CHAPTER 8. REPRESENTATIONS

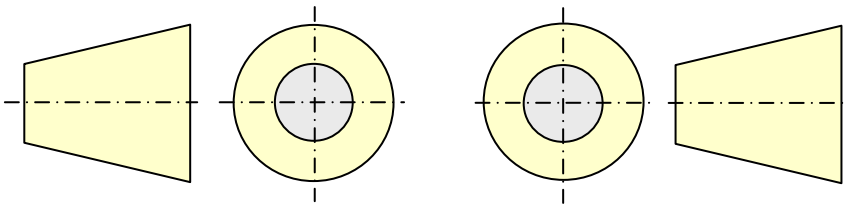
8.1 Basic Rules and Definitions

The previous chapters were concerned with the elements of descriptive geometry, which is considered to be the basis of technical drawing. The representations of geometric bodies and the simplest objects were constructed by parallel orthogonal projecting on two or three basic mutually perpendicular projection planes and on the auxiliary planes.

But rather often, three basic planes are not enough for technical drawings of details, devices and other apparatuses. To simplify the process of drawing, to lessen the number of drawing sheets and to save visualisation and unambiguity of a drawing understanding, there are some rules and conventions.

Representations of objects in technical drawing are completed by the method of rectangular (orthogonal) projections. Six faces of a cube are taken as the basic projection planes. The orthogonal projections are completed either in first angle projection (the E-method, "European", applied in Russia and in most of the continental countries) or in third angle projection (the A-method, "American", applied in the USA, England, Holland).

To distinguish what method is used, the International Standards Organisation (ISO) recommends applying special symbols (Fig.8.1). They are placed above the main inscriptions. If a drawing is completed in the European system, the symbol may be omitted.



E-system symbol A-system symbol

Fig.8.1

Projecting in First Angle Projection (E-Method)

When this method is used, imagine an object to be placed inside a cube and projected on the interior surfaces of its faces. The projecting beams are directed from the viewer to the cube faces. Six faces of the cube are taken as the basic projection planes, they coincide with a drawing plane, as shown in Fig.8.3 and 8.4. The image on the frontal projection plane is assumed to be the principal one. An object is located relative to the frontal projection plane

so that the image on it represents the form and dimensions of the object with sufficient clarity.

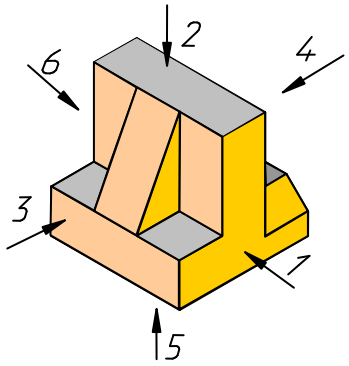


Fig.8.2

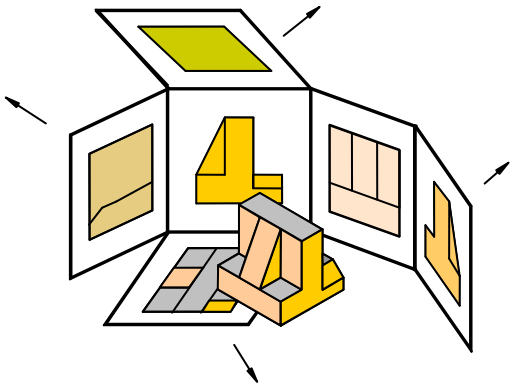


Fig.8.3

Fig.8.2 shows the directions determining the corresponding views of an object on the projection planes (the cube faces). The rear face is taken for the frontal projection plane. All the rest are coincided with it by rotation around their intersection lines (Fig.8.3). The drawing thus obtained includes six projections (Fig.8.4).

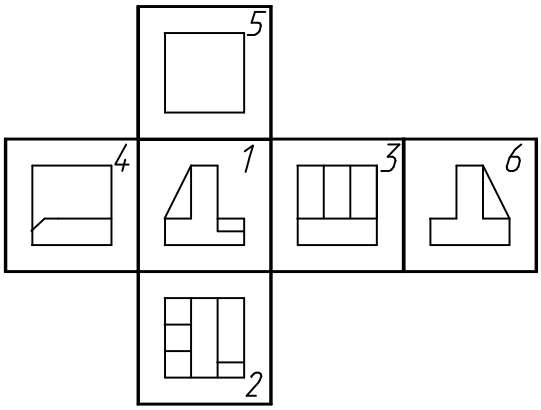
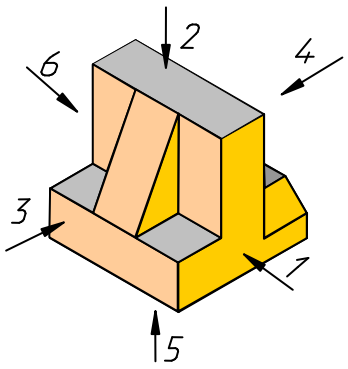


Fig.8.4

Positioning of the images (views) relative to the principal view (the front elevation), after the development (unfolding) of the projection planes in one, is the following: 1 - front elevation; 2 - plan; 3 - left-side elevation; 4 - right-side view; 5 - bottom view, 6 - rear elevation (the last one may be located to the left from the right-side view).

Third Angle Orthographic Projection (A-Method)

When this method is applied, the projection planes are assumed to be transparent and located between the viewer and the object being represented.



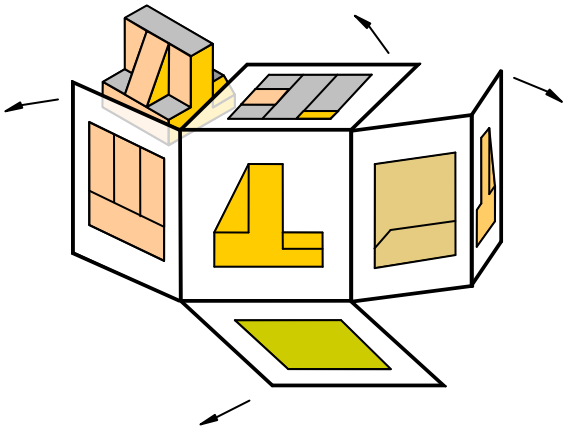


Fig.8.5 Fig.8.6

Fig.8.5 shows the directions of viewing the object.

When the projection planes were coincided, we obtain the system of elevations, in which the plan takes the position of the bottom view and the left-side elevation - the position of the right-side view (Fig.8.6).

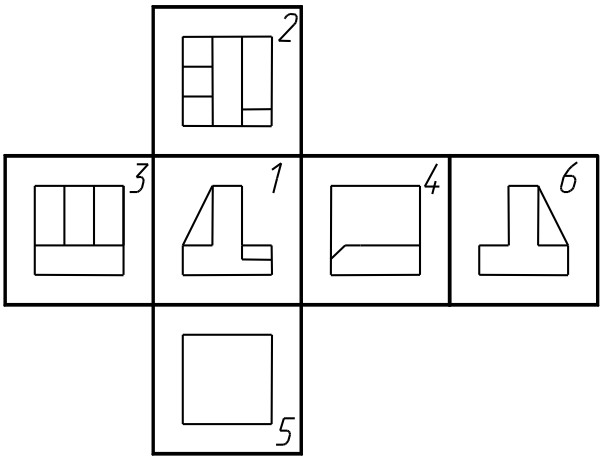


Fig.8.7

Fig.8.7 demonstrates the positioning of the elevations relative to the principal view (the front one) after development of the projection planes; the names of the elevations is similar to the E-system.

All drawing representations are classified into *views*, *sections* and *sectional views*.

View (*elevation*) - is a representation of a visible, facing the viewer, part of an object surface. To lessen the number of representations, it is admissible to show the necessary hidden parts in short dashes (Fig.8.8)

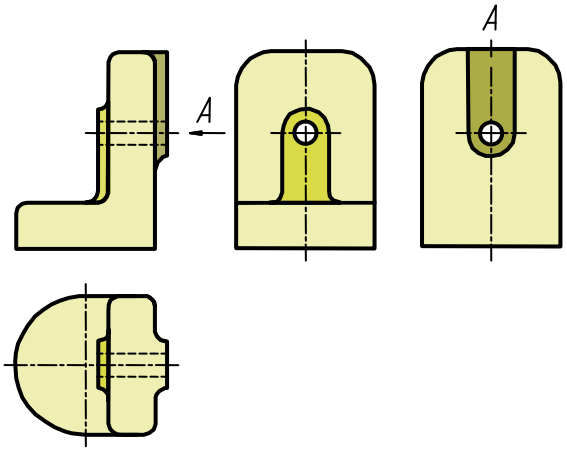


Fig.8.8

Sectional View - is a representation of an object with imaginary cut by one or several planes (the imaginary cutting corresponds only to a given section but none of the other views are affected. They keep their normal full outline). When a section is projected, the remaining visible features which can be seen on the other side of the cutting plane are also drawn on the sectional view. But it is admissible to draw not all of them if the construction of the object is clear (e.g. stiffening ribs, Fig.8.10).

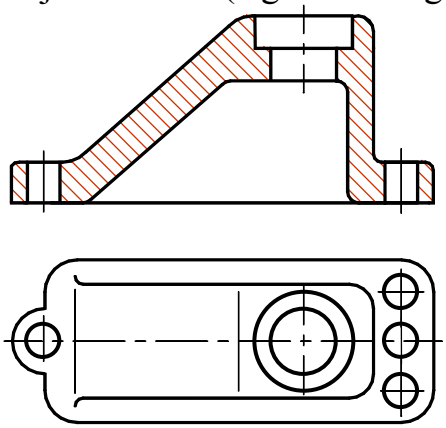


Fig.8.9

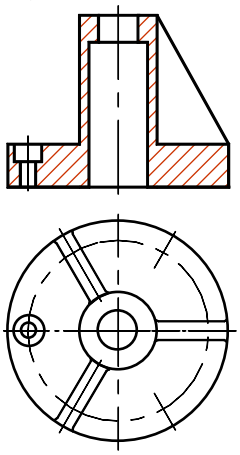


Fig.8.10

Section - is a figure representation obtained by imaginary cutting of an object by one or several planes. On the section we draw only the elements obtained in the cutting plane.

A cylindrical surface, then developed into a plane, may be applied as a cutting plane (Fig.8.12).

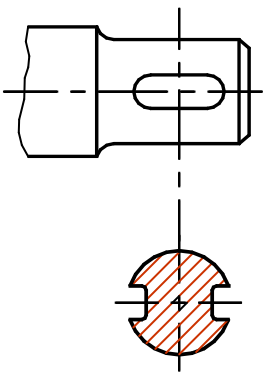


Fig.8.11

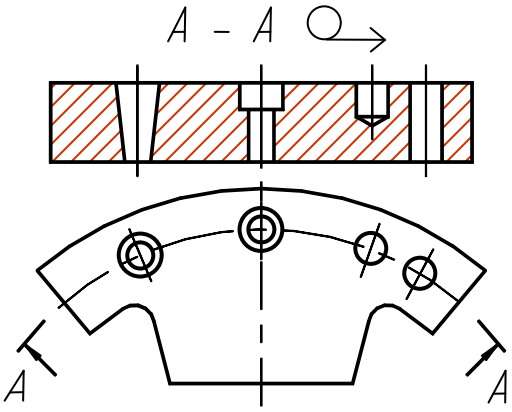


Fig.8.12

The number of representations (elevations, sections, sectional views) should be minimal, still providing a clear pictorial view of an object.

Application of different designations allows us to lessen the number of representations on a drawing. In the simplest cases, it is enough to draw only one view and the corresponding designation. The designation ∅ (Fig.8.13) means that a cylinder is drawn, □ (Fig.8.14) - a bar of a square section. The letters are also used to save time and space on drawings: *s* denotes the thickness of a drawn object (Fig.8.15), *l* - its length (Fig.8.16). These letters are written on the shelf of an extension line. The extension line ends in a dot inside the outline of the representation. To distinguish a sphere from the other surfaces, the word "Sphere" or the symbol are marked down preceding a dimension, e.g. ∅25 (Fig.8.17). The diameter of the sphere symbol is equal to the size of the dimensioning figures in a drawing.

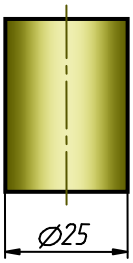


Fig.8.13

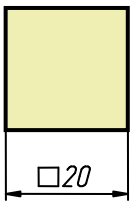


Fig.8.14

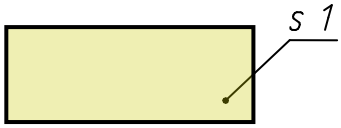


Fig.8.15

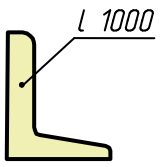


Fig.8.16

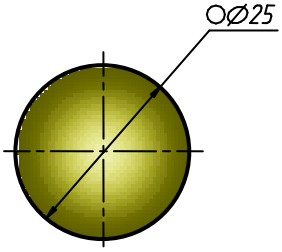


Fig.8.17

8.2. The Views

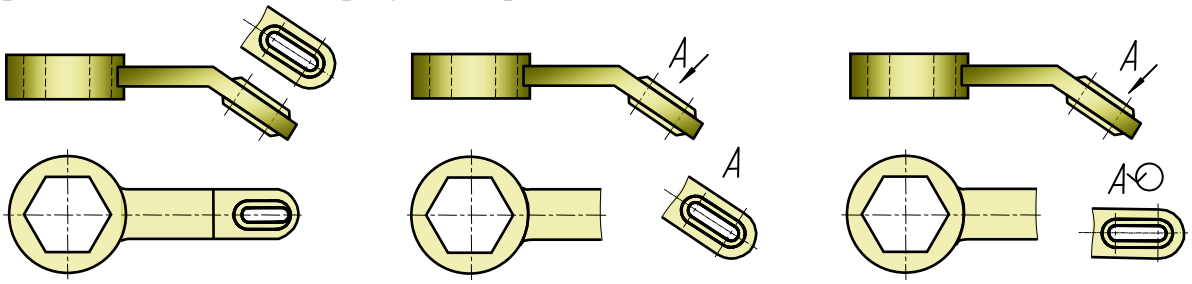
There are principal, auxiliary and detail views.

The principal views are the views obtained by projecting an object on the six principal projection planes.

If the top, left-side, right-side, rear views have no direct projection link with the principal representation (an elevation or sectional view on the frontal projection plane), an arrow should be drawn to point in the direction that the view is projected. One and the same capital letter should be written above the arrow and above the view (Fig.8.8)

Similar presentation of a drawing is used when the views mentioned above are separated from the principal view by the other views or located on the other sheets.

If some part of the object cannot be shown in true shape on the above elevations, the auxiliary views are applied. The auxiliary views are obtained on the planes not parallel to the principal projection planes (Fig.8.18). Thus, an *auxiliary view* is an object (or its part) representation on a plane, which is parallel to none of the projection planes.



a b c

Fig.8.18

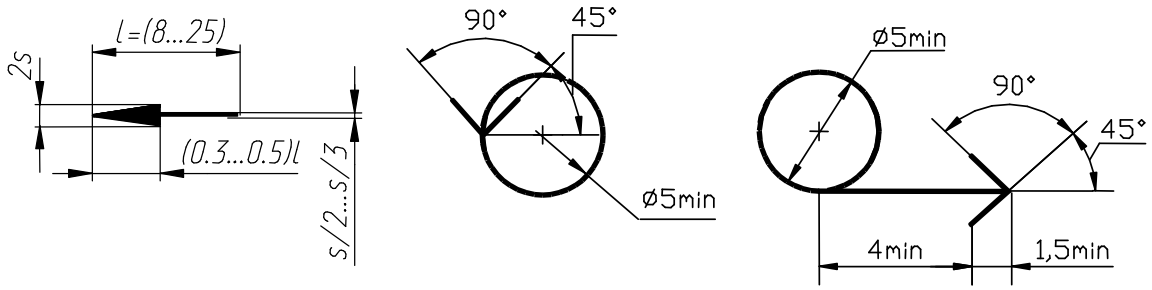
When there is a direct projection link between the auxiliary view and the corresponding representation, the arrow and the designation are not drawn (Fig.8.18, a).

If there is no projection link between the principal and the auxiliary views, the later should be marked with a capital letter, and the linked (with the auxiliary view) representation with an arrow pointing in the direction of the view, plus the corresponding lettering (the arrow A, Fig.8.18, b, c).

An auxiliary view may be rotated (but the position of the object, as a rule, corresponds to the principal view), then the view is marked with a special symbol of rotation – ↺ (Fig. 8.18, c).

If necessary, the angle of rotation may also be shown after the symbol. Several similar auxiliary views of one object are designated by one letter and only one view is drawn. If, in this case, the parts of the object, linked with

the auxiliary view, are positioned at different angles, the symbol of rotation is not shown.



a b c

Fig.8.19

Fig.8.19 presents the dimensions of the arrow, showing the direction of view (Fig.8.19, a), and the symbols of the words “rotated” (Fig.8.19, b) and “unfolded” (or “developed”) (Fig.8.19, c). The size of the capital letter placed at the arrow must exceed the size of dimensions on a drawing by approximately two times.

Representation of a certain limited part of an object surface is referred to as a *detail (partial) view* (views A and B, Fig.8.20). A detail view may be terminated with a continuous irregular line in the possible minimal size (Fig.8.20); or it may not be terminated (view B, Fig.8.20). A detail view must be marked on a drawing in a similar fashion as an auxiliary view.

If a detail view is to a scale which differs from the scale of the other representations in a drawing, its scale is shown in brackets next to the lettering of the view.

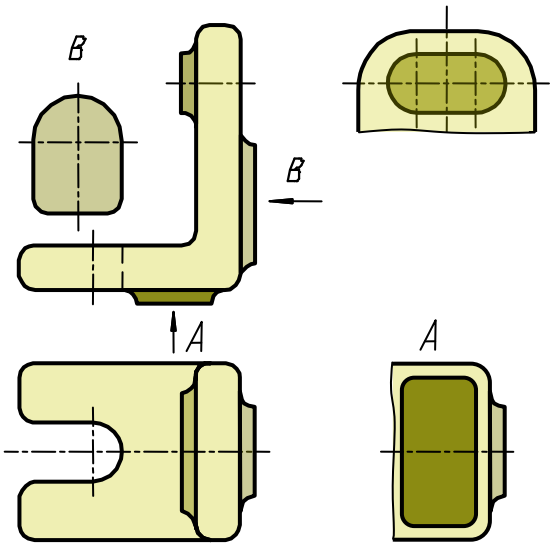


Fig.8.20

8.3 Sectional Views

According to a cutting plane's position relative to the horizontal projection plane, the sectional views are classified as:

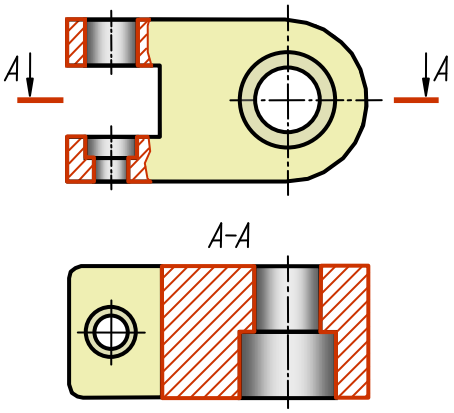


Fig.8.21

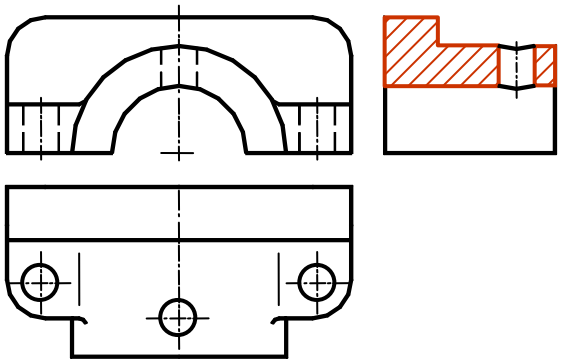


Fig.8.22

horizontal – a cutting plane is parallel to the horizontal projection plane (e.g. sectional view *A-A*, Fig.8.21; sectional view *B-B*, Fig.8.23);

vertical – a cutting plane is perpendicular to the horizontal projection plane (e.g. sectional view on the place of the left-side view, Fig.8.22);

oblique – the cutting plane is inclined to the horizontal projection plane at an angle different from a right one (e.g. sectional views *A-A* and *C-C*, Fig.8.23).

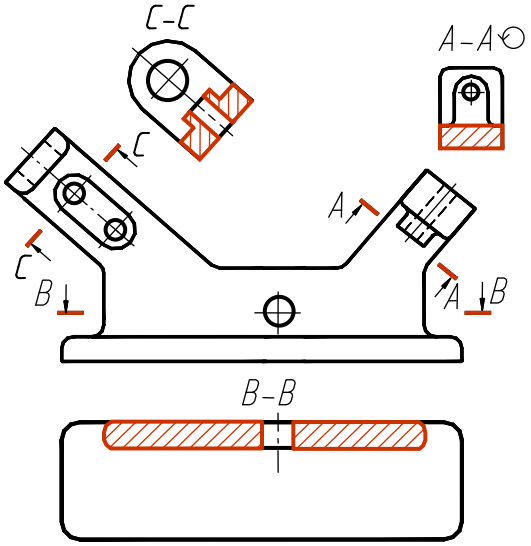


Fig.8.23

A vertical sectional view is called a frontal one if a cutting plane is parallel to the frontal projection plane, or it is called a profile one if a cutting plane is parallel to the profile projection plane (Fig.8.22).

Depending on the number of the cutting planes, the sectional views are classified as:

Simpel – one cutting plane (Fig.8.21-8.23);

Complex – several cutting planes.

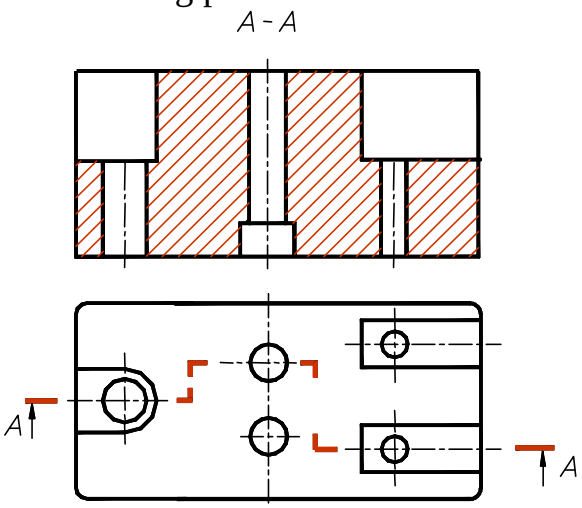


Fig.8.24

The complex sectional views may be step-type when the cutting planes are parallel (e.g. step-type frontal section *A-A* at Fig.8.24); and polygonal, when the cutting planes intersect (e.g. *A-A* sectional view at Fig.8.25). If the cutting planes are directed along the object's length or height (Fig.8.24), the sectional views are referred to as lengthwise. If the cutting planes are directed perpendicular to the object's length or height, they are referred to as transverse (Fig.8.22).

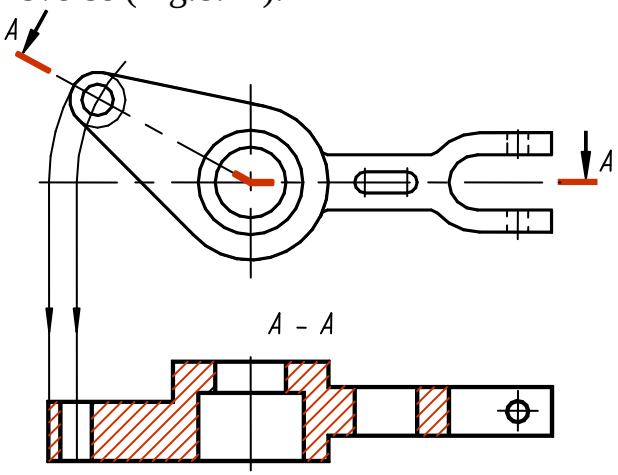


Fig.8.25

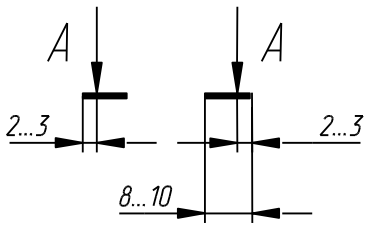


Fig.8.26

The position of the cutting plane is denoted by the section line.

The section line in a drawing is a broken line, (1…1.5)*s* thick. It is thick at the ends and at changes of direction. The ends of the line are marked with arrows showing the direction of view. The arrows are drawn at a distance of 2-3 mm from the ends (Fig.8.26).

The ends of the broken line must not intersect the outline of the corresponding image.

When a complex sectional view is drawn, a change of cutting planes is conventionally not shown.

Fig.8.27 presents a case when the direction arrows are placed on one line.

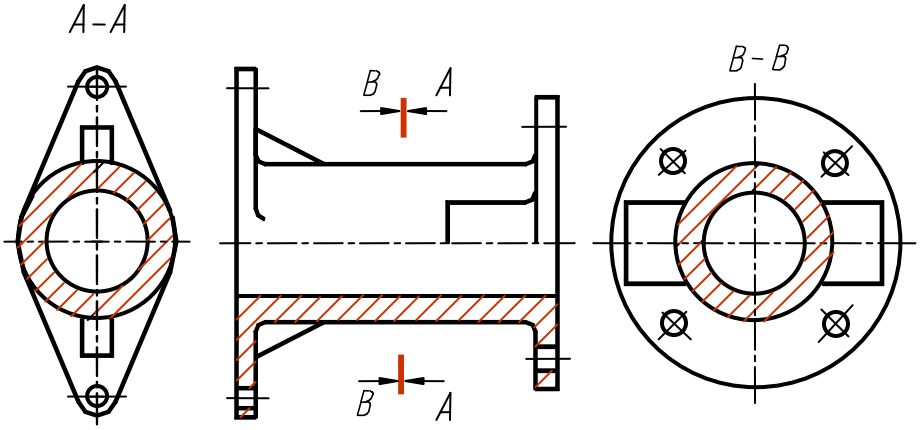


Fig.8.27

The same Latin capital letter is marked down at the ends of a section line and, if necessary, at the intersection points of the cutting planes. The letters are located near the direction arrows, so that the arrows are between the letter and the view.

Every sectional view should be marked with two letters written with a dash, e.g. "*A*-*A*".

In a case when a cutting plane coincides with the symmetry plane of the object, and the corresponding views are located on one and the same sheet in a direct projecting link and there are no other views between them, the position of the cutting plane of the horizontal, frontal and profile sectional views is not marked and there is no lettering (e.g. sectional view on the place of the left-side view, Fig.8.22).

The horizontal, frontal and profile sectional views are located, as a rule, on the drawing space of the corresponding principal views.

The vertical sectional view (when a cutting plane is not parallel to the frontal or profile projection planes) and the oblique one are to be constructed in conformity with the direction pointed by the arrows on the section line.

Such sectional views may be positioned in any drawing space (sectional view B-B, Fig.8.23), and they may also be revolved to correspond the position of the object in the principal view. But then a conventional graphic representation must be added to the lettering (sectional view A-A, Fig.8.23).

It is often necessary to show a small section showing the true shape across an object (polygonal sectional view). Then the revolved section is

obtained by revolving the section in the position and breaking the outline to accommodate the section (Fig.8.28-8.30). The revolving direction may not coincide with the direction of view (Fig.8.29).

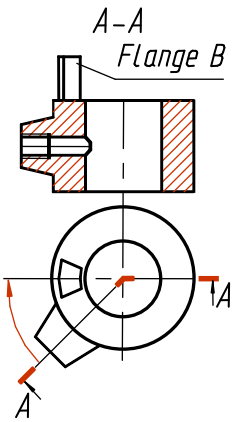


Fig.8.28

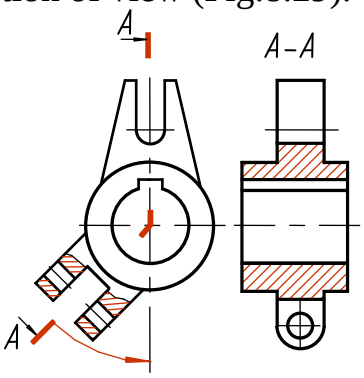


Fig.8.29

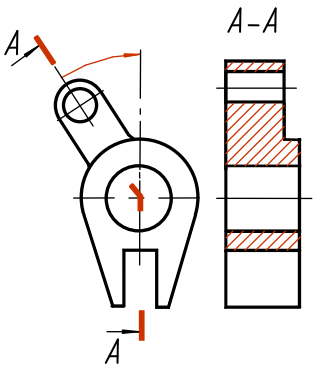


Fig.8.30

The elements located on the other side of the cutting plane are drawn in the way they are projected on the corresponding plane (Fig.8.28, the flange B).

Remembering that sections are used only to clarify a drawing, it is quite likely that you will come across a case where only a small part of the drawing needs to be sectioned to clarify a point. In this case a part or scrap sectional view is permitted.

A scrap cut is distinguished on a drawing by a continuous irregular line (Fig.8.29, 8.33, 8.34).

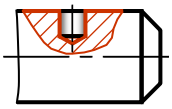


Fig.8.31

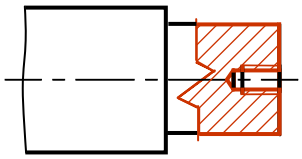


Fig.8.32

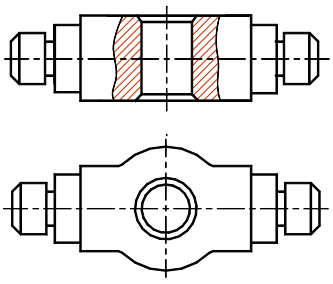


Fig.8.33

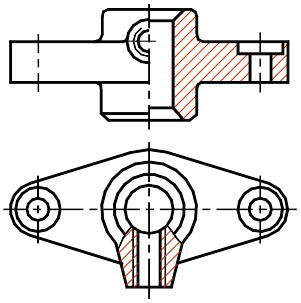


Fig.8.34

A part of a view and a part of a corresponding section may be joined together and separated by a continuous irregular line or by a continuous polygonal line (Fig.8.32). If a half view and a half section are each a symmetric figure, the axis of symmetry serves as a separating line (Fig.8.34). It is also permitted to use a dash-and-dot thin line (Fig.8.35), which

coincides with the plane of the symmetry trace (not of the whole object, but of its part representing the revolving body).

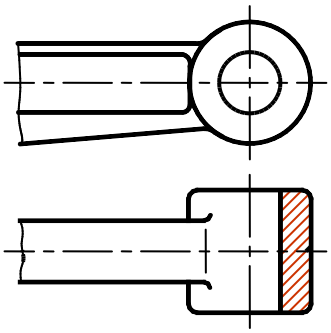


Fig.8.35

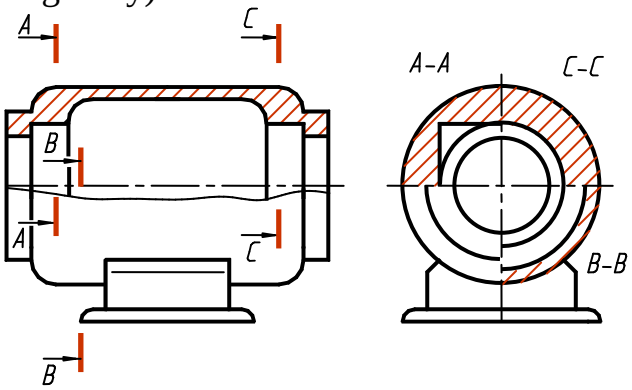


Fig.8.36

It is also possible to join a quarter of a view and the quarters of three sectional views: a view quarter, a quarter of one section and a half of the other, etc., provided each of these representations is a symmetrical one (Fig.8.36).

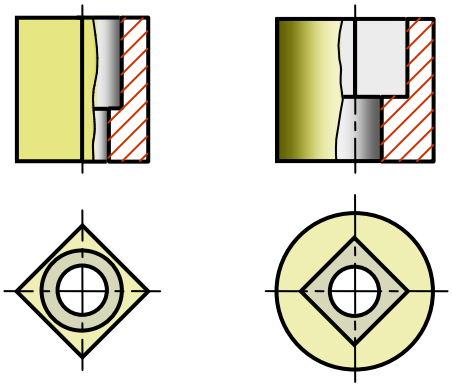


Fig.8.37

If an edge representation of a symmetric part coincides with the axis of symmetry, its half view cannot be joined to its half section. A part or scrap sectional view is applied here. And it should be constructed in such a way that the edge is visible (Fig.8.37).

8.4 Sections

The sections not included in the sectional view are classified as *removed* (Fig.8.38) and *covering* (Fig.8.39).

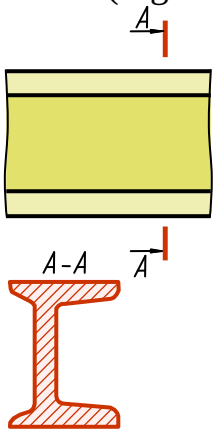


Fig.8.38

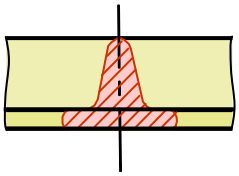


Fig.8.39

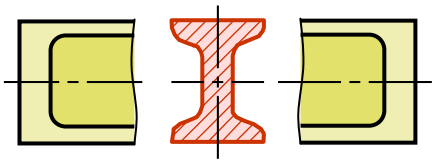


Fig.8.40

The removed section should be used in preference to the covering one if there is room on the drawing. It may be located in the break between the parts of one view (Fig.8.40).

The outline of a removed section as well as of that included in a sectional view, is drawn in continuous thick lines, the outline of a covering section - in continuous thin lines. Note: the outline of a view under a covering section is not broken (Fig.8.39).

The axis of symmetry of a removed or covering section (Fig.8.39) is denoted with a dash-and-dot thin line without any lettering or arrows, and the section line is not drawn.

Fig.8.40 shows that on a symmetric section figure the section line is not drawn.

In all other cases the section line is drawn with a broken line. The arrows show the direction of the view. The line is designated with the same Latin capital letters. There is a lettering like, e.g., “A-A” of the section (Fig.8.38).

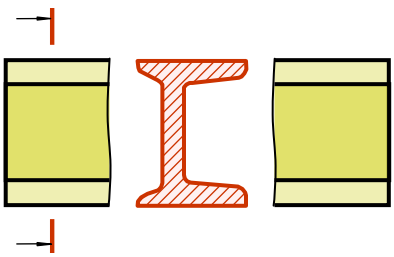


Fig.8.41

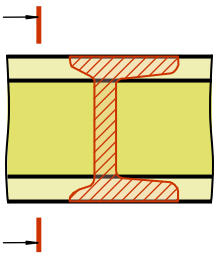


Fig.8.42

The section line of the asymmetric sections located in a break (Fig.8.41) or of the covering ones (Fig.8.42) is marked with arrows, no lettering.

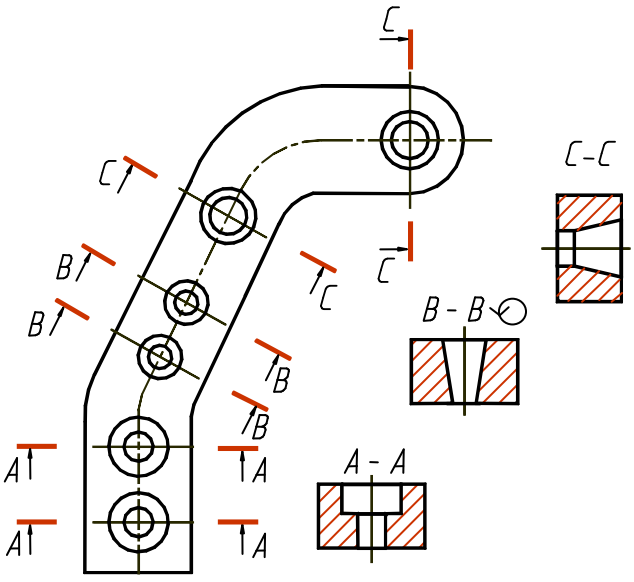


Fig.8.43

The construction and position of a section should correspond with the direction pointed by the arrows (Fig.8.43). The location of the section is not restricted by any rules.

The section line of several similar sections of one object is denoted by one letter, and only one section is drawn (Fig.8.43, section A-A and B-B).

If, in such a case, the cutting planes are inclined at

different angles, the graphical convention ⌀ is not applied. If the positioning of the similar sections is precisely determined by the representation or dimensions, it is admissible to draw only one section line and to show the number of sections above their representation.

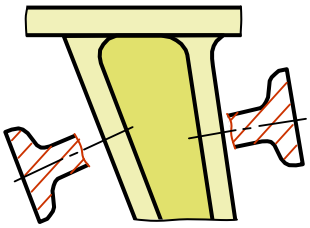


Fig.8.44

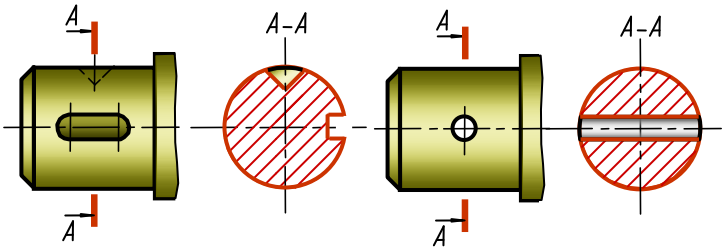


Fig.8.45

The cutting planes should be chosen so that one obtains the normal cross sections (Fig.8.44).

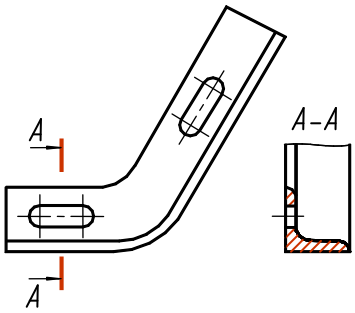
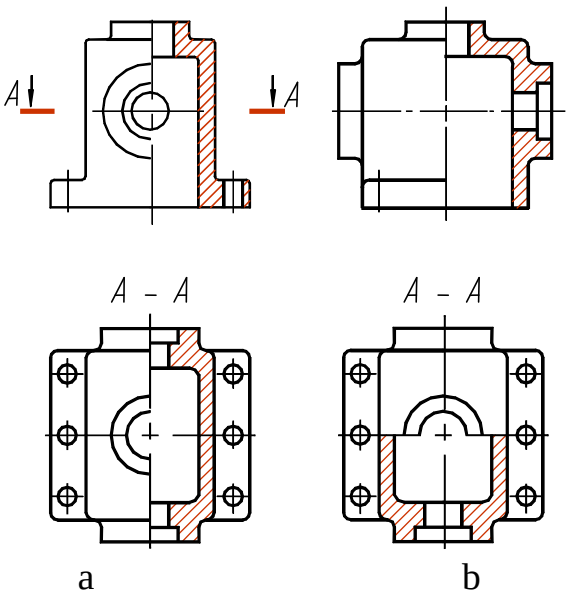


Fig.8.46

If a cutting plane passes through an axis of a rotation surface which limits a hole or a recess, the outline of the hole or the recess behind the cutting plane is drawn in the section too (Fig.8.45).

If a section consists of separate independent parts then the sectional views should be drawn (Fig.8.46).

8.5 Conventions and Simplifications



a b

Fig.8.47

If a view, sectional view or a section represent a symmetric figure, only half of the representation may be drawn (Fig.8.20), or a bit more than half, but in this case a break line should be passed.

If in constructing a sectional view, you join a half view and a half section, each being a symmetric figure, the axis of symmetry serves as a separating line. The sectional view here should be drawn to the right or below this axis (Fig.8.47).

If an object consists of several similar elements, located evenly, only two or three such elements are represented on a drawing (for example, one or two holes), the rest of the elements are to be shown simplified or conventionally (Fig.8.49).

It is also possible to draw a part of an object (Fig.8.50) with the appropriate designation of the number and location of the elements.

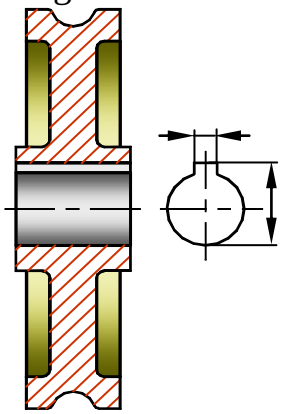


Fig.8.48

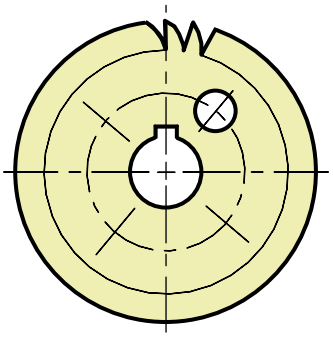


Fig.8.49

Projections of the intersection lines of surfaces are also simplified on sections and sectional views, unless their precise constructions are required. For instance, the arcs of circles and straight lines are drawn instead of French curves (Fig.8.51). The even change of surfaces is denoted conventionally or not at all (Fig.8.52).

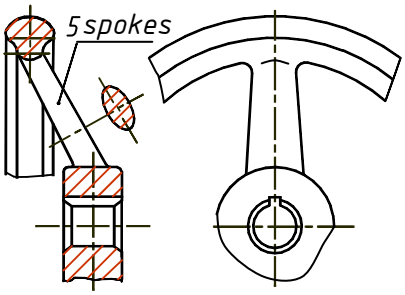


Fig.8.50

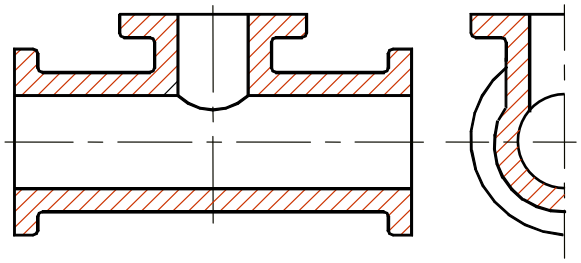
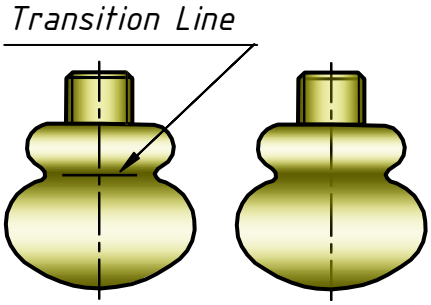


Fig.8.51



a b

Fig.8.52

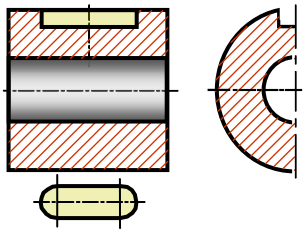


Fig.8.53

Simplifications, similar to those shown in Fig.8.53, are permitted.

There are some engineering details that, if sectioned, lose their identity or create a wrong impression and these items are never shown sectioned. They are: screws, rivets, keys, shafts, spindles, connecting rods, handles, balls, nuts, washers, etc.

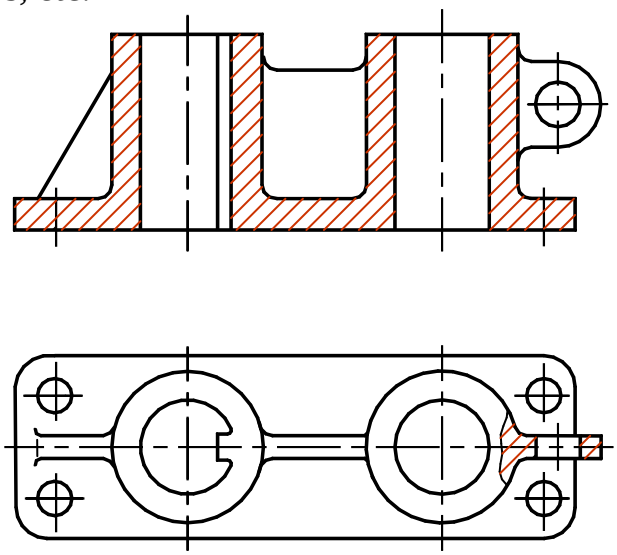


Fig.8.54

Such elements like spokes of flywheels, pulleys, pinions, thin walls, say, of stiffening ribs, are not hatched if a cutting plane is directed along the axis or long side of the element (Fig.8.54).

If in such elements there is a local drilling, a recess and the like, a scrap section should be drawn.

The plates, as well as elements of details (holes, chamfers, slots, recesses, etc.) dimensioned on a drawing 2 mm or less, are constructed as larger size than the scale of the whole drawing.

Small angles of taper or slopes may also be represented with an increase.

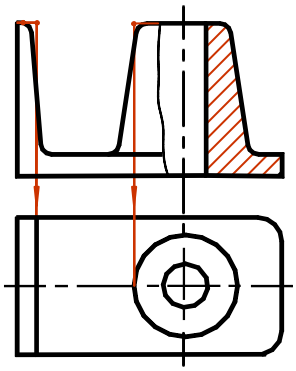


Fig.8.55

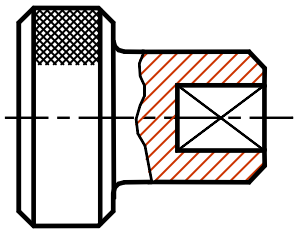


Fig..8.56

On representations of the elements with an indistinctly disclosed slope or taper (the plan in Fig.8.55), only one line is passed, corresponding to the least dimension of an element with a slope or to the smaller cone base.

If it is necessary to mark out the plane surfaces of an object on a drawing, draughtsmen pass the diagonals with the continuous thin lines (Fig.8.56).

Objects or elements with a permanent or regularly changing cross section (shafts, chains, rods, structural shapes, connecting rods, etc.) may be drawn with breaks (Fig.8.57).

The partial or broken representations are terminated with one of the following lines:

a) a continuous thin line with a break. The line may extend from 2 mm to 4 mm past the outline. This line may be inclined to the contour line;

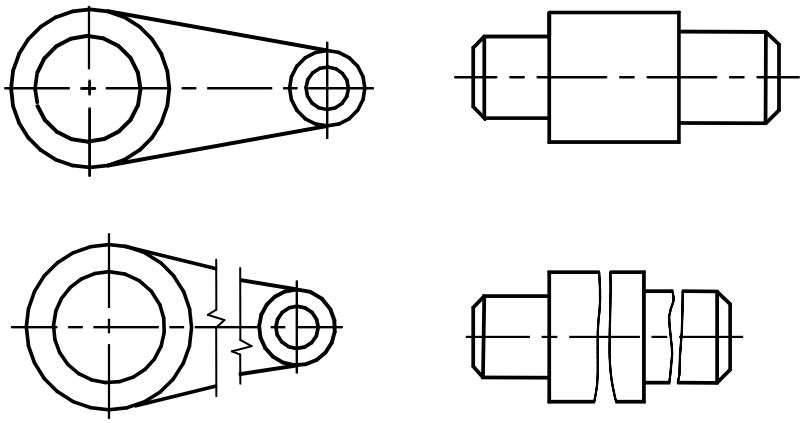


Fig.8.57

b) a continuous irregular line connecting the corresponding lines of the outline (Fig.8.57).

If you deal with a drawing of entirely gauze, wicker-works, ornaments, knurling, etc., you may draw these elements partially, with all possible simplifications (Fig.8.56).

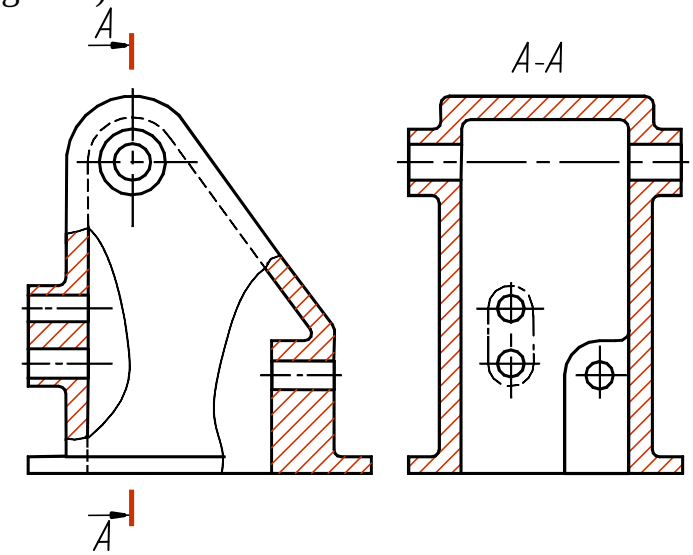


Fig.8.58

To simplify the drawings or lessen the number of representations it is permitted:

a) to draw an object part located between a viewer and a cutting plane with a chain dot line which is thickened at the proper section (the covering projection, Fig.8.58);

b) to apply complex sections (Fig.8.24 and 8.25);

c) to show only the outline of a hole (Fig.8.48) or a slot (Fig.8.53) instead of the full representation of a detail (when drawing the hub holes of pinions, pulleys and the like, as well as key slots);

c) to draw the sectional views of the holes situated on a round flange which is not in the cutting plane (Fig.8.27).

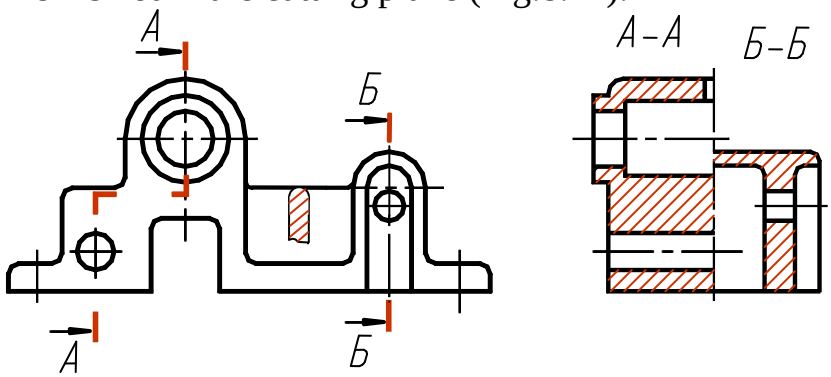


Fig.8.59

If the plan is not required and a drawing is compiled from the frontal and profile projection planes, the section line and the lettering of a step-type section are completed as shown in Fig.8.59.

Conventions and simplifications permitted for permanent joints, drawings of electric and radio technical devices, etc. are established by the corresponding standards.

8.6 Extension Elements

An extension element is an auxiliary independent representation (usually enlarged) of a certain part of an object which requires the graphic and other designations to clarify the object form, dimensions and other data.

An extension element may include the details not shown on the corresponding representation and may differ from it in contents (e.g. the representation may be a view, where as the extension element - a sectional view).

When an extension element is drawn, the corresponding space on a view, sectional view or a section is marked with a closed continuous thin line (a circle, an oval, etc.) with the extension element designation (a capital letter) on an extension line. The designation and the scale are denoted above the extension element representation (Fig.8.60).

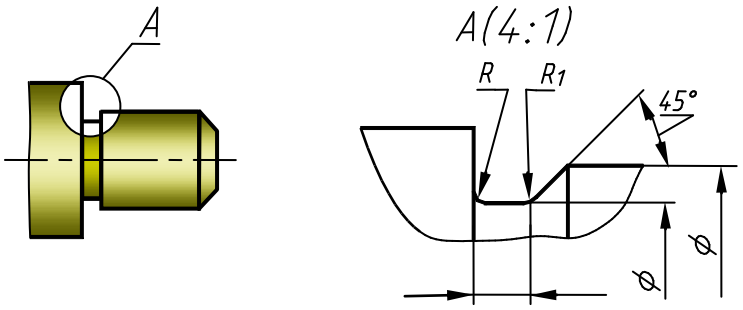


Fig.8.60

The extension element is usually placed as close as possible to the corresponding part of an object representation.

Questions to Chapter 8

What are the principal views? How are they positioned on a drawing?

What are the rules of designating a view having no projecting link with the principal view?

What representation is called an auxiliary view, a detail view? In what cases are they applied and how are they denoted?

When is it permitted to apply a break of a representation?

What representation is called a sectional view? How are the sectional views classified depending on a cutting plane position relative to the horizontal projection plane or relative to the object; depending on a number of the cutting planes?

What sectional view is referred to as a scrap one?

In what cases are the sectional views not designated?

What letters denote the sectional views?

How are the complex sections classified?

What are the peculiarities of drawing a complex step-type sectional view?

When is it permitted to join a half view and a half sectional view?

What line separates a scrap section from the view and how is it drawn?

What elements of an object are not hatched on a section?

What simplifications are used when the projections of the intersection lines of surfaces are drawn?

Are the small angles of taper and slopes shown in all drawings?

How is knurling drawn?

What is a covering projection and what are the rules of its construction?

What is an extension element?

How are the extension elements denoted on drawings?