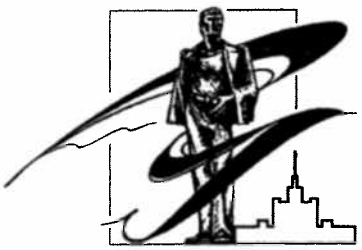

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DRAWING

Textbook

Chelyabinsk
2009

CHAPTER III

DRAWINGS OF OBJECTS AND ARTICLES

§1. Representations – Views, Sectional Views and Sections

1.1. Classification of Articles and Design Documents

An object is a collection of some geometrical bodies and their parts. Any object or a number of objects manufactured at a factory is called an article. GOST 2.101-68 stipulates some kinds of articles, such as: 1) parts; 2) assembly units; 3) complexes (systems); 4) sets.

A part is an element made of the material having the same name and type without using assembly operations, e.g.: a moulded (cast) body, a portion of a cable or wire of a given length; a screw subjected to chromium plating; a pipe sealed or welded of one piece of sheet material; a box, glued of one piece of board.

An assembly unit is a combination of individual parts that are assembled at a factory by means of assembly operations (screwing, riveting, welding, sealing, subjecting to pressure tests, flaring, etc.), e.g.: a car, a machine, a telephone, a welded body, a plastic flywheel with metal fittings.

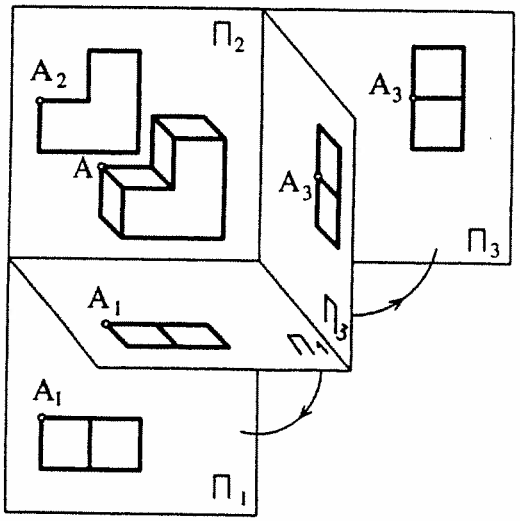
The main document according to which components are made, machines are assembled and buildings are built is a drawing. GOST 2.102-68 specifies types of design plans for all articles and all branches of industry.

A drawing of a part is a document containing representations of a part and other data required for its manufacturing and control.

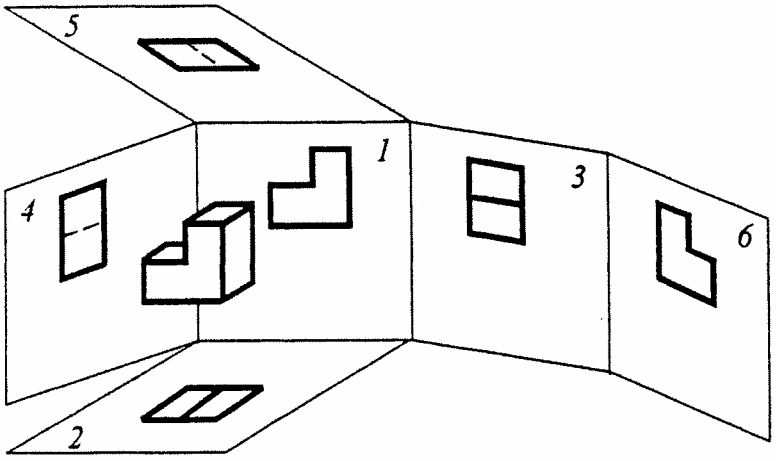
An assembly drawing is a document containing representations of an industrial product and other data required for its assembly (manufacturing) and control.

A drawing of a general view is a document determining the design of an industrial product and interaction of its main components and explaining the operation principle of an industrial product.

Rules to represent objects (articles, structures and their elements) on drawings for all branches of industry and construction engineering are specified by GOST 2.305-68. The representation of objects is carried out by the method of rectangular projection. An object is placed between a viewer and a corresponding projection plane (Fig. 78). Attention should be paid to the difference between the representation and the projection of the object. Not every object representation is its projection.



a



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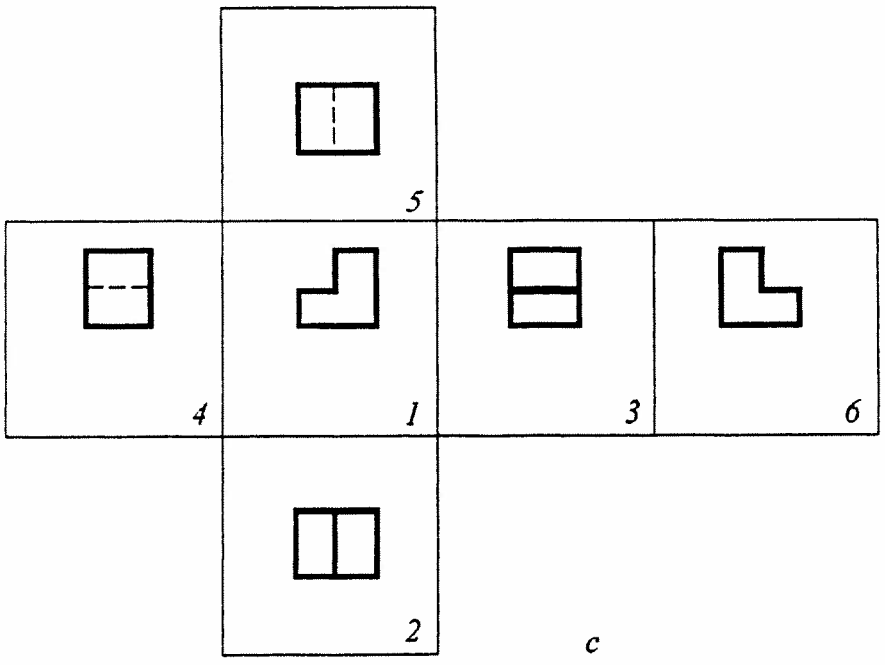


c

Fig. 78

There exists one to one correspondence when a definite projection point (e.g. A_1) corresponds to each point (A) of an object and vice versa. While constructing an object representation standards state the usage of conventialities and simplicities so that the above correspondence is violated. Therefore, figures received in projecting objects are called representations not projections. A number of conventionalities can be used corresponding to the rules specified by Standards.

Depending on their content representations on drawings are divided into views, sectional views and sections.

The number of representations (views, sectional views, sections) on the drawing must be minimum but sufficient for a complete and unique representation of an object.

1.2. Views

A view is a projection of a visible portion of an object facing the viewer surface.

Objects around us are combinations of geometrical bodies placed differently relatively each other. To represent one geometrical body only three planes of projections are sufficient, whereas generally to represent objects with very complicated forms a greater number of projection planes is required.

In representing objects six cube faces are taken as main projection planes, they are brought into alignment with the drawing plane in the way it is depicted in Fig. 78, *b*. There are generally six views (principal views, Fig 78, *c*): 1 — a front or main view; 2 — a top view; 3 — a left-hand view; 4 — a right-hand view; 5 — a bottom view; 6 — a rear view.

The representation on the frontal projection plane, i.e. the main view is taken as the principal one on the drawing. An object is located relatively the frontal projection plan in such a way that the image would give a complete representation of an object shape and sizes.

Before making views an object is imagined to be divided into simple geometrical bodies. Then each body is represented taking into account the projection connection and the relative position of bodies. For instance, the drawing of an object shown in Fig. 79, *a* consists of a view of the prism I, the cylinder II, the semi-sphere III and prisms IV and V in three projections (Fig. 79, *b*).

The names of the views are not given in drawings when they are in a projection connection (Fig. 79, *b*). If top, left-hand and right-hand views are not in the projection connection with the main view, they are designated on the drawing by

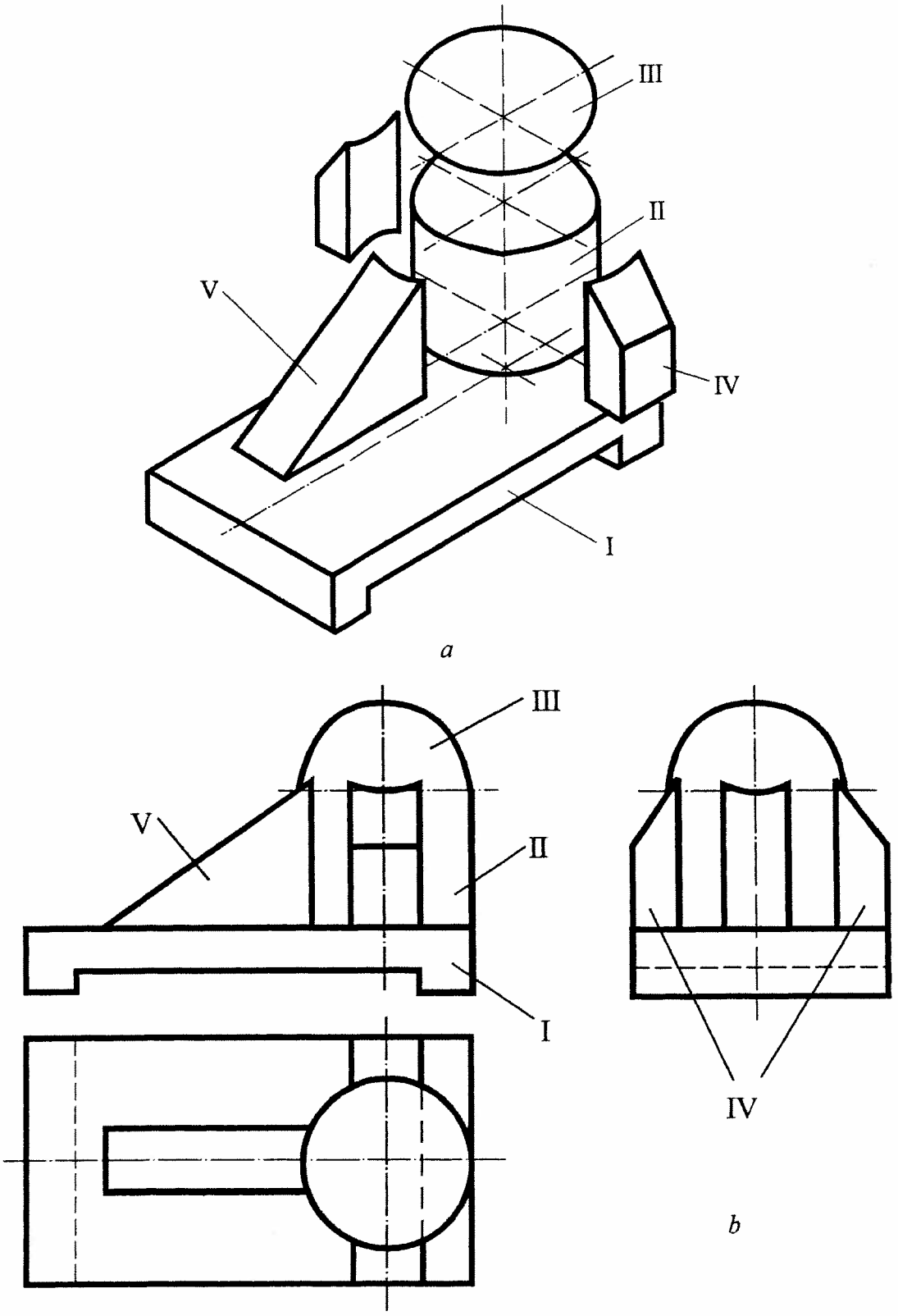


Fig. 79

the letter "A". The direction of the viewing is indicated by an arrow designated by the capital letter of the Russian alphabet (Fig. 80).

Arrow sizes and forms are stipulated by GOST 2.305-68 and are shown in Fig. 81, *a*.

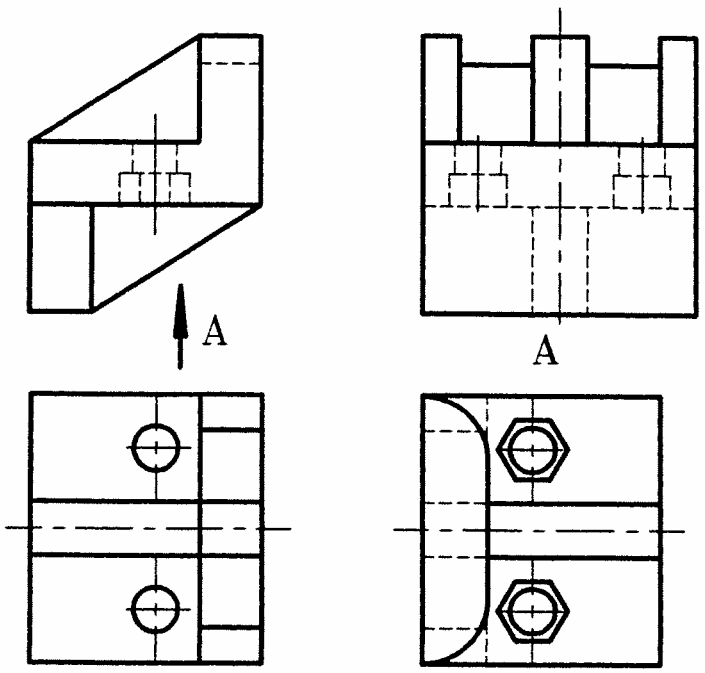


Fig.80

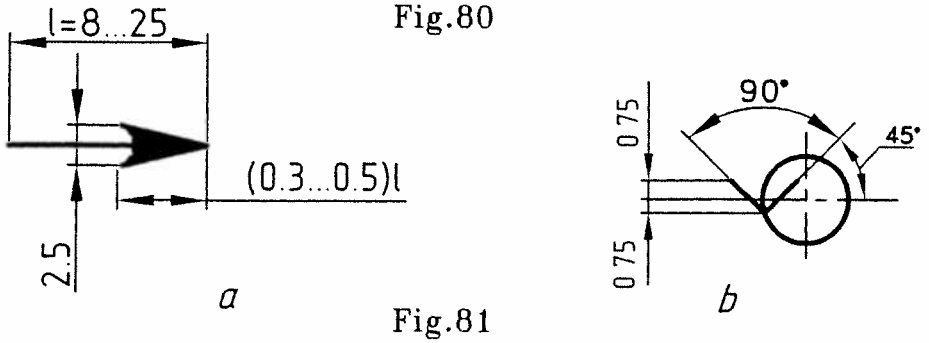


Fig.81

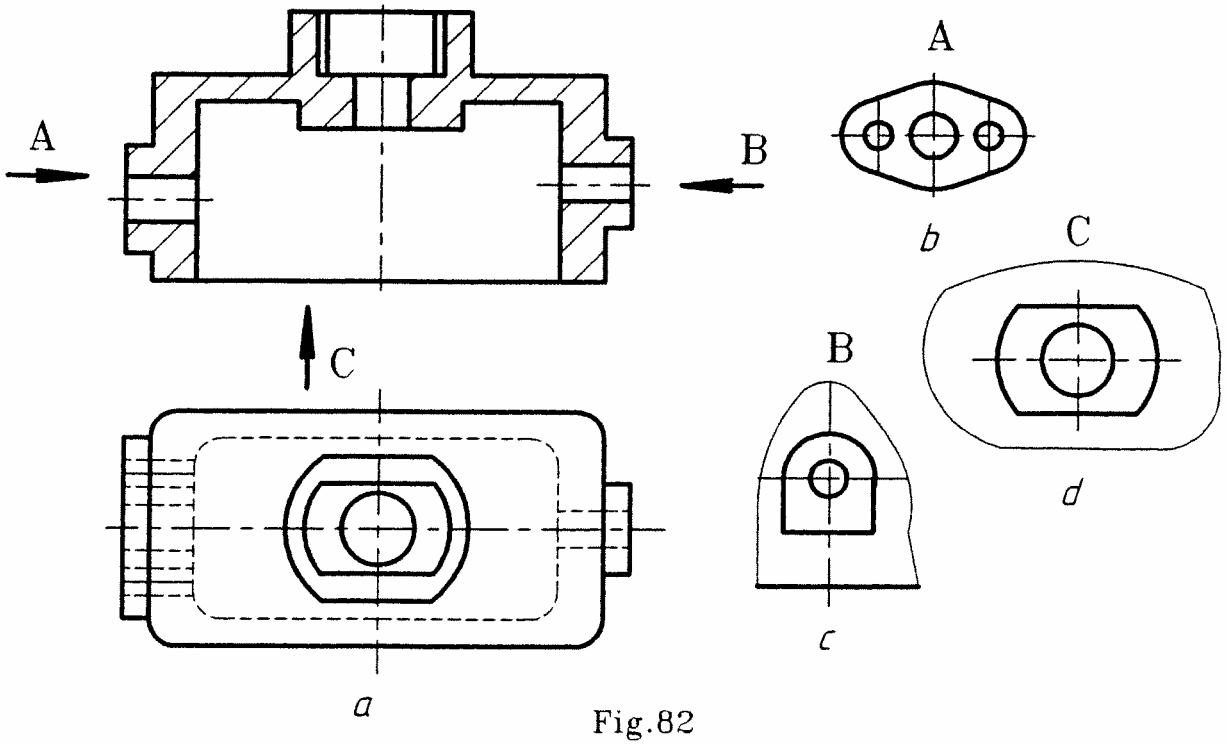


Fig.82

A local view is a representation of a separate restricted part of an object's surface on one of the main projection planes. The local view can be positioned in any vacant part of the drawing and is designated, for instance, by the letter "A". An object's view connected with the local view must be supplied with an arrow indicating the direction of viewing and it must be designated by the corresponding letter (Fig. 82).

The local view can be limited by a break line of the smallest size (Fig. 82 *c*, *d*) or it can't be limited (Fig. 82, *b*).

Auxiliary views are obtained on planes non-parallel to main projection planes. They are used in cases when some portion of an object cannot be shown on the main views without distortion of its shape and sizes (Fig. 83, *a*).

An auxiliary view is designated on the drawing, for instance, by the inscription "A" (Fig. 83, *b*), the projection of the part connected with an auxiliary view must be supplied with an arrow indicating the direction of viewing accompanied by the corresponding letter (Fig. 83, *a*). An auxiliary view can be turned retaining the position taken for the given object on the main view, the inscription "A" being accompanied by the sign "⌒" (Fig. 83, *c*). Sizes and the shape of the sign are given in Fig. 81, *b*. When an auxiliary view is located in a direct projection connection with the corresponding view, the arrow and the sign are not marked above the view (Fig. 83, *d*).

Main, auxiliary and local views are used for representing the shape of external surfaces of an object while for indicating the internal (invisible) part of an object conventional representations are used, such as sections and sectional views.

1.3. Sections

A section is a representation of a figure obtained when an object is imagined to be cut by one or several planes (Fig. 84). The section shows everything that is obtained directly on the cutting plane. Cutting planes are chosen in order to obtain normal cross-sections.

There are sections constituting a sectional view and those not constituting it, the latter are divided into removed and revolved sections (Fig. 85, *b*).

Removed sections are more preferable and may be drawn in a break between the portions of the same view (Fig. 85, *a*), on the extension of the trace of the cutting

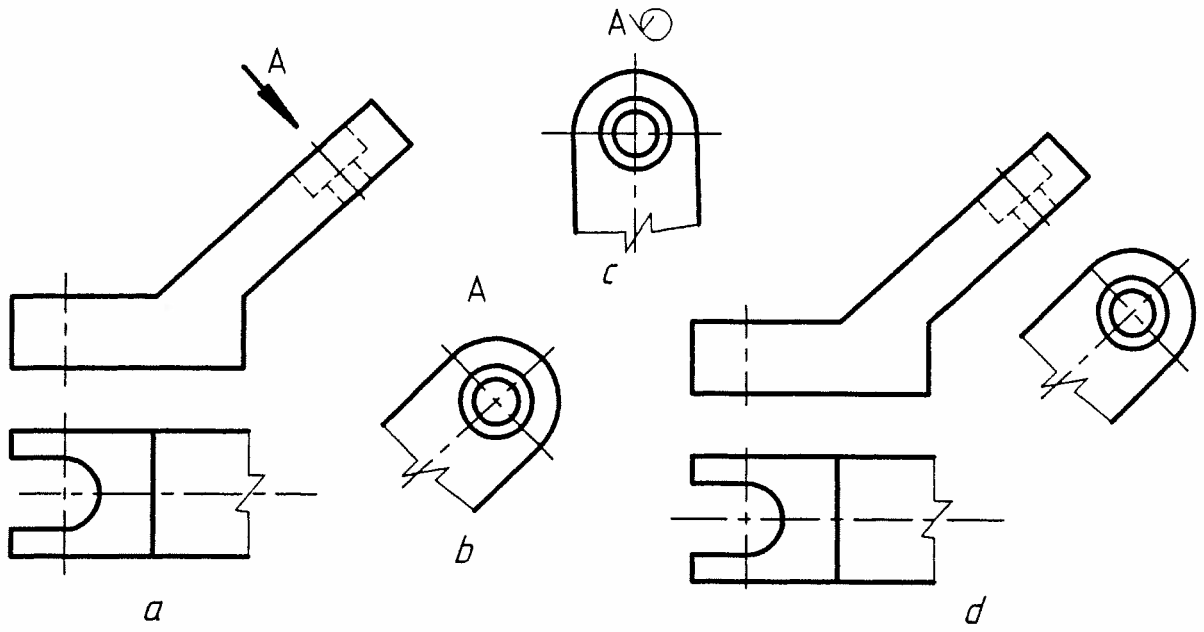


Fig.83

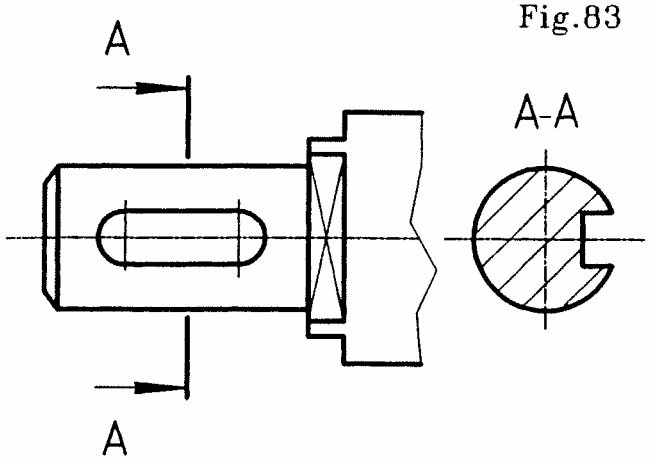


Fig.84

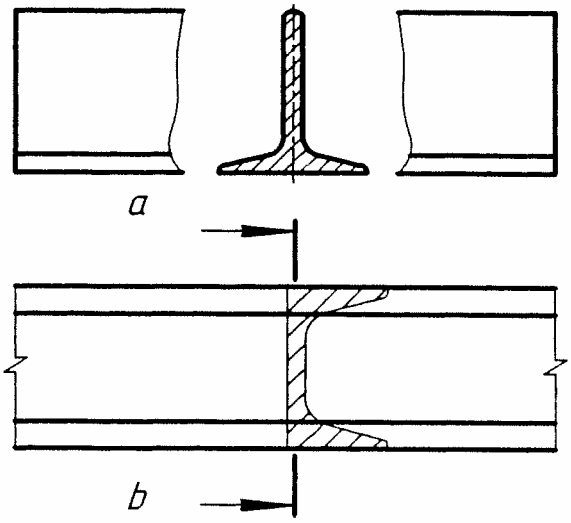


Fig.85

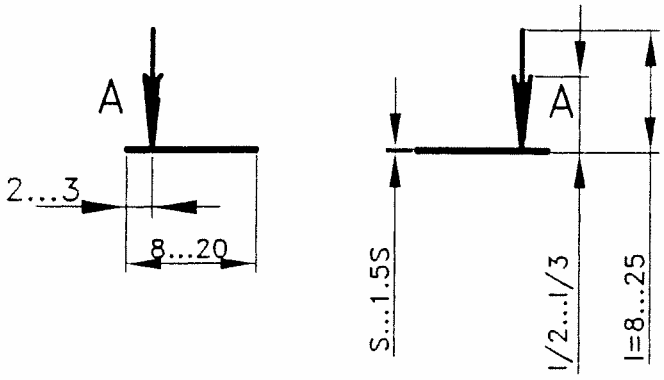


Fig.86

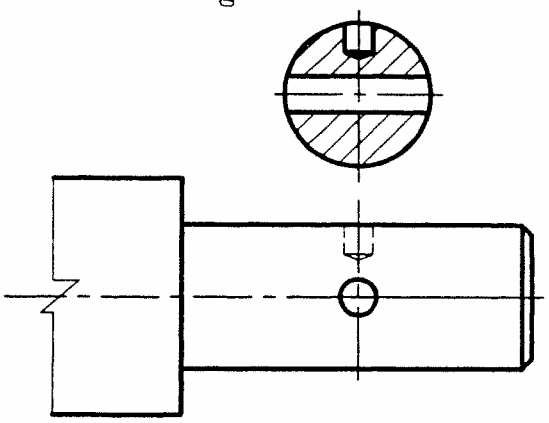


Fig.87

plane with a symmetrical figure of the section (Fig. 87), on any place of the drawing (Fig. 84), as well as with a turn (Fig. 88).

The position of the cutting plane is shown on the drawing by a section line (Fig. 84, 85*b*, 88, 90). To denote the section line a broke line is used alongside with arrows indicating the direction of viewing. Arrows are marked at a distance of 2–3 mm from the end of hatching (Fig. 86). At the beginning and end of the section line the same capital letter of the Russian alphabet is put at the side of the exterior angle opposite the arrows (Fig. 84, 85, 88, 90).

The relationship between the arrow sizes and hatching of a broke line is to correspond to Fig. 86.

Initial and final hatching should not intersect the view outline (Fig. 84, 85*b*, 88, 90). Lettering is made in the alphabetical order avoiding repetition and passes.

The lettering size should be twice larger than the dimension size number. Letters are designated parallel to the main sign independent from the position of the cutting plane (Fig. 88).

Section position must correspond to the direction indicated by arrows (Fig. 84) and must be designated, for instance, by the inscription "А–А" (Fig. 84), whereas the section constructed with a turn — by the inscription "А–А ↻" (Fig. 88).

The outline of the detail section and of the section constituting a sectional view is represented by continuous base lines (Fig. 85, *a*, 87, 88), and the outline of a revolved section — by continuous thin lines (Fig. 85, *b*).

Sections are generally distinguished on drawings by crosshatching. Its type depends on the graphic representation of the material the element is made of and it must correspond to GOST 2.306–68. Metals and hard alloys are shown in sections by inclined parallel lines drawn at an angle of 45° to the outline of the drawing or to its axis (Fig. 89, *a, b*). If hatching drawn to the lines of the drawing frame at an angle of 45° coincides in the direction with the outline lines or the axis, a 30° or 60° angle should be taken instead of an angle of 45° (Fig. 89, *c*).

If a cutting plane passes through the axis of the revolution surface bounding the hole or recess, the outline of the hole or recess is represented in the section completely (Fig. 87). If a cutting plane passes through a non-circular hole and the section is composed of separate independent parts, then sectional views should be used (Fig. 90).

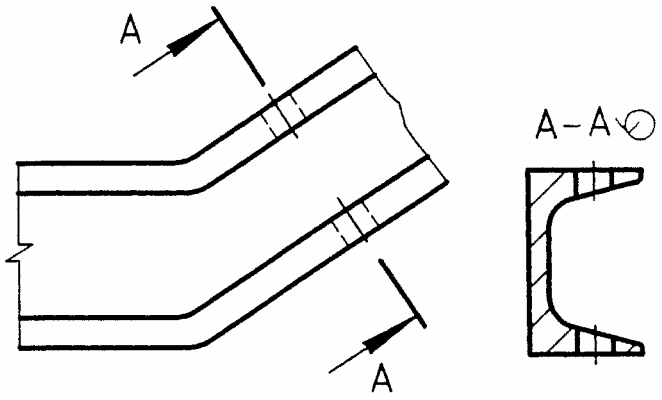


Fig.88

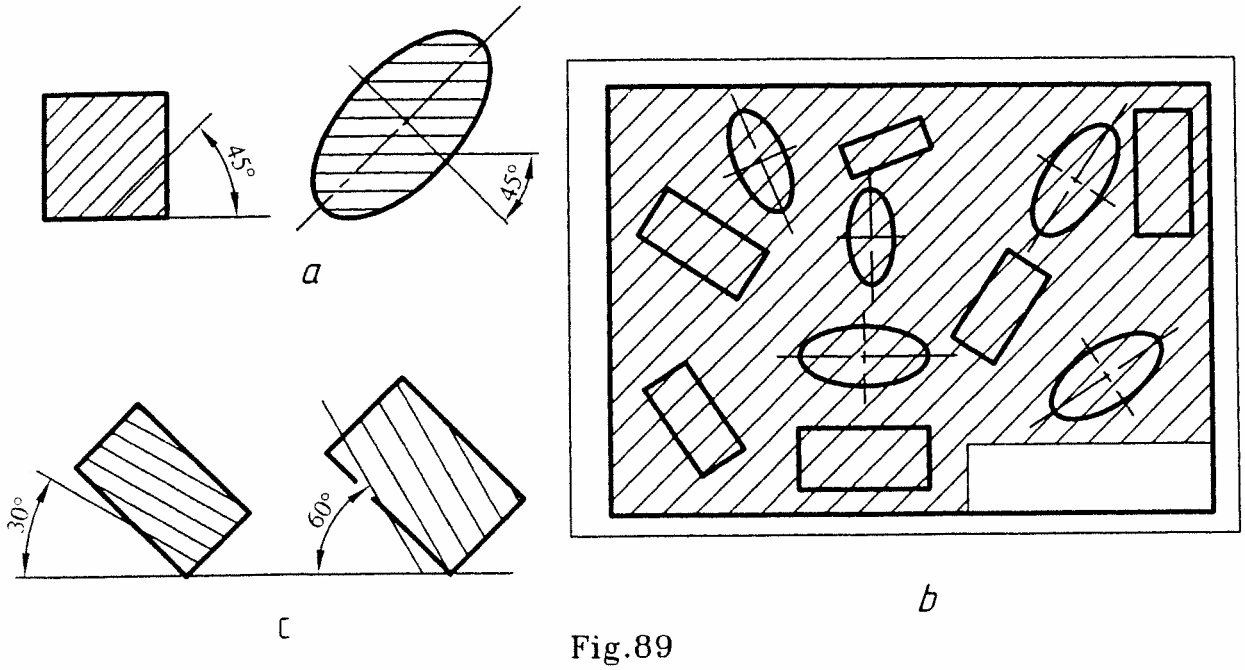


Fig.89

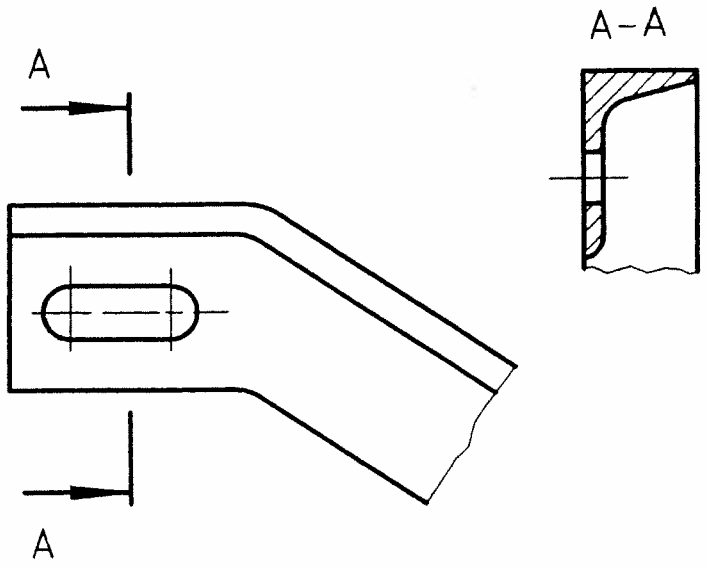


Fig.90

1.4. Construction of a True View of the Inclined Object Section by Method of Replacing Projection Planes

The inclined section is obtained as a result of an object's intersection with the plane making with the horizontal projection plane an angle another than the right angle. The true view of the inclined section can be obtained by the method of replacing projection planes, i.e. a geometrical element is projected on a new plane replacing one of principal planes leaving the geometrical element fixed in position. The position of an auxiliary projection plane is chosen on account of the problem stated (parallel to a geometrical object).

An auxiliary plane must be perpendicular to another one, i.e. to an irreplaceable projection plane.

Problem. Construct the true view of an object's section by the frontal-projecting plane A–A (Fig. 91).

Imagine an object to be divided into simple geometrical elements constituting it, such as: a truncated cone, a sphere part, and two prisms. There is a through cylindrical hole inside. Coaxial conical and spherical surfaces intersect along the circle.

Intersection lines of prismatic surfaces and the sphere are the assemblage of circle parts.

The frontal-projecting plane A–A intersects the truncated cone along the ellipse parts, the sphere — along two arcs of the circle and the prism – along the broken line. The internal cylindrical hole is intersected by the plane along the ellipse. All these lines limit the figure of the section A–A, the true view of which can be obtained by replacing the horizontal projection plane Π_1 by the auxiliary plane Π_4 that is parallel to the cutting plane.

Make constructions on the drawing (Fig. 91, *a*).

1. On the frontal projection plane mark projections of control points of intersection lines, i.e. points at which section lines A–A intersect the projection outlines of external and internal object surfaces (points 1_2, 2_2, 4_2, 5_2, 7_2) as well as the image axis (points $3_2 = 3'_2 = 3''_2 = 3'''_2$). At points 4_2 and 6_2 marked on the projections of intersection lines of surfaces forming an object the shape of the line limiting the figure of the section changes.

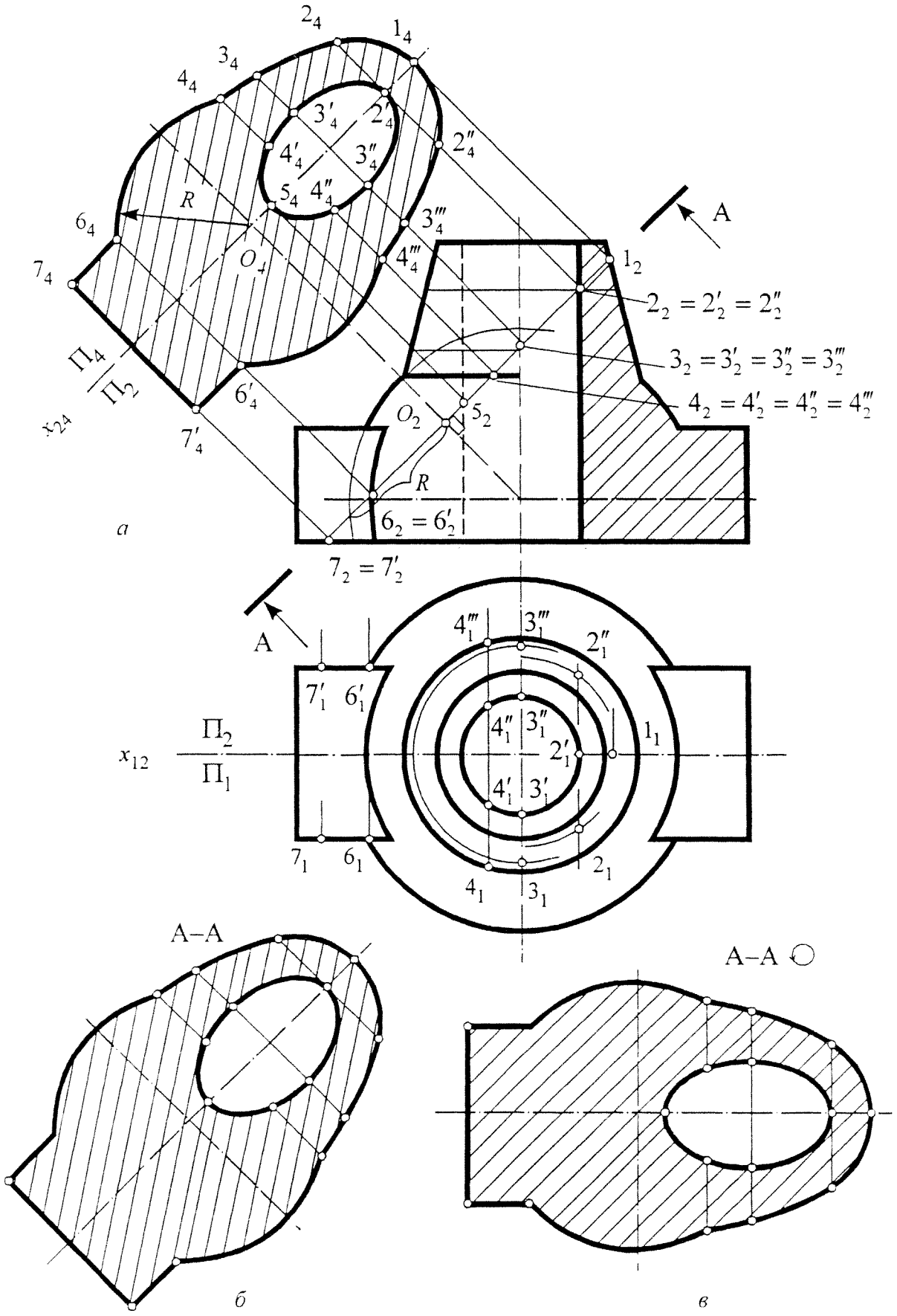


Fig. 91

Mark the projection O_2 of the circle centre O of the sphere intersection with the given plane A–A. The radius R of this circle is determined by drawing the outline line of the sphere frontal projection till the intersection with the line A–A.

2. Horizontal projections of control points marked are constructed on account of their belonging to corresponding surfaces.

3. Draw a projection axis x_{12} through the symmetry axis of the figure (to make the construction easier).

4. On a vacant place of the drawing draw a new projection axis x_{24} parallel to the line A–A.

5. New communication lines in the system of planes $\frac{\Pi_2}{\Pi_1}$ are drawn perpendicular to the axis x_{24}.

6. On the communication lines drawn find the location of each point of the section line (of an external and internal outline), lying off along both sides from the axis of the section symmetry segments taken from the horizontal projection. For example $|2'_1 2_1| = |2'_4 2_4|$ and $|2'_1 2''_1| = |2'_4 2''_4|$.

7. Connect the constructed points belonging to both internal and external outlines of the section line on account of the line shape.

8. Make section hatching according to the rules specified in GOST 2.306-68.

9. Outline the section by lines of the required thickness according to GOST 2.303-68.

In mechanical engineering projection axes and communication lines are not drawn on drawings containing object sections by the inclined plane, projections of the section line points are not marked and the section figure can be located at any place of the drawing in accordance with GOST 2.305-68. The section axis is drawn parallel to the section line and the distance between points 1 ... 7 and their relative position remains unchanged. The section is marked by A–A (Fig. 91, *b*). The section with the turn is also allowable. In this case the inscription is followed by the sign "○" (Fig. 91, b).

1.5. Sectional Views

A sectional view is an object representation when it is imagined to be cut by one or some planes. Sectional views reveal everything that is obtained in the cutting plane (section) and beyond it, i.e. the view of an object portion situated beyond the cutting plane (Fig. 92). An object portion between the observer's eye and the cutting plane is imagined to be removed.

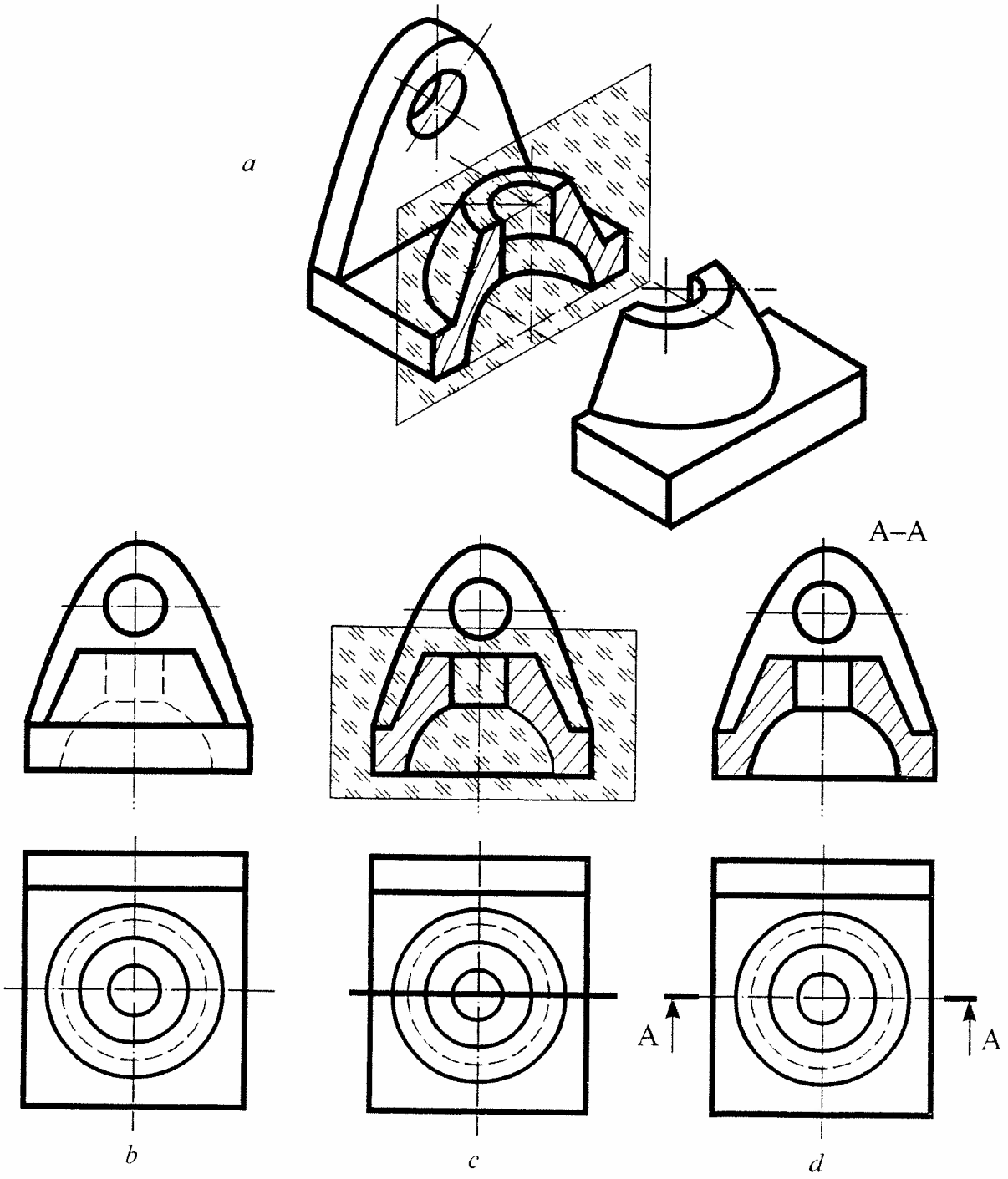


Fig. 92

Problem. Given an object (Fig. 92, *a*, *b*) consisting of a prismatic base, a conical boss with a through cylindrical hole changing into a semi-sphere, and an ear with a cylindrical hole. Required: to make a sectional view to reveal the internal (invisible) outline of the object.

The cutting plane passes parallel to the frontal projection plane through the axis of revolution surfaces forming the boss (Fig. 92, *c*). An object portion, which is situated in front of the cutting plane, is imagined to be removed.

The section figure consists of two plane figures located symmetrically relatively the axis. Each figure is bounded by a circle arc obtained as a result of intersecting the cutting plane with the internal semi-sphere and by the broken line consisting of six segments. The segments of the broken line are in fact segments of straight lines along which the cutting plane intersects the prismatic base, the truncated cone of the boss with a cylindrical hole inside.

The view of the object portion located beyond the cutting plane (Fig. 92, *d*) contains the view of the rest parts of the internal semi-sphere and a cylindrical surface as well as the rest parts of low and upper faces of the prismatic base, the upper base of the truncated cone of the boss and the ear.

Classification of Sectional Views According to GOST 2.305-68

Depending on the number of cutting planes sectional views are divided into:

a) simple (with one cutting plane);

b) complex (with two or more cutting planes).

Depending on the position of the cutting plane relative to the horizontal projection plane sectional views may be:

a) horizontal, when the cutting plane is parallel to the horizontal projection plane;

b) vertical, when the cutting plane is perpendicular to the horizontal projection plane;

c) oblique, when the cutting plane forms an acute angle with the horizontal projection plane.

The vertical sectional view is called:

a) a frontal view, if the cutting plane is parallel to the frontal projection plane;

b) a profile view, if the cutting plane is parallel to the profile projection plane.

Simple Sectional Views

They are designed in the same way as sections (Fig. 92). The position of the cutting plane is not marked if the cutting plane coincides with the symmetry plane of an object. Completely corresponding views are located in a direct projection communication or when the sectional view is horizontal, frontal or profile (Fig. 93).

Sectional views can be made with the turn till the position corresponding to that taken for the given object on the main view. In this case the sign "↻" must accompany the inscription (Fig. 94).

Horizontal, frontal and profile sectional views can be located on corresponding main views (Fig. 93).

A sectional view used for revealing an object's design only in a certain limited place is called a local sectional view. It is marked on the view by a continuous wavy line (Fig. 94).

One-half of the view and a half of the corresponding sectional view can be joined separating them by a continuous wavy line (Fig. 94). If only one-half of the view and one-half of the section view are joined, each being a symmetrical figure, the symmetry axis can be used as a dividing line (Fig. 93). It is not allowable to join the half of the view with the half of the sectional view unless any representation line coincides with the axis (Fig. 95). In this case the major part of the view is joined with the minor part of the sectional view (Fig. 95, *a*) or the major part of the sectional view is joined with the minor part of the view (Fig. 95, *b*) depending on to what projection of an object surface (external or internal) the line coinciding with the axis belongs.

Complex Sectional Views

They are divided into:

a) stepped, if cutting planes are parallel (section A–A, Fig. 96);

b) broken, if cutting planes are intersected (section A–A, Fig. 97; section A–A, Fig. 99).

When designating complex sectional views dashes of a broken line are drawn not only at the beginning and at the end of a section line but also at places of intersecting cutting planes (Fig. 96, 97, 98, 99).

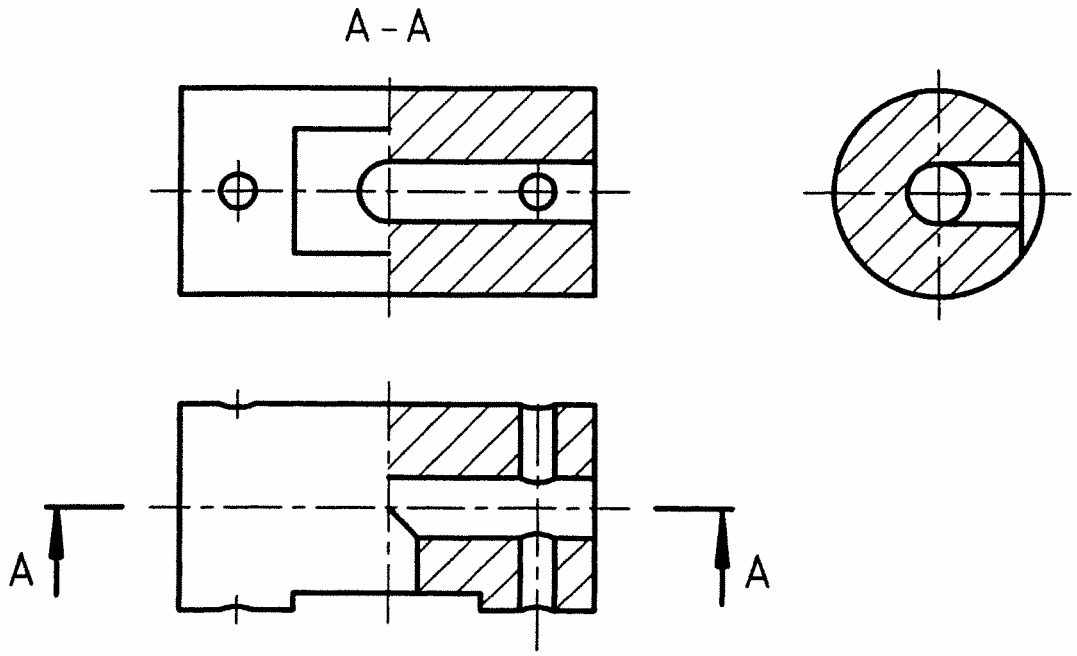


Fig.93

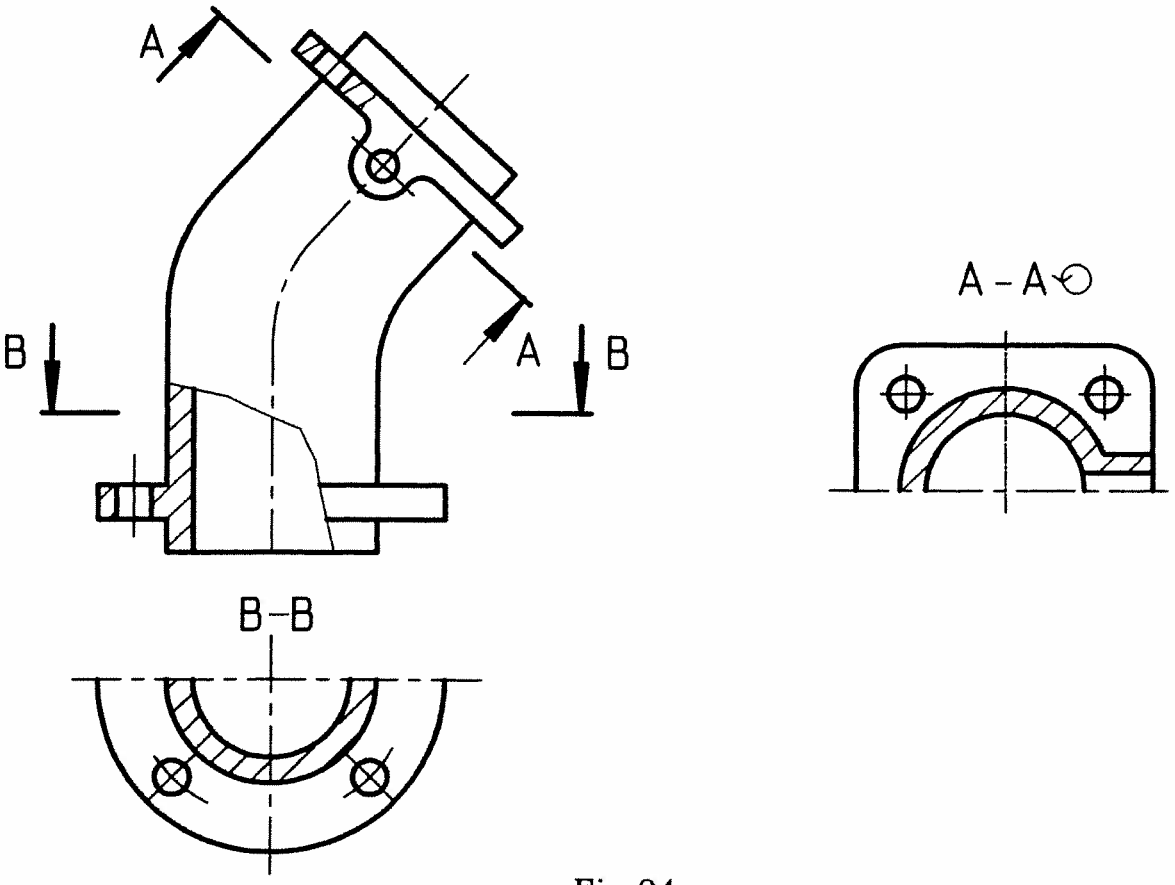


Fig.94

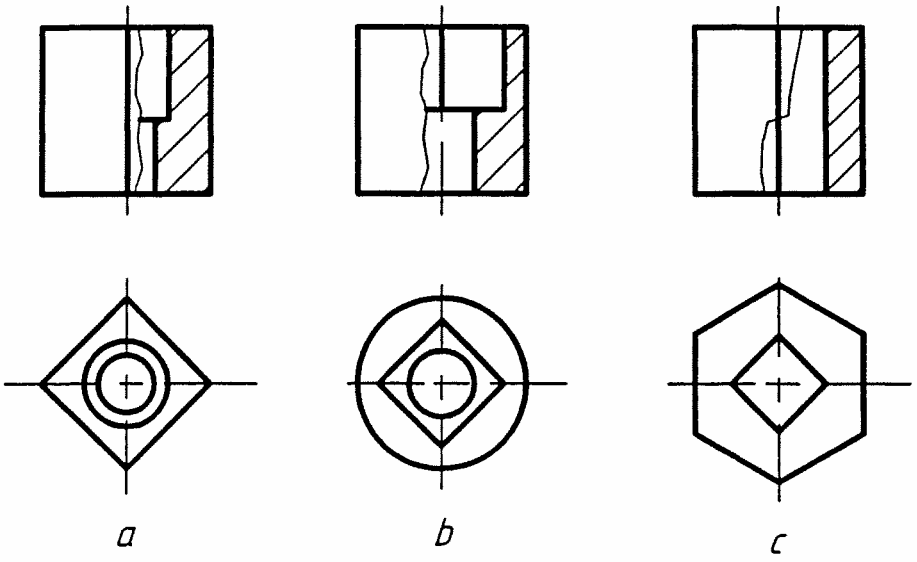


Fig.95

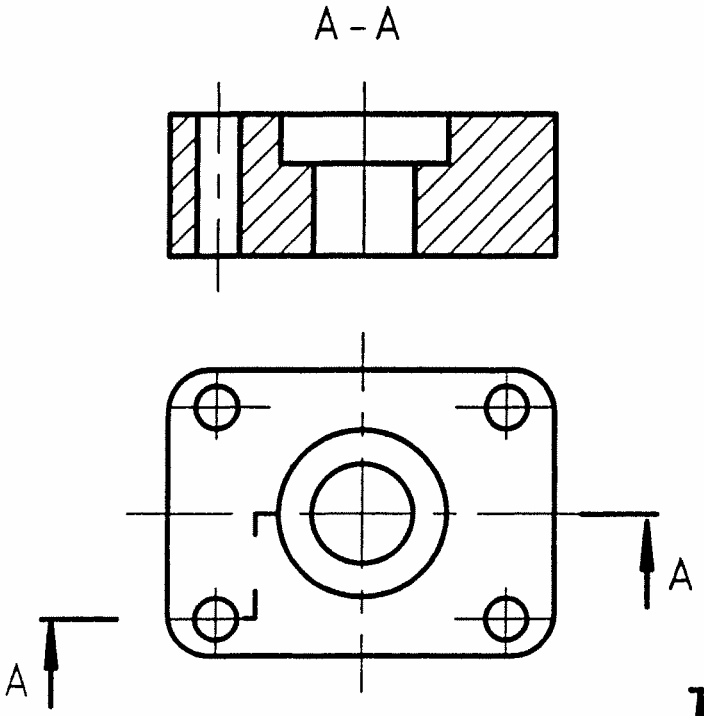


Fig.96

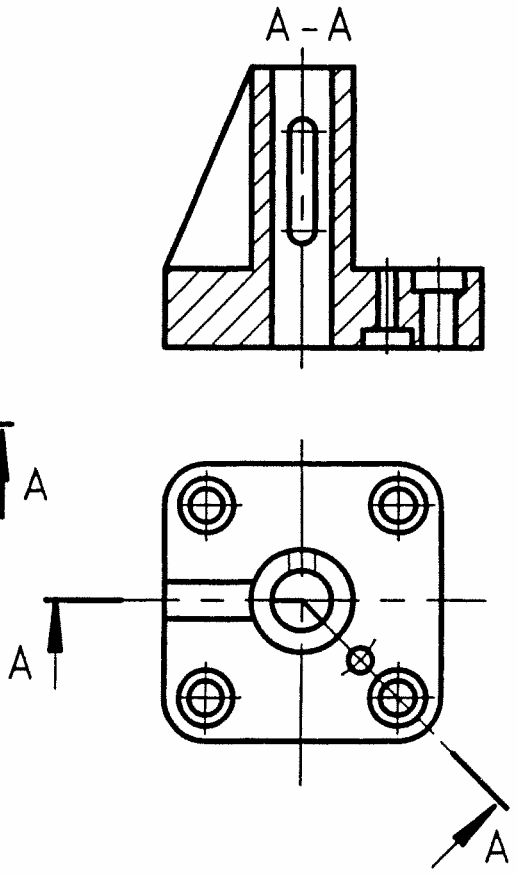


Fig.97

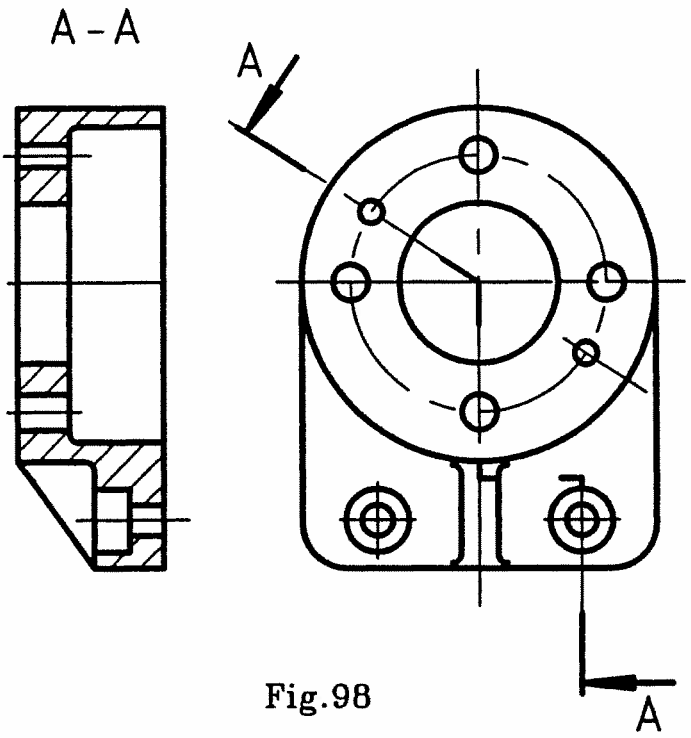


Fig.98

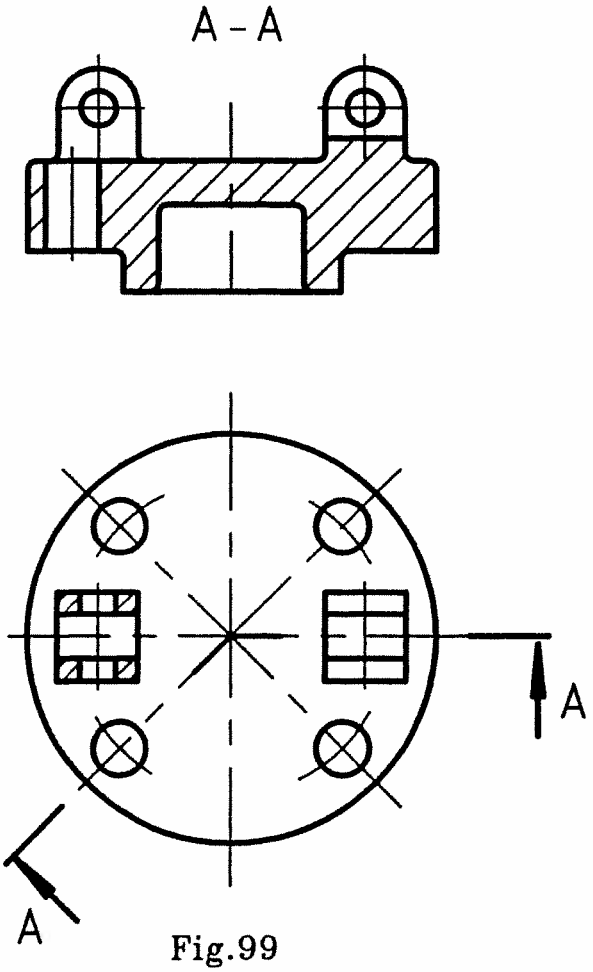


Fig.99

Section figures obtained by various cutting planes of a complex sectional view are not separated from one another by any lines (Fig. 96, 97, 98, 99).

A complex stepped sectional view is located on the corresponding main view (Fig. 96) or in any place of the drawing.

In broken sectional views cutting planes are turned conventionally till their coincidence in one plane, the direction of the turn may not coincide with the direction of viewing (Fig. 98). If the coincided cutting planes are parallel to one of the main projection planes, the broken sectional view may be located on the corresponding view (Fig. 97, 98, 99).

While turning the cutting plane, object's elements situated beyond it are drawn in the way they are projected on the corresponding plane with which they coincide (Fig. 99).

In making sectional views some simplifications are made to comply with the standard. For example, such elements as thin walls (stiffening ribs, non-hollow handle shaft, etc.) may not be hatched if the cutting plane is directed along the axis or the longest side of such element (Fig. 97). Holes situated on the circular flange may be shown in the sectional view when they do not enter the cutting plane (Fig. 94).

§2. Model Sketching

In manufacturing and designing new details temporary drawings, i.e. sketches are sometimes required. A sketch is a drawing made without using a drawing instrument (freehand) not observing the scale exactly yet keeping the proportionality of detail elements and observing regulations specified by Standards for making drawings. A sketch contains detail views and other data for its manufacturing and control (sizes, allowances, designation of surface roughness, type of material, etc.).

A model sketch should contain the following:

1) three images — a combination of three views with sectional views shown (three views of each model irrespective its form are constructed in teaching aims);

2) sizes required for its manufacturing;

3) main inscription according to the form 1 GOST 2.104-68.

The following sequence of making model sketches is recommended, such as:

1. Prepare a sheet of checked paper sized A3 in compliance with GOST 2.301-68, mark the frame, and make the main inscription in the right-hand lower corner.

2. Examine the model carefully, analyze its form by exploding it imaginarily into the simplest geometrical figures or their parts (Chapter III, 1.2.).

3. Choose the model position in order to construct its main view (Chapter III, 1.2.).

4. Estimate correlation reading of overall model dimensions, draw overall rectangles corresponding to model images in thin full lines for the uniform filling up the drawing field. Draw the axes (axes of the surfaces of filling, axes of image symmetry).

5. Construct three views of the model in thin lines observing the projection communication. Show the internal model outline in dash lines (in case of efficient skills of making drawings dash lines can be avoided).

6. Make given sectional views in thin lines.

7. Hatch sectional views in compliance with GOST 2.306-68.

8. Draw extension and dimension lines, arrows, mark diameters, radii, grades and conicity (GOST 2.307-68, Chapter III, §3).

9. Mark sectional views if needed (GOST 2.305-68, Chapter III, 1.3, 1.4).

10. Check the correctness of making views, remove unnecessary lines.

11. Measure the model and write down dimension numbers.

12. Outline the sketch in lines of thickness required in compliance with GOST 2.303-68.

13. Make the main inscription.

14. Recheck the correctness of the sketch made.

P r o b l e m. Draw a sketch of the model given in Fig. 100.

Let's analyze the form of the model. It consists of the base (a parallelepiped with four cylindrical holes), a hexagonal prism and two adjoining triangular prisms (stiffening ribs). Inside, the model has two coaxial cylindrical holes. Choose the main view.

The view along the arrow A gives the most complete representation of the external shape of the model (Fig. 100). Draw overall rectangles for each of the three views on a prepared sheet size (Fig. 101, *a*). Draw the axes. Construct three views of the model in projection communication thin lines. Show the internal outline of the model in dash lines (Fig. 101, *b*).

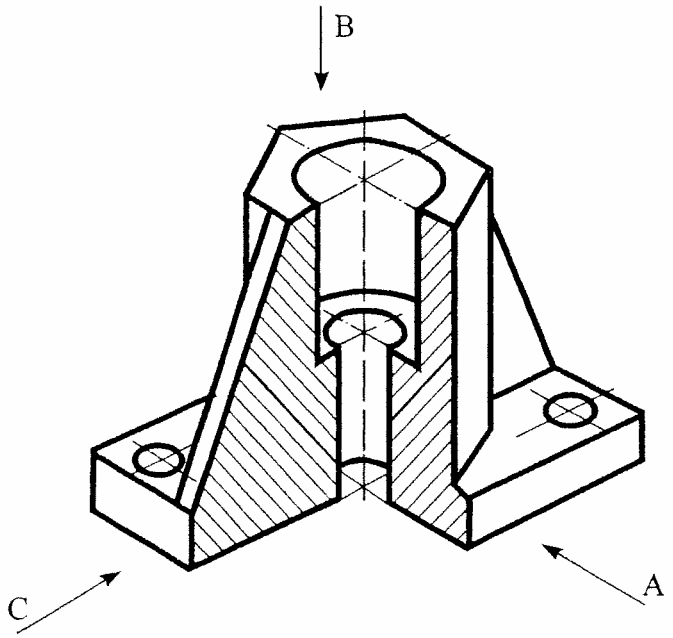


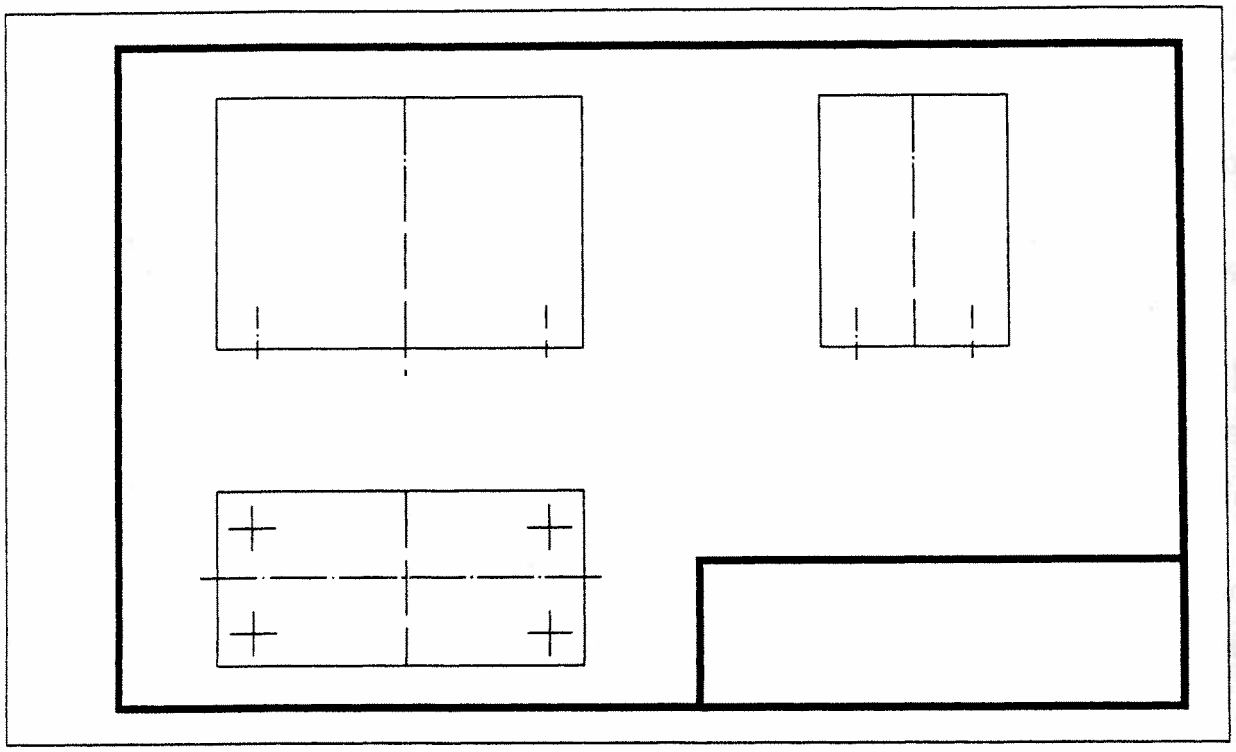
Fig. 100

To reveal the internal model shape it is sufficient to make the frontal sectional view by the plane coinciding with the symmetry model plane. The view along the arrow A and the frontal sectional view are symmetrical views though the coincidence of the half of the view with the half of the sectional view can't be made since the projection of the rib external surface coincides with the symmetry axis. Therefore the main view is to consist of a combination of a part of the view (more than a half) and a part of the frontal view (less than a half). The boundary between the part of the view and the part of the sectional view is a thin wavy line (Fig. 101, *c*).

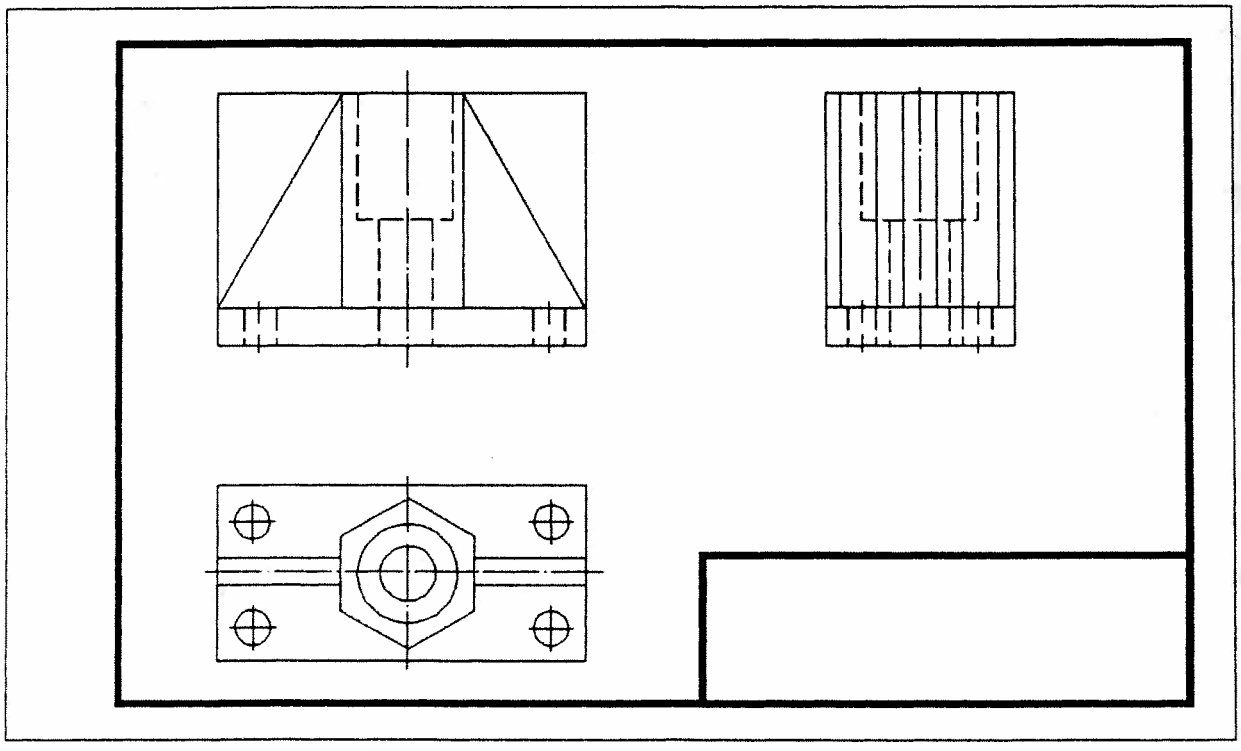
A left-side view and a profile view are symmetrical views, therefore it is possible to make a connection between the left-side view and the half of the profile view. The boundary between them is the symmetry axis (Fig. 101, *c*). The part of the sectional view on the main view and the half of the sectional view on the left-side view are located to the left from the axis.

Hatch sectional views. Sectional views are not designated since cutting planes coincide with symmetry planes of the model. To determine the hole depth in the model base it is necessary to make a local view (Fig. 101, *c*).

Further constructions are made according to the above sequence (Fig. 101, *d*).

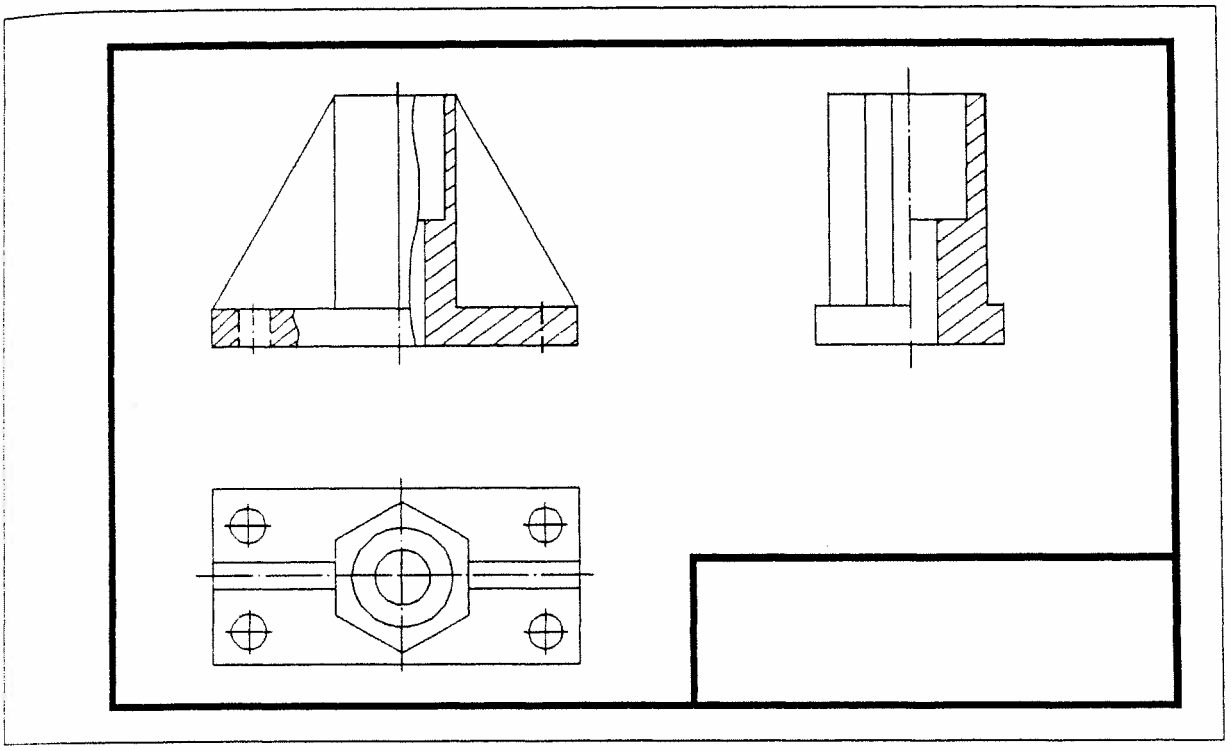


a

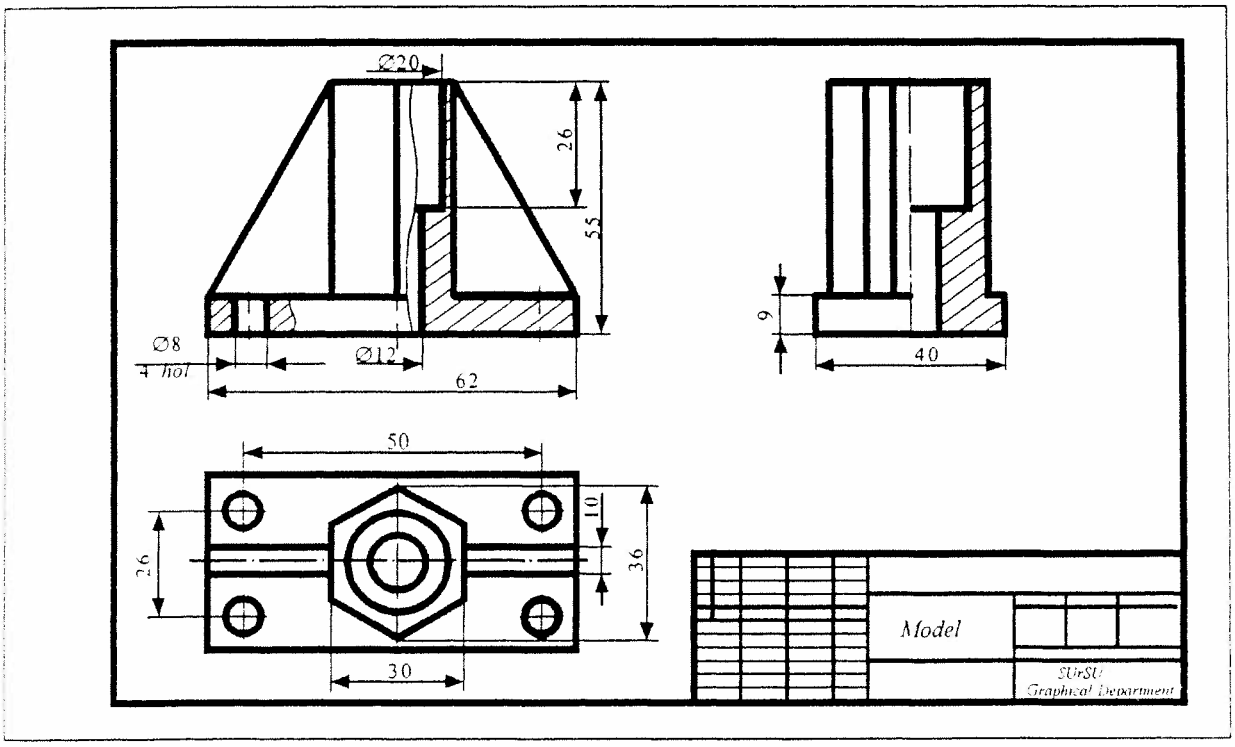


b

Fig. 101



c


Ø20
26
55
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10
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30
Model
SUrSU
Graphical Department

d

Fig. 101

§3. Dimensioning

While making sketches and drawings of different parts, the geometrical principle of specifying the sizes is used in engineering graphics.

The following sizes are specified:

a) form sizes determining each of the simplest geometrical forms constituting the model;

b) position (coordinate) sizes characterizing the relative position of geometrical forms constituting the model;

c) overall dimensions — distances between final points of an object in length, height and width.

Overall dimensions are in fact the sum of the form sizes or they coincide with them. They may not be specified if they are the sum of the form sizes and that of position.

GOST 2.307-68 stipulates dimensioning rules.

Sizes are shown on drawings by dimension members and dimension lines. While dimensioning the straight line segment, the dimension line is drawn parallel to this segment, whereas the removed lines are drawn perpendicular to the dimension ones (Fig. 102). Linear dimensions are given on drawings in millimeters without adding a measurement unit. In dimensioning an angle the dimension line is drawn in the form of an arc with the centre in its vertex, extension lines being drawn radially (Fig. 103, *a*). When dimensioning an arc of a circle the dimension line is drawn concentric on the arc. Extension lines are drawn parallel to the angle bisector, the sign "⌒" is marked above the dimension number (Fig. 103, *b*).

The dimension line is bounded by arrows on both ends. One of the variants of an arrow form and an approximate correlation of its elements are shown in Fig. 104. Arrows are drawn on the drawing approximately equal.

Extension lines must extend 1 to 5 mm beyond the ends of arrowheads of the dimension line (Fig. 102).

Dimension lines are drawn preferably outside the drawing outlines (Fig. 102, 105). Minimum distances between parallel dimension lines should be 7 mm and those between the dimension line and the drawing outline being 10 mm. Distances are chosen irrespective of the scale and the weight of the drawing. It is necessary to avoid the intersection of dimension and extension lines.

Dimensions belonging to the external outline are drawn on the side of the view, while those belonging to the internal outline — on the side of the sectional view.

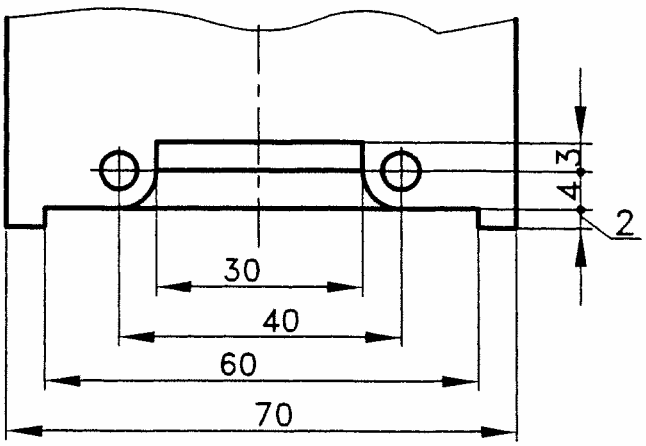


Fig.102

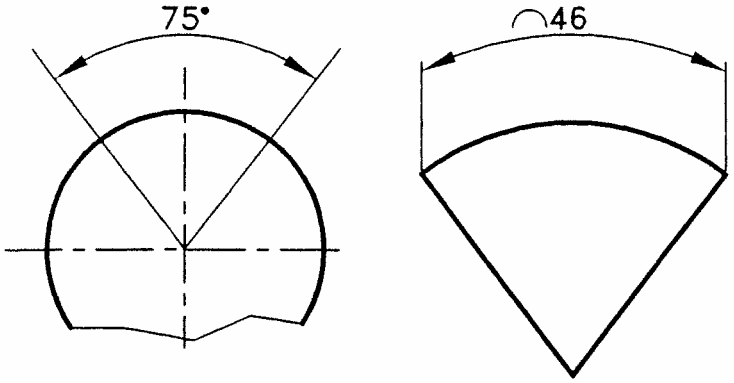
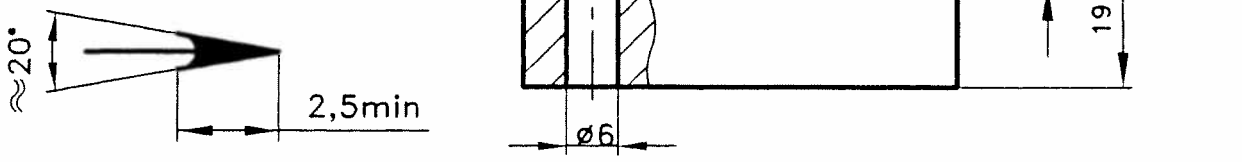


Fig.103



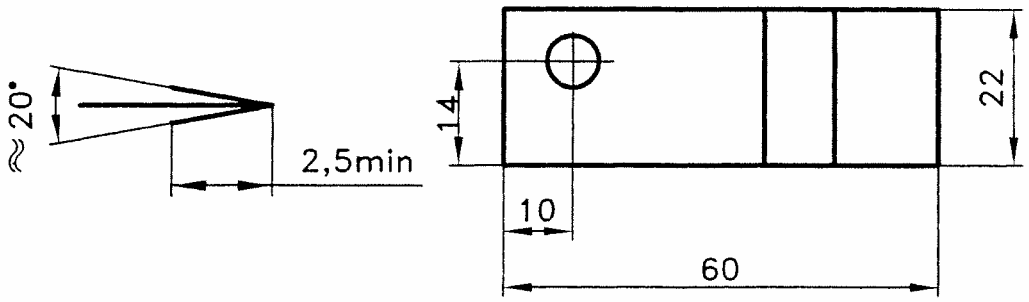


Fig.104

Fig.105

If a view or a sectional view of a symmetrical object or some symmetrical arranged elements is drawn only till the symmetry axis or with a break, dimension lines belonging to these elements are drawn with a break. The break of the dimension line is made far from the axis of the breaking line of an object (Fig. 106).

If the length of the dimension line is not sufficient for drawing arrows on it, the dimension line is drawn beyond the outlines, extension, axial lines, etc (Fig. 107). If there is not enough space for arrows on dimension lines arranged in chains, they may be replaced by points (Fig. 102).

When dimensioning several parallel or concentric dimension lines dimension figures are written above in a chess type way (Fig. 102).

If it is necessary to show the coordinates of the vertex of the rounded angle or the arc centre of the rounding-off, extension lines are drawn from the intersection point of the angle sides or the centre of the rounding-off arc (Fig. 108).

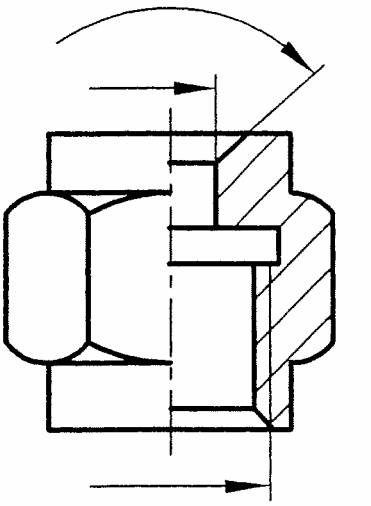
Dimension figures of linear dimensions with different slopes of dimension lines are arranged as shown in Fig. 109, those of angular dimension — in Fig.110.

Dimensions belonging to one and the same structural element (recess, projection, hole, etc) are recommended to be given in a group in one place arranging them on the view where the geometrical form of the given element is shown completely (Fig. 105). For convenient reading the drawing dimensions of cylindrical or conical holes should be given on the view where the hole depth is shown (Fig. 105).

Dimension figures and arrows must not be intersected by any drawing lines. In certain cases the latter are to be broken (Fig. 111). While dimensioning a radius, the dimension figure is preceded by the capital letter R. While dimensioning a diameter and a square, the dimension figure is preceded by the signs "∅" and "□" respectively. When it is difficult to separate the sphere from other surfaces, the dimension figure of the diameter (radius) is preceded by the sign "O", for example, OR12. The height of all signs is the same as the size of dimension figures on the drawing (Fig. 112).

If there is not enough space above the dimension line to write the dimension figure or to draw arrows, they are given in the way shown in Fig. 113. At a large radius value the centre may approach the arc, in this case the dimension line of the radius is drawn with a break at an angle of 90° (Fig. 114, *a*). If there is no need to give dimensions determining the position of the circle arc centre the the dimension line of the radius may not be drawn till the centre but skirted of the arc relatively the centre (Fig. 114, *b*).

Radii of external and internal rounding are dimensioned as shown in Fig. 115.



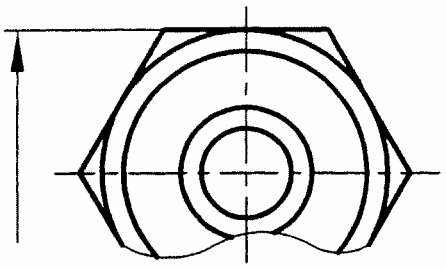


Fig.106

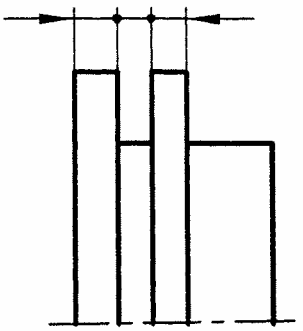


Fig.107

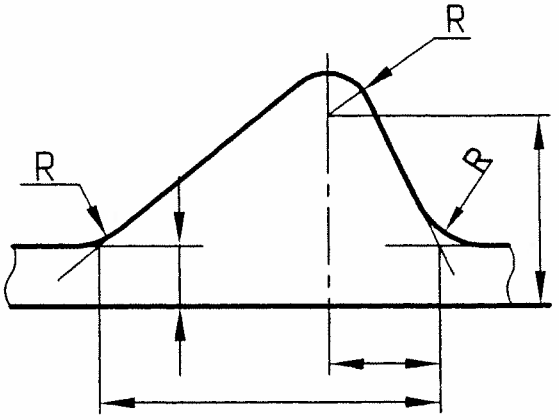


Fig.108

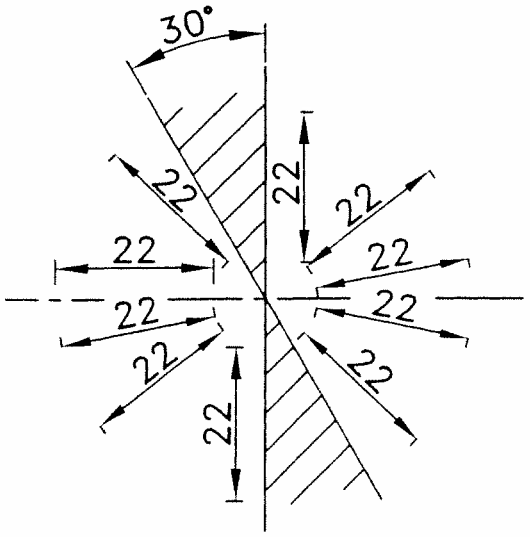


Fig.109

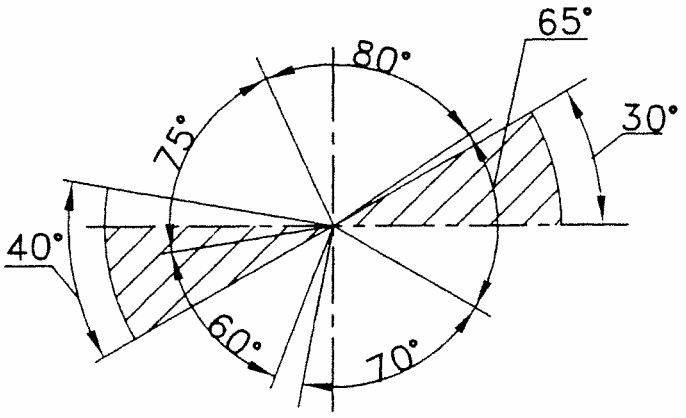


Fig.110

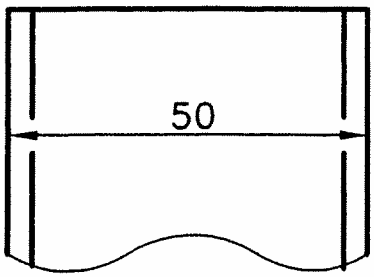


Fig.111

R, ∅, □, ○ R10

Fig.112

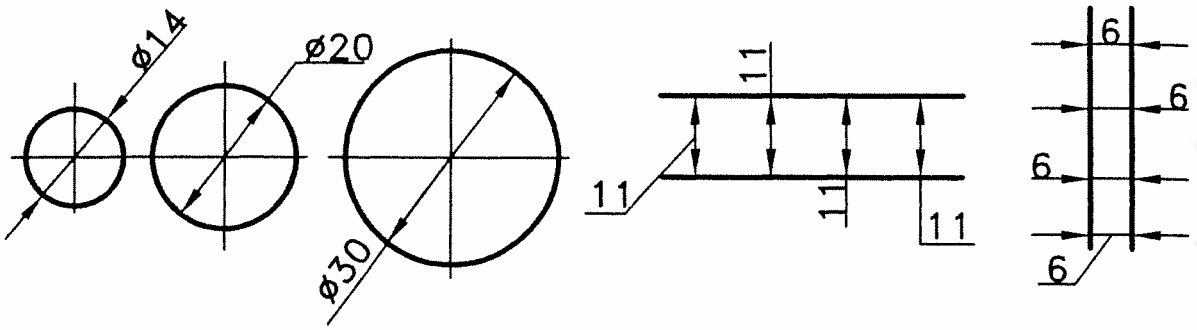


Fig.113

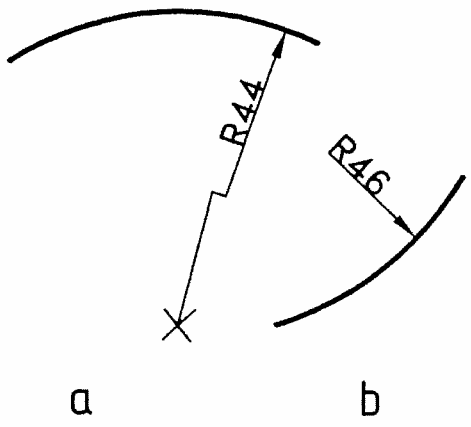


Fig.114

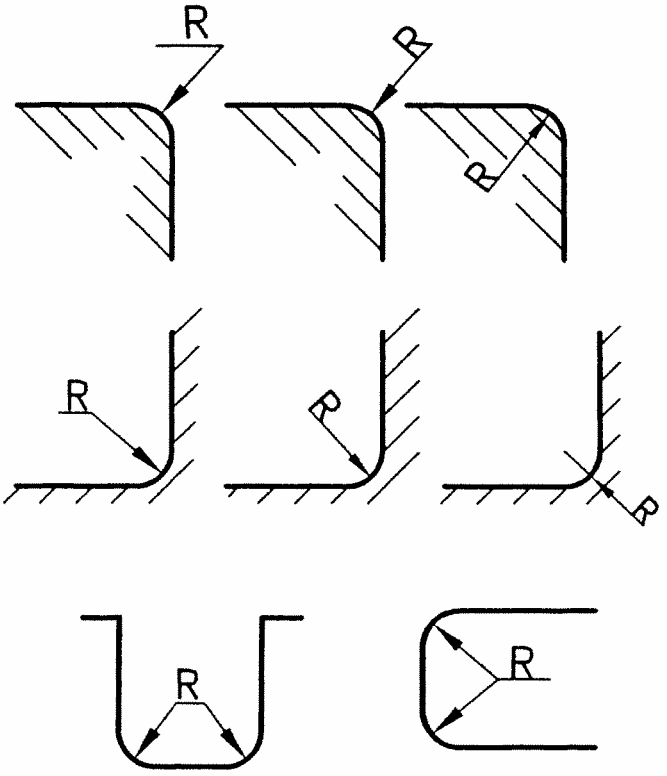


Fig.115

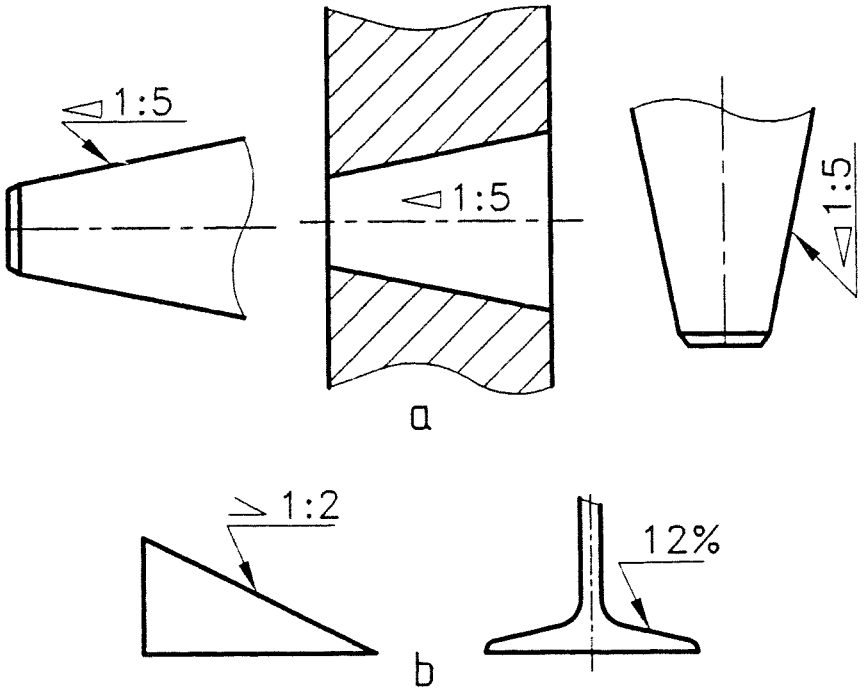


Fig.116

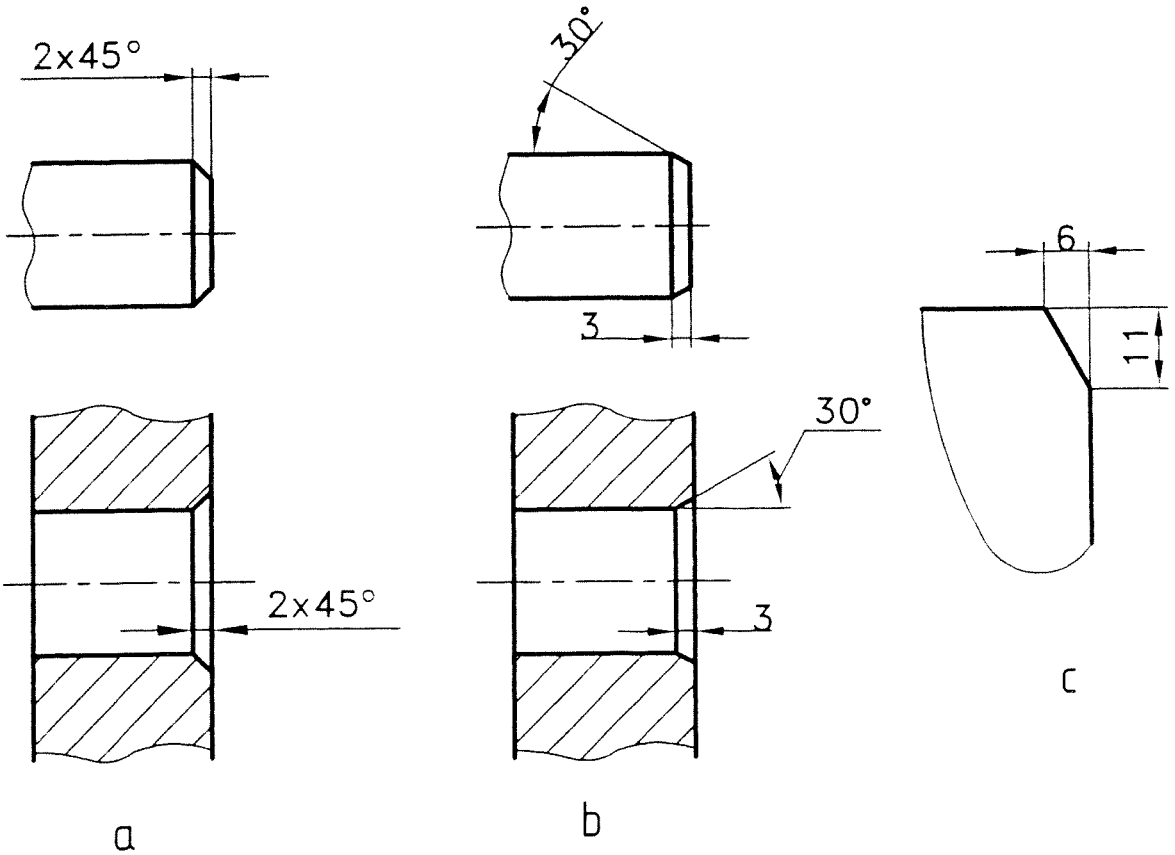


Fig.117

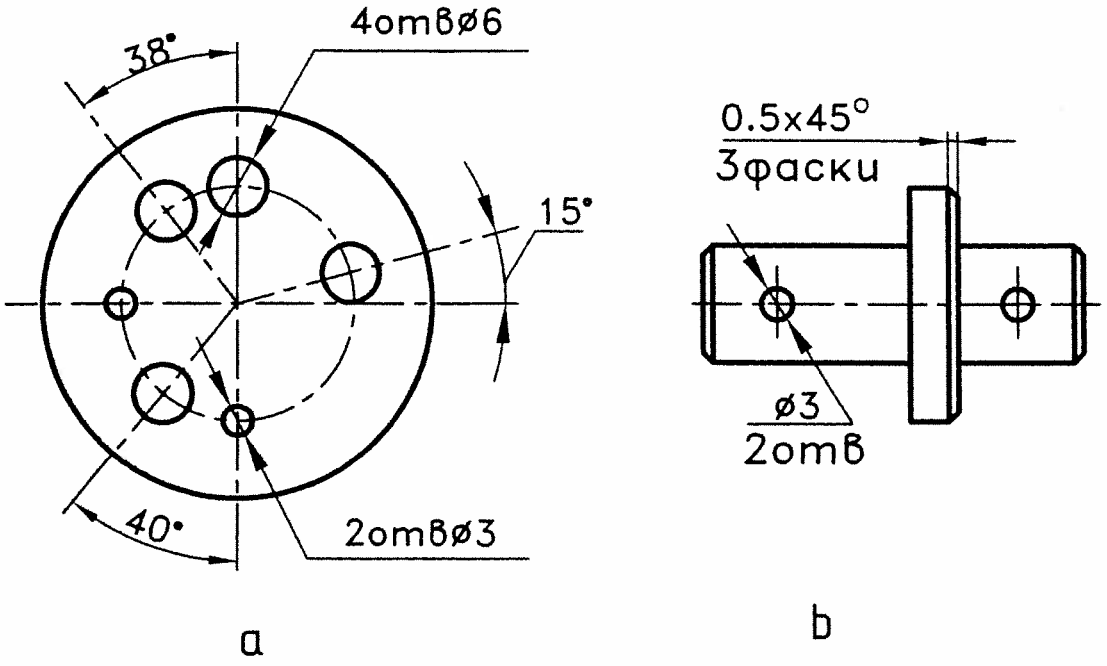


Fig.118

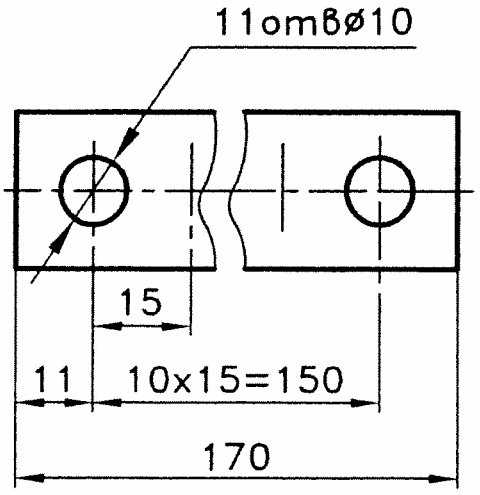


Fig.119

The dimension figure characterizing the conicity is preceded by the sign "◁", its acute angle must be pointed to the side of the cone vertex (Fig. 116, *a*). The sign of the cone and conicity in the form of the correlation should be given above the axial line or on the shelf of the extension line.

The surface slope should be shown on the view of the slope surface or on the shelf of the extension line (Fig. 116, *b*). The dimension line denoting the slope is preceded by the sign "∠", its acute angle must be pointed to the side of the slope.

A 45-degree chamfer is dimensioned as shown in Fig. 117, *a*. Chamfers cut at other angle are dimensioned according to general rules: either with the linear and angular dimensions (Fig. 117, *b*) or with two linear dimensions (Fig. 117, *c*).

Several similar elements are generally dimensioned only when accompanied by the indication of the number of these elements on the extension line (Fig. 118).

When dimensioning the distances between equally situated similar elements (holes, for example), instead of dimension chains adjoining elements are recommended to be dimensioned as well as the finite elements in the product form of the number of intervals between elements by the interval size (Fig. 119).

Questions for self-control

1. What is the importance of a Drawing?
2. What is a single complex of standards?
3. What standards are studied at the beginning of the drawing course?
4. What instruments and articles should be used to make drawings of graphical tasks?
5. What is a part sketch?
6. What can you tell about the standard "Sizes"?
7. Can you name diminution and increase scales stipulated by GOST 2.302-68?
8. What types of lines are used in an engineering drawing? Enumerate them.
9. What are thick continuous lines used for?
10. What are thin continuous lines used for?
11. What are short-dash lines used for?
12. What are thin dot-and-dash lines used for?
13. Can you tell about the title block on design drawings according to GOST2.104-68?
14. What is the GOST number which is named "Images-Views, Sectional Views and Sections"?
15. How many main (principal) views are stipulated by GOST 2.305-68? Can you name them?

16. What is a view?
17. What is a local view?
18. What is an auxiliary view?
19. What is a section?
20. What is a sectional view?
21. What is the difference between a section and a sectional view?
22. What is the classification of sectional views depending on the number of cutting planes?
23. What is a local sectional view called?
24. What are complex sectional views divided in?
25. What is the main difference between removed and revolved sections? Where are removed and revolved sections drawn?
26. What lines are used for the representation of removed and revolved sections?
27. What are sections and sectional views used for?
28. In what case is the position of the cutting plane not marked?
29. What is the classification of sectional views depending on the position of the cutting plane relative to the horizontal plane?
30. What is the geometrical principle of specifying sizes while making sketches and drawings of parts in engineering graphics?
31. What are form sizes?
32. What are position (coordinates) sizes?
33. What are overall dimensions (sizes)?
34. By what GOST are dimensioning rules stipulated?

§4. Representation of an Object in Axonometric Projections

4.1. Main Definitions

An axonometric projection is the representation of a geometrical object obtained by its parallel projecting onto some plane Π' together with the Cartensian system of rectangular coordinates *Oxyz* to which it belongs in space.

The reversibility of axonometric projections is conditioned by the fact that not only a geometrical object with the Cartensian system of rectangular coordinates is

projected onto the axonometric plane, but also one of its orthographic projections is projected onto the coordinate plane.

Fig. 120 shows an example of constructing the axonometry of the point A belonging to the Cartensian system of coordinates $Oxyz$. The direction of projecting S is chosen not to be parallel to any coordinates axis. An arbitrary plane Π' onto which the projection is made is called the plane of axonometric projections. Axes x', y', z' — projections of coordinate axes x, y, z are called axonometric axes. The point A' — is an axonometric projection of the point A, the point A_1' being its secondary projection. The projections A' and A_1' provide the reversibility of the axonometric drawing.

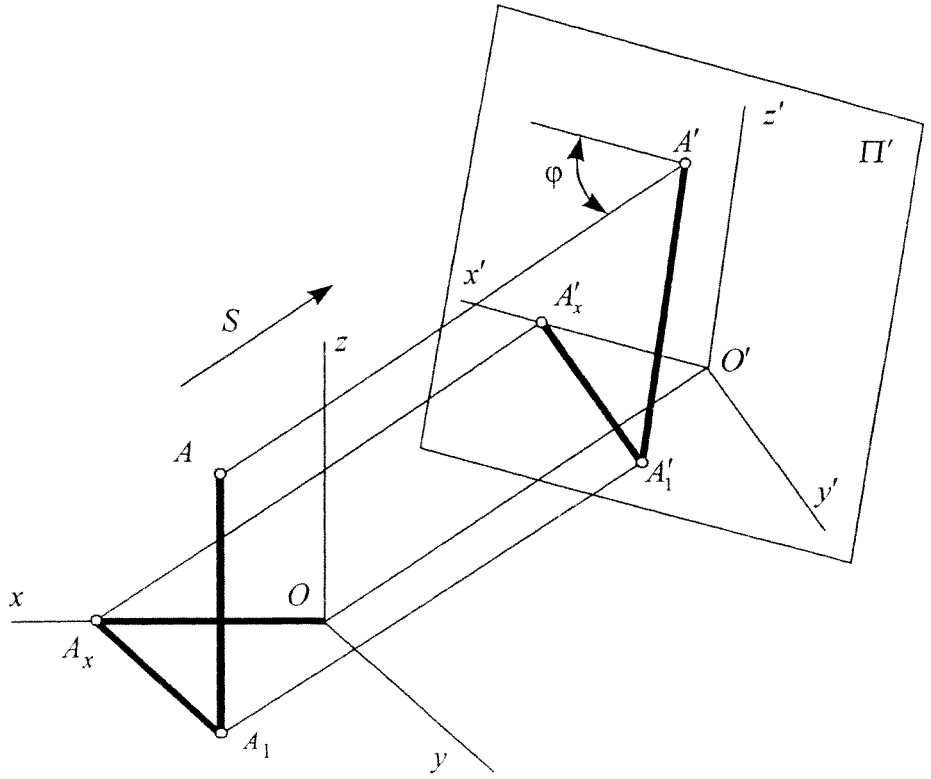


Fig. 120

Since the plane Π' is not generally parallel to any coordinate axis x, y, z, it is obvious that the axis segments or segments parallel to them are projected onto the plane Π' with a distortion.

The ratio of the axonometric projection length of the segment of the coordinate axis or the segment parallel to this axis to the segment length itself is called the distortion factor along the axes and is designated:

along the axis X: $u = \dfrac{O'A_X'}{OA_X}$;

along the axis Y: $v = \frac{A'_X A'_1}{A_X A_1}$;

along the axis Z: $w = \frac{A'_1 A'}{A_1 A}$.

4.2. Axonometry Types

Depending on the projection direction axonometric projections are divided into rectangular, i.e. the direction of projecting is perpendicular to the plane Π' and the oblique ones, i.e. the direction of projecting is not perpendicular to the plane Π'.

According to the comparable value of distortion factors along the axes, axonometry can be divided into three types, such as:

1) *isometry*, when three distortion factors are equal: $u = v = w$;

2) *dimetry*, when two distortion factors are equal, whereas the third one is not equal to the former two, e.g. $u = w \neq v$;

3) *trimetry*, when all three distortion factors are not equal: $u \neq v \neq w$.

The mail rule of the axonometry was formulated by the German scientist K. Polke and later it was generalized by G. Shwartz: "Any three segments drawn from one point of the plane can be assumed to be parallel projections of three equal and mutually perpendicular segments in space".

According to this theorem any three lines drawn from one point and not coinciding between each other are assumed to be axonometric axes. Any arbitrary segment lengths on these lines lain off from the intersection point can be assumed as axonometric scales. Distortion factors are joined by the following relationship:

$$u^2 + v^2 + w^2 = 2 + ctg\varphi \ ,$$

where φ — an angle between the projection direction and the plane of axonometric projections. In a rectangular axonometry, when $\angle\varphi = 90°$, this relationship has the view

$$u^2 + v^2 + w^2 = 2 \ , \qquad (1)$$

i.e. the sum of squares of distortion factors is equal to 2.

GOST 2.317–69 recommends using the following types of axonometric projections on drawings for all branches of industry and engineering:

1) rectangular projections — isometric and diametric projections;

2) oblique projections — frontal and horizontal isometric projections, a frontal diametric projection.

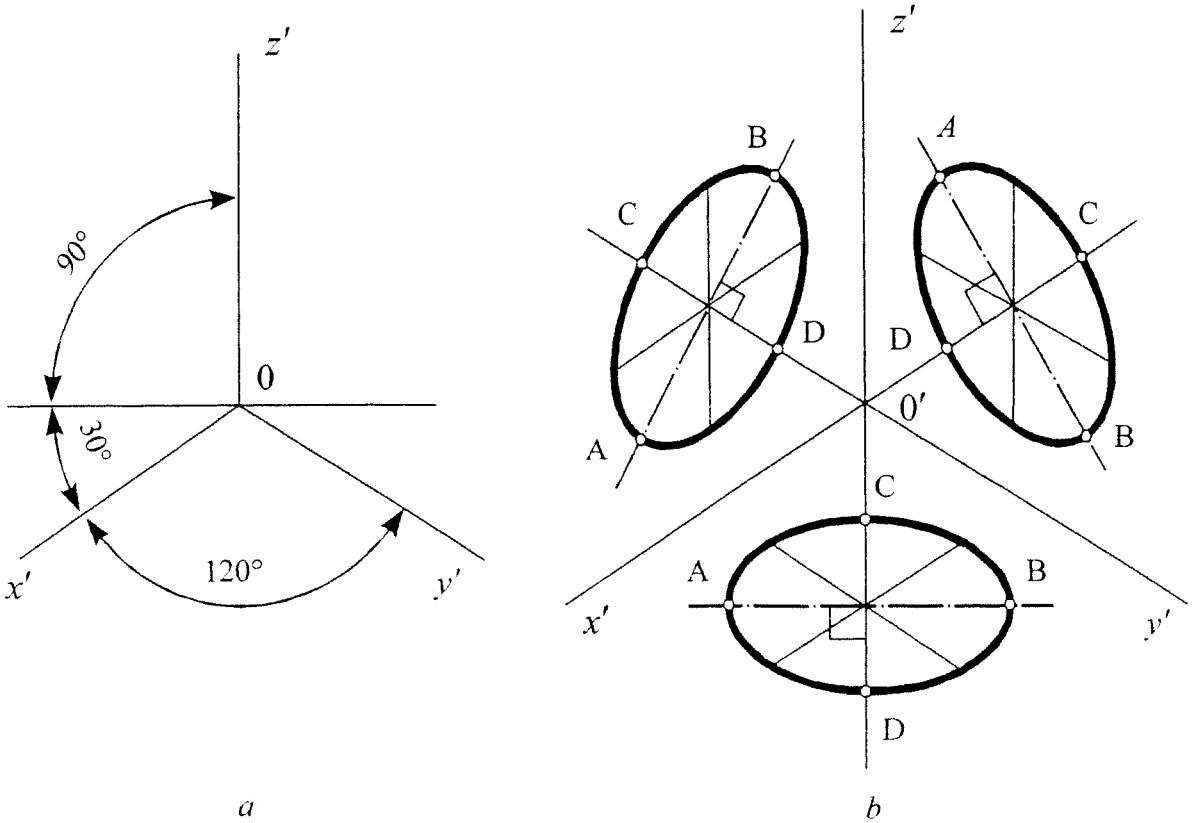
4.3. Rectangular Isometry

The location of axonometric axes is given in Fig. 121, *a*. From the relationship (1) for a rectangular isometry we obtain

$$3u^2 = 2 \quad \text{or} \quad u = v = w = \sqrt{\frac{2}{3}} \approx 0{,}82 \ ,$$

i.e. the segment of coordinate axes 100 mm in length will be shown in a rectangular isometry by a segment of an axonometric axis 82 mm in length.

In practice the isometric projection is generally made without distortion along the axes x, y, z, i.e. $u = v = w = 1$. The drawing thus made will be 1,22 times larger than the object itself, i.e. the drawing scale in a rectangular isometry will be M 1,22 : 1.



a *b*

Fig. 121

Circles belonging to projection planes or planes parallel to them are projected onto the axonometric projection plane as ellipses. If an isometric projection is made with a distortion factor $u = v = w = 0{,}82$, the major ellipse axis is equal to the diameter of the circle, the minor axis being equal to 0,58 of the circle diameter. If $u = v = w = 1$, the major ellipse axis is equal to 1,22, the minor one being

equal to 0,71 of the circle diameter. The location of the major and the minor axes of ellipses is shown in Fig. 121, *b*. Ovals are generally constructed instead of ellipses. Such a substitution does not influence the representation evidence.

Fig. 122 indicates one of the ways of constructing a four-centre oval replacing an ellipse in a rectangular isometry.

Fig. 124 shows a hexagonal in isometry located parallel to frontal (*a*), horizontal (*b*) and profile (*c*) projection planes.

4.4. Rectangular Dimetry

The position of axonometry axes is given in Fig. 125, *a*. From the relationship (1) for the rectangular dimetry we obtain the following:

$$u^2 + \left(\frac{u^2}{2}\right) + u^2 = 2;$$

$$u^2 = \frac{8}{9},\ u = w = \sqrt{\frac{8}{9}} \approx 0{,}94,\ v = 0{,}47.$$

In practice the dimetric projection is generally constructed undistorted along the axis x and z with the distortion factor of 0,5 along the axis y. The representation scale in a rectangular dimetry is 1,06 : 1.

Circles belonging to projection planes or planes parallel to them are projected onto the axonometric projection plane into ellipses. If a dimetric projection is constructed with the distortion factors $u = w = 1$ and $v = 0{,}5$, the major axis of ellipses *1*, *2*, *3* (Fig. 125, *b*) is equal to 1,06 of the circle diameter, while the minor axis *1* = 0,95 of the circle diameter, axes of ellipses *2* and *3* are equal to 0,35 of the circle diameter. If a diametric projection is constructed with the distortion factor $u = w = 0{,}94$ and $v = 0{,}47$, the major axis of ellipses *1*, *2*, *3* is equal to the circle diameter, the minor axis of the ellipse *1* — 0,9 of the circle diameter the axis of ellipses *2* and *3* is equal to 0,33 of the circle diameter.

The position of the major and minor axes of ellipses *1*, *2* and *3* is shown in Fig. 125, *b*.

For the sake of simplicity ellipses are replaced with ovals. Fig. 123 indicates the way of constructing an oval, if AB=1,06d and CD=0,35d (see ovals *2* and *3*

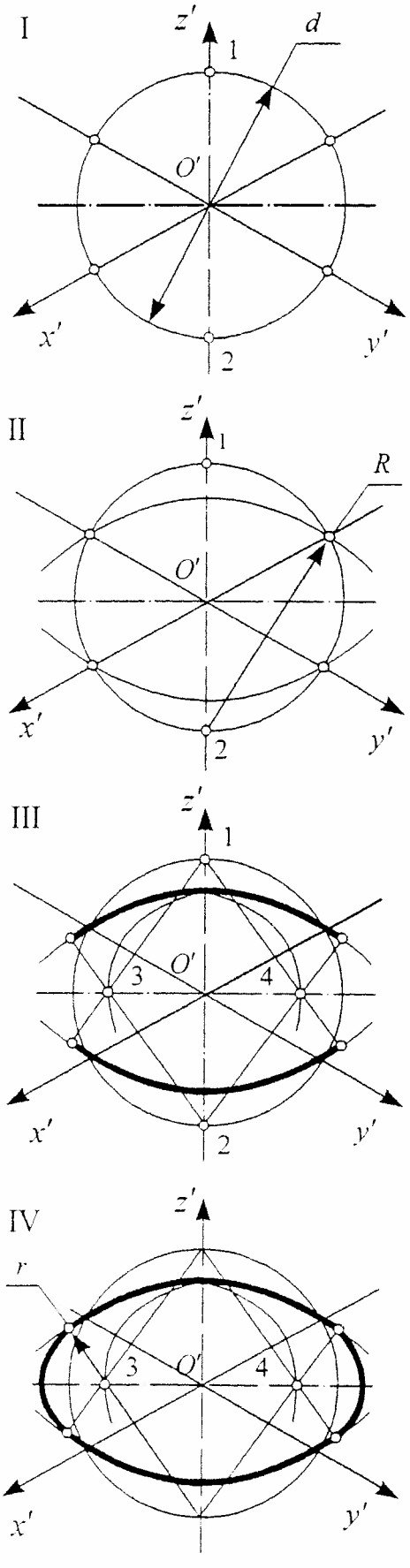


Fig. 122

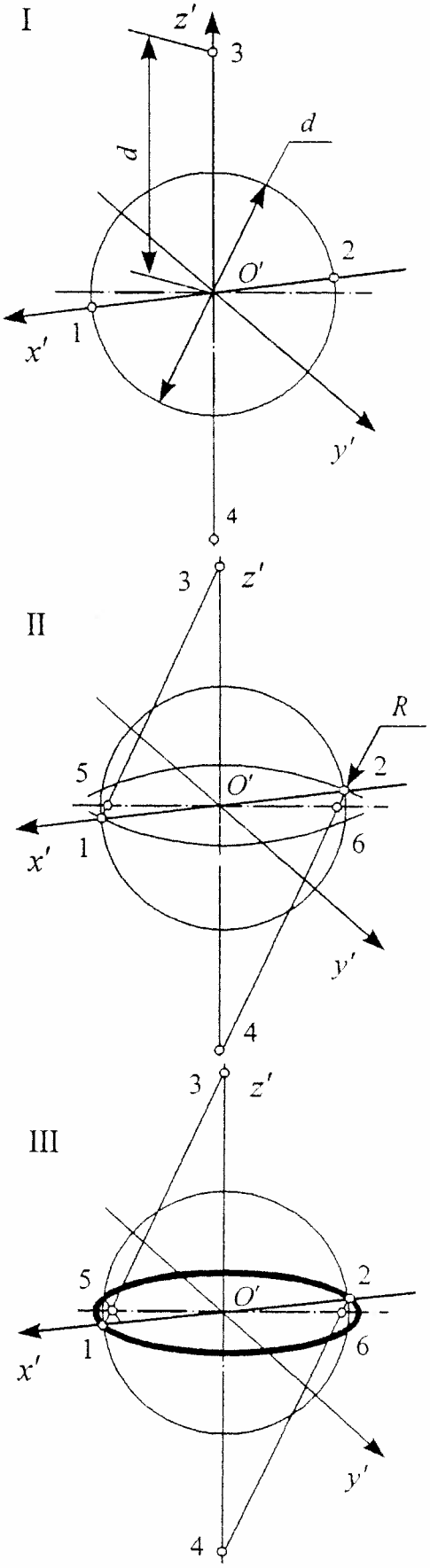
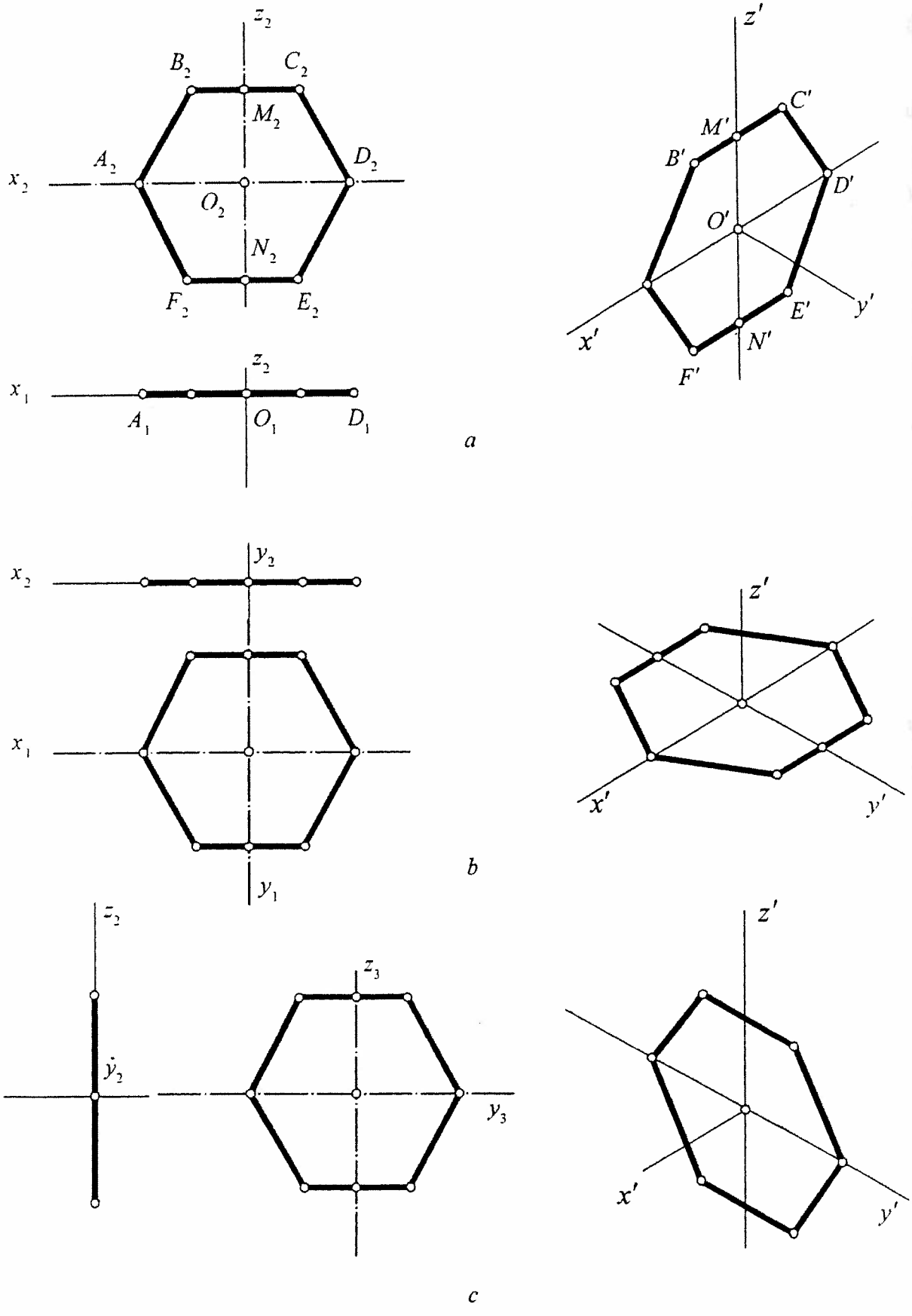


Fig. 123


z_2
B_2
C_2
M_2
A_2
D_2
x_2
O_2
N_2
F_2
E_2
z_2
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A_1
O_1
D_1
a
z'
C'
M'
B'
D'
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y'
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y_2
x_2
x_1
y_1
b
z'
x'
y'
z_2
z_3
y_2
y_3
c
z'
x'
y'

Fig. 124

in Fig. 125, *b*). The construction of the oval with tthe major axis $AB=1{,}06d$ and the minor axis $CD=0{,}94d$ (see oval 1 in Fig. 125, *b*) is illustrated in Fig. 126.

Fig. 127 indicates a pentagon in dimetry located parallel to horizontal (*a*), frontal (*b*) and profile (*c*) projection planes.

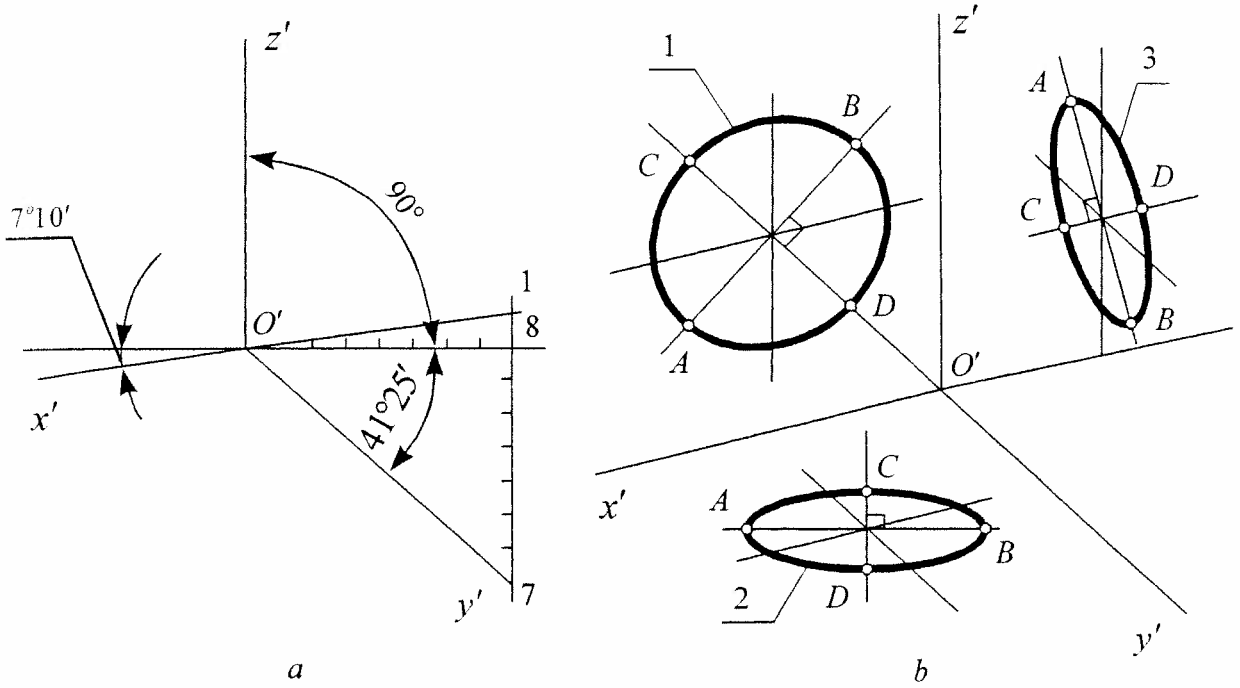


Fig. 125

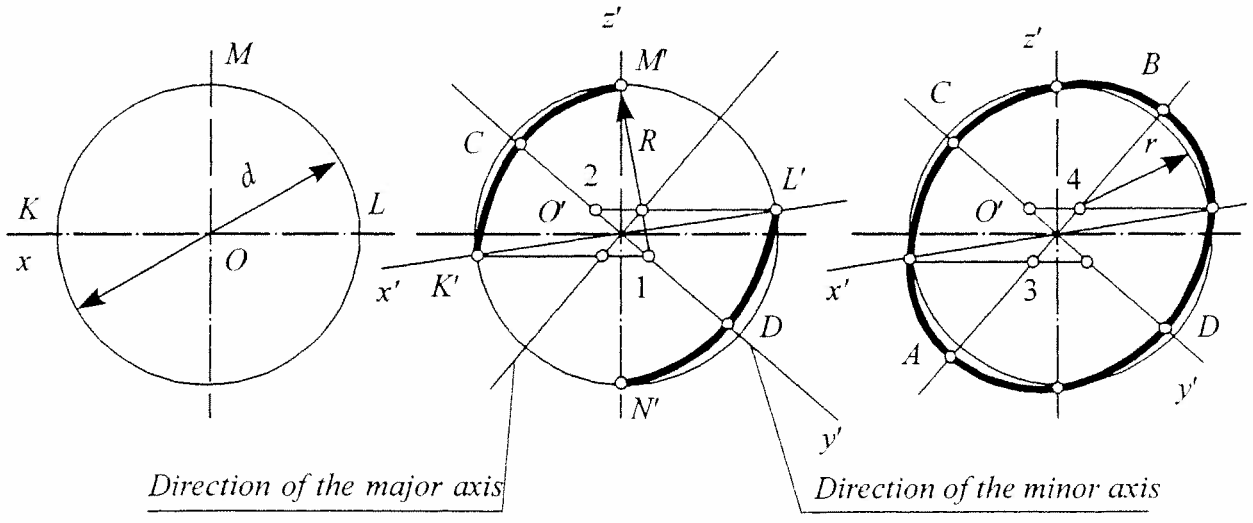


Fig. 126

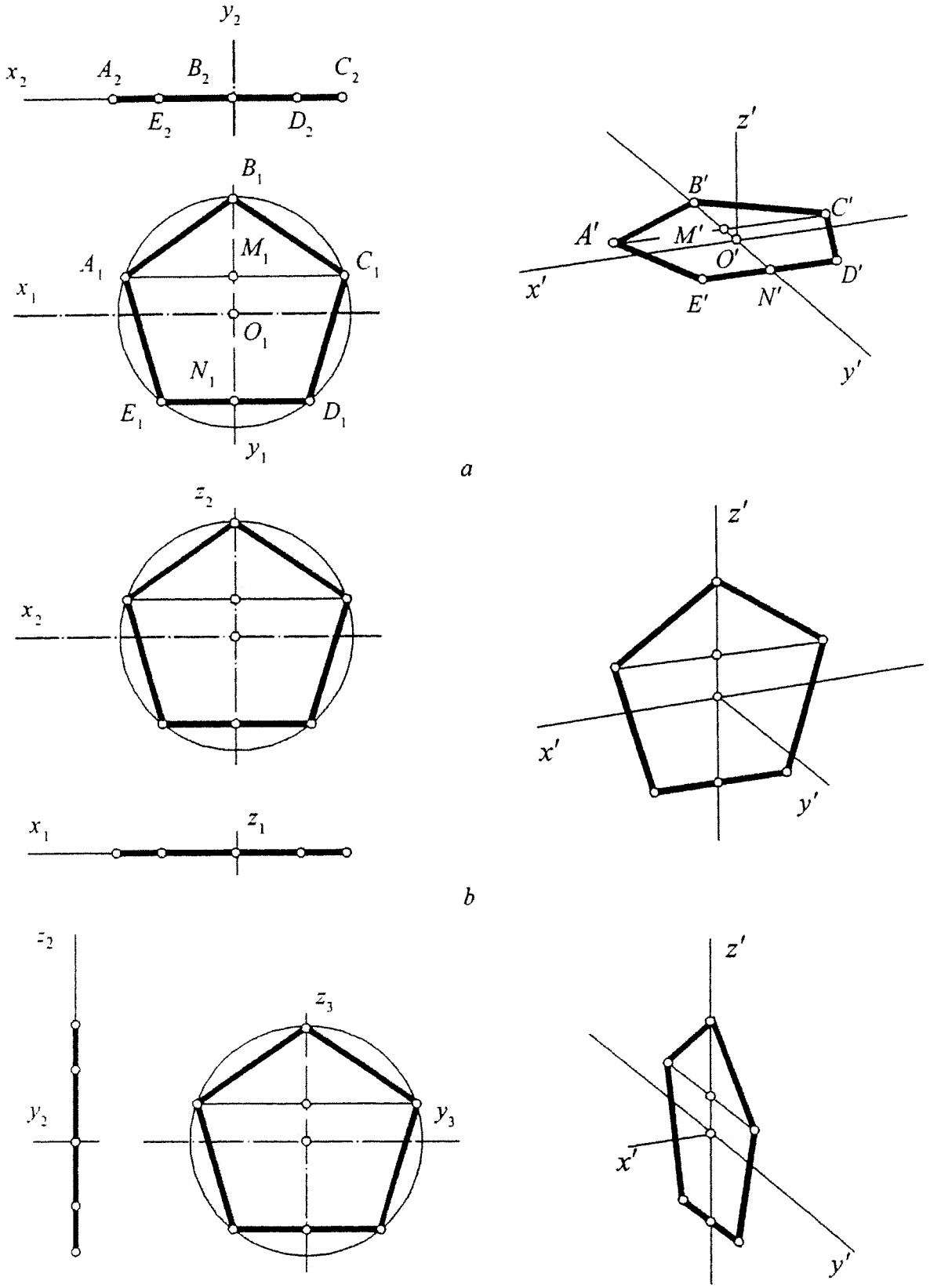

y_2
x_2
A_2
B_2
C_2
E_2
D_2
B_1
A_1
M_1
C_1
x_1
O_1
N_1
E_1
D_1
y_1
z'
B'
C'
A'
M'
O'
D'
x'
E'
N'
y'
a
z_2
x_2
x_1
z_1
z'
x'
y'
b
z_2
z_3
y_2
y_3
z'
x'
y'
c

Fig. 127

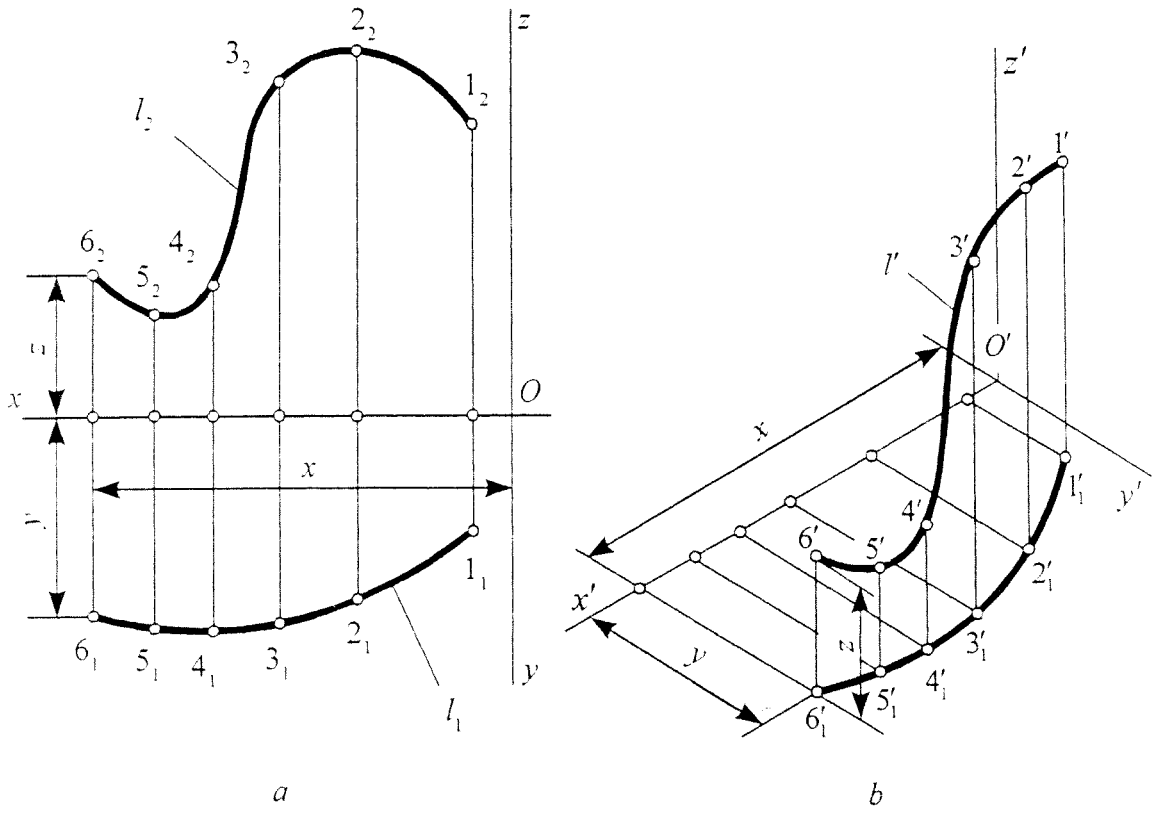


Fig. 128

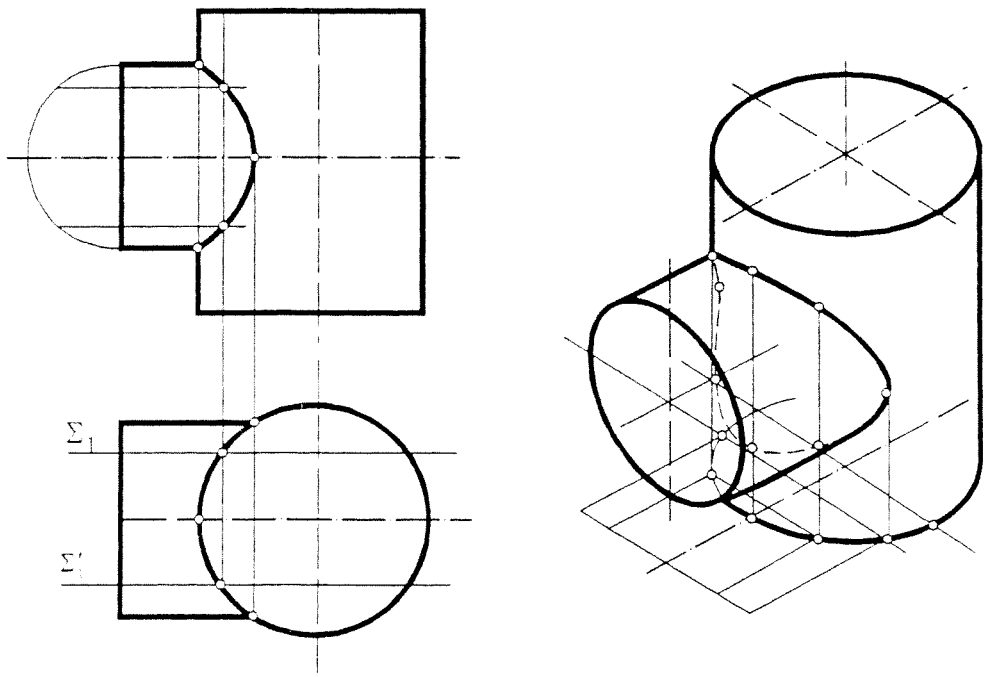


Fig. 129

4.5. Constructing of Axonometric Projections of Curved Lines

Axonometric projections of a curved line should be constructed in the following way (Fig. 128):

1) refer the given line to the Cartesian system of coordinates (Fig. 128, *a*);

2) take points 1, 2, 3 ... on the curved line and define their coordinates (see Fig. 128, *a*);

3) using coordinates of points 1, 2, 3 ... construct their secondary projections $1'_1$, $2'_1$, $3'_1$, ... (Fig. 128, *b*);

4) draw straight lines parallel to the axis z' through the secondary point projection and lay off z — axes of points;

5) connect the obtained axonometric point projections 1′, 2′, 3′, ... n′ by a smooth curved line l' which is an axonometric projection of the curved line l.

The axonometric projection of the intersection line of two surfaces is constructed similarly (Fig. 129).

4.6. Sequence of Constructing Axonometric Projections of Objects

Two ways of constructing axonometric projections of objects are recommended:

1) constructing object sections by planes parallel to coordinate planes with further constructions till the complete axonometric representation of an object (Fig. 130);

2) constructing the axonometry of the whole object with further constructing sectional views by planes parallel to coordinate planes (Fig. 131).

The first way is more rational since all unnecessary lines are removed from the drawing.

In any case the process of constructing should be divided into two steps.

Step I — preparatory:

1) read the drawing;

2) choose the type of the axonometric projection;

3) determine what sectional views are required to reveal the internal part of an object (cutting planes must be parallel to the coordinate planes x′O′z′ and y′O′z′);

4) determine the sequence of constructing the representation of surfaces limiting the object.

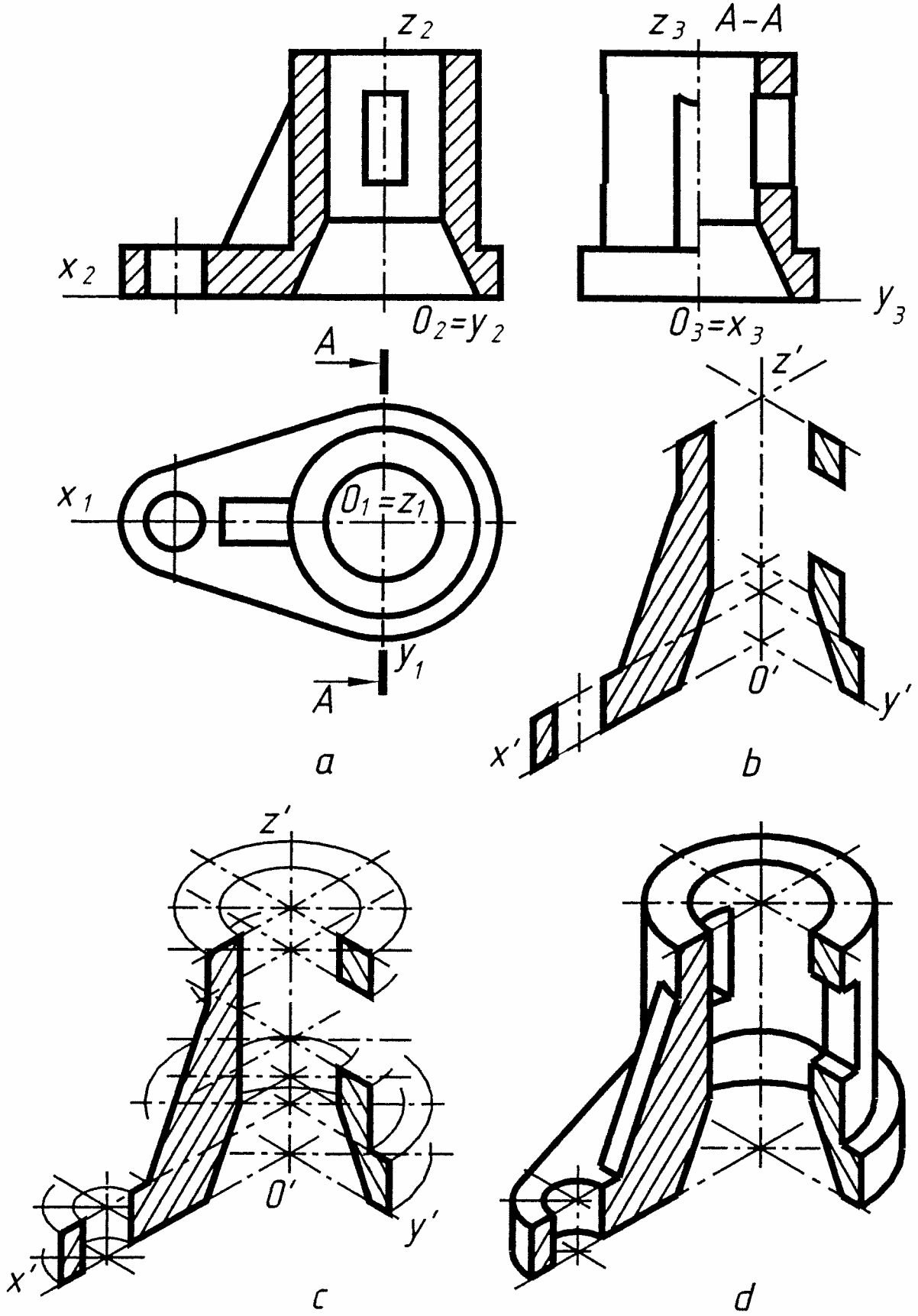


Fig. 130

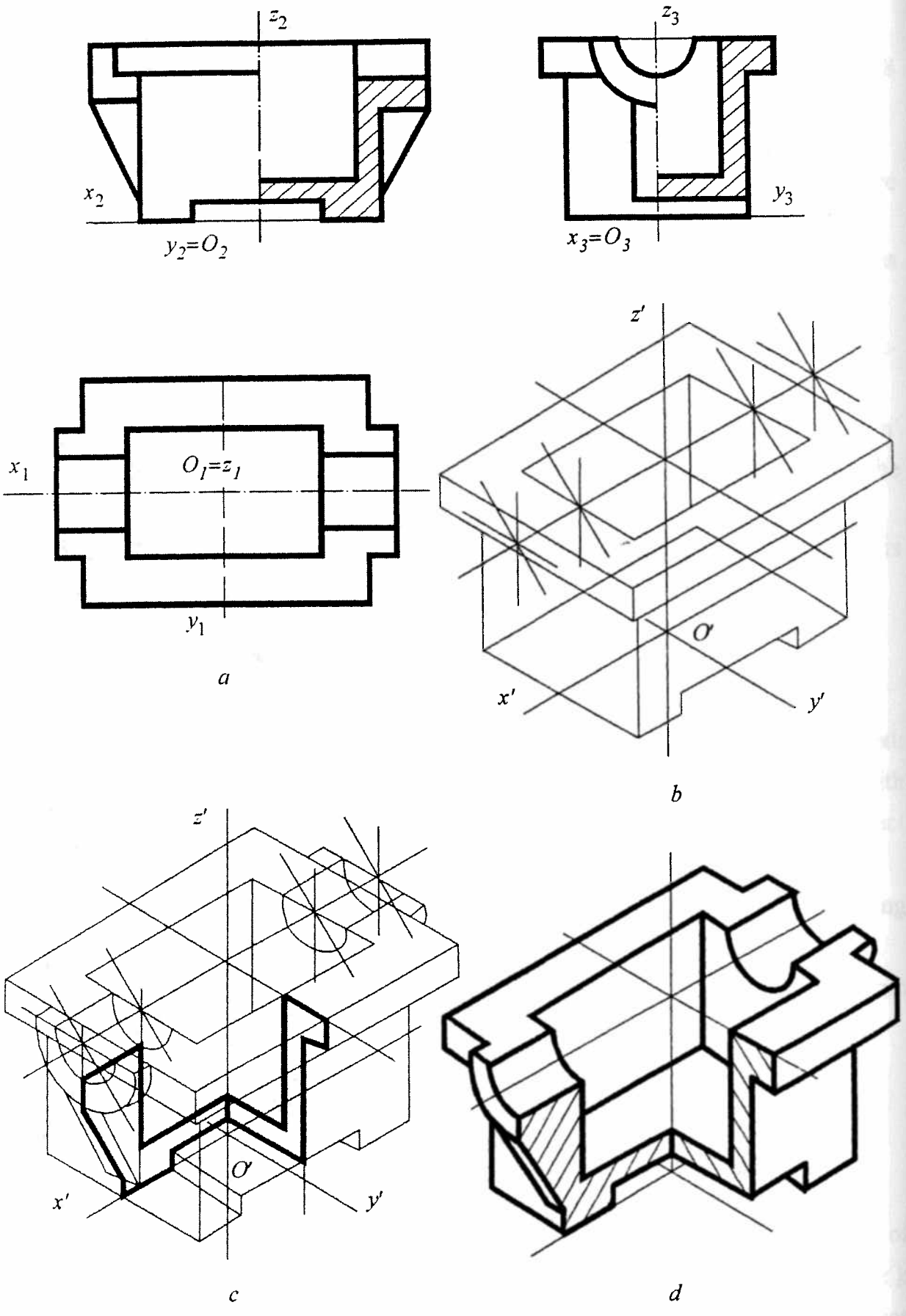
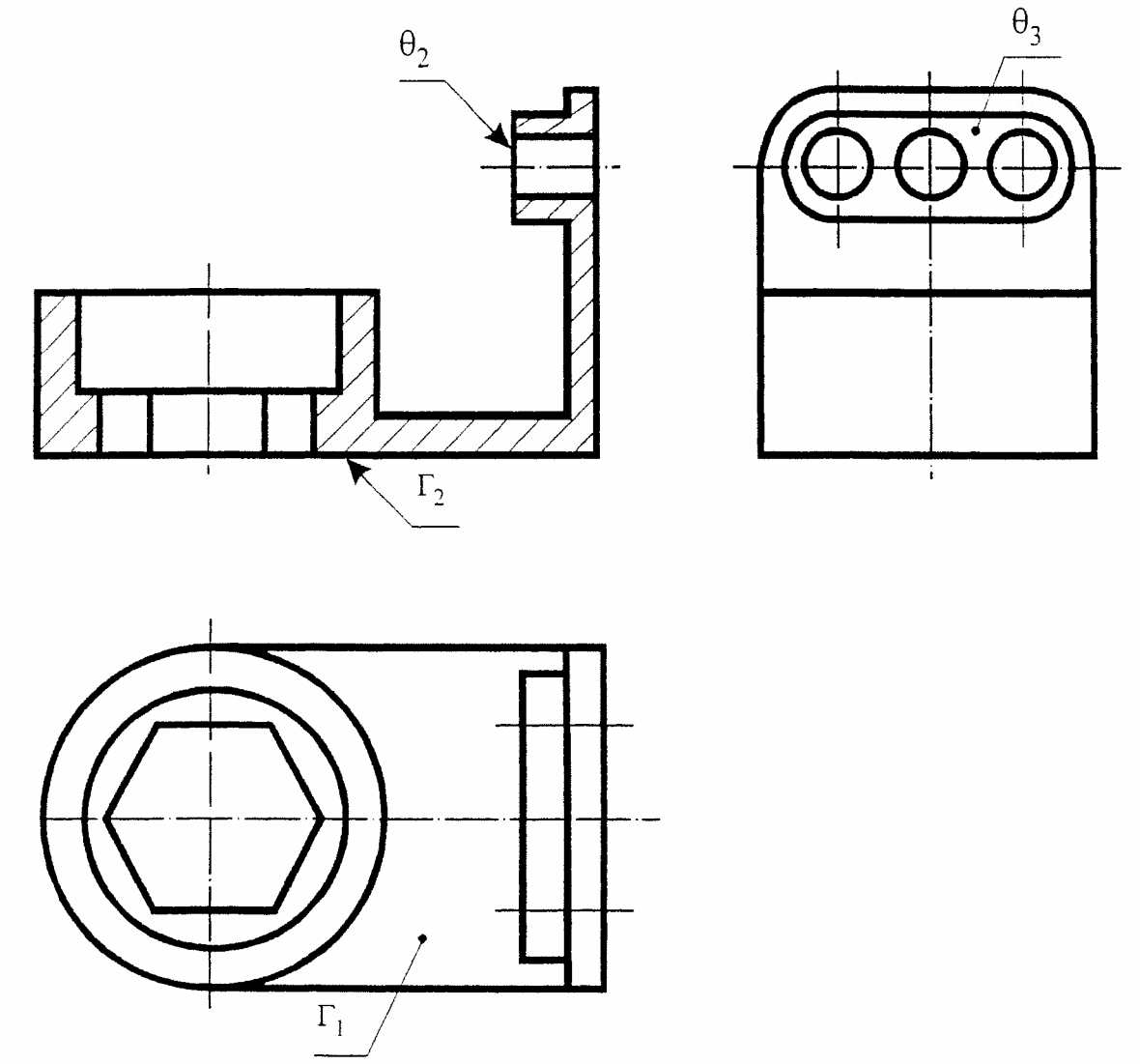


Fig. 131



a

b

c

Fig. 132

Step II — graphical (see Fig. 130):

1) refer the given object to the Cartesian system of coordinates and construct projections of coordinate axes on the drawing (Fig. 130, *a*);

2) construct axonometric axes and axonometric projections of sections with coordinate planes x′O′z′ and y′O′z′; construct axonometric projections of all circle centers (Fig. 130, *b*);

3) construct ellipses which are projections of cylinder circles and cone bases bounding separate parts of a machine part (Fig. 130, *c*);

4) construct linear sections and outline the lines of the visible outline of the detail (Fig. 130, *d*);

5) remove auxiliary lines, make a hatching and the final outline of the drawing.

The graphic representation of the second way of constructing the detail axonometry is given in Fig. 131.

In teaching practice it is sometimes necessary to construct an axonometric plane figure. Fig.132 indicates the rectangular dimetry of the plane figure $\Gamma(\Gamma_1,\Gamma_2)$ (Fig. 132, *a, b*) and the rectangular isometry of the figure $\theta\ (\theta_2,\theta_3)$ (Fig. 132, *a, c*).

4.7. Conventionalities of Constructing Axonometric Projections

According to GOST 2.317-69 section lines are hatched parallel to one of the diagonals of square projections belonging to corresponding coordinate planes, their sides being parallel to axonometric axes, in the rectangular dimetry — Fig. 133, *a*, in the rectangular isometry — Fig. 133, *b*.

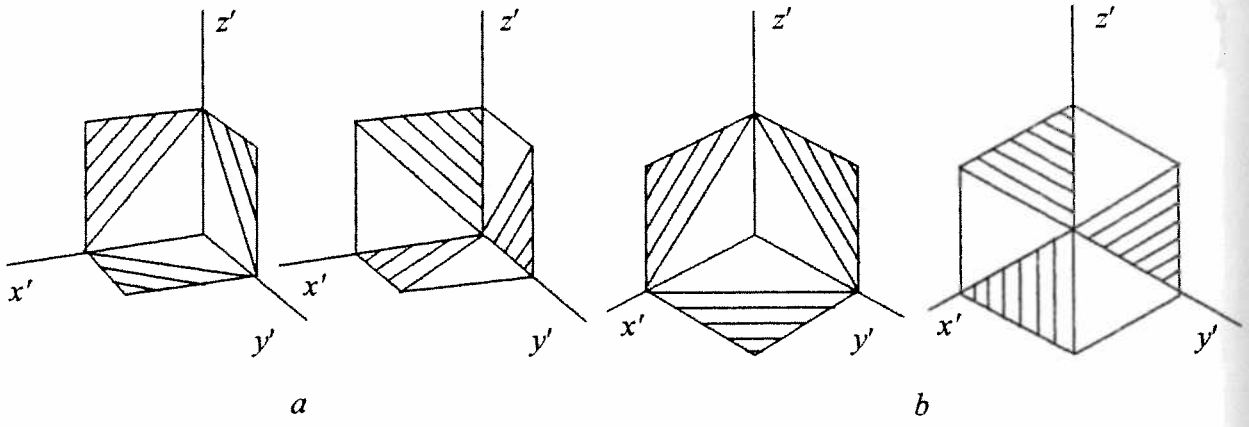


Fig. 133

Questions for self-control

1. What is an axonometric projection of a geometrical object?
2. By what GOST are axonometric projections rules of construction stipulated?
3. What is the distortion factor along the axes?
4. Could you name (enumerate) three types of axonometry according to the distortion factors along the axes?
5. What is the secondary projection of a point?
6. What is the difference between an oblique and a rectangular axonometric projection?
7. What is the rule of hatching sections in axonometric projection?
8. Could you tell about the construction of four center oval replacing an ellipse in isometry (In dimetry – onto axonometric planes xOy and xOz)?

§ 5. Threads

Most commonly used in engineering practice are detachable joints of machine parts, which are made by means of threads.

A thread is a screw protrusion located on the surface of a cylinder or a revolution cone (Fig. 134). In the first case the thread is called cylindrical (Fig. 134, *a*) whereas in the second one – conical (Fig. 134, *b*).

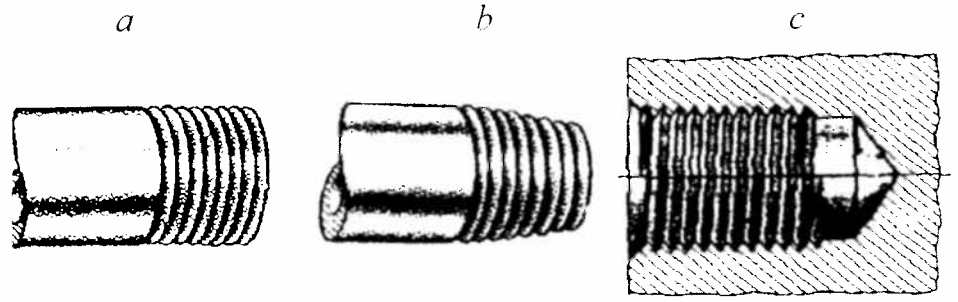


Fig. 134

The sectional view of the screw protrusion obtained by the plane passing through the thread axis is called the thread profile. The angle between the side faces of the profile is called the profile angle (angles 60° and 30° in Fig. 135, *a,b,d*).

According to the profile shape threads are classified into triangular, trapezoidal, rectangular and circular (Fig. 135). The thread with the triangular profile is called a screw thread since it is cut on fasteners, such as bolts, studs, screws, nuts, etc. The cylindrical thread with a triangular profile with an angle of 60° at the vertex is called a metric thread, and that with an angle of 55° – a pipe thread. Threads with trapezoidal and rectangular profiles (Fig. 135, *b,c*) are called motion threads as they are cut on pieces used for transforming the rotary motion into the translational one (motion machine screws, jack screws, etc). Threads with circular profiles are used in sanitary and electrical engineering fittings.

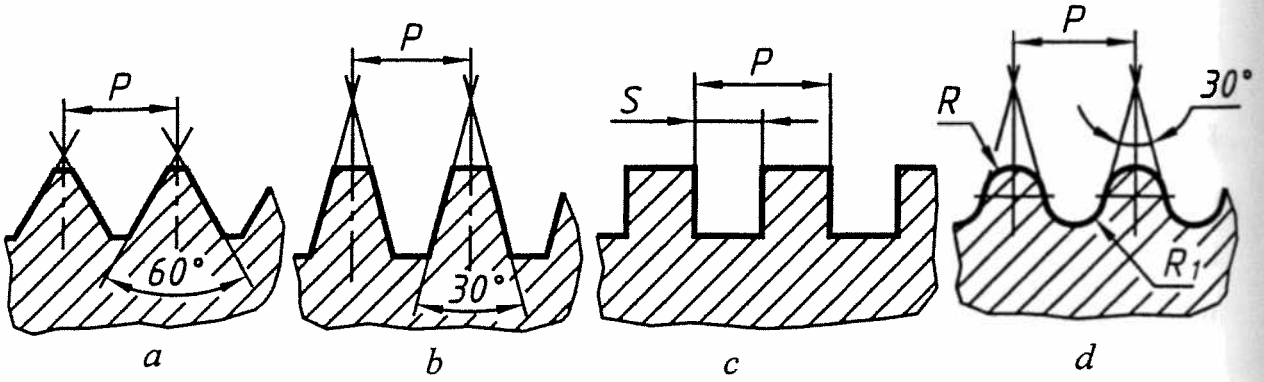


Fig. 135

Depending on the direction of the helix rise threads are divided into right-hand and left-hand threads (Fig. 136).

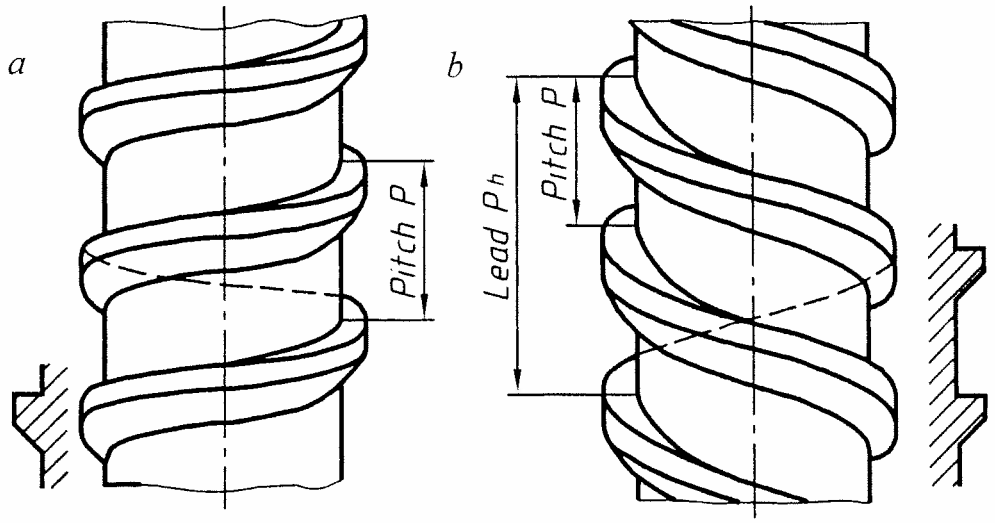


Fig. 136

According to the member of parallel helices threads are divided into single and multiple threads, the number of helices can be counted on the face of the bar or the hole.

The distance between the neighbouring identical lateral sides of the profile measured parallel to the thread axis is called the *pitch* (P) (Fig. 136, *a*). The distance between the nearest identical lateral sides of the profile, belonging to one and the same a screw protrusion measured parallel to the thread axis is called the *lead* (P_n) (Fig. 136, *b*).

On a single-thread screw the lead and the pitch are identical, on a double-thread screw the lead is twice the pitch; on a triple-thread screw – three times the pitch, etc. Thus, for a screw having *n* threads, the lead P_n is equal to the pitch P multiplied by the number of threads, i.e., $P_n = P \times n$.

Three diameters of threads are distinguished such as:

d – major diameter of the external thread (bolt);

D – major diameter of the internal thread (nut);

d_2 – middle diameter of the bolt thread;

D_2 – middle diameter of the nut thread;

d_1 – minor diameter of the bolt thread;

D – minor diameter of the nut thread (Fig.137).

The portion with the thread finite helixes with incomplete profile are called the vanish, or washout threads (Fig. 138). It is formed during removing the cutting tool.

The vanish is not usually shown on drawings. The thread length is assumed to be the thread length of the complete profile in which the chamfer is included at the end of the bar or at the beginning of the hole (Fig. 138).

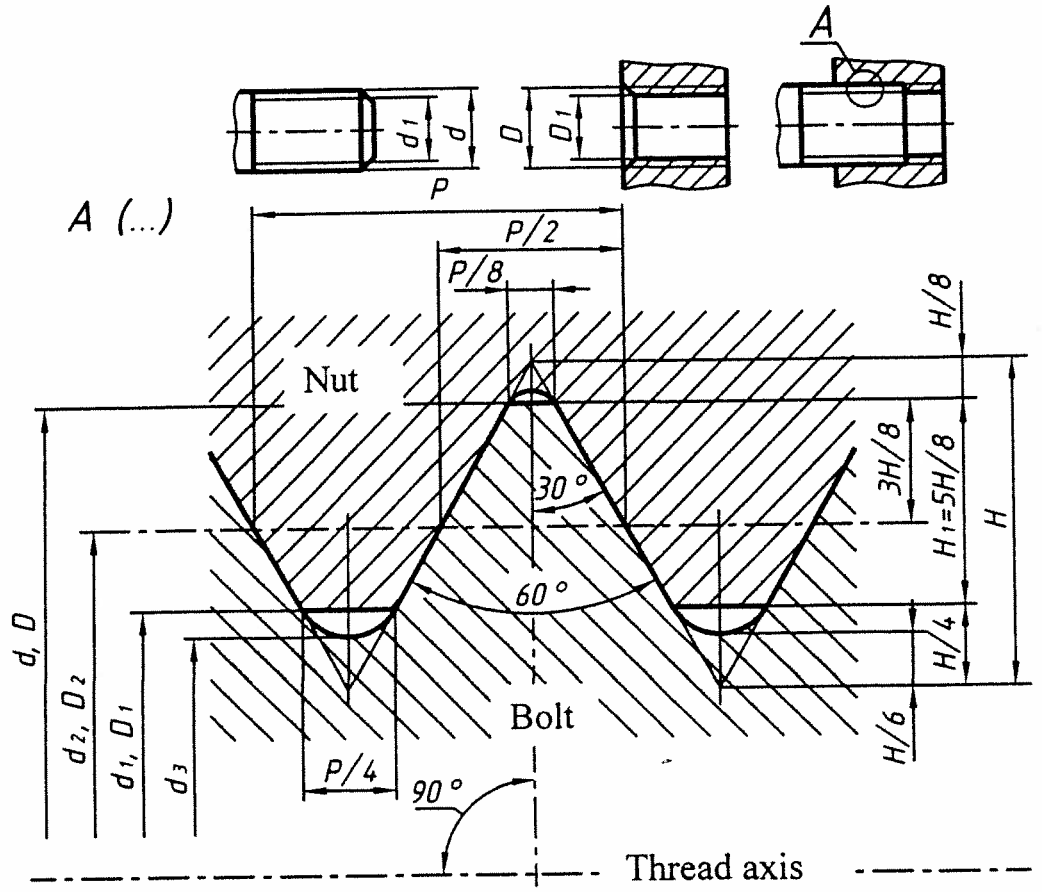
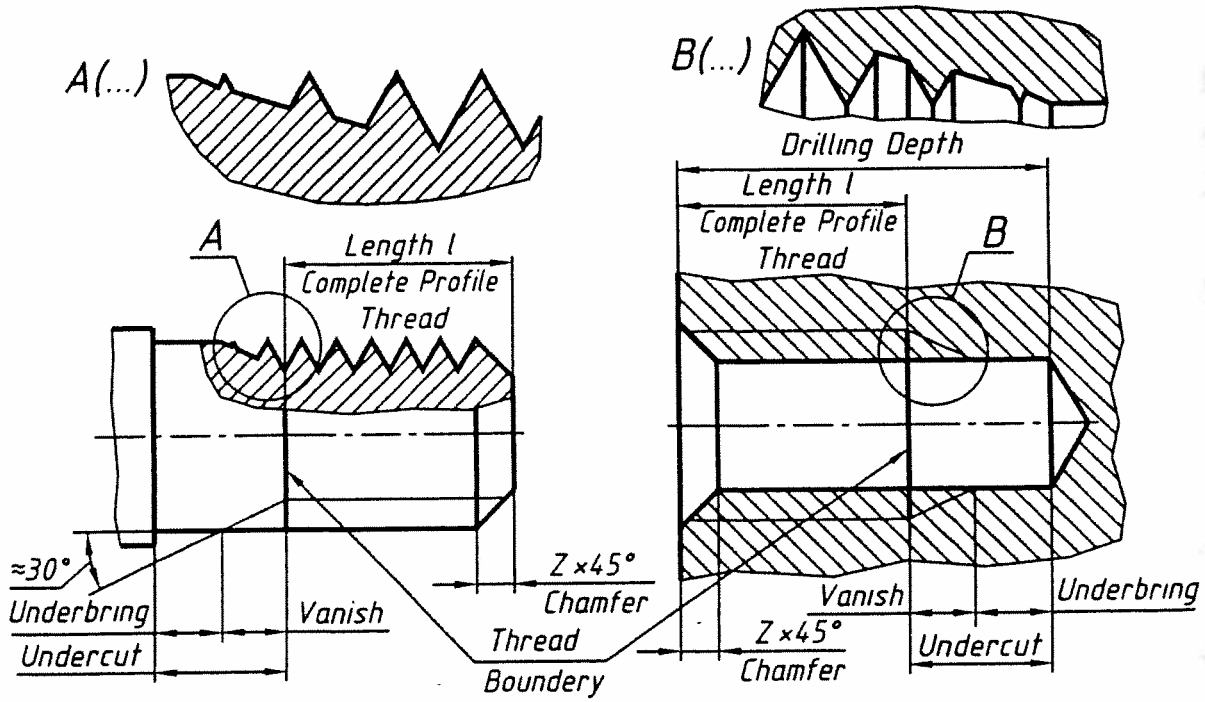


Fig. 137. Metric Thread



a *b*

Fig. 138

In order to avoid the formation of the rise a special recess for the removing of the thread-cutting instrument is made on the piece (Fig. 139 *a, b*). The recess width (Fig. 139 *a, b*) is included in the thread length *l*. The recess sizes are given in Table 1, the chamfer sizes at the ends of the bolts, screws and studs are shown in Table 2.

All the rest thread types are specified in detail by GOST 11708-82. All threads used in engineering except rectangular ones are standardized (Table 3).

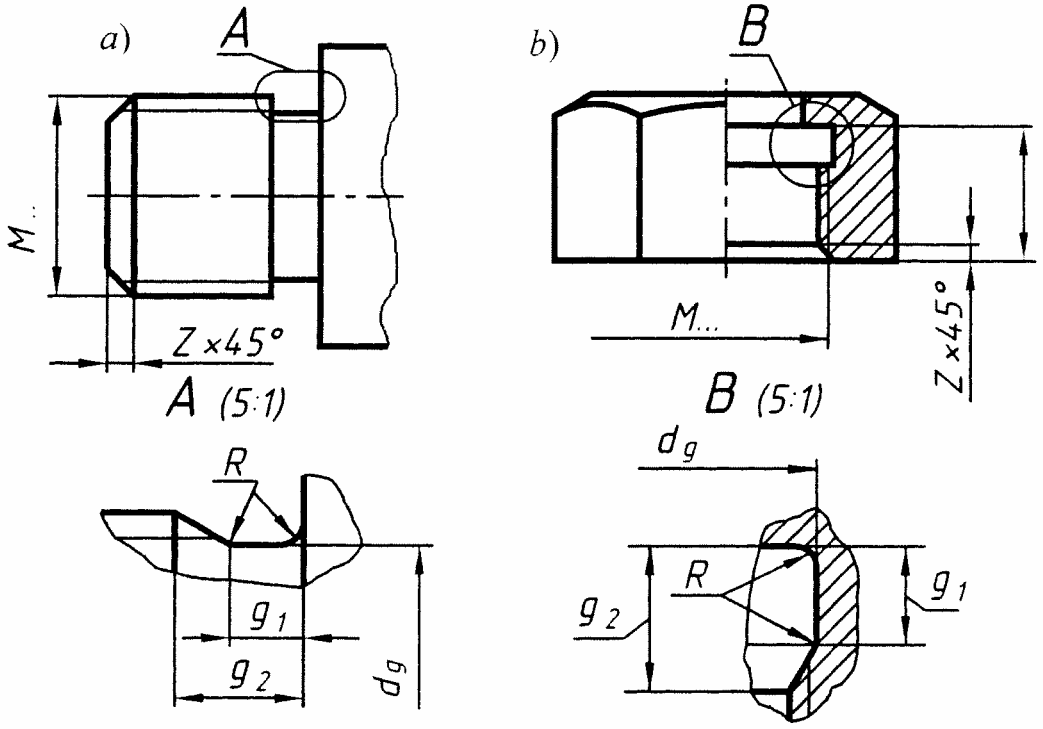


Fig. 139. Recess for Metric Thread: *a* — major, *b* — minor

Table 1

Recess Sizes (According to GOST 27148-86, mm)

Thread pitch P	Radius R	Major (Fig. 139, *a*)			Minor (Fig. 139, *b*)				
		q_1 not <	q_2 not >	d_g	normal	narrow	normal	narrow	d_g
					q_1 not <		q_2 not >		
1,0	0,5	1,6	3,00	d-1,6	4,0	2,5	5,2	3,7	d+0,5
1,25	0,6	2,0	3,75	d-2,0	5,0	3,2	6,7	4,9	d+0,5
1,5	0,8	2,5	4,50	d-2,3	6,0	3,8	7,8	5,6	d+0,5
1,75	1,0	3,0	5,25	d-2,6	7,0	4,3	9,1	6,4	d+0,5
2,0	1,0	3,4	6,00	d-3,0	8,0	5,0	10,3	7,3	d+0,5
2,5	1,2	4,4	7,50	d-3,6	10,0	6,3	13,0	9,3	d+0,5
3,0	1,6	5,2	9,00	d-4,4	7,0	7,5	15,2	10,7	d+0,5

Table 2

Chamfer Sizes. According to GOST 10549-80, mm

Thread pitch P	1	1,25	1.5	1.75	2	2.5	3
Chamfer Z×45°	1	1.6	1.6	1.6	2	2,5	2.6

Table 3

Thread Designations

Thread type	Standard number	Conventional designation of thread type	Thread parameters shown on drawings	Examples of thread designations
1	2	3	4	5
Metric coarse(60°)	GOST 9150-81 (profile), GOST 8724-81, GOST 16967-81 (diameters and pitches)	M	Major diameter allowance field LH – for left-hand thread.	External: M16–6g. Internal: M12–6H. Left-hand thread: M12LH–6g; M12LH–6H
Metric fine(60°)	GOST 24705-81, GOST 24706-81(main sizes) GOST 16O93-81, (allowances)		Major diameter, pitch, allowance field LH for left–hand thread	External: M12x1–6g. Internal: M12x1–6H. Left–hand thread: M12x1LH–6g, M12x1Lh–6H.
Trapezoidal singlestart thread (30°)	GOST 9484-81(profiles), GOST 24738-81(diameters and pitches) GOST 9562-81 (allowances)	Tr	Major diameter, pitch, LH – for left–hand thread, allowance field	External: Tr40x6–7e. Internal: Tr40x6–7H. Left–hand: Tr40x6LH–7e, Tr40x6LH–7H.

1	2	3	4	5
Trapezoidal, multistart thread (30°)	GOST 24739-81(diameters, pitches, thread leads allowances), GOST 9484-81 (profiles)	Tr	Major diameter, in brackets and numerical pitch value LH- –for left-hand thread, allowance field	Externals Internals Tr20 x8(P4)–7H Left-hand: Tr20x8(P4)LH–8e, Tr20x8(P4)LH–7H
Buttress thread (33°)	GOST 10177-82 (profile, diameters, pitches, main sizes), GOST 25096-82 (allowances)	S	Major diameter, pitch, LH--for left-hand thread, allowance field	S80x10–7h S80x10LH–7h
Pipe cylindrical thread (55°)	GOST 6357-81 (profile, main sizes, allowances)	G	Designation of thread size, accuracy class, LH – for left-hand thread	G 11/2–A G 11/2–B G 11/2 LH–A G1 1/2LH–B
Pipe Taper thread (55°)	GOST 6211-81 (profile, main sizes, allowances)	R – major thread; R_c– minor thread	Designation of thread size, LH – for left-hand thread	External: R11/2 Internal: R_c 11/2 Left-hand thread: R1 1/2 LH R_c 11/2LH
Round thread for caps and lamp-holders	GOST 6042-83	E	Nominal thread diameter (5, 10, 14, 27, 40)	E14 GOST 6042-83
Round thread for Sanitary Engineering Fittings	GOST 13536-68	K_p	Nominal diameter, pitch	Kp12x2,54 GOST 13536-63
Metric Taper thread	GOST 25229-82	MK	Nominal diameter, pitch, LH for left-hand thread	External MK20x1,5 Internal M20 x1,5 GOST 25229-82. Left-hand thread: MK20 x1,5LH GOST 25229-82

Table 4

Metric Thread (According to GOST 42705—81, GOST 8724—81, mm)

Nominal Thread Diameter	Pitch		Thread Diameters	Nominal Thread Diameter	Pitch		Thread Diameters
d	coarse	fine	$d_1 = D_1$	d	coarse	fine	$d_1 = D_1$
6	1,00		4,917	18	2,5		15,294
		0,75	5,188			2,0	15,835
		0,5	5,459			1,5	16,376
8	1,25		6,647			1,0	16,917
		1,0	6,917			0,75	17,188
		0,75	7,188			0,5	17,495
		0,5	7,459	20	2,5		17,294
10	1,5		8,376			2,0	17,835
		1,25	8,647			1,5	18,376
		1,0	8,917			1,0	18,917
		0,75	9,188			0,75	19,188
		0,5	9,459			0,5	19,459
12	1,75		10,106	22	2,5		19,294
		1,5	10,376			2,0	19,835
		1,25	10,647			1,5	20,376
		1,0	10,917			1,0	20,917
		0,75	11,188			0,75	21,188
		0,5	11,459			0,5	21,459
14	2,0		11,835	24	3,0		20,752
		1,5	7,376			2,0	21,835
		1,25	7,648			1,5	22,376
		1,0	7,917			1,0	22,917
		0,75	13,188			0,75	23,188
		0,5	13,459	27	3,0		23,752
16	2,0		13,835			2,0	24,835
		1,5	14,376			1,5	25,376
		1,0	14,917			1,0	25,917
		0,75	15,188			0,75	26,188
		0,5	15,459				

GOST 8724-82 for each diameter of the metric thread provides one large pitch and some small ones. For example, in M16 the coarse pitch is equal to 2 mm, whereas the fine pitch can be equal to 1,5; 1; 0,75; 0,5 mm (Table 4). Therefore, when designating metric threads the coarse pitch is not indicated, whereas the fine pitch should be indicated.

Accuracy Classes and Allowance Ranges for Metric Threads

G0ST 16093-81 is used for metric threads with the profile according to GOST 9150-81, with diameters according to GOSTs 8724-81 and 16967-81, main sizes according to GOSTs 24705-81 and 24706-81. It also specifies the allowance system for clearance fits.

The allowance range of the thread giving the clearance number between external and internal threads is formed by the combination of the allowance range of the average diameter with the allowance range of the projection diameter (diameters d or D_1.).

Designation of the allowance range of the thread diameter contains the figure denoting the accuracy degree and Latin letters (low case letters for external threads and capital letters for internal ones) denoting main deflection, e.g. 4h, 6g; 6H.

In thread designation the allowance range should follow the thread size after three dashes.

Table 5

Allowance Ranges for Metric Threads. Screwing Length N (normal).

(According to GOST 16093—81)

Accuracy class	Thread Allowance Range						
	External Thread					Internal Thread	
Accurate				4g	4h	4H5H	5H
Average	6d	6e	6f	6g	6h	6G	6H
Rough				8g	8h	7G	7H

Note: Allowance ranges in brackets should be preferably used.

Examples of Thread Designation:

with coarse pitch: external M12–6g;

internal M12–6H;

with fine pitch: external M12x1–6g;

internal M12x1–6H.

The fit in a threaded joint is denoted by the fraction, the numerator shows the allowance range of the internal thread while the denominator shows the allowance range of the external thread, e.g. M12–6H/6g, M12xl,25–6H/6g, M12xl,25 LH–6H/6g.

5.1. Representation and Designation of Threads on Drawings

GOST 2.311-68 specifies the rules of representing and designating threads on drawings for all branches of industry and engineering.

The external thread on the bar is represented by continuous thick lines (the major diameter) and by continuous fine lines (the minor diameter) (Fig. 138, 139, 140).

On views perpendicular to the thread axis a circle is represented by a continuous thick line for the major diameter, for the minor diameter an arc is drawn as a continuous fine line of about three fourth of a circle and broken in any place. Chamfers are not shown on this view (Fig, 140, *a, g, i*).

The internal thread in the hole on the longitudinal view is represented by continuous thick base lines for the minor diameter and by continuous thin lines for the major diameter, the lines being drawn along the whole thread length. On the view perpendicular to the thread axis a circle is represented by a continuous thick base line for the minor diameter, and an arc of about three-fourth of a circle and broken in any place is drawn for the major diameter as a continuous fine line, the chamfers on this view are not shown (Fig. 140, *b, c, f, j*).

The hidden thread is represented by dash shot lines of the same thickness both for major and minor diameters (Fig. 140, *d*).

The line representing the thread boundary is drawn where the thread with a complete profile ends and the thread rise begins. The thread boundary is drawn till

the line of the major diameter of the thread and is represented by a continuous thick base line (Fig. 140, *a, b, c, d, e, f*).

Hatching is represented on sections and sectional views till the line of the major diameter of the thread on the bar and till the line of the minor diameter in the hole, i.e. in both cases till the continuous thick base line (Fig. 140, *b, c, e, f, g, h, j*).

The thread line size on the bar and in the hole is generally shown without a vanish (Fig. 140, *a, b, c*).

The end of a blind threaded hole is represented as shown in Fig. 140, *c*. The blind threaded hole is called a socket. The socket ends in a cone with the vertex angle of 120° that is obtained by the drill. The angle size is not shown on the drawing.

The thread with a non-standard profile is represented by one of the methods shown in Fig. 141 with all required sizes and limit deflections. Besides sizes and limit thread deflections additional data relating to the number of helices are represented on the drawing as well as on the left-hand direction of the thread, etc. adding the word "thread".

On sectional views of threaded connections in the representation parallel to its axis only the portion of the thread, which is not closed by the bar, is shown (Fig. 140, j, *h*).

Thread designations are given according to existing standards relating to sizes and limit thread deflections and they are used in all threads except conical and pipe cylindrical ones for the major diameter as shown in Fig. 140, *a, b, c*.

Conical and pipe cylindrical threads are designated as shown in Fig. 140, *g, i, j*. In Fig. 140 places of possible thread designations except those shown are represented by the sign *. Cases of designations of some thread types are illustrated in Table 3.

If the left-hand thread is cut on the bar or in the hole, letters LH are added to the thread designation on the drawing, for example: M16 LH – 6g; M16x 1,5 LH – 7H; G ¾ LH–B.

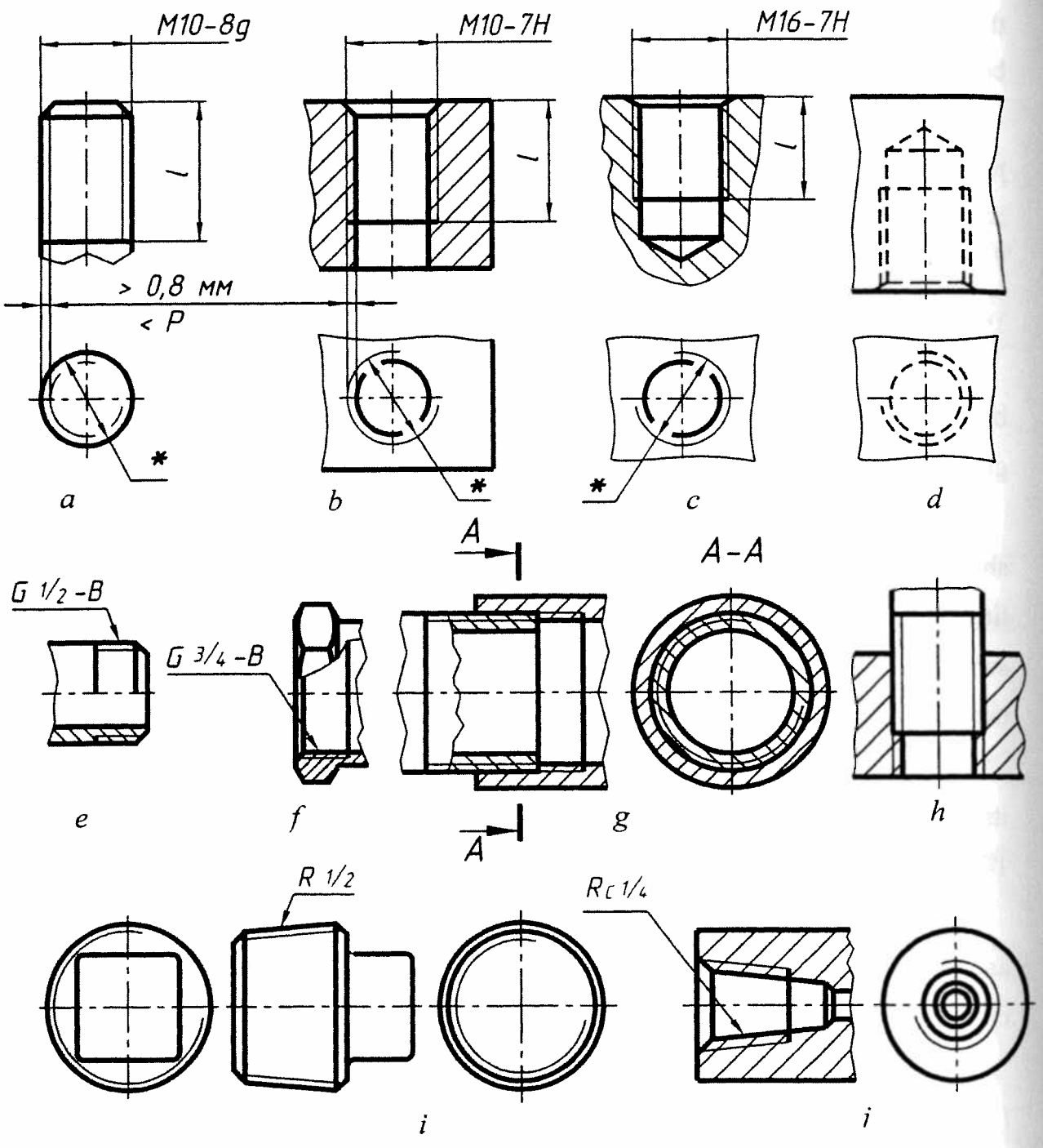


Fig. 140

Attention should be paid to the conventionalities of designating a pipe cylindrical thread. If for metric and other threads the number following the conventional designation of the thread type (M, Tr, S, MK) corresponds to the major diameter in millimeters, in a pipe thread the number following the letter G in a thread designa-

tion corresponds to the size of the minor diameter of the pipe on which the thread is cut, in inches. The minor diameter of the pipe is called a nominal bore and is denoted by D_y. For instance, if the thread is designated by G1, it means that it is cut on the pipe having a nominal bore of about 1" (~ 25mm), the major diameter being 33,5 and the major diameter of the thread being equal to 33,249 mm according to GOST 6357-81. In all engineering calculations one inch is generally assumed to be equal to 25,4 mm.

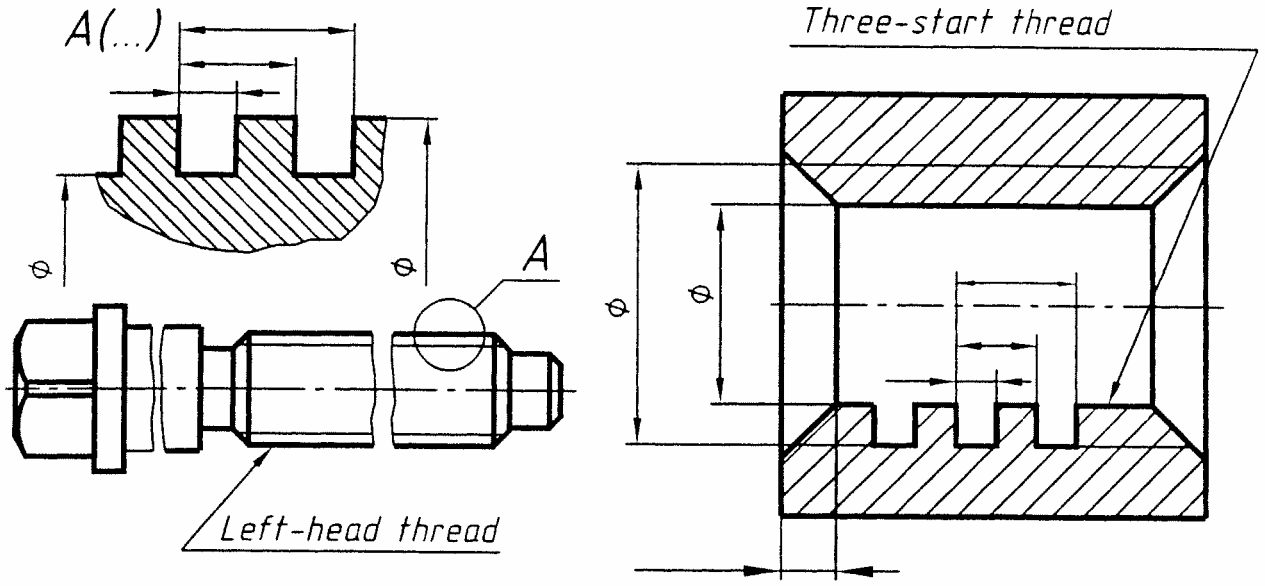


Fig. 141. Non-Standard Threads

5.2. Threaded Fastenings

Threaded fastenings are bolts, studs, nuts, screws and fittings. They are used in fixed detachable joints of machine elements.

5.2.1. Hexagon Head Bolts

The bolt consists of a cylindrical shank with a head on one end and a thread for the nut on the other one (Table 6). Bolt heads are of various types specified in the appropriate GOST. Most commonly used in machine building are bolts with hexagonal heads (of normal accuracy) according to GOST 7798-70.

While drawing the head of the bolt and the nut, it is necessary to construct curve projections lying on their side faces. These curves result from the intersection of the faces with the cone chamfer surface and are represented as congruent hyperbolas. These hyperbola projections are also hyperbolas. On the drawing (of the bolt or the nut) these hyperbolas are changed by circle arcs. To find the center of the radii R, R_1, R_2 of the circle arcs three points should be used: the vertex of a hyperbola (point A) and the ends of a hyperbola (point B), which are found in conform with the rules of drawing geometry. Fig. 143, *a* demonstrates the way of finding the center 0 for the radius R of the circle arc on the projection of the central face. Determination of centers for the radii R_1 and R_2 is carried out similarly.

On assembly drawings bolt and nut heads can be drawn with sizes which are the function of the major diameter d of the bolt thread (Fig. 143).

Chamfers at the ends of the bolts, studs, screws as well as on the edges of threaded holes of nuts, sockets and fittings are provided to protect the finite thread loop from damage and to screw easily. The chamfer sizes for the ends of bolts, studs, screws and threaded holes are chosen according to Table 2. While making a drawing of a screw thread piece according to the existing pattern, all the required sizes are determined by mere measuring followed by checking in the table of the corresponding standard. The location of sizes on the drawing of a fastener must correspond to their location in GOST.

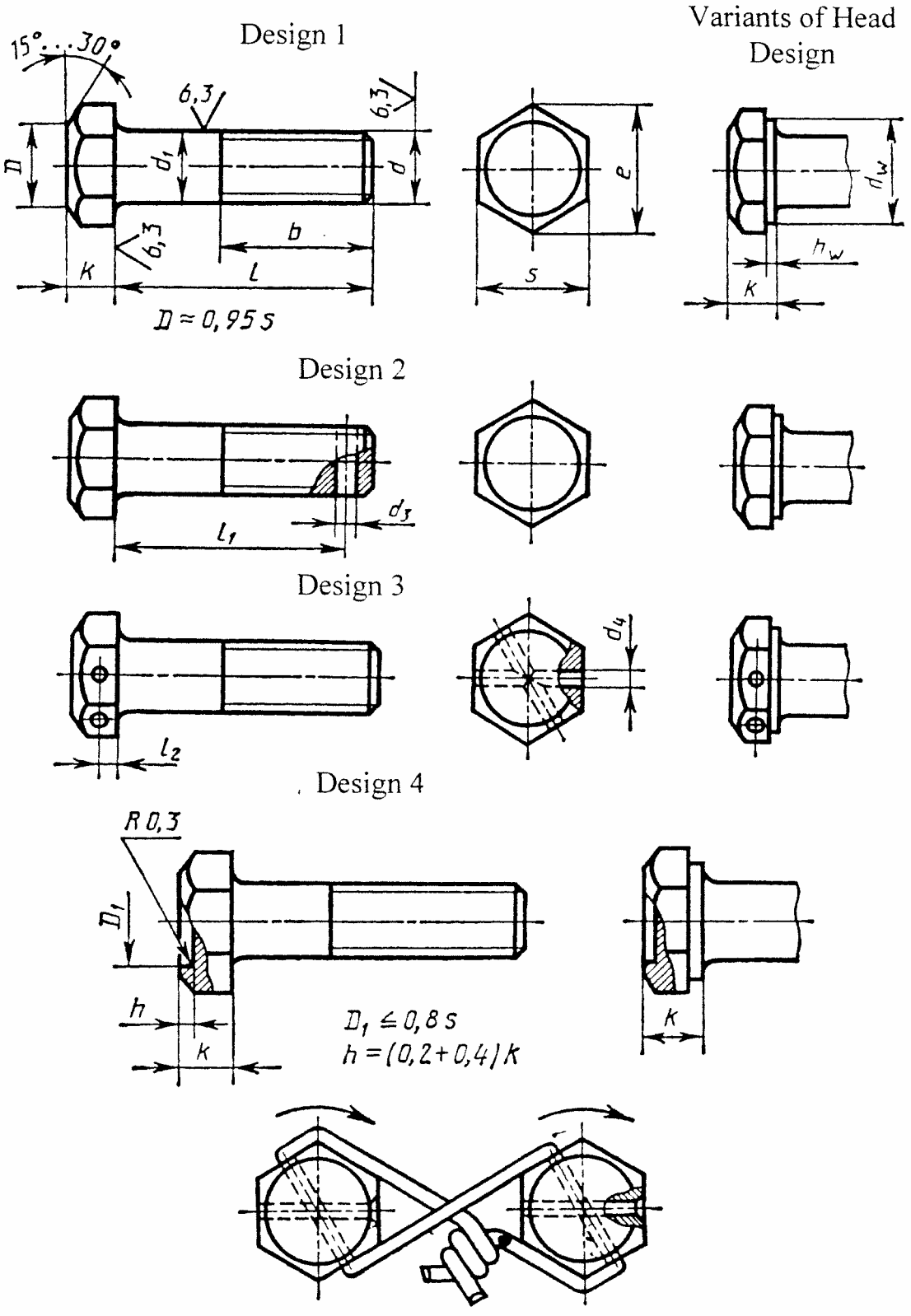
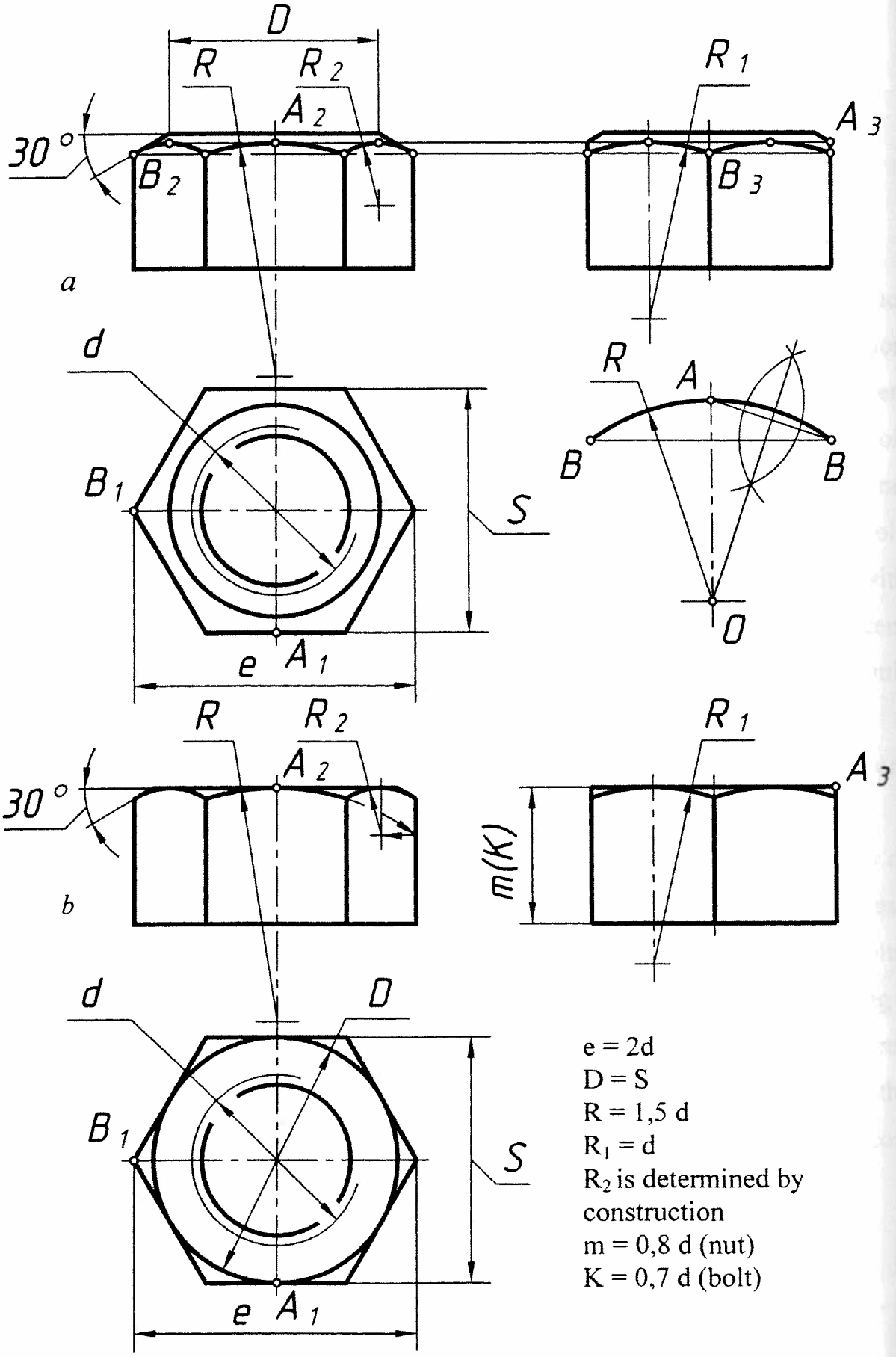


Fig. 142. Designs of Hexagon Head Bolts



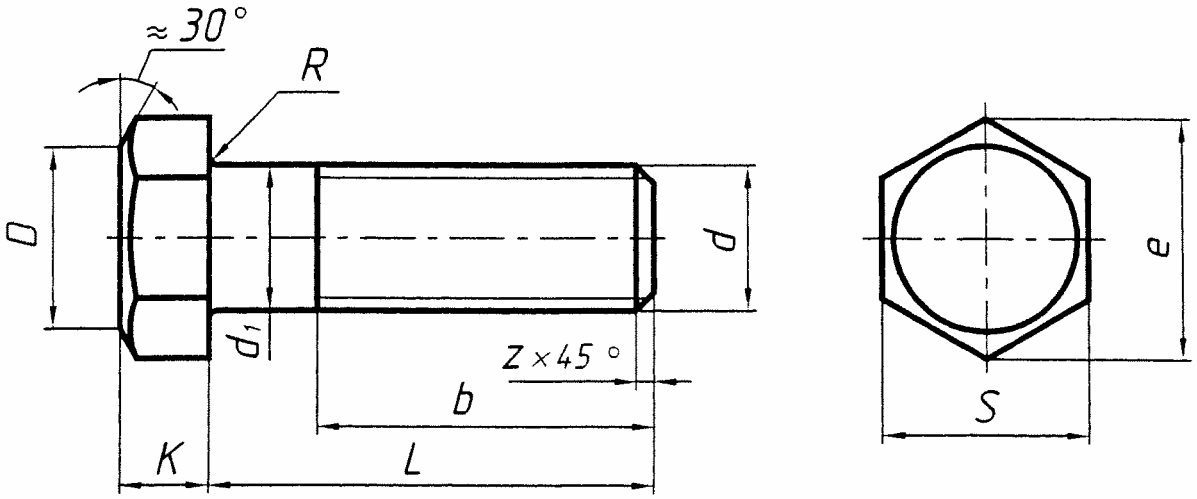
e = 2d
D = S
R = 1,5 d
R_1 = d
R_2 is determined by construction
m = 0,8 d (nut)
K = 0,7 d (bolt)

Fig. 143. Designs of Bolt Head and Nut:
a — on part drawing, *b* — on assembly drawing

Table 6

Hexagon Head Bolts (Normal Accuracy

According to GOST 7798–70)



Nominal thread Diameter d, мм		6	8	10	12	14	16	18	20	22	24
Thread Pitch P	coarse	1	1,25	1,5	1,75	2	2	2,5	2,5	2,5	3
	fine		1	1,25	1,25	1,5	1,5	1,5	1,5	1,5	2
Dimension "for key" S		10	13	17	19	22	24	27	30	32	36
Head Height K		4	5,5	7,0	8,0	9,0	10,0	12,0	13,0	14,0	15,0
Diameter of Circum-scribed Circle e		10,9	14,2	18,7	20,9	24,3	26,5	29,5	33,3	35	39,6
Radius Under the Head R		0,25	0,4	0,4	0,6	0,6	0,6	0,6	0,8	0,8	0,8
Chamfer Diameter e = (0,9...0,95)S; Bar Diameter d_1= d											
Bolt Length L, mm		Thread Length l_0, mm									
25		18	25	25	25	25	25	25	25		
30		18	22	30	30	30	30	30	30	30	30
35		18	22	26	30	35	35	35	35	35	35
40		18	22	26	30	34	40	40	40	40	40
45		18	22	26	30	34	38	45	45	45	45
50		18	22	26	30	34	38	42	50	50	50
55		18	22	26	30	34	38	42	46	50	55
60		18	22	26	30	34	38	42	46	50	55
65		18	22	26	30	34	38	42	46	50	55
70		18	22	26	30	34	38	42	46	50	55
75		18	22	26	30	34	38	42	46	50	55
80		18	22	26	30	34	38	42	46	50	55

Examples of conventional designations of bolts:

Bolt M12–8g x 60.58 GOST 7798-70,

– where d = 12mm – thread diameter, with coarse pitch, 1–design, 8g – thread allowance (rough), *l* = 60mm – bolt length, 5.8 –strength class, uncoated.

Bolt 2M12 x 1,25 – 6g x 60.109. 40X. 016 GOST 7798-70,

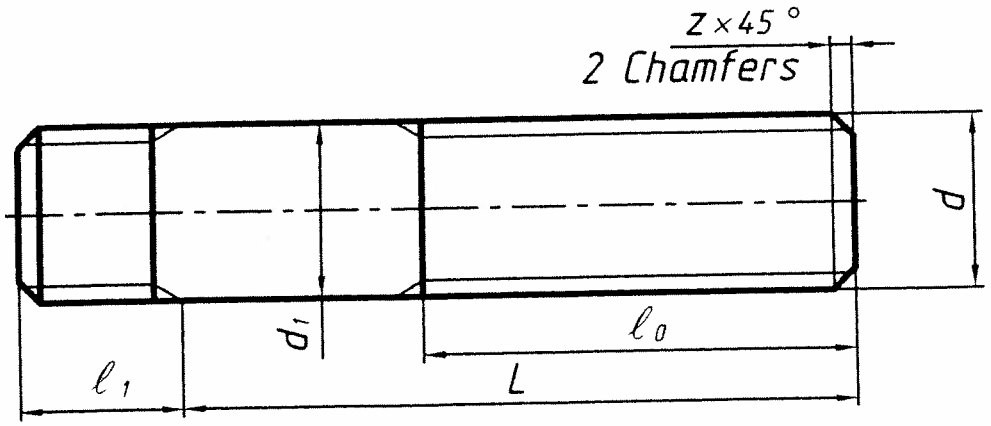
– where 2 – design, 6g – thread allowance (average), 10.9 – strength class, 40X – made of steel, 01 – coating, 6 MKM – coating thickness.

5.2.2. Studs

A stud is a cylindrical rod with threads on both ends (Table 7). One end of the stud which is screwed into the threaded hole of the part is called a screwed end, while the end on which adjoining pieces and a washer are inserted and the nut is threaded is called a nut end. The design and stud sizes are specified by GOST 22032-76 – GOST 22043-76. The length l_1 of the screwed stud end depends on the material of the piece in which it is screwed (Table 8).

Table 7

Stud for Pieces with Threaded Holes (Normal Accuracy According to GOST 22032–76, 22034–76, 22038–76)



Cotinuation of Table 7

Nominal Thread Diameter, mm		6	8	10	12	14	16	18	20	22	24
Thread Pitch	coarse	1	1,25	1,5	1,75	2	2	2,5	2,5	2,5	3
	fine		1	1,25	1,25	1,5	1,5	1,5	1,5	1,5	2
Length of Screwed Threaded end -	ℓ_1 = d GOST 22032–76	6	8	10	12	14	16	18	20	22	24
	ℓ_1 = 1,25d GOST 22034–76	7,5	10	12	15	18	20	22	25	28	30
	ℓ_1 = 2d GOST 22038–76	12	16	20	24	28	32	36	40	44	48

Stud Length *L*	Length of Nut's end ℓ_0									
25	18	21	20	19	18					
30	18	22	25	24	23					
35	18	22	26	29	28	27	26			
40	18	22	26	30	33	32	31	30		
45	18	22	26	30	34	37	36	35	34	33
50	18	22	26	30	34	38	41	40	39	38
55	18	22	26	30	34	38	42	45	44	43
60	18	22	26	30	34	38	42	46	49	48
65	18	22	26	30	34	38	42	46	50	53
70	18	22	26	30	34	38	42	46	50	54
75	18	22	26	30	34	38	42	46	50	54
80	18	22	26	30	34	38	42	46	50	54

Notes: Diameter of the bar is equal to the thread nominal diameter (d_1 = d).

Table 8

Usage of Studs Due to Material

Studs of Normal Accuracy According to GOST	Length of Screwed Thread End	Field of Usage
22032-76	ℓ_1 = d	For thread holes in steel, bronze and brass parts; elements made of titanium alloys.

22034-76	ℓ_1 = 1,25d	For thread holes in parts made of malleable and grey cast iron.
22038-76	ℓ_1 = 2d	For thread holes in parts made of light alloys.

Examples of Conventional Designations of Studs:

Stud M16–6g × 120.58 GOST 22032-76;

Stud M16–6g × 120.58 GOST 22034-76;

Stud M16–6g × 120.58 GOST 22038-76;

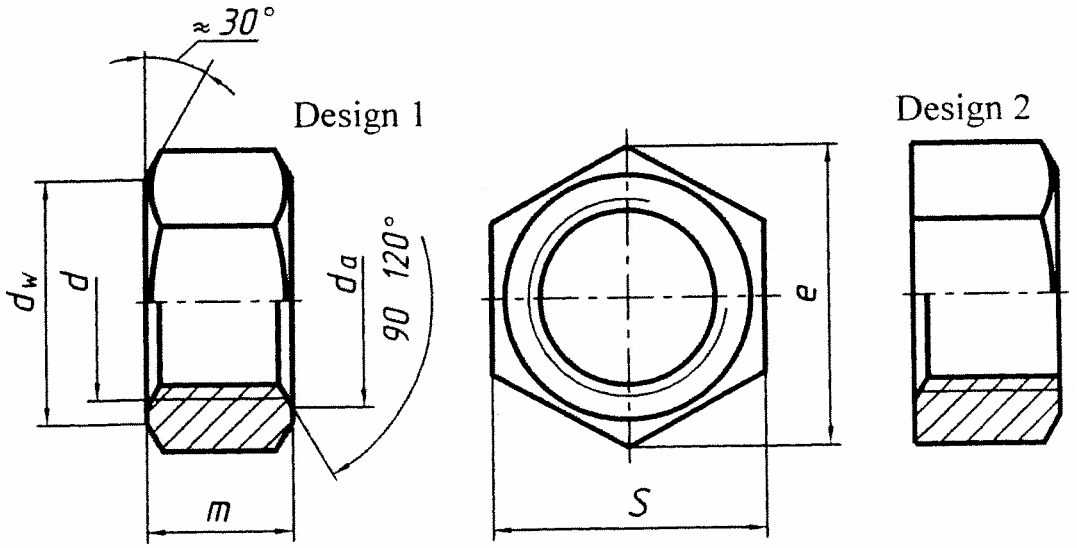
where d = 16 – thread diameter, with a coarse thread pitch, 6g –allowance (average), ℓ = 120 –length, 5.8 – strength class, uncoated.

5.2.3. Hexagonal Nuts

A nut consists of a prism or a cylinder with a through (or blind) threaded hole for threading on the bolt or stud (Table 9). According to their form nuts are divided into hexagonal, square, ring, wing nut, etc. Hexagonal nuts are subdivided into standard, slotted and eastle; normal, thin, thick and extremely thick; with one or two chamfers. Most commonly used in machine building are standard hexagonal nuts (with normal accuracy) according to G0ST 5915-70.

Table 9

Hexagon Nuts (Normal Accuracy According to GOST 5915-70)



Cotinuation of Table 9

Nominal Thread Diameter d.		6	8	10	12	14	16	18	20	22	24
Thread Pitch	coarse	1	1,25	1,5	1,75	2	2	2,5	2,5	2,5	3
	fine		1	1,25	1,25	1,5	1,5	1,5	1,5	1,5	2
Dimension "for key" S		10	13	17	19	22	24	27	30	32	36
Diameter of Circum-scribed Circle e		10,9	14,2	18,7	20,9	24,3	26,5	29,5	33,3	35	39,6
Height m		5	6,5	8.0	10,0	11,0	13,0	15,0	16,0	18,0	19,0
Chamfer Diameter d_w min		9	11,7	15,5	17,2	20,1	22,0	24,8	27,7	29,5	33,2
Chamfer Diameter d_a min		6	8	10	12	14	16	18	20	22	24
Chamfer Diameter d_a max		6,75	8,75	10,8	13,0	15,1	17,3	19,4	21,6	23,8	25,9

Examples of Conventional Designations of Nuts:

Nut 2M12 x 1,25 – 6H. 12.40X. 016 GOST 5915-70;

– where d = 12 mm – the thread diameter, 2 – design, 1,25 – a fine pitch, 6H – thread allowance (average), 12 – strength class, 40X – made of steel, 01 – steel-coated, 6 mkm – thickness of coating.

5.2.4. Screws

A screw consists of a cylindrical bar with a head at one end and a thread for screwing into one of the adjoining pieces at the other one (Tables 10–14). Screws used for fixed joining of pieces are called cap screws; those used for fixing the relative position of pieces are called setscrews. Depending on the way of screwing they are divided into screws with the head for a screwdriver or for a wrench. Heads are of various forms specified in the appropriate GOST.

Most commonly used are the following cap screws:

1) fillister-head screw – GOST 1491-80;
2) cup-head screw – GOST 17473-80;

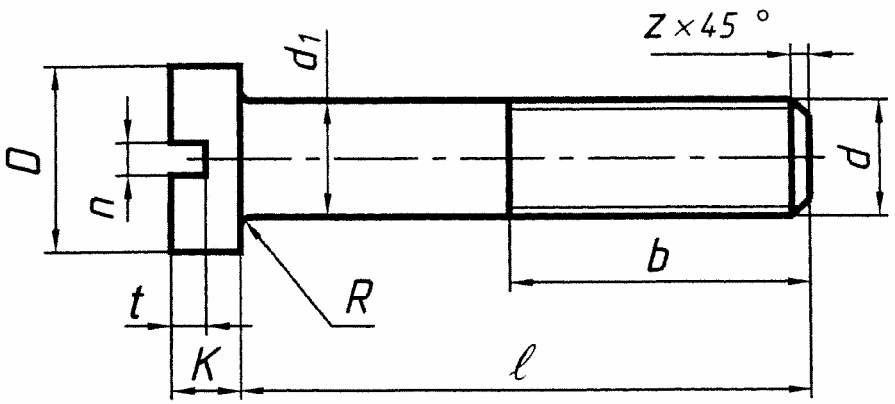
3) semi-countersunk screw – GOST 17474-80;

4) countersunk screw – GOST 17475-80;

5) fillister-head screw with a hexagon pocket "for key" – GOST 11738-80.

Table 10

Fillister-Head Screws, Accuracy Glass B
(Nominal Accuracy According to GOST 1491-80)



Nominal Thread Diameter d		4	5	6	8	10	12	14	16
Thread Pitch P	coarse	0,7	0,8	1	1,25	1,5	1,75	2	2
	fine.				1	1,25	1,25	1,5	1,5
Head Diameter D		7,0	8,5	10,0	13,0	16,0	18,0	21,0	24,0
Head Height K		2,6	3,3	3,9	5,0	6,0	7,0	8,0	9,0
Slot Width	not less	1,06	1,26	1,66	2,06	2,56	3,06	3,06	4,07
	not more	1,2	1,51	1,91	2,31	2,81	3,31	3,31	4,37
Slot Depth	not less	1,2	1,5	1,8	2,3	2,7	3,2	3,6	4,0
	not more	1,6	2,0	2,3	2,8	3,2	3,8	4,2	4,6
Radius Under Head R, not less		0,35	0,5	0,6	1,1	1,1	1,6	1,6	1,6

Note:

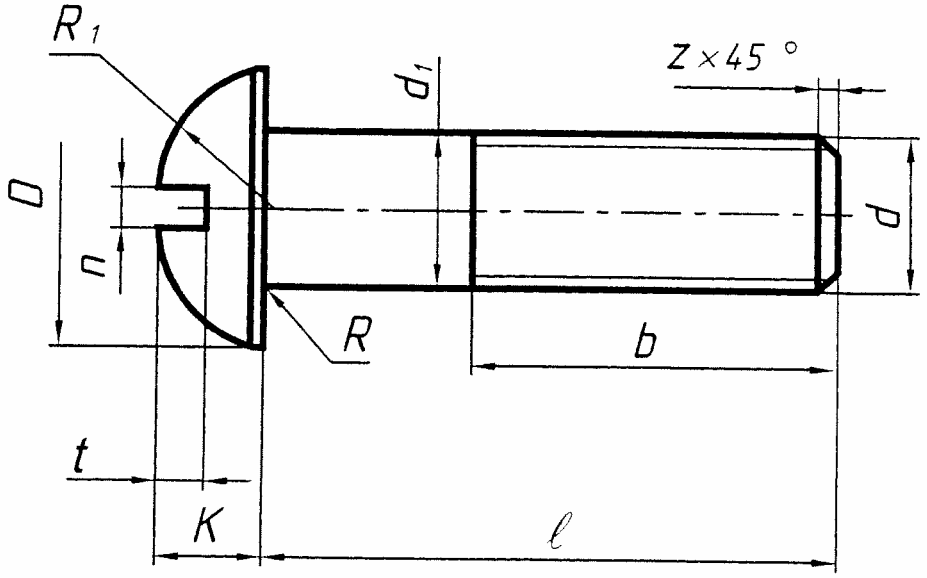
1. Rod diameter d_1= d.

2. For length ℓ and b look Table 15.

3. For machined screws, other cases are not standardized.

Table 11

Cup-Head Screws of Accuracy Glass B (Normal Accuracy According to GOST 17473-80)



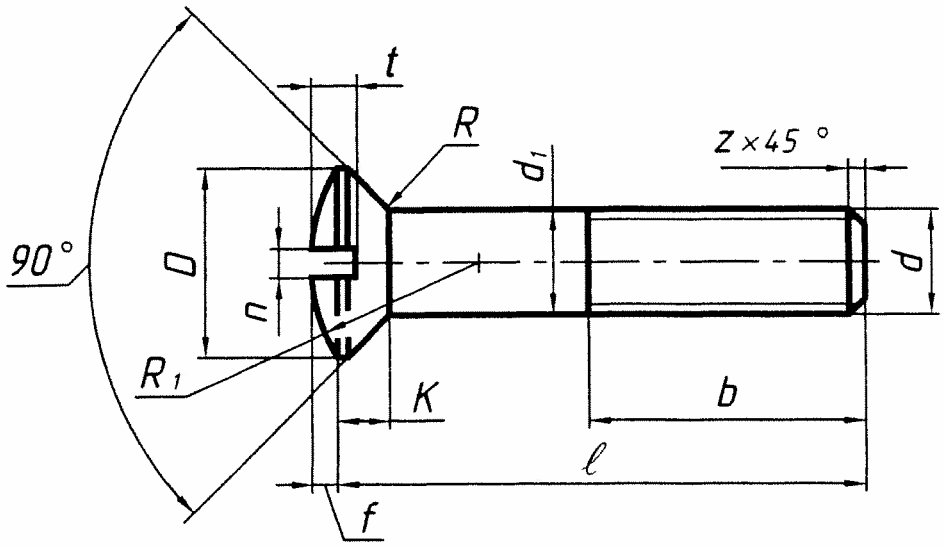
Nominal Thread Diameter d, mm		4	5	6	8	10	12	14	16
Thread Pitch P	coarse	0,7	0,8	1	1,25	1,5	1,75	2	2
	fine.				1	1,25	1,25	1,5	1,5
Head Diameter D		7,0	8,5	10,0	13,0	16,0	18,0	21,0	24,0
Head Height K		2,8	3,5	4,2	5,6	7,0	8,0	9,5	11,0
Sphere Radius R1		3,6	4,4	5,1	6,6	8,1	9,1	10,6	12,1
Slot Width	not less	1,06	1,26	1,66	2,06	2,56	3,06	3,06	4,07
	not more	1,2	1,51	1,91	2,31	2,81	3,31	3,31	4,37
Slot Depth	not less	1,6	2,1	2,3	3,26	3,76	3,96	4,26	4,76
	not more	2,0	2,5	2,7	3,74	4,24	4,44	4,74	5,24
Radius Under Head K, not less		0,35	0,5	0,6	1,1	1,1	1,6	1,6	1,6

Note:

1. Rod diameter d_1= d.
2. For length ℓ and b look Table 15.
3. For machined screws, other cases are not standardized.

Table 12

Semi-Countersunk Screws of Accuracy Class B (Normal Accuracy According to GOST 17474-80)



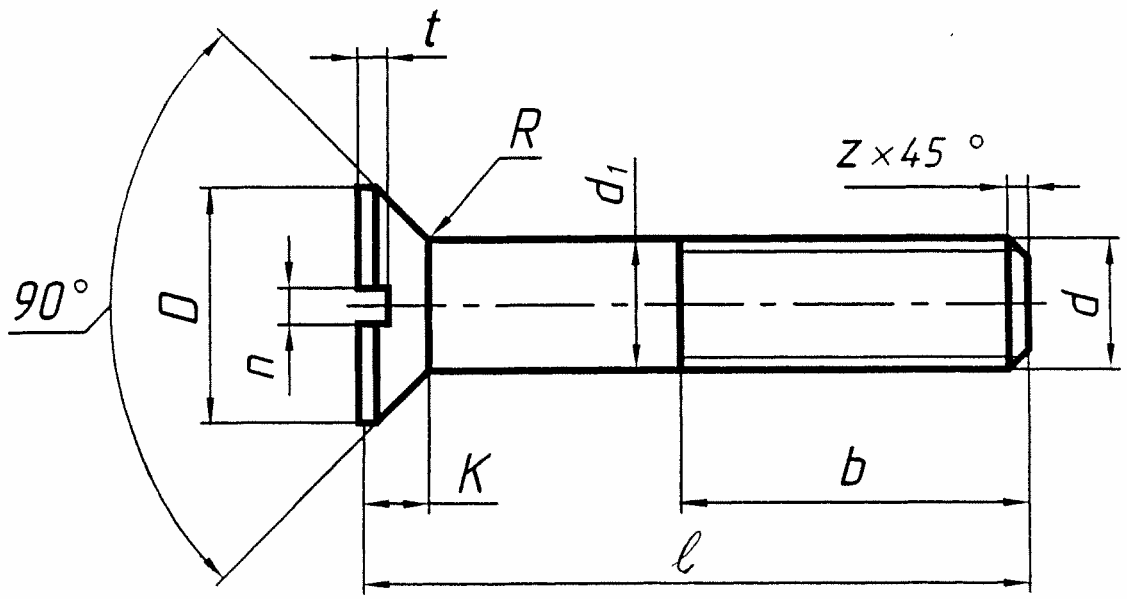
Nominal Thread Diameter d, mm		4	5	6	8	10	12	14	16
Thread' Pitch P	coarse	0,7	0,8	1	1,25	1,5	1,75	2	2
	fine				1	1,25	1,25	1,5	1,5
Head Diameter D		7,4	9,2	11,0	14,5	18,0	21,5	25,0	28,5
Head Height K		2,2	2,5	3,0	4,0	5,0	6,0	7,0	8,0
Sphere Height f		1,0	1,25	1,5	2,0	2,5	3,0	3,5	4,0
Sphere Radius R1		8,0	9,4	12	15	19	22,5	26	30
Width of Straight Slot n	not less	1,06	1,26	1,66	2,06	2,56	3,06	3,06	4,07
	not more	1,2	1,51	1,91	2,31	2,81	3,31	3,31	4,37
Depth of Straight Slot t	not less	1,6	2,0	2,4	3,2	4,0	4,8	5,6	6,4
	not more	1,9	2,3	2,8	3,7	4,5	5,4	6,3	7,2
Radius Under Head R, not less		0,35	0,5	0,6	1,1	1,1	1,6	1,6	1,6

Note:

1. Rod diameter d_1= d.
2. For length ℓ and b look Table 15.
3. For machined screws, other cases are not standardized.

Таблица 13

Countersunk Screws of Accuracy Class B (Normal Accuracy According to GOST 17475-80)



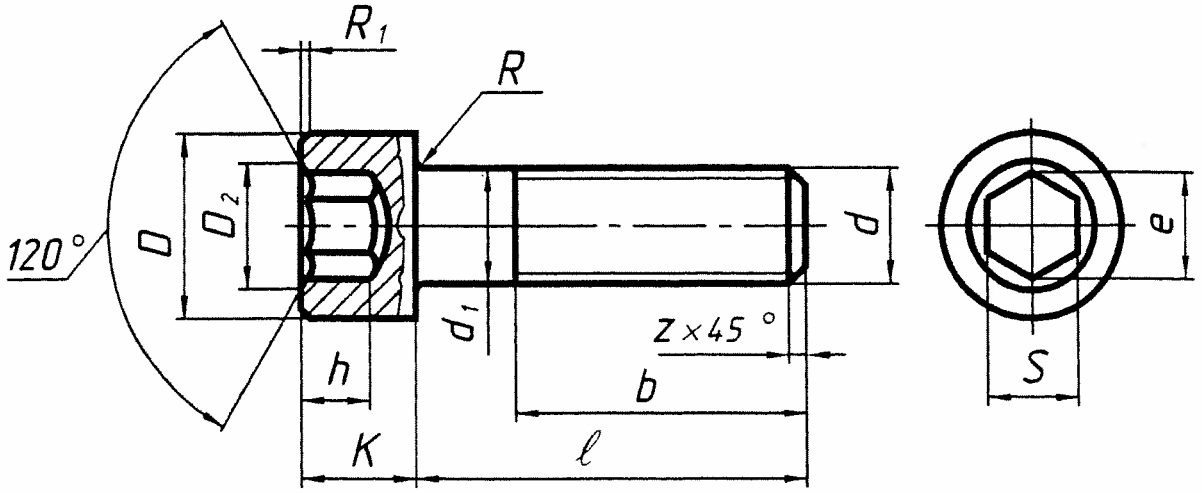
Nominal Thread Diameter d, mm		4	5	6	8	10	12	14	16
Thread' Pitch P	coarse	0,7	0,8	1	1,25	1,5	1,75	2	2
	fine				1	1,25	1,25	1,5	1,5
Head Diameter D		7,4	9,2	11,0	14,5	18,0	21,5	25,0	28,5
Head Height K		2,0	2,5	3,0	4,0	5,0	6,0	7,0	8,0
Width of Straight Slot n	not less	1,06	1,26	1,66	2,06	2,56	3,06	3,06	4,07
	not more	1,2	1,51	1,91	2,31	2,81	3,31	3,31	4,37
Depth of Straight Slot t	not less	0,8	1,00	1,8	2,3	2,7	3,2	3,6	4,0
	not more	1,1	1,35	2,3	2,8	3,2	3,8	4,2	4,6
Radius Under Head R, not less			0,5	0,6	1,1	1,1	1,6	1,6	1,6

Note:

1. Rod diameter d_1= d.
2. For length ℓ and b look Table 15.
3. For machined screws, other cases are not standardized.

Table 14

Fillister-Head Screw with Hexagon Pocket "for key" of Accuracy Class B (Normal Accuracy, According to GOST 11738-80)



Nominal Thread Diameter d, mm		6	8	10	12	14	16	18	20
Thread' Pitch P	coarse	1	1,25	1,5	1,75	2	2	2,5	2,5
	fine	–	1	1,25	1,25	1,5	1,5	1,5	1,5
Head Diameter D		10,0	13,0	16,0	18,0	21,0	24,0	27,0	30,0
Head Height K		6	8	10	12	14	16	18	20
Dimension "for key" S		5	6	8	10	12	14	16	17
Diameter of Circumscribed Circle e		5,8	6,9	9,2	11,5	13,7	16,2	17,7	19,6
Chamfer Diameter D_2		6,1	7,2	9,7	12,0	14,2	16,7	18,2	20,4
Hexagon Height h		3,5	4,5	6,0	7,0	8,0	9,0	10,0	11,0
Head Radius R_1		0,5	0,8	0,8	1,0	1,0	1,0	1,0	1,6
Width of Straight Slot n	not less	1,66	2,06	2,56	3,06	3,06	4,07	4,07	5,07
	not more	1,91	2,31	2,81	3,31	3,31	4,37	4,37	5,37
Depth of Straight Slot t	not less	1,8	2,3	2,7	3,2	3,6	4,0	4,5	5,0
	not more	2,3	2,8	3,2	3,8	4,2	4,6	5,1	5,6
Radius Under Head R, not less			0,4	0,4	0,6	0,6	0,6	0,6	0,8

Note:

1. Rod diameter d_1= d.
2. For length *ℓ* and *b* look Table 15.
3. For machined screws, other cases are not standardized.

Table 15

Screw Length
(According to GOST 1491-80, 17473-80, 17474-80, 17475-80; 11738-75),mm

Nominal Thread Diameter d	4	5	6	8	10	12	14	16	18
Screw Length ℓ	Thread Length b (normal)								
10	10	10	10						
12	12	12	12	12					
14	14	14	14	14					
16	16	16	16	16					
20	14	16	20	20	20				
25	14	16	18	22	25	25	25	25	
30	14	16	18	22	26	30	30	30	30
35	14	16	18	22	26	30	35	35	35
40	14	16	18	22	26	30	34	40	40
45	14	16	18	22	26	30	34	38	45
50	14	16	18	22	26	30	34	38	42
55	14	16	18	22	26	30	34	38	42
60	14	16	18	22	26	30	34	38	42
65	14	16	18	22	26	30	34	38	42
70	14	16	18	22	26	30	34	38	42

Examples of Conventional Designations of Screws:

Screw A.M8-6g × 50.48 GOST 17473-80 – a cup-head screw;

Screw A.M8-6g × 50.48 GOST 17474-80 – semi-countersunk headed screw;

Screw A.M8-6g × 50.48 GOST 17475-80 – a countersunk screw.

In all screws A – accuracy class, d = 8 mm – thread diameter, with coarse thread pitch, 6g – thread allowance (average), *l* = 50 mm – length, 4.8 – strength class, uncoated.

5.2.5. Fittings

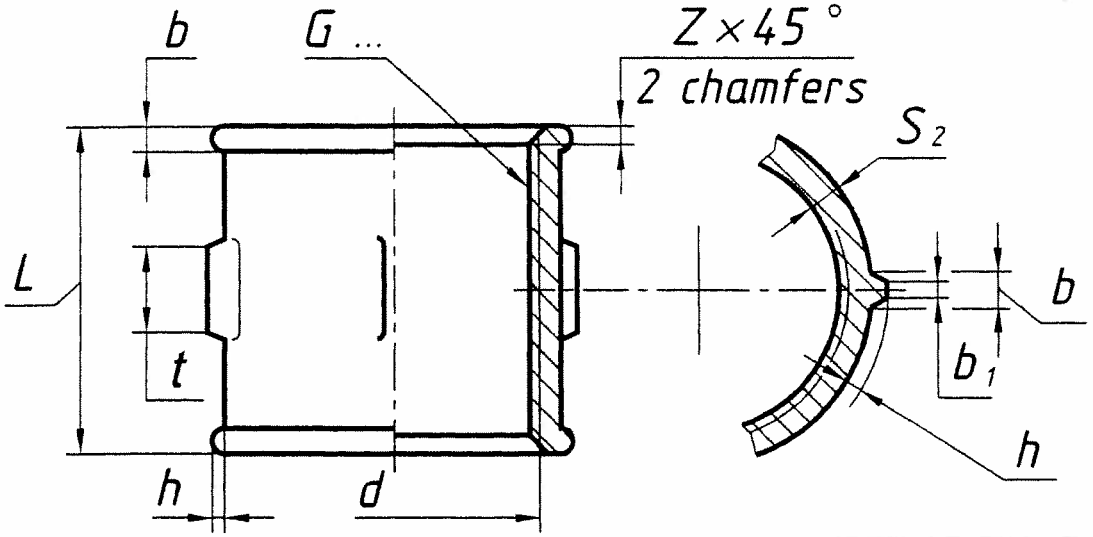
Fittings, i.e. triangles, T-joints, clutches (straight-pipe couplings and adapters). etc. are connecting threaded pieces used for gas and water supply pipes (Table 16). On screw thread pieces except fittings a metric thread is cut with coarse and fine

pitches according to GOST 8724-81, GOST 16098-81 specifies the thread allowance.

The pipe cylindrical thread is cut on fittings and pipes according to GOST 6357-81. Two accuracy classes of the thread average diameter are specified for this thread type, i.e. A and B.

Table 16

Straight Long Clutch (According to GOST 8955-75)



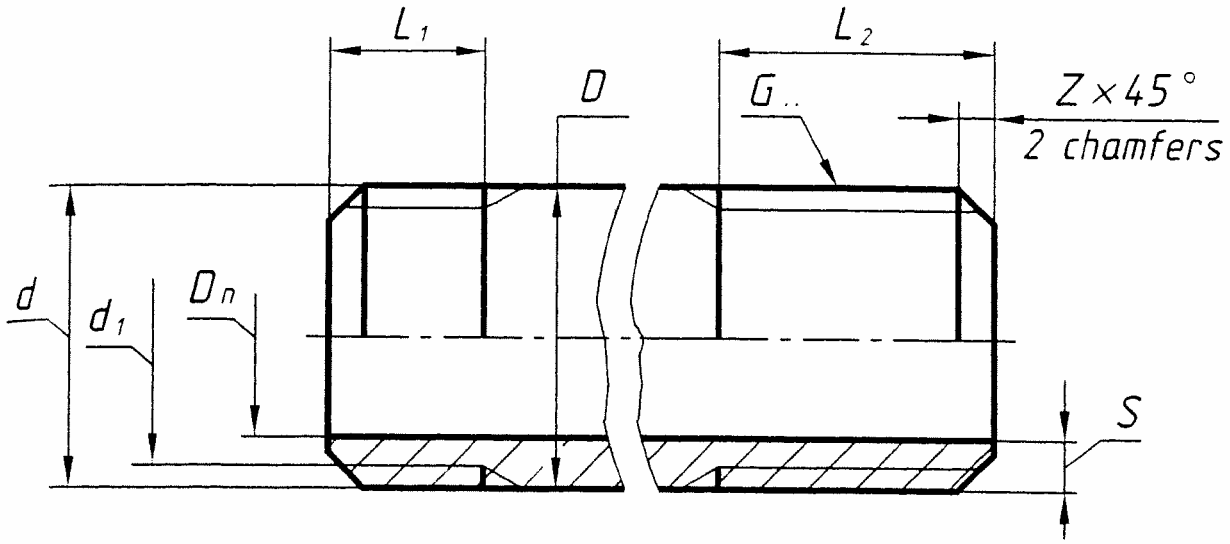
Nominal Hore D_n, мм	Thread (GOST-6357–81)			Design Dimensions (GOST 8944–75), mm							
	Designation on Drawings	Minor Diameter d, mm	Length L	Rib Number	S_2	b	h	t	b_1	b_2	Z
8	G 1/4	13,158	27	2	3,5	3,0	2,0	7	2,0	3,5	1,0
10	G 3/8	16,663	30	2	3,5	3,0	2,0	8	2,0	3,5	1,0
15	G 1/2	20,956	36	2	4,2	3,5	2,0	9	2,0	4,0	1,6
20	G 3/4	26,442	39	4	4,4	4,0	2,5	10,5	2,0	4,0	1,6
25	G 1	33,250	45	4	5,2	4,0	2,5	11	2,5	4,5	1,6
32	G 1 1/4	41,912	50	4	5,4	4,0	3,0	13	2,5	5,0	1,6
40	G 1 1/4	47,805	55	4	5,8	4,0	3,0	15	3,0	5,0	1,6
50	G 2	59,616	65	6	6,4	5,0	3,5	17	3,0	6,0	1,6

Example of conventional designation of a straight long uncoated clutch where D_n=25: a) long clutch 25 GOST 8955-75;

b) long clutch with zinc coating – long clutch Ц-25 GOST 8955-75.

Table 17

Steel Gas and Water-Supply Pipes (GOST 3262–75)



Nominal Hore D_n, mm	Thread (GOST-6357–81)				Design Dimensions (GOST 8944–75), mm			
	Designation on Drawings	Major Diameter d, mm	Length L_1, mm	Length L_2, mm	Major Diameter D	Thickness S		Chamfer Z
						Normal	Strengthened	
8	G 1/4	13,158	7	10	13, 5	2,2	2,8	1,6
10	G 3/8	16,663	8	12	17,0	2,2	2,8	1,6
15	G 1/2	20,956	9	14	21,3	2,8	3,2	2,0
20	G 3/4	26,442	10,5	16	26,8	2,8	3,2	2,0
25	G 1	33,250	11	18	33,5	3,2	4,0	2,5
32	G 1 1/4	41,912	13	20	42,3	3,2	4,0	2,5
40	G 1 1/4	47,805	15	22	48,0	3,5	4,0	2,5
50	G 2	59,616	17	24	60,0	3,5	4,5	2,5

Examples of pipes with a nominal bore 25

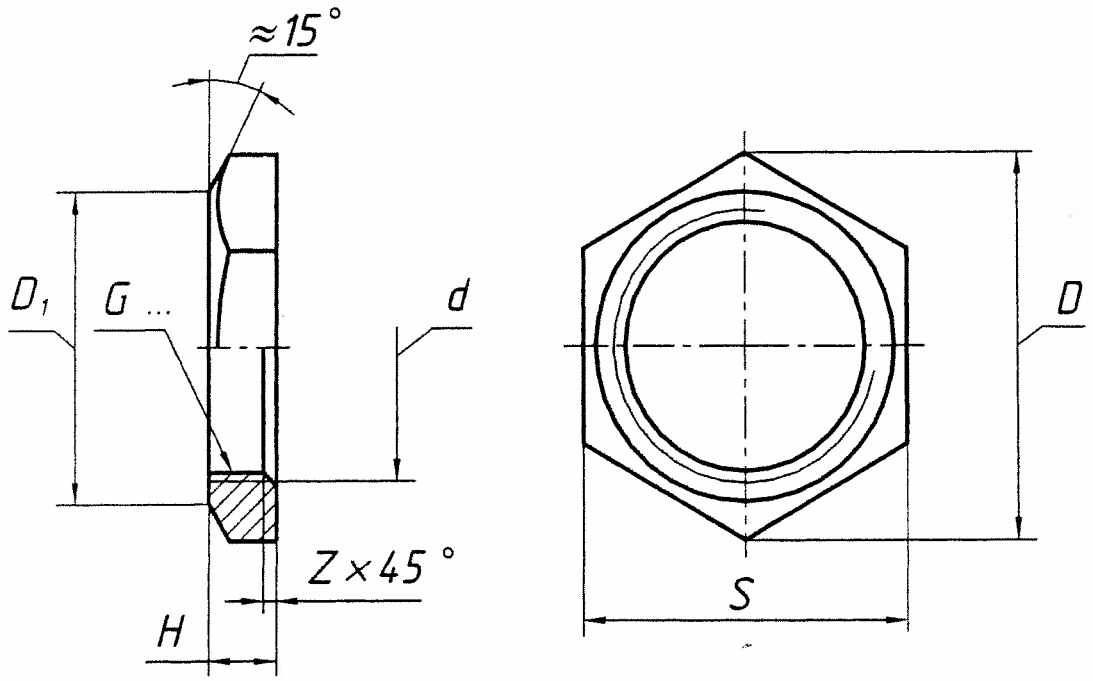
Pipe 25 × 3.2 GOST 3262-75 – a pipe of a black non-measured length, bare pipe;

Pipe P-25 × 3.2 GOST 3262-75 – the same with a cylindrical thread;

Pipe Ц-P-25 × 3,2 GOST 3262-75 – a pipe with zinc coating, of non-measured length, with a cylindrical thread.

Table 18

Lock Nuts for Pipe-Lines (GOST 8961–75)



Nominal Bore D_y, mm	Thread (GOST 6357–81)			Dimensions, mm				
	Designation on Drawings	Major Diameter of Thread d, mm	Minor Diameter of Thread, mm	H	S	D	D_1	Z
8	G 1/4	13,158	11,445	6	22	24,5	20	1,0
10	G 3/8	16,663	14,950	7	27	31,2	25	1,0
15	G 1/2	20,956	18,631	8	32	36,9	30	1,6
20	G 3/4	26,442	24,119	9	36	41,6	33	1,6
25	G 1	33,250	30,292	10	46	53,1	43	1,6
32	G 1 1/4	41,912	38,954	11	55	63,5	52	1,6
40	G 1 1/4	47,805	44,847	12	60	69,3	56	1,6
50	G 2	59,616	56,656	13	75	86,5	70	1,6

Example of lock nut designations, with D = 40 mm is as follows:
Lock nut 40 GOST 8961-75 – uncoated;
Lock nut Ц40 GOST 8961-75 – with zinc coating.

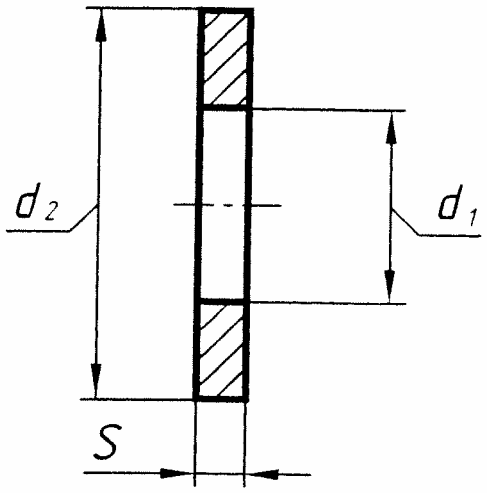
5.2.6. Washers

Washers that are put under the nut in bolted and stud joints can be round, square, spring, lock, etc. They protect the adjoining surface of the element from wearing and damage while screwing the nut, increase the base surface and overlap the unevenness if the element surface is untreated. Spring and lock washers protect nuts from self-unscrewing and are used when a joint is subjected to alternating load sand vibration. Sizes of round washers according to GOST 11371-78 are given in Table 19.

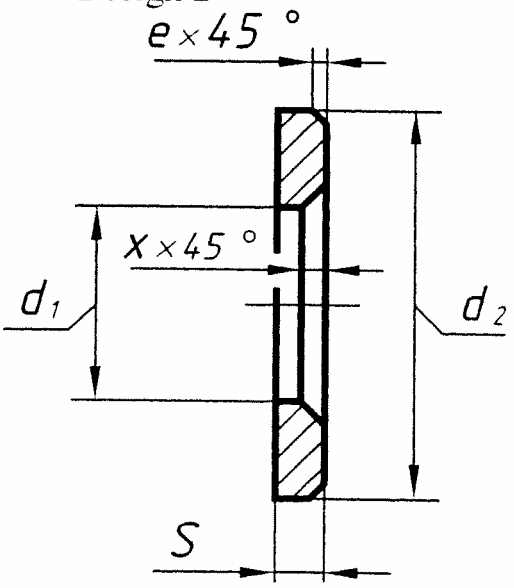
Table 19

Washers (According to GOST 11371-78)

Design 1



Design 2

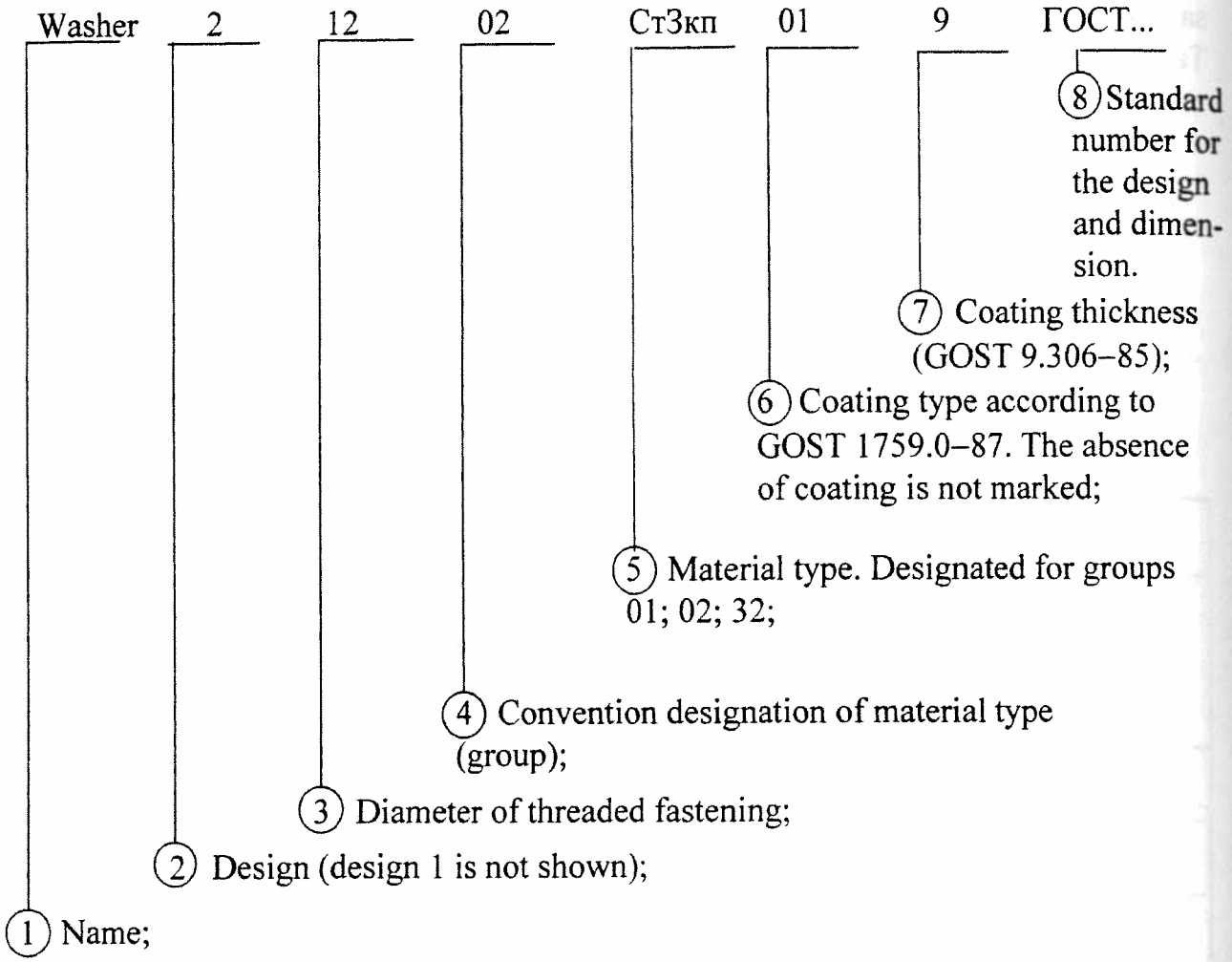


Thread Diameter of Fastener, mm	External Diameter of Washers d_2, mm	Internal Diameter of Washers d_1, mm	Thickness of Washers S, mm	Chamfer e, mm		Chamfer X
				Not less	Not more	Not less
6	12,5	6,4	1,6	0,40	0,80	0,80
8	17	8,4	1,6	0,40	0,80	0,80
10	21	10,5	2,0	0,50	1,00	1,00
12	24	13,0	2,5	0,60	1,25	1,25
14	28	15,0	2,5	0,60	1,25	1,25
16	30	17,0	3,0	0,75	1,50	1,50
18	34	19,0	3,0	0,75	1,50	1,50
20	37	21,0	3,0	0,75	1,50	1,50
22	39	23,0	3,0	0,75	1,50	1,50
24	44	25,0	4,0	1,00	2,00	1,50

Conventional Designation of Washers (According to GOST 19123-82):

Washers should be designated according to the following schemes:

Washer 2.12.02. Ст3кп 019 GOST 11371-78, where:



Example of Washer Designation (According to GOST 18123-82)

Washer 12.03.019 GOST 11371-78 – a washer with a design 1, for the screwed piece with the thread diameter 12 mm, 03 – material group (15 – mark of steel), 01 – coating, 9 mkm – coating thickness.

Note: The type of the material for washers and their designation are taken from Table 20. Types of coatings and their designations are taken from Table 24. Coating thickness is specified according to GOST 9.306-85.

Table 20

Types of Materials for Washers and Their Designation (According to GOST 18123-82)

Material			
Type	Mark	Standard Number	Conventional Designation of Material Type (Group)
Carbon Steels	08, 08кп, 10, 10кп	GOST 1050–88	01
	Ст3, Ст3кп	GOST 380–88	02
	15	GOST 1050–88	03
	20		04
	35		05
	45		06
Alloyed Steels	40Х	GOST 4543–71	11
Corrosion-Resistant Steels	12Х18Н10Т	GOST 5632–72	21
	20 Х13		22
Brass	Л63	GOST 15527–70	32
	ЛС59–1		
	Л63 Antimagnetic		33
Bronze	БрАМц9-2	GOST 18175–78	34
Copper	М3	GOST 859–78	38
Aluminum Alloys	АМг5	GOST 4784–74	31
	Д1		35
	АД1		37

5.2.7. Technical Requirements for Bolts, Screws, Studs and Nuts

Table 21

Technical Specifications for Bolts, Screws and Studs Made of Carbon and Alloyed Steels and for Steel Qualities (extractions from GOST 1759.4-87)

Strength Class	Steel Quality	Standard Number
3.6	Ст3, Ст3кп	GOST 380–88
	10, 10кп	GOST 10702–78
4.6	20	GOST 1050–88
4.8	10, 10кп	GOST 1050–88
5.6	30, 35	GOST 1050–88
5.8	10*, 10кп *	GOST 10702–78
	20*, 20кп*	GOST 1050–88
6.6	35, 45, 40Г	GOST 1050–88 GOST 10702–78 GOST 4543–71
6.8	20, 20кп	GOST 5663–79
8.8	35Х, 35ХА, 40Г	GOST 4543–71
9.8	40Х**	GOST 4543–71
10.9	30ХГСА, 16ХСН	GOST 4543–71
12.9	35ХГСА	GOST 4543–71
14.9	40ХНМА	GOST 4543–71

Notes:
1. Used only for thread diameters less than 12 mm inclusive.
2. Used only for thread diameters less than 16 mm inclusive.

Table 22

Technical Specifications for Nuts Made of Carbon and Alloyed Steels and for Steel Qualities (extractions from GOST 1759.4-87)

Strength Class	Steel Quality	Standard Number
4	Ст3, Ст3кп	GOST 380–88
	20	GOST 1050–88
5	10, 10кп, 20	GOST 1050–88
6	Ст5	GOST 380–88
	15, 15кп	GOST 1050–88
8; 9	35, 40, 45,	GOST 1050–88
10	35Х, 35ХА, 40Г	GOST 4543–71
12	40Х, 30ХГСА, 16ХСН	GOST 4543–71
14	35ХГСА, 40ХНМА	GOST 4543–71

Table 23

Technical Specifications for Bolts, Screws, Studs, Nuts Made of Non-ferrous Alloys

Strength Class	Steel Quality	Standard Number
31	Амг5, Амг5П	GOST 4784–74
32	ЛС59-1, Л63	GOST 15527–70
33	ЛС59-1, Л63 antimagnet	GOST 15527–70
34	БрАМц 9-2	GOST 18175–78
35	Д1, Д1П, Д16, Д16П	GOST 4784–74

Table 24

Types and Designations of Coatings for Bolts, Screws, Studs and Nuts

Coating Types	Designation of Coatings According to GOST 1759.0–87 (numerical)
Zinc, chromate	01
Cadmium, chromate	02
Multi-layer: copper–nickel	03
Multi-layer: copper–nickel–chrome	04
Oxide, oil impregnated	05
Phosphate, oil impregnated	06
Tin	07
Copper	08
Zinc	09
Oxide, chromate filled	10
Oxide, from acid solution	11
Silver	12
Nickel	13

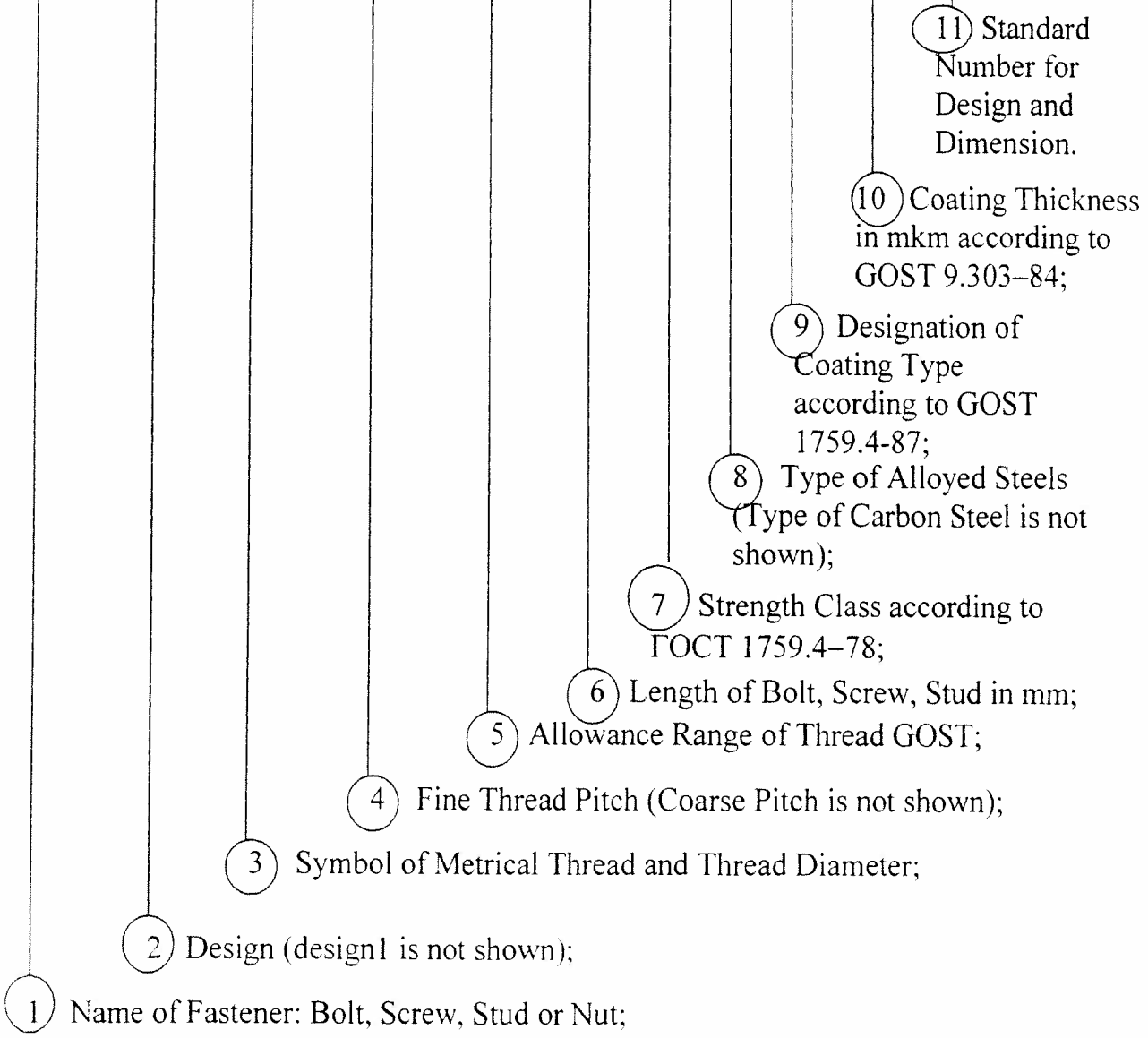
Coating type for a definite material is chosen according to GOST 9.303-84. Thickness of metal coatings (zinc, nickel and other metals and their alloys) are chosen in the following way: 1; 3; 6; 9; 12; 15; 18; 21; 24; 30; 35; 40; 45; 50; 60 mkm (according to GOST 9. 306-85). Coating thickness of 1 mkm and less is not marked.

5.2.8. Conventional Designation of Bolts, Screws, Studs and Nuts

Bolts, screws, studs and nuts made of carbon, alloyed steels and alloys as well as products made of non-ferrous alloys should be designated according to the following scheme:

Bolt 2M12 × 1,25–6g × 60.58.35X.029 GOST...

Bolt 2 M12 × 1,25 – 6g × 60. 58. 35X. 02 9 GOST...



Notes:

1. Strength class is designated without using a point, separating the figures, e.g. 58 is written instead of 5.3.
2. Between parameters 1 and 2, 2 and 3, 10 and 11 intervals are left which are equal to the capital letter of the given lettering size.
3. Between parameters 3 and 4 a multiplication sign (x)is put according to GOST 2.304-81; between 4 and 5 - a dash is placed; a multiplication sign is put between parameters: 5 and 6. Nuts latch the parameter 6. Distinct points are put between parameters 6 and 7, 7 and 8, 8 and 9 inside the intervals.

5.3. Detachable Joints of Machine Elements

Each machine consists of separate elements joined fixed or being in relative movement.

Joints of machine elements can be detachable and permanent. Joints that are disassembled not violating the integrity of elements and means of joining are called detachable (Fig. 144).

Joints that can be disassembled violating the integrity of joining elements and means of joining (riveted, welded, soldered, adhesive, etc.) are called permanent joints.

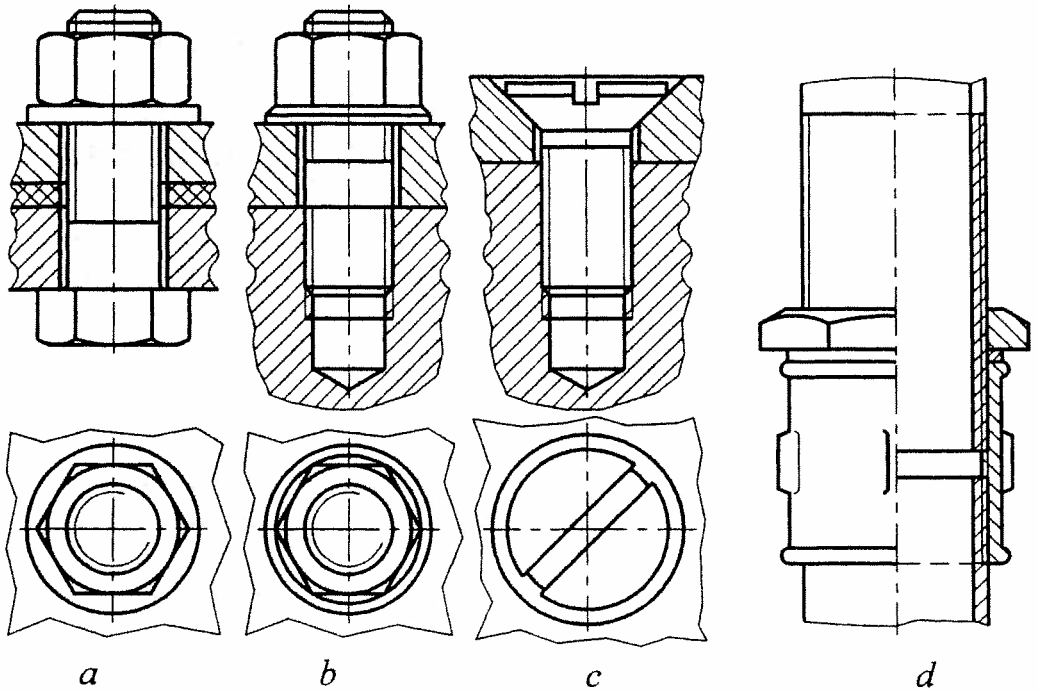


Fig. 144. Thread Joints

5.3.1. Bolted Joints

Joining of two or more elements by means of bolts, nuts and washers is called a bolted joint (Fig. 144, *a*). For passing the bolt the elements joined have smooth holes, i.e. threadless coaxial cylindrical holes of the diameter are much more than the diameter of the bolt (Table 27). On the bolt end, projected from the elements joined, the washer is inserted and the nut is screwed.

While drawing a bolted joint, design sizes of bolts, nuts and washers are taken from corresponding standards (Tables 6, 9, 19).

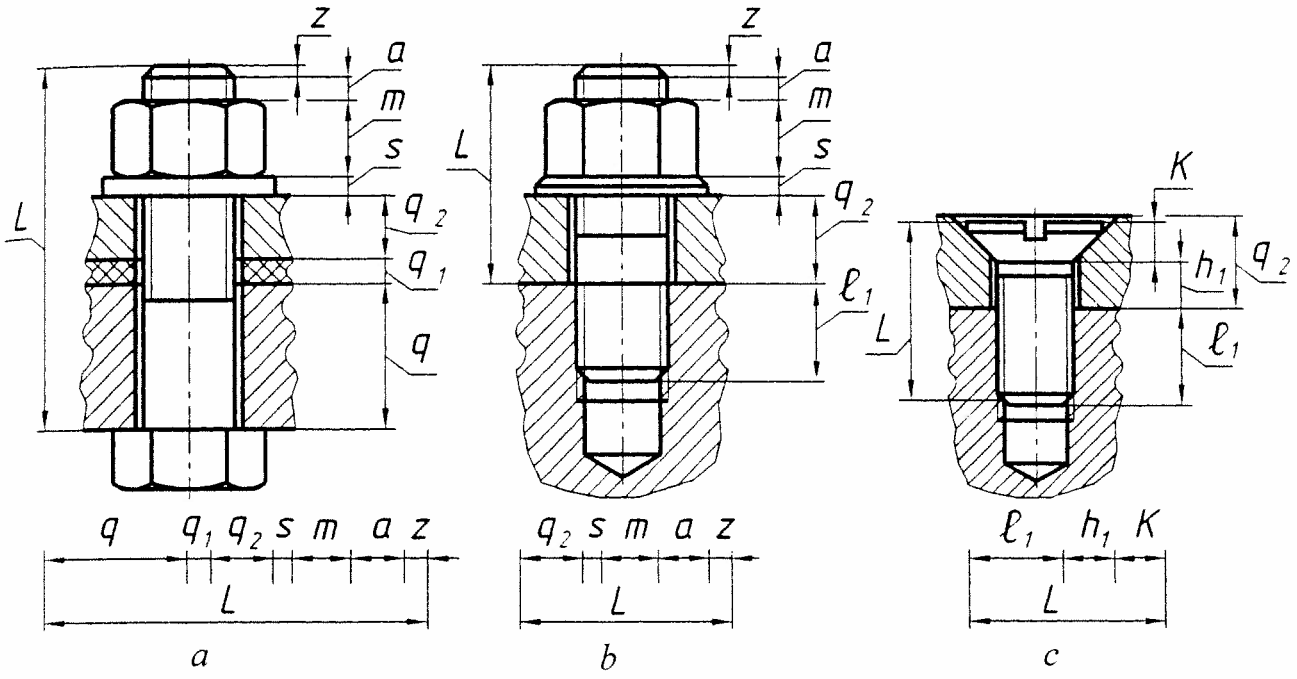


Fig. 145. Assembly Dimension Chains

Fig. 145, *a* demonstrates an assembly dimension chain denoting dimension connections of bolted joints. This dimension chain enables to determine the bolt length *L*, providing the required amount of the thread when the bolt end leaves the nut (size *a*). Analytically this dimension chain can be represented by the equation:

$$L = q + q_1 + q_2 + s + m + a + z,$$

where q, q_1 and q_2 – thickness of elements joined;

s— wrench thickness;

m— nut height;

a— thread amount at the place where the bolt leaves the nut;

z— height of the bolt chamfer.

Values q and q_1 are known, s and m are given in corresponding Standards, z and a are taken from Table 25. The size obtained is rounded till the nearest size of the bolt length in Table 6 GOST 7798-70. The thread length b is taken from this table as well.

5.3.2. Stud Joints

Studs, nuts and washers carry out joining of two or more elements. This joint is used instead of the bolted one when it is undesirable to make through holes in one of the elements joined due to its high thickness or the absence of the place for the bolt head. The length l_1 of the stud screwed end is taken due to the element material (Table 8). First, the hole for the stud is drilled, then the chamfer is made and the thread is cut (socket for the stud). On the nut end of the stud some other elements are inserted and joined with the first one, they have smooth coaxial cylindrical-holes of a larger diameter (GOST 11284-75) than the stud diameter (Table 26). On the stud end projecting out of the elements joined, the washer is inserted and the nut is screwed (Fig. 144, *b*).

While drawing the stud joint, the design sizes of studs, nuts and washers are taken from corresponding Standards (Tables 7, 9, 19). While choosing a stud it is necessary to keep in mind that the length l of the screwed end depends on the material the element is made of and in which it is screwed (Table 8).

1) $l_1 = d$ for steel, bronze, brass elements and elements made of titanium alloys (GOST 22032-76);

2) $l_1 = 1{,}25d$ for elements made of malleable cast iron and grey cast iron (GOST 22034-76);

3) $l_1 = 2d$ for elements made of light alloys (GOST 22038-76) (d – major diameter of the stud thread).

To determine the nut end length of the stud it is necessary to construct an assembly dimension chain. Fig. 145, *b* demonstrates an assembly dimension chain showing dimension connections of the joint by a stud. This dimension chain enables to determine the length of the nut end of the stud providing the required amount of the thread at the place where the stud end leaves the nut (size *a*).

Analytically this dimension chain can be represented by the equation:

$$L = q_2 + s + m + a + z,$$

где q_2 – the thickness of the element joined;

s – washer thickness;

m – nut height;

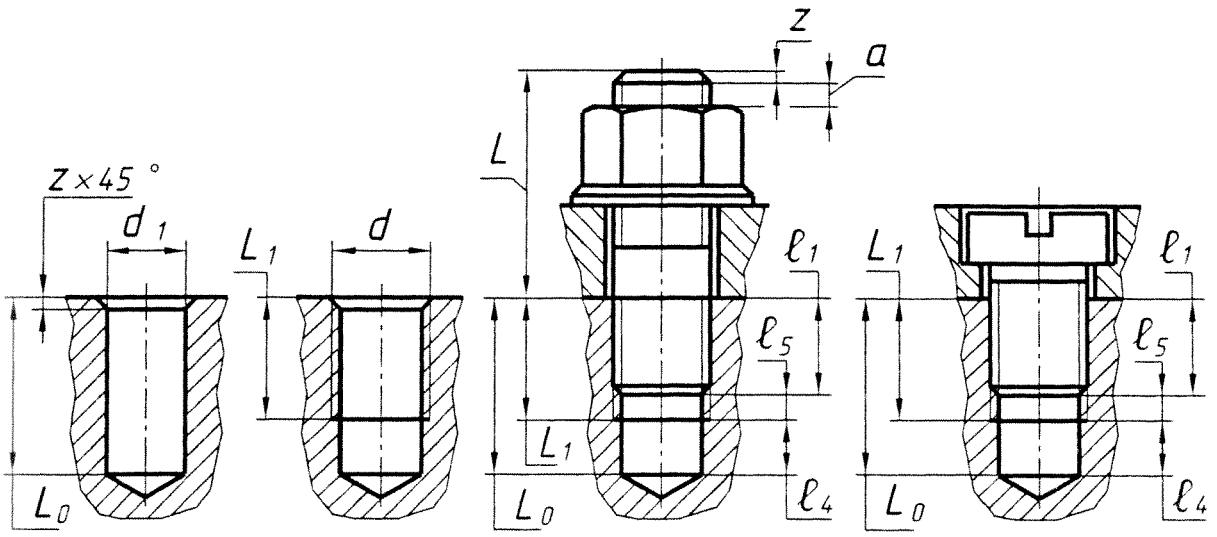
a – amount of thread at the place where the stud leaves the nut;

z – height of the stud chamfer.

The value q_2 is known, s and m are given in corresponding Standards, z and a are taken from Table 25. The size L obtained is rounded till the nearest size of the length of the nut end of the stud according to Table 7. From this table the length l_0 of the stud end is determined for the nut. The depth L of the hole drilled for the thread as well as the thread length. L_1 are calculated on account of Table 25. Hole diameters for cutting the metric thread are taken from Table 26.

Table 25

Thread Outlet and Supply, Undercuts, Chamfers for Metric Threads (According to GOST 10549-80), mm



Thread Pitch P	Thread Supply ℓ_5	Undercut ℓ_4		Thread Supply a	Chamfer z
		Normal	Shot		
1,00	3,0	6,0	4,0	2,0	1,0
1,25	3,5	8,0	4,0	2,5	1,6
1,50	4,0	9,0	4,0	3,0	1,6
1,75	5,0	11,0	5,0	3,5	1,6
2,00	5,5	11,0	5,0	4,0	2,0
2,5	7,0	12,0	6,0	5,0	2,5
3,00	8,5	15,0	7,0	6,0	2,5
3,50	10,0	17,0	8,0	7,0	2,5

Table 26

Hole Diameters for Cutting Metric Thread with Coarse Pitch (According to GOST 19257-73)

Nominal Thread Diameter d, mm	Thread Pitch P, mm	Thread Hole Diameter d_1 with Allowance Range	
		5H; 6H; 7H	6G; 7G
1	2	3	4
6	1,00	4,95	5,00
8	1,25	6,70	6,75
10	1,50	8,43	8,50
12	1,75	10,20	10,25
14	2,00	11,90	11,95
16	2,00	13,90	13,95
18	2,50	15,35	15,40
20	2,50	17,35	17,40
22	2,50	19,35	19,40
24	3,00	20,85	20,90
27	3,00	23,85	23,90

5.3.3. Joining of Elements by Screws

Screws can be used to join two or more elements. For the purpose a threaded hole is made in the final element, and smooth coaxial holes with the diameter more than the screw diameter are made in the rest. The screw passes freely through smooth holes of elements joined and is screwed in the threaded hole of the last one (Fig. 144, c). The screwing length *l* depends on the element material and is assumed to be equal to *1d* for steel, bronze and brass; *1,25d* – for malleable and grey cast iron; *2d* – for light alloys (d – major diameter of the screw thread).

In the first joining element a cone countersink drill (recess under the head) is made for instrument-headed and countersunk screws.

A cylindrical countersink drill is made for fillister-head screws (Fig. 144, *c*).

In order to count the screw length it is necessary to make an assembly dimension line (Fig. 145, *c*). The result obtained in the calculation is rounded till the nearest size of the screw length taken from the Table of the corresponding Standard (Ta-

ble 13). The length of the threaded screw section is also determined from this Table. When making a dimension chain, it is necessary to keep in mind that the countersunk section of instrument-headed and countersunk screws is included into the screw length. While drawing the screwed joints, the design sizes of screws are taken from the corresponding Standard (Tables 10–14).

Head slots of screws are represented on assembly drawings on top views, (or left-side views) at an angle of 45° to the drawing frame (Fig. 145,*c*) corresponding to GOST 2.315-68.

Hole diameters for screws are taken from Table 27.

The thread outlet and supply, undercuts, chamfers for metric threads are taken from Table 25.

Table 27

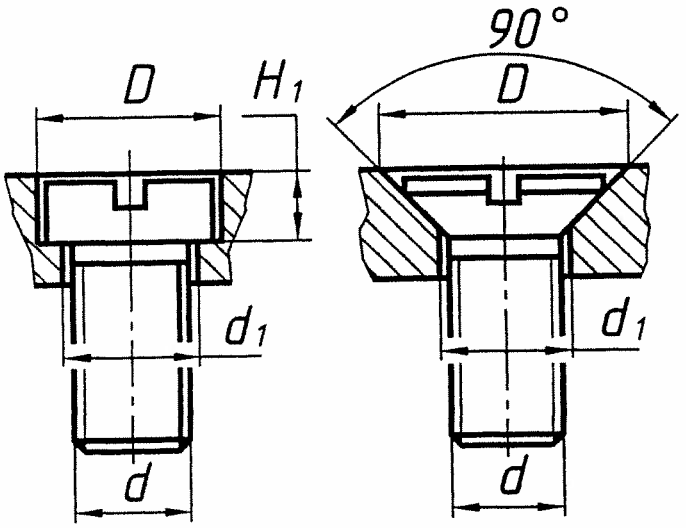
Through Holes for Screwed Fastenings (According to GOST 11284-75)

Rod Diameters of Fastenings d, mm	Diameters of Through Holes d_1, mm	
	1 row	2 row
6,0	6,4	6,6
8,0	8,4	9,0
10,0	10,5	11,0
12,0	13,0	14,0
14,0	15,0	16,0
16,0	17,0	18,0
18,0	19,0	20,0
20,0	21,0	22,0
22,0	23,0	24,0
24,0	25,0	26,0

The sizes of countersink drills for instrument-headed, countersunk and fillister-head screws are listed in Table 28. Chamfers, thread amount, outlets of bolt ends and studs from the nut are shown in Table 25.

Table 28

Countersinking for Screw Heads (According to GOST 12876-77)



Nominal Thread Diameter d, mm	Round Head Screws			Countersunk and Semicountersunc Screws
	D, mm		H_1, mm	D, mm
	1st row*	2nd row**		
6	11	12	4,7	12,3
8	14	15	6,0	16,5
10	17	18	7,0	20
12	19	20	8,0	24
14	22	24	9,0	28
16	26	28	10	31
18	28	30	11	35
20	32	34	12	39

Notes:

1. *Used in through holes in the 1st row, according to GOST 11284-75;

2. *Used in through holes in the 2nd row, according to GOST 11284-75 (see Table 27).

5.3.4. Pipe Joints

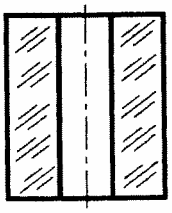
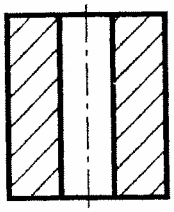
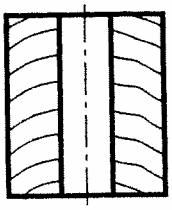
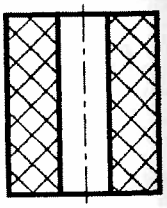
Joining of water and gas-supply pipes is provided by means of joining threaded elements – fittings (triangular, T-joints, couplings, etc. Fig. 144, *d*). While drawing the pipe joint by a coupling, design sizes of pipes, couplings and lock-nuts are taken from corresponding Standards (Tables 16 – 18). On one pipe the thread length on the side of the coupling should be L_1, on the other one – L_2. Each pipe is screwed in the coupling by the value L_1. The lock nut is screwed on the pipe on the side of the longer thread (L_2) and is used for locking the coupling.

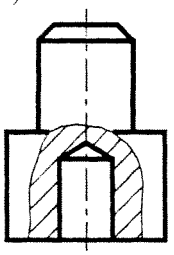
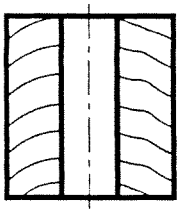
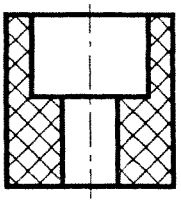
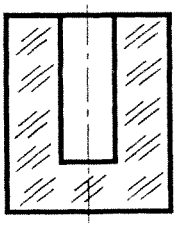
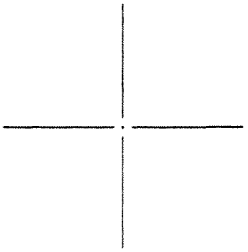
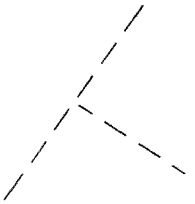
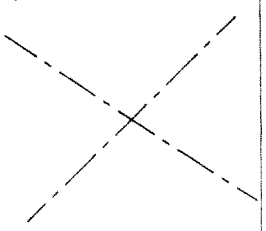
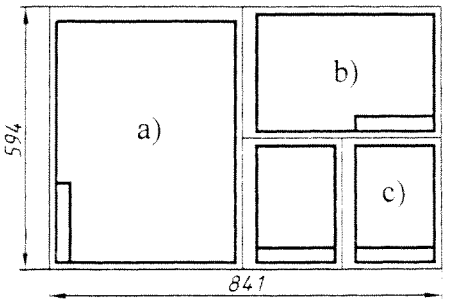
Questions for self-control

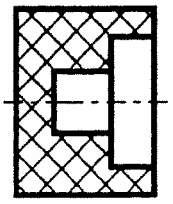
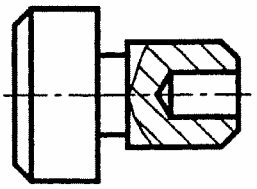
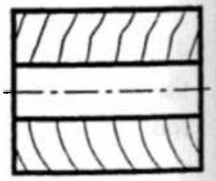
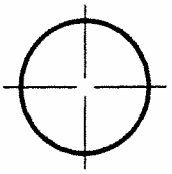
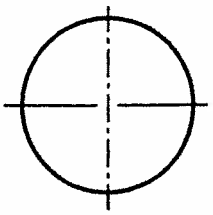
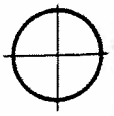
1. What is a thread?
2. What is a thread profile?
3. Give the definition of a thread lead.
4. Give the definition of a thread pitch.
5. What thread types are basic for fasteners?
6. What thread is used in pipe joints?
7. What thread is called a non-standard profile?
8. What rules for the thread representation are established by GOST 2.311-68?
9. Name thread elements which are formed in its making.
10. Tell about the thread designation.
11. Enumerate thread fastenings which are used in fixed detachable joints of machine elements.
12. Tell about the designation of enumerated thread fastenings.

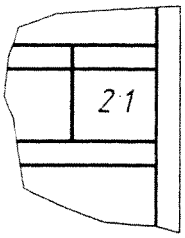
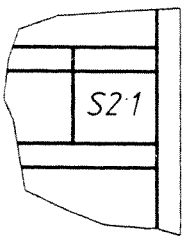
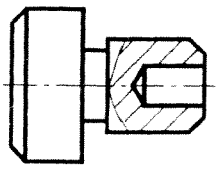
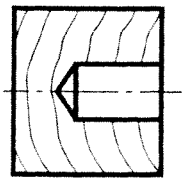
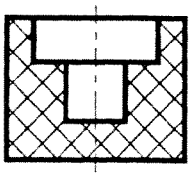
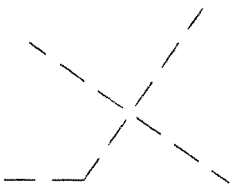
CHAPTER IV

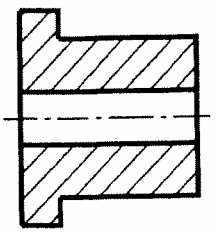
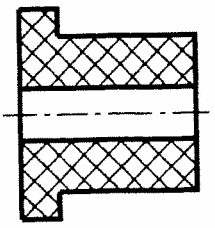
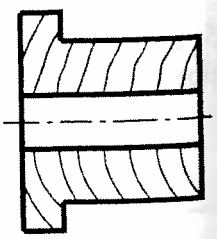
PROGRAMED CONTROL

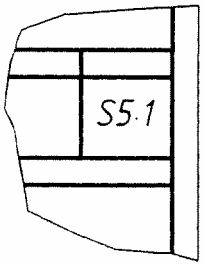
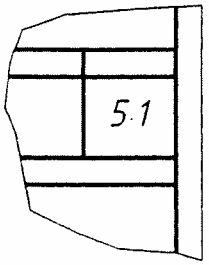
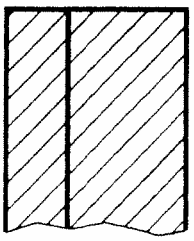
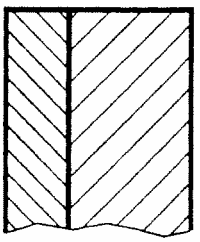
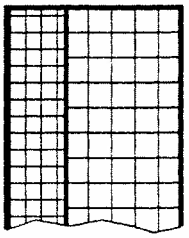
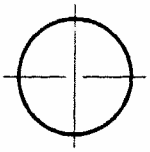
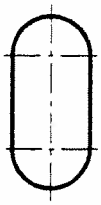
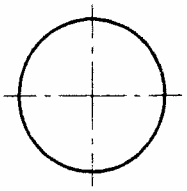
<table>
<tr><td>Test 1
Card 1</td><td colspan="4">Engineering Graphics
Theme: Designation of Drawings</td></tr>
<tr><td rowspan="4">1. What line must be used for a drawing frame?</td><td colspan="4">a) Shot dash
– – – – – – – – – – – – – – – – – –</td></tr>
<tr><td colspan="4">b) Thin long chain
——— · ——— · ———</td></tr>
<tr><td colspan="4">c) Thin continuous
———————————</td></tr>
<tr><td colspan="4">d) Thick continuous
———————————</td></tr>
<tr><td>2. Show a format in which a title block must be arranged along a short side only?</td><td>a)
A4</td><td>b)
A1</td><td>c)
A3</td><td>d)
A2</td></tr>
<tr><td>3. Show the representation of a metal part.</td><td>a)
  </td><td>b)
  </td><td>c)
  </td><td>d)
  </td></tr>
<tr><td>4. A drawing is made in scale S2:1. How should the sizes be marked on this drawing?</td><td>a)
true sizes</td><td>b)
increased in twice</td><td colspan="2">c)
diminished in twice</td></tr>
<tr><td>5. Show the height of a small letter of the Lettering number 5.</td><td>a)
5 mm</td><td>b)
3,5 mm</td><td colspan="2">c)
7 mm</td></tr>
</table>

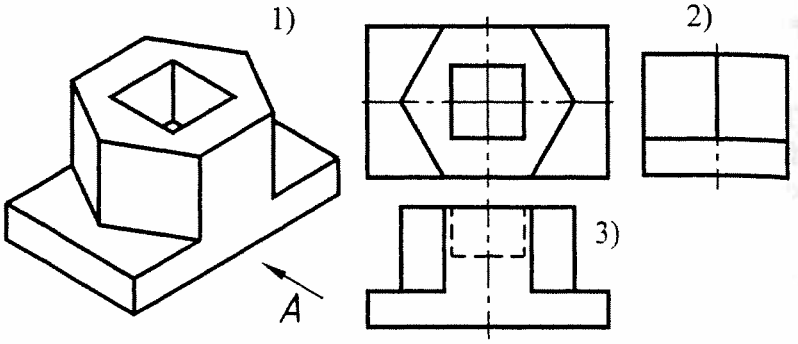
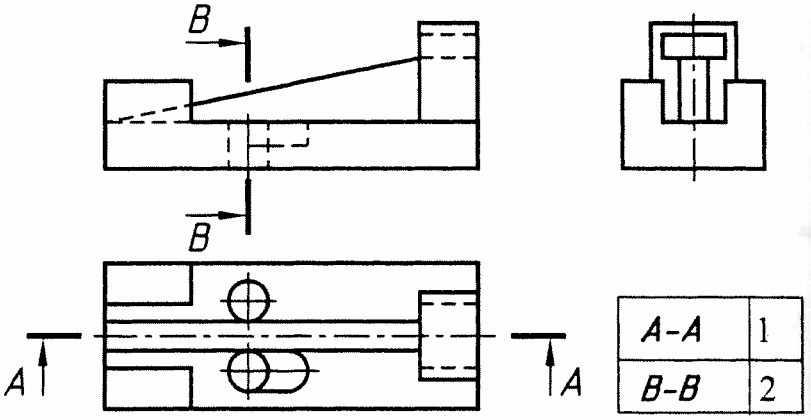
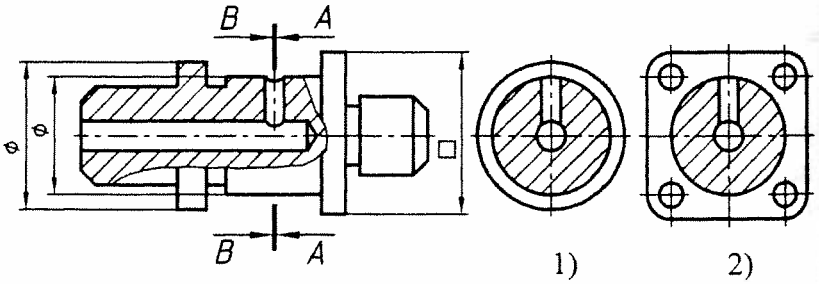
Test 1 Card 2	Engineering Graphics Theme: Designation of Drawings			
1. Choose the line which is used as a line of a visible outline.	a) Thick continuous 			
	b) Thin long chain 			
	c) Thin continuous 			
	d) Shot dash 			
2. Show the representation of a glass part.	a) 	b) 	c) 	d) 
3. Choose the scale of the increase.	a) S 1:5	b) S 1:1	c) S 2:1	d) S 1:10
4. Show the drawing in which the intersection of two lines is marked correctly.	a) 	b) 	c) 	
5. Show the format A4.				

Test 1 Card 3	Engineering Graphics Theme: Designation of Drawings		
1. Choose the line that is used as an axis line on drawings.	a) Thin continuous b) Thin long chain c) Thick continuous d) Shot dash		
2. Show format sizes where a title block must be arranged along a short side only.	a) 420×594	b) 297×420	c) 210×297
3. Choose the scale with which a representation of a part corresponds to its true value.	a) S 5:1	b) S 1:1	c) S 1:50
4. Where is a wood part represented?	a) 	b) 	c) 
5. Show the drawing in which the centre of circumference is marked correctly.	a) 	b) 	c) 

Test 1 Card 4	Engineering Graphics Theme: Designation of Drawings		
1. Show the line which must be used for representing a visible outline of views and section views.	a) Thin continuous b) Thin long chain c) Thick continuous d) Shot dash		
2. Show the size of a small letter of Lettering number 7.	a) 5mm	b) 7mm	c) 3,5mm
3. Where is the designation of a scale in a space of a title block made correctly?	a) 	b) 	
4. Choose the representation of a plastic part.	a) 	b) 	c) 
5. In what case is the broken line represented correctly?	a) 	b) 	c) 

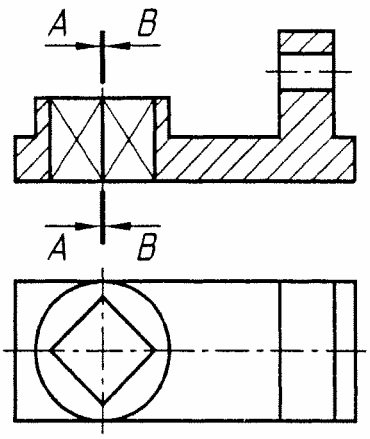
Test 1 Card 5	Engineering Graphics Theme: Designation of Drawings		
1. Choose the line which must be used as an axis line on drawings.	a) Thick continuous b) Thin long chain c) Thin continuous d) Shot dash		
2. Show a scale of the increase.	a) S 2:1	b) S 1:20	c) S 1:1
3. Which of the given formats has sizes 297×420.	a) A1	b) A2	c) A3
4. Show the size of capital letters of Lettering number 5.	a) 5mm	b) 7mm	c) 3,5mm
5. Show the representation of a rubber part.	a) 	b) 	c) 

Test 1 Card 6	Engineering Graphics Theme: Designation of Drawings		
1. Choose the line that is used for an invisible outline on drawings.	a) Thick continuous b) Thin continuous c) Shot dash d) Thin long chain		
2. How is the scale designated in a space of a title block?	a) 	b) 	
3. Show sizes of format A4.	a) 297×420	b) 420×594	c) 210×297
4. Show the drawing on which hatching lines of two adjoining part sections are made correctly.	a) 	b) 	c) 
5. On which drawing are symmetry axes intersected correctly?	a) 	b) 	c) 

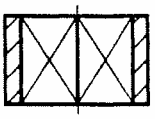
Test 2 Card 1	Engineering Graphics Theme: Views, Simple Sectional Views
1. Show the representation corresponding to a rear view, if the view along the arrow *A* is considered to be the main view.	
2. Show the cutting plane (*A–A* or *B–B*), where a stiffening rib must not be hatched.	 *A-A* 1 *B-B* 2
3. A drawing of the part is given. Choose the representation where the sectional view ***B-B*** is made.	
4. Define the place of the left–hand view relative to the main view.	*A* — The main view — *B* ***A*—1** ***B*—2**

Test 2	Engineering Graphics Theme: Views, Simple Sectional Views
Card 2	

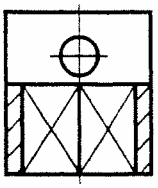
1. Choose the representation corresponding to the sectional view *B-B* (a drawing of a part: the main view and the top view are given here)



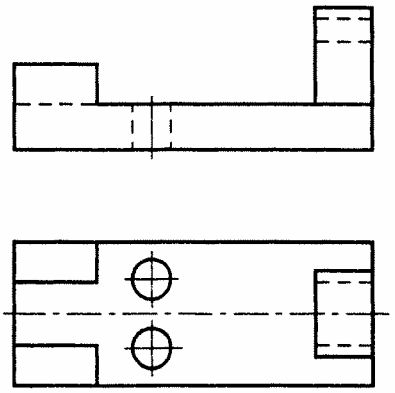
1)



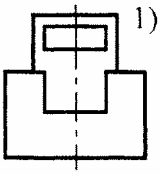
2)



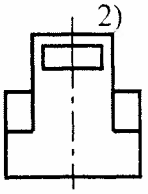
2. Which of the views is the right-hand view for the given part?



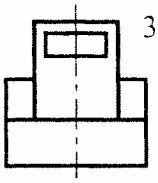
1)



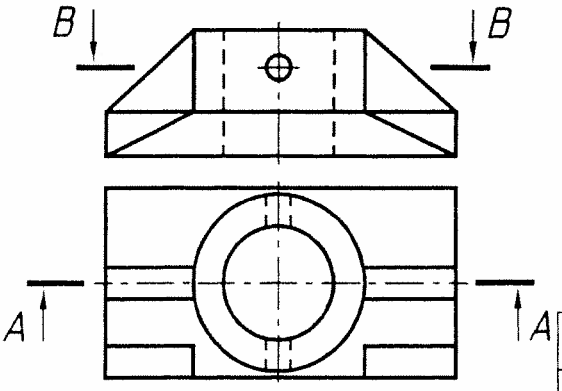
2)



3)



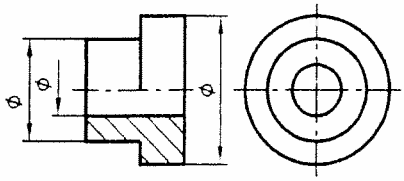
3. Show the position of a cutting plane where a stiffening rib must not be hatched.



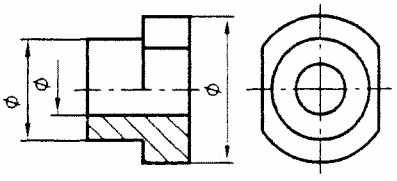
A-A	1
B-B	2

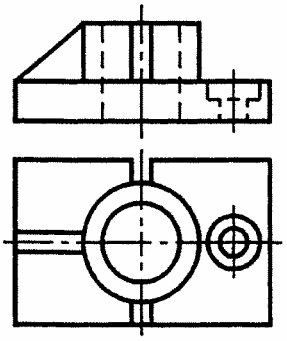
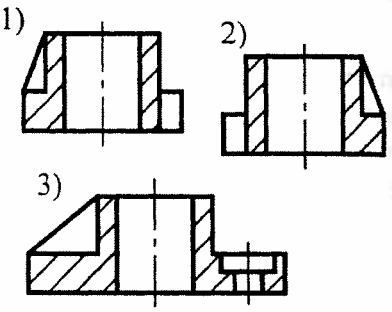
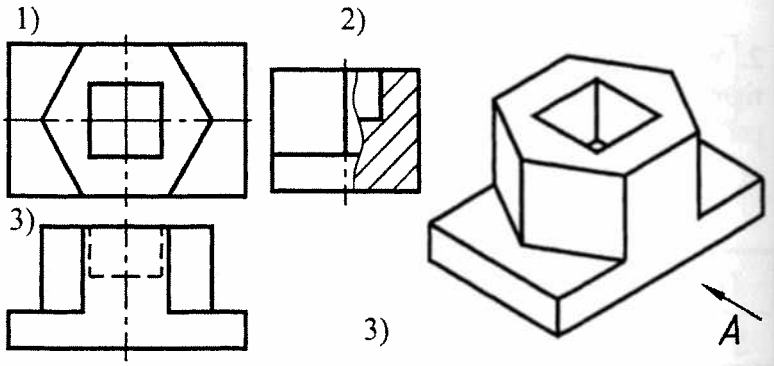
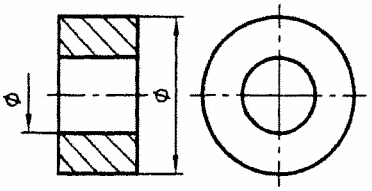
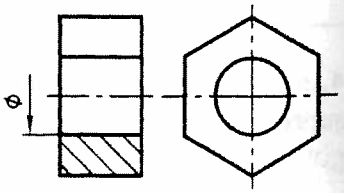
4. Show the drawing where a superfluous representation is given.

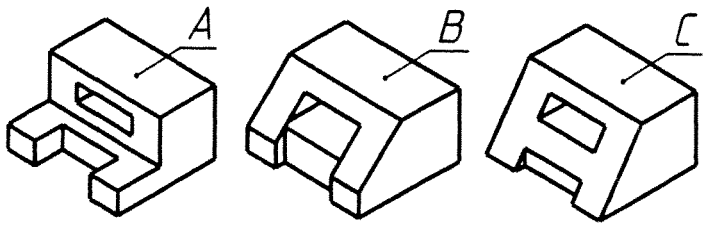
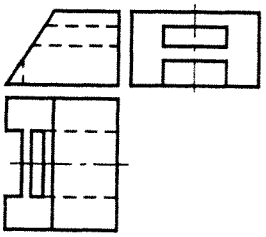
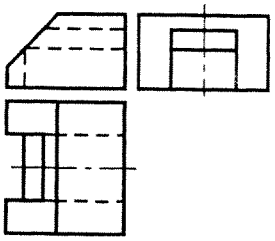
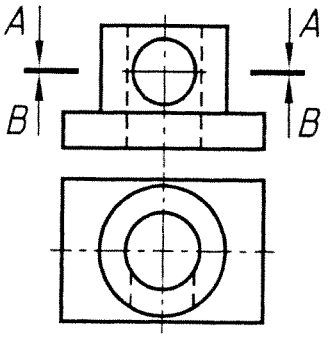
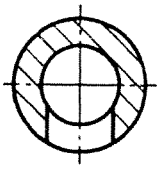
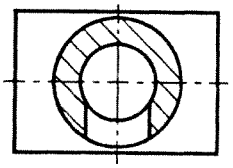
1)



2)



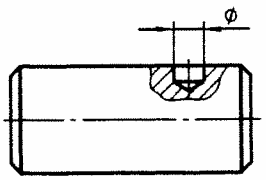
Test 2 Card 3	Engineering Graphics Theme: Views, Simple Sectional Views	
1. A drawing of the part (the main view and the top view) is given. Show the frontal sectional view of this part.		1) 2) 3) 
2. Show the representation corresponding to the top view, if the view along the arrow *A* is considered to be the main view.	1) 2) 3) 	3)
3. What representations are necessary to reveal the shape of the given part?	1) a) Main representation: joining a half view along the arrow *B* with a half frontal sectional view; b) Top view; c) Left-hand view.	2) a) Main representation: joining a half view along the arrow *B* with a half frontal sectional view; b) Top view;
4. Show the drawing where an unnecessary representation is given.	1) 	2) 

Test 2	Engineering Graphics Theme: Views, Simple Sectional Views
Card 4	
1. Look at the parts *A*, *B*, *C* and look at the drawings arranged below. What drawing is the part *B* represented on?	 1)  2) 
2. Which representation corresponds to the sectional view *B-B*?	 1)  2) 
3. Show the position of a cutting plane for the formation of the horizontal sectional view.	1) The cutting plane is parallel to the horizontal projection plane. 2) The cutting plane is perpendicular to the horizontal projection plane.
4. Which line is used for separating a half view and a half sectional view?	1) Shot dash line 2) Thin continuous line 3) Thin long chain line

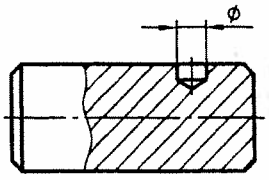
Test 2	Engineering Graphics Theme: Views, Simple Sectional Views
Card 5	

1. Which of the local sectional views is made more correctly?

1)



2)



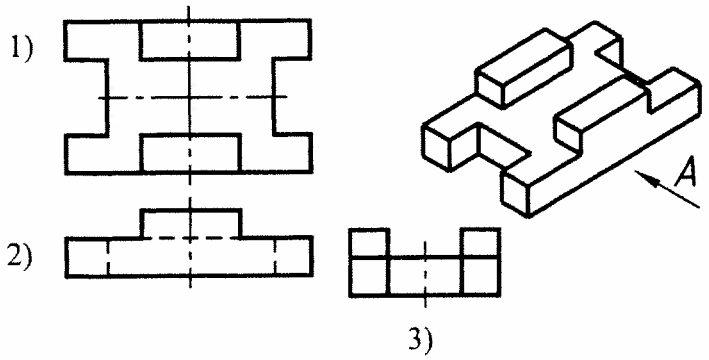
2. Show the position of a cutting plane for the formation of a vertical sectional view.

1) The cutting plane is parallel to the horizontal projection plane.

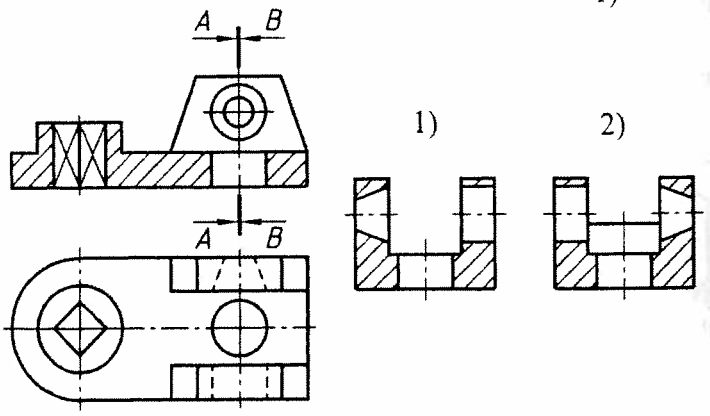
2) The cutting plane is perpendicular to the horizontal projection plane.

3) The cutting plane is inclined to the horizontal projection plane.

3. Show the representation corresponding to the top view, if the view along the arrow *A* is considered to be the main view.

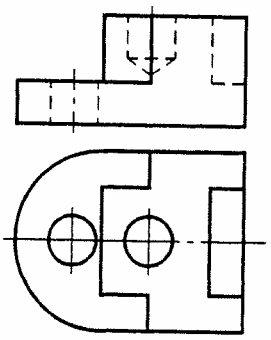


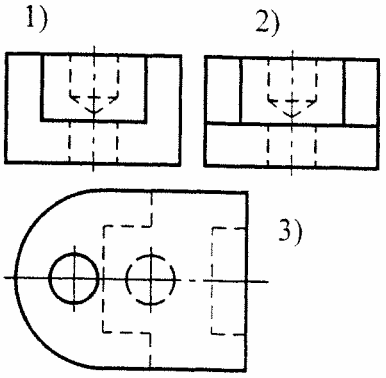
4. Choose the representation corresponding to the sectional view *B–B*.



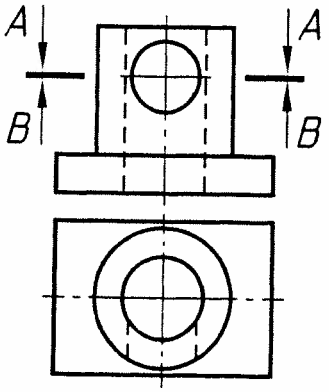
Test 2	Engineering Graphics Theme: Views, Simple Sectional Views
Card 6	

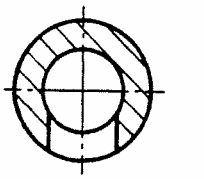
1. A drawing of the part (the main view and the top view) is given here. Show the representation corresponding to the left-hand view.

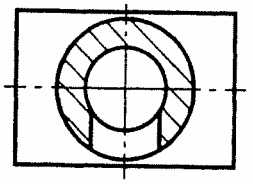




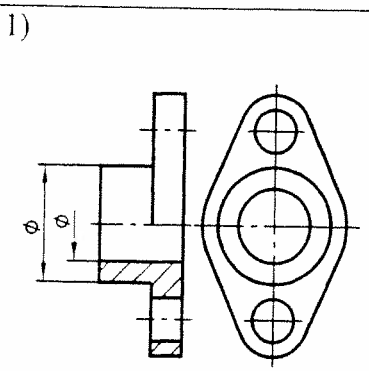
2. Choose the representation corresponding to the sectional view *B–B*.

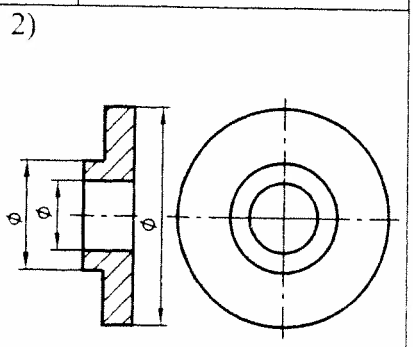




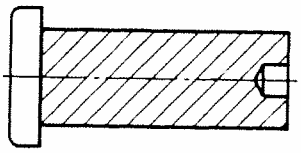


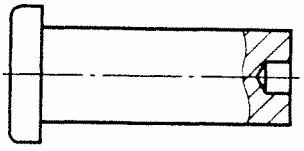
3. Show the drawing where an unnecessary representation is given.





4. Which of the local sectional views are made more correctly?





Test 3	Engineering Graphics Theme: Views; Complex Sectional Views; Sections; Axonometric Projection
Card 1	

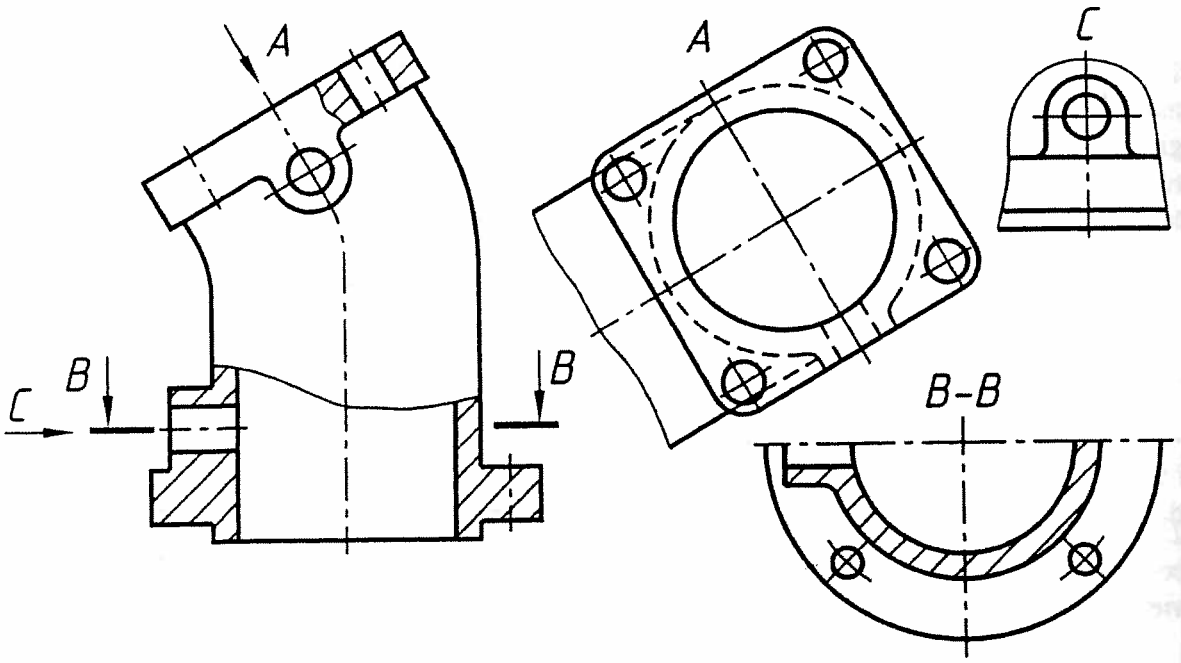
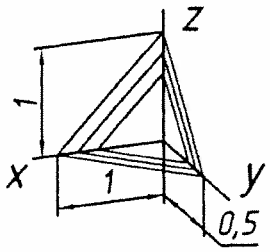
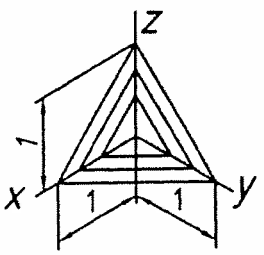
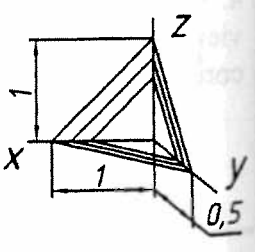


Fig. 1

1 Show the representation corresponding to the auxiliary view (Fig. 1)	1) *A*	2) *B-B*	3) *C*
2. What is the representation *C* called?	1) Left–hand view	2) Auxiliary view	3) Local view
3 In what case are the hatching lines made in conformity with the rule of Rectangular Dymetry?	1) 	2) 	3) 

Test 3	Engineering Graphics Theme: Views; Complex Sectional Views; Sections; Axonometric Projection
Card 1	

4. Choose the name corresponding to the sectional view *A–A* (Fig. 2).

1) Vertical

2) Complex broken

3) Complex stepped

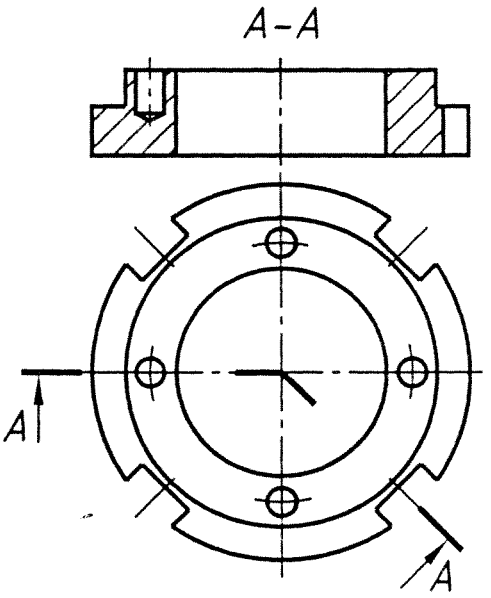
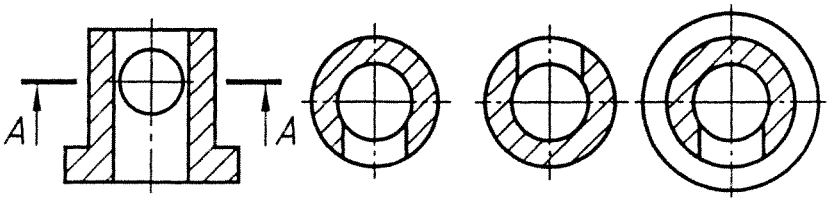


Fig. 2

5. Show the representation corresponding to the section *A–A*.



1) 2) 3)

6 What is the made section called (Fig. 3)?

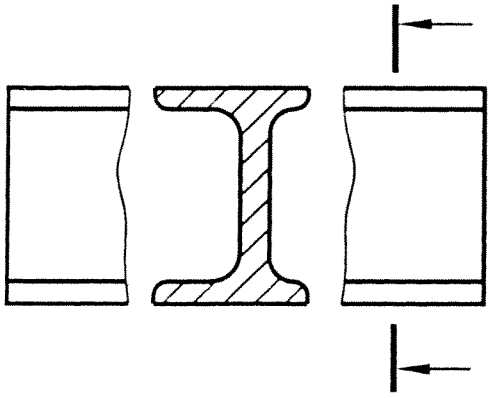


Fig. 3

Oblique—1
Removed—2
Revolved—3

Test 3	Engineering Graphics Theme: Views; Complex Sectional Views; Sections; Axonometric Projection
Card 2	

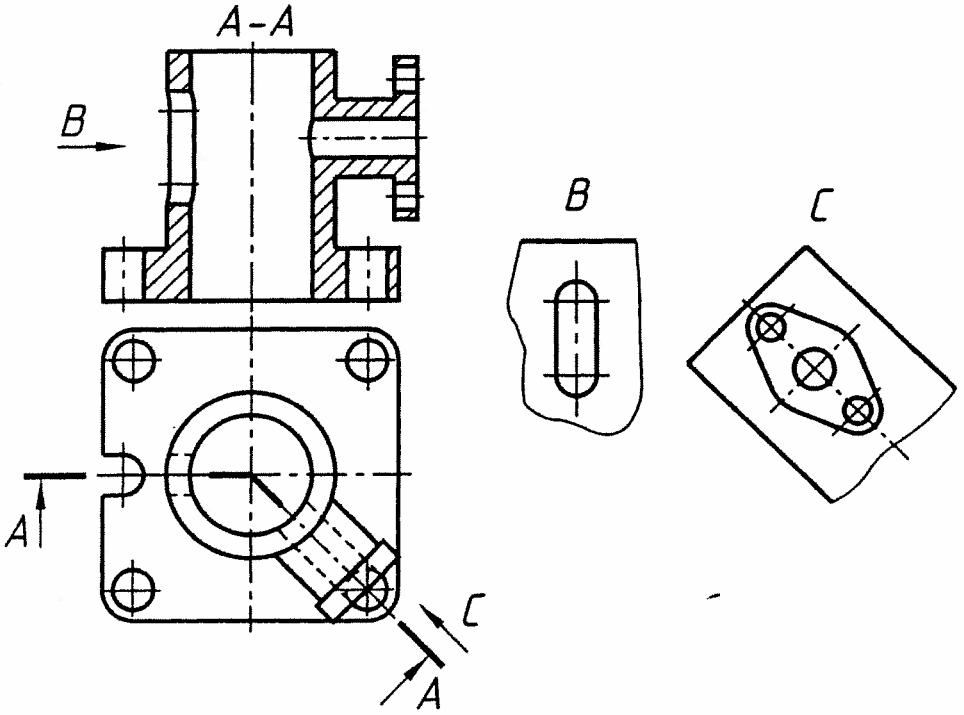


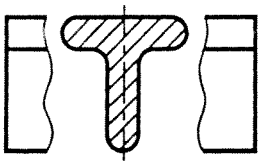
Fig. 1

1 Show the representation corresponding to an auxiliary view (Fig. 1).	1) *A–A*	2) *B*	3) *C*
2. What is the representation *B* called (Fig. 1)?	1) Left–hand view	2) Local view	3) Auxiliary view
3. What is the sectional view *A–A* called (Fig. 1)?	1) Complex stepped	2) Complex broken	3) Frontal sectional view

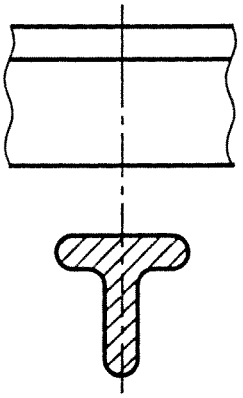
Test 3	Engineering Graphics Theme: Views; Complex Sectional Views; Sections; Axonometric Projection
Card 2	

4. Show the drawing where a revolved section is made.

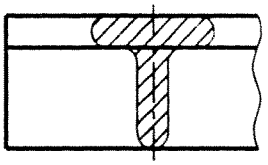
1)



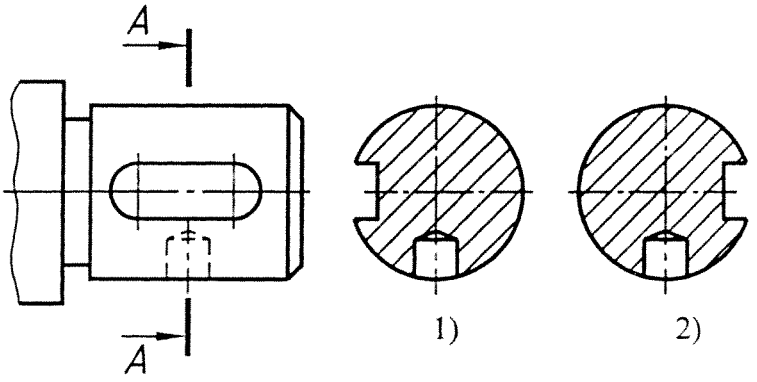
2)



3)

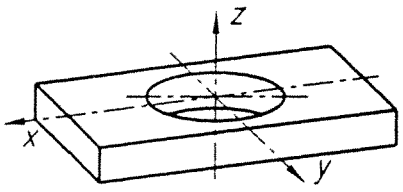


5 Choose the representation corresponding to the section *A–A*.

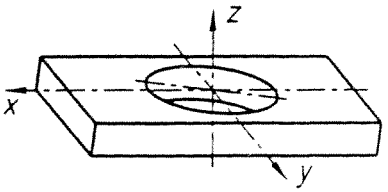


6. Which representation is made in Rectangular Dymetry?

1)



2)



Test 3	Engineering Graphics Theme: Views; Complex Sectional Views; Sections; Axonometric Projection
Card 3	

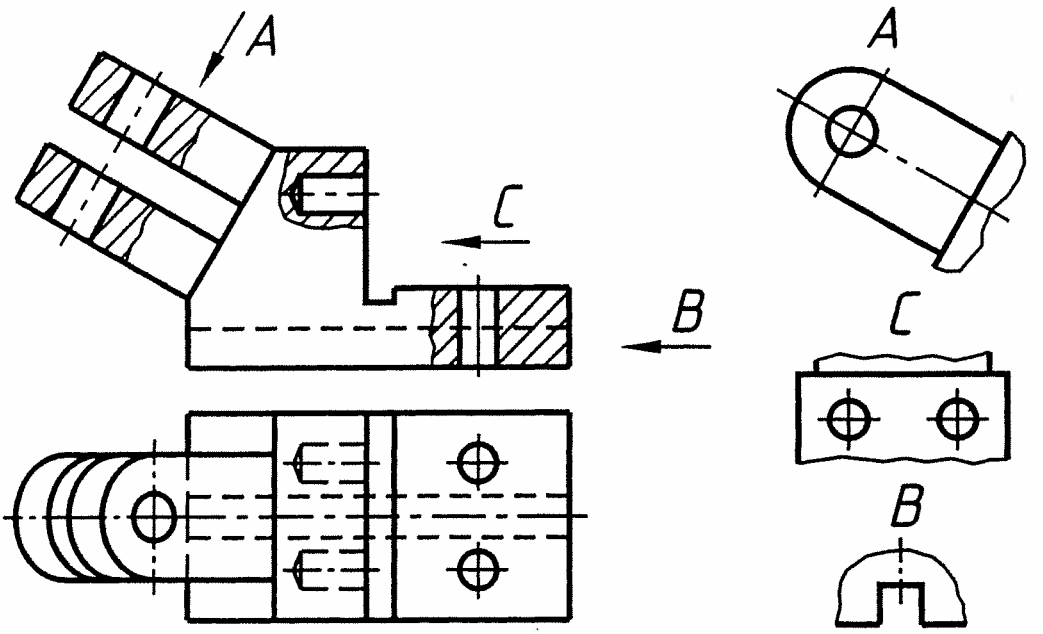
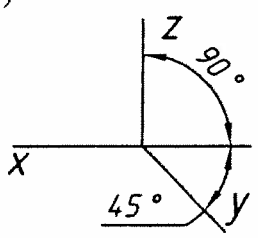
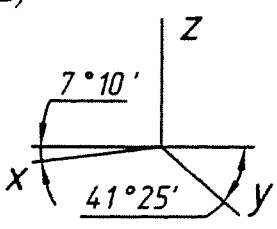
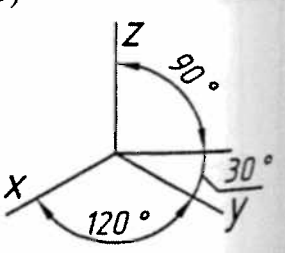


Fig. 1

1 Show the representation corresponding to an auxiliary view (Fig. 1)	1) *C*	2) *A*	3) *B*
2. What is the representation *B* called (Fig. 1)?	1) Right- hand view	2) Local view	3) Auxiliary view
3 What position of axonometric axes corresponds to Rectangular Isometry?	1) 	2) 	3) 

Test 3	Engineering Graphics Theme: Views; Complex Sectional Views; Sections; Axonometric Projection
Card 3	

4. What is the representation *A–A* called (Fig. 2)?

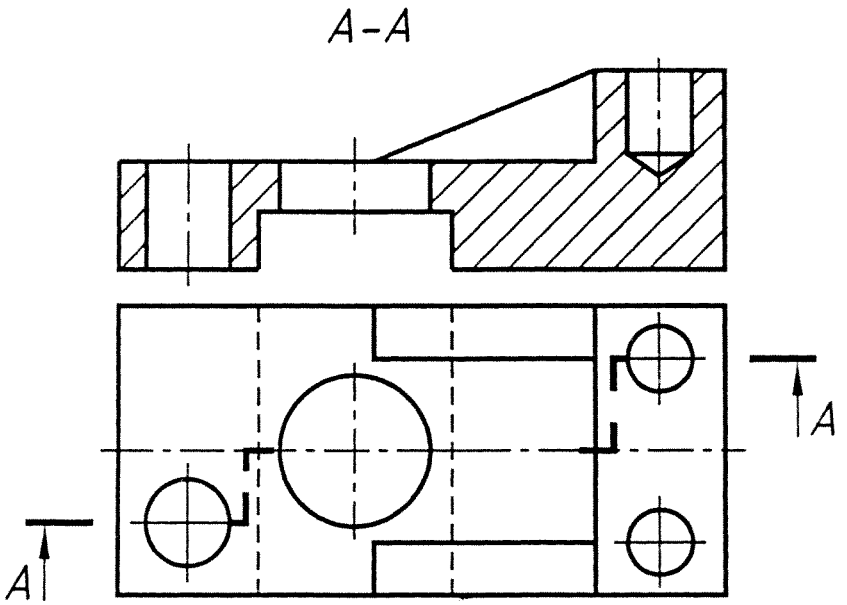
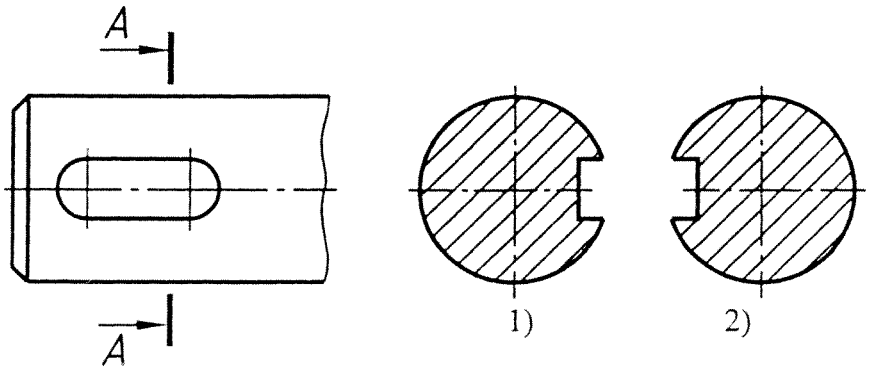


Fig. 2

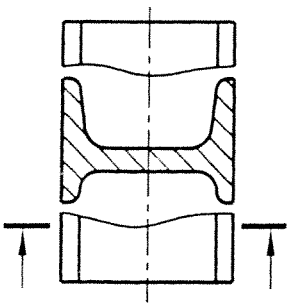
1)	2)	3)
Frontal sectional view	Complex broken sectional view	Complex stepped sectional view

5. Choose the representation corresponding to the section *A–A*.

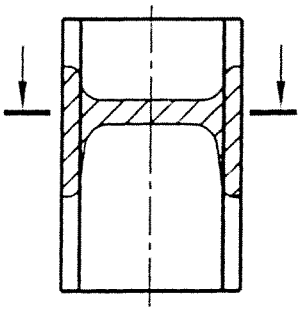


6. Show the drawing where a revolved section is made.

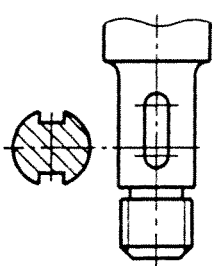
1)



2)



3)



Test 3	Engineering Graphics Theme: Views; Complex Sectional Views; Sections; Axonometric Projection
Card 4	

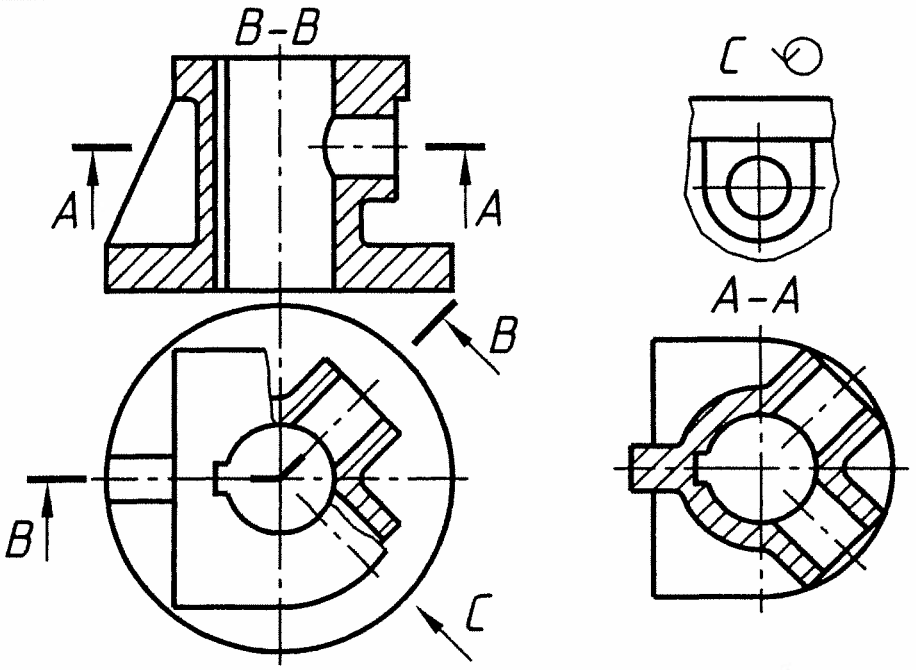


Fig. 1

1. Name the sectional view *B–B* (Fig. 1)	1) Frontal	2) Complex stepped	3) Complex broken
2. What is the representation *C* called (fig. 1)?	1) Local view	2) Rear view	3) Auxiliary view
3. What line must be used for the representation of a revolved section?	1) Thin long chain	2) Thick continuous	3) Thin continuous

Test 3	Engineering Graphics Theme: Views; Complex Sectional Views; Sections; Axonometric Projection
Card 4	

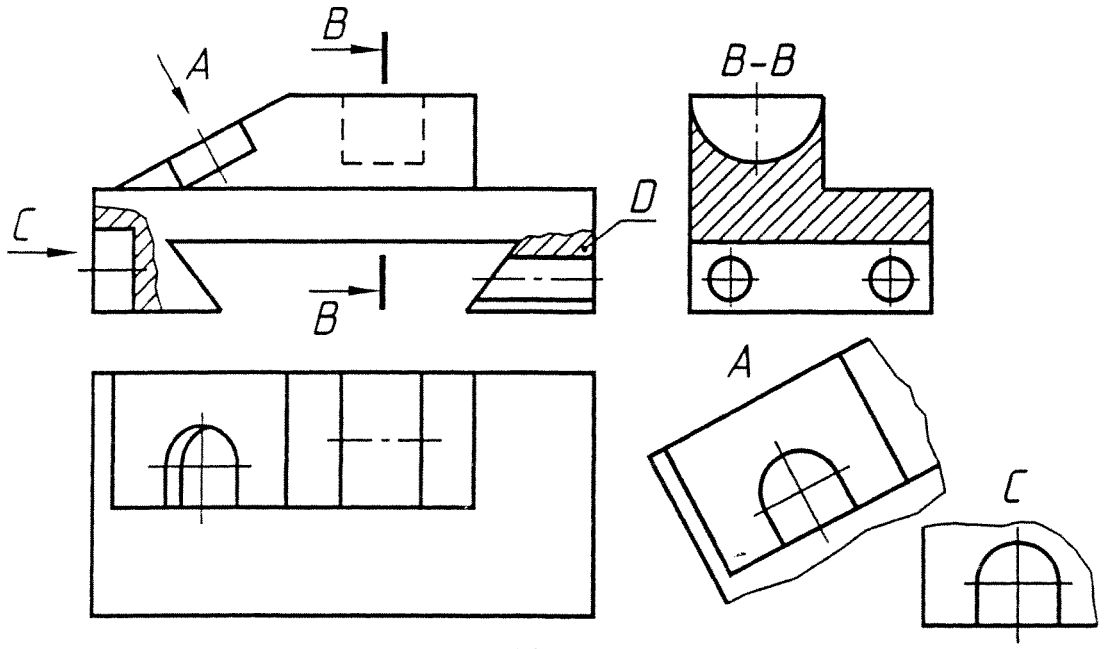


Fig. 2

4 Show the representation corresponding to a local view (Fig. 2).	1) A	2) B–B	3) C

5

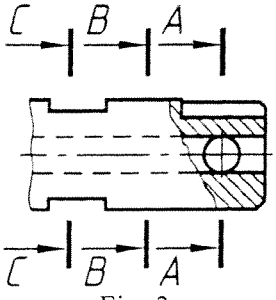
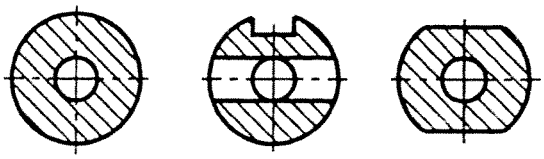


Fig. 3

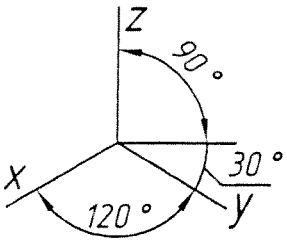
Choose the representation of the section B–B



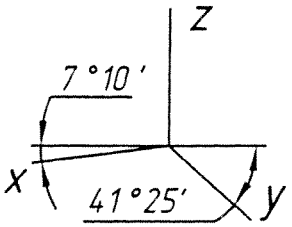
1) 2) 3)

6. What position of axonometric axes corresponds to Rectangular Dymetry?

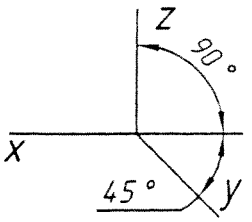
1)



2)



3)



Test 3	Engineering Graphics Theme: Views; Complex Sectional Views; Sections; Axonometric Projection
Card 5	

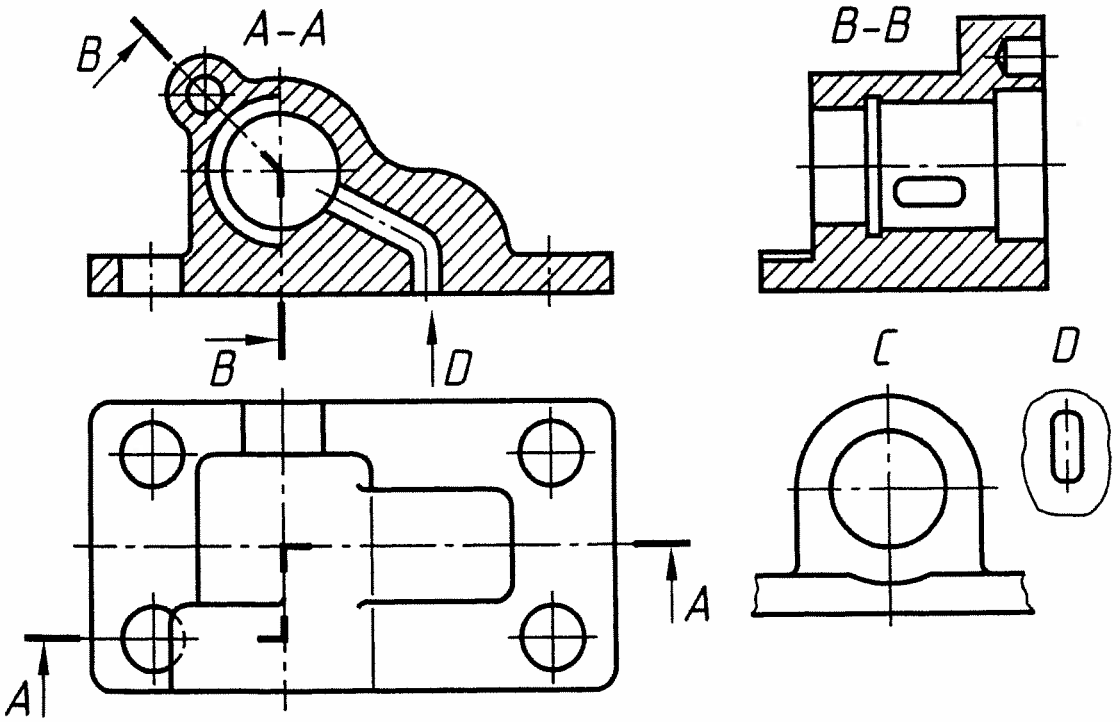


Fig. 1

1. Show the representation corresponding to the complex broken sectional view?	1) *A–A*	2) *B–B*	3) *C*
2. Define the name of the sectional view *A–A*.	1) Frontal	2) Complex stepped	3) Complex broken
3. What is the representation *D* called?	1) Bottom view	2) Local view	3) Auxiliary view

Test 3	Engineering Graphics Theme: Views; Complex Sectional Views; Sections; Axonometric Projection
Card 5	

4. Name the representation *A* (Fig. 2).

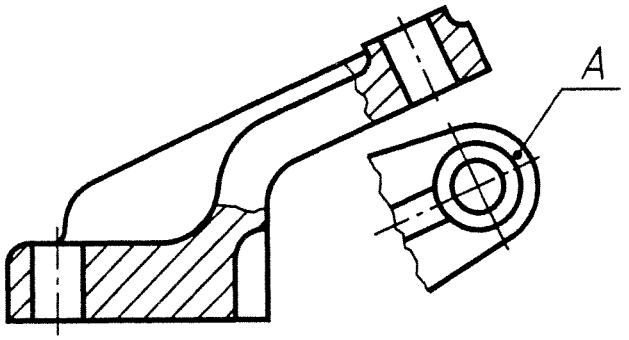


Fig. 2

1)	2)	3)
Local view	Top view	Auxiliary view

5.

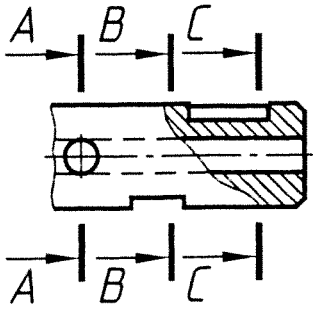
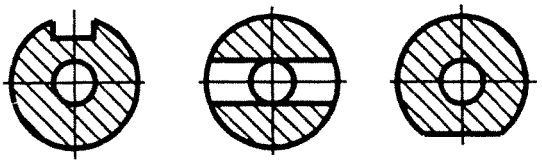


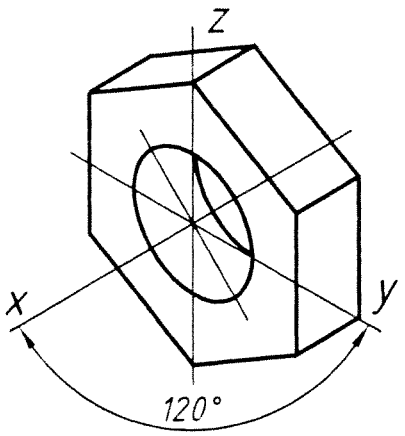
Fig. 3

Choose the representation of the section *B–B* (Fig. 3).



1) 2) 3)

6. Choose the name of the axonometric projection in which the drawing of the part is made.



1) Rectangular Dymetry

2) Rectangular Isometry

3) Trimetry

Test 3	Engineering Graphics Theme: Views; Complex Sectional Views; Sections; Axonometric Projection
Card 6	

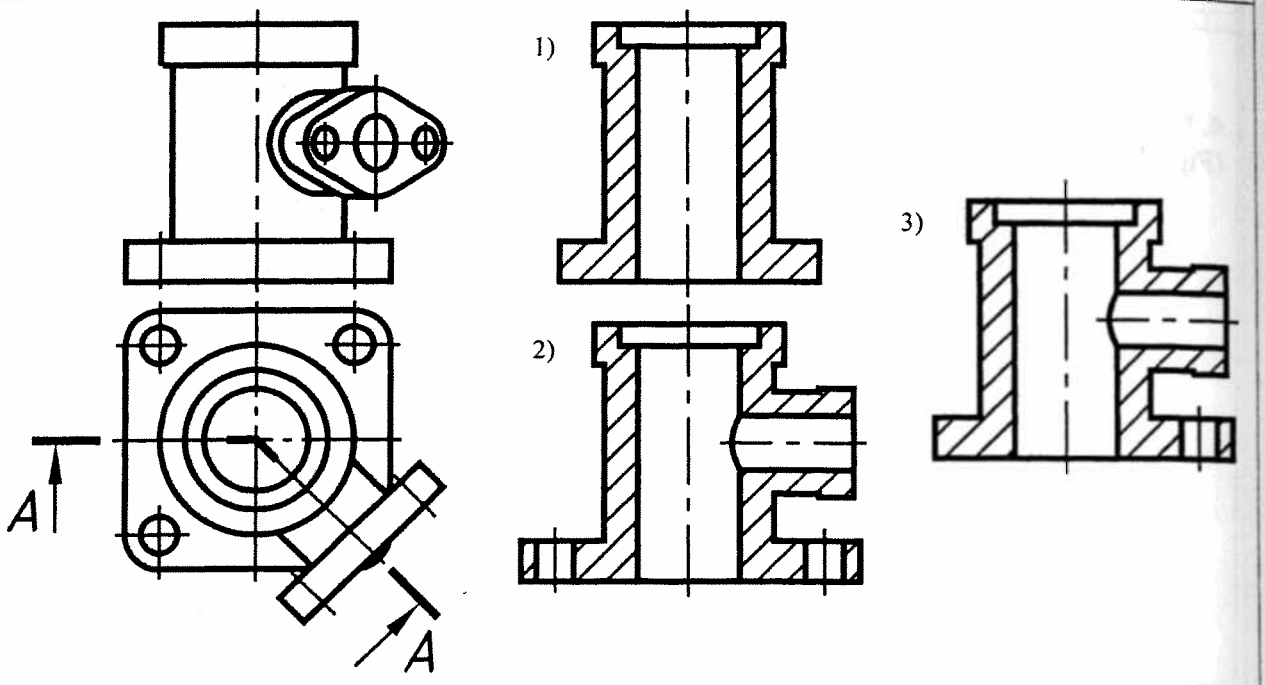
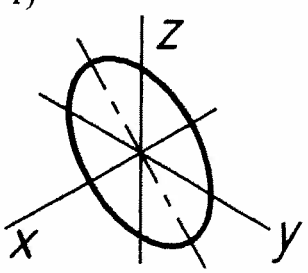
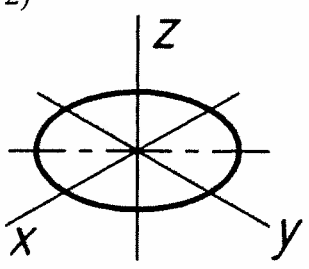
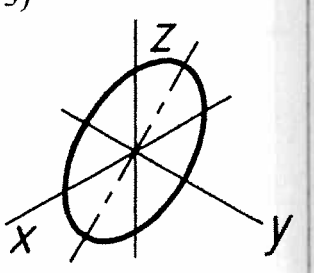


Fig. 1

1. Show the representation corresponding to the sectional view *A–A* (Fig. 1).	1)	2)	3)
2. Define the name of the sectional view *A–A* (Fig. 1).	1) Complex stepped	2) Frontal	3) Complex broken
3. Show the axonometric projection of the circle belonging to the plane parallel to the frontal projection plane.	1) 	2) 	3) 

Test 3	Engineering Graphics Theme: Views; Complex Sectional Views; Sections; Axonometric Projection
Card 6	

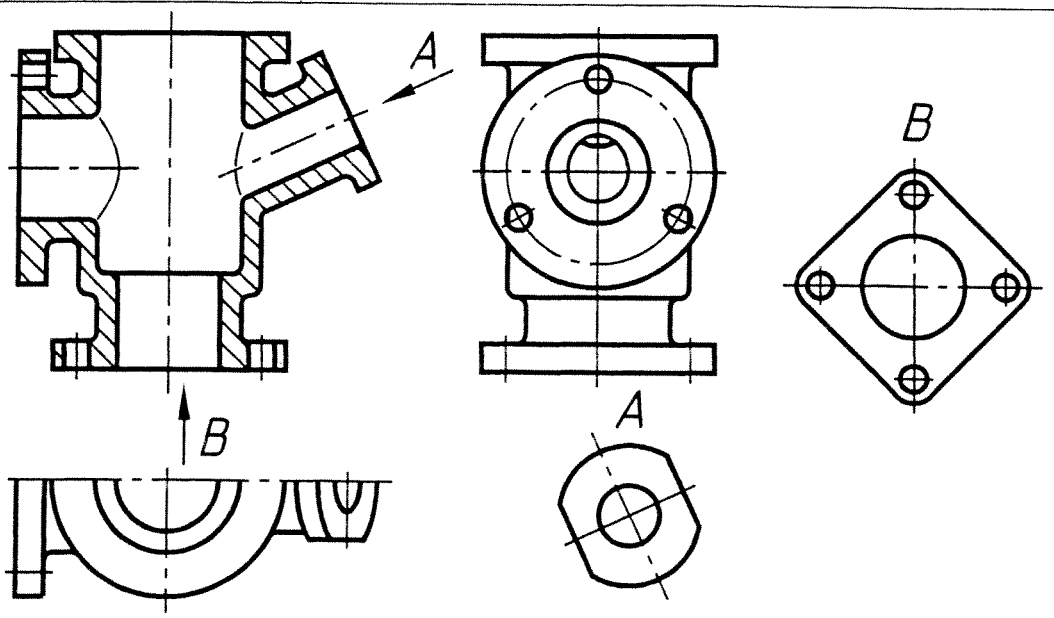
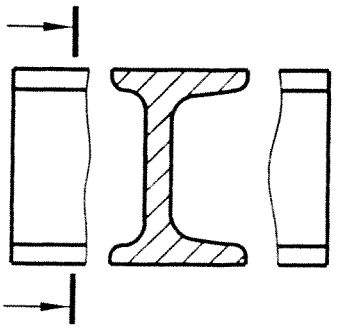
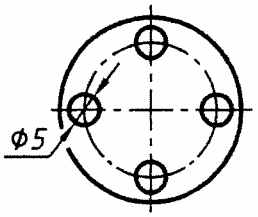
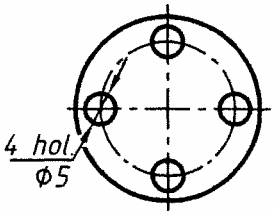
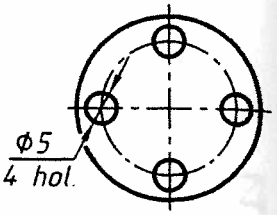
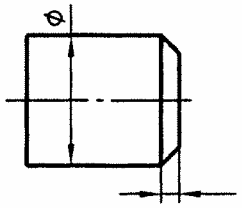
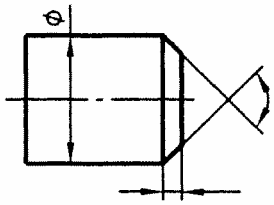
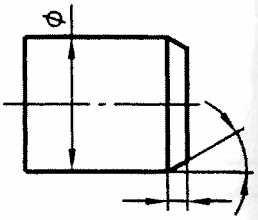
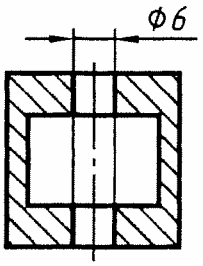
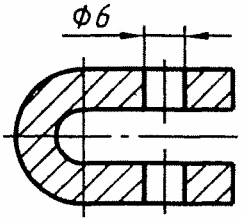
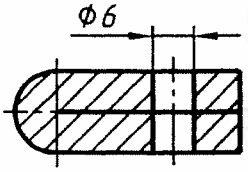
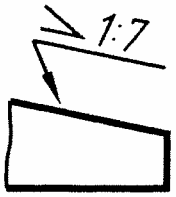
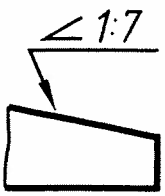
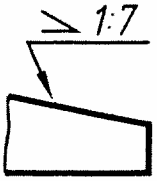
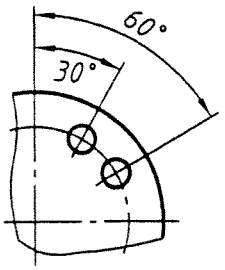
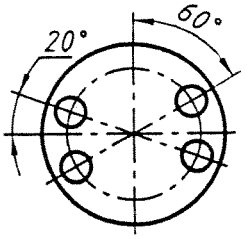
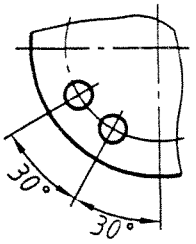
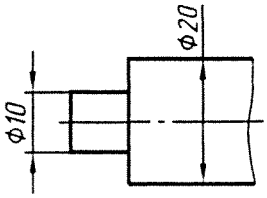
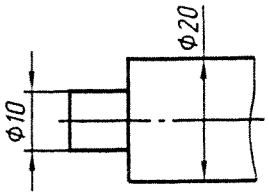
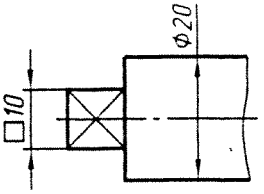
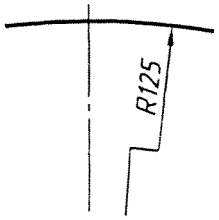
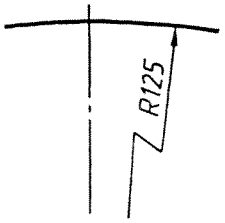
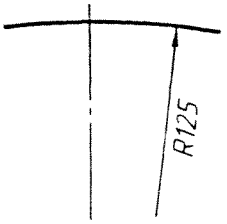
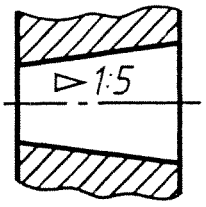
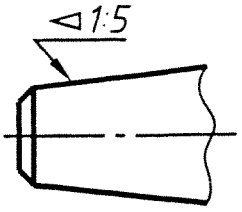
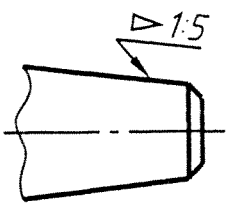


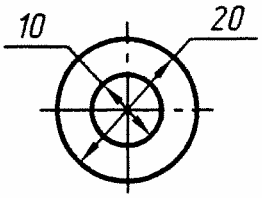
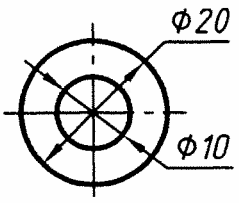
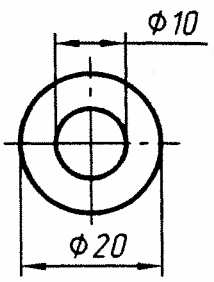
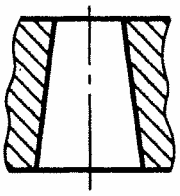
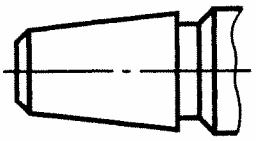
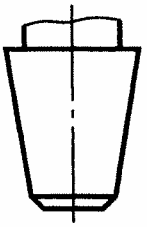
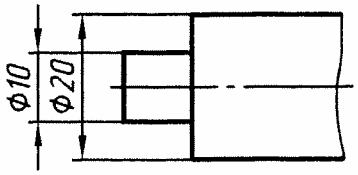
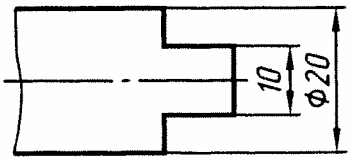
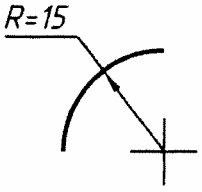
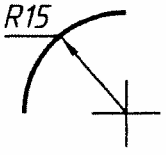
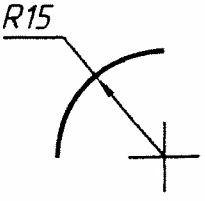
Fig. 2

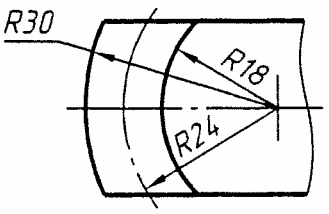
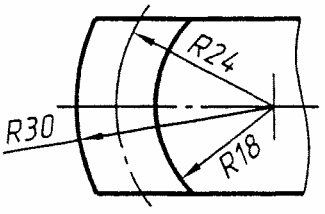
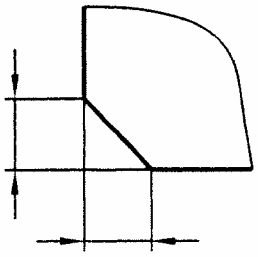
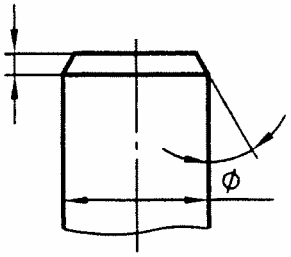
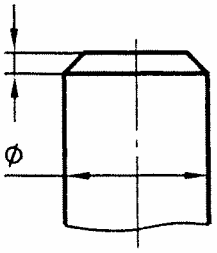
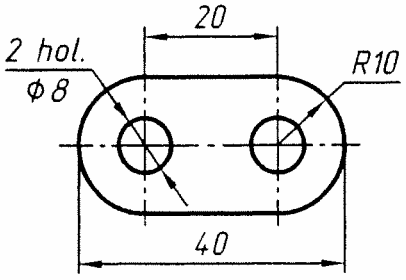
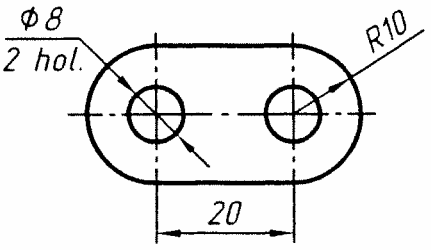
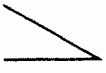
4. What is the representation *A* called (Fig. 2)?	1) Local view	2) Auxiliary view	3) Right–hand view
5. Choose the name of the section made (Fig. 3)?	 Fig. 3		1) Removed 2) Revolved
6. What line must be used for therepresentation of a revolved section?	1) Thin continuous	2) Thin long chain	3) Thick continuous

Test 4	Engineering Graphics Theme: Dimensioning. GOST 2.307-68		
Card 1			
1. In what case is dimensioning of several similar elements designated correctly?	1) 	2) 	3) 
2. Where are dimension lines drawn for dimensioning a 30-degree chamfer?	1) 	2) 	3) 
3. In what drawing should the number of similar holes be designated?	1) 	2) 	3) 
4. Where is the slope designated correctly?	1) 	2) 	3) 

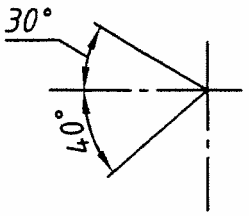
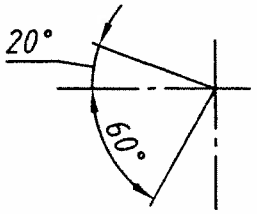
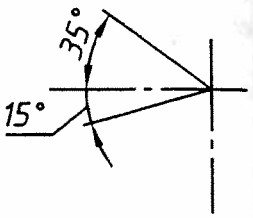
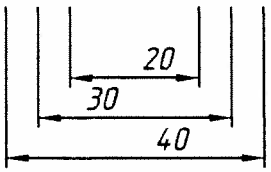
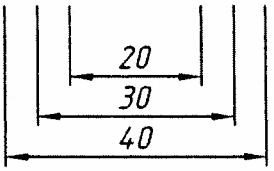
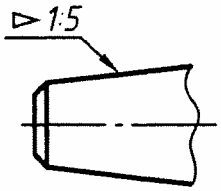
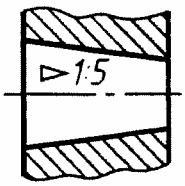
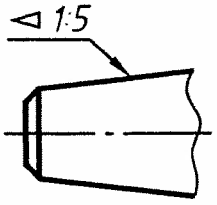
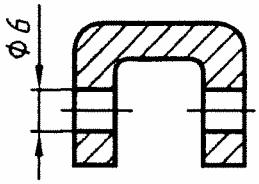
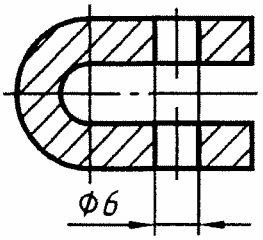
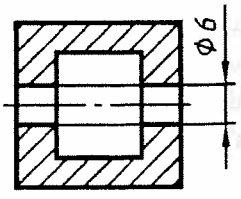
Test 4	Engineering Graphics Theme: Dimensioning. GOST 2.307-68
Card 2	

1. Choose the drawing where dimensioning of angles is made correctly.	1) 	2) 	3) 
2. Show the representation of the part having a square element (component).	1) 	2) 	3) 
3. In what case is arc dimensioning made correctly?	1) 	2) 	3) 
4. Show the drawing where dimensioning of the conicity is made correctly.	1) 	2) 	3) 

Test 4 Card 3	Engineering Graphics Theme: Dimensioning. GOST 2.307-68		
1. Show the drawing where the mistake is made while dimensioning the diameter.	1) 	2) 	3) 
2. On which drawing should the sign characterizing the conicity be preceded the following " ▽ " ?	1) 	2) 	3) 
3. In what case is the mistake made while dimensioning?	1) 	2) 	
4. Show the drawing where dimensioning of the radius is made correctly.	1) 	2) 	3) 

Test 4 Card 4	Engineering Graphics Theme: Dimensioning. GOST 2.307-68	
1. Where is a mistake on the drawing?	1) 	2) 
2. In what case should dimensioning of the 45-degree chamfer be made as follows: "n×45°"?	1) 	2) 
	3) 	
3. Choose the drawing where dimensioning is represented correctly.	1) 	2) 
4. What is the sing which precedes the dimension number denoting the slope?	1) 	2) 
	3) 	

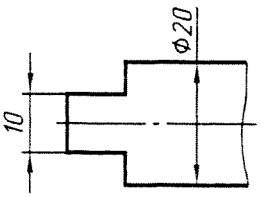
Test 4	Engineering Graphics Theme: Dimensioning. GOST 2.307-68
Card 5	

1. Show the drawing with a mistake made while dimensioning.	1) 	2) 	3) 
2. In what drawing is the recommended dimension shown?	1) 	2) 	
3. Where is the mistake made while dimensioning the conicity sign?	1) 	2) 	3) 
4. On what drawing of a part should the quantity of the holes be indicated while dimensioning them?	1) 	2) 	3) 

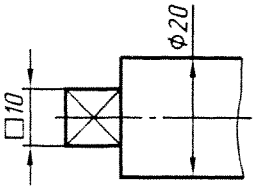
Test 4	Engineering Graphics Theme: Dimensioning. GOST 2.307-68
Card 6	

1. In what drawing is the representation of a part having a square element given?

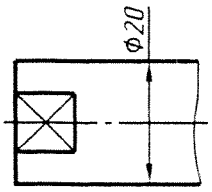
1)



2)

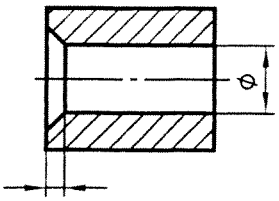


3)

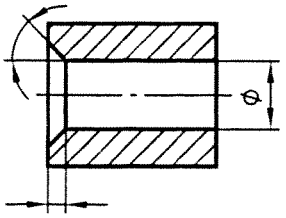


2. Show the drawing where dimensioning of the 45-degree chamfer should be made as follows: "n×45°".

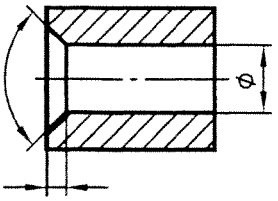
1)



2)

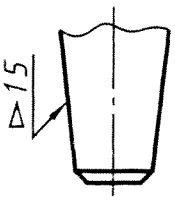


3)

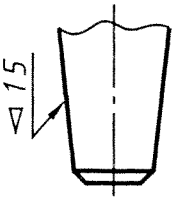


3. In what case is dimensioning of the conicity correct?

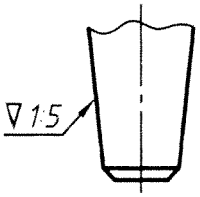
1)



2)

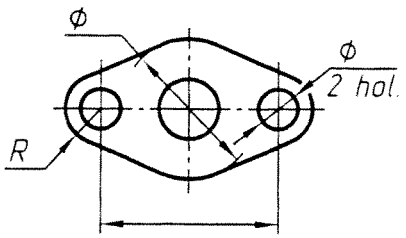


3)

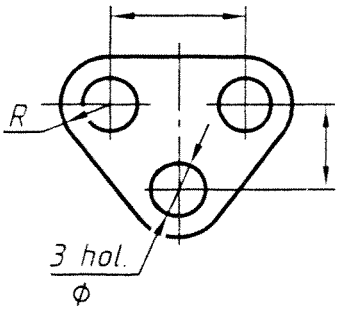


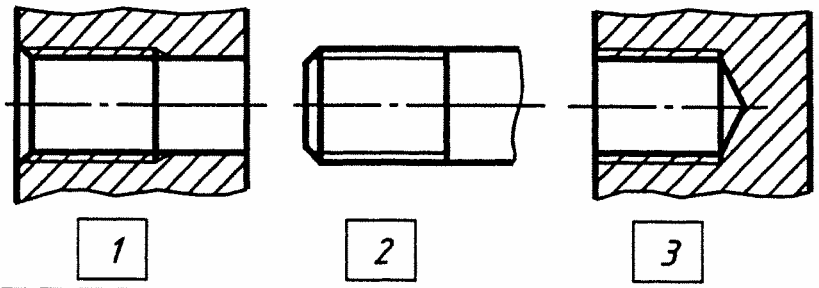
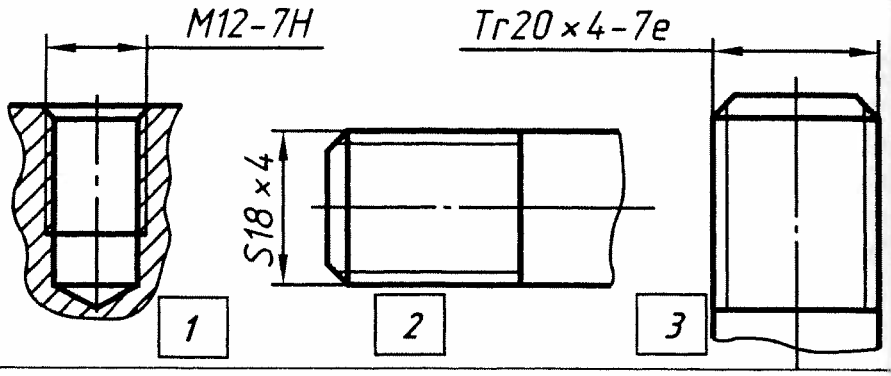
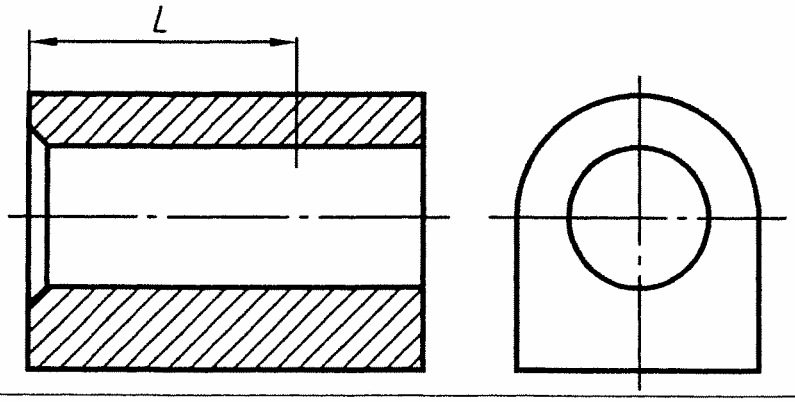
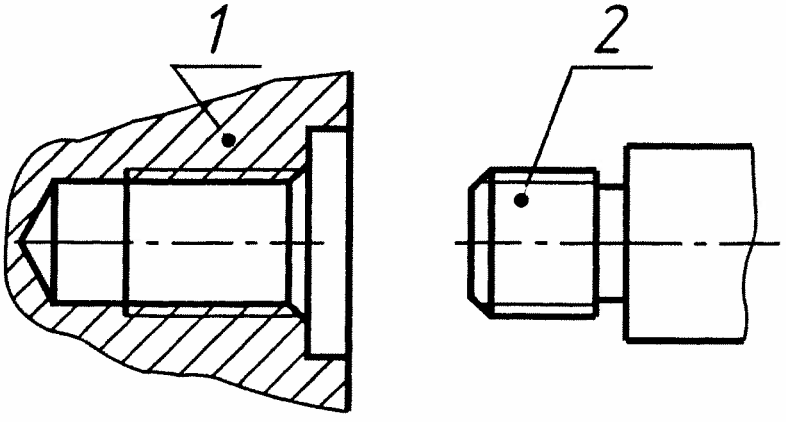
4. Choose the drawing where there are no mistakes made while dimensioning.

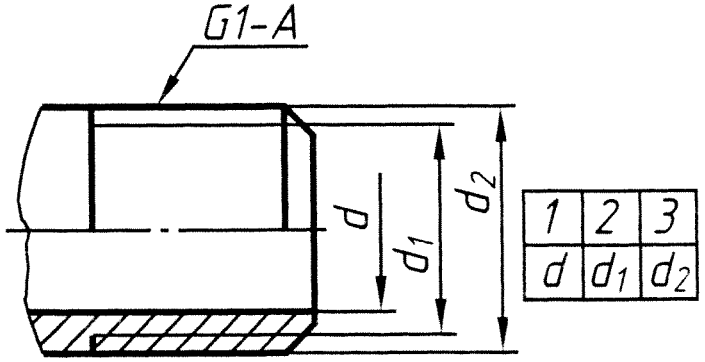
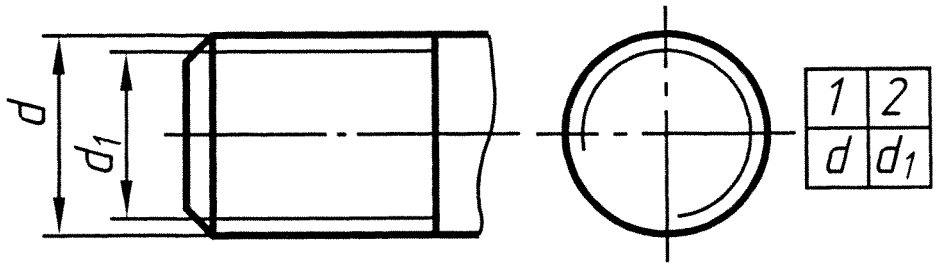
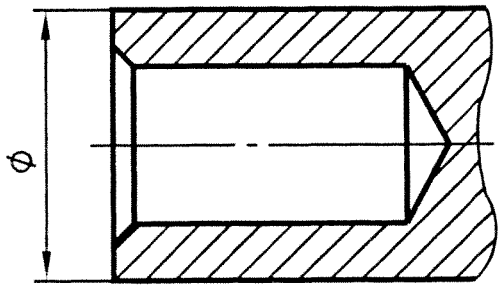
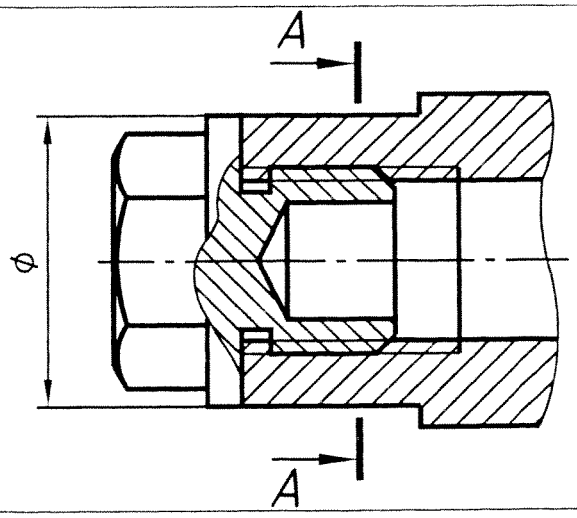
1)

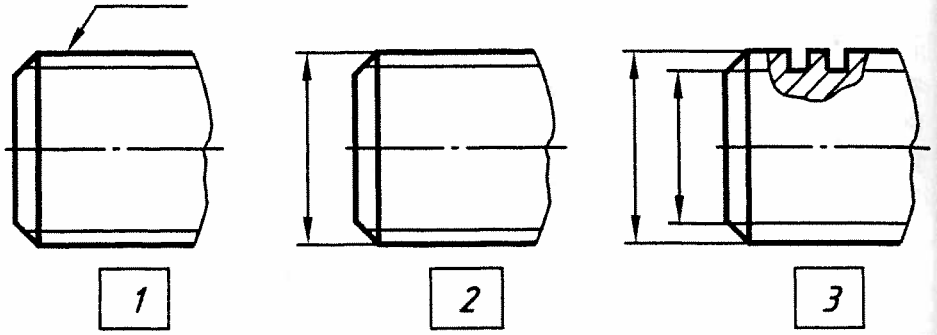
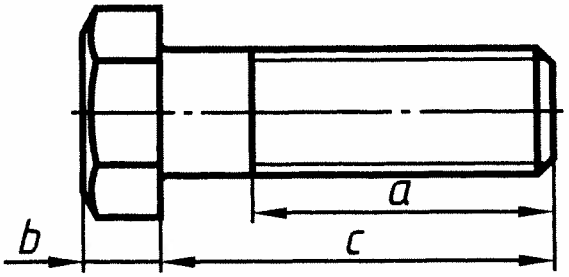
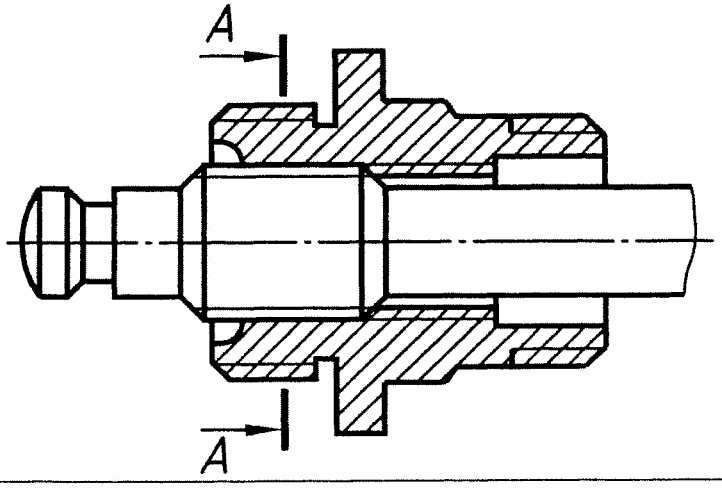
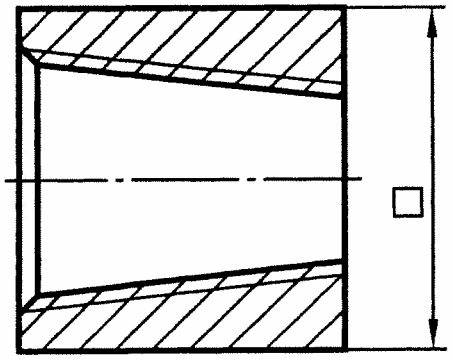


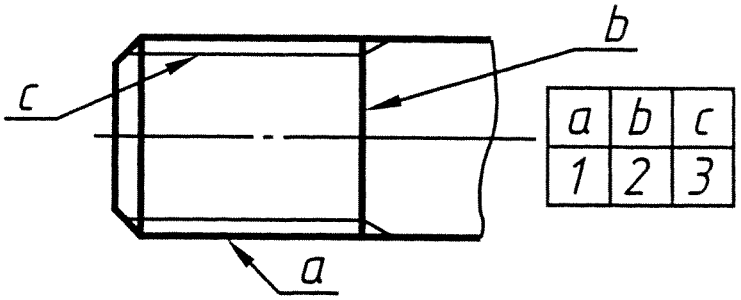
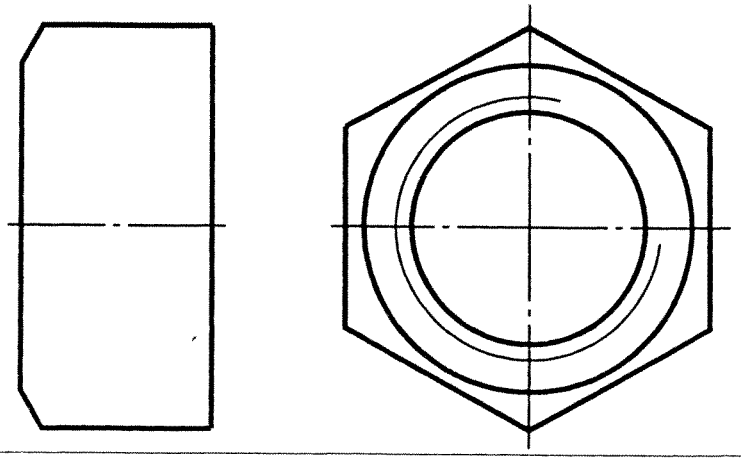
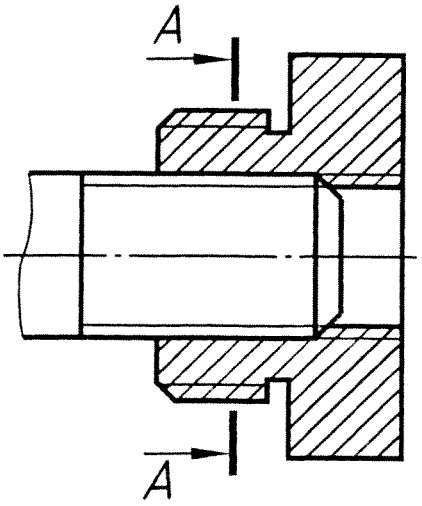
2)

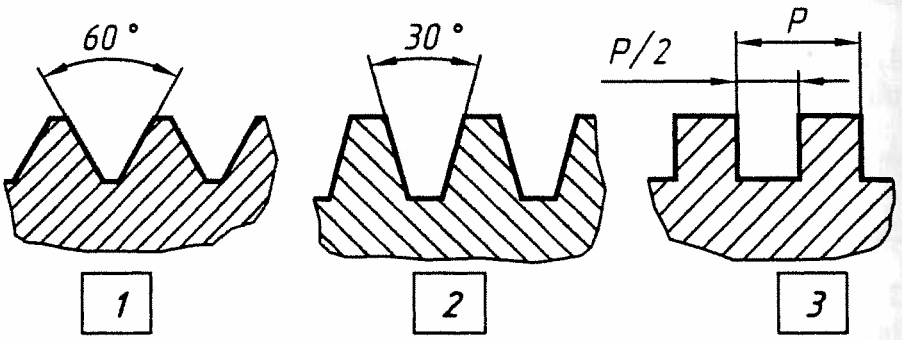
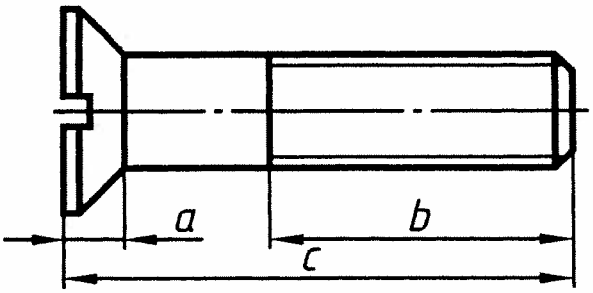
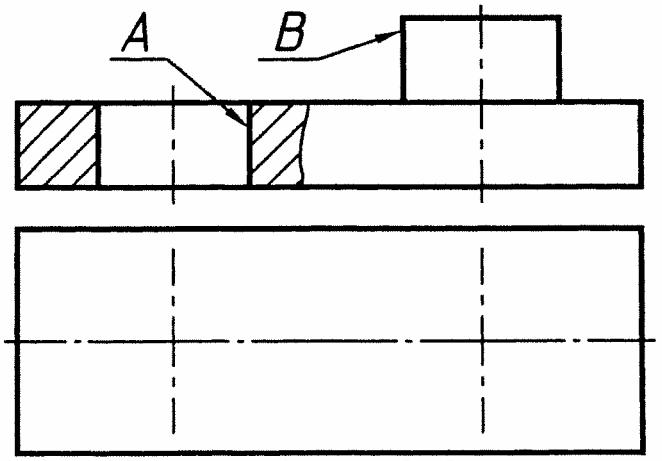
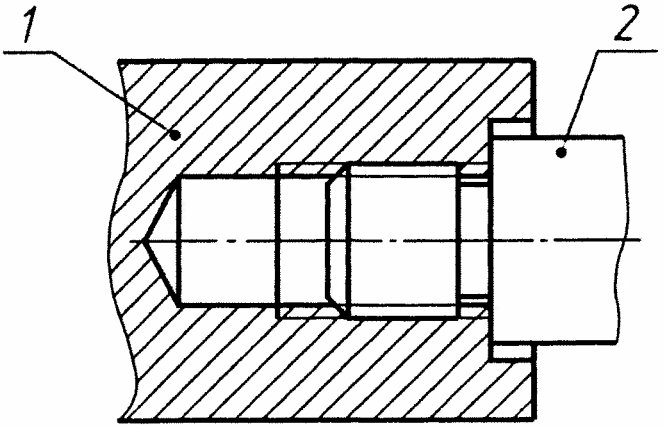


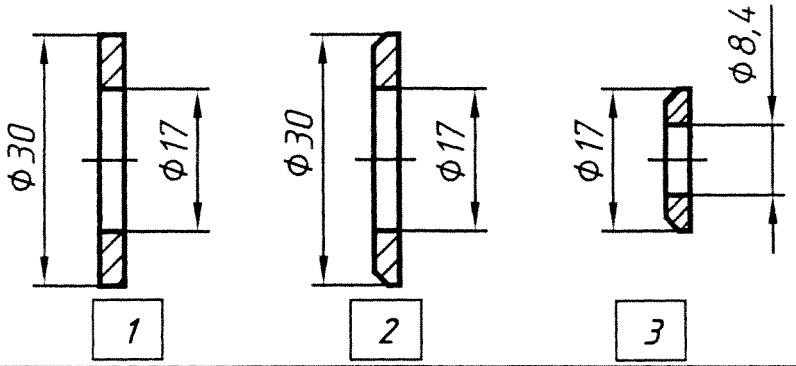
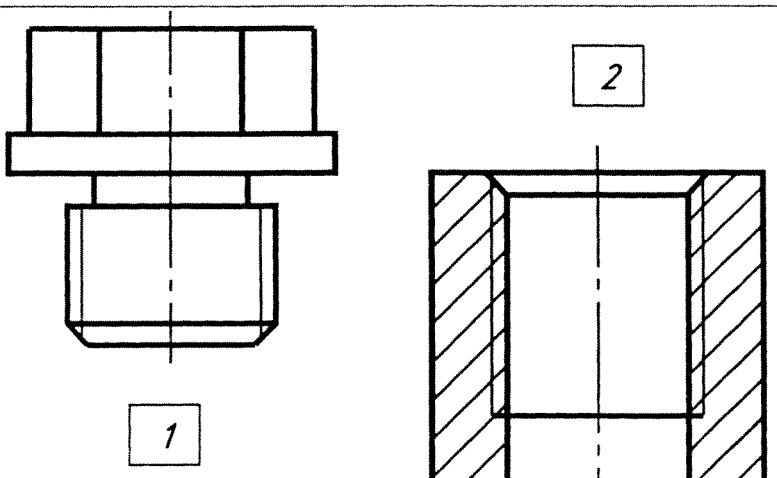
Test 5	Engineering Graphics Theme: Representation and Designation of Thread on Drawings (GOST 2311– 68) Thread Fastenings and Joints
Card 1	
Questions	Choose the correct answer
1. Show the representation of the thread with a vanish.	
2. Show the drawing where the thread with the profile of the equilateral triangle is designated symbolically?	
Tasks	Construct the answer
3. Redraw the representation of the part. Represent symbolically the thread in the through hole on the length *L*. Draw the left-hand view.	
4. Draw the threaded connection of the part *1* and the part *2*. Don't redraw the given drawings.	

Test 5	Engineering Graphics Theme: Representation and Designation of Thread on Drawings (GOST 2311– 68) Thread Fastenings and Joints
Card 2	
Questions	Choose the correct answer
1. Show the diameter corresponding to the nominal bore of the pipe.	
2. Show the diameter, which should be designated, if the metric cylindrical thread is represented symbolically.	
Tasks	Construct the answer
3. Redraw the given representation. Represent symbolically the thread in the blind hole. Draw the left-hand view.	
4. Draw the section *A-A*. Don't redraw the given drawings.	

Test 5	Engineering Graphics Theme: Representation and Designation of Thread on Drawings (GOST 2311– 68) Thread Fastenings and Joints
Card 3	
Questions	Choose the correct answer
1. In which case should the conventional sign of the cylindrical pipe thread be made?	 1 2 3
2. What bolt part length should be written in its conventional designation?	 a, b, c 1 | 2 | 3 a | b | b+c
Tasks	Construct the answer
3. Draw the section A–A. Don't redraw the given drawing.	 A, A
4. Redraw the representation of the part. Draw the left-hand view.	

Test 5	Engineering Graphics Theme: Representation and Designation of Thread on Drawings (GOST 2311– 68) Thread Fastenings and Joints
Card 4	
Questions	Choose the correct answer
1. Show the definition of a thread pitch.	1. The distance between neighbouring identical lateral sides of a profile measured parallel to the thread axis. 2. The distance between the nearest identical lateral sides of a profile belonging to one and the same a screw protrusion, measured parallel to the thread axis.
2. Which of the marked lines is a symbolical representation of the thread boundary?	
Tasks	Construct the answer
3. Redraw the representations of the Hexagonal Nut. Combine the representation of the main view with a half of the longitudinal section.	
4. Draw the section *A-A*. Don't redraw the given drawing.	

Test 5	Engineering Graphics Theme: Representation and Designation of Thread on Drawings (GOST 2311– 68) Thread Fastenings and Joints
Card 5	
Questions	Choose the correct answer
1. Show the representation corresponding to the profile of a metric thread.	
2. Which screw part length should be written in its conventional designation?	 1 b 2 c-a 3 c
Tasks	Construct the answer
3. Redraw the given front view and the top view of the part. On surfaces *A* and *B* represent a thread according to the standard.	
4. The drawing of the threaded connection of part *1* and part *2* is given. Draw part *1* without part *2*. Don't redraw the given drawing.	

Test 5	Engineering Graphics Theme: Representation and Designation of Thread on Drawings (GOST 2311– 68) Thread Fastenings and Joints
Card 6	
Questions	Choose the correct answer
1. To which diameter must a conventional sing in all threads (except conical and pipe cylindrical) be related?	*1*.....to external diameter *2*.....to inside diameter *3*.....to middle diameter
2. Which representation corresponds to the conventional sing: *Washer 2.16.03* *GOST 11371–78.*	
Task	Construct the answer
3. Draw the threaded connection of part *1* and part *2*. Don't redraw the given drawing.	
4. Redraw the representation of the blind threaded hole. Draw the longitudinal section view and the left-hand view.