MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
National Aerospace University «Kharkiv Aviation Institute»

SHAFTS AND GEARS.
REPRESENTATION IN A DRAWING

Manual

Kharkiv «KhAI» 2019

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S53

У навчальному посібнику розглянуто частину розділу машинобудівного креслення «Креслення деталей машин».

Подано розрахунок геометричних параметрів валів, зубчастих коліс типових конструкцій, геометричних параметрів циліндричного зубчастого зачеплення. Наведено приклади робочих креслень зубчастих коліс і складальних креслень зубчастих зачеплень, а також усі необхідні довідкові матеріали.

Для студентів технічних спеціальностей всіх форм навчання.

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S53 **Shafts** and gears. Representation in a drawing [Text] : manual / Andrii Y. Cherniavskyi, Andrii V. Chumachenko, Kateryna P. Msallam, Oksana I. Panchenko, Nataliia V. Perekhrest. – Kharkiv : National Aerospace University «Kharkiv Aviation Institute», 2019. – 84 p.

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The manual covers section of the “Drawings of machine parts” course.

The manual includes geometrical parameters of typical shafts, gear wheels, gear joints and their calculations. Examples of working drawings of gear wheels and assembly drawings of spur gear joints are given, as well as all necessary reference materials.

For students of technical specialties of all forms of study.

Figs 75. Tables 28. Bibliogr.: 9 names

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INTRODUCTION

Drawing is one of the oldest forms of human communication. It is known that cave dwellers communicated by simple figures drawn on the walls of caves. Reading and understanding of drawings is required in different areas of modern industry. Drawings are used to convey technical information in a clear and precise way. Designers' ideas can be expressed using drawings and graphics that would take thousands of words to express. A drawing is a graphic representation of an idea in the mind of the person creating the drawing. Object details such as size, shape and locational relationships can be clearly described with drawings

Drawing is one of the first communication technologies and the closest thing to a universal language form.

This tutorial has been prepared taking into account the engineering graphics program for engineering specialties and complements the existing textbooks and tutorials with specific materials.

The manual is intended for practical use in the development and design of working drawings of standard machine parts on the basis of modern standardized parts and their elements.

SHAFT. TECHNOLOGICAL ELEMENTS OF PART

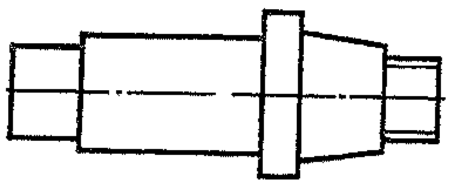
Introduction

All modern machines consist of elements called parts, connected to each other, forming assembly units, units and machines.

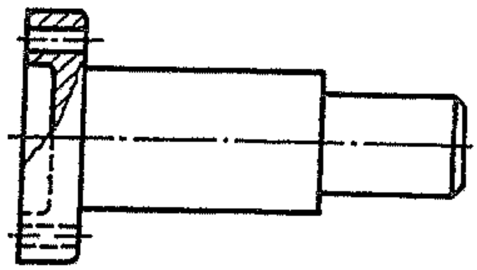
Machines are assembled from various parts, different in shape, size, material, purpose, etc. Among the variety of details, it is possible to distinguish those that perform the same purpose in different machines. For example, such a wide spread detail as a shaft can be found in most of engines, gear boxes, machine tools, etc. And wherever it is used it performs the same role: transmission of rotation from one part to another. So, a shaft is rotating machine element, used to transmit power from one place to another.

The power is delivered to the shaft by applied tangential force and the resultant torque (or twisting moment) set up within the shaft permits the power to be transferred to various machines joined to the shaft. In order to transfer the power from one shaft to another, the various members such as pulleys, gears etc., are mounted on it. These members along with the forces exerted upon them causes the shaft to bending. In other words, we may say that a shaft is used for the transmission of torque and bending moment. The various members are mounted on the shaft by means of keys or splines.

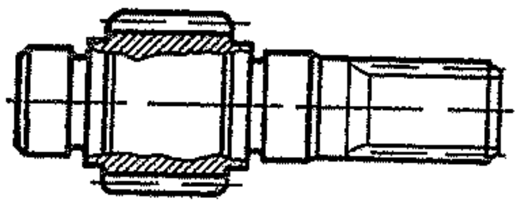
A shaft is a part that transmits torque and bears the revolving parts. There are many types of shafts: smooth shaft, stepped shaft, flanged shaft, pinion shaft etc (Fig. 1).



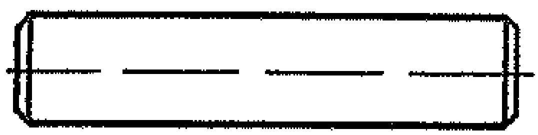
Stepped shaft



Flanged shaft



Pinion shaft



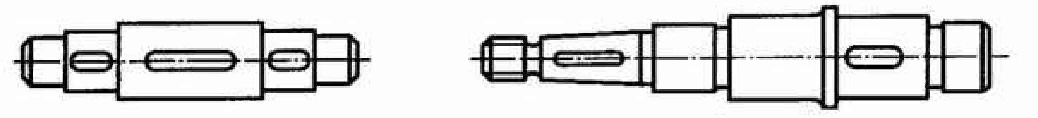
Smooth shaft

Fig. 1

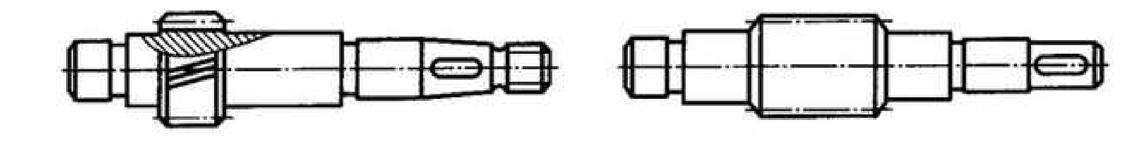
The other various mechanical elements like gears, cams, sprockets, etc. are mounted on shaft at required locating.

Notes:

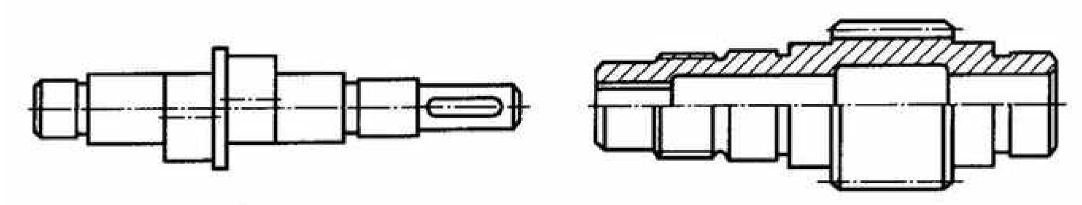
1. The shafts are usually cylindrical, but may be square or cross-shaped in section. They are solid in cross-section but sometimes hollow shafts are also used (Fig. 2).



Stepped Stepped



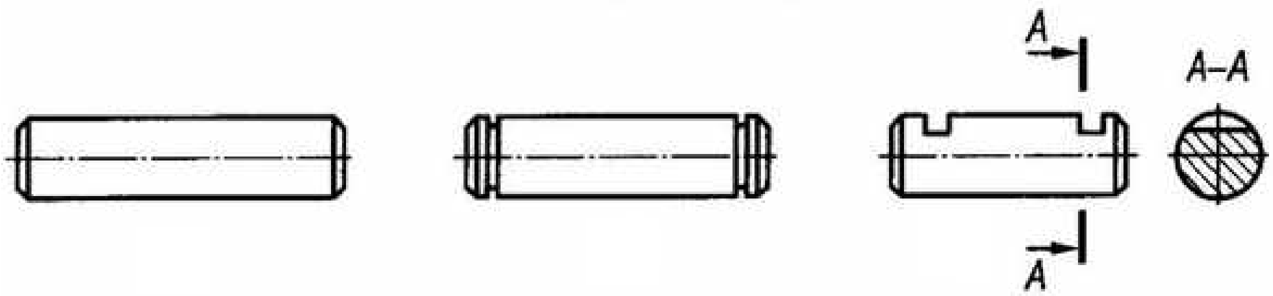
Gear shaft Shaft worm



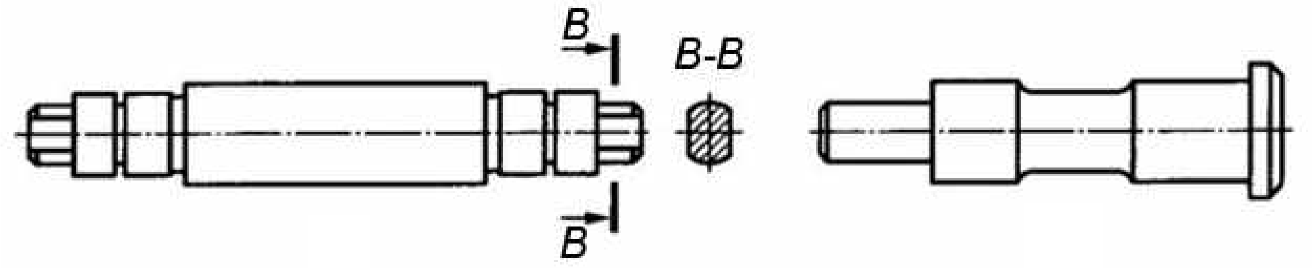
Eccentric shaft Hollow shaft

Fig. 2

2. An axle, though similar in shape to the shaft, is a stationary machine element and is used for the transmission of bending moment only. It simply acts as a support for some rotating body such as hoisting drum, a car wheel or a rope sheave (Fig. 3).



Smooth



Stepped

Fig. 3

3. A spindle is a short shaft that imparts motion either to a cutting tool (e.g. drill press spindles) or to a work piece (e.g. lathe spindles) (Fig. 4).

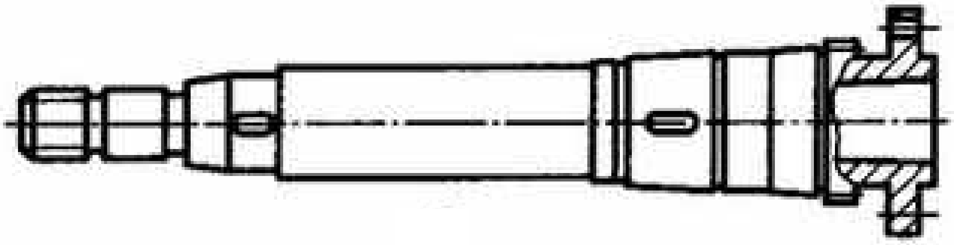


Fig. 4

Parts like a shaft belong to a group of revolving details made on turning lathe. Their axes are horizontal by machining. By drawing such parts one takes into consideration also position that it makes the greatest effort of works by part making. The cutter has working stroke by support movement from right to left (support is mechanism of turning lathe where cutting tool secures and moves). Thus on the main view the shaft is placed so that its revolving axis disposes parallel to title block of drawing.

Structural elements of the shaft

Machine parts contain a variety of different structural elements. The most spread structural elements of a shaft are (Figs 5, 6): *threaded elements; necks, undercuts and thread relief; chamfers; slots and key seats; splined elements; fillets; wrenches; flats or flattened surfaces; center holes; knurls*.

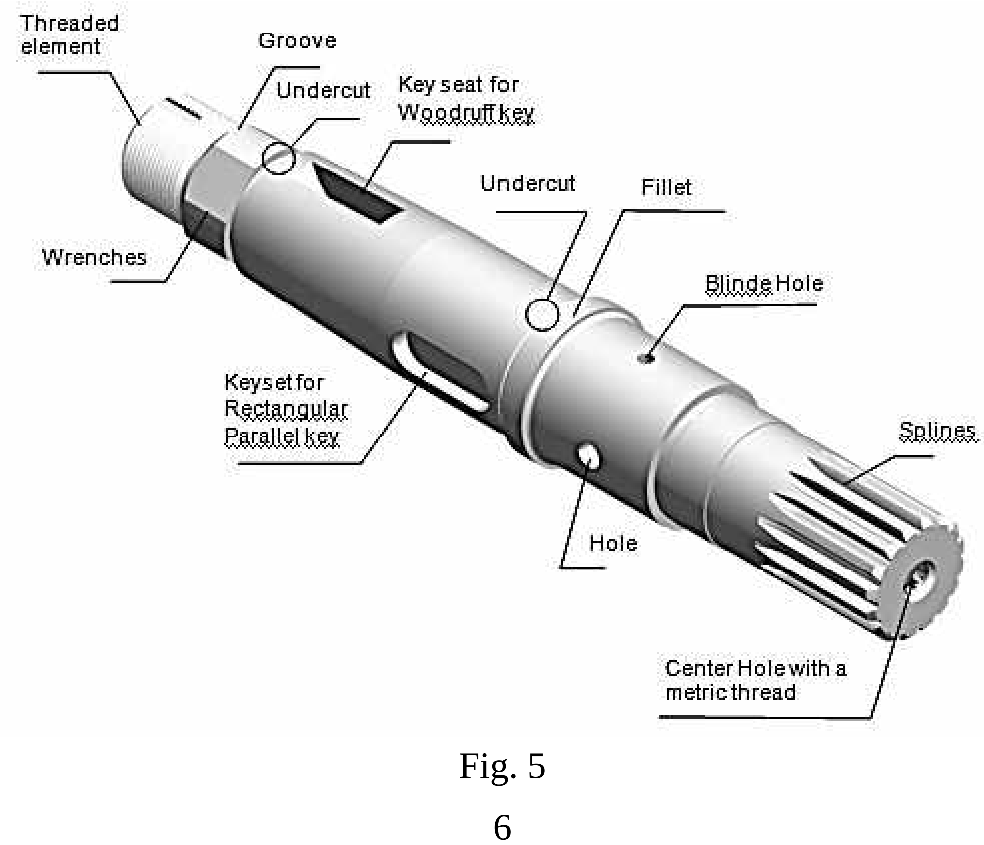


Fig. 5

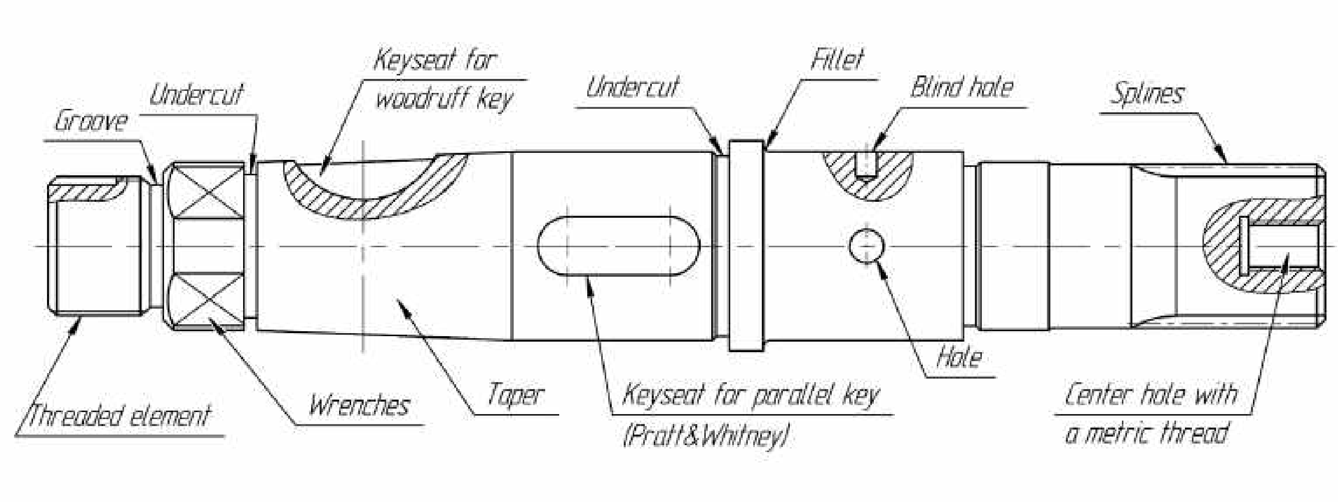
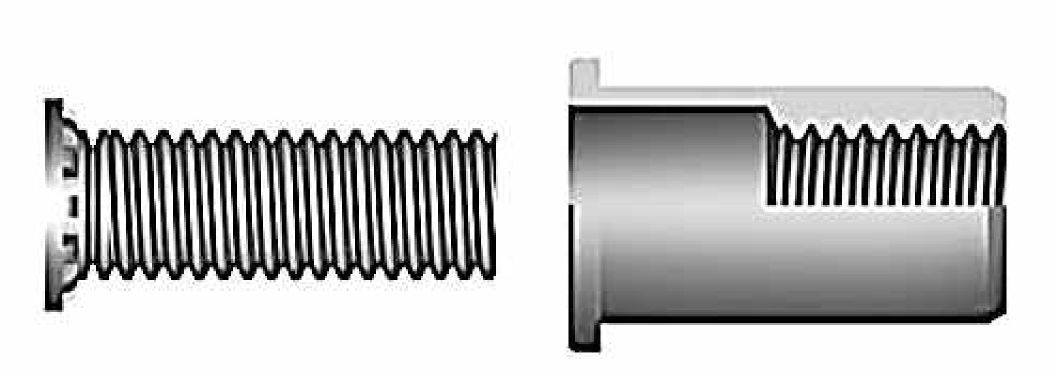


Fig. 6

Threaded elements

A thread is obtained from a cylinder on which one (or several) helix groove(s) have been created. The full section remaining is known as the screw thread. A shank is described as being “threaded”, whilst a hole is described as being “tapped” (Fig. 7).



Threaded shank Tapped hole

Fig. 7

A thread coil is a portion of a screw thread encompassed by one pitch. On a singlestart thread it is equal to one turn. Screw thread can be defined as a ridge of uniform section in the form of a helix on the external or internal surface of a cylinder or hole.

A true representation of a thread is not needed on a working drawing. Symbols are used instead. Three types of symbols are in use: detailed, schematic and simplified. Fig. 8 shows conventional representation of a thread.

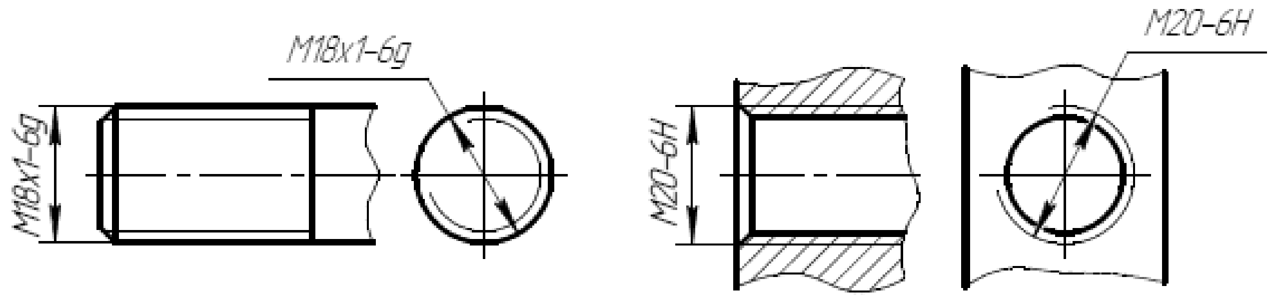


Fig. 8

Necks, undercuts and thread relief

A neck is a groove cut around the circumference of a cylindrical part. When cylinders of different diameters join, a neck ensures that the assembled parts fit flush at the shoulder of the larger cylinder and allows trash that would cause binding to drop out of the way.

A neck is a groove cut into the outside of a cylinder there the cylinder changes from a small to a larger diameter as illustrated in Fig. 9.

Fig. 9 shows how to put dimensions for a neck.

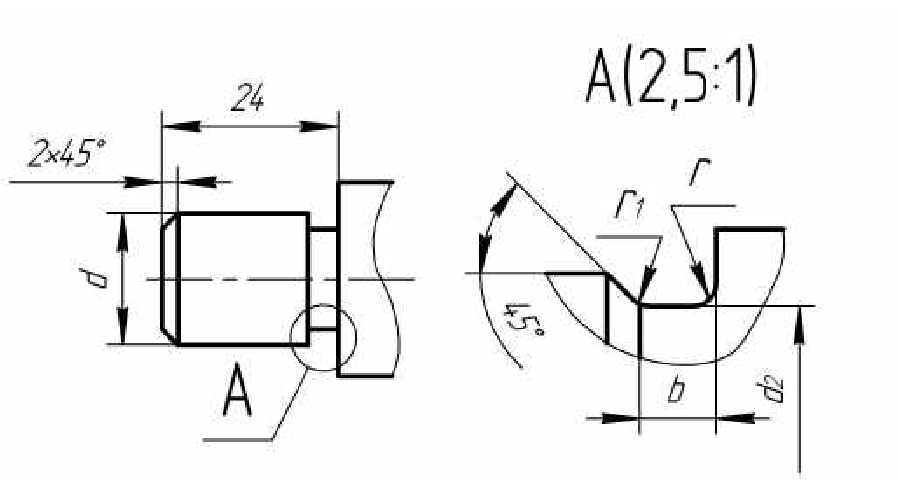


Fig. 9

A neck allows the shoulder of the large cylinder or fastener to sit flush in a hole as illustrated in Fig. 10. Without the neck a small radius is left by the cutting tool that prevents the fastener from seating flush.

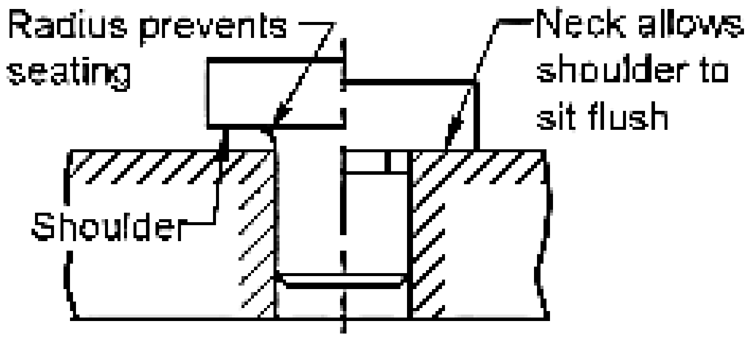


Fig. 10

An **undercut** is a groove cut into the inside face of a cylinder as illustrated in Fig.11. An example use of an undercut is to provide a groove for an "O" ring which is a torus shaped rubber seal (doughnut). Or a snap ring retaining clip which looks like a horse shoe with the opening that allows it to be pinched to make its outside diameter smaller or spread apart to make its inside diameter smaller. It is used to prevent something such as a bearing from sliding along the interior axis of the cylinder.

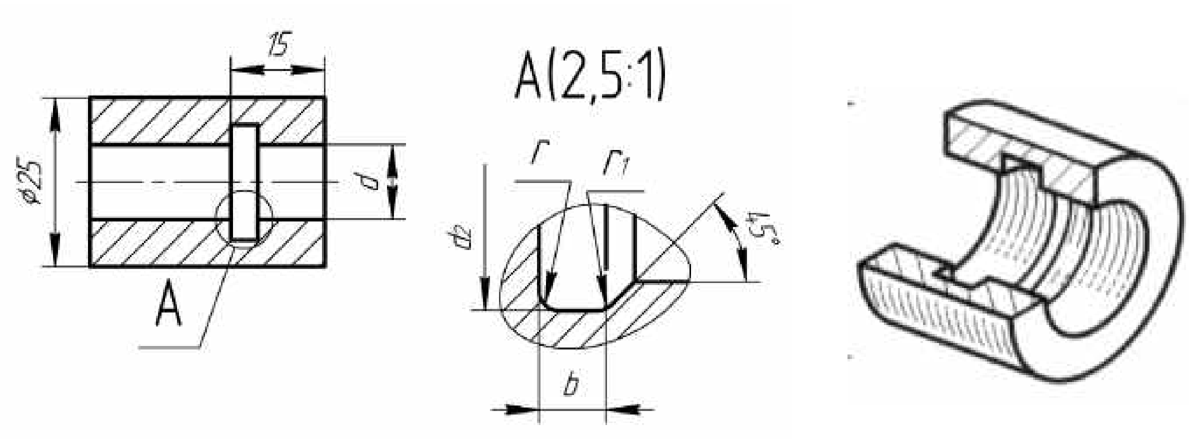


Fig. 11

The dimensions of the neck and undercut depend on the diameter of the grinding section of the shaft.

A neck at the transition from threads to a larger diameter allows the thread cutting tool to be easily removed as it approaches the larger diameter as illustrated in Fig.12. This type of neck is referred to as a **thread relief (threaded grooves).**

A thread relief is a neck that has been cut at the end of a thread to ensure that the head of the threaded part will fit flush against the part it screws into.

A thread relief is annular groove on the rod or annular undercut in the hole, performed in order to obtain the same thread profile on the entire cut section without overrun.

They are often used at the end of the threaded length of a shaft or screw to provide clearance for the cutting tool.

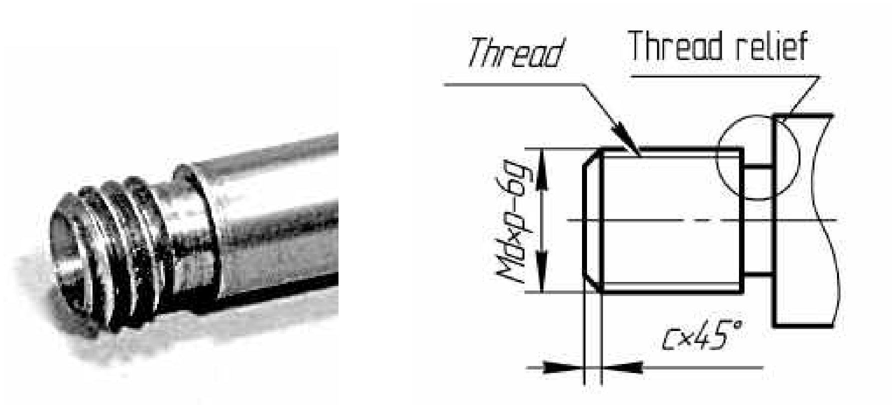
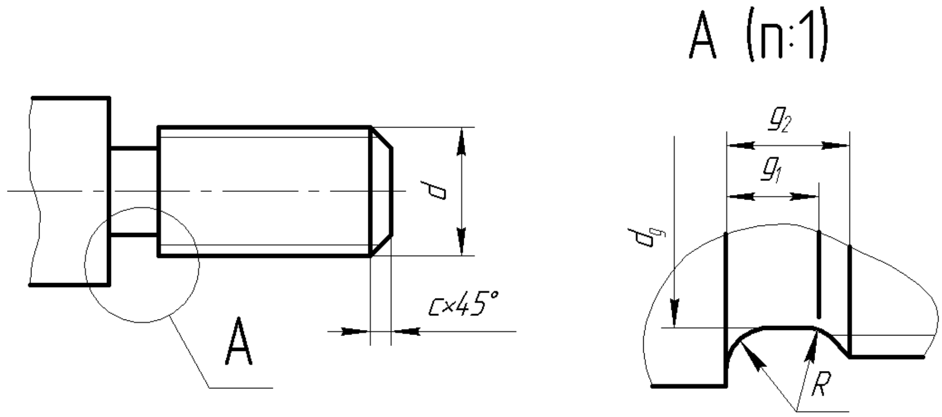
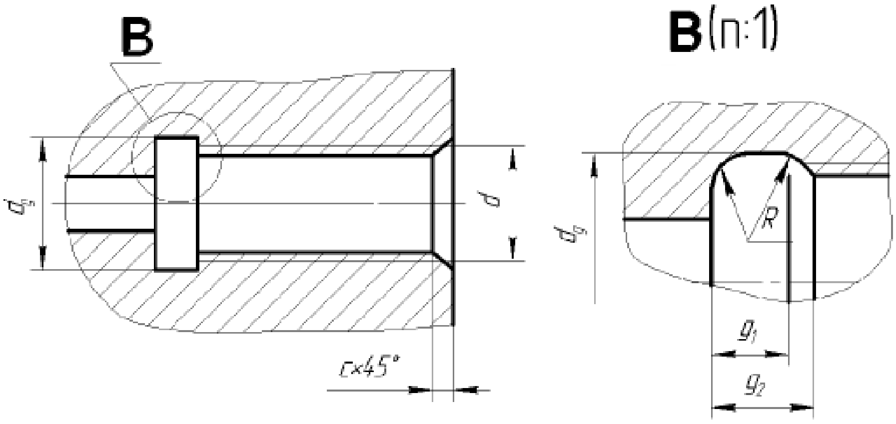


Fig. 12

The shape and size of grooves depend on the type and parameters of the thread. Examples of the image of grooves are shown in Fig. 13. All parameters are used according to standards (see Fig. 13).



External Thread



Internal Thread

Fig. 13

Chamfers

Chamfer is a conical surface at the starting end of a thread. A chamfer is a transitional edge between two faces of an object. Chamfers are made at the end of the rod (with external thread) and at the beginning of the hole (with internal thread) before threading.

Chamfer provides a convenience of mating parts, because it helps to eliminate the sharp cutting edges, resulting from technological reasons at the ends of the parts. The chamfer protects the extreme turns from damage, simplifies the process of threading, facilitates the connection between the threaded parts.

A chamfer can be formed by removing material at an angle around the entire diameter at the end of a cylinder as illustrated in Fig. 13. The chamfered end of the cylinders dulls the sharp edge and aids when assembling the cylinder into a hole.

A 45° chamfer also may be dimensioned in a manner similar to that shown in Fig. 14. We should dimension angles by specifying the angle in degrees and a linear dimension. We can also give coordinate dimensions for two legs of a right triangle.

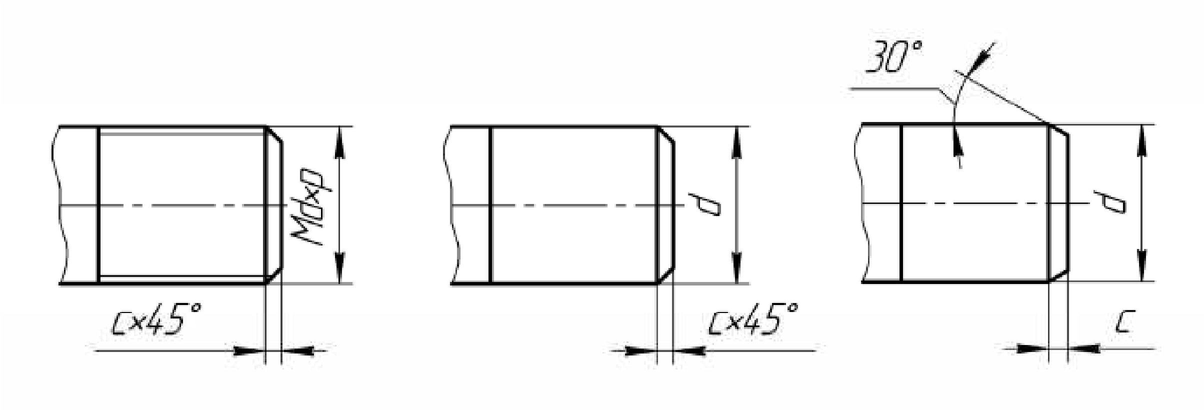


Fig. 14

When inside openings of holes are chamfered, dimension them as shown in Fig. 15.

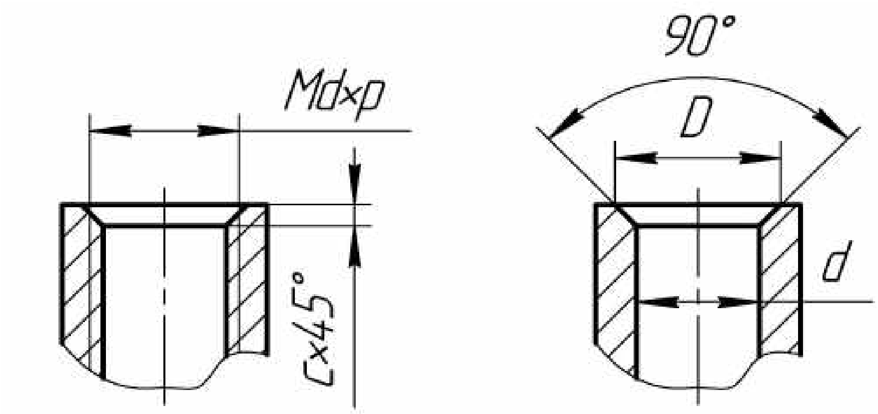


Fig. 15

The ends of threaded fasteners are also chamfered for the same reason. The most common chamfer angle is 45°. The chamfer size is determined by the thread pitch.

Fillets and Rounds

A fillet is an internal rounding between intersecting surfaces. A round is an external rounding between intersecting surfaces. Fillets can also be formed at the intersection of planar and cylindrical surfaces.

Stress concentration is a problem of load-bearing mechanical parts which is reduced by employing fillets on points and lines of expected high stress. These features effectively make the parts more durable and capable of bearing larger loads (Fig. 16). Fillets parameters are determined by technological process.

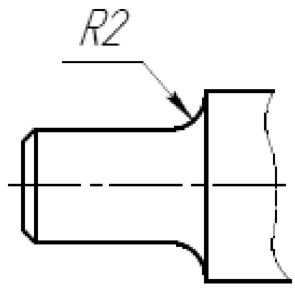


Fig. 16

Fillets are slightly rounded inside curves at corners, generally used to ease the machining of inside corners or to allow patterns be released more easily from castings and forgings. Fillets can also be designed into a part to allow additional material on inside corners for stress relief (Fig. 17, *a*).

The size of the fillet often depends on the precision of the casting method. Fillets are also common on machined parts, because it is difficult to make sharp inside corners.

Rounds are rounded outside corners that are used to relieve sharp exterior edges. Rounds are also necessary in the casting and forging process for the same reasons as fillets. Fig. 17, *b* shows rounds represented in views.

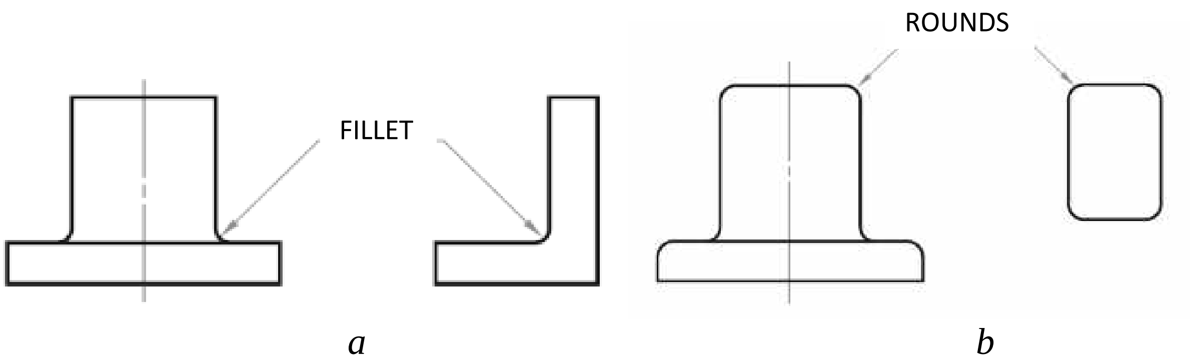


Fig. 17

Keys, Keyways and Key seats

In mechanical engineering, a **key** is a machine element used to connect a rotating machine element to a shaft. The key prevents relative rotation between the two parts and may enable torque transmission. For a key to function, the shaft and rotating machine element must have a keyway and a keyseat, which is a slot and pocket in which the key fits. The whole system is called a keyed joint (Fig. 18). A keyed joint may allow relative axial movement between the parts.

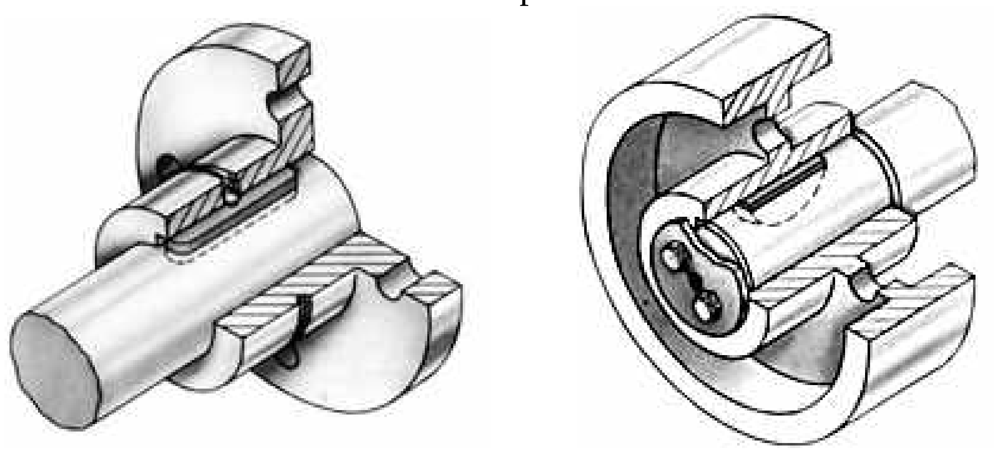


Fig. 18

A key is a mechanical link between a shaft and a hub that transmits the torque from the shaft to the hub as illustrated with pulley and shaft in Fig. 18. Half the height of the key fits into a groove in the shaft called a key seat. The other half of the key fits into a groove in the hub called a key way as illustrated in Fig. 19.

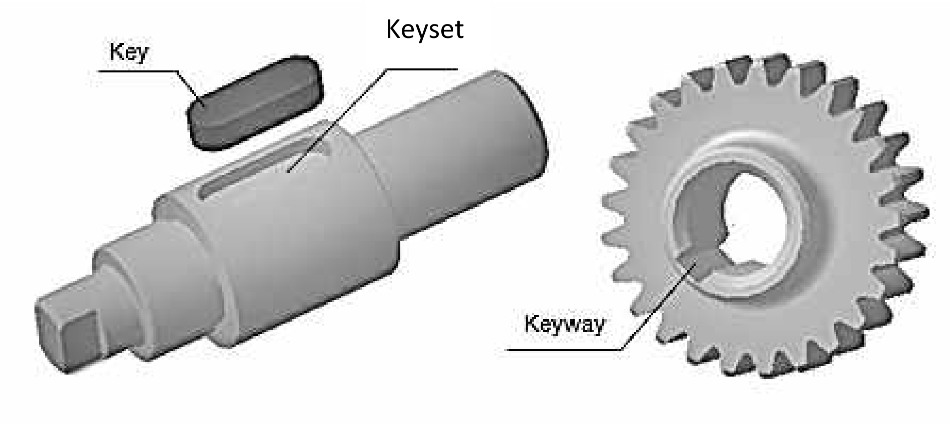
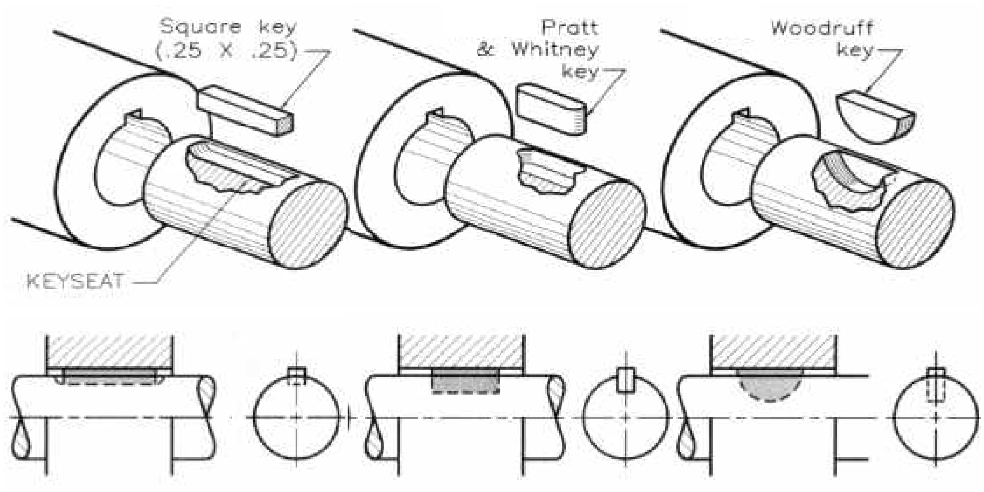


Fig. 19

There are five main types of keys: sunk, saddle, tangent, round, and spline.

Types of sunk keys: rectangular, square, parallel sunk, gib-head, feather, and Woodruff. There are three main types of keys mostly used in the course of engineering graphics: Parallel (according to GOST 23360-78) and Woodruff (according to GOST 24071-97) (Fig. 20).

For heavy-duty functions, rectangular keys (flat or square) are used, and sometimes two rectangular keys are necessary for one connection. For even stronger connections, interlocking splines may be machined on the shaft and in the hole.



Square key Pratt & Whitney Woodruff key

Fig. 20

Fig. 21 shows how the keyseat and the keyway are dimensioned for a standard rectangular shaped key.

Note that in each case it is essential to show the dimension to the bottom of the keyway measured across the diameter of the shaft and the bore of the hub.

Sizes of keys for given shaft diameters are standardized. For average conditions, select a key whose diameter is approximately equal to the shaft diameter.

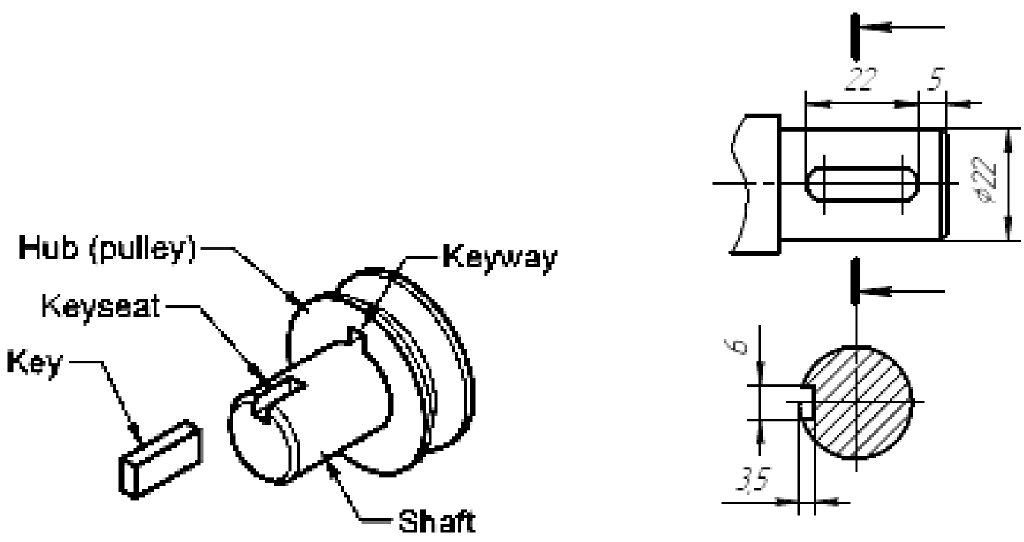


Fig. 21

How to dimension a keyseat for a woodruff key which has a radial bottom is shown at the Fig. 22.

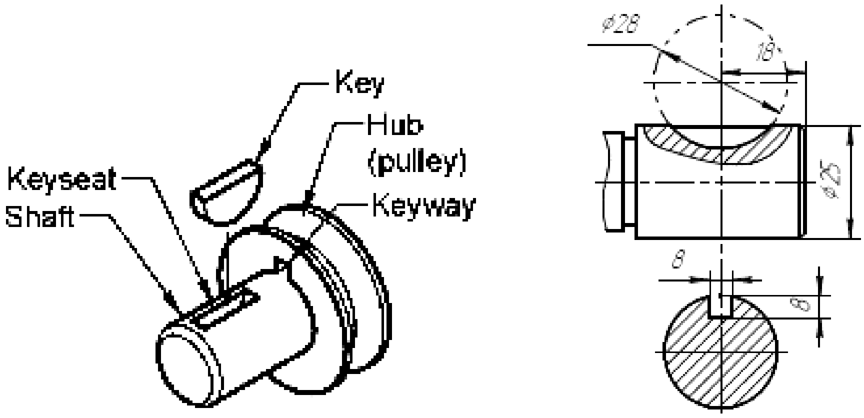


Fig. 22

Pratt&Whitney keys are the most widely used. They have a square or rectangular cross-section. Square keys are used for smaller shafts and rectangular faced keys are used for shaft diameters over 170 mm. Set screws often accompany parallel keys to lock the mating parts into place so they do not move (Fig. 23).

Main parameters for Pratt&Whitney keys are (see Fig. 23): b – width of key; h – height or thickness of key; l – length of key; d – diameter of shaft. All parameters are used only according to GOST for Parallel keys.

Example of designation – ***Key 2-18x11x60 GOST 23360-78***; where 2 – series (series 1 is not indicated), 18x11 – nominal key size (18–width, 11–height), 60–length.

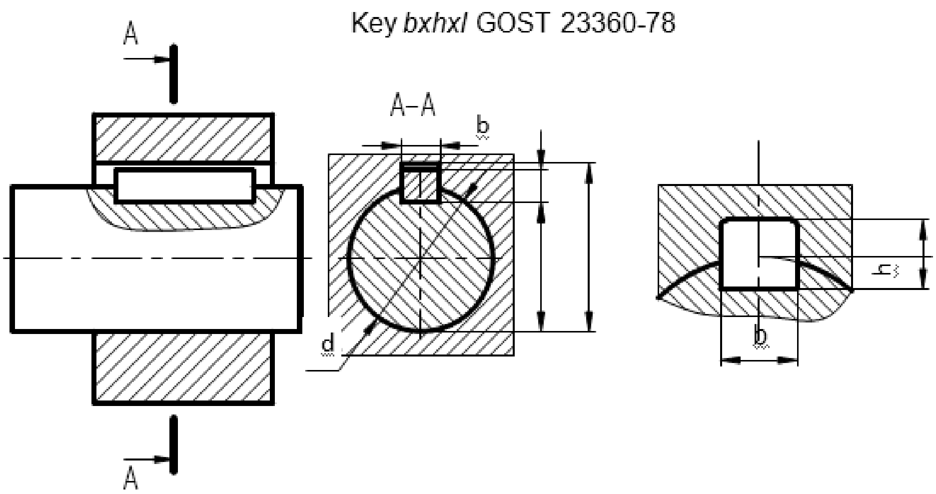


Fig. 23

A Woodruff key is a sunk key, in the form of an almost semi-circular disk of uniform thickness as shown in Fig. 24. They are used to improve the concentricity of the shaft and the mating part, which is critical for high speed operations. The main advantage of the Woodruff key is that avoids the milling of a keyway near shaft shoulders, which already have stress concentrations.

Main parameters for Woodruff key are (Fig. 24): b – width of key; h – height or thickness of key; d – diameter of shaft.

All parameters used only according to GOST for Woodruff keys.

Example of designation – Key 9x6,5 GOST 24071-97; where 9 – key width, 6,5 – key height.

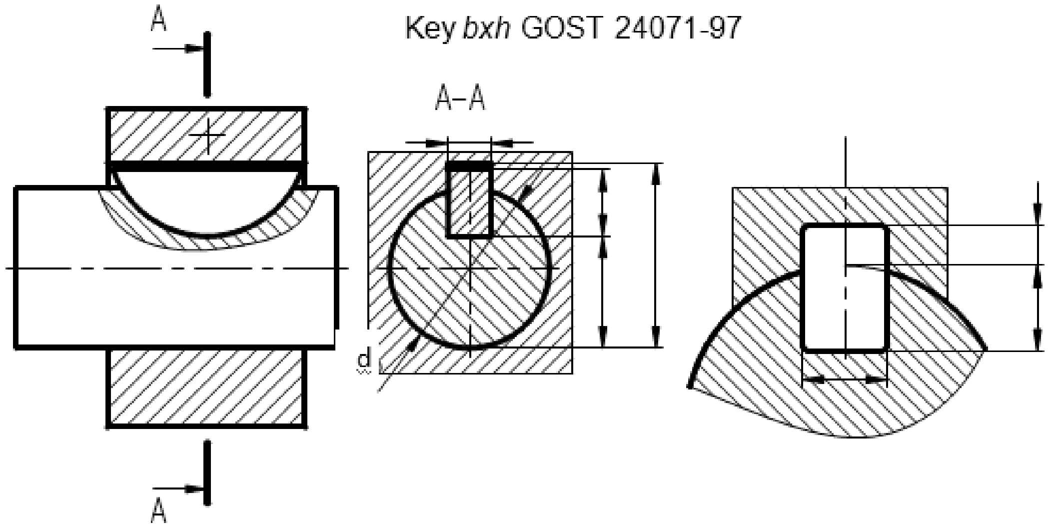


Fig. 24

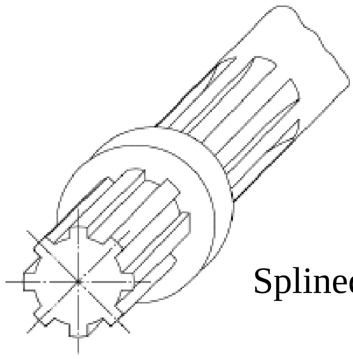
Spline elements

One of the most spread technological elements of shaft are ***Spline elements***. They are usually used for transmitting rotational torque and allow an axial sliding movement.

Spline elements are made integrally with a shaft (Fig. 25). They are used when there is a relative axial motion between the shaft and the nub (gear). Spline elements are cut on the shaft by milling and on the nub by broaching.

If a shaft is carrying very heavy loads, it should be obvious that the load is transferred to the hub (or vice versa) via the key. This means that the power that any shaft or hub can transmit is limited by the strength of the key. If heavy loading is expected, the shaft and hub will be splined (see Fig. 19). The number of splines will be dependent upon the load to be carried; the greater the number of splines, the greater the permissible loading.

There are several types of spline elements. Mostly used in course of engineering graphics are two types of splines: **Parallel-side splines** (GOST 1139-80), **Involute Splines** (GOST 6033-80).



Splined shaft and nub

Fig. 25

Parallel-side splines. This type has equally spaced teeth that are straight sided. The teeth on the shaft has an equal thickness at any point measured radially out from the axis of rotation (Fig. 26).

Example of designation:

– shaft – d-8x36e8x40a11x7f8 GOST 1139-80;

– nub – d-8x36H7x40H12x7D9 GOST 1139-80;

– combination – d-8x36H7/e8x40H12/a11x7D/f8 GOST 1139-80; where d – centering by inner diameter (D – centering along outer diameter, b – centering along width); 8 number of teeth; 36 – inner diameter with tolerances for nub H7 and for shaft – e8; 40 – outer diameter with tolerances for nub – H12 and for shaft – a11; 7 – toth width with fits D9 and f8.

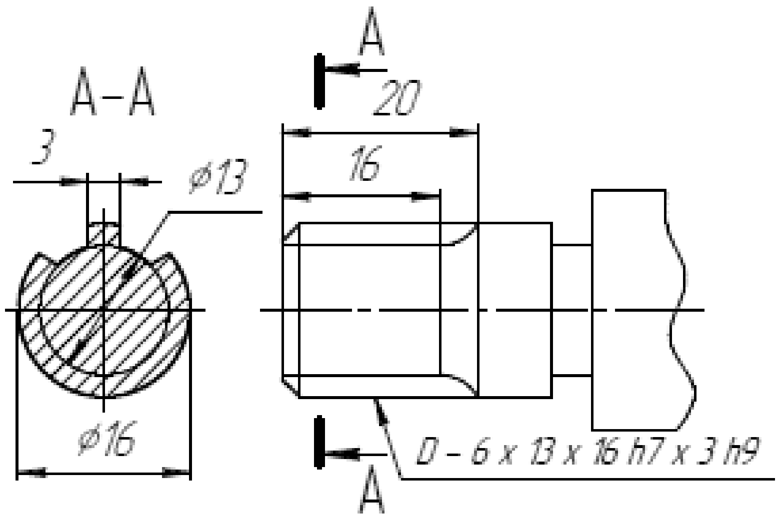


Fig. 26

Involute Splines. This type has equally spaced teeth, but they are not straight sided. The teeth have an involute form, just like a gear teeth (Fig. 27). The teeth do not have the same proportions as a gear teeth; they are shorter in height to provide greater strength. Involute splines come in several varieties: Flat root side fit, fillet root side fit, and major diameter fit.

Proportions, dimensions, fits, and tolerances are given in detail in GOST. External and internal involute splines (Fig. 27) have the same general form as involute gear teeth, except that the teeth are one-half the depth of standard gear teeth and the pressure angle is 30°.

Example of designation:

– for shaft – 50x2-9g GOST 6033-80;
– for nub – 50-2-9H/9g GOST 6033-80;
– combination – 50x2x9H/9g GOST 6033-80; where 50 – nominal diameter, 2 – module, 9H and 9g – tolerances.

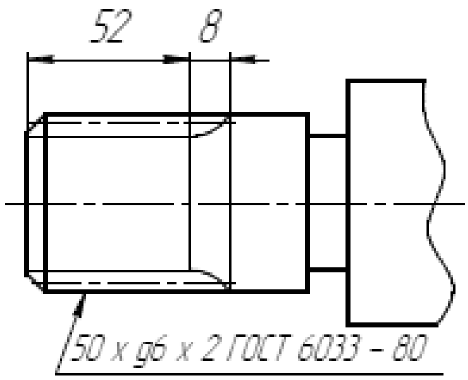
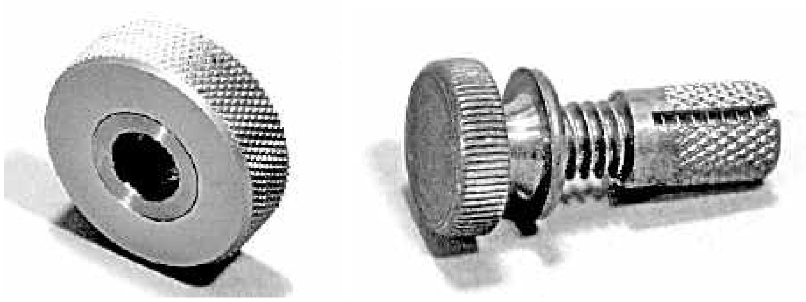


Fig. 27

Knurling

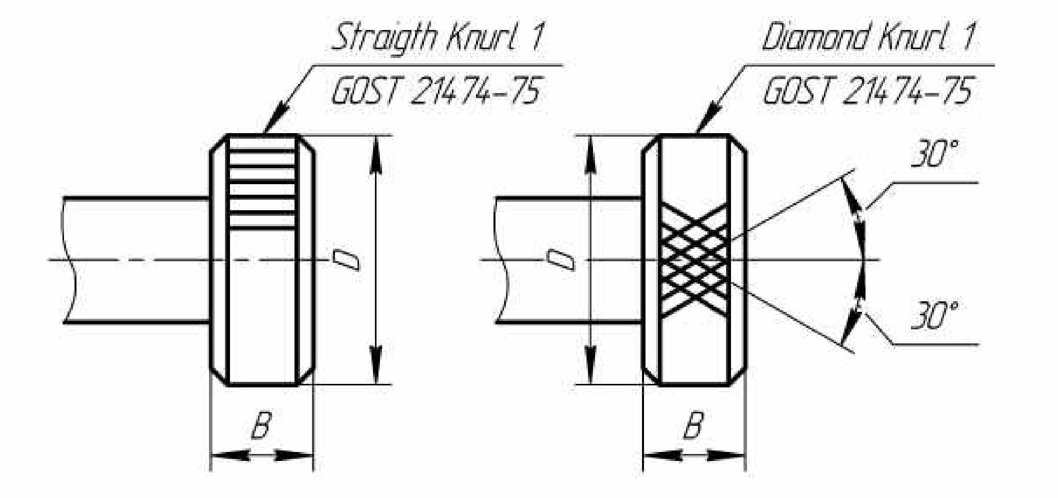
Knurling is the operation of cutting diamond-shaped or parallel patterns on cylindrical surfaces for gripping, decoration, or press fits between mating parts that are permanently assembled. Knurling results in putting a straight or diamond pattern on a cylinder as it is illustrated in Fig. 28. Knurling does not cut into the cylinder but displaces material under high pressure. Since no cutting takes place, the diameter of the knurled section is slightly larger than the cylinders diameter. Knurling provides a better gripping surface.



Diamond knurls Straight knurls

Fig. 28

Drawing of diamond knurls and straight knurls as shown in Fig. 29, with notes that specify type, pitch, and diameter.



Diamond knurls Straight knurls

Fig. 29

Center holes

Center holes are required on shafts, spindles, and other conical or cylindrical parts for turning, grinding, and other operations. Such a center may be dimensioned, as shown in Fig. 30. Normally the centers are produced by a combined drill and counter-sink.

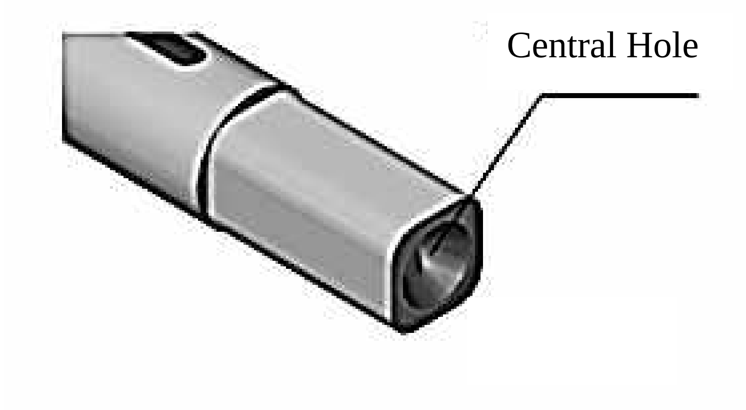


Fig. 30

Center holes must have the same dimensions at both ends of the shaft, even if the diameters of the end necks of the shaft are different. Center holes do not depict and do not provide any instructions in the specifications if the presence of holes is structurally indifferent.

If in the finally manufactured product there should be center holes, then they are represented conditionally by the sign as shown in Figs 31, 32.

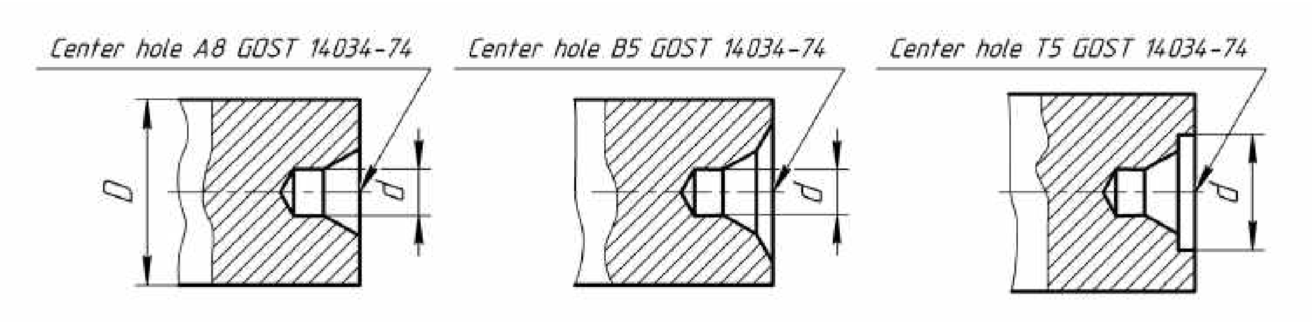
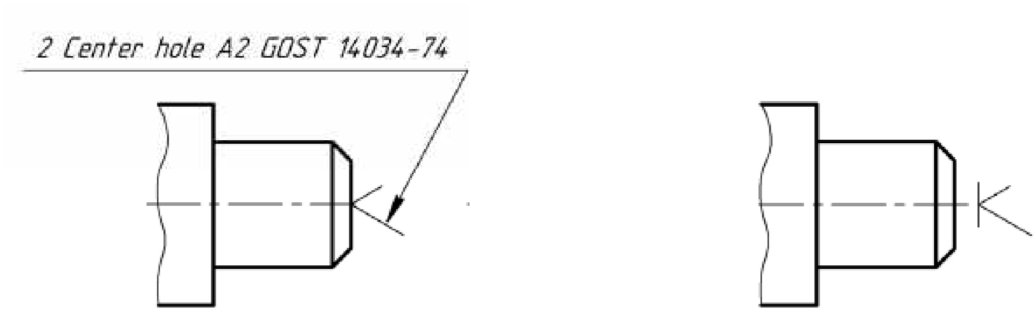


Fig. 31

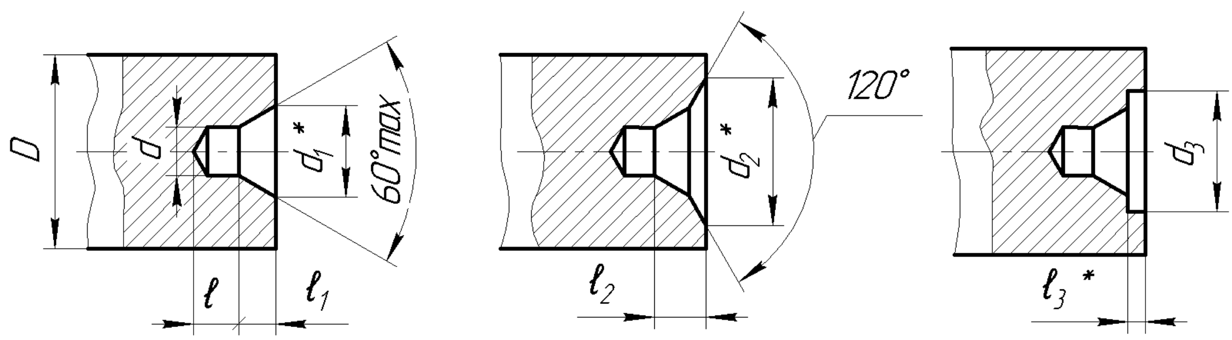


The center holes must be in the finished product

Center holes are not allowed in the finished product

Fig. 32

Center holes are technological and used for mechanical processing of the shaft (Fig. 33). All parameters are used only according to GOST 14034-74 (see Table 19).



a *b* *c*

Fig. 33

Centre drill: *a* – centre drill type A (for centring angular or plane end faces of parts), *b* – centre drill type B (for centring end faces of parts which are not angular or plane), *c* – centre drill type C (for centring of parts the end faces of which are not plane and the 60° countersunk holes of which are to be protected against impact).

Square Ends on Shafts / Flats on Shafts

Square Ends on Shafts / Flats on Shafts serves to capture a part with a key (handwheel, handle) to give it a rotary motion. They are necessary to fix shaft for assembly or disassembly shaft's elements, or to rotate the shaft for functional check of a mechanical unit.

Square Ends on Shafts are frequently used for hand driven adjustments with removable handles, such as those found on machine tools, etc (Fig. 34).

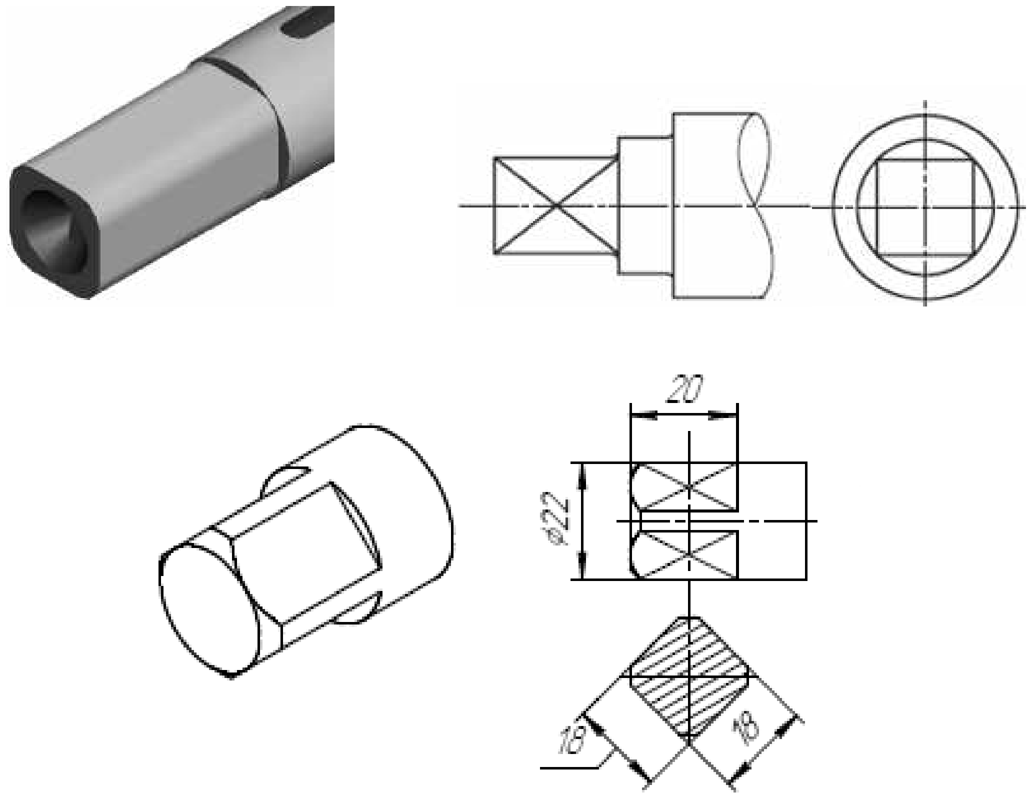


Fig. 34

Flats on Shaft is a surface machined parallel to the shaft axis (Fig. 35).

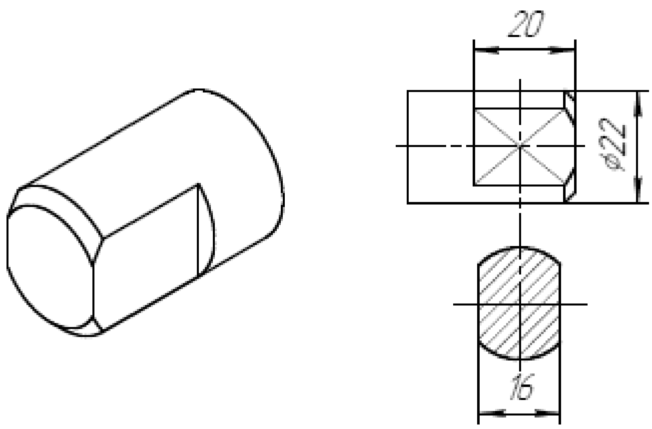


Fig. 35

All parameters are used only according to GOST 9523-84 (Fig. 36) or GOST 6424-73 for shaft and nub wrenches.

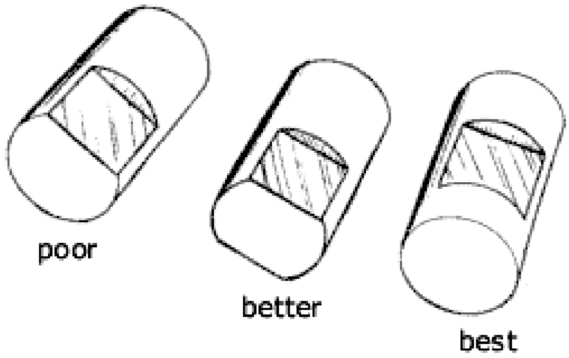


Fig. 36

For a flat at the end of a shaft, it is preferable to incorporate a matching flat on the opposite side of the shaft. This will prevent a high spot from forming opposite the flat. Alternatively, the flat can be brought inboard so that the end is a complete cylinder, as shown below in the right-hand view.

Taper and slope

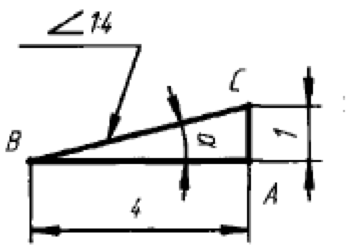
A taper is a conical surface on a shaft or in a hole.

Taper and slope symbols display taper rates and slopes as ratios, percentage values, or codes such as Morse numbers.

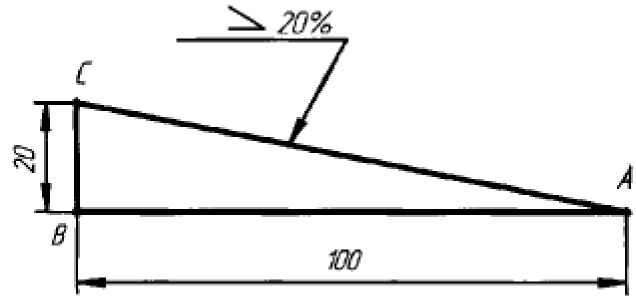
The ▷ symbol indicates tapers while the ⊿ symbol indicates slopes.

Slope is the value characterizing the slope of one straight line to another straight line. The slope is expressed as a fraction or percentage.

By GOST 2.307-68 before the dimensional number that determines the slope, put a symbol, the acute angle of which should be directed toward the slope (Fig. 37).



The slope is expressed as a fraction

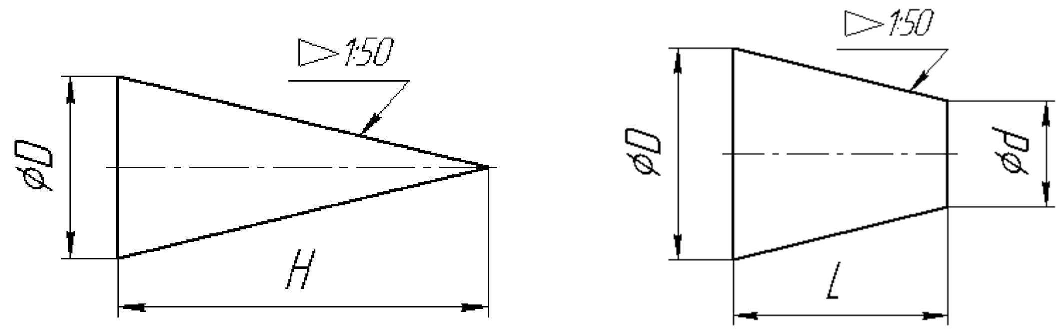


The slope is expressed as percentage

Fig. 37

Taper (C) is the ratio of the diameter of the circle (D) of the base of the cone to its height (H) for full cones or the ratio of the difference of the diameters of two end cross sections of the cone (D and d) to the distance between them (L) for truncated cones (Fig. 38):

$$C = \frac{D}{H} = \frac{D-d}{L}.$$



Full cone Truncated cone

Fig. 38

REPRESENTATION OF SHAFT ELEMENTS IN A DRAWING

It is the custom not to section many recognizable components in assembly drawings positioned along the cutting plane; these include nuts, bolts, washers, rivets, pins keys, balls, rollers, spokes of wheels and similar symmetrical parts.

Screw, Studs, Rivets, Keys, solid Shafts, sometimes Washers, Nuts, Handles, etc. are drawn unsectioned (Fig. 39).

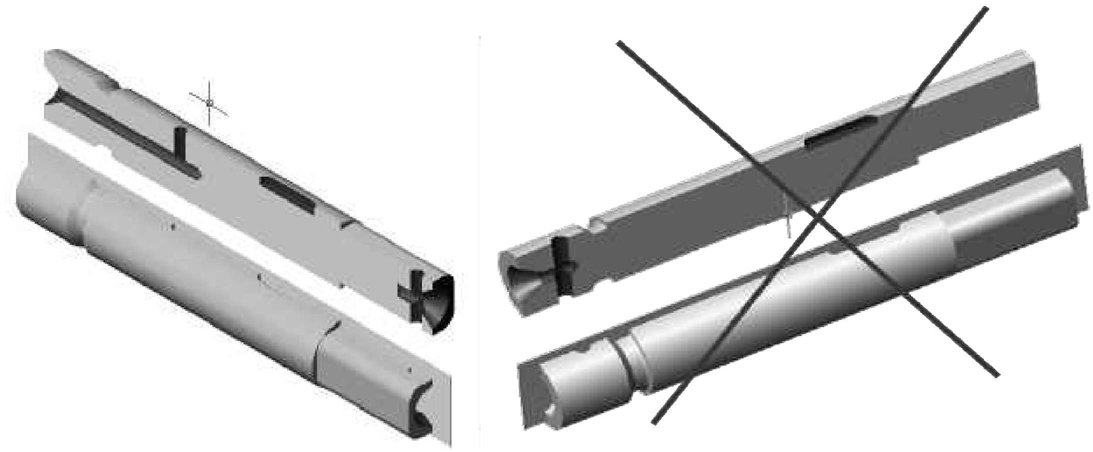


Fig. 39

When it is necessary to expose only a small portion of the internal shape of an object but not enough to warrant a full or half section, use a **broken out section.** Define a broken-out section with a break line or a combination of a break line and a centerline.

It is not always necessary to draw a complete section through a component if a small amount of detail only needs to be illustrated (Fig. 40).

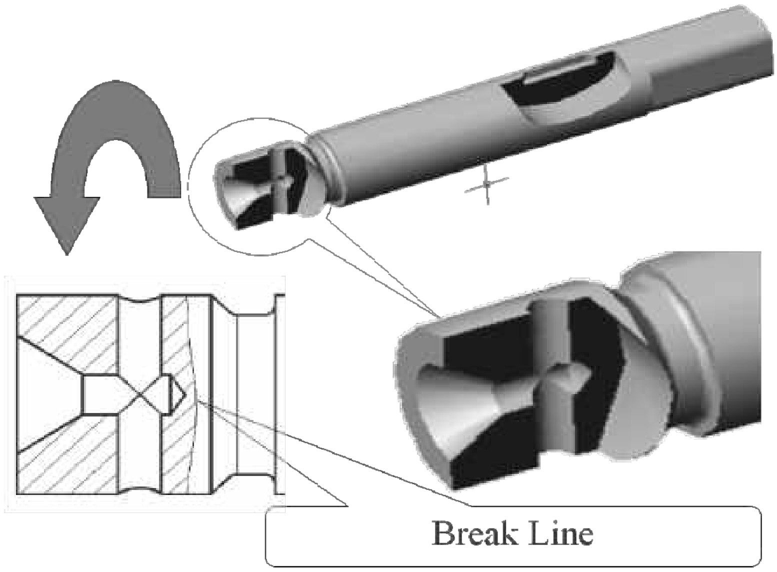


Fig. 40

A typical example is shown in Fig. 41, where a keyway is drawn in a section. The irregular line defines the boundary of the section. It is not required to add a section plane to this type of view.

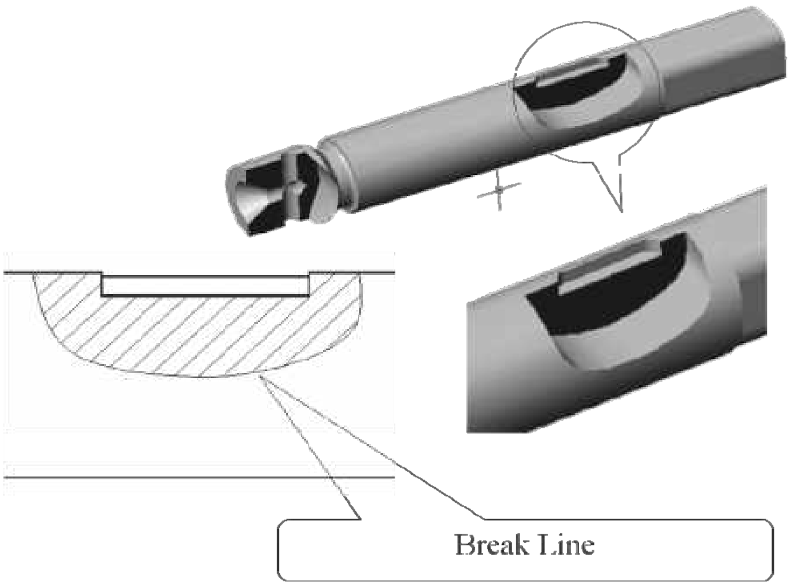


Fig. 41

To show holes in gear naves or keyseats in shafts it’s allowed to draw only contours of a hole or keyseat (Fig. 42).

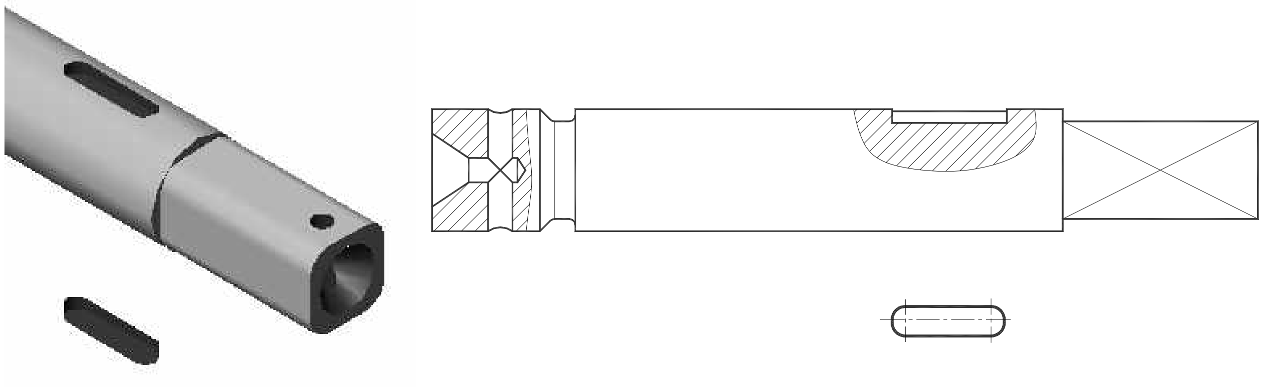


Fig. 42

Long parts of the same cross-section can be shown using break-out lines (Fig. 43). Short breaks shall be indicated by solid freehand lines. For long breaks, full ruled lines with freehand zigzags shall be used. Shafts, rods, tubes, etc., which have a portion of their length broken out, shall have the ends of the break drawn as indicated in Fig. 43.

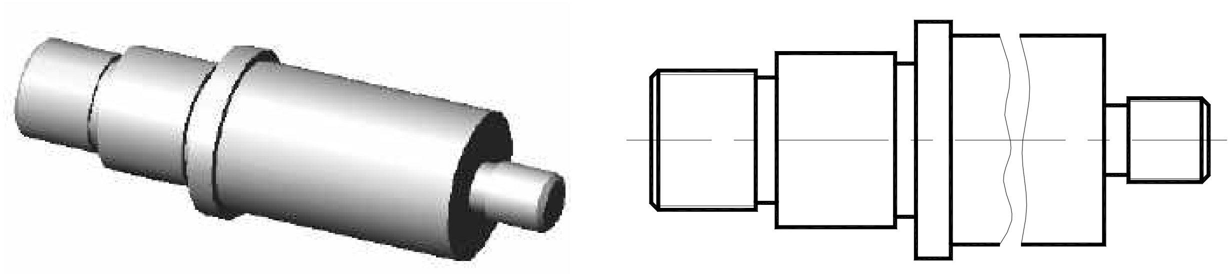


Fig. 43

Flat surfaces (like wrenches etc.) can be indicated by thing-line cross-sectioned diagonals in the drawing (Fig.44).

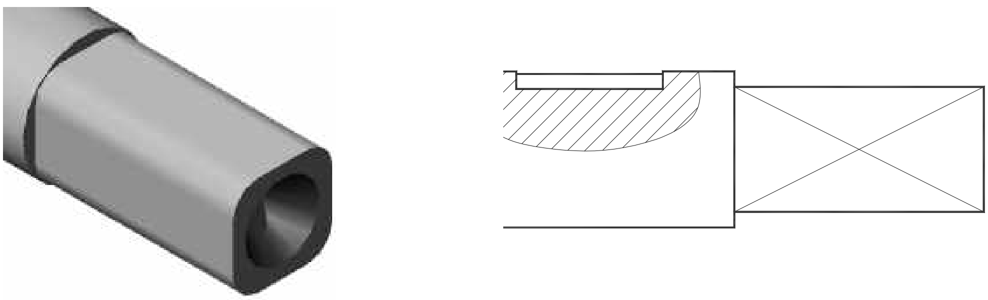


Fig. 44

To identify the cross-shaft shape (Fig. 45, *a*), it is mentally cut through with three cross-cutting planes A, B and B. Flat figures are formed (Fig. 45, *b*): the first one reveals the shape of the part in the place where the flathead was removed and the blind hole was drilled; the second shows the transverse form and dimensions of the keyway; on the third – the location and depth of the three holes. Having constructed these figures on the drawing, they obtain a section (Fig. 46).

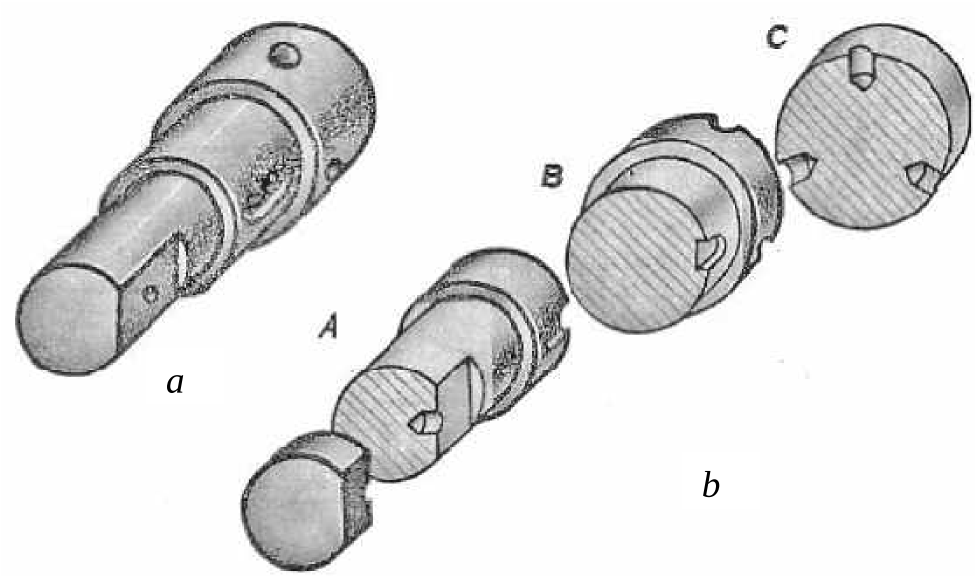


Fig. 45

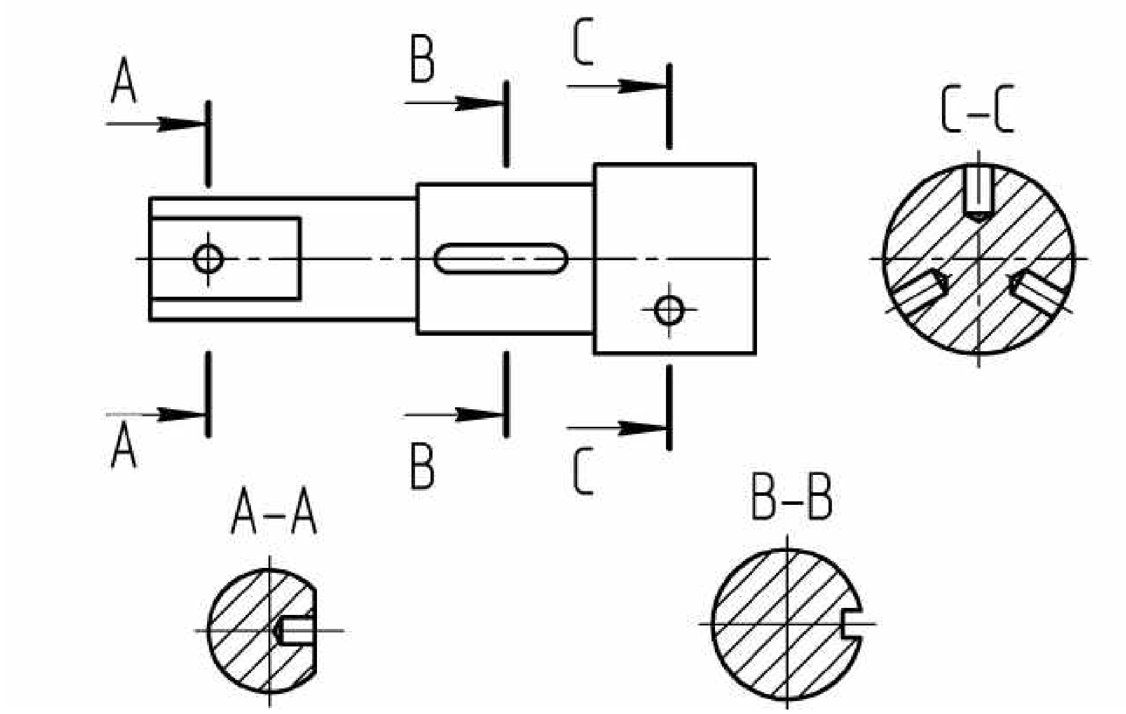


Fig. 46

Fig. 47 is an example of a shaft with several features, example of a typical shaft design.

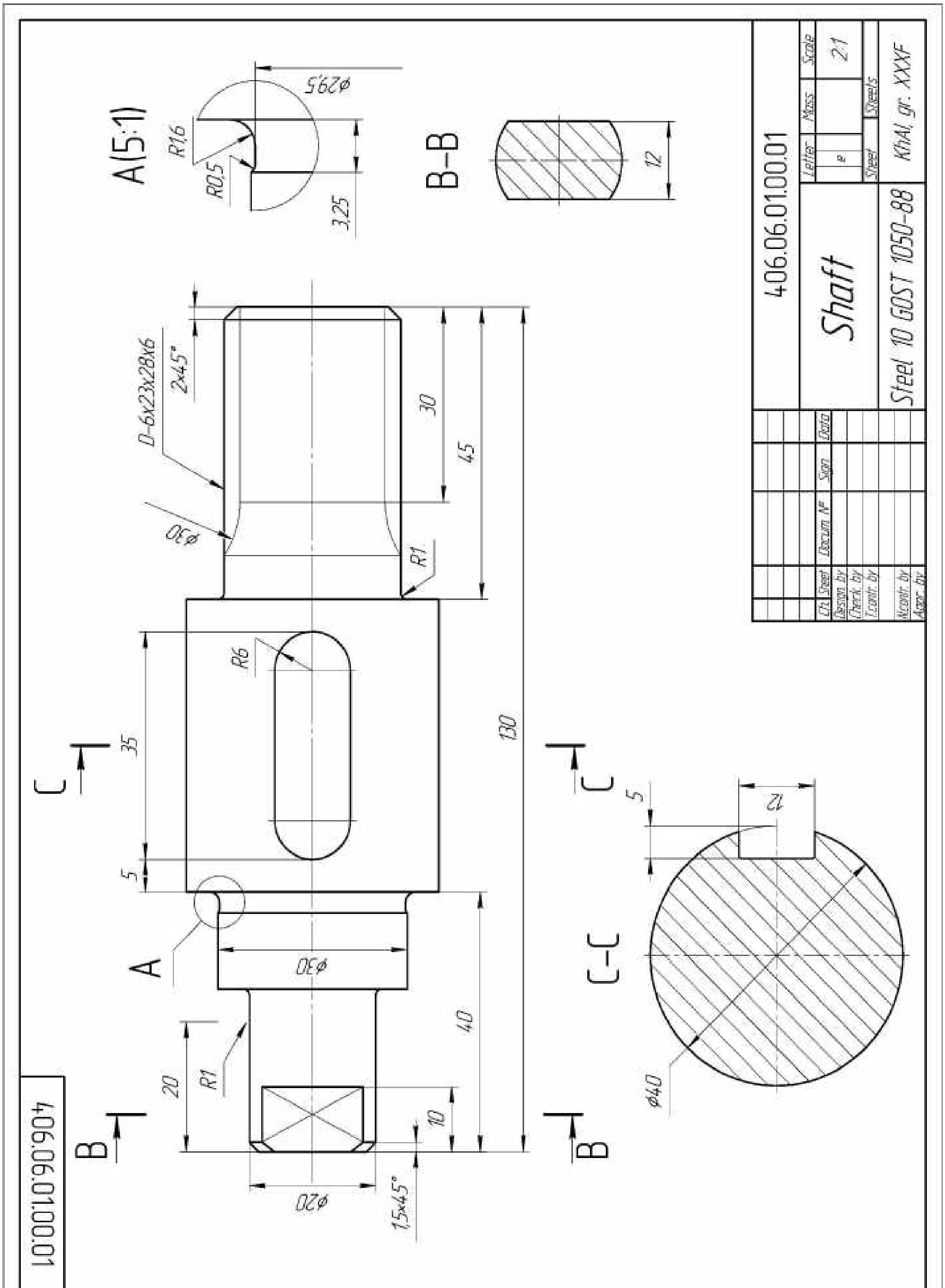

A(5:1)
R1,6
R0,5
ø29,5
3,25
B–B
12
D–6x23x28x6
2x45°
30
45
ø30
R1
R6
35
5
130
C
C–C
5
12
ø40
A
ø30
40
20
R1
10
ø20
1,5x45°
B
406.06.01.00.01
Shaft
Steel 10 GOST 1050–88
Letter
Mass
Scale
2:1
Sheet
Sheets
KhAI, gr. XXXF
Ch. Sheet
Docum №
Sign
Data
Design. by
Check. by
T.contr. by
N.contr. by
Appr. by

Fig. 47

Assignments for individual work

Exercise 1. Write down in Table 1 which of the sections (Fig. 48) corresponds to the direction of view, the shape of the object, the rules for the implementation of the sections.

Table 1

Variant	I	I I	I I I	IV	V
Answer					

Tasks	Sections			
	1	2	3	4

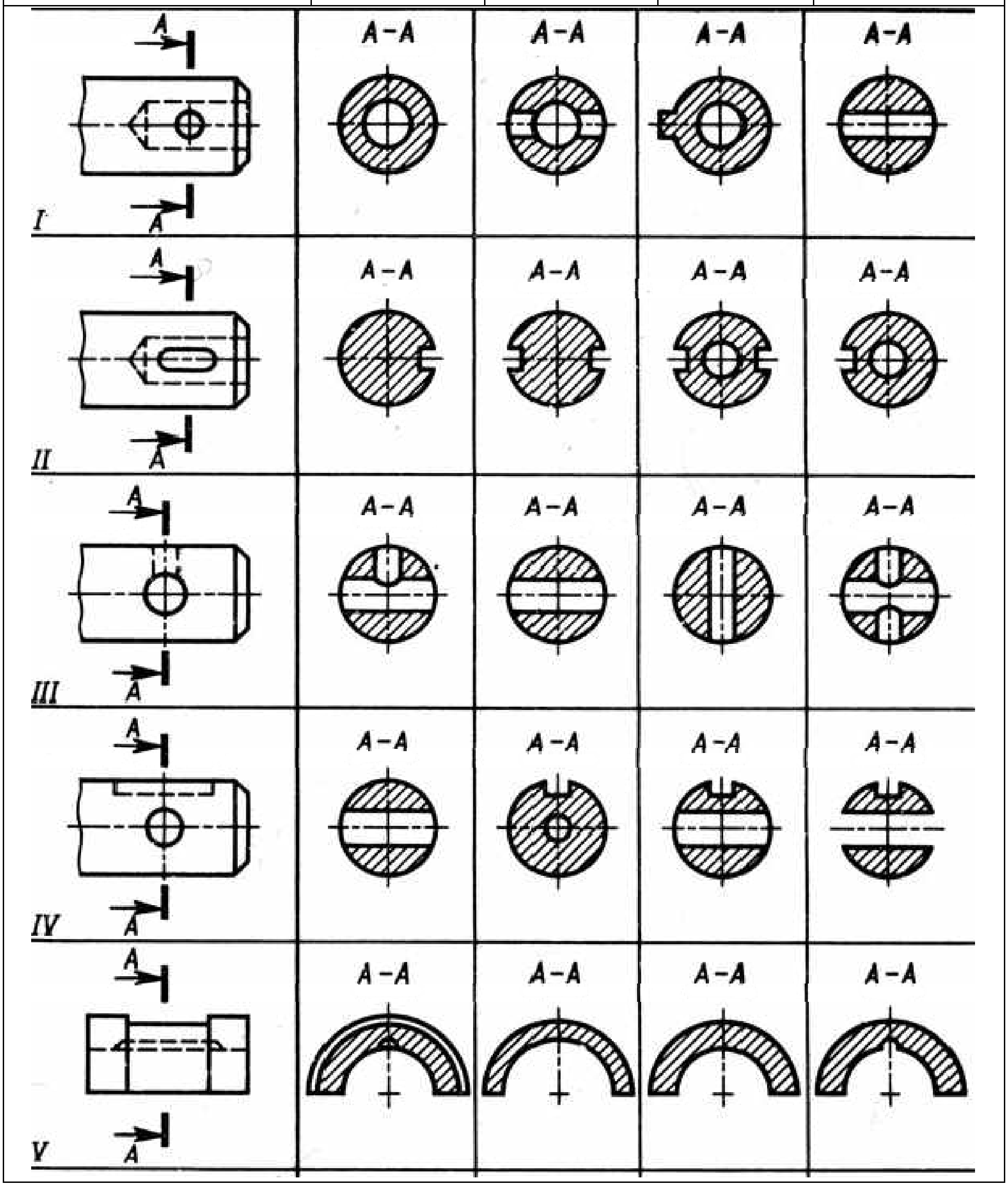


Fig. 48

Exercise 2. The main view of the shaft and six sections are given (Fig. 49). The letters indicate the result of the section at the given shaft. Write down letter's designation of the sections in the Table 2. What lettering should be applied over the sections instead of question mark?

Table 2

Variant	1	2	3	4	5	6
lettering						

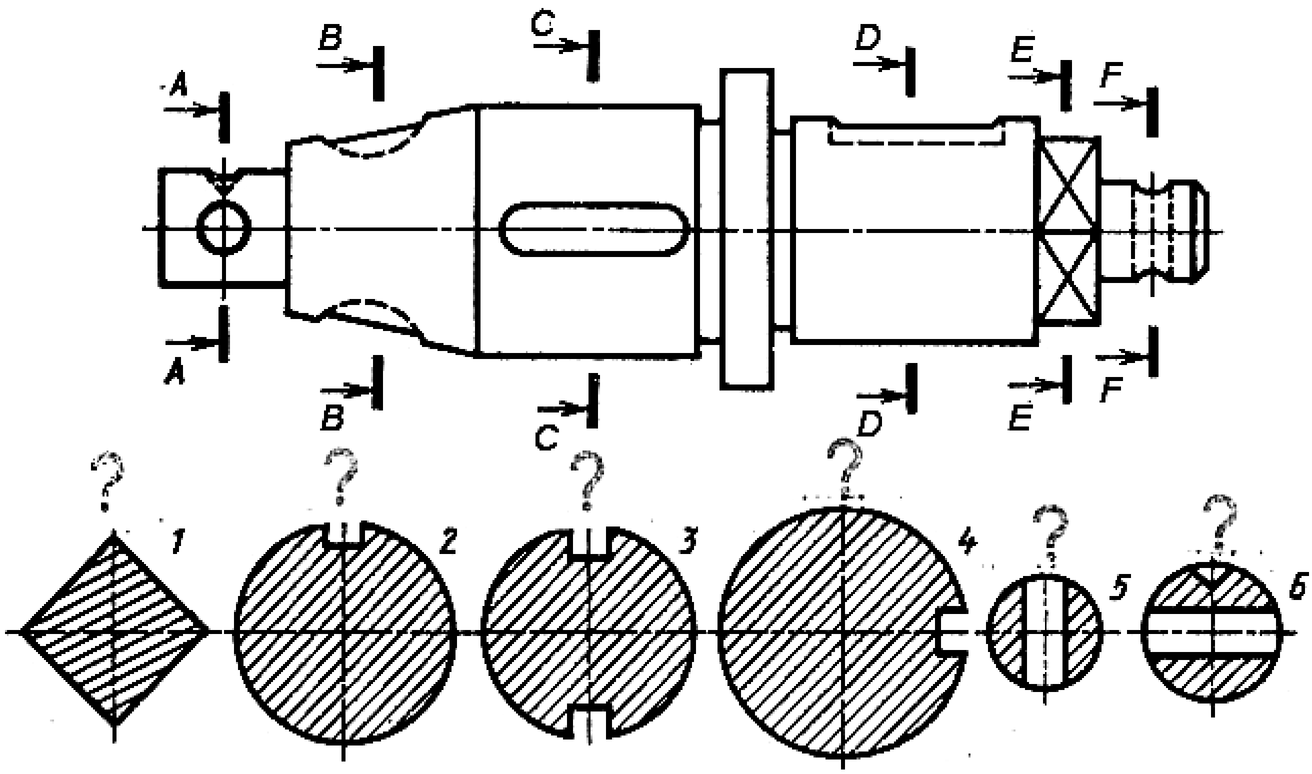


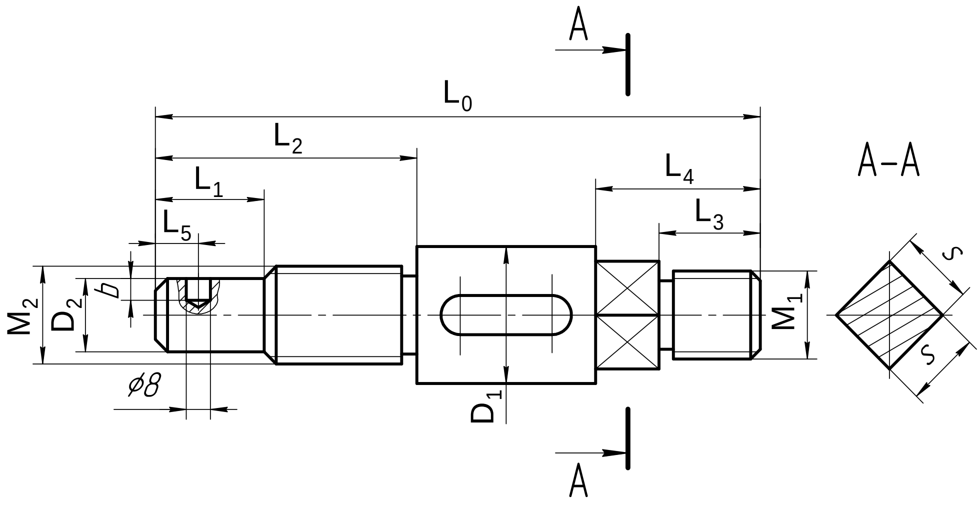
Fig. 49

Exercise 3. According to the specified dimensions (Table 3), you carry out a shaft drawing on an A3-size sheet (an example of a working shaft drawing with several elements is shown in Fig. 50).

Identify and draw the necessary cross sections (for example, cross sections of keyways, holes, shanks), make the necessary local cuts, arrange the remote elements (threaded grooves). Place necessary dimensions.

Exercise 4. Parameters for working drawing of a shaft, mm.

Table 3



Variant	D_1	D_2	M_1	M_2	L_1	L_2	L_3	L_4	L_5	b	S	L_0
1	40	20	20x2	24x1,5	25	55	40	60	7	5	22	200
2	54	35	36x1,5	42x2	30	60	35	50	10	5	36	185
3	60	45	30x2	48x2	20	65	40	60	7	10	41	200
4	68	35	36x2	39x1,5	30	80	35	50	20	7	46	205
5	54	22	30x1	27x1,5	20	60	55	70	10	5	36	170
6	55	42	30x2	45x1	45	85	60	80	20	12	36	230
7	58	38	30x1	42x1	30	100	65	75	10	10	36	215
8	55	44	39x2	48x1	40	65	50	65	15	12	41	205
9	56	34	36x2	39x1	30	80	55	70	10	10	36	215
10	45	26	30x1,5	30x1	20	60	65	85	7	6	30	225
11	52	32	36x2	36x1	30	60	60	70	10	10	36	210
12	38	24	24	27x1	40	80	40	60	15	5	24	200
13	40	28	24x1	36x3	30	70	35	55	7	10	24	185
14	42	26	24x1	32x1,5	25	50	50	70	10	7	27	195
15	45	38	30	42x1	25	50	40	60	7	30	30	200
16	50	30	30x2	39x3	35	70	30	50	10	7	32	190
17	55	32	36x2	36x1,5	30	80	30	50	15	10	36	195
18	58	42	36x2	48x3	35	70	50	70	10	10	36	205
19	55	36	30x1	42x2	35	80	50	70	15	8	30	220
20	56	34	36	39x1	30	85	40	60	10	10	36	200
21	40	30	24	36x1	25	65	35	55	7	8	24	180
22	55	40	39x1	48x2	25	75	65	85	10	10	41	225
23	50	42	30x2	45x1,5	25	55	50	70	10	10	30	180
24	45	38	30	42x1	25	50	40	60	7	30	30	170
25	52	40	36x1	45x2	25	60	55	75	10	10	36	200
26	45	22	24x2	27	20	60	50	70	7	12	27	195
27	60	48	36x2	52x2	60	95	35	60	20	36	36	250
28	40	30	24	36x1	25	65	35	55	7	8	24	180
29	55	32	36x2	36x1,5	30	80	30	50	15	10	36	195
30	68	35	36x2	39x1,5	30	80	35	50	20	7	46	205

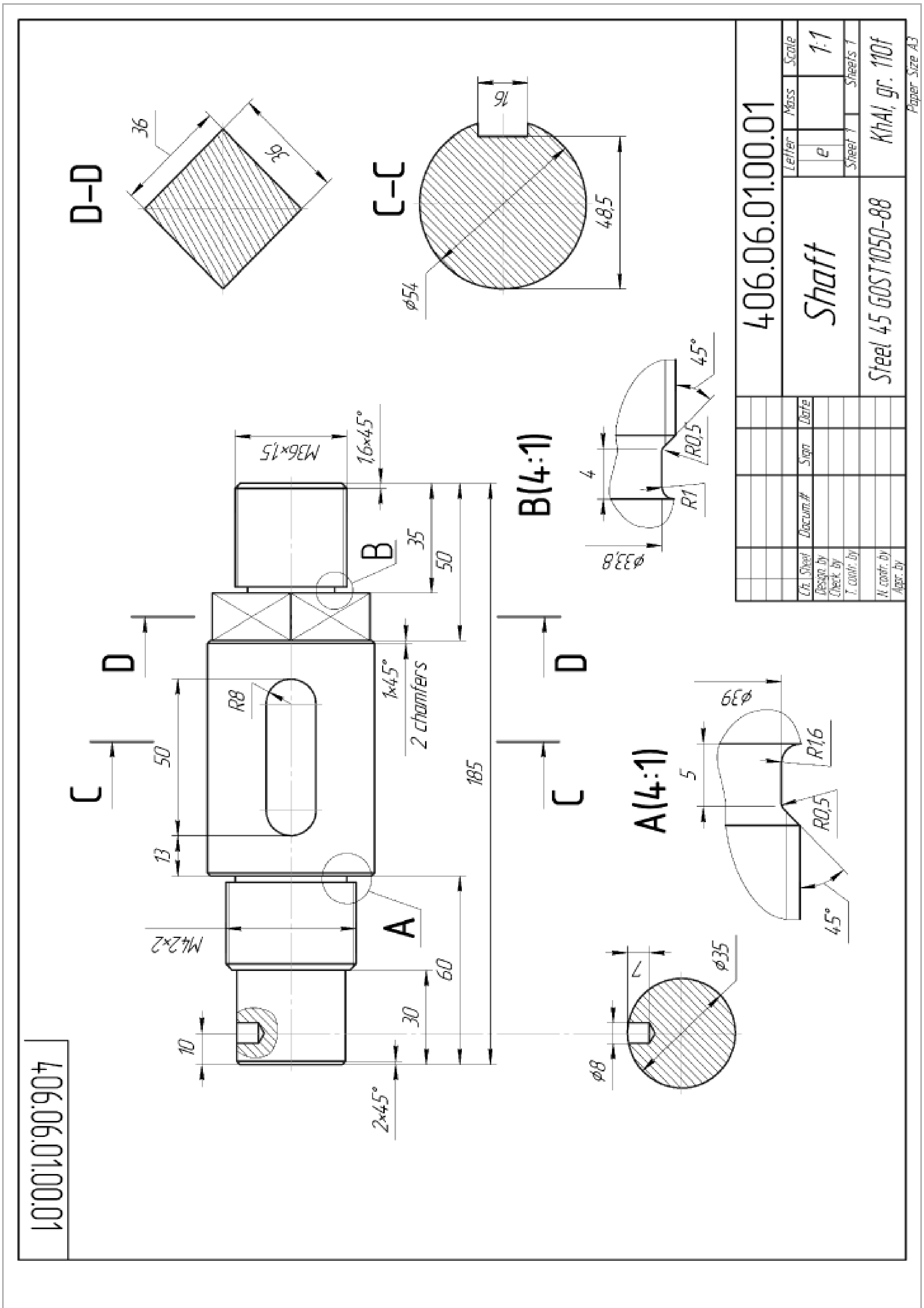

4.06.06.01.00.01
Shaft
Steel 45 GOST1050-88
KhAI, gr. 110f
Paper Size A3
Scale
1:1
Letter
Mass
Sheet 1
Sheets 1
D–D
C–C
B(4:1)
A(4:1)
M36×1,5
M42×2
1,6×45°
1×45°
2 chamfers
2×45°
R8
R0,5
R1
R1,6
ø54
ø35
ø8
ø39
ø33,8
185

Fig. 50

Exercise 5. Draw a front view of the shaft along arrow A and complete the three sections indicated. The section by plane “A-A” should be placed on the continuation of the track of the section plane, section plane “B-B” in the free space of the drawing, and the section by the “C-C” plane is in projection connection with the main view. Dimension. The drawing must be done on A3 format. An example of the drawing of the shaft is shown in Fig. 51.

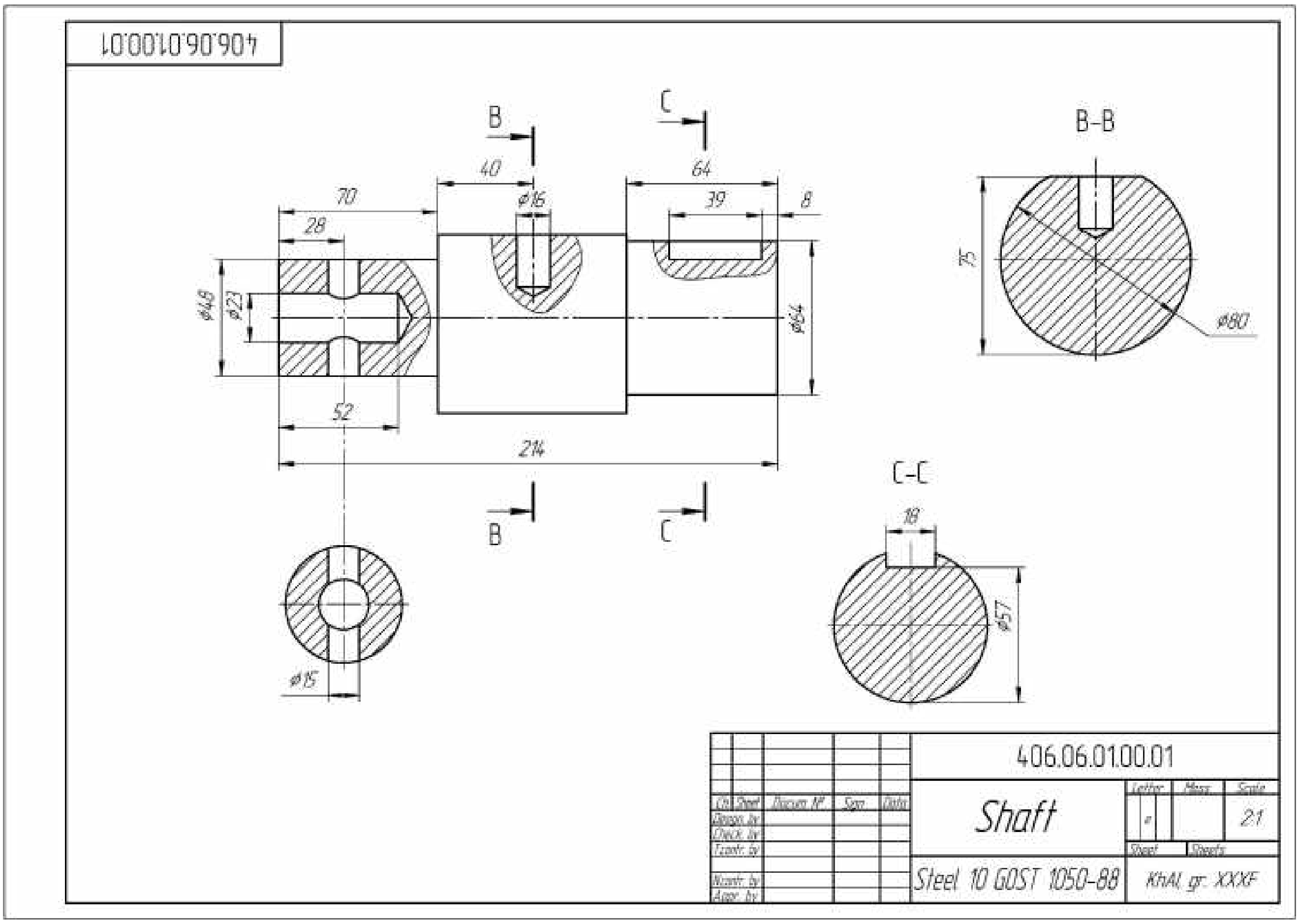
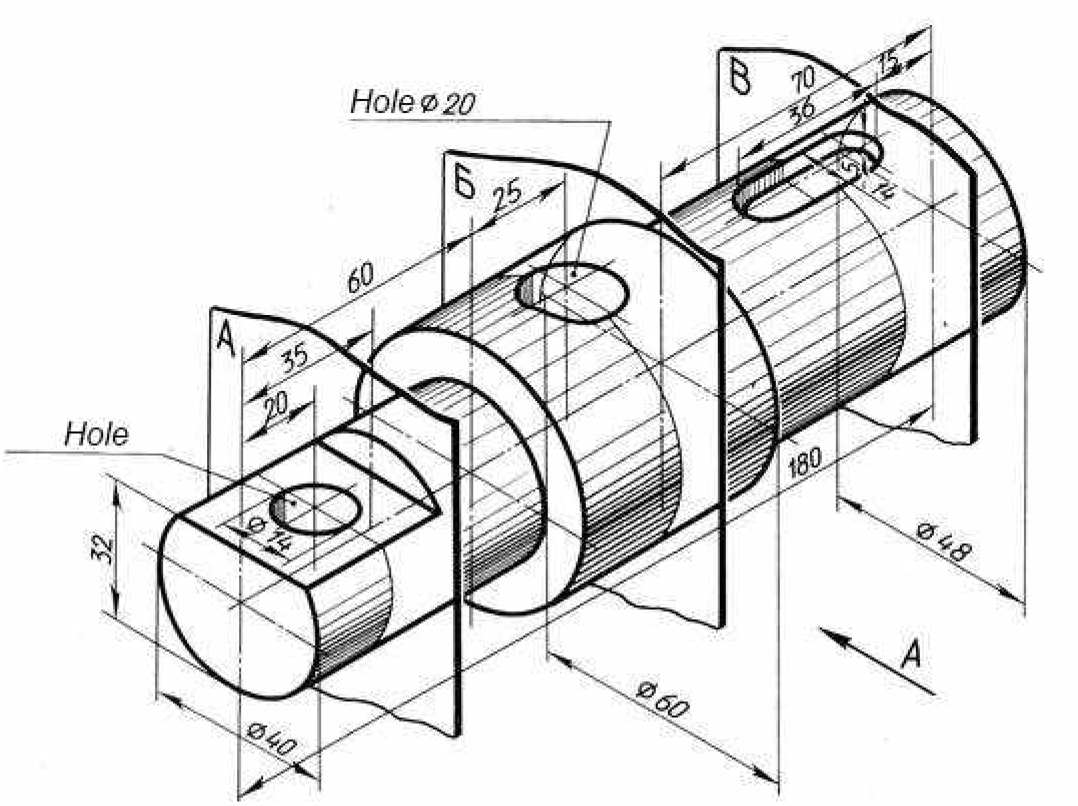
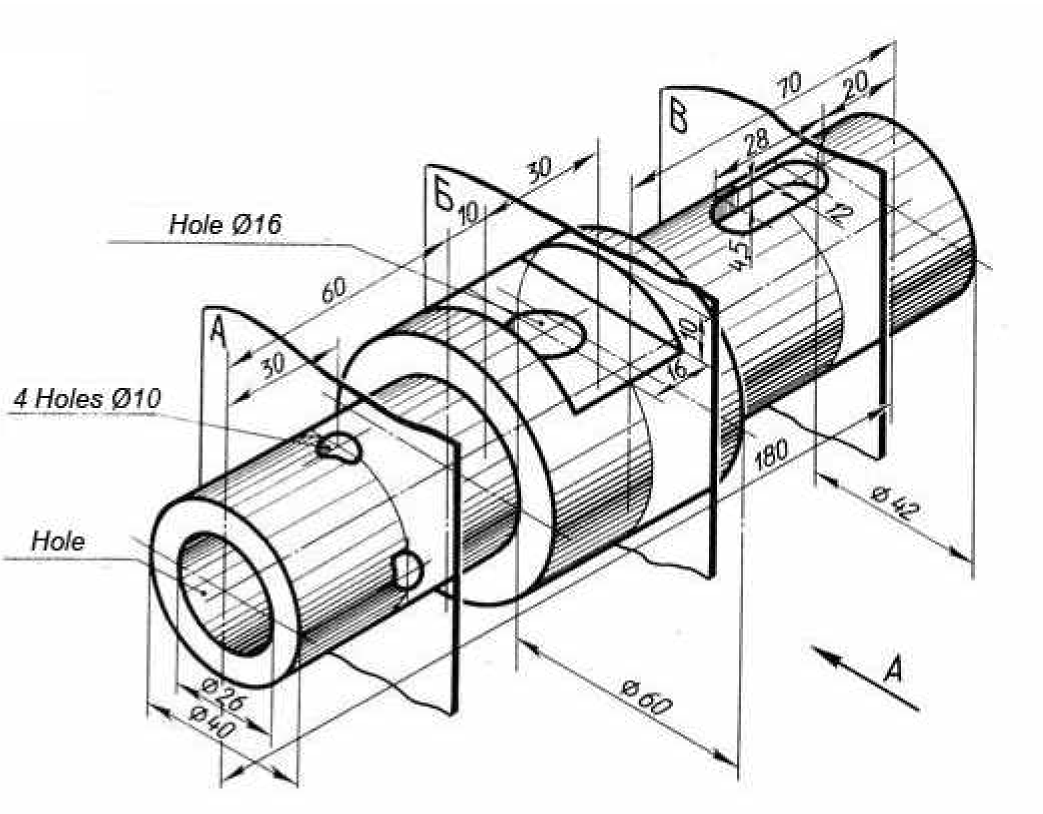


Fig. 51

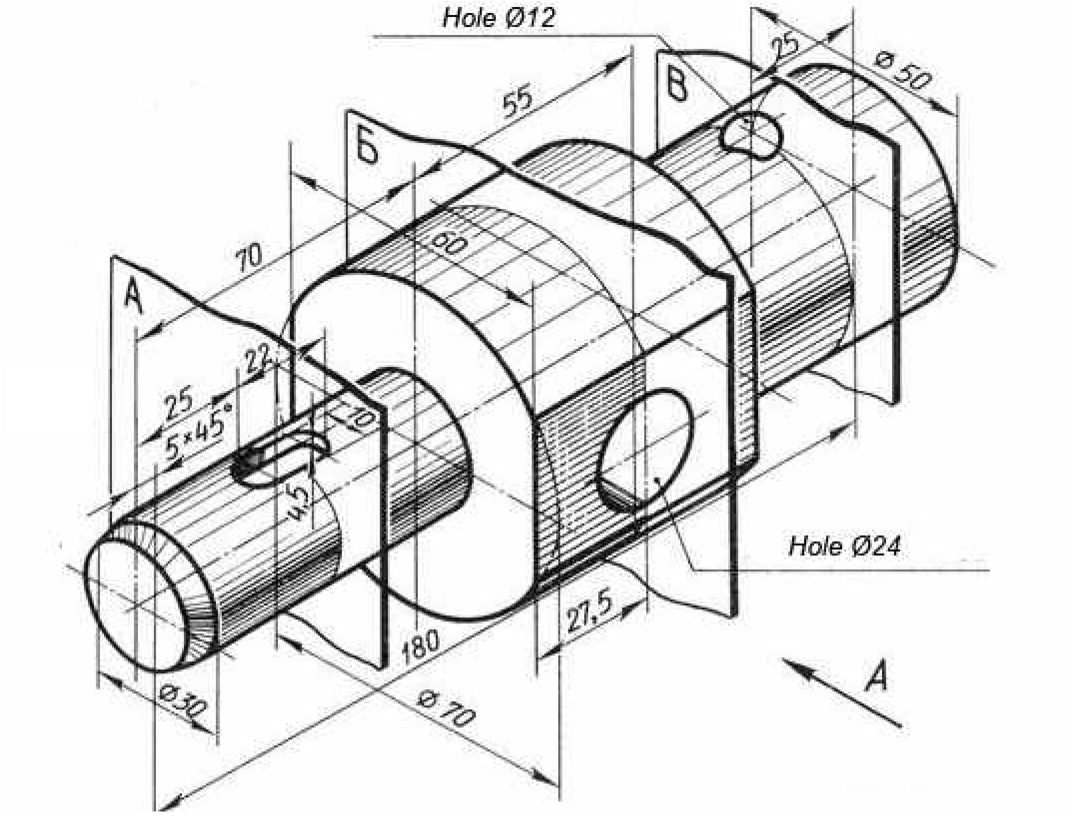
Variant № 1



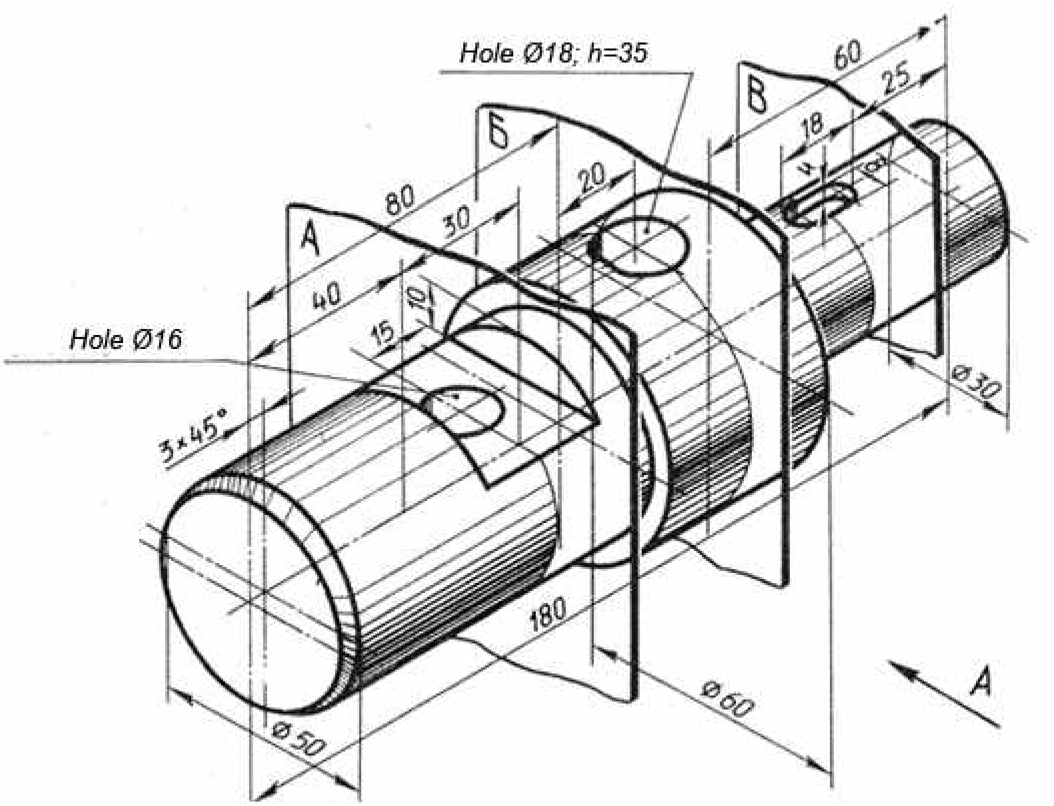
Variant № 2



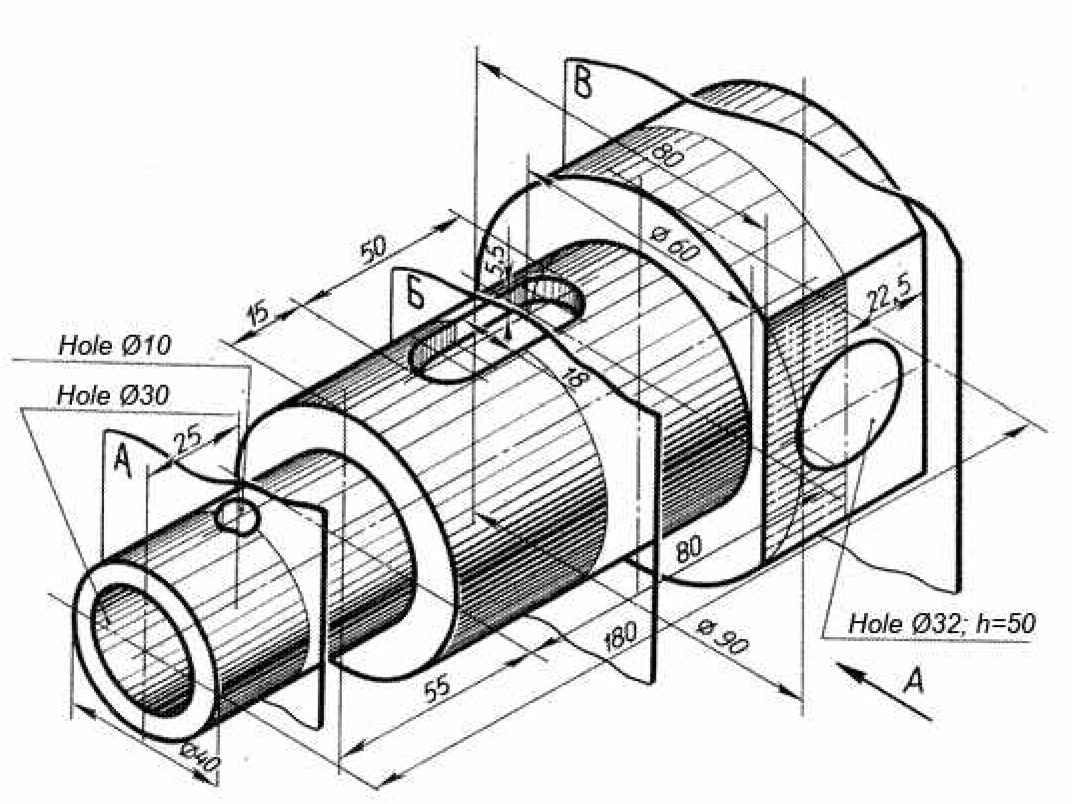
Variant № 3



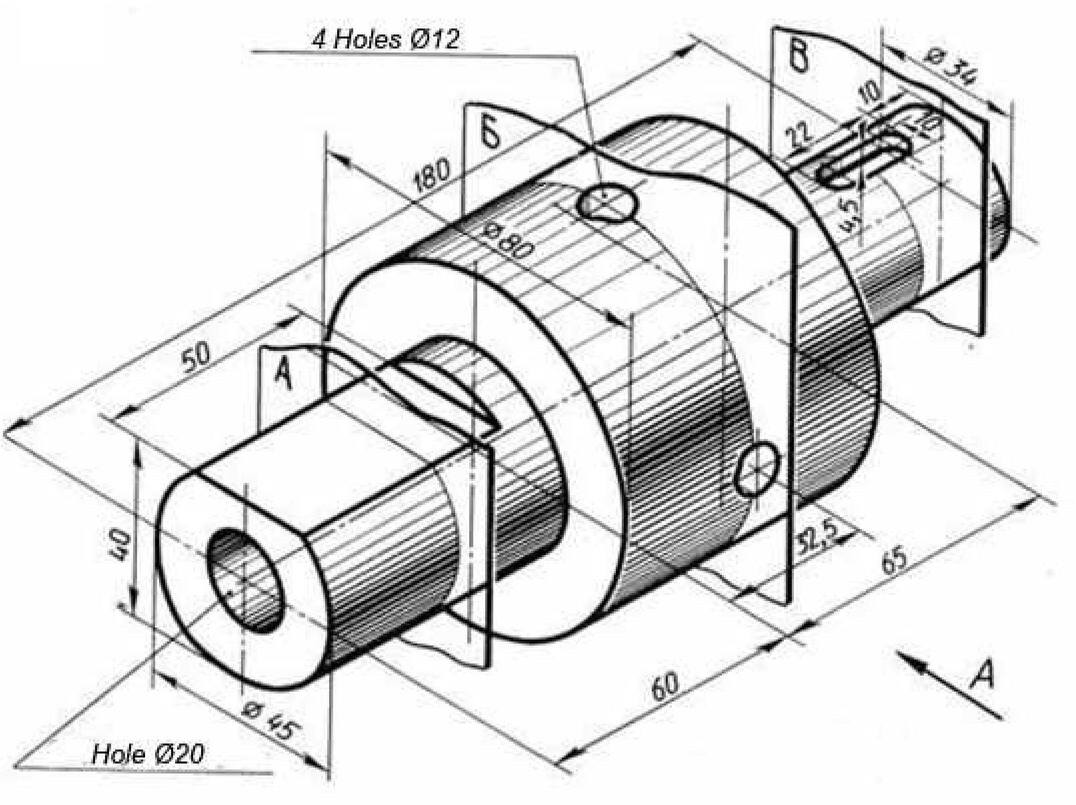
Variant № 4



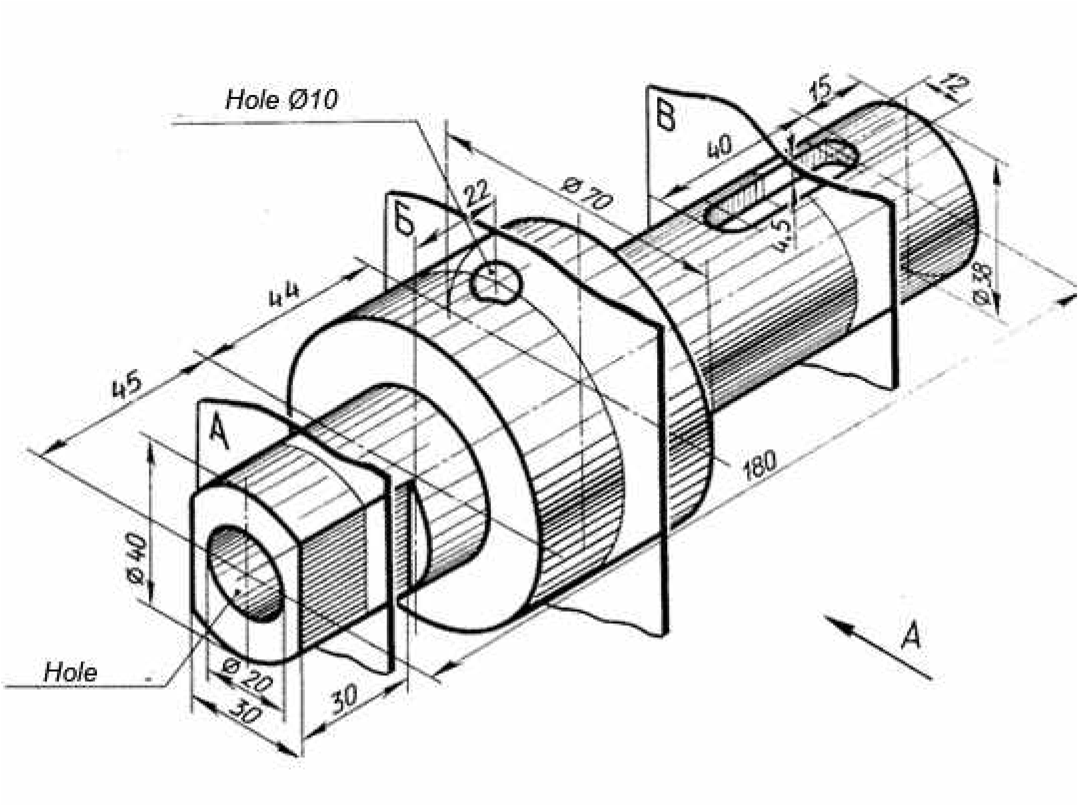
Variant № 5



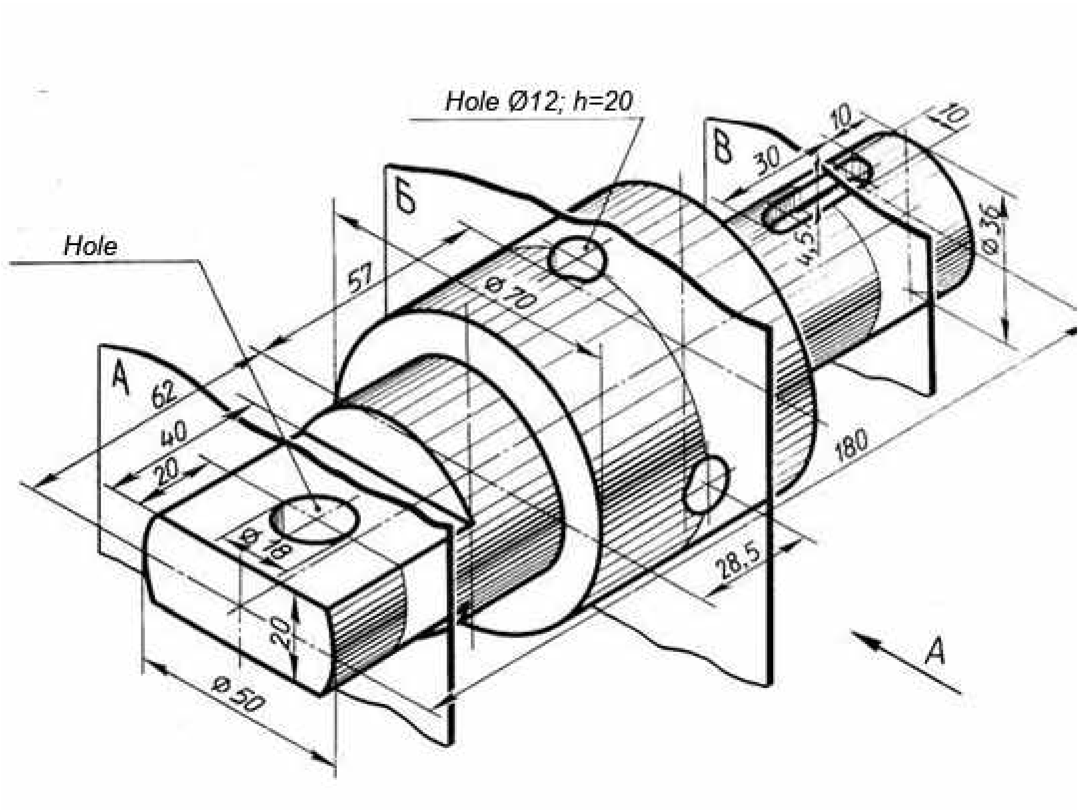
Variant № 6



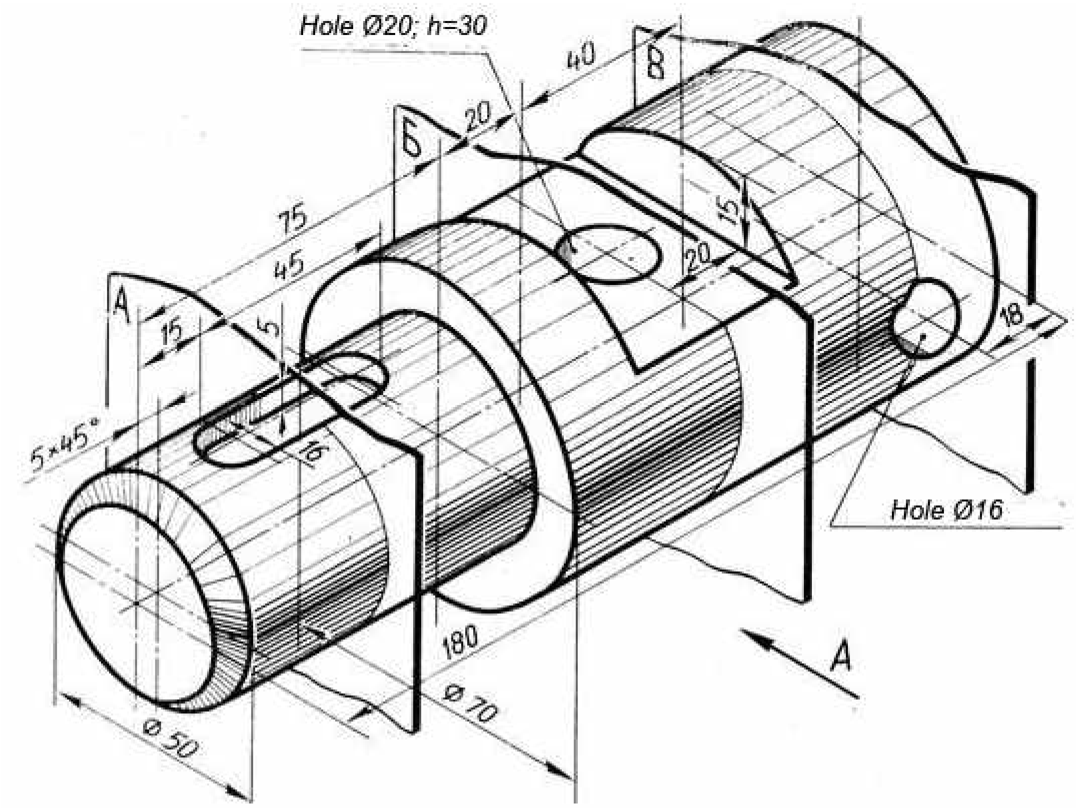
Variant № 7



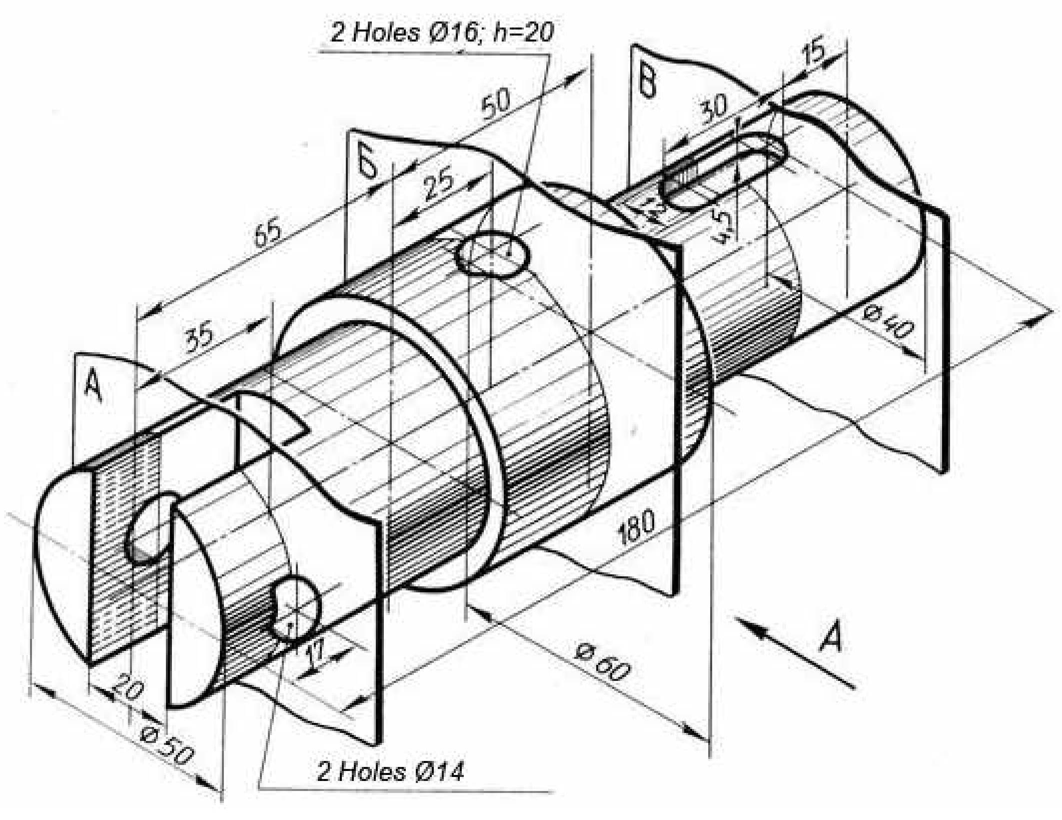
Variant № 8



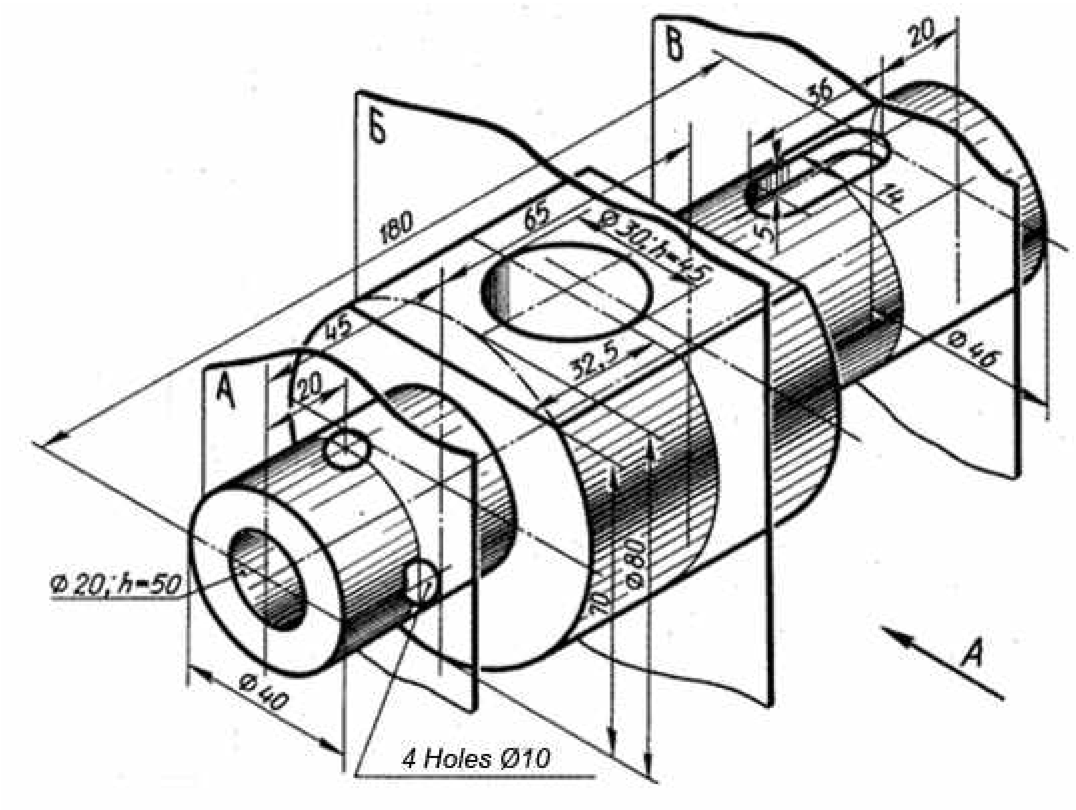
Variant № 9



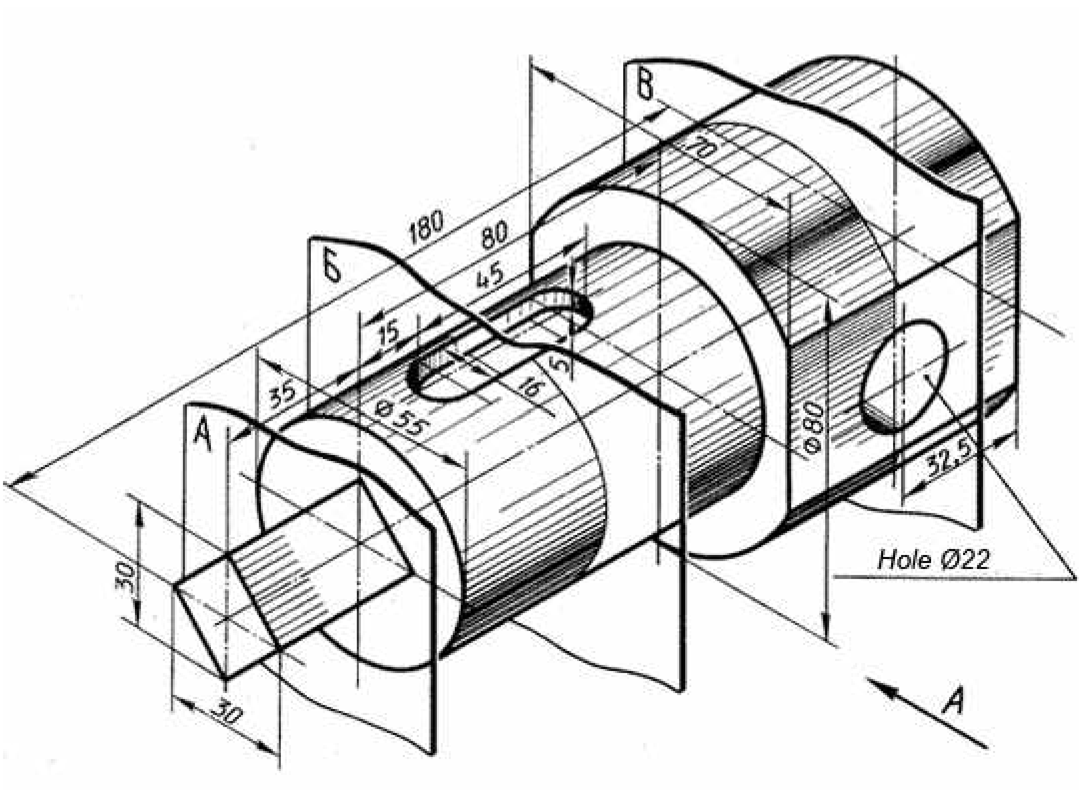
Variant № 10



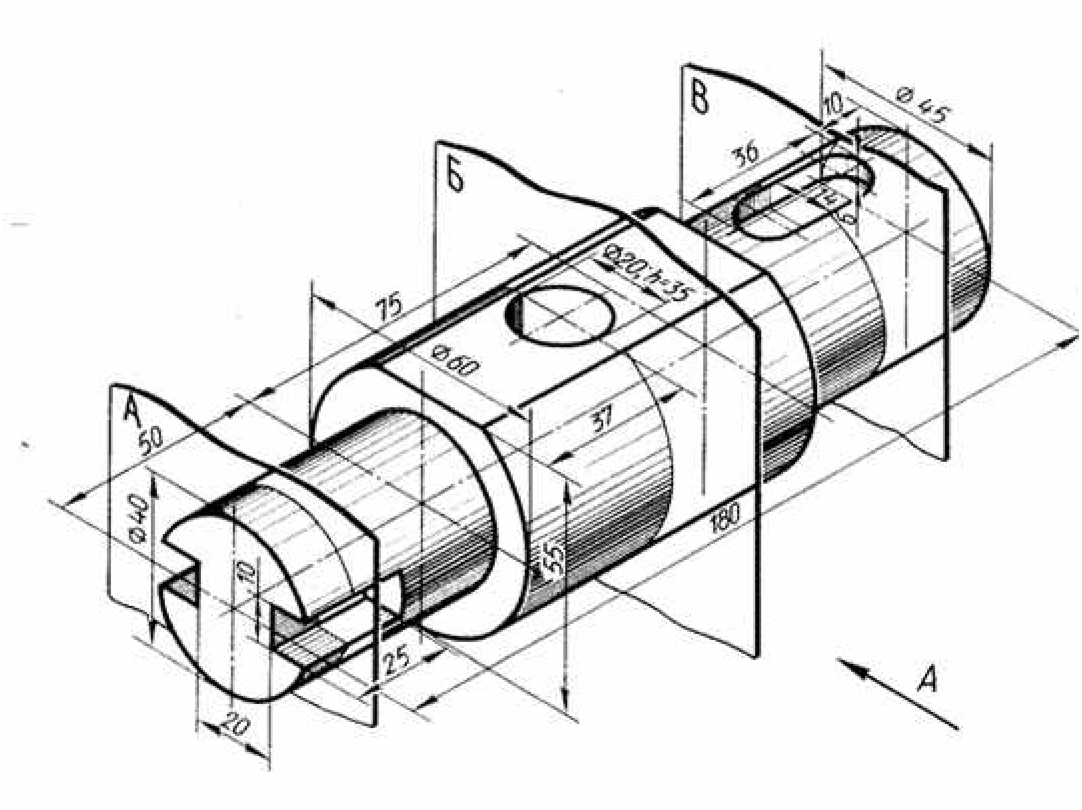
Variant № 11



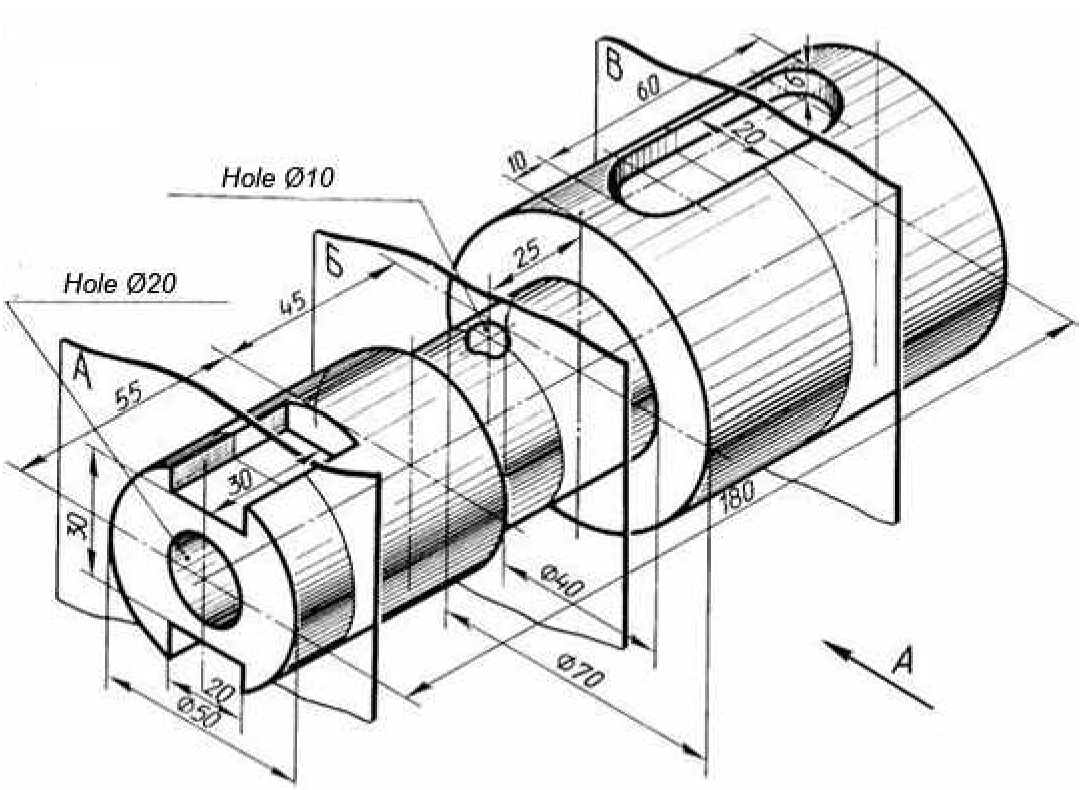
Variant № 12



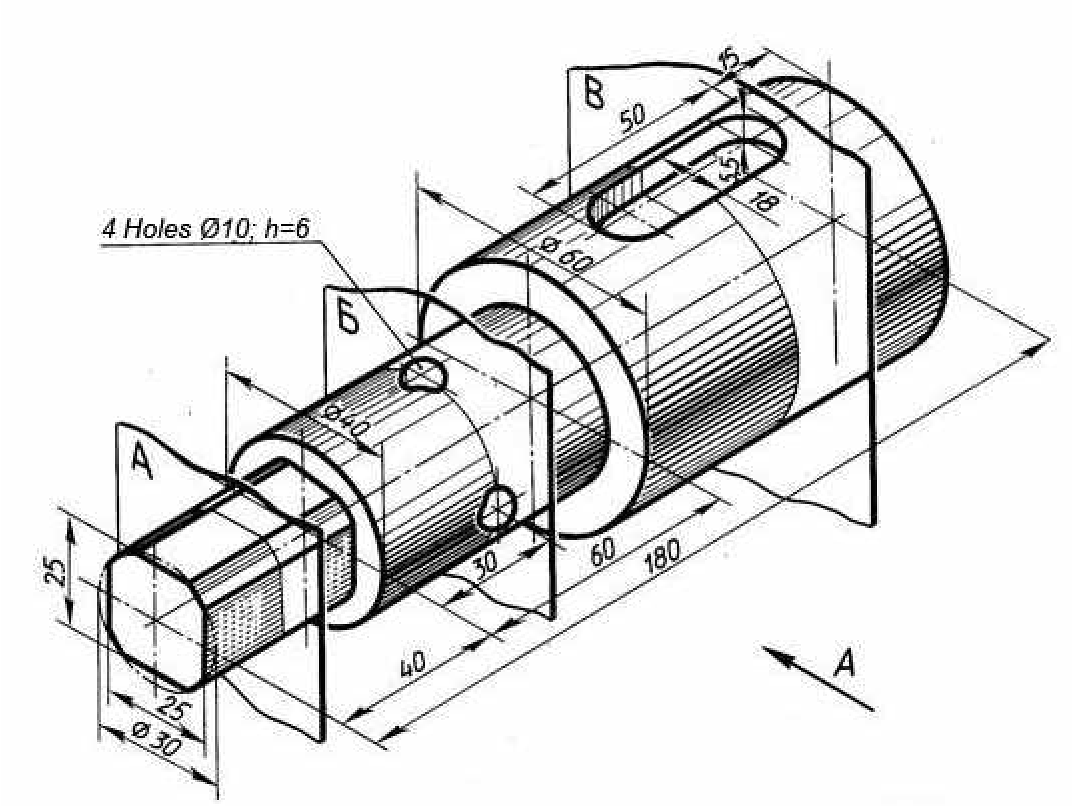
Variant № 13



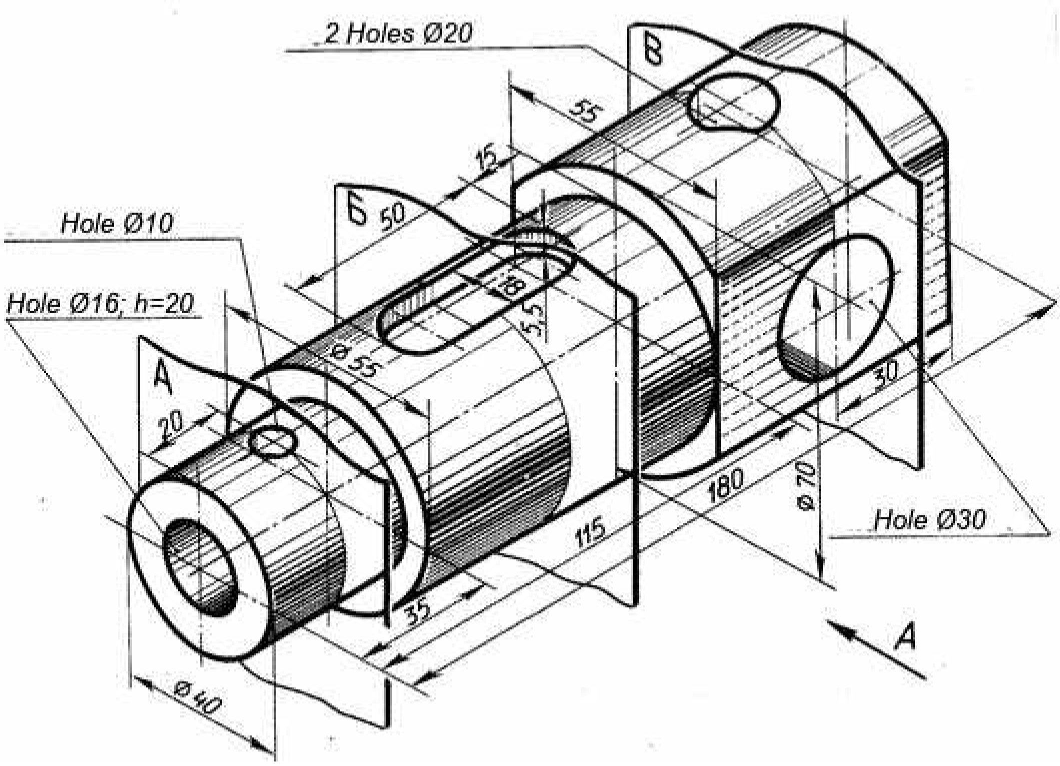
Variant № 14



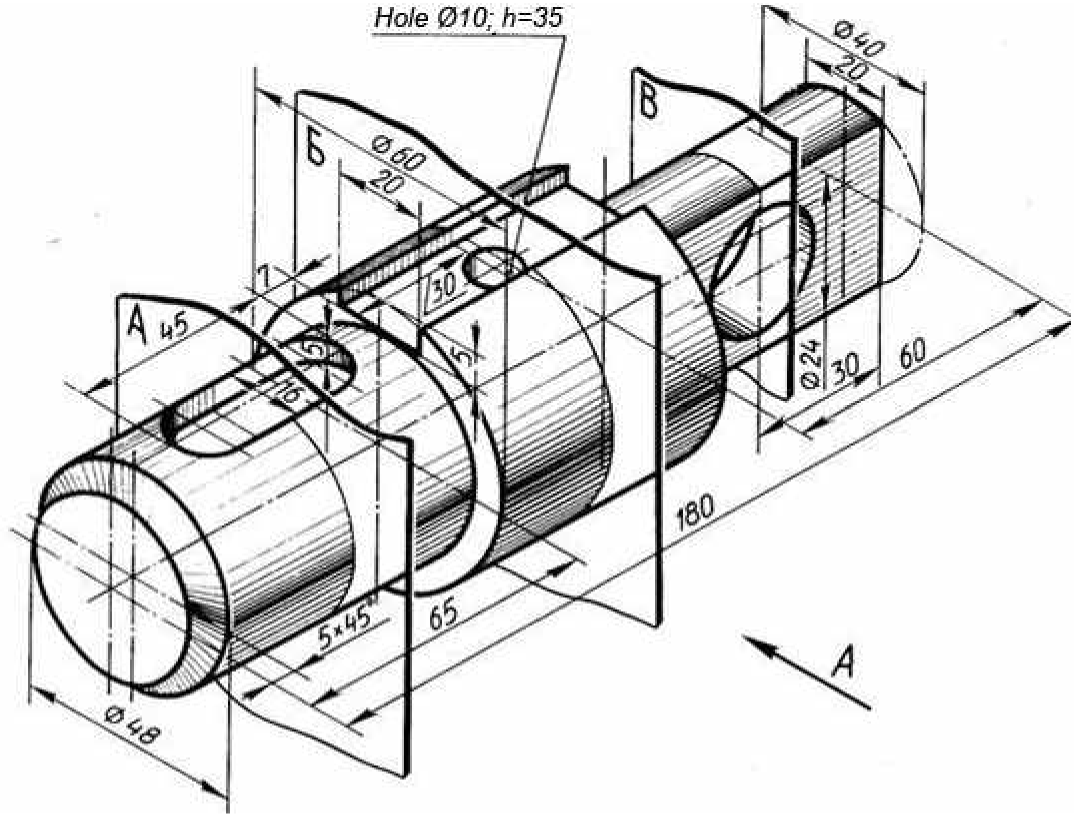
Variant № 15



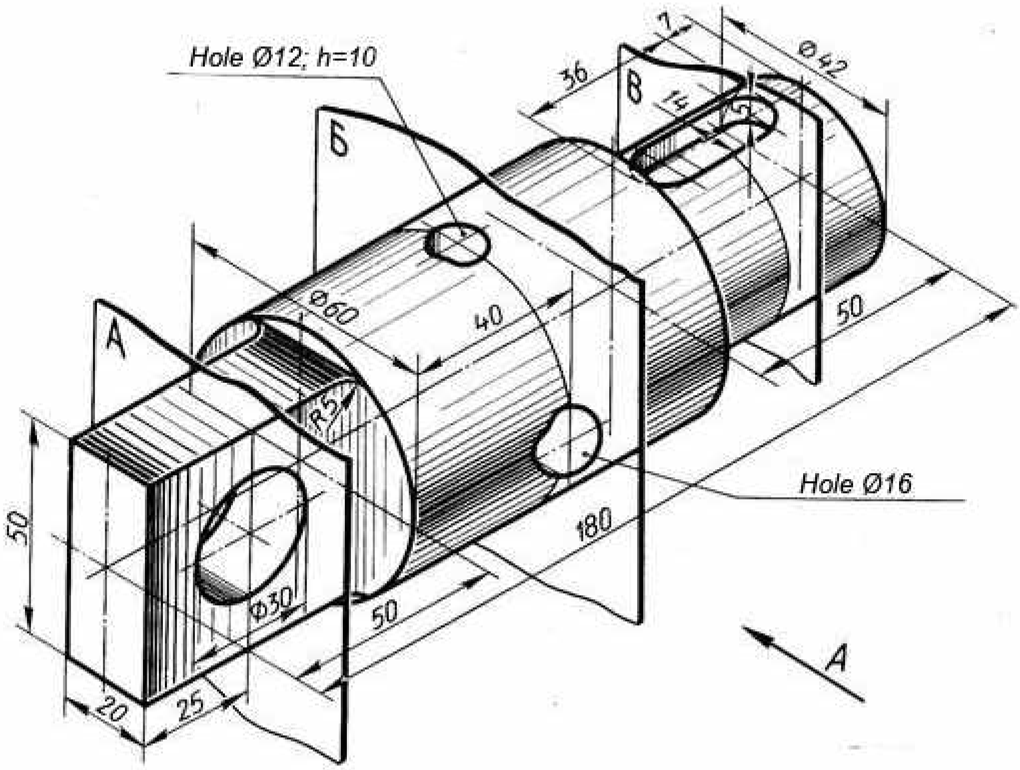
Variant № 16



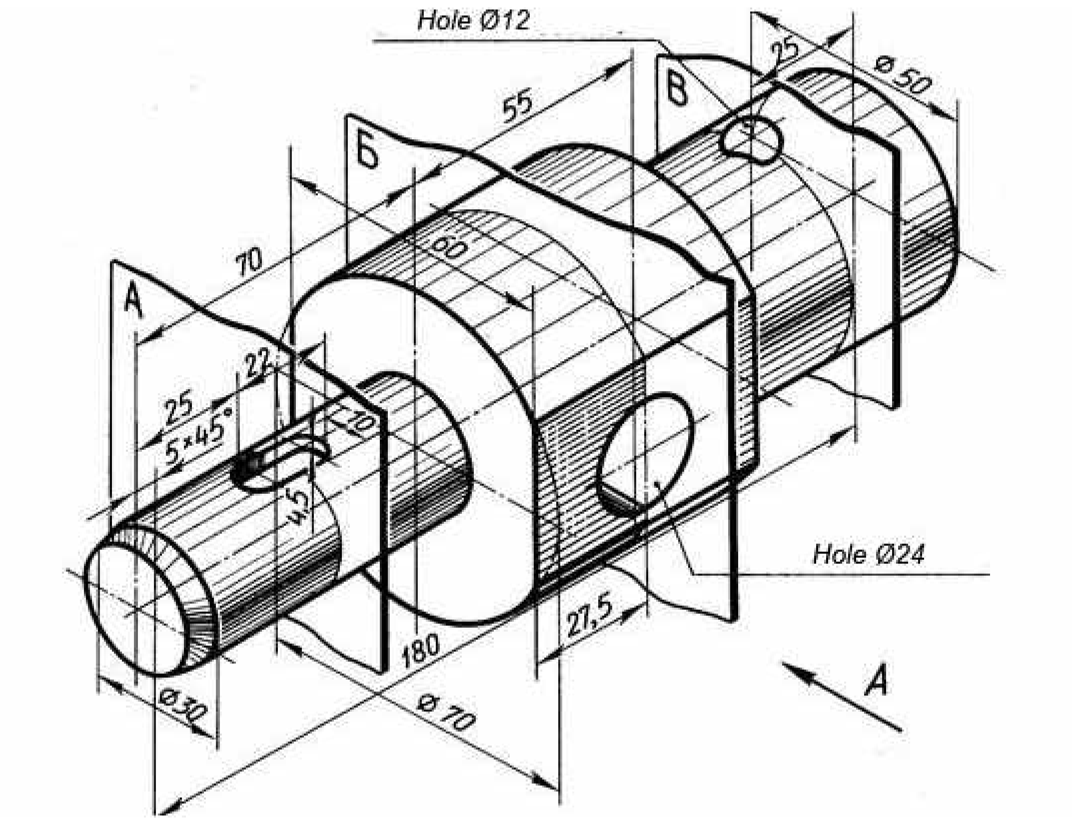
Variant № 17



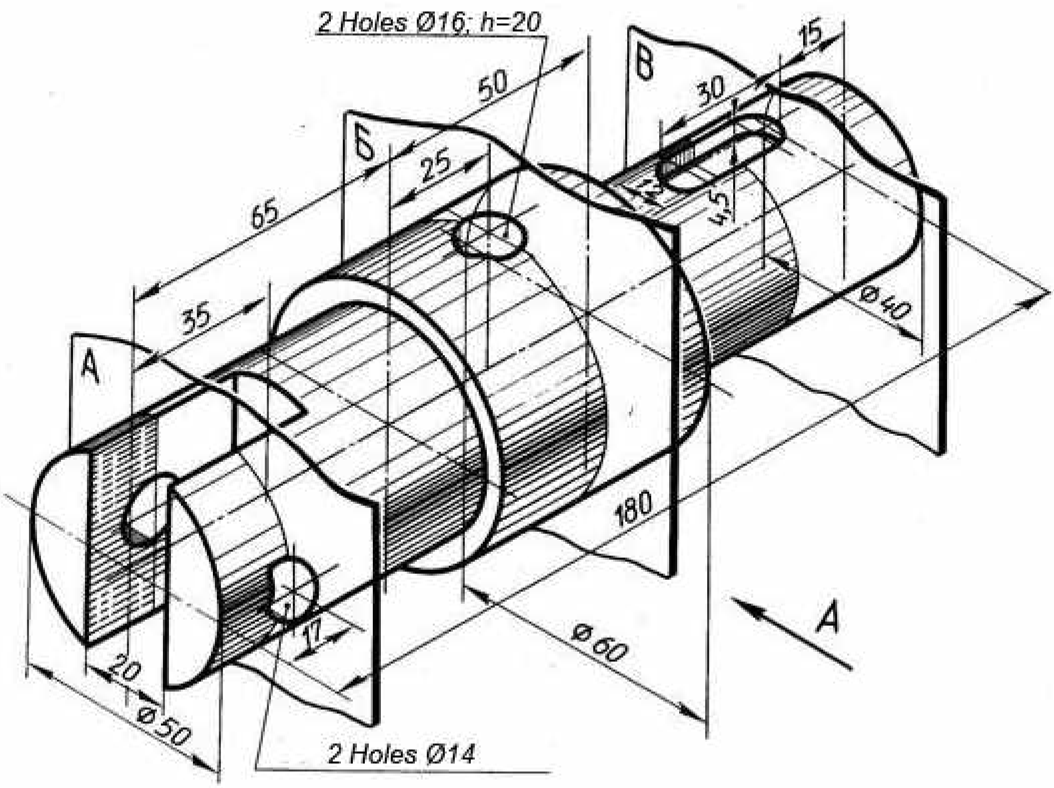
Variant № 18



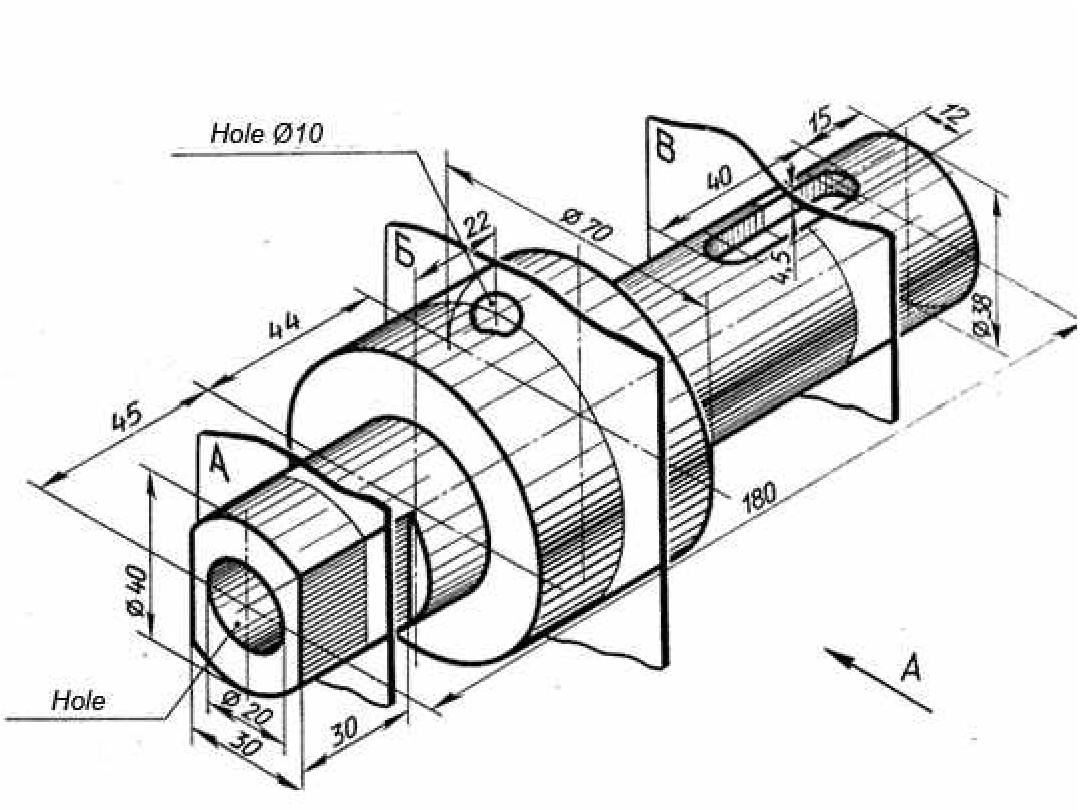
Variant № 19



Variant № 20



Variant № 21



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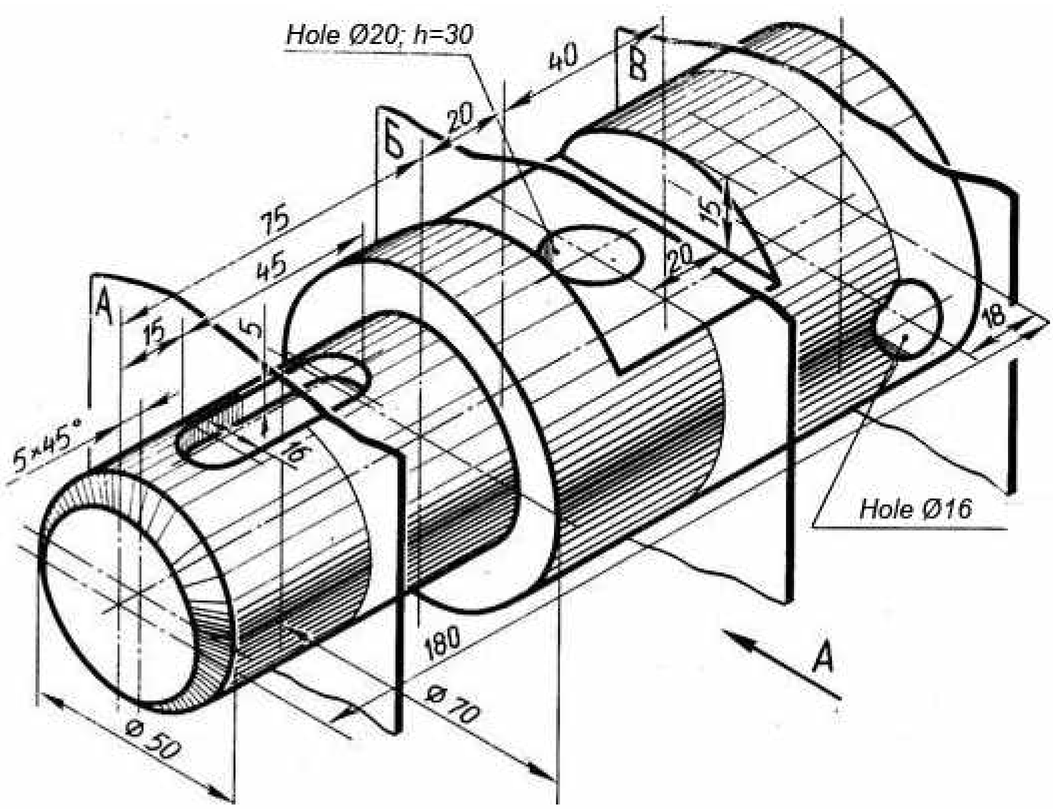
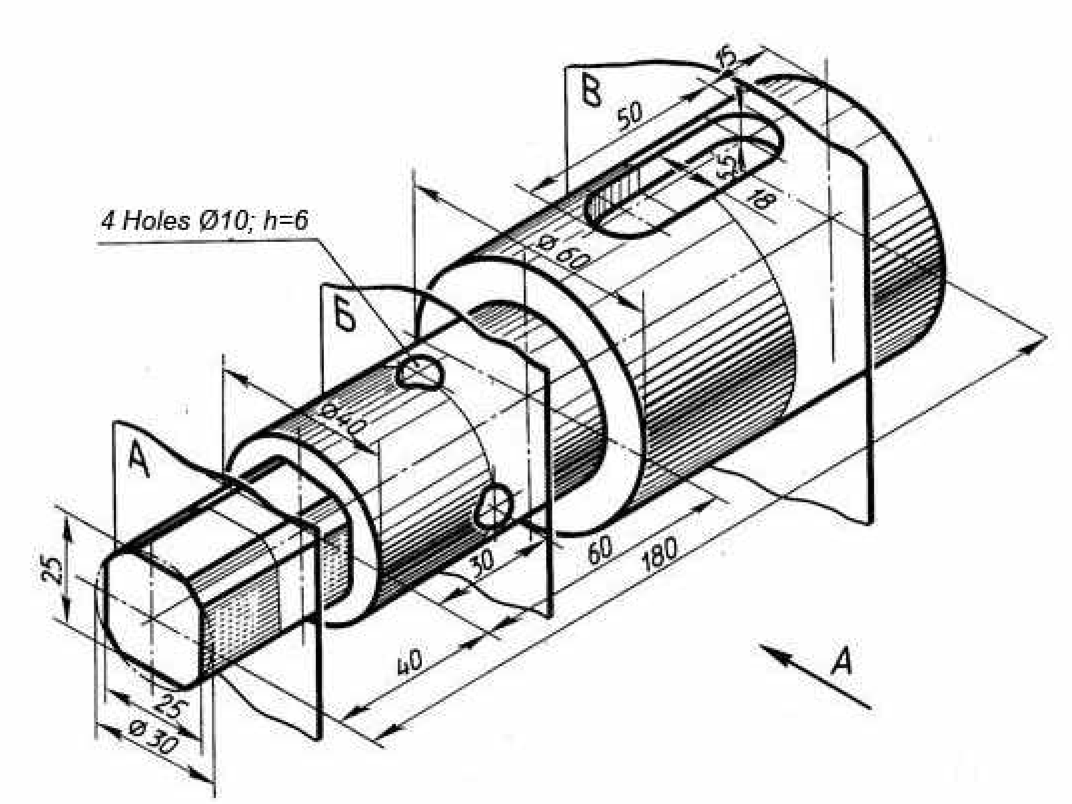
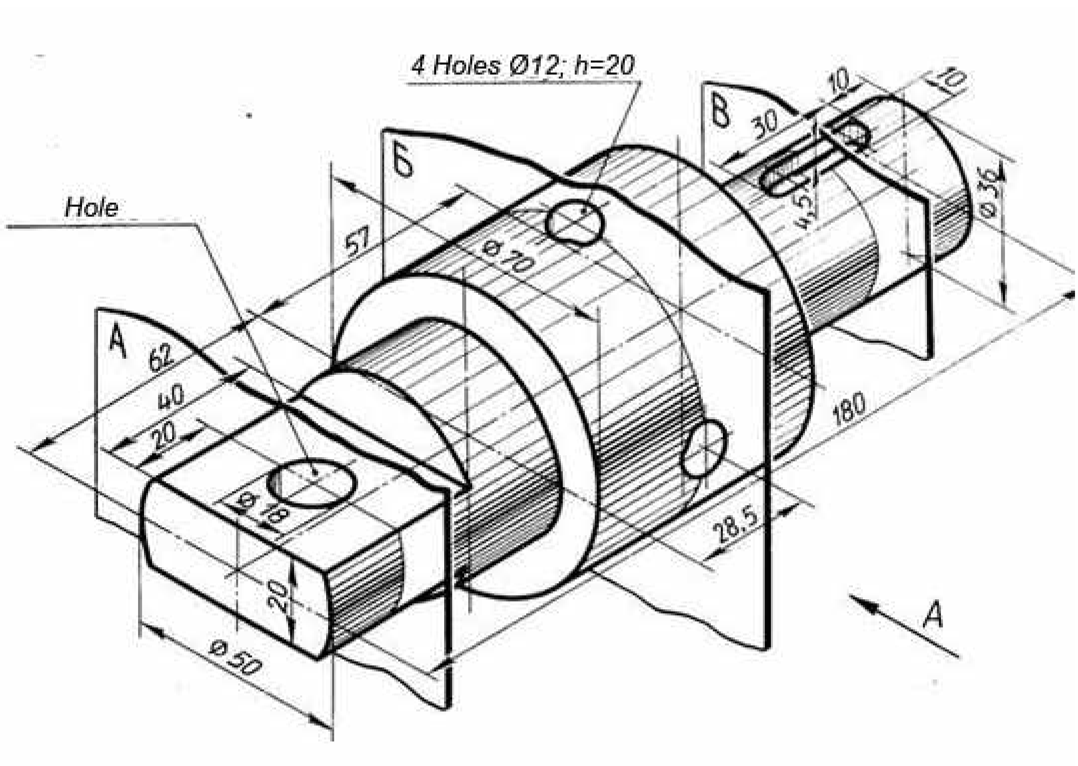


Variant № 23



Variant № 24



GEARS

Overview

Gears are very important power transmission elements. A gear is a rotating machine element having cut teeth which mesh with another toothed part, usually having teeth of similar size and shape, in order to transmit power. *Two or more gears working together* are called a *"transmission"* (*or gear set*) and can produce *"mechanical advantage"* and thus may be considered a simple machine. The *mechanical advantage* is a measure of the *force or torque amplification* that is obtained using mechanical devices (Fig. 52).

When two gears mesh with *one gear bigger than the other* (*the size of the teeth must match thus the bigger gear has more teeth*), a mechanical advantage is obtained where the rotational speeds and the torques of the two gears will be different. Since the input and output power must be equal (*ignoring friction losses*), there is an inverse relationship between the speed and torque ratios (*the small gear will have higher speed and lower torque and the larger gear will have lower speed and higher torque*).

A transmission (*or gear set*) can be used to change the speed, torque, direction of rotation, direction of a power source, or the type of motion. The most common configuration for a gear is to mesh with another gear, however, a gear can also mesh with a non-rotating toothed part, called a "*rack*", thereby producing translation instead of rotation, as shown in the figure. Such arrangement is refered to as "*rack and pinion*" and it is commonly used in the steering systems of automobiles.

Fig. 52

ISO/ GOST/ANSI publishes detailed standards for gear design and drawing. Refer to these standards for current design specification and inspection practices for all of the gear types discussed in this chapter.

Types of gears

Gears or toothed wheel may be classified according to the axes of the two shaft between which the motion is to the transmitted, may be:

- Parallel Axes (Spur Gear, Helical Gear, Gear Rack, Internal Gear);
- Intersecting Axes (Miter Gear, Straight Bevel Gear, Spiral Bevel Gear);
- Nonparallel, Nonintersecting Axes (Screw Gear, Worm, Worm Gear (Worm Wheel));
- Others (Involute Spline Shaft and Bushing, Gear Coupling, Pawl and Ratchet).

The types of gears are determined by area of their application.

The pictorial views of some of the most commonly used gear trains, are shown in Fig. 53.

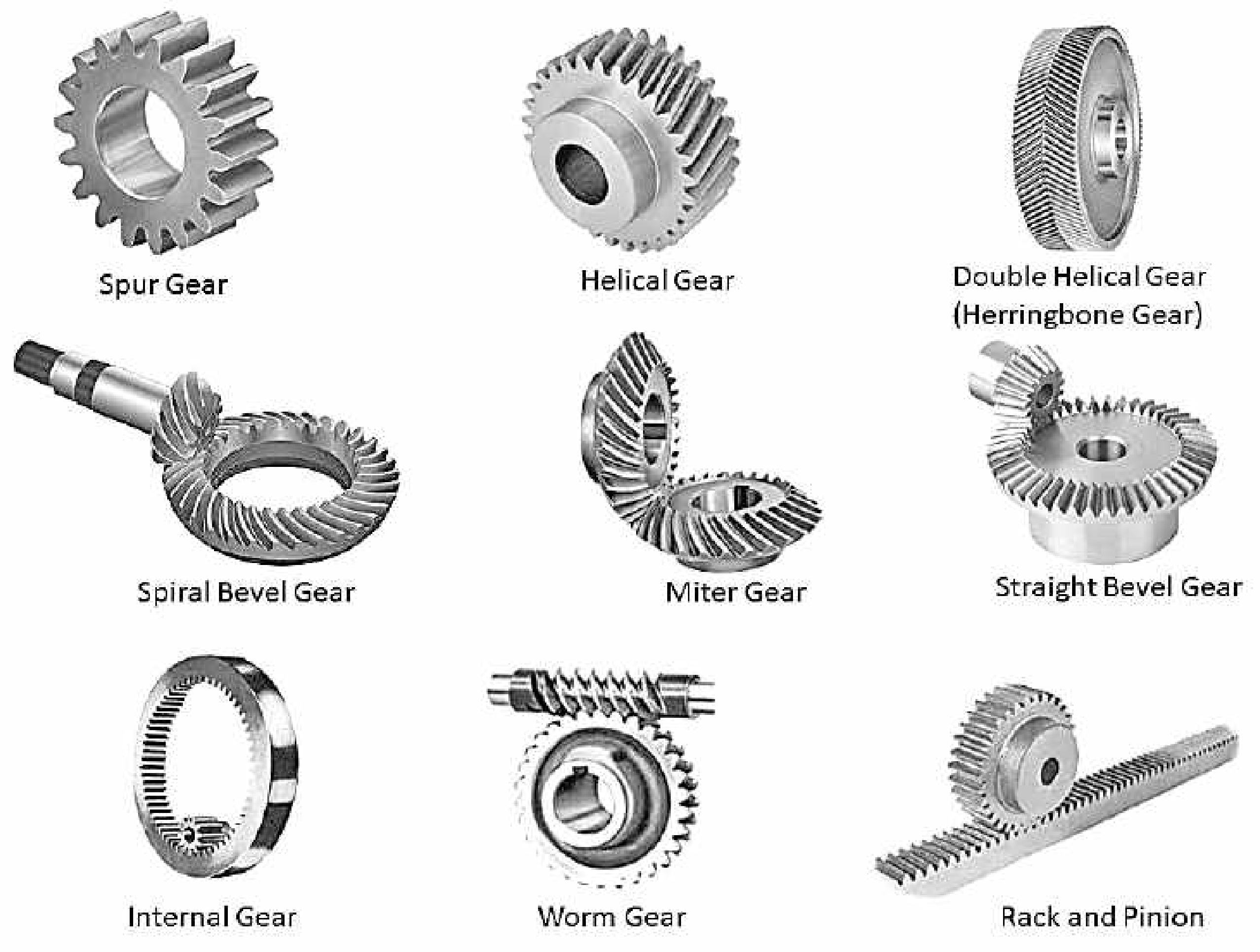


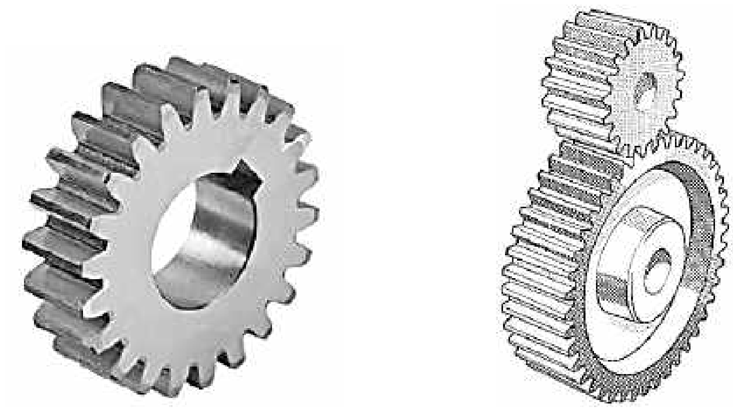
Fig. 53

There are four principal types of gears:

Spur gears: The simplest type of gears. The teeth are parallel to the axis of rotation, as seen in the Fig. 54, *a*. It transmits rotation between parallel shafts.

When two spur gears of different sizes are joined together, the larger gear is called a gear wheel, and the smaller gear is called a pinion (Fig. 54, *b*). In a simple gear train of two spur gears, the input motion and force are applied to the driver gear. The output motion and force are transmitted by the driven gear. The driver gear rotates the driven gear without slipping.

Spur gears are used when shafts must rotate in the same plane. The teeth are straight and parallel to the shaft. The pinion is the smaller of a gear pair. All forces are in the gear plane.



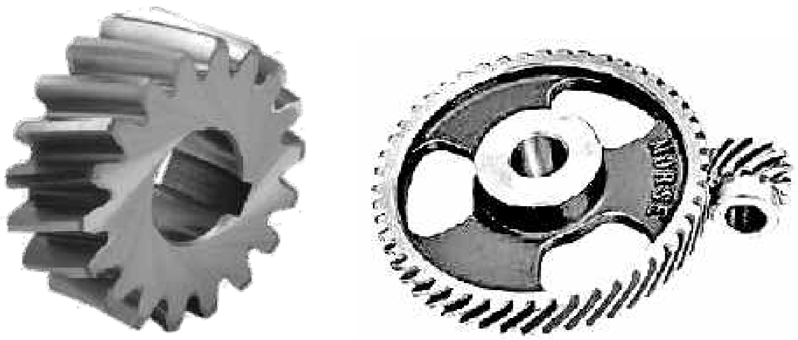
a *b*

Fig. 54

Helical gears: The teeth are inclined with respect to the axis of rotation, as seen in the Fig. 55, *a*. Same as spur gears, it transmits rotation between parallel shafts, but it is less noisy than spur gears because of the more gradual engagement of the teeth during meshing and thus it is more suitable for transmitting motion at higher speeds.

In some cases, helical gears can also be used to transmit rotation between perpendicular shafts, as seen in the Fig. 55, *b*.

Helical gear has curved teeth at an angle to the shaft. These teeth grip with less noise than straight teeth. A thrust force is produced by the mesh.



a *b*

Fig. 55

Herringbone gear has teeth that are V-shaped, like a double helical gear. No thrust force (Fig. 56).

Fig. 56

Bevel gears: This type of gear is used when the shafts to be turned and meet at an angle. Bevel gears have teeth cut on a cone instead of a cylinder blank (Fig. 59, *a*).

The teeth are somehow similar to those of a spur gear but they are formed on conical surfaces instead of cylinders. Bevel gears transmit rotation between intersecting shafts.

The gear shown in the Fig. 57, *b* has straight teeth where this is the simplest type. However, there are other types were the teeth form circular arcs and it is called spiral bevel gears, as shown in the Fig. 57, *c*. With spiral bevel gears, the teeth engagement will be more gradual (similar to helical gears) and thus it is less noisy and it is suitable for higher speeds.

Bevel gears are used in pairs to transmit rotary motion and torque where the bevel gear shafts are at right angles (90 degrees) to each other. Spiral and hypoid bevel gears are used in the automotive industry.

a *b* *c*

Fig. 57

Worms and worm gears: It is a high-wear gear mesh (Fig. 58). Transmit rotation between perpendicular shafts (not intersecting, there is an offset between them).

A gear which has one tooth is called a worm. The tooth is in the form of a screw thread. The worm resembles a screw which can be right handed or left handed. A wormwheel meshes with the worm. The wormwheel is a helical gear with teeth inclined so that they can engage with the thread-like worm. The wormwheel transmits torque and rotary motion through a right angle. The worm always drives the wormwheel and never the other way round. Worm mechanisms are very quiet running.

Worm gear sets are usually used when high reduction in speed is desired (speed ratios of 3 or higher). It transmits rotation from the worm to the worm gear, but not the opposite.

Worm gear joint Worm Worm wheel (spider)

Fig. 58

Spur gears. Terminology

Since spur gears are the simplest type, it will be used for illustration and to define the primary parameters of gears and their relations. The Fig. 59 illustrates the terminology of spur gears.

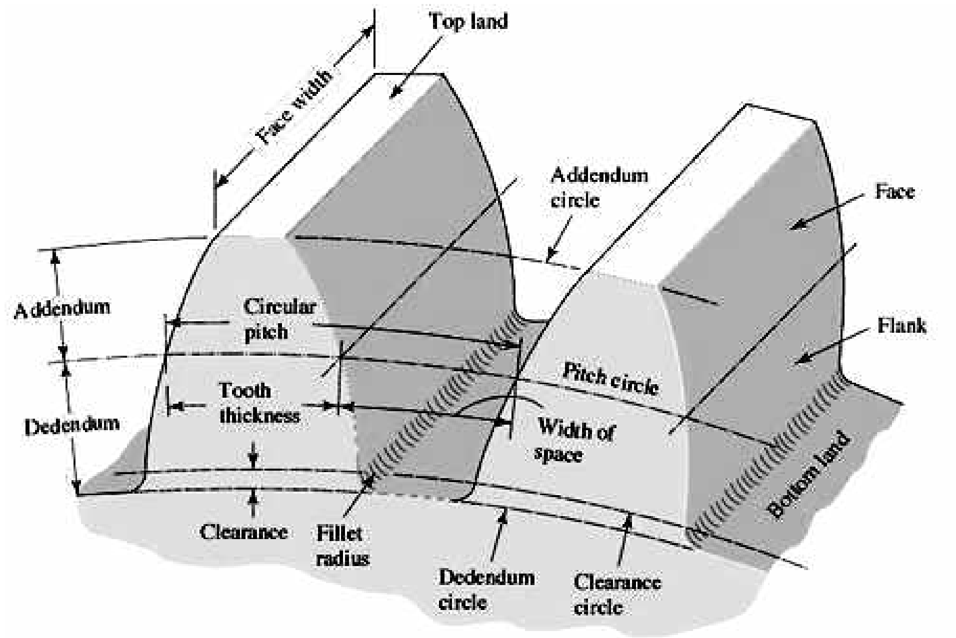


Fig. 59

Pitch circle: the theoretical circle upon which all gear calculations are based and its diameter is called the “***pitch diameter***”.

Pitch circles of mating gears are *tangent* to each other.

The “***centers distance***” between two mating gears is the *sum of the pitch radiuses of the two gears* (Fig. 60).

The *smaller* of two mating gears is called the "*pinion*" and the larger is called the "gear wheel" or "pinion".

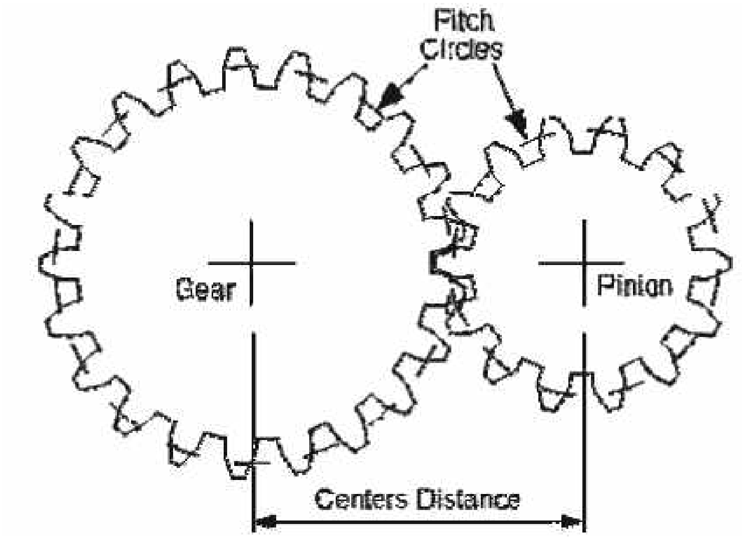


Fig. 60

Addendum and Dedendum circles: the circles defining the <u>top</u> and <u>bottom</u> faces of the teeth.

Addendum *"h_a"*: the radial distance from the pitch circle to the top surface of the teeth.

Dedendum *"h_d"*: the radial distance from the pitch circle to the bottom surface of the teeth.

Clearance circle (or *working depth circle*): the circle tangent to the addendum circle of the mating gear. The radial distance between the addendum circle and the clearance circle is called the "*working depth*".

Clearance *"c"*: the distance between the tooth top surface and the bottom surface of a mating gear (Fig. 61).

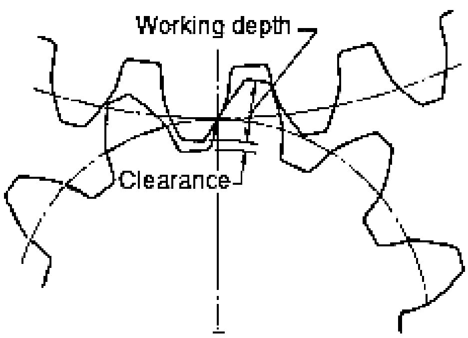
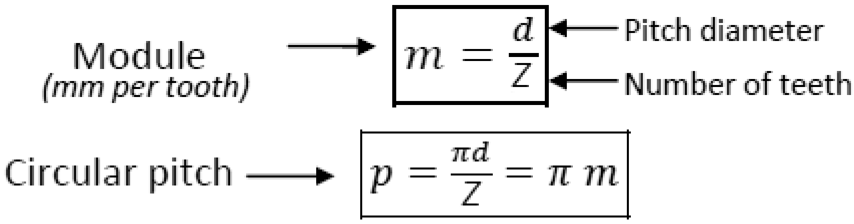


Fig. 61

Circular pitch *"p"*: the distance measured on the pitch circle from a point on one tooth to the corresponding point on an adjacent tooth. The circular pitch is equal to the sum of "*tooth thickness*" and "*width of space*". The width of space is slightly larger than the tooth thickness such that mating teeth can engage easily without obstruction.

Module *“m”*: is a *ratio* of pitch diameter to the number of teeth of a gear. The unit of the module is millimeters:



Important Notes:

- The module (or the diametral pitch) determines the size of gear teeth.
- In order for gears to be able to mesh (work together), **they must have the same module** (or diametral pitch).
- Pitch diameter of a gear (i.e., its size) is determined based on its module (or diametral pitch) and the number of teeth: $d=mz$

Gears Standards

Generally, gears are designed based on proper standards.

- Standards specify different parameters used to define geometry of gears (such as, module, addendum, dedendum, tooth thickness, pressure angle, etc.) and relationships between these parameters.
- The standards were developed to attain interchangeability of gears having the same pressure angle and module regardless of the number of teeth.
- The Table 6 gives the preferred values of Module according to ISO and GOST standards.

Table 4

Module	
Preferred	1, 1.25, 1.5, 2, 2.5, 3, 4, 5, 6, 8, 10, 12, 16, 20, 25, 32, 40, 50
Next Choice	1.125, 1.375, 1.75, 2.25, 2.75, 3.5, 4.5, 5.5, 7, 9, 11, 14, 18, 22, 28, 36, 45

Proportions and shapes of gear teeth are well standardized, and the terms illustrated and defined in Fig. 62 and Table 5 are common to all spur gears.

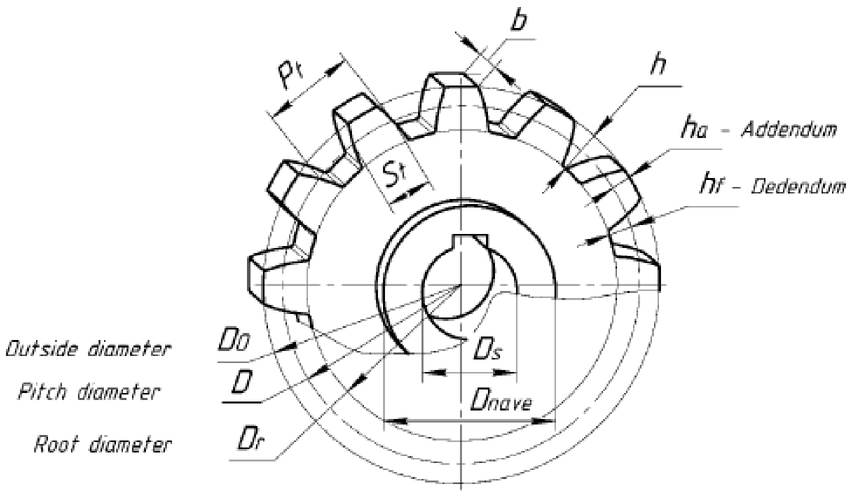


Fig. 62

Table 5

Term	Sym-bol	Definition	Formula
Number of teeth	z	Number of teeth on the gear.	
Module	m	Module indicates the tooth size and is the number of mm of pitch circle diameter (p.c.d.) per tooth. For gears to mesh, their modules must be equal.	
Pitch diameter	D	The diameter of the pitch circle.	$D = mz$
Addendum	h_a	The radial distance from the pitch circle to the outside diameter.	$h_a = m$
Dedendum	h_d	The radial distance between the pitch circle and the root diameter.	$h_d = 1{,}25m$
Outside diameter	D_a	The major diameter of the gear.	$D_a = D + 2h_a = m(z + 2)$
Root diameter	D_r	The diameter of the root circle measured from the bottom of the tooth spaces.	$D_r = D - 2h_d = m(z - 2{,}5)$
Circular pitch	P_t	The length of the arc of the pitch circle from one point on a tooth to the same point on the adjacent tooth.	$P_t = \pi m$
Circular thickness	S_t	The distance of the arc along the pitch circle from one side of a gear tooth to the other.	$S_t = 0{,}5 P_t = 0{,}5 \pi m$
Whole depth	h	The total depth of a tooth space equal to the sum of the addendum and dedendum.	$h = h_a + h_d$
Face Width	b_w	The face width of a gear is the length of teeth in an axial plane.	$b_w = (6...8)m$
Shaft diameter	d_s	Diameter of a shaft.	$d_s \approx D_a / 3$
Nave diameter	d_{nave}	Diameter of the central part, usually cylindrical, of a wheel; the nave.	$d_{nave} = (1{,}6...1{,}8)d_s$
Nave length	l_{nave}	Length of the central part, usually cylindrical, of a wheel; the nave.	$l_{nave} \approx 1{,}5d$
Gear ratio	i	The gear ratio is the relationship between the number of teeth on two gears that are meshed.	$i = z_{spur} / z_{pinion}$
Center distance	a_w	The distance between the centers of the pitch circles.	$a_w = (D_{spur} + D_{pinion})/2$

Calculations

Before starting a working drawing of a gear, you have to calculate the gear's dimensions (Fig. 63).

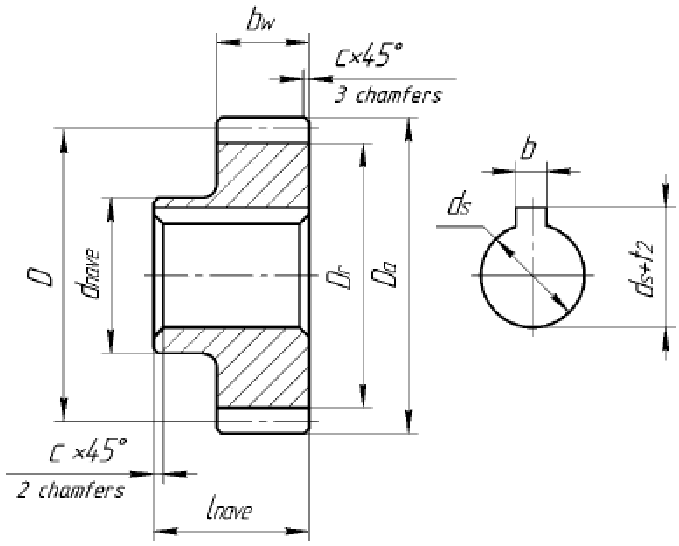


Fig. 63

Problem. Calculations the geometric parameters of a spur gear. Given: number of teeth, z = 25; outside diameter, D_a = 54 mm (Fig. 64).

Calculations of the geometric parameters of a gear

Given: number of teeth, z = 25; outside diameter, Da = 54 mm.

1. Module: **m = Da / (z + 2)** = 54 / 27 = 2
The numeric value of the modul verify by the table of standard values for modules (GOST 9563-80).

2. Pitch diameter: **D = z m** = 25 x 2 = 50 mm.

3. Addendum: **ha = m** = 2 mm.
Dedendum : **hf = 1,25 m** = 1,25 x 2 = 2,5 mm.

4. Outside diameter:
Da = D + 2ha = m (Z + 2) = 50 + 4 = 54 mm.
(clarify the measured outside diameter).

5. Root diameter:
Df = D – 2hf = m (Z – 2,5) = 50 – 5 = 45 mm.

6. Circular pitch:
Pt = π m = 3,14 x 2 = 6,28 mm.

7. Circular thickness: **St = 0,5 Pt = 0,5πm** = 3,14 mm.

8. Face width: **b = (6 – 8) m**; choose 20 mm.

9. Shaft diameter: **ds ≈ Da/3**; choose 18 mm.

10. Nave diameter:
dnave ≈ (1,6 – 1,8) ds; choose 35 mm;
nave length: **lnave ≈ 1,5 ds**; choose 30 mm.

Fig. 64

Working drawing of a spur gear

Since the teeth are cut to standard shape, it is not necessary to show individual teeth on the drawing. Instead, draw the addendum and root circles as phantom lines and the pitch circle as a centerline.

The drawing actually shows only a gear blank – a gear complete except for teeth. Since the machining of the blank and the cutting of the teeth are separate operations, the necessary dimensions arc arranged in two groups: the blank dimensions are shown on the views, and the cutting data are given in a note or table.

Normally, gear drawings include a table of information, called cutting data, for manufacturing (Figs 65, 66). A detail drawing of a gear to be manufactured would also include other dimensions not found in the table.

A typical working drawing of a spur gear is shown in Fig. 66. The dimensions shown in Fig. 66 are the minimum requirements for the spur gear.

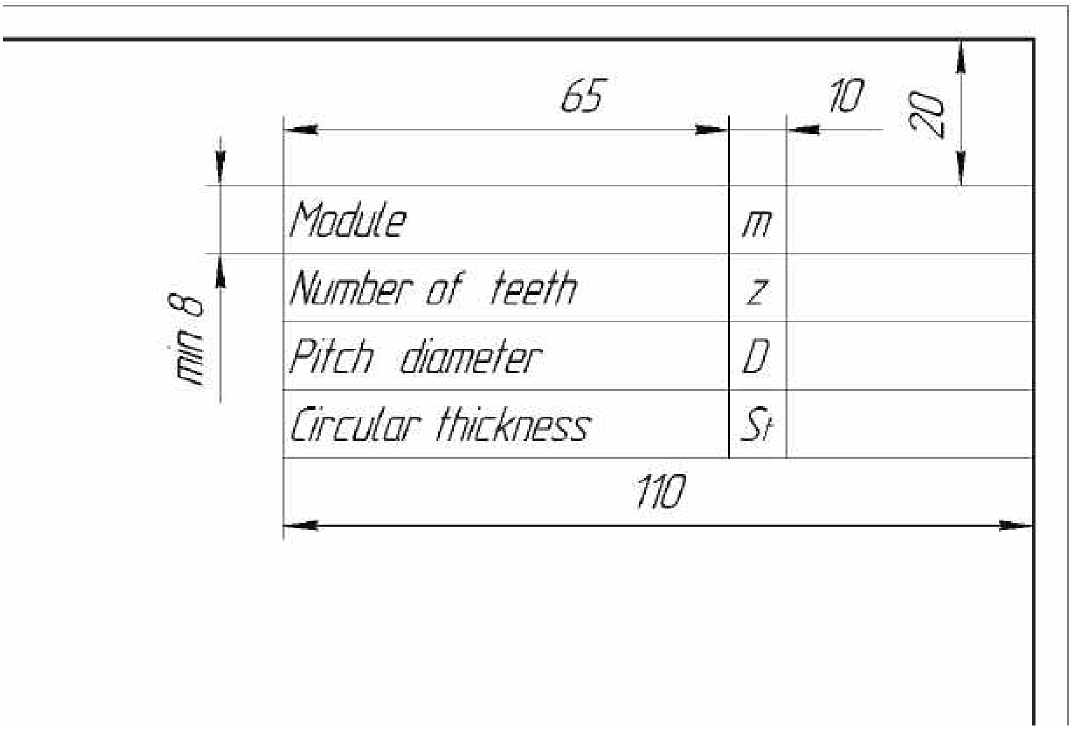


Fig. 65

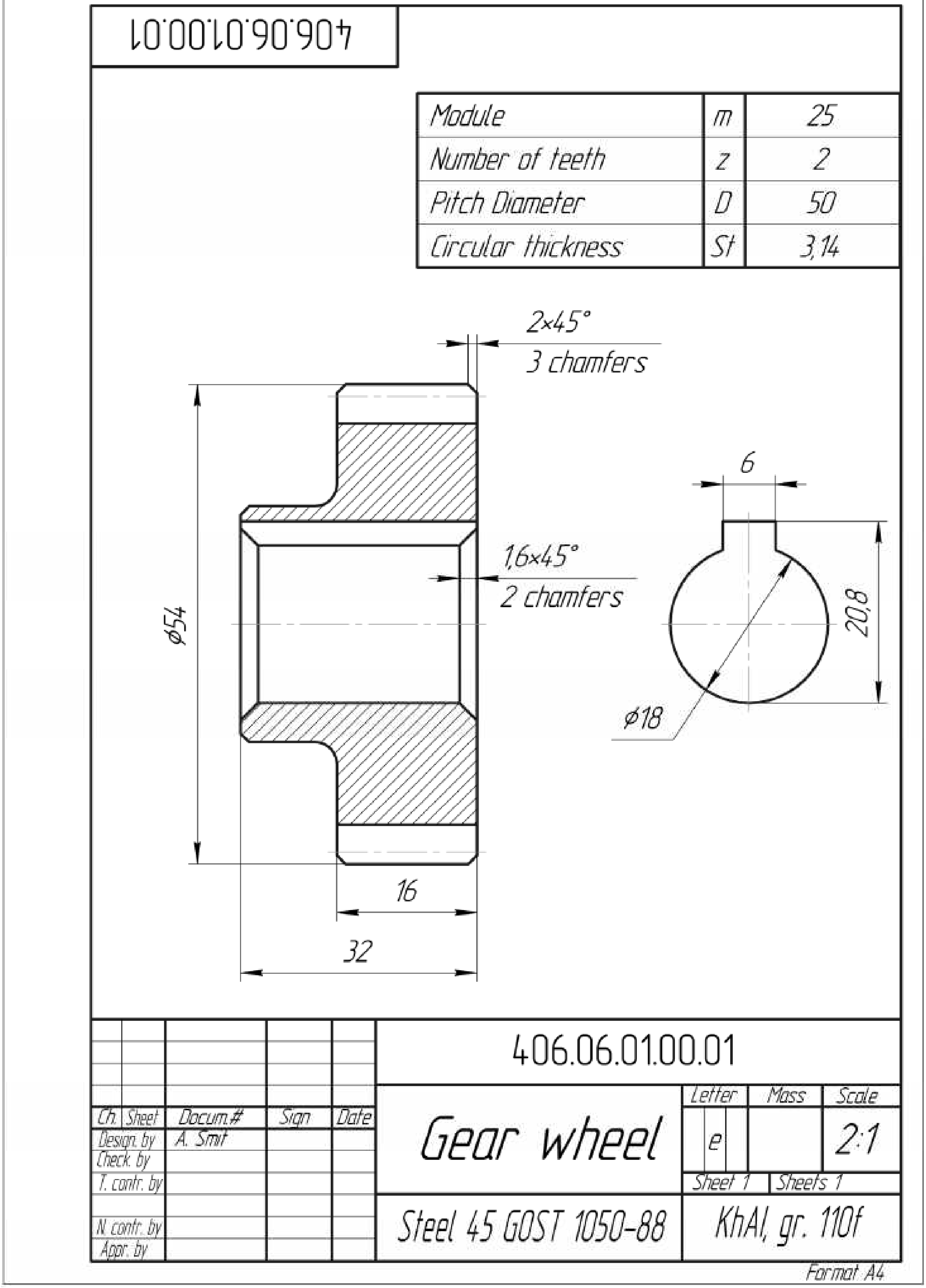

406.06.01.00.01
Module m 25
Number of teeth z 2
Pitch Diameter D 50
Circular thickness St 3,14
2×45°
3 chamfers
1,6×45°
2 chamfers
6
20,8
⌀18
⌀54
16
32
406.06.01.00.01
Ch. Sheet Docum.# Sign Date
Design. by A. Smit
Check. by
T. contr. by
N. contr. by
Appr. by
Gear wheel
Letter Mass Scale
e
2:1
Sheet 1 Sheets 1
Steel 45 GOST 1050-88
KhAI, gr. 110f
Format A4

Fig. 66

GEAR JOINT

The spur gear is a circular gear with teeth cut around its circumference. Two meshing spur gears transmit power from one shaft to a parallel shaft. When the two meshing gears are unequal in diameter, the smaller gear is called the pinion and the larger one the gear wheel (Figs 67, 68).

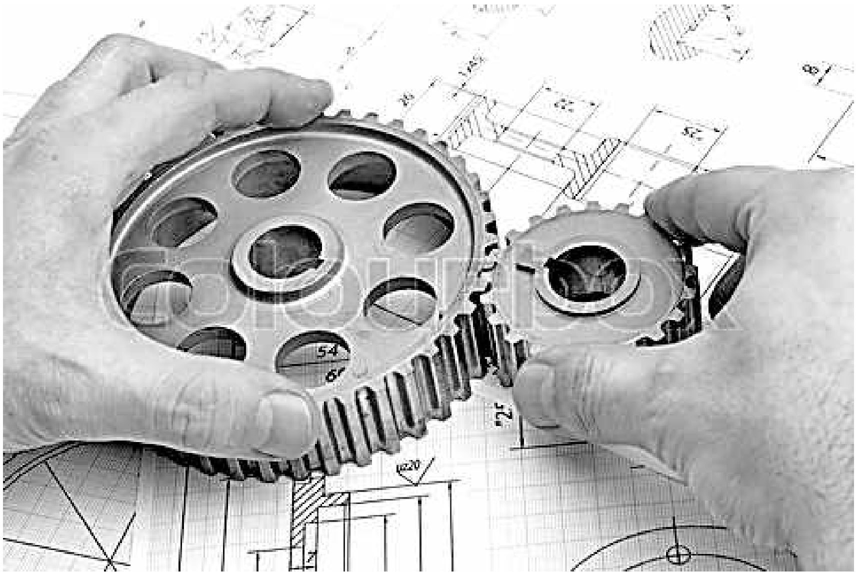


Fig. 67

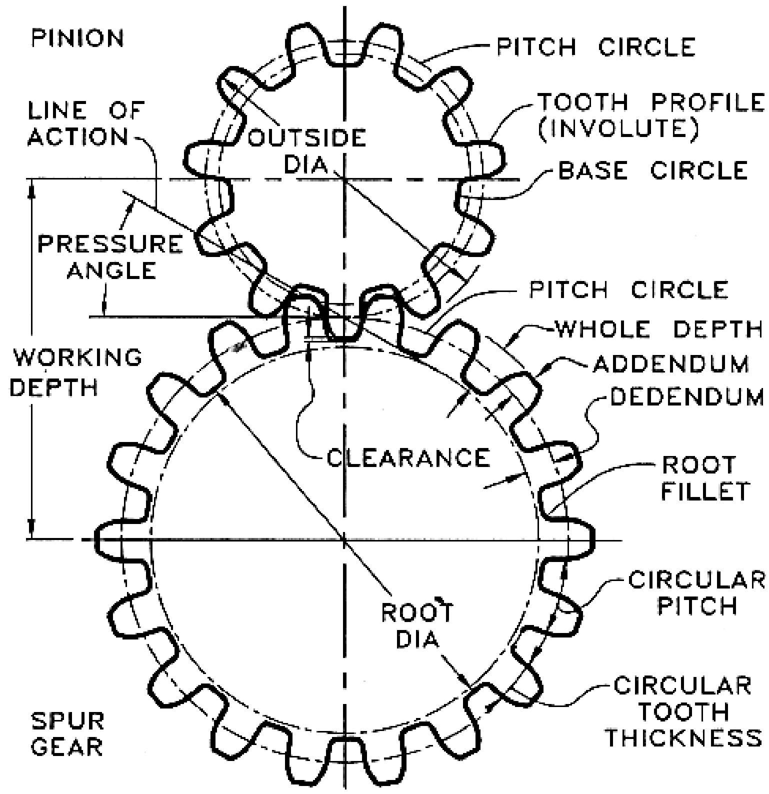


Fig. 68

Two gears will be able to mesh if, and only if, they have the same sized teeth and module.

The main parameters of the gear joint are (Fig. 69):

- **gear ratio *i***, equal to the ratio of the number of teeth of the spur to the number of teeth of the pinion - $i = z_{spur} / z_{pinion}$;
- **center distance** of gear joint ***aw***, equal to half the sum of pitch diameter of spur and pinion - $a_w = (D_{spur} + D_{pinion})/2$.

Parameters of the gearing

1. Gear ratio: i = **Zspur / Zpinion** = 1,5, where
   Zspur – the number of teeth of the spur;
   Zpinion – the number of teeth of the pinion.
   Accept Zspur = 38.
2. Centre distance:
   aw = (Dspur + Dpinion) / 2 = 63 mm.

Fig. 69

The pitch circles of the gear and pinion touch at a point lying on the center line. The circles of the outside diameter and root diameter in the engagement zone form a radial clearance of 0.25m (Figs 70, 71).

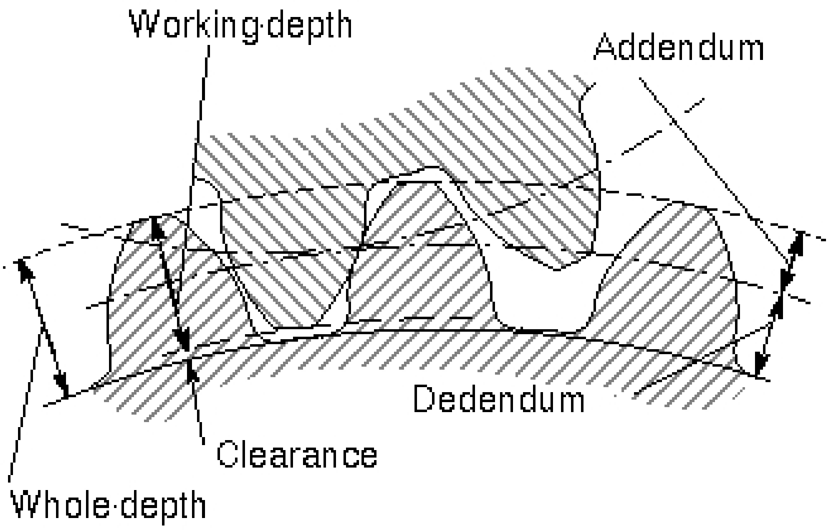


Fig. 70

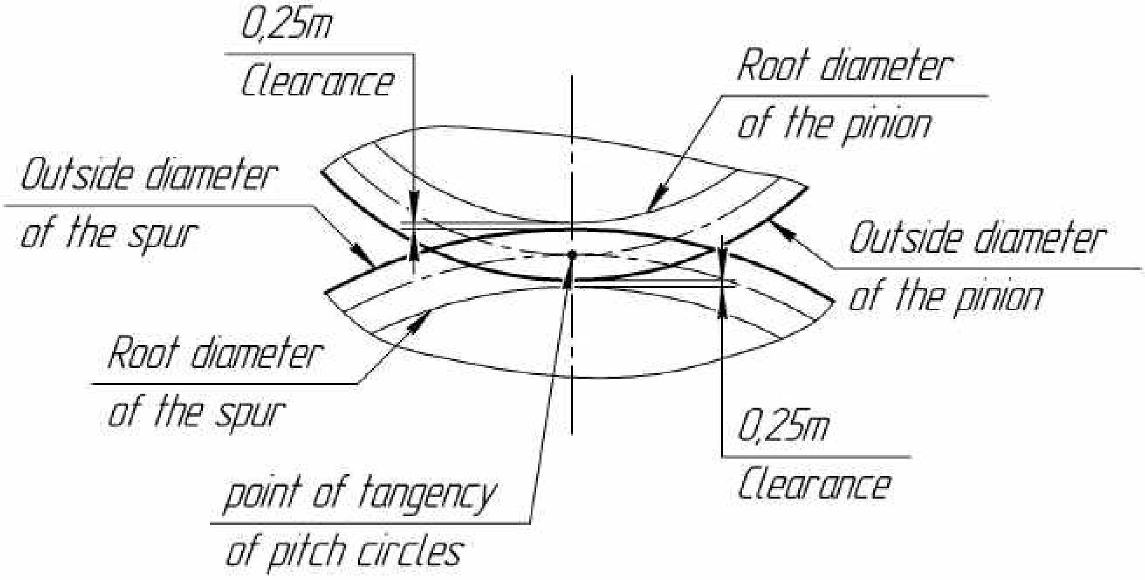


Fig. 71

Gear joints are represented in assembly drawings. An assembly drawing shows complete structure of a machine and relative dispositions and working relationship between its component parts. The purpose of an assembly drawing is to represent proper working relationship between component parts of a structure or mechanism. An assembly drawing usually contains following information:

- Main view to show the best advantage of an assembly;
- Necessary projection views, auxiliary views, sections and sectioned views, pictorial views, if required, for better understanding;
- Overall dimensions, center to center distances, joining and installation distances, axel bases, etc., indicating relationship among the parts and the machine or mechanism in a whole;
- Identification of individual parts or subassembly units (by leaders).

Assembly drawing is performed on A3 paper (Figs 72, 74).

Bill of Material (BOM or associated list) to the assembly drawing is performed on a standard form A4 (GOST 2.108-68) (Figs 73, 75).

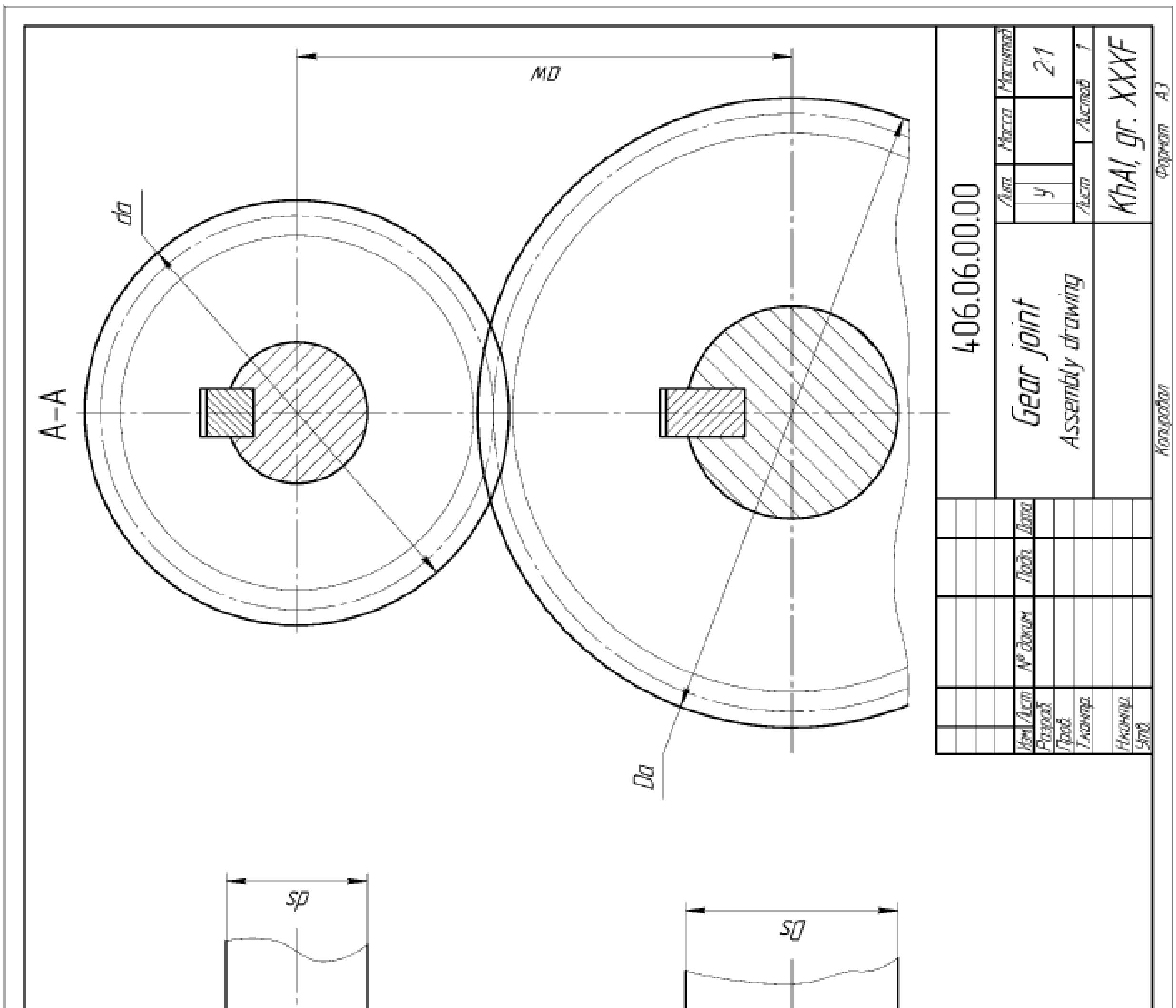

A–A
dw
da
Da
ds
Ds
1
2
3
4
5
6
406.06.00.00
Gear joint
Assembly drawing
KhAI, gr. XXXF
2:1

Fig. 72

Format	Zone	Item No.	Part No.	Title	No. off	Note
				<u>Documentation</u>		
A3			406.06.01.00.00 AD	Assembly drawing		
				<u>Parts</u>		
A4		1	406.06.01.00.01	Pinion	1	m=2,z=25
A4		2	406.06.01.00.02	Spur	1	m=2,z=38
A4		3	406.06.01.00.03	Shaft	1	⌀18
A4		4	406.06.01.00.04	Shaft	1	⌀27
				<u>Standart parts</u>		
		5		Key 6x6x22 GOST 23360–78	1	
		6		Key 6x10 GOST 24071–97	1	

Ch.	Sheet	Docum. №	Sign	Data	406.06.01.00.00		
Design. by					Gear Joint	Letter	Sheet	Sheets
Check. by						e		
N.contr. by						KHAI, gr. XXXF		
Appr. by								

Format A4

Fig. 73

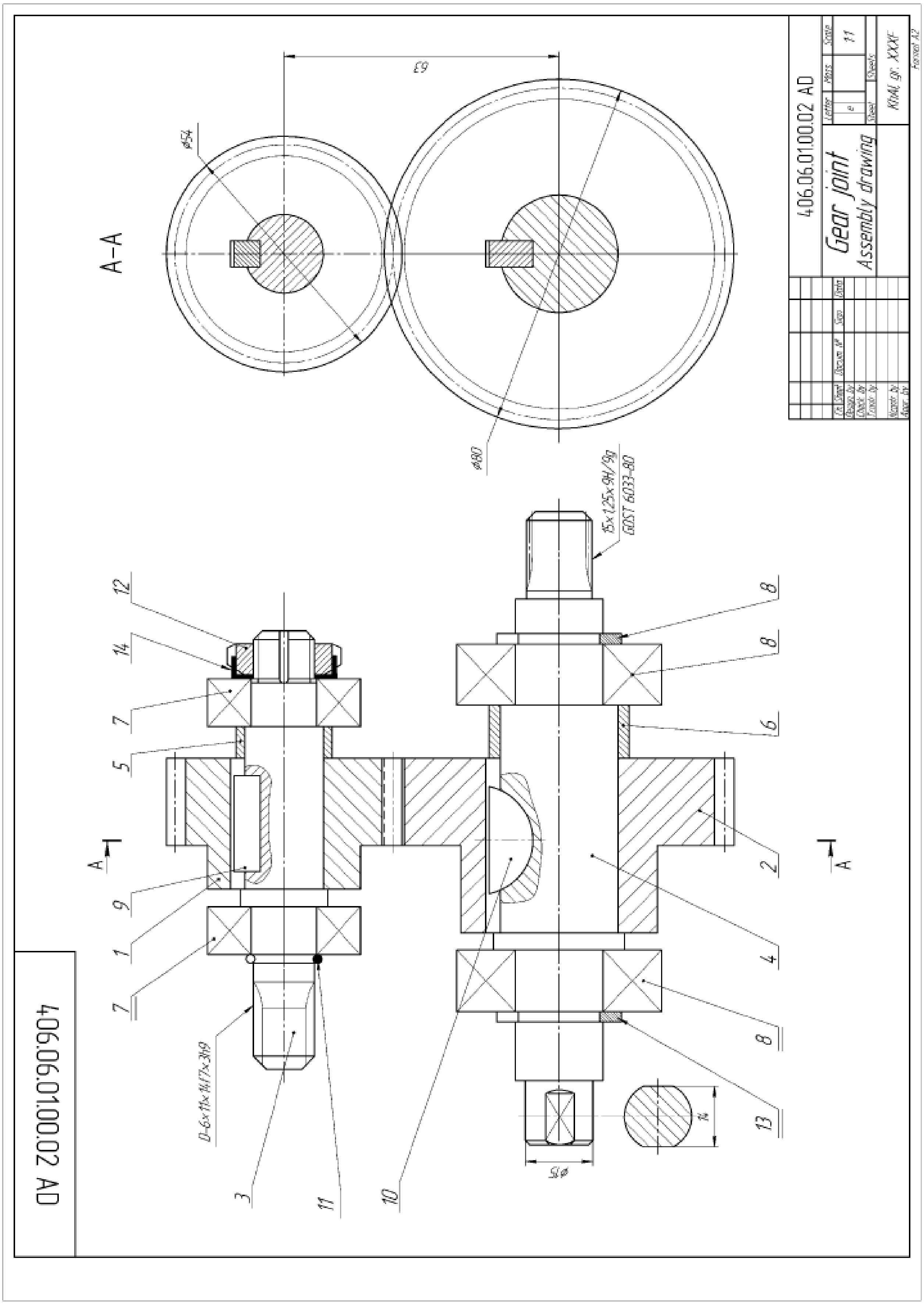

A–A
406.06.01.00.02 AD
Gear joint
Assembly drawing
Ø54
Ø80
63
15x1.25x9H/9g
GOST 6033-80
Ø15
14

Fig. 74

Format	Zone	Item No.	Part No.	Title	No. off	Note
				Documentation		
A2			406.06.01.00.00 AD	Assembly drawing		
				Parts		
A4		1	406.06.01.00.01	Pinion	1	m=2,z=25
A4		2	406.06.01.00.02	Spur	1	m=2,z=38
A4		3	406.06.01.00.03	Shaft	1	⌀18
A4		4	406.06.01.00.04	Shaft	1	⌀27
A4		5	406.06.01.00.05	Sleeve	1	
A4		6	406.06.01.00.06	Sleeve	1	
				Standart parts		
		7		Bearing 50202 GOST 2893-82	2	
		8		Bearing 50204 GOST 2893-82	2	
		9		Key 6x6x22 GOST 23360-78	1	
		10		Key 6x10 GOST 24071-97	1	
		11		Lock ring 14 MN 470-61	1	
		12		Nut M14 GOST 11871-88	1	
		13		Ring A20 GOST 13942-86	2	
		14		Washer N.14 GOST 11648-75	1	

Ch.	Sheet	Docum. №	Sign	Data	406.06.01.00.00		
Design. by					Gear Joint	Letter: e	Sheet	Sheets
Check. by							
N.contr. by						KHAI, gr. XXXF	
Appr. by							

Format A4

Fig. 75

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APENDIX

Table A.1

Normal linear dimensions

(extract from ISO 1119:2011/GOST 6636-69), mm

Rows				Additional dimensions	Rows				Additional dimensions
Ra 5	**Ra 10**	**Ra 20**	**Ra 40**		**Ra 5**	**Ra 10**	**Ra 20**	**Ra 40**	
1,0	1,0	1,0	1,0 1,05	-	25	32	32	32 34	33 35
		1,1	1,1 1,15				36	36 38	37 39
	1,2	1,2	1,2 1,3	1,25 1,35	40	40	40	40 42	41 44
		1,4	1,4 1,5	1,45 1,55			45	45 48	46 49
1,6	1,6	1,6	1,6 1,7	1,65 1,75		50	50	50 53	52 55
		1,8	1,8 1,9	1,85 1,95			56	56 60	58 62
	2,0	2,0	2,0 2,1	2,05	63	63	63	63 67	65 70
		2,2	2,2 2,4	2,15 2,30			71	71 75	73 78
2,5	2,5	2,5	2,5 2,6	2,7		80	80	80 85	82 88
		2,8	2,8 3,0	2,9 3,1			90	90 95	92 98
	3,2	3,2	3,2 3,4	3,3 3,5	100	100	100	100 105	102 108
		3,2	3,6 3,8	3,7 3,9			110	110 120	112 115
4,0	4,0	4,0	4,0 4,2	4,1 4,4		125	125	125 130	118 135
		4,5	4,5 4,8	4,6 4,9			140	140 150	145 155
	5,0	5,0	5,0 5,3	5,2 5,5	160	160	160	160 170	165 175
		5,6	5,6 6,0	5,8 6,2			180	180 190	185 195
6,3	6,3	6,3	6,3 6,7	6,5 7,0		200	200	200 210	205 215
		7,1	7,1 7,5	7,3 7,8			220	220 240	230
	8,0	8,0	8,0 8,5	8,2 8,8	250	250	250	250 260	270
		9,0	9,0 9,5	9,2 9,8			280	280 300	290 310
10	10	10	10 10,5	10,2 10,8		320	320	320 340	330 350
		11	11 11,5	11,2 11,8			360	360 380	370 390
	12	12	12 13	12,5 13,5	400	400	400	400 420	410 440
		14	14 15	14,5 15,5			450	450 480	460 490
16	16	16	16 17	16,5 17,5		500	500	500 530	515 545
		18	18 19	18,5			560	560 600	580 615
	20	20	20 21	19,5 20,5	630	630	630	630 670	650 690
		22	22 24	21,5 23,0			710	710 750	730 775
25	25	25	25 26	27		800	800	800 850	825 875
		28	28 30	29 31			900	900 950	925 975

Table A.2

Metric Thread. Diameters and Pitches

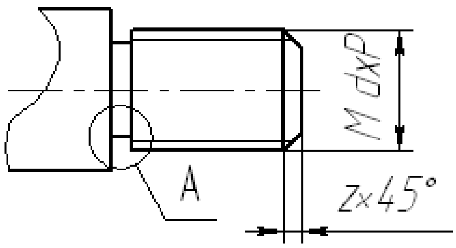
(extract from ISO 5408:2009/GOST 8724-2002), mm

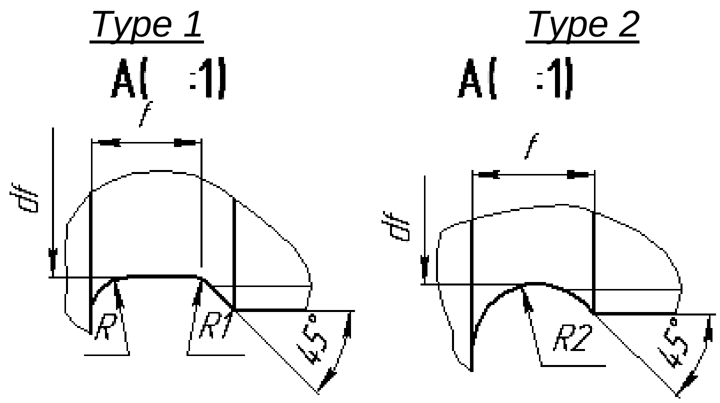
Nominal thread diameter d, mm			Pitch P, mm		Nominal Thread Diameter d, mm			Pitch P, mm	
1-st row	2-nd row	3-rd row	regular	fine	1-st row	2-nd row	3-rd row	regular	fine
1	—	—	0,25	0,2	—	—	**38**	—	1,5
—	**1,1**	—	0,25	0,2	—	**39**	—	4	3; 2; 1,5; 1
1,2	—	—	0,25	0,2	—	—	**40**	—	3; 2; 1,5
—	**1,4**	—	0,30	0,2	**42**	—	—	4,5	4; 3; 2; 1,5; 1
1,6	—	—	0,35	0,2	—	**45**	—	4,5	4; 3; 2; 1,5; 1
—	**1,8**	—	0,35	0,2	**48**	—	—	5	4; 3; 2; 1,5; 1
2	—	—	0,40	0,25	—	—	**50**	—	3; 2; 1,5
—	**2,2**	—	0,45	0,25	—	**52**	—	5	4; 3; 2; 1,5; 1
2,5	—	—	0,45	0,35	—	—	**55**	—	4; 3; 2; 1,5
3	—	—	0,50	0,35	**56**	—	—	5,5	4; 3; 2; 1,5; 1
—	**3,5**	—	0,60	0,35	—	—	**58**	—	4; 3; 2; 1,5
4	—	—	0,70	0,5	—	**60**	—	5,5	4; 3; 2; 1,5; 1
—	**4,5**	—	0,75	0,5	—	—	**62**	—	4; 3; 2; 1,5
5	—	—	0,80	0,5	**64**	—	—	6	4; 3; 2; 1,5; 1
—	—	**5,5**	—	0,5	—	—	**65**	—	4; 3; 2; 1,5
6	—	—	1	0,75; 0,5	—	**68**	—	6	4; 3; 2; 1,5; 1
—	—	**7**	1	0,75; 0,5	—	—	**70**	—	6; 4; 3; 2; 1,5
8	—	—	1,25	1; 0,75; 0,5	**72**	—	—	—	6; 4; 3; 2; 1,5; 1
—	—	**9**	1,25	1; 0,75; 0,5	—	—	**75**	—	4; 3; 2; 1,5
10	—	—	1,5	1,25; 1; 0,75; 0,5	—	**76**	—	—	6; 4; 3; 2; 1,5; 1
—	—	**11**	1,5	1; 0,75; 0,5	—	—	**78**	—	2
12	—	—	1,75	1,5; 1,25; 1; 0,75; 0,5	**80**	—	—	—	6; 4; 3; 2; 1,5; 1
—	**14**	—	2	1,5; 1,25; 1; 0,75; 0,5	—	—	**82**	—	2
—	—	**15**	—	1,5; 1	—	**85**	—	—	6; 4; 3; 2; 1,5
16	—	—	2	1,5; 1; 0,75; 0,5	**90**	—	—	—	6; 4; 3; 2; 1,5
—	—	**17**	—	1,5; 1	—	**95**	—	—	6; 4; 3; 2; 1,5
—	**18**	—	2,5	2; 1,5; 1; 0,75; 0,5	**100**	—	—	—	6; 4; 3; 2; 1,5
20	—	—	2,5	2; 1,5; 1; 0,75; 0,5	—	**105**	—	—	6; 4; 3; 2; 1,5
—	**22**	—	2,5	2; 1,5; 1; 0,75; 0,5	**110**	—	—	—	6; 4; 3; 2; 1,5
24	—	—	3	2; 1,5; 1; 0,75	—	**115**	—	—	6; 4; 3; 2; 1,5
—	—	**25**	—	2; 1,5; 1	—	**120**	—	—	6; 4; 3; 2; 1,5
—	—	**26**	—	1,5	**125**	—	—	—	6; 4; 3; 2; 1,5
—	**27**	—	3	2; 1,5; 1; 0,75	Comments: choosing thread diameter, give preference to the first row, then to the second and only then to the third one.				
—	—	**28**	—	2; 1,5; 1					
30	—	—	3,5	3; 2; 1,5; 1; 0,75					
—	—	**32**	—	2; 1,5					
—	**33**	—	3,5	3; 2; 1,5; 1; 0,75					
—	—	**35**	—	1,5					
36	—	—	4	3; 2; 1,5; 1					

Table A.3

Grooves for external metric thread

(extract from ISO 1502:1996/GOST 10549-80), mm



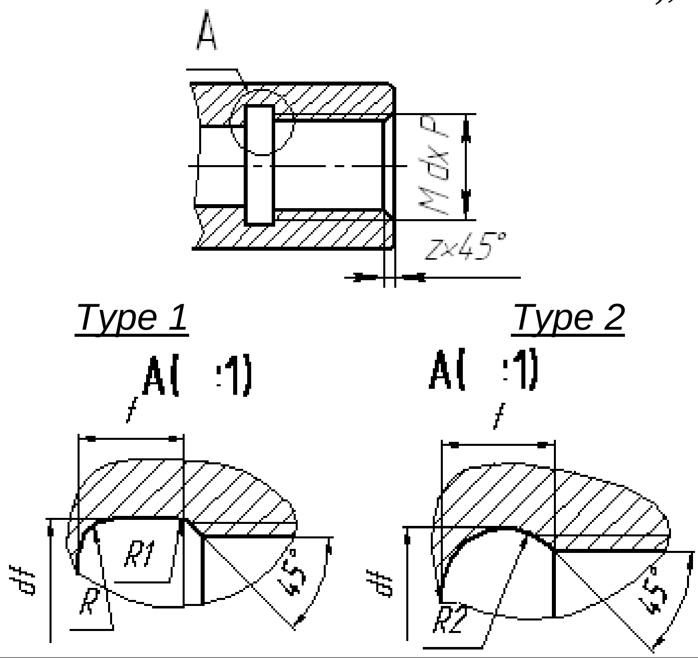


Thread pitch *P*, mm	Groove sizes									Chamfer *z*, mm
	Type 1						Type 2		*df*	
	normal			narrow						
	f	*R*	R_1	*f*	*R*	R_1	*f*	R_2		
0,2	–	–	–	–	–	–	–	–	–	0,2
0,25										
0,3										
0,35									*d* - 0,6	0,3
0,4	1,0	0,3	0,2							
0,45									*d* - 0,7	
0,5	1,6	0,5	0,3	1,0	0,3	0,2			*d* - 0,8	0,5
0,6									*d* - 0,9	
0,7	2,0			1,6	0,5	0,3			*d* - 1,0	
0,75									*d* - 1,2	1,0
0,8	3,0	1,0	0,5							
1				2,0			3,6	2,0	*d* - 1,5	
1,25	4,0			2,5	1,0	0,5	4,4	2,5	*d* - 1,8	1,6
1,5							4,6		*d* - 2,2	
1,75							5,4	3,0	*d* - 2,5	
2	5,0	1,6		3,0			5,6		*d* - 3,0	2,0
2,5	6,0		1,0	4,0			7,3	4,0	*d* - 3,5	2,5
3							7,6		*d* - 4,5	
3,5	8,0	2,0		5,0	1,6		10,2	5,5	*d* - 5,0	
4							10,3		*d* - 6,0	3,0
4,5	10,0	3,0		6,0		1,0	12,9	7,0	*d* - 6,5	
5							13,1		*d* - 7,0	4,0
5,5	12,0			8,0	2,0		15,0	8,0	*d* - 8,0	
6							16,0	8,5	*d* - 9,0	

Table A.4

Grooves for internal metric thread

(extract from ISO 1502:1996/GOST 10549-80), mm

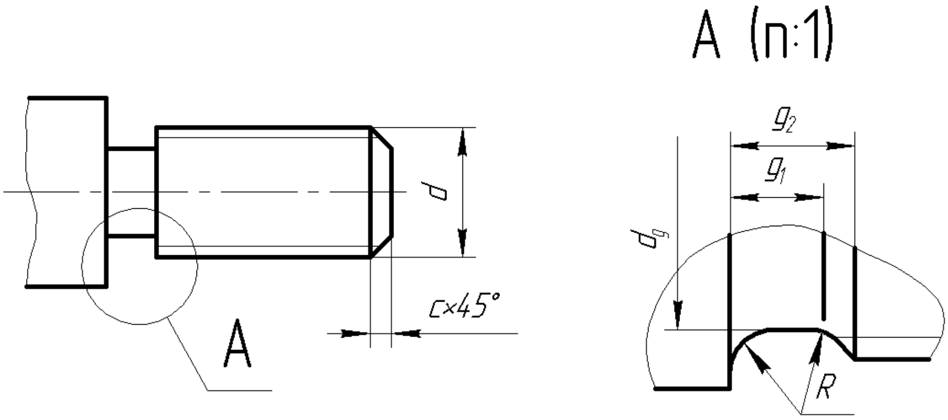


<table>
<tr><th rowspan="4">Thread pitch
P, mm</th><th colspan="9">Groove sizes</th><th rowspan="4">Cham-fer
z, mm</th></tr>
<tr><th colspan="6">Type 1</th><th colspan="2">Type 2</th><th rowspan="3">*df*</th></tr>
<tr><th colspan="3">normal</th><th colspan="3">narrow</th><th colspan="2"></th></tr>
<tr><th>*f*</th><th>*R*</th><th>R_1</th><th>*f*</th><th>*R*</th><th>R_1</th><th>*f*</th><th>R_2</th></tr>
<tr><td>**0,2**</td><td rowspan="6">–</td><td rowspan="6">–</td><td rowspan="6">–</td><td rowspan="6">–</td><td rowspan="6">–</td><td rowspan="6">–</td><td rowspan="11">–</td><td rowspan="11">–</td><td rowspan="6">–</td><td rowspan="4">0,2</td></tr>
<tr><td>**0,25**</td></tr>
<tr><td>**0,3**</td></tr>
<tr><td>**0,35**</td></tr>
<tr><td>**0,4**</td><td rowspan="2">0,3</td></tr>
<tr><td>**0,45**</td></tr>
<tr><td>**0,5**</td><td>2,0</td><td>0,5</td><td>0,3</td><td>1,0*</td><td>0,3</td><td>0,2</td><td>*d* + 0,3</td><td rowspan="3">0,5</td></tr>
<tr><td>**0,6**</td><td rowspan="2">–</td><td rowspan="2">–</td><td rowspan="2">–</td><td rowspan="2">–</td><td rowspan="2">–</td><td rowspan="2">–</td><td rowspan="2">–</td></tr>
<tr><td>**0,7**</td></tr>
<tr><td>**0,75**</td><td>3,0</td><td>1,0</td><td>0,5</td><td>1,6*</td><td>0,5</td><td>0,3</td><td>*d* + 0,4</td><td rowspan="3">1,0</td></tr>
<tr><td>**0,8**</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>**1**</td><td>4,0</td><td>1,0</td><td rowspan="2">0,5</td><td>2,0</td><td>0,5</td><td>0,3</td><td>3,6</td><td>2,0</td><td rowspan="2">*d* + 0,5</td></tr>
<tr><td>**1,25**</td><td>5,0</td><td rowspan="3">1,6</td><td rowspan="2">3,0</td><td rowspan="2">1,0</td><td rowspan="4">0,5</td><td>4,5</td><td>2,5</td><td rowspan="3">1,6</td></tr>
<tr><td>**1,5**</td><td>6,0</td><td rowspan="11">1,0</td><td>5,4</td><td>3,0</td><td rowspan="2">*d* + 0,7</td></tr>
<tr><td>**1,75**</td><td>7,0</td><td rowspan="2">4,0</td><td rowspan="2">1,0</td><td>6,2</td><td rowspan="2">3,5</td></tr>
<tr><td>**2**</td><td>8,0</td><td>2,0</td><td>6,5</td><td rowspan="2">*d* + 1,0</td><td>2,0</td></tr>
<tr><td>**2,5**</td><td rowspan="3">10</td><td rowspan="8">3,0</td><td>5,0</td><td rowspan="3">1,6</td><td>8,9</td><td>5,0</td><td rowspan="2">2,5</td></tr>
<tr><td>**3**</td><td>6,0</td><td rowspan="7">1,0</td><td>11,4</td><td>6,5</td><td rowspan="2">*d* + 1,2</td></tr>
<tr><td>**3,5**</td><td>7,0</td><td>13,1</td><td>7,5</td><td rowspan="2">3,0</td></tr>
<tr><td>**4**</td><td>12</td><td>8,0</td><td>2,0</td><td>14,3</td><td>8,0</td><td rowspan="2">*d* + 1,5</td></tr>
<tr><td>**4,5**</td><td>14</td><td rowspan="2">10</td><td rowspan="4">3,0</td><td>16,6</td><td>9,5</td><td rowspan="4">4,0</td></tr>
<tr><td>**5**</td><td rowspan="3">16</td><td>18,4</td><td rowspan="3">10,5</td><td rowspan="2">*d* + 1,8</td></tr>
<tr><td>**5,5**</td><td rowspan="2">12</td><td>18,7</td></tr>
<tr><td>**6**</td><td>18,9</td><td>*d* + 2,0</td></tr>
</table>

Table A.5

Grooves for external metric thread

(extract from ISO 1502:1996/GOST 27148-86), mm

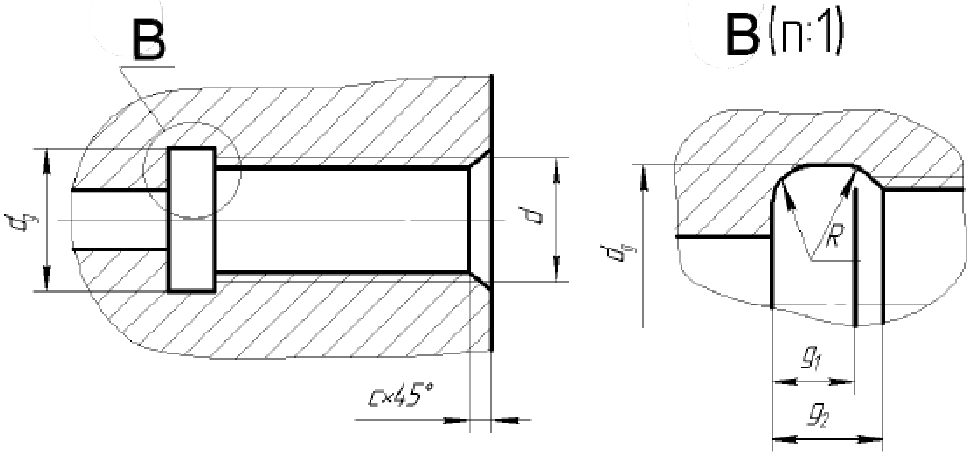


Thread pitch, p	g_1, min		g_2, min		d_g	R≈0,5p	Chamfer, c×45°
	normal	narrow	normal	narrow			
0,35	0,7	0,4	1,2	0,9	d – 0,5	0,17	0,3
0,4	0,8	0,5	1,4	1,0	d – 0,7	0,2	0,3
0,45	1,0	0,5	1,6	1,1	d – 0,7	0,22	0,3
0,5	1,1	0,5	1,75	1,25	d – 0,8	0,25	0,5
0,6	1,2	0,6	2,1	1,5	d – 1,0	0,3	0,5
0,7	1,5	0,8	2,45	1,75	d – 1,1	0,35	0,5
0,75	1,6	0,9	2,6	1,9	d – 1,2	0,4	1,0
0,8	1,7	0,9	2,8	2,0	d – 1,3	0,4	1,0
1	2,1	1,1	3,5	2,5	d – 1,6	0,5	1,0
1,25	2,7	1,5	4,4	3,2	d – 2	0,6	1,6
1,5	3,2	1,8	5,2	3,8	d – 2,3	0,75	1,6
1,75	3,9	2,1	6,1	4,3	d – 2,6	0,9	1,6
2	4,5	2,5	7	5,0	d – 3,0	1,0	2,0
2,5	5,6	3,2	8,7	6,3	d – 3,6	1,25	2,5
3,0	6,7	3,7	10,5	7,5	d – 4,4	1,5	2,5
3,5	7,7	4,7	12,5	9,0	d – 5	1,75	2,5
4,0	9,0	5,0	14	10	d – 5,7	2,0	3,0
4,4	10,5	5,5	16	11	d – 6,4	2,25	3,0
5	11,5	6,5	17,5	12,5	d – 7	2,5	4,0
5,6	12,5	7,5	19	14,5	d – 7,7	2,75	4,0
6	14,0	8,0	21	15	d – 8,3	3,0	4,0

Table A.6

Grooves for internal metric thread

(extract from ISO 1502:1996/GOST 27148-86), mm



Thread pitch, p	g_1, min		g_2, min		d_g	R≈0,5p	Chamfer, c×45°
	normal	narrow	normal	narrow			
0,35	1,4	0,9	1,9	1,4	d+0,2	0,17	0,3
0,4	1,6	1,0	2,2	1,5	d+0,2	0,2	0,3
0,45	1,8	1,1	2,4	1,7	d+0,2	0,22	0,3
0,5	2,0	1,25	2,7	2,0	d+0,3	0,25	0,5
0,6	2,4	1,25	3,3	2,4	d+0,3	0,3	0,5
0,7	2,8	1,75	3,8	2,75	d+0,3	0,35	0,5
0,75	3,0	1,9	4,0	2,9	d+0,3	0,4	1,0
0,8	3,2	2,0	4,2	3,0	d+0,3	0,4	1,0
1	4,2	2,5	5,2	3,7	d+0,5	0,5	1,0
1,25	5,0	3,2	6,7	4,9	d+0,5	0,6	1,6
1,5	6,0	3,8	7,8	6,6	d+0,5	0,75	1,6
1,75	7,0	4,3	9,1	6,4	d+0,5	0,9	1,6
2	8,0	5,0	10,3	7,3	d+0,5	1,0	2,0
2,5	10	6,3	13	9,3	d+0,5	1,25	2,5
3,0	12	7,5	15,2	10,7	d+0,5	1,25	2,5
3,5	14	9,0	17,0	12,7	d+0,5	1,75	2,5
4,0	16	10,0	20,0	14	d+0,5	2,0	3,0
4,5	18	11	23,0	16	d+0,5	2,25	3,0
5	20	12,5	26,0	18,5	d+0,5	2,5	4,0
5,5	22	14,0	28,0	20,0	d+0,5	2,75	4,0
6	24	15,0	30,0	21,0	d+0,5	3,0	4,0

Table A.7

Basic dimensions of taper pipe thread

(from ISO 2284:2017/GOST 6211-81)

Designation of a thread *d*, inch	**Pitch *P*, mm**	**Outer diameter *d*, mm**
1/4	1,337	13,157
3/8		16,662
1/2	1,814	20,955
3/4		26,441
1	2,309	33,249
1 ¼		41,910
1 ½		47,803
2		59,614
2 ½		75,184
3		87,884
3 ½		100,330
4		113,030

Table A.8

Basic dimensions of Acme single-start and multi-start thread

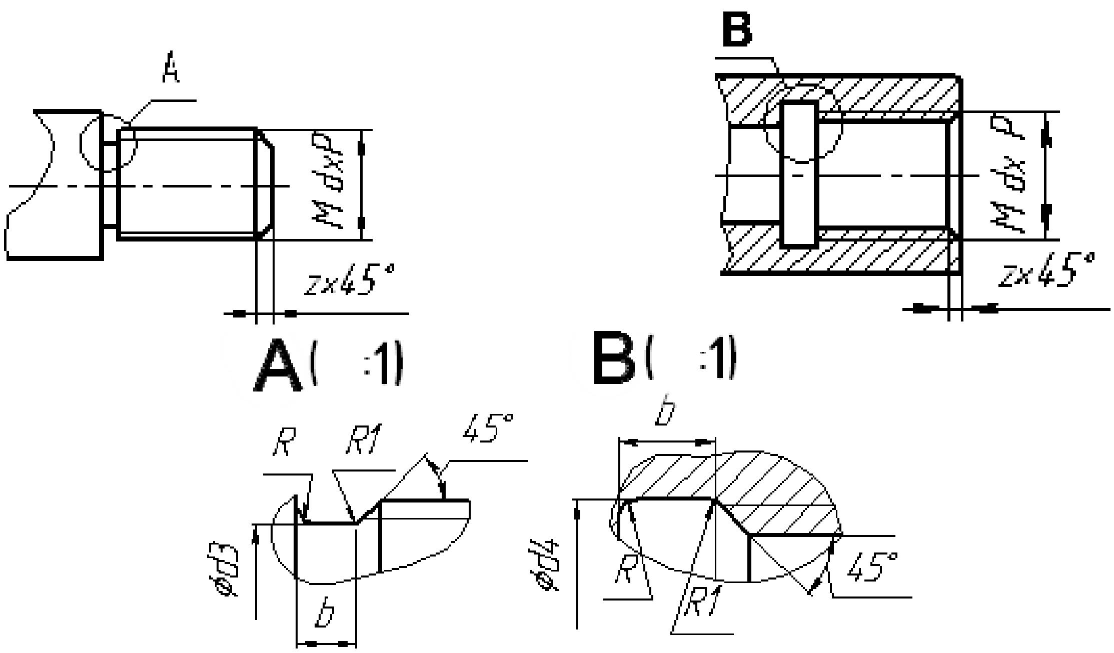
(from ISO 2902:2016/GOST 9484-73)

Thread diameter d, мм		**Pitch *P*, mm**	**Number of starts, n**		
Row 1	**Row 2**		**2**	**3**	**4**
			Lead		
10	–	1,5	3	4,5	6
		2	4	6	8
12	–	2	4	6	8
		3	6	9	12
16	–	2	4	6	8
		4	8	12	16
20	–	2	4	6	8
		4	8	12	16
24	–	(2)	4	6	8
		3	6	9	12
		5	10	15	20
		8	16	24	32
–	**28**	(2)	4	6	8
		3	6	9	12
		5	10	15	20
		8	16	24	32
32	–	3	6	9	12
		6	12	18	24
		10	20	30	40
–	**36**	3	6	9	12
		6	12	18	24
		10	20	30	40
40	–	3	6	9	12
		(6)	12	18	24

Table A.9

Grooves for Acme thread
(extract from ISO 2902:2016/GOST 10549-80), mm

External thread **Internal thread**

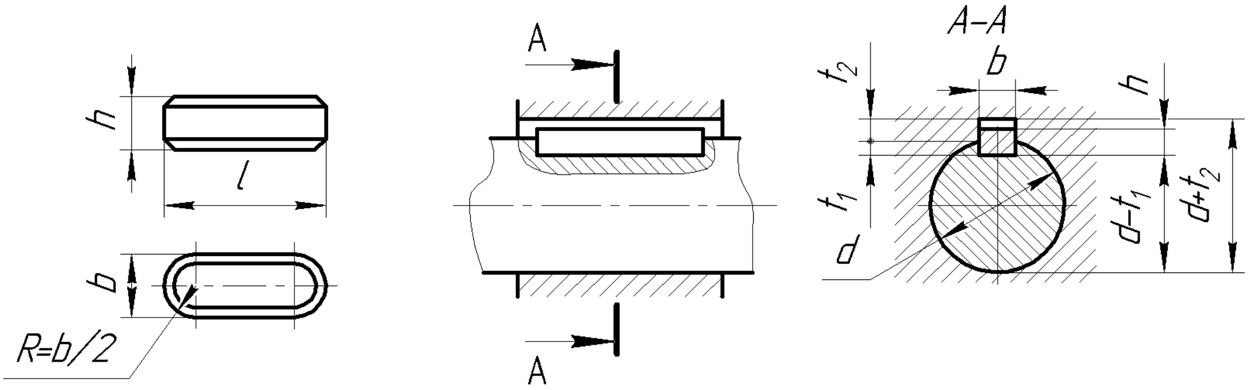


Thread pitch *P*, mm	b, мм	R, mm	R1, mm	d3, mm	d4, mm	Chamfer *z*, mm
1,5	2,5	1,0	0,5	d-2,5	d+1,0	1,0
2	3	1,0	0,5	d-3,0	d+1,0	1,6
3	5	1,6	0,5	d-4,2	d+1,0	2,0
4	6	1,6	1,0	d-5,2	d1,1	2,5
5	8	2,0	1,0	d-7,0	d+1,6	3,0
6	10	3,0	1,0	d-8,0	d+1,6	3,5
7	12	3,0	1,0	d-0,9	d+1,6	4,0
8	12	3,0	1,0	d-10,2	d+1,8	4,5
9	14	3,0	1,0	d-11,2	d+1,8	5,0
10	16	3,0	1,0	d-12,5	d+1,8	5,5
12	18	3,0	1,0	d-14,5	d+2,1	6,5
14	20	5,0	2,0	d-16,5	d+2,5	8,0
16	25	5,0	2,0	d-19,5	d+2,8	9,0
18	25	5,0	2,0	d-22,5	d+3,0	10,0
20	25	5,0	2,0	d-24,0	d+3,0	11,0
22	30	5,0	2,0	d-26,0	d+3,0	12,0
24	30	5,0	2,0	d-28,0	d+3,5	13,0
28	40	5,0	2,0	d-32,0	d+3,5	16,0
32	40	5,0	2,0	d-36,5	d+3,5	17,0
36	50	5,0	2,0	d-45,5	d+4,0	20,0
40	50	5,0	2,0	d-44,5	d+4,0	21,0
44	60	5,0	2,0	d-48,5	d+4,0	25,0

Table A.10

Standard keys and keyways (by DIN 6885-1/GOST 23360-78), mm

Series 1 (Pratt & Whitney key)



Shaft diameter	Nominal keysize		Dimensions		Keyway fillet radius r		Key length
			Keyseat	Keyway			
d	**b**	**h**	t_1	t_2	**min**	**max**	**L**
From 8 to 10	3	3	1,8	1,4	0,08	0,16	6-28
From 10 to 12	4	4	2,5	1,8			8-32
From 12 to 17	5	5	3	2,3	0,16	0,25	10-45
From 17 to 22	6	6	3,5	2,8			14-56
From 22 to 30	7;8	7	4	3,3			18-70
From 30 to 38	10	8	5	3,3	0,25	0,4	22-90
From 38 to 44	12	8	5	3,3			28-110
From 44 to 50	14	9	5,5	3,8			36-140
From 50 to 58	16	10	6	4,3			45-180
From 58 to 65	18	11	7	4,4			50-200

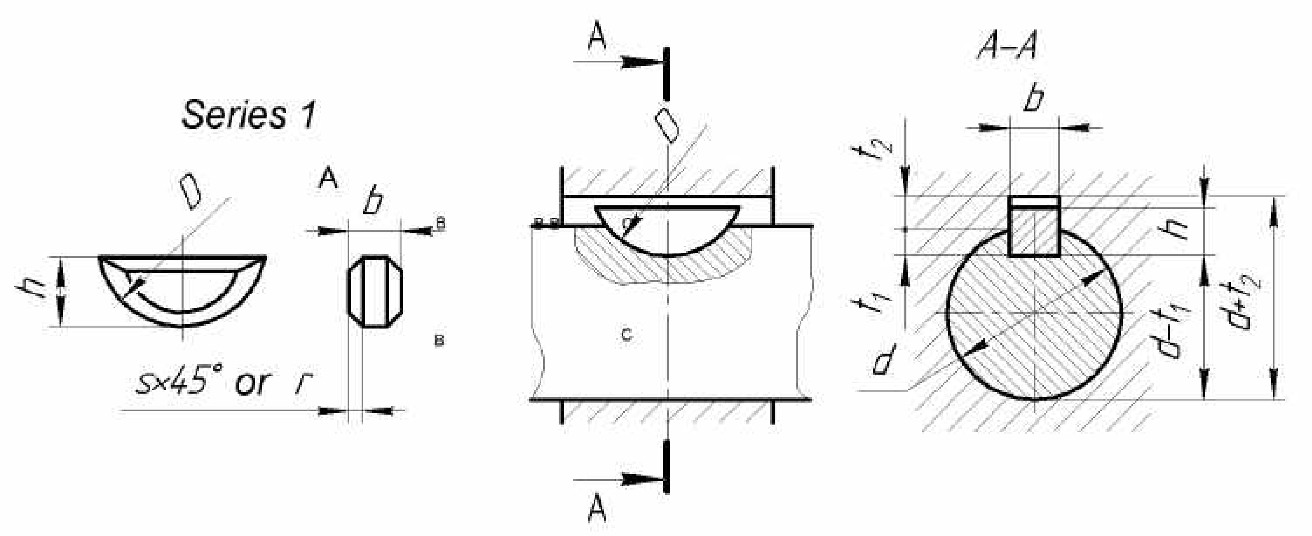
Row of normal key length: 6, 8, 10, 12, 14, 16, 18, 20, 22, 25, 28, 32, 40, 45, 50, 56, 63, 70, 80, 90, 100, 110, 125.

Example of designation:

Key 2-18x11x60 GOST 23360-78; where ***2*** - series (series ***1*** won't indicate), ***18x11*** – nominal key size (***18*** - width, ***11*** - height), ***60*** - length.

Table A.11

Woodruff keys, keyseats and keyways
(by ISO 3912:1977/GOST 24071-97), mm



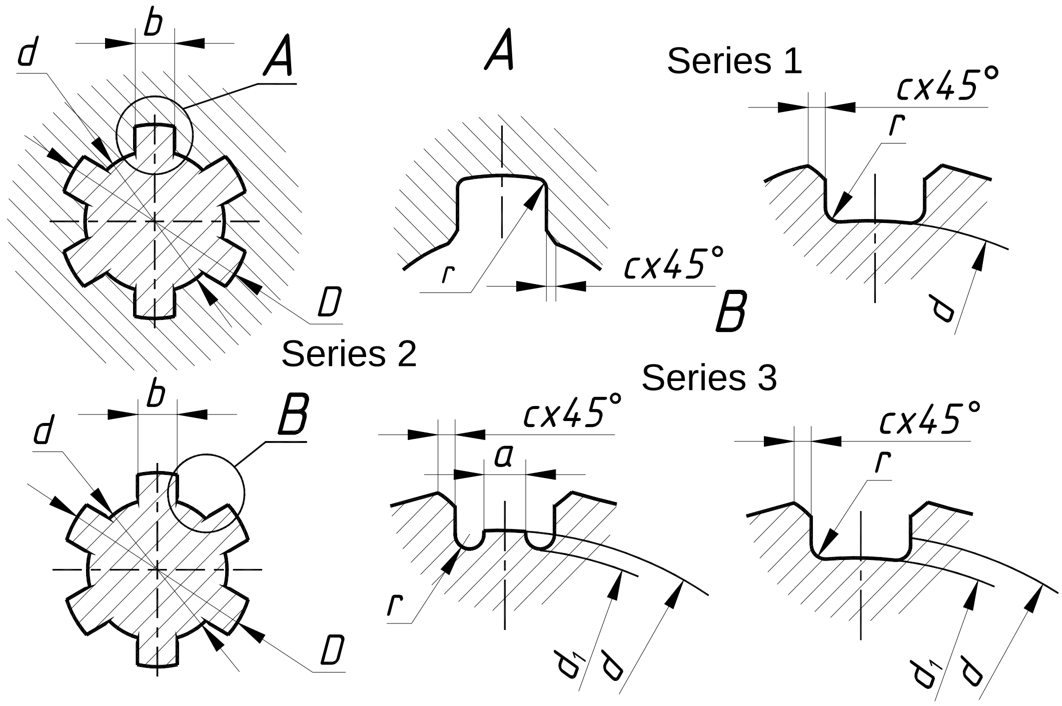
<table>
<tr><th colspan="2">Shaft diameter D</th><th colspan="3">Nominal Keysize</th><th rowspan="2">Keyseat t_1</th><th rowspan="2">Keyway t_2</th><th colspan="2">Fillet radius r</th></tr>
<tr><th>Rotational moment transmission</th><th>Element fixation</th><th>b</th><th>h</th><th>d</th><th>min</th><th>max</th></tr>
<tr><td>From 8 to 10</td><td>From 12 to 15</td><td rowspan="2">3</td><td>5</td><td>13</td><td>3,8</td><td rowspan="2">1,4</td><td rowspan="2">0,08</td><td rowspan="2">0,16</td></tr>
<tr><td>From 10 to 12</td><td>From 15 to 18</td><td rowspan="2">6,5</td><td rowspan="2">16</td><td>5,3</td></tr>
<tr><td>From 12 to 14</td><td>From 18 to 20</td><td rowspan="2">4</td><td>5</td><td rowspan="2">1,8</td><td rowspan="6">0,16</td><td rowspan="6">0,25</td></tr>
<tr><td>From 14 to 16</td><td>From 20 to 22</td><td>7,5</td><td>19</td><td>6</td></tr>
<tr><td>From 16 to 18</td><td>From 22 to 25</td><td rowspan="2">5</td><td>6.5</td><td>16</td><td>4.5</td><td rowspan="2">2,3</td></tr>
<tr><td>From 20 to 22</td><td>From 28 to 32</td><td rowspan="2">9</td><td rowspan="2">22</td><td>7</td></tr>
<tr><td>From 22 to 25</td><td>From 32 to 36</td><td rowspan="2">6</td><td>6,5</td><td rowspan="2">2,8</td></tr>
<tr><td>From 25 to 28</td><td>From 36 to 40</td><td>10</td><td>25</td><td>7,5</td></tr>
<tr><td>From 25 to 32</td><td>From 40</td><td>8</td><td>11</td><td>28</td><td>8</td><td>3,3</td><td>0,25</td><td>0,40</td></tr>
<tr><td>From 32 to 33</td><td>From 40</td><td>10</td><td>13</td><td>32</td><td>10</td><td></td><td></td><td></td></tr>
</table>

Example of designation:

Key 9x6,5 GOST 24071-80, where ***5*** – key width, ***6,5*** – key height.

Table A.12

Splined shaft (by ISO 14:1982/GOST 1139-80), mm



Nominal size ZxdxD	Z	d	D	b	d min	$d\text{-}d_1$ min	c nominal	r min
6x23x26	6	23	26	6	22,1	3,54		
6x26x30	6	26	26	6	24,6	3,85	0.3	0,2
6x29x32	6	28	32	7	26,7	4,03		
8x32x36	8	32	36	6	30,4	2,71	0,4	0,3
8x36x40	8	36	40	7	34,5	3,46	0,4	0,3
8x42x46	8	42	45	8	40,4	5,03	0,4	0,3
8x46x50	8	46	50	9	44,6	5,75	0,4	0,3
8x52x58	6	52	58	10	49,7	4,89	0,5	0,5
8x62x68	8	62	68	12	53,6	6,38	0,5	0,5
16x72x78	10	72	78	12	69,6	5,45	0,5	0,5
10x82x88	10	82	88	12	79,3	8,62	0,5	0,5

Example of designation:

– shaft – ***d - 8x36e8x40a11x7f8 GOST 1139-80***,

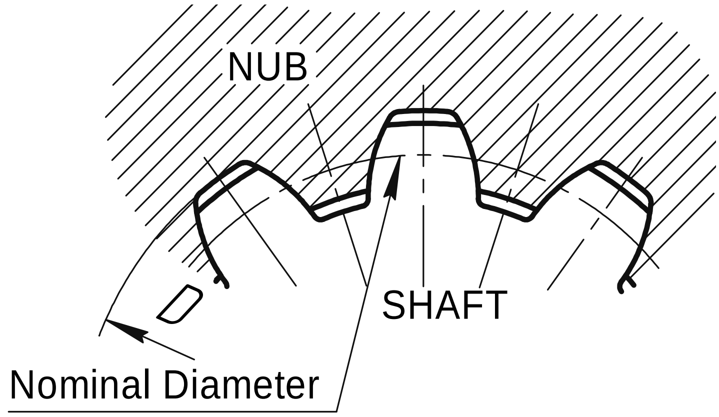
– hub – ***d - 8x36H7x40H12x7D9 GOST 1139-80,***

– combination – ***d - 8x36H7/e8x40H12/a11x7D9/f8 GOST 1139-80,***

where d – centering by inner diameter (D – centering by outer diameter, b – centering by width); 8 – number of teeth; 36 – inner diameter with tolerances for hub H7 and for shaft – e8; 40 – outer diameter with tolerances for hub – H12 and for shaft – a11; 7 – tooth width with fits D9 and f8.

Table A.13

Involute splined shaft (by ISO 4156:2005/GOST 6033-80), mm



Nominal diameter D, mm	**Number of teeth Z with module m, mm**					**Nominal diameter D, mm**	**Number of teeth Z with module m**		
	0,5	0,8	1,25	2	3		3	5	8
6	10	6	–	–	–	85	27	15	–
8	14	8	–	–	–	90	28	16	–
10	18	11	–	–	–	95	30	16	–
12	22	13	–	–	–	100	32	18	–
15	28	17	–	–	–	110	35	20	–
17	–	20	12	–	–	120	38	22	–
20	–	23	14	–	–	140	45	26	–
25	–	30	18	–	–	160	52	30	18
30	–	36	22	–	–	180	56	34	21
35	–	–	26	16	–	200	–	38	24
40	–	–	30	18	–	220	–	42	26
45	–	–	34	21	–	240	–	46	28
50	–	–	38	24	–	260	–	50	31
55	–	–	–	26	17	300	–	58	36
60	–	–	–	28	18	340	–	–	41
65	–	–	–	31	20	380	–	–	46
70	–	–	–	34	22	400	–	–	48
75	–	–	–	36	24	440	–	–	54

Example of designation:

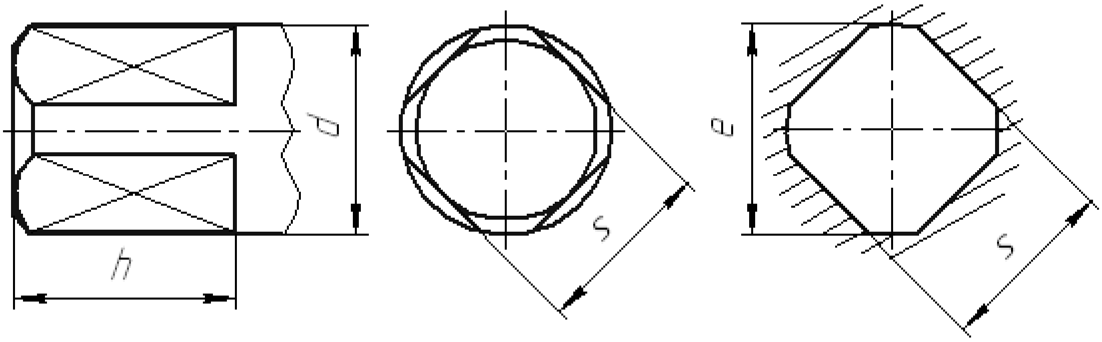
- for shaft – ***50x2 -9g GOST 6033-80,***
- for hub – ***50x2x9H GOST 6033-80,***
- for combination – ***50x2x9H/9g GOST 6033-80,***

where ***50*** – nominal diameter, ***2*** – module, ***9H*** and ***9g*** – tolerances.

Table A.14

Shaft and hub wrenches

(by ISO 2236:1991/GOST 9523-84), mm

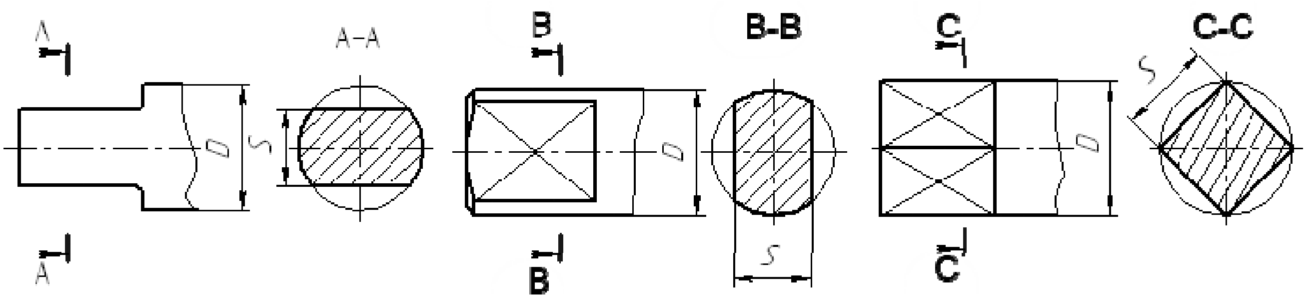


d	***s***	***h***	***e_{min}***	***d***	***s***	***h***	***e_{min}***
7,1	5,6	8	7,65	28,0	24,0	26	30,21
8,0	6,3	9	8,65	31,5	25,0	28	33,75
9,0	7,1	10	9,65	35,5	28,0	31	37,75
10,0	8,0	11	10,78	40,0	31,5	34	42,75
11,2	9,0	12	11,98	45,0	35,5	38	47,75
12,5	10,0	13	13,38	50,0	40,0	42	53,3
14,0	11,2	14	15,18	56,0	45,0	46	60,3
16,0	12,5	16	17,18	63,0	50,0	51	67,3
18,0	14,0	18	19,21	71,0	56,0	56	75,3
20,0	16,0	20	21,41	80,0	63,0	62	85,35
22,4	18,0	22	23,81	90,0	71,0	68	95,35
25	20,0	24	26,71	100,0	80,0	75	106,35

Table A.15

Nominal wrench sizes

(by ISO 1711-1:2019/GOST 6424-73), mm

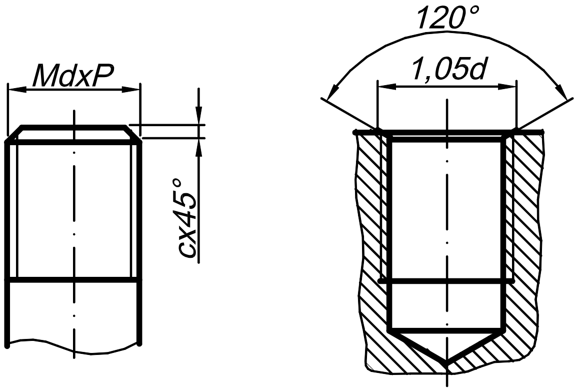


S, мм	7	8	10	12	14	17	19	22	24	27	30	32	36	41	46

Table A.16

Chamfers for External and Internal Metric Thread fastenings

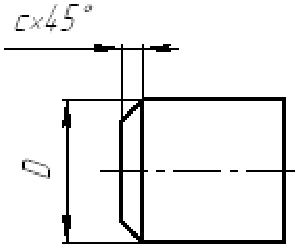
(by ISO 4753:2011/GOST 10549-80), mm



Pitch P, mm	0,5	0,75	1,0	1,25	1,5	1,75	2	2,5	3	3,5	4
Chamfer distance c, min	0,5	1,0	1,0	1,6	1,6	1,6	2,0	2,5	2,5	2,5	3,0

Table A.17

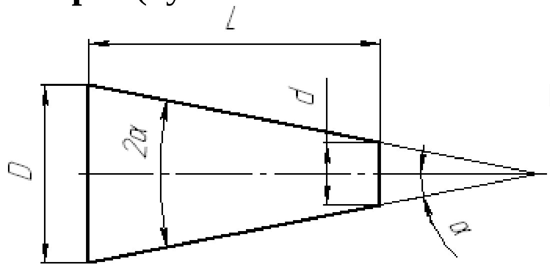
Chamfers for smooth shafts (ISO 4753:2011/GOST 10549-80)



Shaft diameter *D*, mm	16 … 20	20…30	30…50	50…100	> 100
Chamfer, *c*, mm	1	1,5	2	3	4

Table A.18

Standard taper (by ISO 1119:2011/GOST 8593-81)

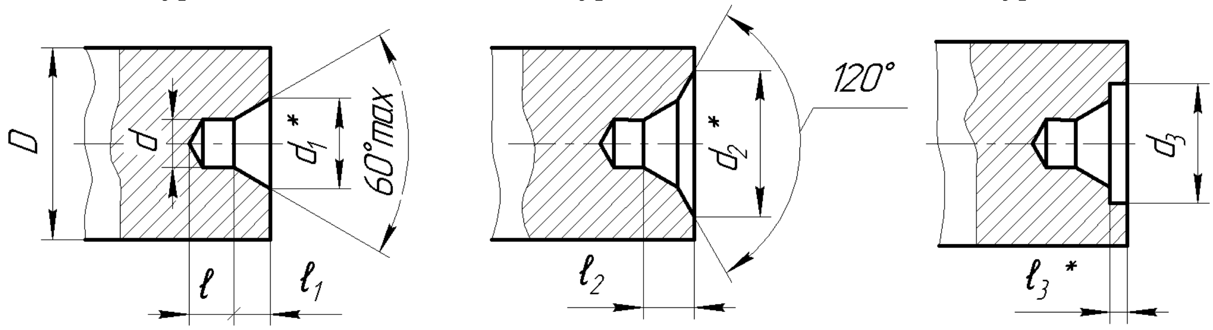


$K=(D-d)/L=2tg\alpha$

Taper ratio	**Cone angle 2α**	**Taper ratio**	**Cone angle 2α**
1:30	1º 54’ 35”	1:3	18º 55’ 29”
1:20	2º 51’ 51”	1:1,866025	30º
1:15	3º 49’ 6”	1:1,207107	45º
1:12	4º 46’ 19”	1:0,866025	60º
1:10	5º 43’ 29”	1:0,651613	75º
1:8	7º 9’ 10”	1:0,500000	90º
1:7	8º 10’ 16”	1:0,288675	120º

Table A.19

Recommended diameters for center holes
(by ISO 866:2016; ISO 2540:2016; 2541:2016/GOST 14034-74), mm

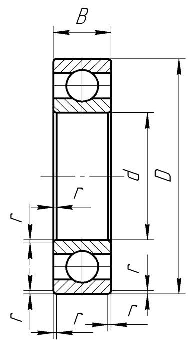


** Size for reference*

D	d	d_1	d_2	d_3	ℓ, no less	$ℓ_1$, nom.	$ℓ_2$	$ℓ_3$, no less
4	1,0	2,12	3,15	-	1,3	0,97	1,27	-
5	(1,25)	2,65	4,0	-	1,6	1,21	1,60	-
6	1,6	3,35	5,0	-	2,0	1,52	1,99	-
10	2,0	4,25	6,30	7,0	2,5	1,95	2,54	0,6
14	2,5	5,30	8,0	9,0	3,1	2,42	3,20	0,8
20	3,15	6,70	10,0	12,0	3,9	3,07	4,03	0,9
30	4	8,50	12,5	16,0	5,0	3,90	5,06	1,2
40	(5)	10,60	16,0	20,0	6,3	4,85	6,41	1,6
60	6,3	13,20	18,0	25,0	8,0	5,98	7,36	1,8
80	(8)	17,00	22,4	32,0	10,1	7,79	9,35	2,0

Table A.20

Single row ball bearings (by ISO 12044:2014/GOST 8338-75), mm



d – nominal hole's diameter of the inner ring;
D – nominal outer cylindrical surface diameter of the outer ring;
B – nominal bearing width;
r – nominal chamfer coordinate.

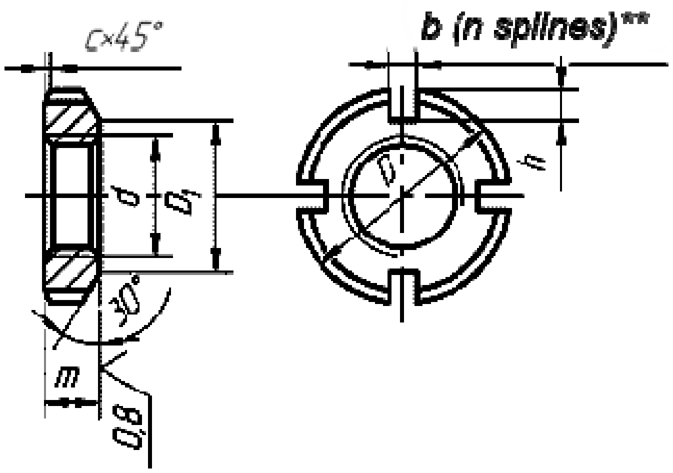
Bearing designations	**d**	**D**	**B**	**r**	**Balls**	
					D_w	**z**
Light series of diameters 2, narrow series of widths 0						
200	10	30	9	1,0	5,95	6
201	12	32	10	1,0	5,56	7
202	15	35	11	1,0	5,95	8
203	17	40	12	1,0	7,14	7
204	20	47	14	1,5	7,94	8
205	25	52	15	1,5	7,94	9
206	30	62	16	1,5	9,53	9
207	35	72	17	2,0	11,11	9
208	40	80	18	2,0	12,7	9
209	45	85	19	2,0	12,7	9
210	50	90	20	2,0	12,7	10
211	55	100	21	2,5	14,29	10
212	60	110	22	2,5	15,88	10
213	65	120	23	2,5	16,67	10
214	70	125	24	2,5	17,46	10
215	75	130	25	2,5	17,46	11
216	80	140	26	3,0	19,05	10
217	85	150	28	3,0	19,84	11
Medium series of diameters 3, narrow series of widths 0						
300	10	35	11	1,0	7,14	6
301	12	37	12	1,5	7,94	6
302	15	42	13	1,5	7,94	7
303	17	47	14	1,5	9,53	6
304	20	52	15	2,0	9,53	7
305	25	62	17	2,0	11,51	7
306	30	72	19	2,0	12,3	8
307	35	80	21	2,5	14,29	7
308	40	90	23	2,5	15,08	8
309	45	100	25	2,5	17,46	8
310	50	110	27	3,0	19,05	8
311	55	120	29	3,0	20,64	8
312	60	130	31	3,5	22,23	8
313	65	140	33	3,5	23,81	8
314	70	150	35	3,5	25,4	8

Example of designation: Ball radial bearing of an especially light series of diameters 1, a series of widths 0 with d = 50 mm, D = 80 mm, B = 16 mm: **Bearing 110 GOST 8338-75.**

Table A.21

Slotted round nuts of accuracy class A (by ISO 2982:2019/GOST 11871-88), mm

Series 1



Rounding is allowed instead of chamfer R = c

Nominal threaded diameter, **d**	**Pitch**	**D**	**D_1**	**c, no more**	**b**	**h**
6	1	16	9,5	0,6	2	2,0
8	1	22	13,5		3,5	2,0
10	1,25	24	15,5		4	2,0
12	1,25	26	17,5		4	2,0
14	1,5	28	18,5	0,6	6	2,0
16		30	22	0,6		
18		32	24	1,0		
20		34	26	1,0		
22		38	29	1	6	2,5
24		42	33			
27		45	31			
30		48	38			
33		52	40	1	8	3
36		55	42			
39		60	48			
42		65	52			
45	1,5	70	55	1	8	3
48	1,5	75	58	1	8	3,5
52	1,5	80	61	1	10	3,5
56	2	85	65	1,6	10	4
60	2	90	70	1,6	10	4,0
64		95	75			
68		100	80			
72		105	85			

Note: ** n = 4 for d = 8 – 100 mm.

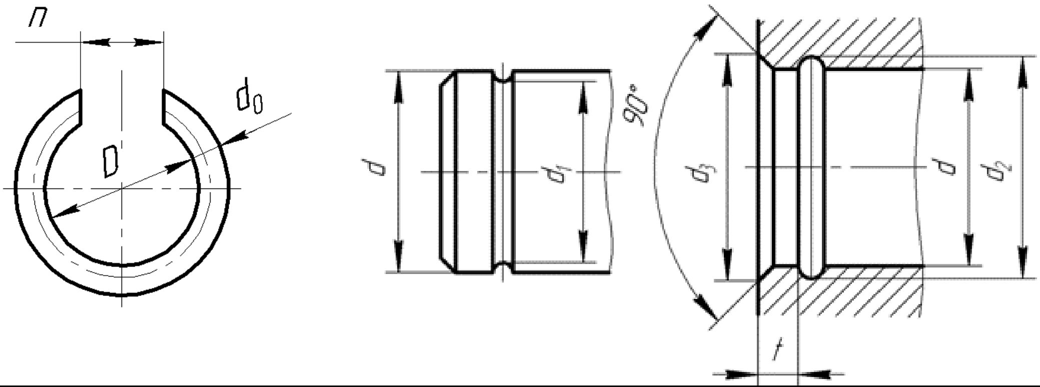
Example of designation:

Nut by GOST 11871-88 series 1, nominal threaded diameter 16 mm with the fine pith 1,5 mm, tolerance band is 6H, from carbon steel 35, with chemical oxide coating soaked in oil:

Nut M16×1,5-6H.05.05 GOST 11871-88.

Table A.22

Retaining rings (MN 470-61), mm



Nominal axis- or hole diameter, d	Ring			Groove for locking rings			
	d_0	D	n	External groove d_1	d_2	d_3	t_{nom}
4	0,8	3,4	2,5	3,6	–	–	–
5		4,4		4,6			
6		5,4		5,6			
8		7,2	4,0	7,6	8,4	9,2	1,6
10		9,2		9,6	10,4	11,2	
12	1,0	11	6,0	11,4	12,6	13,5	2,5
14		13		13,4	14,6	15,5	
16	1,6	14,5	6,0	15,0	17,0	18,0	3,0
18		16,5		17,0	19,0	20,0	
20	2,0	18,2	10,0	18,8	21,2	22,5	4,0
22		20,2		20,8	23,2	24,5	
25		23,2		23,8	26,2	27,5	
28		26,2		26,8	29,2	30,5	
32	2,5	30	12,0	30,5	33,5	35,5	
36		34		34,5	37,5	39,5	
38	2,5	36	12	36,5	39,5	41,5	5,0
40		38		38,5	41,5	43,5	
42		40	16	40,5	43,5	45,5	
45		43		43,5	46,5	48,5	
48		46		46,5	49,5	51,5	
50		48		48,5	51,5	53,5	
55	3,2	52	20	53,0	57,5	60,0	6,0
60		57		58,0	62,5	65,0	
65		62		63,0	67,5	70,5	
70	3,2	67	25	68,0	72,5	75,0	
75		72		73,0	77,5	80,0	
80		77		78,0	82,5	85,0	
85		82		83,0	87,5	90,0	
90		87		88,0	92,5	95,0	
95		92		93,0	97,5	100,0	
100		97	32	98,0	102,5	105,0	

Note: Material – carbon steel spring wire class II – according to GOST 9389-75.

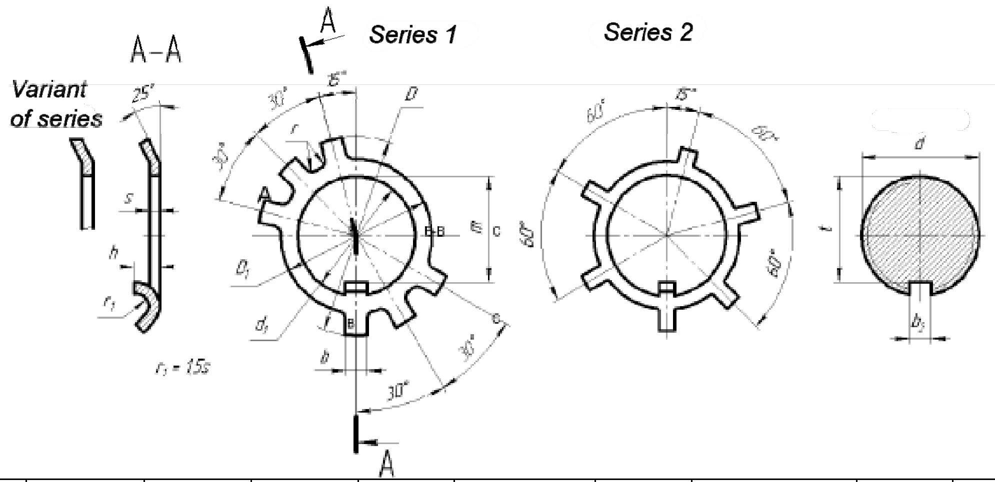
Example of designation: Retaining rings with diameter 20mm:
Retaining rings **20 MN 470-61.**

Table A.23

Key lock washer (by ISO 2982:2019/GOST 11872-89), mm

Key lock washer of accuracy class A is designed to lock round slotted nut; make: L – light; N – normal.

Type N – normal



<table>
<tr><th>Nominal threaded diameter, d</th><th>d_1</th><th>D</th><th>D_1</th><th>b</th><th>h</th><th>m</th><th>r, no more</th><th>s</th><th>t</th><th>b_2</th></tr>
<tr><td>10</td><td>10,5</td><td>26</td><td>16</td><td>3,8</td><td>2,5-4</td><td>7,0</td><td>0,2</td><td rowspan="9">1,0</td><td>8</td><td>4,3</td></tr>
<tr><td>12</td><td>12,5</td><td>28</td><td>18</td><td>3,8</td><td>2,5-4</td><td>9,0</td><td>0,2</td><td>10</td><td>4,3</td></tr>
<tr><td>(14)</td><td>14,5</td><td>30</td><td>20</td><td>3,8</td><td>2,5-4</td><td>11</td><td>0,2</td><td>12</td><td>4,3</td></tr>
<tr><td>16</td><td>16,5</td><td>32</td><td>22</td><td>4,8</td><td>2,5-4</td><td>13</td><td>0,5</td><td>14</td><td>5,3</td></tr>
<tr><td>(18)</td><td>18,5</td><td>34</td><td>24</td><td>4,8</td><td>2,5-6</td><td>15</td><td>0,5</td><td>16</td><td>5,3</td></tr>
<tr><td>20</td><td>20,5</td><td>36</td><td>27</td><td>4,8</td><td>3,5-6</td><td>17</td><td rowspan="8">0,5</td><td>18</td><td>5,3</td></tr>
<tr><td>(22)</td><td>22,5</td><td>40</td><td>30</td><td>4,8</td><td>3,5-6</td><td>19</td><td>20</td><td>5,3</td></tr>
<tr><td>24</td><td>24,5</td><td>44</td><td>33</td><td>4,8</td><td>3,5-6</td><td>21</td><td>21,5</td><td>5,3</td></tr>
<tr><td>(27)</td><td>27,5</td><td>47</td><td>36</td><td>4,8</td><td>4,5-8</td><td>24</td><td>24,5</td><td>5,3</td></tr>
<tr><td>30</td><td>30,5</td><td>50</td><td>39</td><td>4,8</td><td rowspan="4">4,5-8</td><td>27</td><td>1,0</td><td>27,5</td><td>5,3</td></tr>
<tr><td>(33)</td><td>33,5</td><td>54</td><td>42</td><td>5,8</td><td>30</td><td>1,6</td><td>30,5</td><td>6,3</td></tr>
<tr><td>36</td><td>36,5</td><td>58</td><td>45</td><td>5,8</td><td>33</td><td>1,6</td><td>33,5</td><td>6,3</td></tr>
<tr><td>(39)</td><td>39,5</td><td>62</td><td>48</td><td>5,8</td><td>36</td><td>1,6</td><td>36,5</td><td>6,3</td></tr>
<tr><td>42</td><td>42,5</td><td>67</td><td>52</td><td>5,8</td><td>4,5-8</td><td>39</td><td>0,5</td><td rowspan="12">1,6</td><td>39</td><td>6,3</td></tr>
<tr><td>(45)</td><td>45,5</td><td>72</td><td>56</td><td>5,8</td><td>4,5-8</td><td>42</td><td>0,5</td><td>42</td><td>6,3</td></tr>
<tr><td>48</td><td>48,5</td><td>77</td><td>60</td><td>7,8</td><td>4,5-8</td><td>45</td><td>0,8</td><td>45</td><td>8,3</td></tr>
<tr><td>(52)</td><td>52,5</td><td>82</td><td>65</td><td>7,8</td><td>5,5-10</td><td>49</td><td>0,8</td><td>49</td><td>8,3</td></tr>
<tr><td>56</td><td>57</td><td>87</td><td>70</td><td>7,8</td><td rowspan="4">5,5-10</td><td>53</td><td rowspan="8">0,8</td><td>52,5</td><td>8,3</td></tr>
<tr><td>(60)</td><td>61</td><td>92</td><td>75</td><td>7,8</td><td>57</td><td>56,5</td><td>8,3</td></tr>
<tr><td>64</td><td>65</td><td>97</td><td>80</td><td>7,8</td><td>61</td><td>59,5</td><td>8,3</td></tr>
<tr><td>(68)</td><td>69</td><td>102</td><td>85</td><td>9,5</td><td>65</td><td>63,5</td><td>10</td></tr>
<tr><td>72</td><td>73</td><td>107</td><td>90</td><td rowspan="4">9,5</td><td rowspan="4">6,5-13</td><td>69</td><td>67,5</td><td>10</td></tr>
<tr><td>(76)</td><td>77</td><td>112</td><td>95</td><td>73</td><td>70,5</td><td>10</td></tr>
<tr><td>80</td><td>81</td><td>117</td><td>100</td><td>76</td><td>74,5</td><td>10</td></tr>
<tr><td>(85)</td><td>86</td><td>122</td><td>105</td><td>81</td><td>79,5</td><td>10</td></tr>
</table>

Example of designation:

Key lock washer series 1, type N, for round slotted nut with nominal threaded diameter 64 mm, from material group 01, coating 05:

Nut N. 64.01.05 GOST 11872-89.

The light type of washers is not indicated in the designation.

CONTENT

Навчальне видання

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Чумаченко Андрій Вікторович
Мсаллам Катерина Петрівна
Панченко Оксана Іванівна
Перехрест Наталія Вікторівна

ВАЛИ ТА ЗУБЧАСТІ ЗАЧЕПЛЕННЯ. ЗОБРАЖЕННЯ НА КРЕСЛЕННЯХ

(Англійською мовою)

Редактор С. В. Опаріна
Технічний редактор А. М. Ємленінова

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Замовлення 384. Ціна вільна

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Свідоцтво про внесення суб’єкта видавничої справи
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