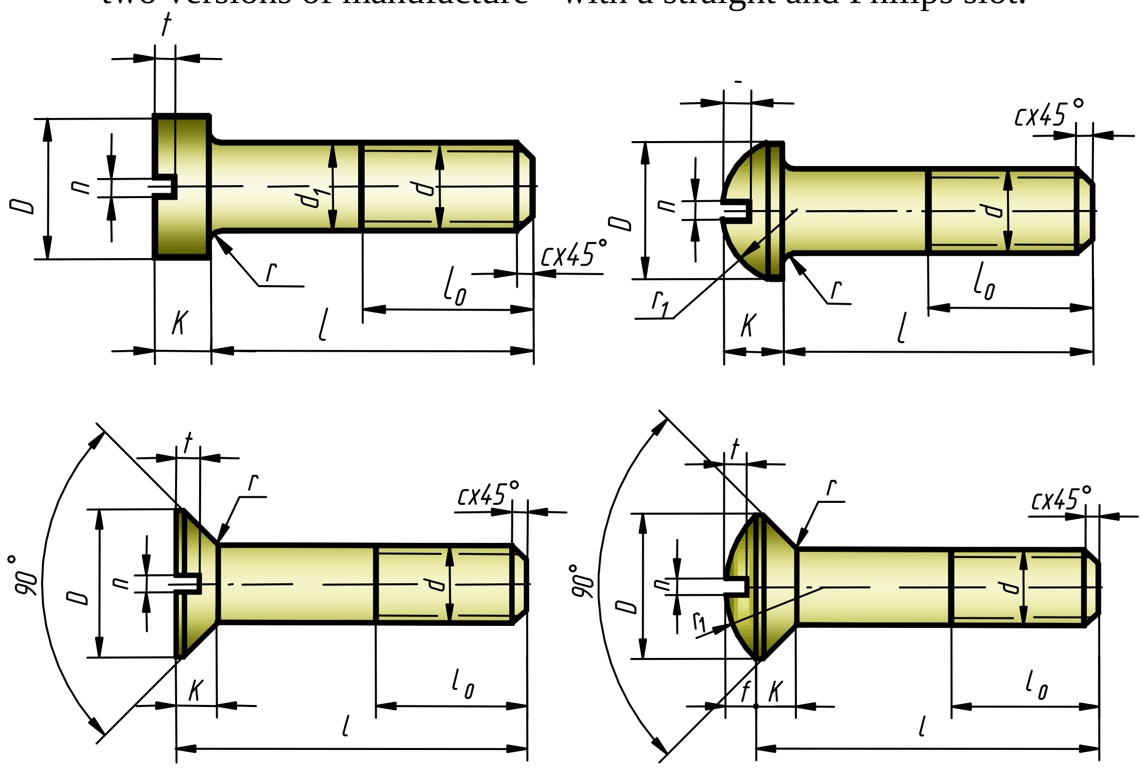


Fig.10.20

The length of the screw body is referred to as the screw length l. The length *l* of countersunk and semicounter-sunk screws includes the body length and the head height *K*.

Examples of designations:

Screw M10x50 - is a screw of version 1 (the version is not to be shown in designations) with the metric thread of diameter 10mm, with a coarse pitch (which is not to be shown in designations) and the screw length 50mm.

Screw 2M10x50, where

2 - version;
M- metric thread;
10- thread diameter in mm;
50- screw length in mm

Wood screws are the screws for fastening wooden and plastic parts, also for fastening the later with metal ones (Fig.10.21). They have a pointed body end and a special profile of thread.

There are four versions of manufacture of the button-head, countersunk and semicounter-sunk wood screws; and only one version of a hexagon wood screw.

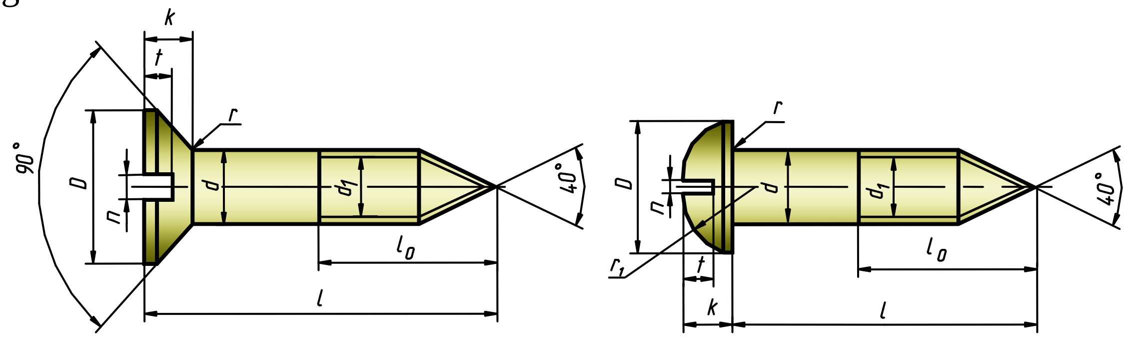


Fig.10.21

Designation example:
Wood screw 4 - 3x20,   where
4 - version;
3 - diameter in mm;
20- screw length in mm

Set screws are manufactured with different types of heads and points - flat-point, cone-point, cylinder-point screws, etc. (Fig.10.22). The designation is similar to that of fastening screws.

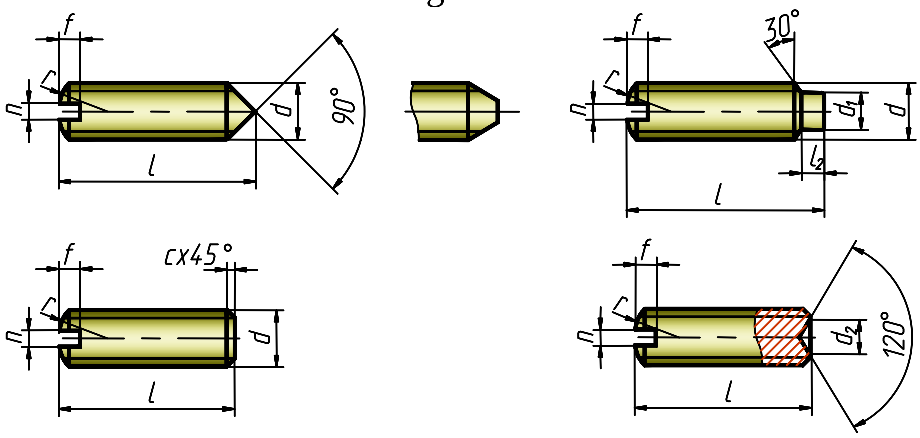


Fig.10.22

Studs. A stud is a fastening detail. It is a cylindrical body with two threaded ends (Fig.10.23). The design and dimensions of the studs are standardised. General-purpose studs are used for fastening parts with both, threaded and smooth holes. They are manufactured in two versions, two accuracy classes. The studs of version 2 have the body diameter d_1 approximately equal to the average thread diameter.

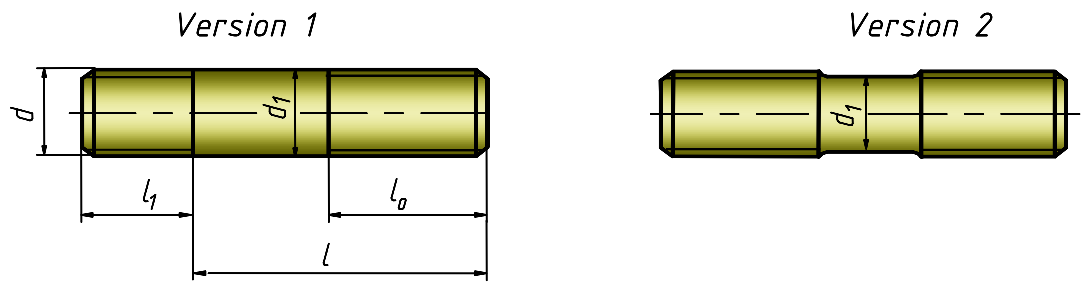


Fig.10.23

Designations of the stud elements:

d - nominal diameter of thread;

l - length of stud (length of tie end);

l_1 - length of driven threaded end;

d_1 - diameter of body;

l_0 - length of nut's end.

The length l_1 of the driven threaded end of a stud depends on the material of the part, the stud is driven into. If it is steel, brass or bronze, $l_1 = 1.25d$ or $l_1 = 1.6d$. If it is a fusible alloy, $l_1 = 2d$ or $l_1 = 2.5d$.

It is permissible to manufacture the stud with different pitches of the ends.

Designation Examples:

* *Stud M20*x*150* - is a stud of version I (the version is not to be shown in designations) with the thread diameter 20 mm, with a coarse pitch p=2.5 mm, and the length l=150 mm.

$$StudM\,20 \times \frac{1.5}{2.5} \times 160,$$

this is a stud of version I with the thread diameter d=20 mm, with a fine pitch p=1.5 mm on the driven in end and with a coarse pitch p=2.5 mm on the nut's end, and the length l=160 mm.

Nut. A nut is a detail with a threaded hole, which is screwed on a bolt or a stud to join two or more pieces together securely but not permanently. The nuts are classified according to:

* the surface shape;
* the way of manufacture;
* the accuracy of manufacture.

Depending on the surface shape, the nuts may be hexagon (Fig.10.24, a), round, wing (butterfly) (Fig.10.24, b), castle and slotted, which are used on bolted joints of version 2 (Fig.10.24, c), square and the like.

The most popular are the hexagon nuts, the accuracy rating B, A, C (normal, long and coarse precision). The accuracy rating specifies the surface finish class. The nuts of the A and B accuracy classes have metric thread with coarse or fine pitch, where as the nut of the C class has the thread with the coarse pitch.

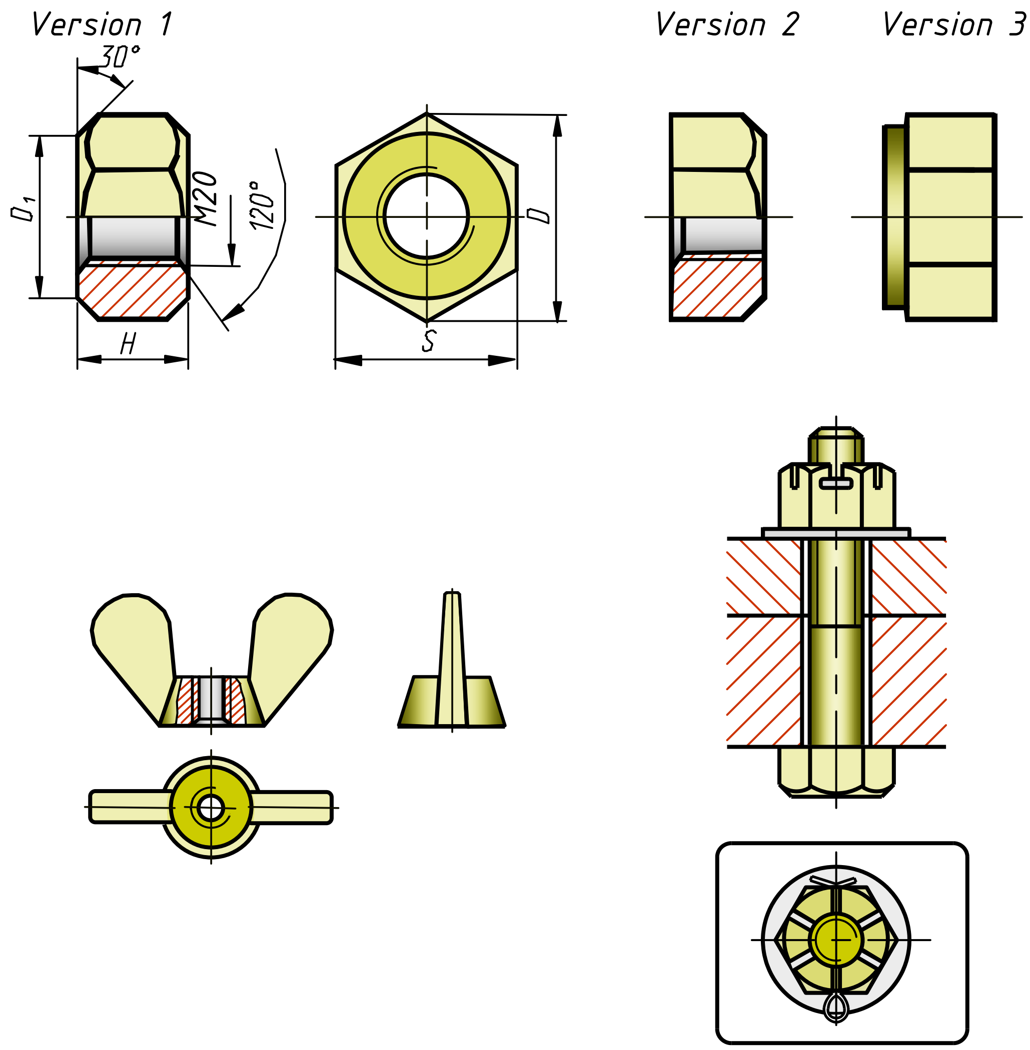
The hexagon nuts are divided into common (Fig.10.24, a), slotted and castle, normal, thin, thick and especially thick.

There are three versions of the hexagon nuts: a

Version 1 - with two external conical chamfers;

Version 2 - with one external conical chamfer;

Version 3 - with a cylindrical or conical flange on one end face, no external chamfers. The nuts of version 3 may be only of the accuracy rate B and C.



b

c

Fig.10.24

The choice of the nut type depends on its application and operational conditions. Thick and especially thick nuts are used, if the threaded joint is often disassembled during operation, or if it is subjected to a large axial force. When the axial forces are not significant, thin nuts are used.

For the joints subjected to vibrations, the slotted and castle nuts with pins are used (Fig.10.24, b).

Designations:

Nut M16 – a nut of version 1, the thread diameter is 16 mm, coarse pitch of thread.

Nut 2M16×1,5 – a nut of version 2, the thread diameter is 16 mm, with a fine pitch 1,5 mm.

Washers. The washer is usually placed between a nut and a detail surface to increase the supporting surface and protect the detail from damage when a nut is tightened, also to exclude the possibility of self-unscrewing of the fastening parts. The washers are classified as round (Fig.10.25), spring (Fig.10.26), oblique (Fig.10.27), lock (Fig.10.28), etc.

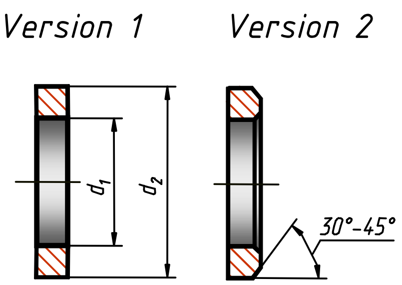


Fig.10.25

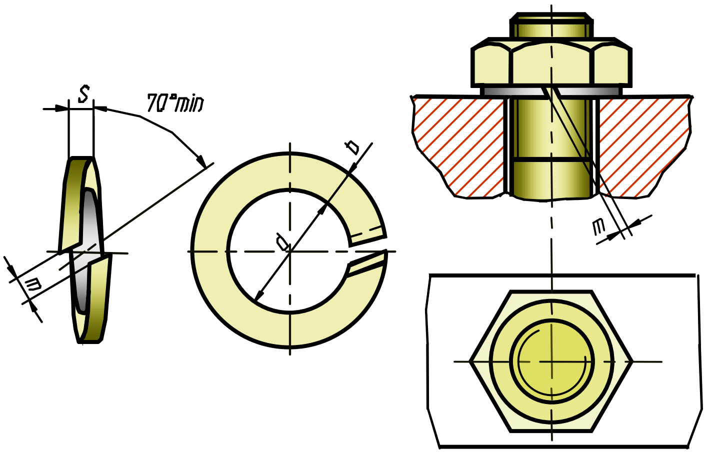


Fig.10.26

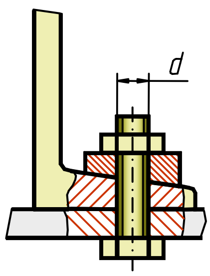


Fig.10.27

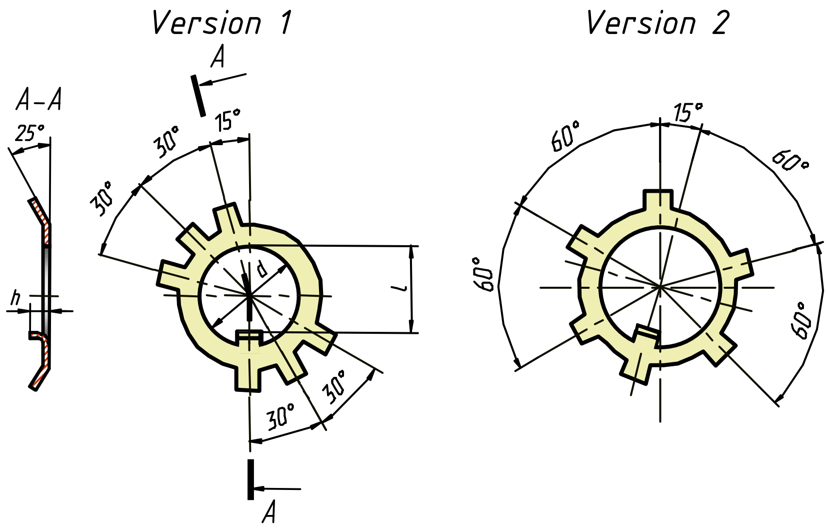


Fig.10.28

Round washers may be normal, large and small. There are two versions of normal washers: version 1 without a chamfer, version 2 with chamfer (Fig.10.25). Their dimensions correspond to the fastening parts with the thread from 1 to 48 mm.

An example of designations for a washer of version 1 intended for a fastening part with the diameter 12 mm:

Washer 12.

For a similar washer but of version 2:

Washer 2.12

Spring washers prevent the loosening of nuts in joints subjected to vibrations and kicks (Fig.10.26).

Spring washers are divided into the following types: light (L), normal (N), hard (H) and especially hard (EH). The designation of spring washers contains the above letters (except N), which are placed after the diameter of the fastening part.

For example: Washer 12L - it means that the spring washer is light, version 1, produced for a fastening part of diameter 12 mm.

Threaded joints for pipes. Any pipe-line consists of pipes and special joining parts called fittings.

The principal parameter for pipes and fittings is the nominal bore D_n, which is approximately equal to the internal nominal diameter of the pipe. Nominal bores are standardised. If it is necessary, the pipes may be completed with couplings.

Designations: "Pipe", coupling and coating (if available), nominal diameter, metric length, designation of standard.

If the pipes are strengthened or, vice visa, light, the corresponding letters S or L are added to the designations after the word 'Pipe'. The pipes of long precision are marked with the letter P placed after the nominal bore.

Examples:

1. The common pipe of normal precision, with the nominal bore 40mm, non-metric length, the wall thickness is 3,5 mm, no thread, no coupling:

Pipe 40 × 3,5

2. The same but with a coupling:

Pipe M–40 × 3,5

3. The same but of metric length 8 m, with thread:

Pipe P–40 × 3,5 – 8000.

The fittings provide the opportunity to join several pipes, to make branches at different angles, to change from one diameter to another and so on.

To obtain the required stiffness of the fittings, they are manufactured with beads; the couplings - with several lateral ribs. Fig.10.29, b shows a right short coupling, Fig.10.29, c - a right elbow, Fig.10.29, d - a right T-joint.

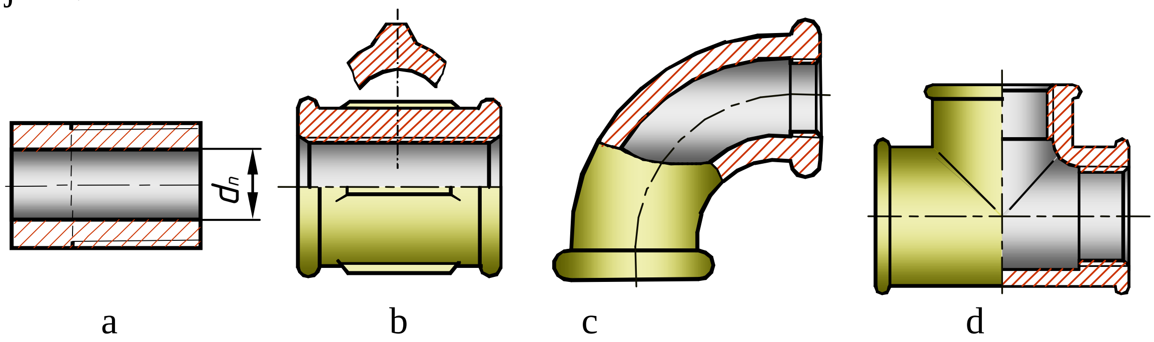


Fig.10.29

The designations of fittings include their names, the nominal bore in mm, the number of standard.

Examples:

Coupling short 40 - a short coupling for a pipe with D_n=40 mm.

Elbow 40 - an elbow for a pipe with D_n=40 mm.

If a coupling is used for joining pipes of different diameters, both diameters are designated:

Coupling 32 x 25 - a transition coupling, no coating, for the pipes of D_n=32 mm and D_n=25 mm

Representation of Detachable Threaded Joints

The fastening parts of joints are represented by one of the following methods: *constructive, simplified or conventional.*

By the constructive method the parts are represented with all details and nominal dimensions taken from the corresponding standards. In training practice it is permitted to complete a constructive drawing of the fastening threaded parts according to the conventional relations of dimensions.

The choice of representation depends on the purpose and scale of the drawing. If the drawing is to a significantly large scale, and the representations of bolted, screw or stud joints are not very small, they are drawn simplified. If the diameters of fastening parts in the drawing are 2mm or less (a reduced scale), the conventional method is used.

There are the following peculiarities of simplified representations of the fastening parts:

a) dimensions for drawing are determined by conventional relations depending on the external thread diameter d;

b) chamfers on shank ends of bolts, screws, studs and fillets, as well as chamfers on nuts, bolt heads and washers are not drawn;

c) thread is conventionally shown along the whole length of bolt (screw, stud) shank;

d) internal thread diameter is assumed to be 0.85d;

e) thread of bolt or stud on the end elevation is not shown;

f) clearance between a bolt, stud, screw and the hole wall of a fastened part (parts) is not represented;

g) thread boundary of the full profile in a blind hole is not shown on a sectional view, and the thread is conventionally drawn up to the hole bottom which is represented flat on the level of the screw body end face;

h) on the elevations, obtained by projecting on the plane parallel to the screw axis the screwdriver slot is drawn along the screw axis with a line 2s thick. On the elevations, obtained by projecting on the plane perpendicular to the screw axis, the slot is drawn at 45° to the drawing frame, also with a line 2s thick. If, in this case, the slot coincides with the centre line or is close to it, it is drawn at 45° to the centre line (Fig.10.30);

j) when drawing hexagonal nuts and bolt heads, situated on flanges, plugs and similar details, their biggest dimension is to be coincided with the radial centre line. It is convenient for drawing hexagons with compasses (Fig.10.31).

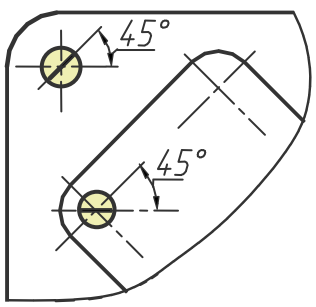


Fig.10.30

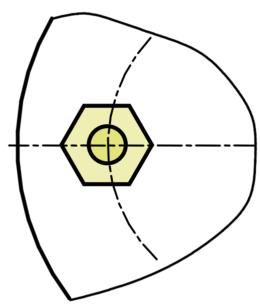
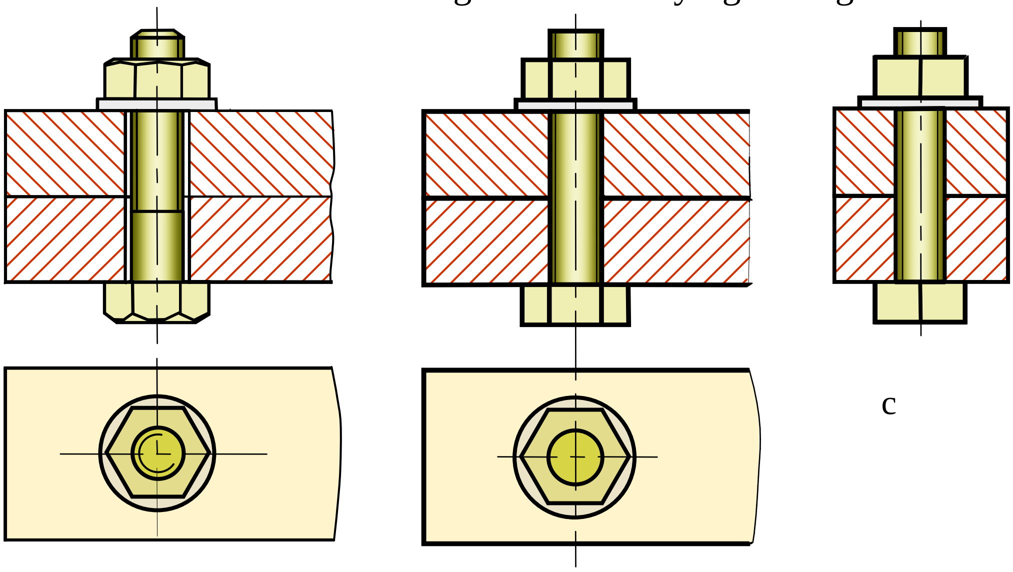


Fig.10.31

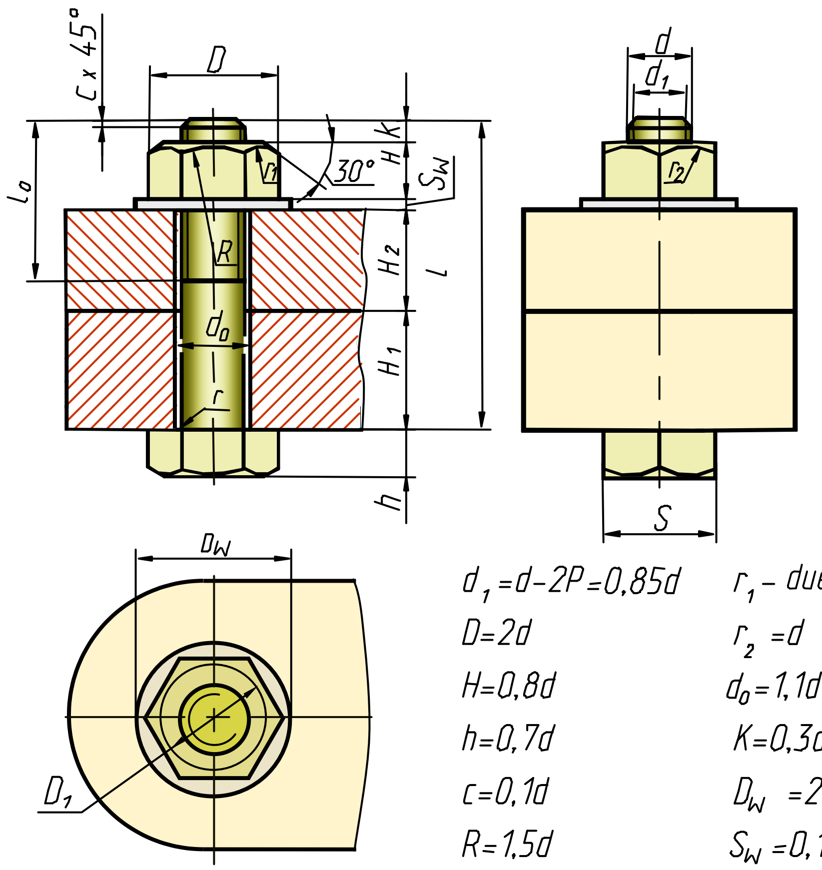
Bolted Joints

There usually must be a clearance between a bolt and the bottom of the hole the bolt is driven in. Joining is obtained by tightening a nut.



a

c



b

$d_1 = d - 2P = 0,85d$ — r_1 – due to construction

$D = 2d$ — $r_2 = d$

$H = 0,8d$ — $d_0 = 1,1d$

$h = 0,7d$ — $K = 0,3d$

$c = 0,1d$ — $D_W = 2,2d$

$R = 1,5d$ — $S_W = 0,15d$

$r = c$ — $S = 1,7d$

$l_o = 2d + 6$ мм — $D_1 = (0,9 - 0,95)S$

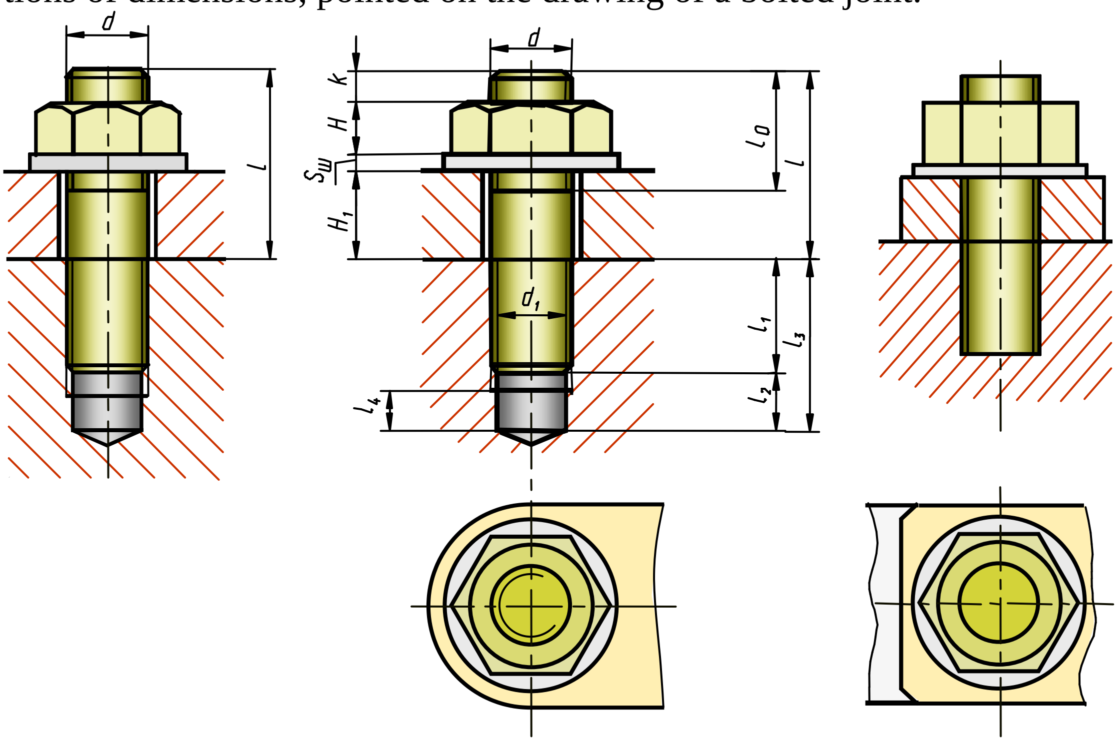
Fig.10.32

Fig.10.32, a shows a constructive representation of a bolted joint. The bolt, the nut and the washer are drawn according to the nominal dimensions taken from the corresponding standards. Fig.10.32, b presents a constructive representation of the above bolted joint according to the conventional relations of dimensions, pointed on the drawing. Fig.10.32, c contains a simplified representation of the same joint, drawn according to the conventional relations of dimensions, too.

In the conventional relationship the external thread diameter d of a bolt is assumed to be the principal one. The length of the bolt is determined in accordance with the sum of thickness' (H_1+H_2) of the joined parts, washer thickness *S*, nut height H and the value K of the minimal bolt protrusion past the nut. Compare the total shank length thus obtained with the data of the corresponding standard and take the closest larger standard length.

Stud Joints

Fig.10.33, a shows a constructive representation of joining by a stud, a nut and a washer, which are drawn according to the true dimensions taken from the corresponding standards. Fig.10.33, b presents a constructive representation of the above joint according to the conventional relations of dimensions, pointed on the drawing of a bolted joint.



a b c

Fig.10.33

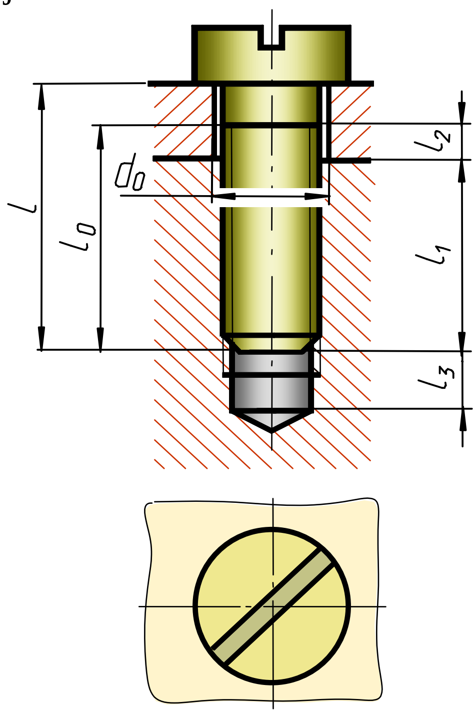
The seat depth is determined due to the formula l_3=l_1+l_2, where l_1=d - for steel, l_1=$1.25d$ - for cast iron, l_1=$2d$ - for aluminium, and l_2=$6P$, where P - pitch of thread, $l_4=4P$. When drawing a constructive representation of a stud joint, the boundary line of the thread of the screwed-in end is conventionally coincided with the line of the parts' detachment. In the upper part of the blind hole, occupied by the stud, the lines of the hole thread change for the lines of the stud thread. The outline generatrices of the hole cone must be spaced from the base-lines of the cylindrical hole. The hatching lines in the section are passed up to the base-lines of the thread on the stud and in the seat.

Fig.10.33, c presents a simplified representation of a stud joint, which is also drawn according to conventional relationships.

If stud length *l* is determined to be similar to that of the bolt, then it is correlated with the standards and the closest value is to be chosen.

Screw Joints

A screw joint is applied for joining together two or more parts. The screws are driven into the basic part. A hole for a screw may be blind or through. The characteristic dimensions of the joint are the thickness of the parts joined and the diameter of the screw shank.



a

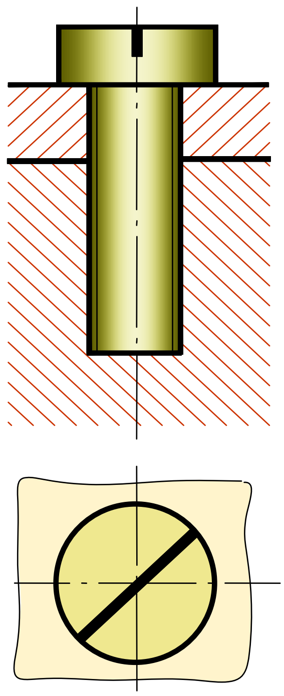

b

Fig.10.34

The depth of driving screws and studs into similar material is approximately the same. Sizes of screws, their thread diameters and the form of heads are taken from the corresponding standards, subject to the designated purpose of the joined parts.

Fig.10.34, a shows a constructive representation of a screw joint with a cylindrical head, drawn according to the nominal dimensions taken from the corresponding standards, and Fig.10.34, b – a simplified representation of this joint. When determining dimensions according to conventional relations, proceeding from the external thread diameter d, assume that:

d_0=1,1d
l_1=d - for steel
l_1=1,25d - for cast-iron;
l_1=2d - for aluminium;
l_2=(0,3-0,5)d;
l_3=(0,5…1)d;
l_0 and l are selected from standards.

In the constructive representation a clearance between a screw and a hole is to be shown, also an end of a blind screw hole. Unlike the stud joint, the boundary line of thread on the screw must be 2...3 pitches higher than the line of the parts' detachment. Otherwise, it will be impossible to tighten the details joined.

10.4. Keyed and Splined Joints

Keys are applied to transmit the torque from one part (shaft) to another (gear-wheel).

The most frequently used keys are: sunk, tapered and Woodruf (semicircular).

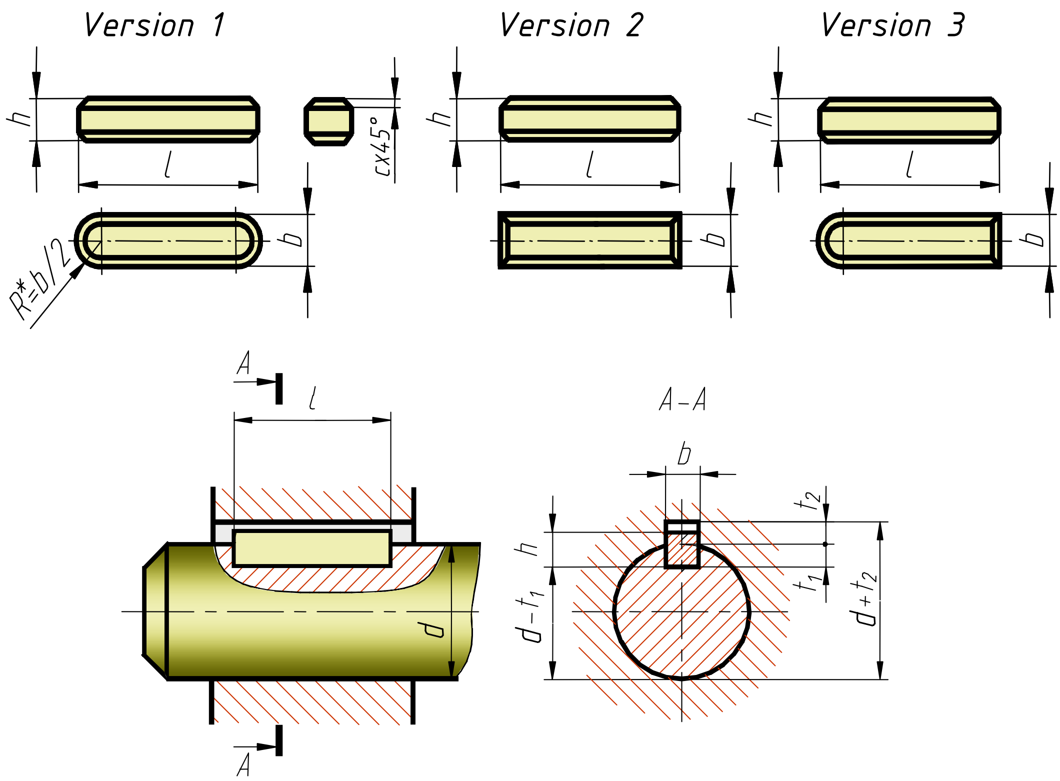


Fig.10.35

Sunk keys may be common and direct.

Tapered keys are manufactured with a head and without it.

Sunk keys are manufactured in three versions (Fig.10.35). The lateral faces of these keys are working, there is a clearance above the upper one.

A key section depends on shaft diameter, length - on transmission torque and the design peculiarities of the joint.

In the general case, designations of sunk keys include the word “Key”, version (except the first one), the parameters *b* x *h* x *l* and key standards.

e.g. Key 2 - 18×11×100, where
2 - version (except version1);
18 - width *b*;
11 - height *h*;
100 - length *l*.

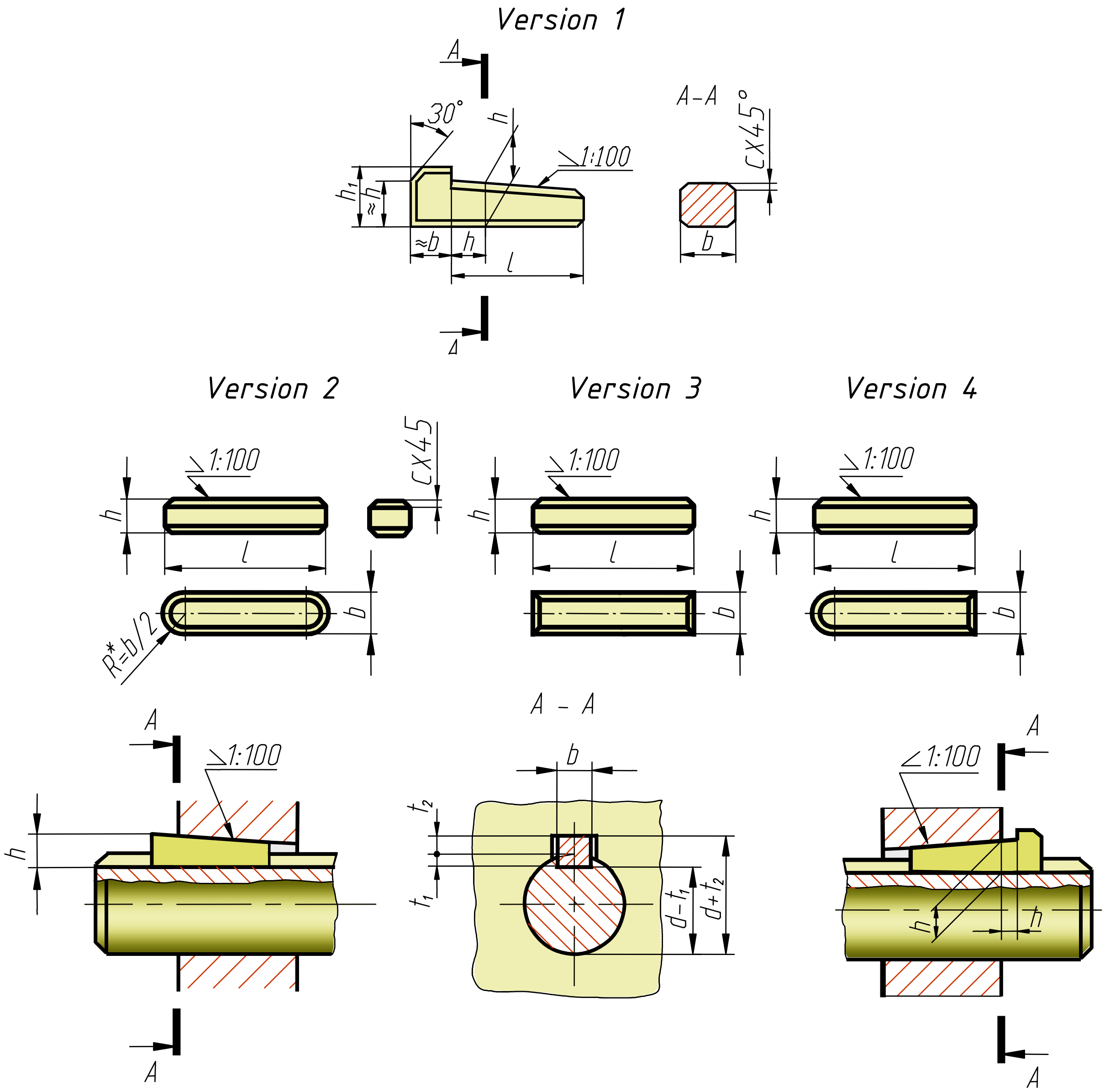


Fig.10.36

Tapered keys are manufactured in 4 versions (Fig.10.36). They are used in slow devices. Their working surfaces are the upper and the lower faces. There are clearances between the key lateral faces and the slot.

Designation is similar to that of the sunk keys.

Key 4 -18x11x100, where
4 - version;
18 - key width;
11 - key height;
100 - key length.

Woodruf keys have two versions (Fig.10.37). They are used for transmitting small torque (as the deep slot weakens the shaft) and at the ends of shafts with small diameters (d⩽55 mm).

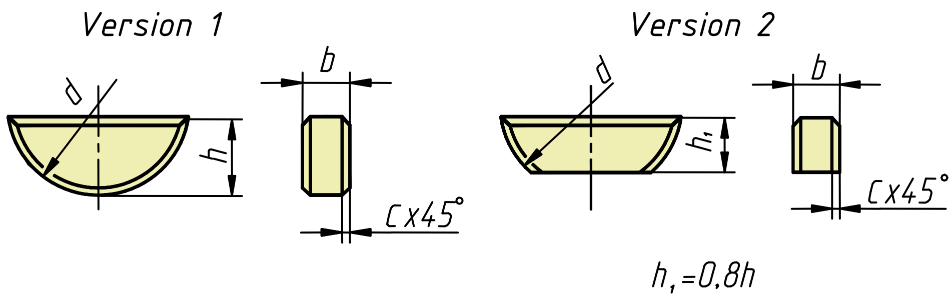


Fig.10.37

Designation:

Key5x6.5, where
5 - width, 6.5 - height of the key (version 1).

Fig.10.38 presents the examples of dimensioning key slots.

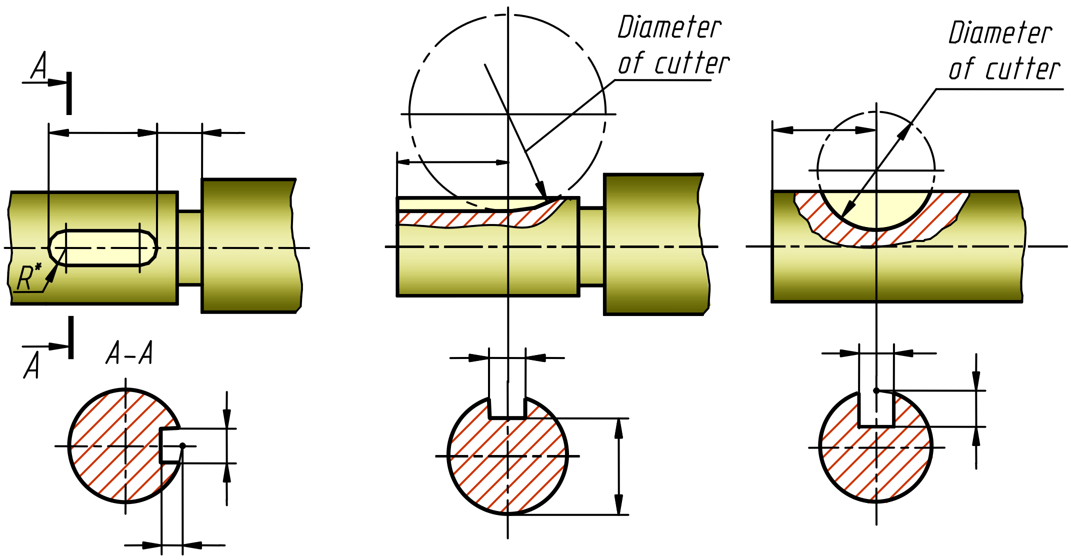
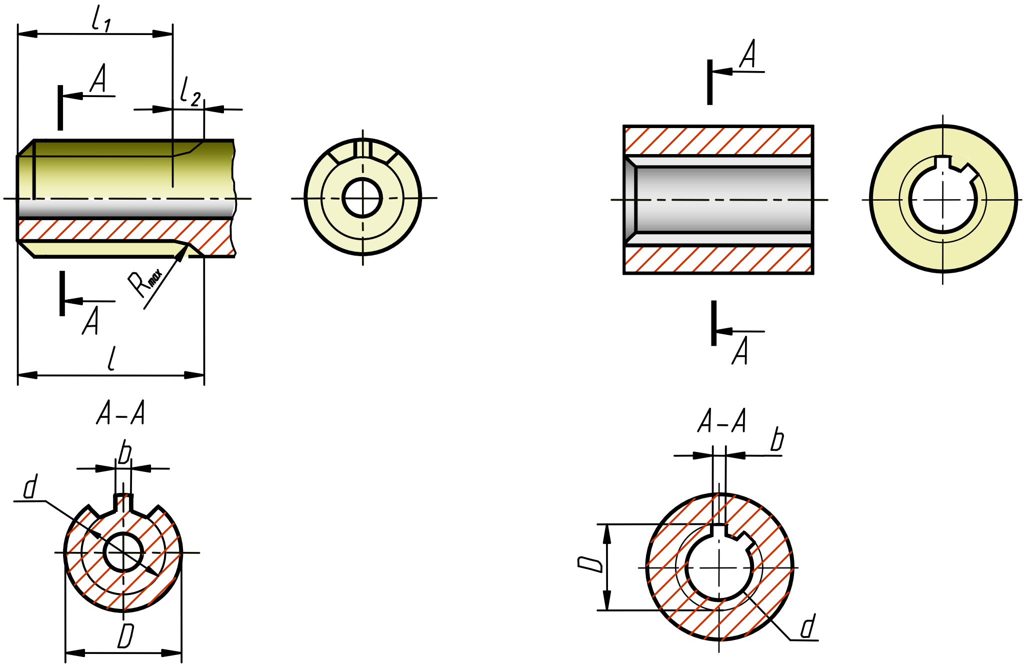


Fig.10.38

Splined joints. These joints are called multikeyed the keys in such joints are made as a single whole with the shaft, which allows to transmit larger torque in comparison with key joints.

The splined joints are manufactured with teeth (protrusions) of a rectangular, involute and triangular form. The teeth (protrusions) of the joint enter into the corresponding tooth spaces of the same profile of the joined part.

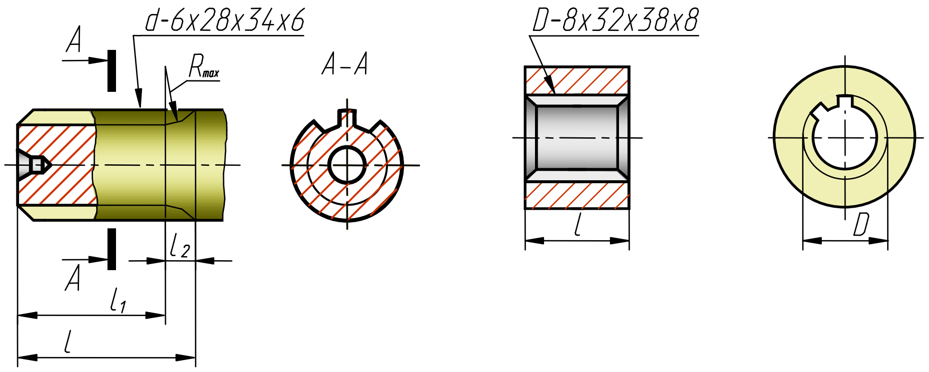


a b

Fig.10.39

The most popular are the splined joints with a rectangular profile of teeth. The rectangular splined joints differ in the method of alignment of the hub relative to the shaft, which is made by the external diameter D, by the internal diameter d or by the lateral faces b (Fig.10.39).

The tooth surfaces of shafts and holes on drawings are represented simplified. Particularly, the circles and generating surfaces of protrusions are drawn with the continuous base-lines, the circles of tooth spaces - with the continuous thin lines (Fig.10.39, a). On the lengthwise (axis) section the surface of the tooth spaces and crests is shown with the continuous base-lines. Note: the splines on the shaft are conventionally shown not cut (Fig.10.39). On the lateral section the circle of roots is drawn with the continuous thin line. On the representations obtained by projecting onto the plane, perpendicular to the axis of the shaft or the hole, the profile of one tooth (protrusion) and two roots without chamfers, slots and round-offs is shown. The boundary of the tooth surface and the boundary between the teeth of full profile and the tapering are shown with the continuous thin line. The teeth length of the full profile l_1 up to the tapering is printed on the drawing. It is also permitted to print the full teeth length l or the longest radius R_{max} of a device or the tapering length l_2 (Fig.10.40, a). On the lengthwise section of a tooth joint that surface part of the hole protrusions, which is not covered by the shaft is shown (Fig.10.41).



a b

Fig.10.40

The designation of the splined joint is subject to the method of alignment:

a) alignment by the internal diameter d (Fig.10.40, a):

d –6×28×34×6, where d – the way of alignment, 6 – number of teeth; 28 – internal diameter; 34 – external diameter; 6 – tooth width;

b) alignment by the external diameter D (Fig.10.40, b):

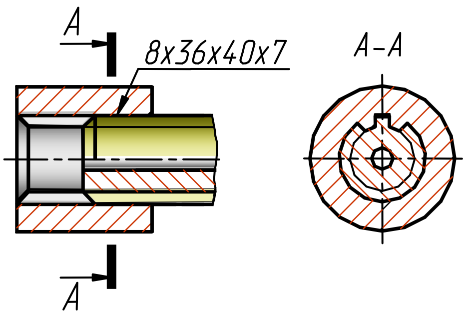


Fig. 10.41

D – 8×32×38×8, where D – the way of alignment, 8 – number of teeth; 32 – internal diameter; 38 - external diameter; 8 - tooth width.

On training drawings it is usually enough to show the number of teeth, dimensions of internal and external diameters and tooth width: 8×36×40×7 (Fig.10.41).

10.5 Permanent Joints.

Welded, Soldered and Adhesive Joints

The permanent welded, soldered (or brazed) and adhesive joints are applied in technological equipment, electronic devices, radio, computation technique, apparatus of automatics and TV mechanics. There are a lot of them and they are quite different. So, let us consider only some of them.

Representation and Designation of Welds

Independent of welding method, all welds are conventionally drawn in the following way: *visible* - with the continuous base-line, s thick; *invisible* - with short dashes, s thick (Fig.10.42).

The conventional representation of visible solitary welded points, independent of the method of welding, is the symbol "+", drawn with continuous base-lines. Invisible solitary points are not showed.

In Russia to designate the locus of a joint weld, the extension line with a single-sided arrowhead is used, drawn with the continuous thin line, s/2…s/3 thick (Fig.10.42). The recommended inclination of this extension line to the weld is 30°…60°. The horizontal shelf of this line is of the same thickness. If it is necessary, the extension line may be broken. It is preferable to pass it from the representation of a visible weld.

The ISO standards of the weld designation on a drawing differ from Russian. They are as follows:

The *elementary designations*, reminding the form of welds, are used to characterise different kinds of welded joints (see Table 10.3).

Designation of a weld on a drawing is made by means of a line with an arrow, pointing to the joint (the arrow must contact the weld), the shelf of an extension line with the weld convention on it, including a certain number of dimensions and symbols. The arrow locus relative to the weld is, usually, of no importance. However, the arrow of welded joints 4, 6, 8 (Table 10.3) must be directed to the bevel (Fig.10.43).

When applying the E-method of projection, depending on the arrow locus, the weld designation is placed on the shelf, if the extension line is passed on the face of a weld (Fig.10.42, a), and under the shelf, if the extension line is passed on the back of a weld (Fig.10.42, b).

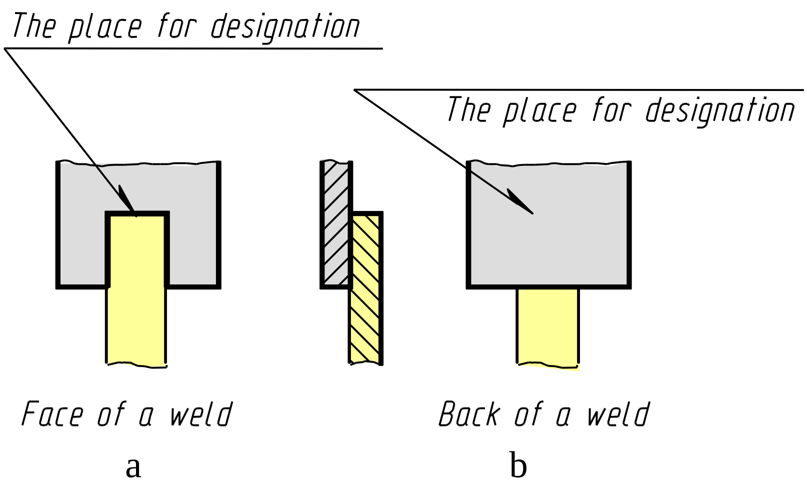
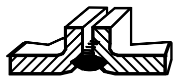
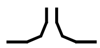
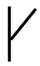
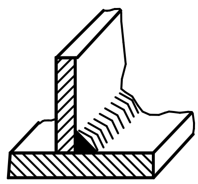
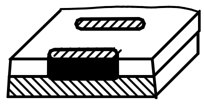
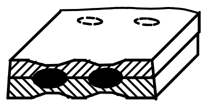
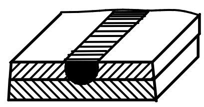
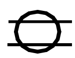


Fig.10.42

Table 10.3

N°N°	Item	Illustration	Designation
1	Flange (butt) weld, flanged edges are completely melted		
2	Nonbevel-butt weld		
3	V-double bevel-butt-weld		
4	V-single bevel-butt-weld		
5	V-double bevel-butt-weld, wide root face		
6	V-single bevel-butt-weld, wide root face		
7	V-double bevel-butt-weld, sigle-sided curvature		
8	V-single bevel-butt-weld, single-sided curvature		
9	Back-up weld, back-up plate (USA)		
10	Fillet weld		
11	Slot weld		
12	Spotted weld		
13	Seam weld		

When applying the A-method, the weld designation is placed under the shelf, if the surface of weld is located on the arrow side, and above the shelf, if the surface of weld is on the reverse side (Fig.10.43).

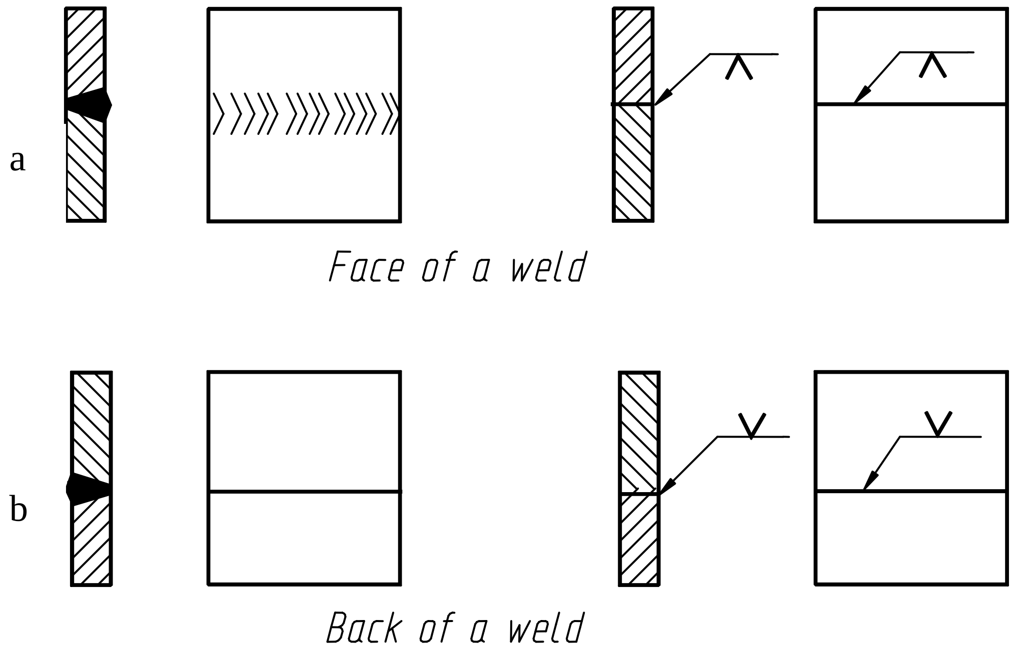


Fig.10.43

Soldered and Adhesive Joints

Soldered and brazed joints are obtained by joining the metal parts with melted metal (solder), the melting point of which is lower than the melting point of the details joined. Soldering is used for hermetic joining, to produce a coating inhibiting corrosion (tin-plating), when fastening parts under small load, etc. Sometimes soldering is better than welding, for example, it is widely used in radio electronics and instrument making.

There is a great number of soldering methods, for example (according to the heating source): with a soldering iron (the simplest method), torch brazing, by metal dip brazing, laser and others.

The solders are:

* according to the melting point - fine solder (up to 145°C), quick solder (up to 450°C), medium (up to 1100°C), hard (above 1850°C);
* according to the basic component - pewter solder (PS), pewter-lead solder (PLS); brazing spelter (BS), copper-zinc (brass) solder (BS), silver solder (SS), etc.

The solders are manufactured as wire, bars, sticks, etc.

The solders' designations:

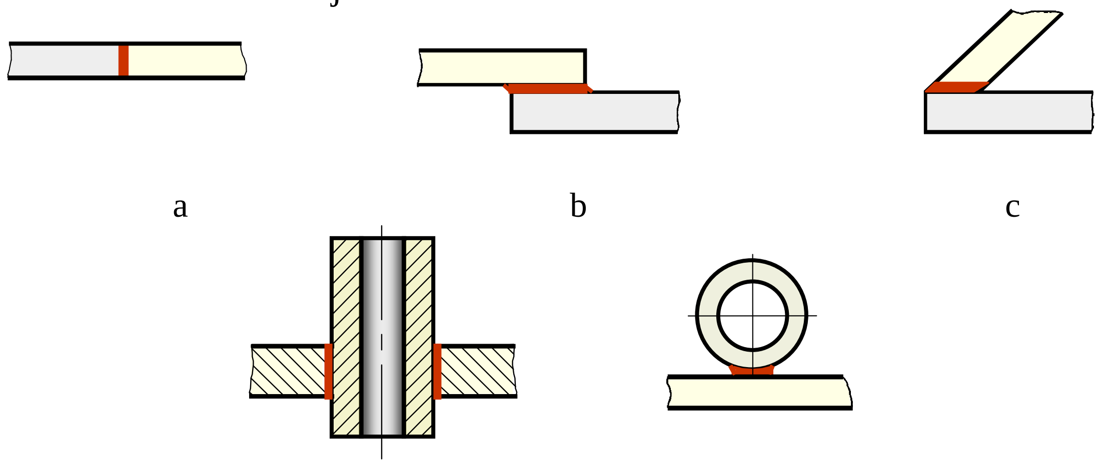
PLS40 (no range of products) where 40 - percentage of tin (the rest is lead)

Solder SS70 - 70% of silver, 26% of copper, 4% of zinc

The solder PLS40 is a soft solder, SS70 is a hard one.

The solder joints (Fig.10.44) are divided into:

- butt joints;
- lap joints;
- fillet joints;
- tee joints (T-joint);
- contact joints.



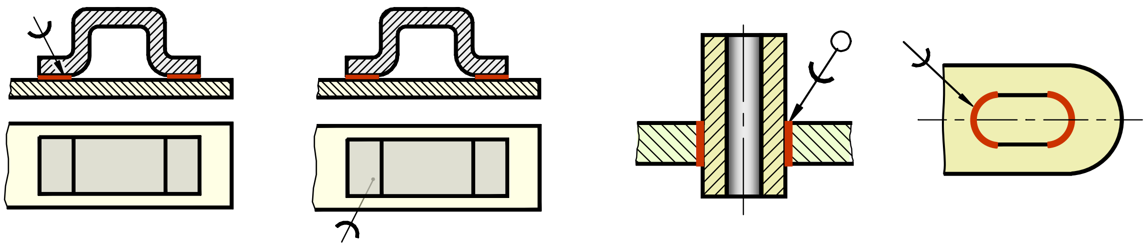
a b c

d e

Fig.10.44

Independent of the method of soldering, the joints on sections and sectional views are drawn with a continuous line, 2s thick (Fig.10.45). The convention of soldering (semicircle) is placed on an extension line (drawn with a thin line and started from the joint representation with a double-sided arrow). The semicircle is drawn with a base-line.

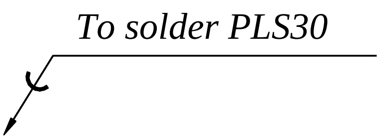
If the joint is produced along a closed line, it is designated with the symbol ○ (circle of diameter 3…5 mm).



a b c d

Fig.10.45

The type of joint is printed on the shelf of the extension line in sketches and technical projects, sometimes in working engineering papers, too. For example:



The adhesive joints are obtained by means of glues of different compositions. This method of joining wooden, plastic and metal products is widely used in production. There are the cases when the adhesive joint is the only one possible, e.g. when joining plastic parts.

The designation rules are similar to those of the soldering joints, described above, only the symbol of soldering is changed for the symbol of adhesion (Fig.10.46).

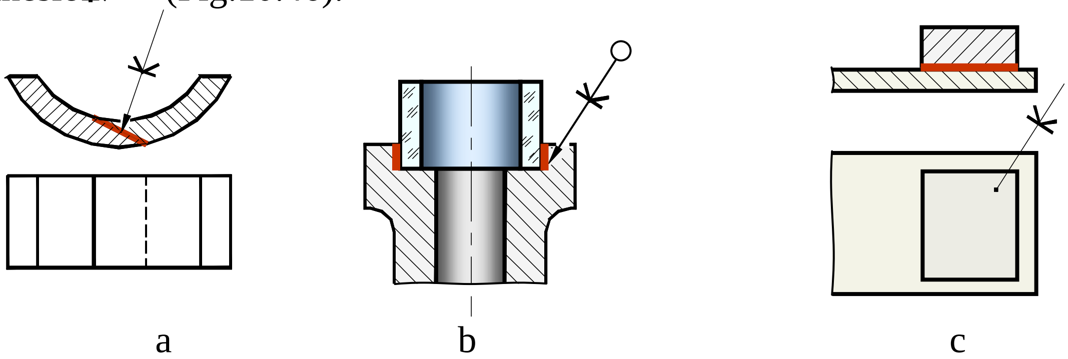


Fig.10.46

Designation of an adhesive substance is printed in the technical notes, in the simplest cases - on shelf of the extension line.

Questions to Chapter 10

1. What is thread?
2. What are the characteristic parameters of thread?
3. What is referred to as the thread profile?
4. What is pitch, lead of thread? How are they related?
5. What is the basic difference between the metric and pipe threads, between trapezoidal and buttress threads?
6. How is thread representation on the shank and in the hole on the elevations obtained by projecting onto the planes, parallel and perpendicular to the axis of shank and hole?
7. How is thread drawn in joints?
8. In what cases and in what way is the thread profile drawn?
9. What data (in what sequence) are printed in standard threads' designations in the general case?
10. What is "right-hand" ("left-hand") thread? How are these terms shown in thread designation?
11. What is the difference between designations of threads with coarse and fine pitch?
12. What are the peculiarities of the pipe thread designation?
13. In what cases are the letters "Sp" present in thread designation, what does it mean?
14. Discuss detachable and permanent joints. Give examples.
15. What is a bolt, screw, stud? Give examples of designations.
16. What is a bolted joint?
17. What is a screw joint?
18. What is the difference between constructive and simplified representations of a detachable threaded joint?
19. Discuss the keys (types, manufacture versions and designations).
20. What is splined joint? Discuss conventional representations and designations.
21. Discuss permanent joints.
22. Discuss welded joints, their conventional representations and designations.
23. Discuss soldered joints, their conventional representations and designations.
24. Discuss adhesive joints, their conventional representations and designations.