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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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THE DESIGN OF VERSATILE JIGS AND DIES, EACH SUITABLE FOR USE IN THE PRODUCTION OF A VARIED GROUP OF PARTS[1]

by

S. Mitrofanov
Union of Soviet Socialist Republics

1/ The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO.

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Contents

In the solution of problems of improving the organisation, control and servicing of production operations, an important part is played by the various technical and organisational measures which, together, make up the technical preparations for production. The proper organization of these technical preparations is the basis for subsequent technical progress in the improvement of the technology, organisation and economics of production. The outmoded system of preparations based on the establishment and utilisation of individual processes, which is still followed in many factories, does not permit the most effective and comprehensive utilisation of the extensive fund of industrial experience available. This is particularly marked in conditions of one-off, short-run and series production, where the change-over to the production of a new type of part usually involves the need to prepare anew large amounts of different kinds of production and technical documentation. Hundreds and even thousands of new jigs, punches, dies and other types of production equipment must be designed and made, and this involves heavy cost as well as leading to inefficient utilisation of the time of designers, technicians and the highly skilled workers of toolmaking shops.

The cost of the planning and manufacture of production equipment accounts for between 50 per cent (in the case of short-run production) and 80 per cent (in the case of long-run production) of the entire cost of the preparations for production, and thus appreciably affects the cost of the product.

In many factories, special equipment has only a short life because of the continuous introductions and production of new machines and instruments. Such equipment is taken out of service when the product is changed, and in the majority of cases this occurs long before the equipment is physically worn out. It would appear that in most cases the need to prepare special equipment for the manufacture of new products could be avoided by using the existing equipment.

When production processes are planned singly and a wide range of parts is produced, however, such a rational approach is almost impossible: each technician and designer prepares new production equipment as he sees fit.

The design of individual processes for each part/operation prevents wide use being made of pneumatic and other fast-running drives, as such rapid running would involve additional expenses which are not always justified. There is thus a conflict between the need for the rapid preparation, at the lowest possible cost in time and money, of large amounts of equipment for producing new parts, on the one hand, and the need for the attainment of maximum productivity on the other hand.

This conflict can be overcome by the development of standardized and unified high-productivity equipment with components which can be adjusted and exchanged. The term "unification", as used in connexion with production equipment, means the designing of a piece of equipment, such as a jig, so that it can be used for the production of different parts by adjusting and/or exchanging its individual components and units.

The unification of equipment is closely linked with its standardization and universalization. Standardization may affect either the individual parts of a jig or the jig as a whole (standardized models of universal equipment).

In designing group-adaptable (adjustable) equipment, the widest possible use must be made of units, parts and elements which comply with established State standard specifications.

It is worth noting that although there are adjustable and exchangeable jig systems which have been amply proved in factory practice, and although the effectiveness of these systems has been clearly demonstrated (especially in one-off and series production), their adoption on a wide scale is proving extremely slow. Once again, this state of affairs is explained by the absence of any clear-cut system for the technological preparation of production.

The question of how best to select and utilize unified high-productivity equipment can only be solved by first undertaking the extensive work needed to solve the more general problem of the scientific organization of the technical preparation of production. The heart of such a solution must be the principle of the unification of production along two basic lines: the establishment of groups of parts and the classification of production processes into certain types. Both these lines of approach are based on the classification of the parts produced according to a system which has already been fully worked out.

Without considering further the question of classification, which is a special subject, let us now consider the main principles of planning production equipment for group applications.

Principles of designing machine tool jigs

Jigs are divided up, accordingly to their universality, into the following groups:

I. Special (SP) jigs designed for a single part/operation or a single operation on a group of parts of similar design and production characteristics. These jigs cannot be adjusted.

II. Universal (UP) jigs, which can be used for different parts because their design enables them to be adjusted.

III. Exchangeable-component multi-purpose jigs, including:

1. Universal exchangeable-component (UMP) jigs, which are universal jigs with exchangeable components enabling them to be used for parts of various types;
2. Group-adaptable (GP) jigs, which are jigs designed to be used for a certain specific group of parts. These jigs may be of three types:
   (a) Jigs with exchangeable components which can be fixed to suit given parts (GPN);
   (b) Jigs with fixed bases, enabling several different parts to be fastened in a single unitary jig for simultaneous machining without the need for changing the jig components (GPP);
3. Universal fabricated jigs (USP).

Let us consider the principles of the design of exchangeable-component multi-purpose jigs designed to suit a certain group of parts.

Group-adaptable and universal exchangeable-component jigs are designed for use on groups of parts which all require setting up and fastening in a similar manner.

The working of parts of different shapes in a single jig is made possible by the existence of exchangeable or adjustable jig components. In order to achieve the requisite productivity and accuracy of machinery, jigs must have the following features:

1. They must permit the rapid and stable setting up of any part from a given group in them, and they must have quick-acting manual, mechanized or automatic clamping devices;
2. They must be simple in operation;
3. They must be of suitably rigid construction;
4. They must be designed for rapid mounting on the machine tool and rapid removal after use.

The provision of all these features may increase the complexity and cost of a jig, but even so, group-adaptable and universal exchangeable-component jigs are economically justified because the expense of their design and preparation is covered by the increase in the number of different parts which they can accept.

When designing group-adaptable jigs, the designer must take into account the production capabilities of the enterprise, the characteristics of its machinery and equipment, the layout of the group process, the special features of the parts forming the group, and the size of the batch of parts to be produced.

In designing such jigs, it is essential to make use of previously accumulated experience by studying existing designs of special jigs which have previously been used for the parts making up the group.

The method of designing group-adaptable jigs is basically the same as for designing ordinary jigs, and comprises the following stages:

1. Study of the basic design data;
2. Preparation of a draft or rough outline of the jig;
3. Calculations regarding accuracy of setting, strength, and clamping forces;
4. Determination of the economic expediency of the selected type of design;
5. Final working out of the design.

The technical requirements which must be satisfied in designing group-adaptable jigs are established basically from an analysis of the design and production features of the parts belonging to the group in question and from study of the nature of the mounting surfaces and means of fastening the parts.

The basic design data are:

1. Drawings of the group of parts for which the jig is being developed;
2. Details of the production process for the parts;
3. Details of the machine tool on which the group-adaptable jig is to be used;
4. Drawings of the individual jigs previously used, if the group-adaptable jig which is being designed is intended to replace individual jigs;
5. Details of the tool to be used for working the parts.

The designer will obtain information bout the machine tool on which the parts are to be worked, the cutting tool, the cutting rates, and the sequence of operations or transfers, when familiarizing himself with the production process.

There are close links between the development of a group production process and the design of the jigs for it. In certain cases, it is not possible to plan group operations without knowing the design of the jig. The production technologist and the jig designer must therefore frequently work together. In the process of designing a jig, it may become necessary to make certain modifications in the grouping of parts and in the production process.

In designing special jigs, the first process in the drafting of the design is usually the preparation of drawings of the outline of the parts to be produced, in the appropriate number of projections. Sketches are then made of the proposed type of jig incorporating the construction which the designer has in mind.

The design of group-adaptable jigs is complicated by the fact that it is necessary to solve the problem of mounting and clamping a whole range of parts rather than merely a single part. The design of the necessary exchangeable units and components must therefore be carried out at the same time as the preparation of the design for the fixed (basic) part of a group-adaptable jig.

In order to solve this problem as effectively as possible, the parts to be manufactured in such a jig must also be classified by the way in which they are mounted for each operation.

At this stage of the classification of the parts according to the features referred to above, the subject of the grouping process is no longer just the part itself, but the part/operation. This is necessary for the following reasons. When exchangeable jig components are used, a series of part/operations which are similar from the point of view of equipment and fittings are carried out at each working point. The basic features of any part/operation are: the surfaces of the parts which are to be machined, the machine tool to be used, and the jig and tool to be employed. If the surfaces to be machined are identical in shape, accuracy and surface finish, then the methods of producing such surfaces will be invariable also. Consequently, the feature "nature of mounting" means that all the parts in a group, regardless of their design, must share a common feature in the way they are mounted in the jig. In any jig, there are a number of elements which determine the location of a part in it. A characteristic feature of group-adaptable jigs is that their locating elements are usually designed separately for each part/operation: i.e., they are exchangeable and are changed for working a new part in the group.

The primary element of a group-adaptable jig is its base section, on which the exchangeable components holding the part are fastened. The bed is the same for the entire group of part/operations for which the jig is designed. The number of possible different methods of action of the mounting and fastening components is usually only small for a given jig.

Thus, for example, even in the case of a large group of parts such as brackets, levers, and plates (Figure 1), which require milling and involve 1.5 thousand possible part/operations there are only 11 different types of mounting (Figure 2).

Each of these different types represents a different design of group-adaptable jig. Thus, for part/operations of mounting types I and II, a table-type, group-adaptable jig with vertically acting clamps is required. For types IV and V, normal and four-jaw pneumatic clamps are used and the jig is rotatable.

For every part/operation coming within the range of a given jig, the jig must be set up by the use of unified exchangeable components.

Figure 3 shows a group-adaptable jig with a pneumatic/hydraulic table 1, used for fastening parts for processing on a milling machine.

Figure 1

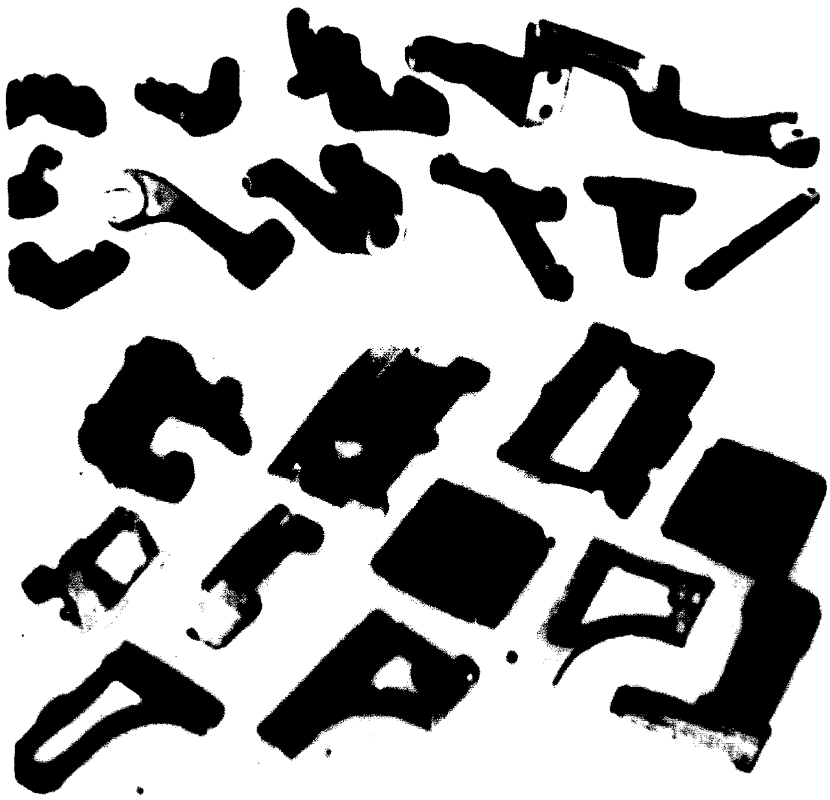
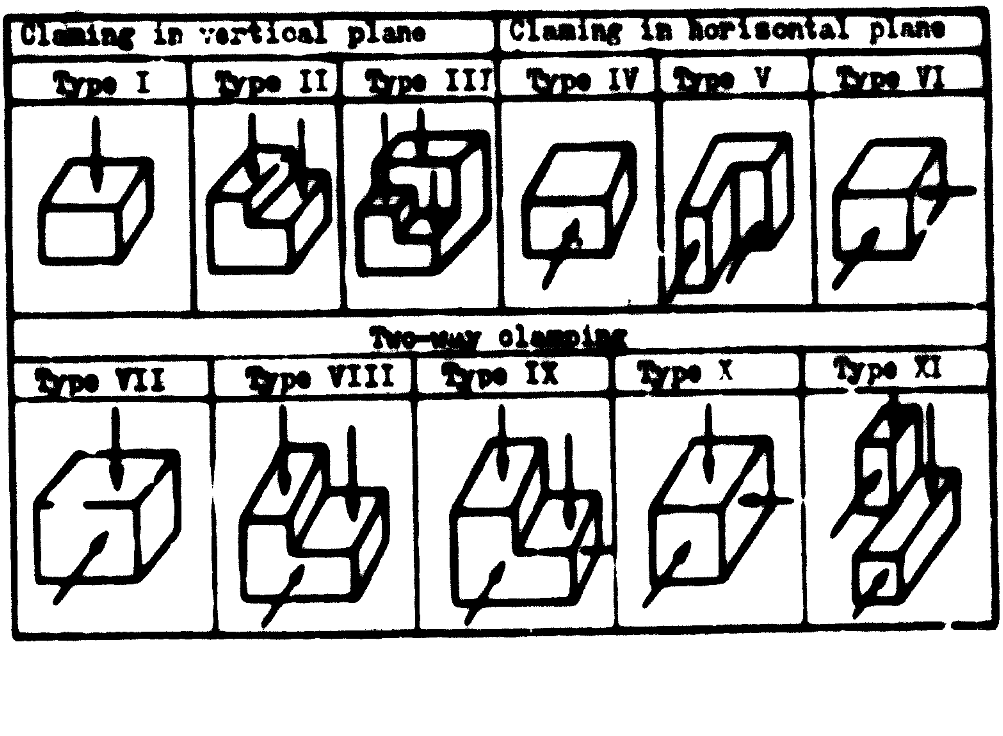


Figure 2



The small and large models of this table have four and twelve built-in hydraulic cylinders, respectively. The rams of the hydraulic cylinders travel above the surface of the table and can be made to actuate, through appropriate linkages, the clamping elements of the exchangeable components mounted on the table.

The parts are located by means of exchangeable stops mounted in T-shaped grooves in the table. If the mounting surface of a part has protrusions, packing pieces are used.

Figure 4 shows one layout for the group-adaptable components of a jig.

Let us consider a number of examples of the design of group-adaptable jigs for the machining of various groups of parts on metal-working machine tools.

Figure 5 shows the groups arrived at, after classification, for parts requiring milling.

Figure 6 shows a group of parts (Group 1, Figure 1) produced by pressure casting; parallel surfaces have to be machined on all these parts. Previously each part was mounted in a special jig, but by assembling all these parts into a production group it has been possible to develop a group-adaptable jig for them.

It can be seen from the diagrams of the mounting and fastening of these parts that the mounting surfaces used are of different sizes and differently located with respect to each other, so that a set of exchangeable inserts is required. Figure 7 shows some varieties of such inserts.

The parallel surfaces of the group of parts in question are machined on a horizontal milling machine with two disc-type milling heads. This method of machining dictated the design of the group-adaptable jig shown in Figure 8.

This jig consists of a baseplate 1 and a yoke 2 with exchangeable clamps and exchangeable plates 3 which locate the various parts in the group in the jig.

The part to be machined, together with the appropriate exchangeable plate, is usually fixed in the jig on the base surface of the plate 3. In order to fix the part, the appropriate exchangeable clamps are selected and fixed on the

Figure 3

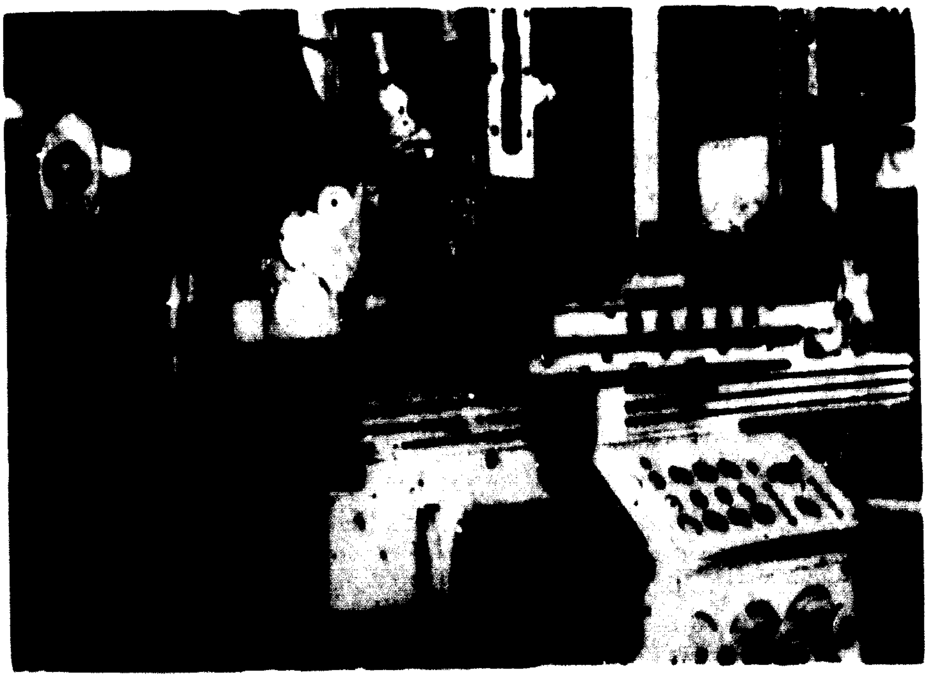
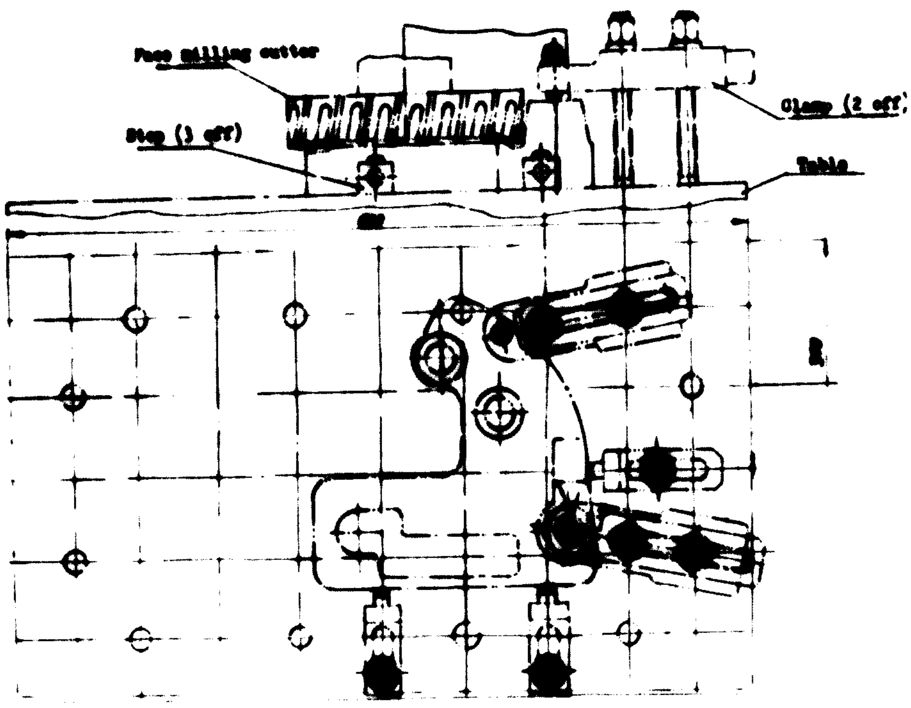
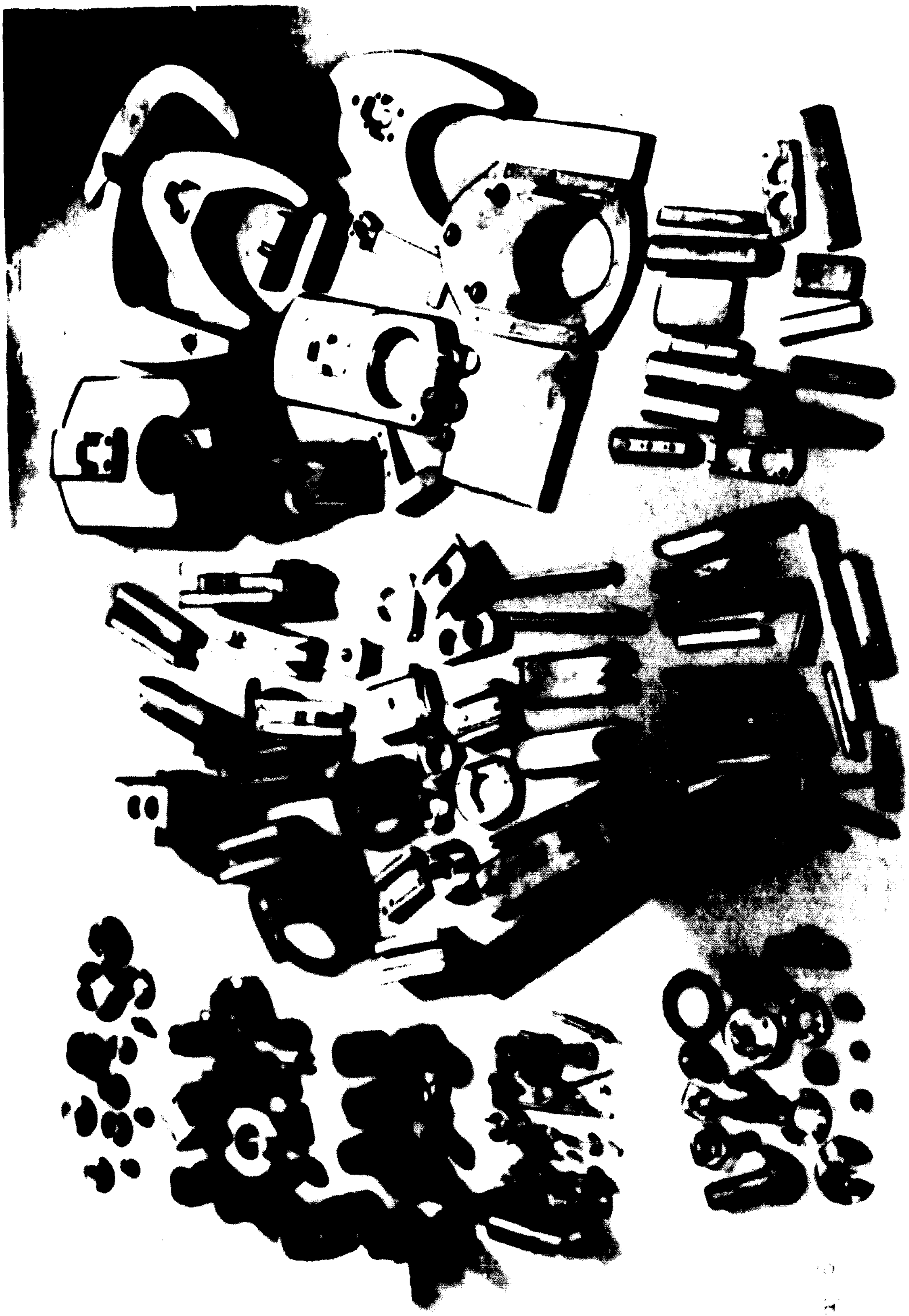


Figure 4



Note: Exchangeable component is used for operation 9 and for machining surfaces 2 and 19 of part 5.

Figure 5



Group 2

Group 3

Figure 6

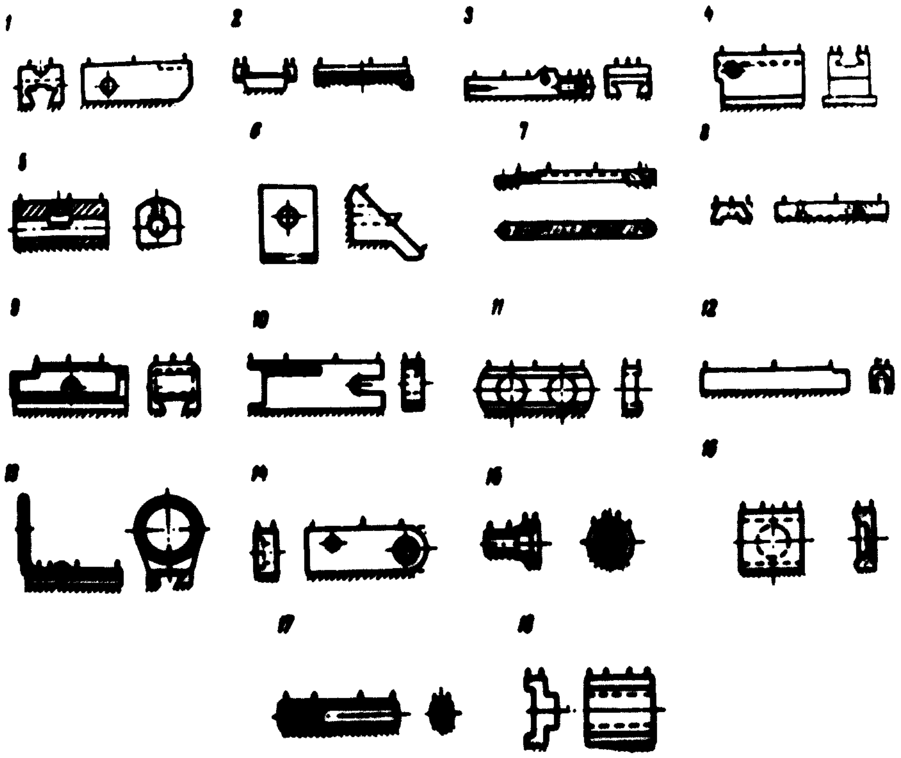


Figure 7

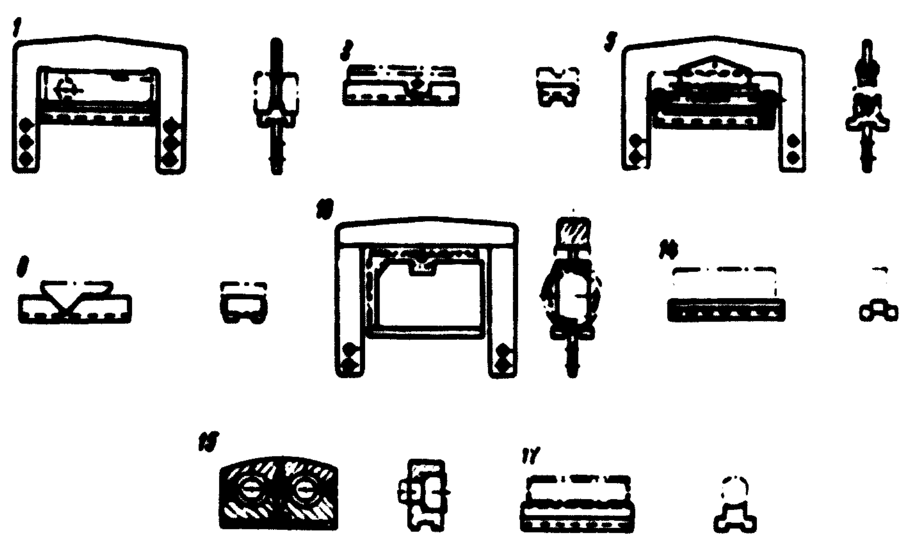
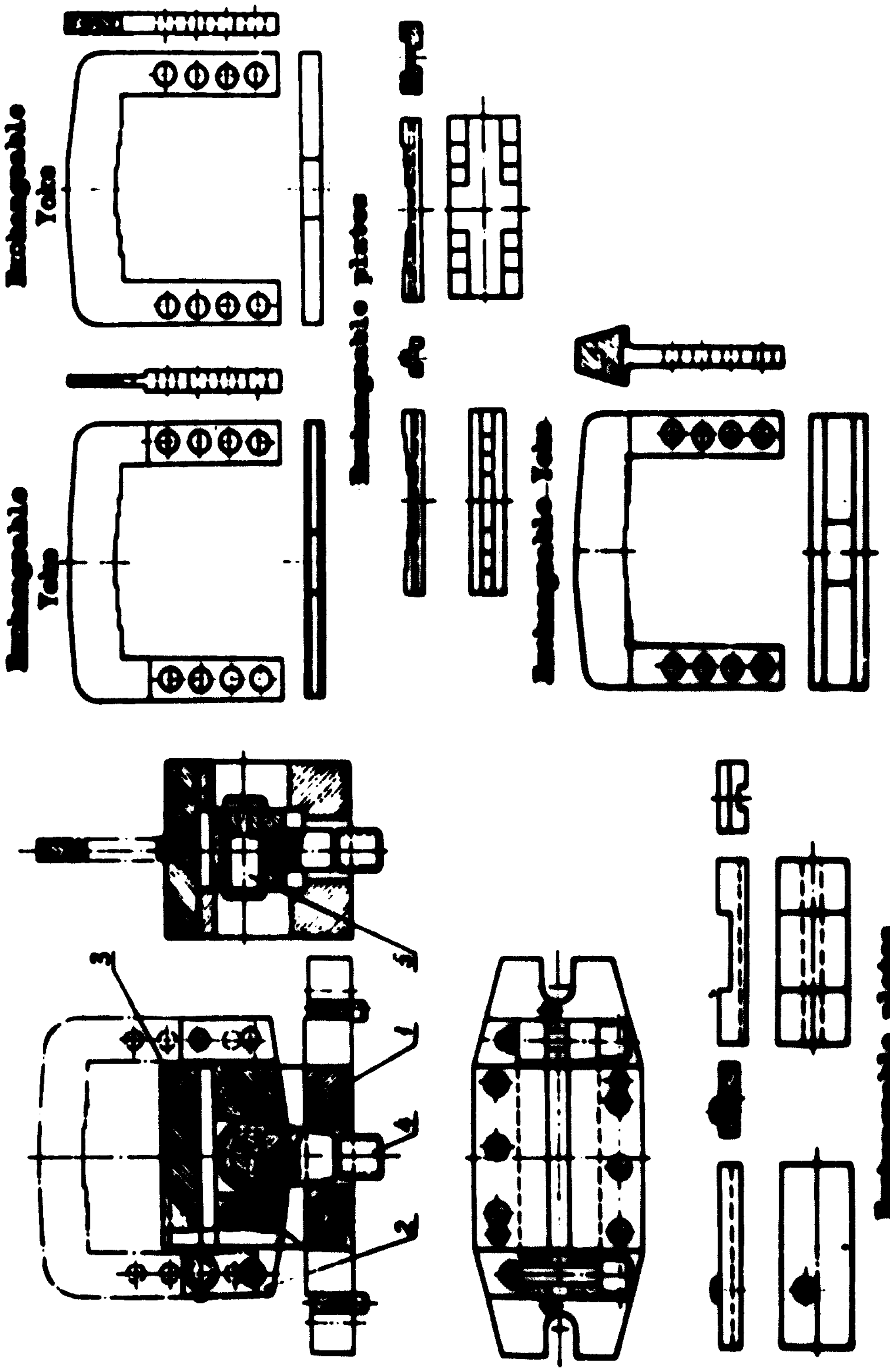


Figure 8



yoke 2 by means of pins fitting into holes in the clamp and the yoke. The jig is installed above a pneumatic cylinder, and when compressed air is admitted to the upper chamber of the cylinder the [illegible] is drawn down, taking with it the yoke 2 carrying the exchangeable clamp, which thus clamps the part.

Figure 9 shows various groups of parts, classified according to the established method referred to above, which require machining on ordinary or turret lathes.

Each of these groups can be machined on ordinary or modernised lathes, but the machining of each of them calls for group-adaptable jigs which make possible the rapid setting up and fastening of the part and the quick adjustment of the lathe when changing over from the machining of one part in the group to that of another. Thus, for example, Figure 10a shows a group of parts whose mounting surfaces are so located as to make their fastening on the lathe a complicated matter necessitating the use of special jigs of quite complex design. The use of the group method of machining has made it possible, however, to develop a group-adaptable jig in which any part of the group in question can be fastened. Figure 10b shows the design of this jig, which is installed on the faceplate of a turret lathe and is fastened to it by means of screws. The jig consists of three basic parts: an angle bracket 1, on which the exchangeable insert 3 is fixed, the faceplate 2, and a clamping device consisting of a clamp 9 with a pivoted pressure plate 10. The bracket 1 and the fixed counterweight 11 are fastened to the faceplate by screws 15. A movable counterweight 4 is provided between the bracket and the fixed counterweight, so that the jig can be accurately balanced.

The jig is set up as follows. An insert is selected to suit the part to be machined, and its shaped end is inserted in the groove of the bracket 1. The two pins 13 are then tightened by turning the nuts 14, thus pressing the insert against the bearing surface of the bracket.

After the part has been set up on the insert, the clamping device is adjusted to suit the height of the part. For this purpose the eye nut 8, to which the clamp 9 is connected by a pivot pin 7, is screwed up or down the pin 6 sufficiently to clamp the part. The nut 12 is adjusted in a similar manner.

After the jig has been adjusted, it is balanced by means of the movable counterweight. In order to do this, the screw 5 is turned so as to raise or

Figure 9

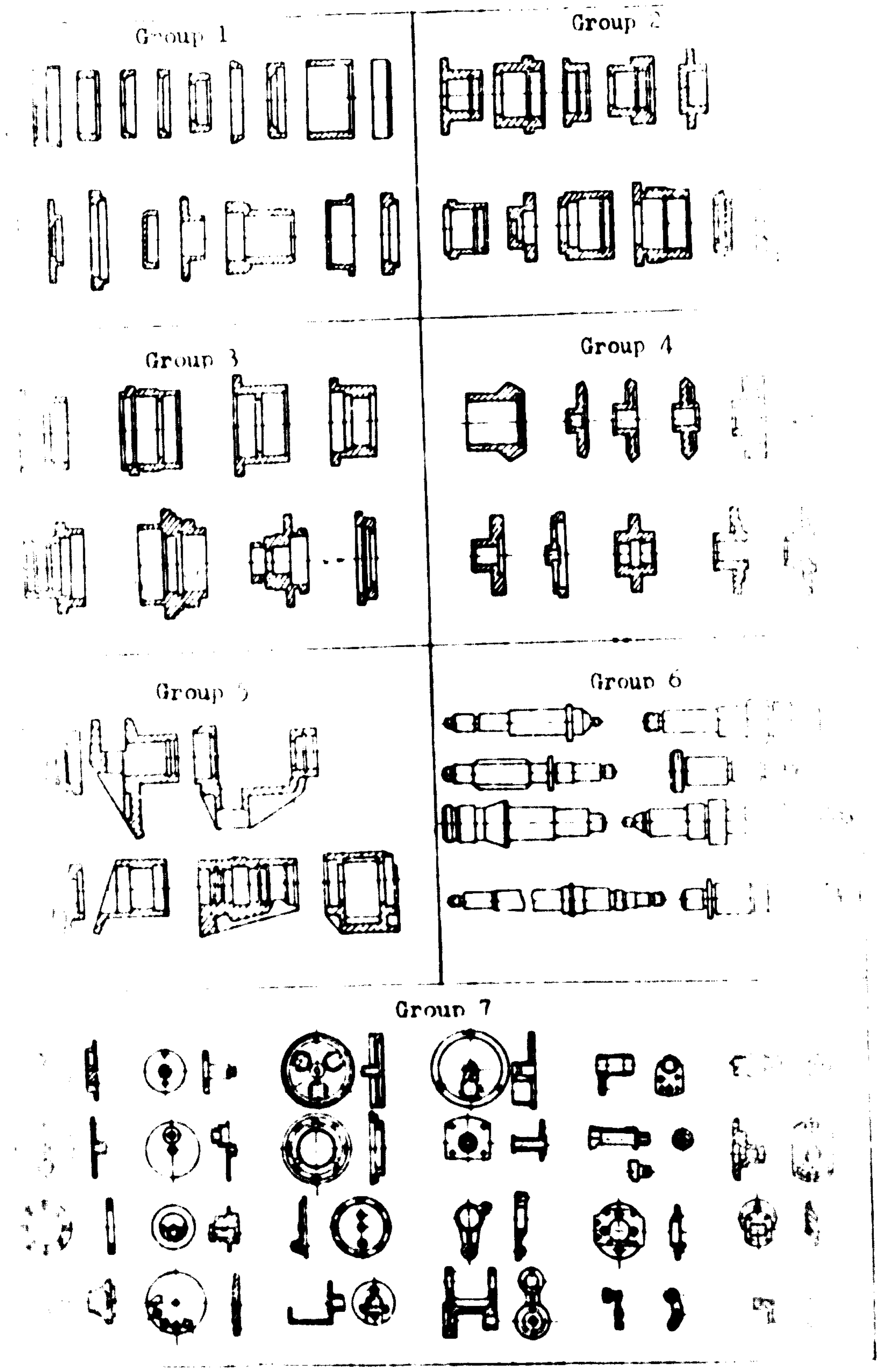
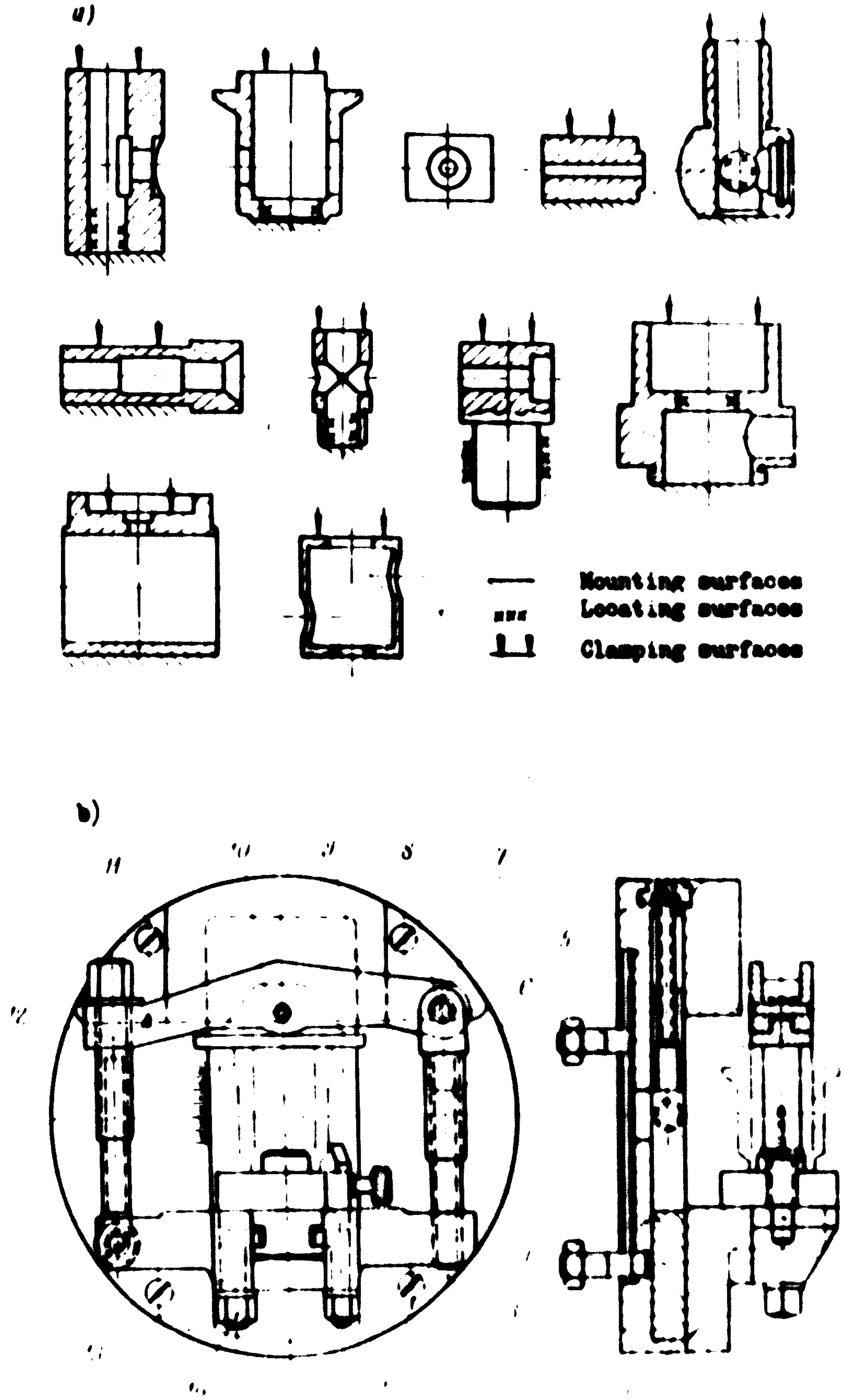


Figure 10


a)
Mounting surfaces
Locating surfaces
Clamping surfaces
b)

lower the counterweight until a groove marked on the latter coincides with a particular degree on the scale engraved on the faceplate (the degree corresponding to the part to be machined is marked on the insert). The counterweight is then blocked with a set screw and the setting up of the jig is complete.

Figure 11 shows the design of inserts with parts fitted on them.

Figure 12 shows the design of a group-adaptable lathe jig.

This jig consists of three basic parts: a faceplate 10, an angle bracket 13 and a clamping device. The clamping device, which is fastened on the bracket 13, consists of a pivoted bolt 8 with a sleeve nut 9, a pivoted arm 2 with a screw 1, and a pivoted prism-shaped block 3, an eye nut 4 and a pin 5. The jig is balanced by a fixed counterweight 12.

The jig is set up as follows. The exchangeable insert required for the part to be machined is installed with its longitudinal groove on the peg 6 and is fastened to the bracket by screws 7. After the part has been set up and fastened on the insert, the clamping device is adjusted to suit the height of the part. In order to do this, the eye nut 4 is screwed up or down the pin 5 sufficiently to clamp the part. The sleeve nut 9 is adjusted in a similar manner. The pivoted arm 2 is attached to the eye nut by a pivot pin. The shape of the prism-shaped block 3 installed on the arm 2 must correspond with the shape of the part to be machined.

After the jig has been set up, it is balanced by means of the movable counterweight 14. In order to do this, the screw 11 is turned so as to raise or lower the counterweight until the groove marked on it coincides with a particular degree of the scale engraved on the faceplate 10 corresponding to the part to be machined. This degree is specified on the insert.

The upper part of the figure shows some typical parts (I-V) machined in such a jig. The design of the exchangeable inserts which locate the parts is shown in the lower part of the figure. Thus, for example, the part I is located by means of a pin. Part II is located by means of a pin in the longitudinal direction, while in the transverse direction it is located by being clamped to the base surface with a set screw. Part IV is located by means of a pin in the longitudinal direction, while in the transverse direction it is pressed against

Figure 11

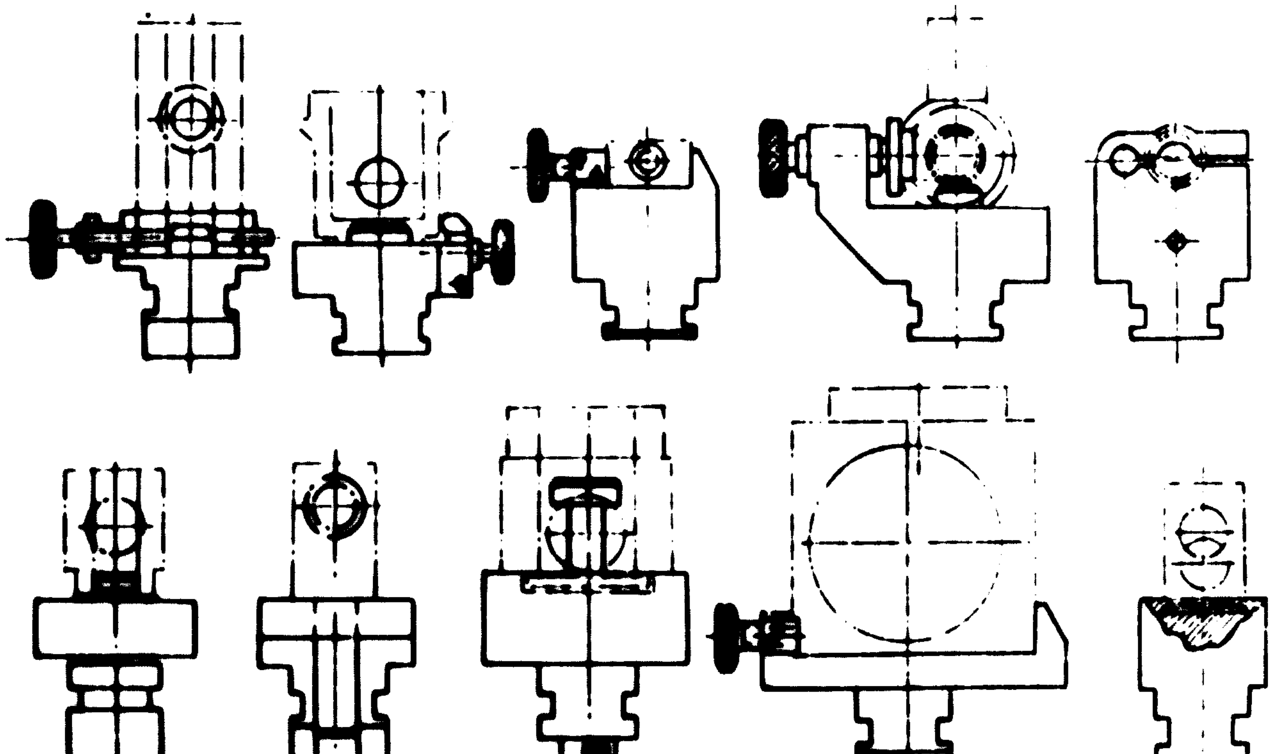
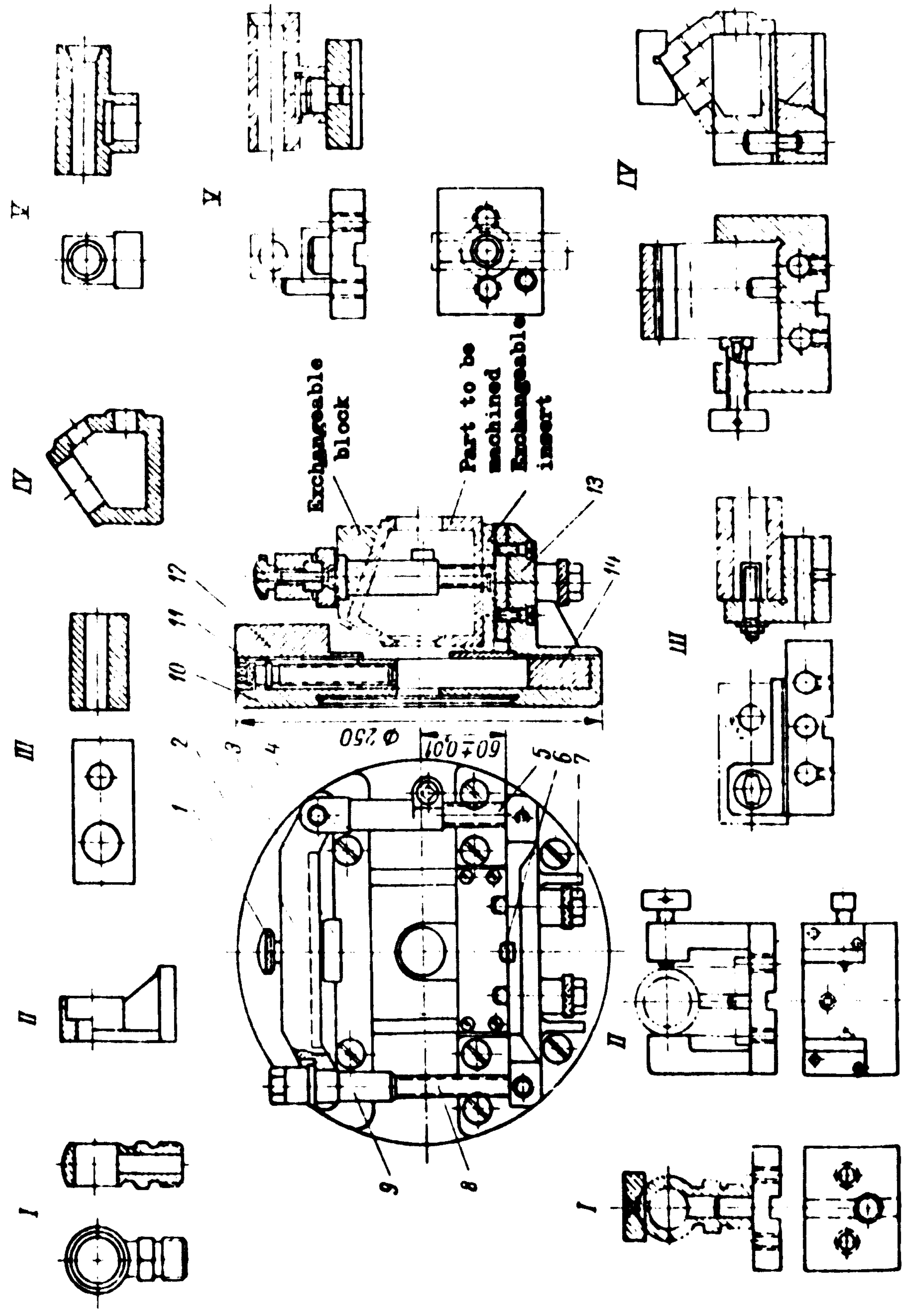


Figure 12


Exchangeable block
Part to be machined
Exchangeable insert
Φ 250
60 ± 0.01
1
2
3
4
5
6
7
8
9
10
11
12
13
14
I
II
III
IV
V

the mounting surface of the insert with a set screw. The part is finally fastened in place by means of an exchangeable prism-shaped clamp

The parts are machined on a lathe equipped with a [illegible]-position turret head, a longitudinal slide and a 3-position head attached to the tail spindle of the tailstock (Figure 13).

A large number of the most varied kinds of equipment are used in connexion with drilling machines, such as: plunger and other types of exchangeable-component and group-adaptable jigs, revolving tables and supports, multi-spindle and turret heads, and all sorts of auxiliary tools.

In the group method of machining, where the parts to be machined are classified in groups (Figure 15) and set up on a given machine tool, all this equipment is particularly widely used. Experience shows that the majority of parts can be machined with the aid of universal and group-adaptable jigs.

By way of example, let us consider the machining of the group of parts shown in Group 4 in Figure 14.

The parts in Group 4, which consist of levers, rocker arms and pull rods in which holes must be drilled, can be mounted and fastened in universal exchangeable-component and group-adaptable jigs.

The group-adaptable pneumatic jig shown in Figure 15 is designed for the machining of parts with a boss diameter of up to 100 mm, a height of up to 80 mm and a diameter of the orifice to be machined of up to 40 mm. Other designs of exchangeable-component plunger jigs are also used for the machining of such parts.

The main body 1 of the jig contains an air chamber 2 with a diaphragm 3 and an air control valve 4. The upper movable plate 5, in which the exchangeable jig inserts 6 and the exchangeable discs 7 are mounted, is connected by two rods 8 with the diaphragm 3.

The figure shows the frequent case of the mounting of a part which consists of a lever with a single boss. The lever is set on the already machined surface of the boss and centred with the exchangeable disc 7. When setting up is complete, the handle 9 is turned to deliver compressed air to the air chamber, whereupon the diaphragm 3 and the rods 8 and plate 5 connected to it are forced down and clamp the part.

Figure 13

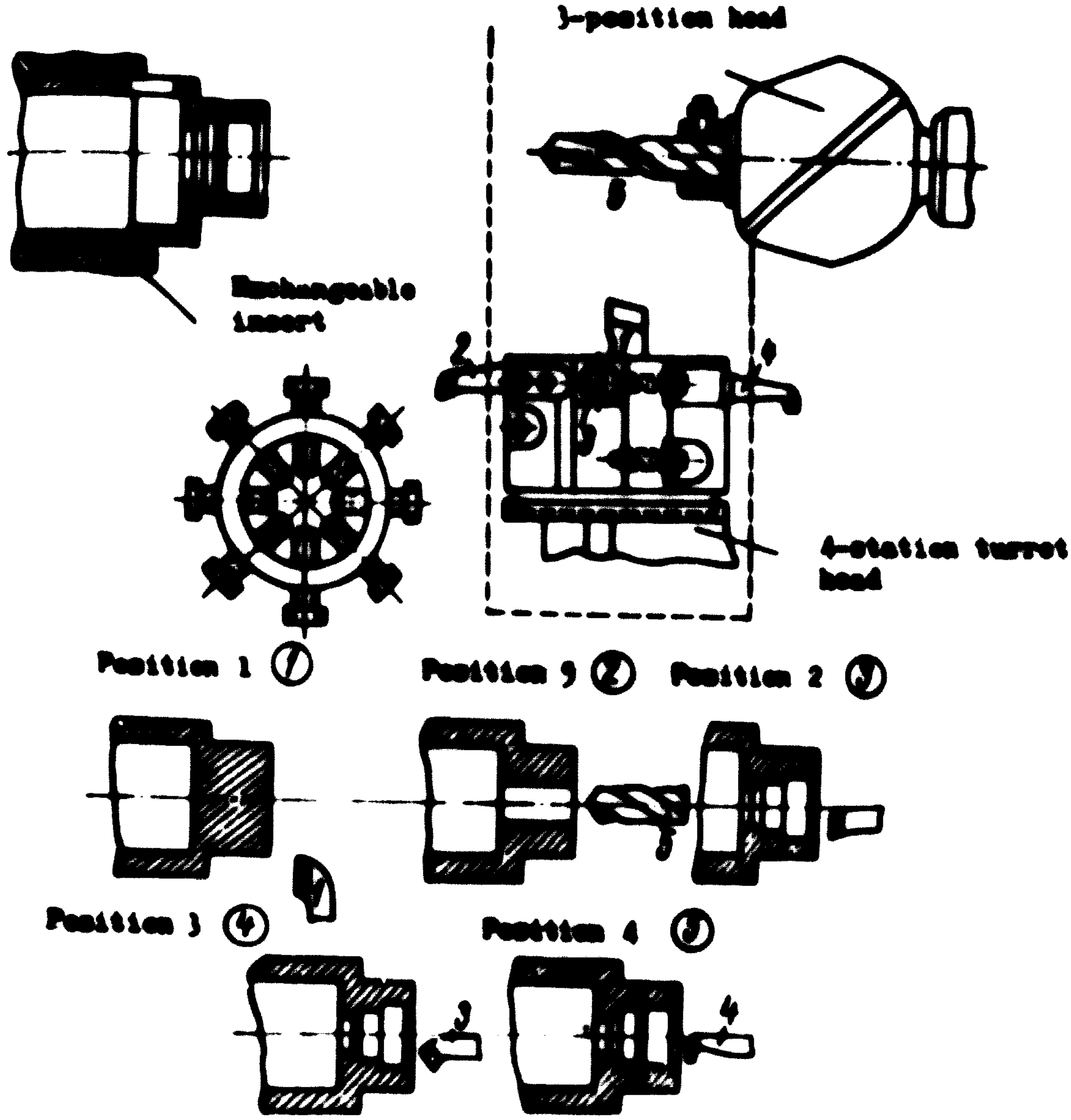

3-position head
Exchangeable insert
4-station turret head
Position 1
Position 5
Position 2
Position 3
Position 4

Figure 14

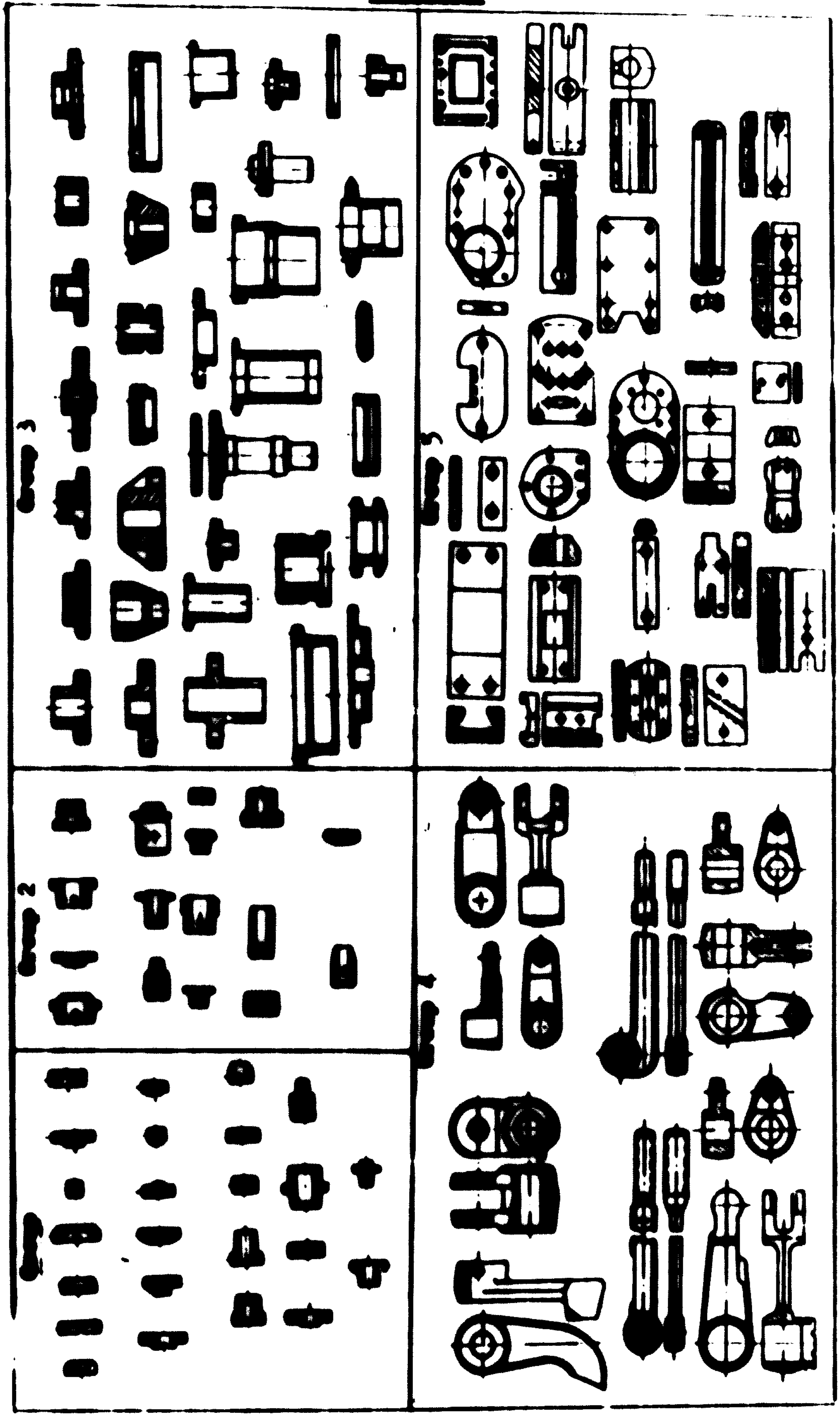
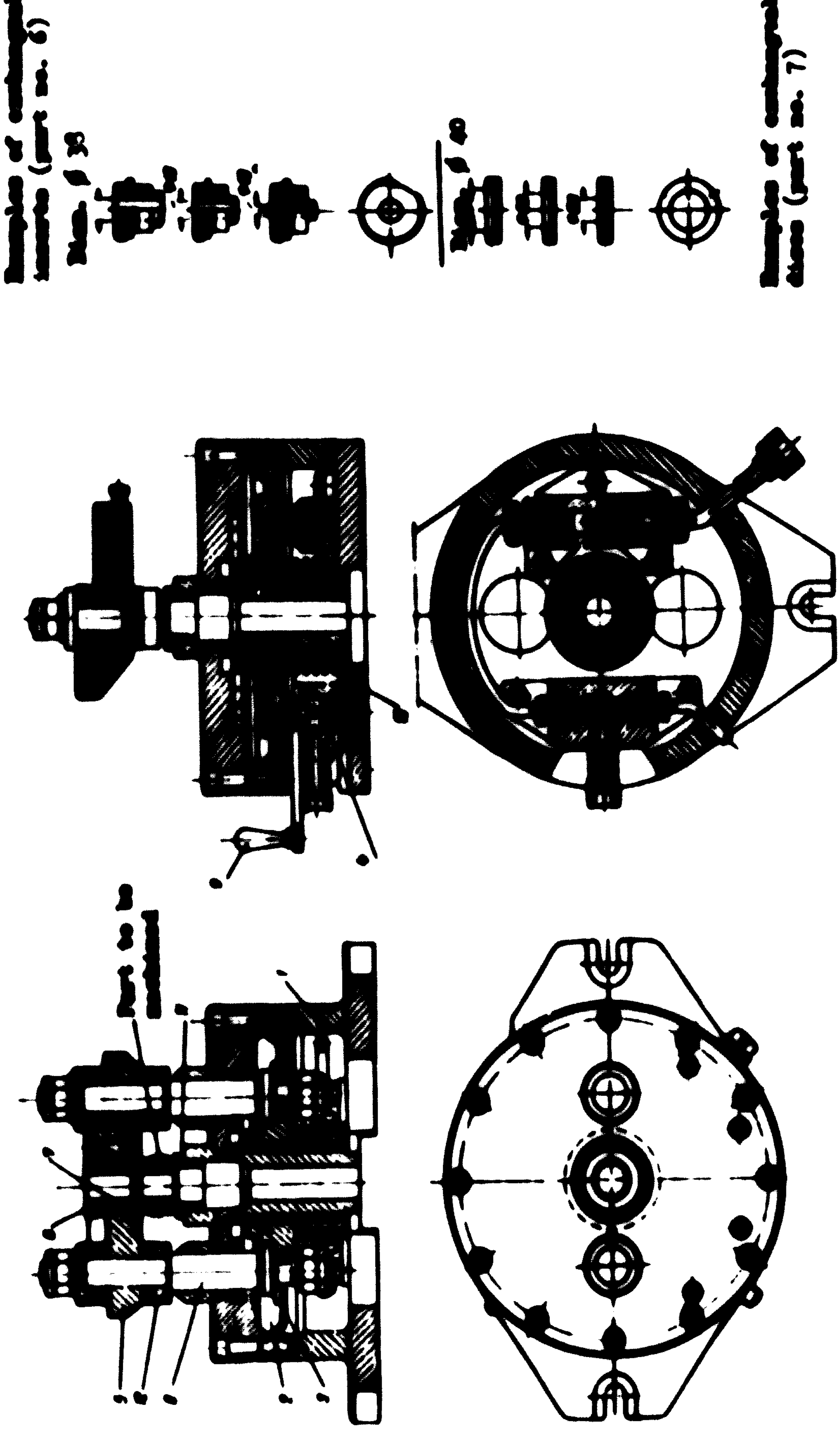


Figure 15



When machining of the part is complete, the air control handle is turned back, the air exhausts by the channel 2, and the entire movable unit is raised by the spring 10, thus freeing the part.

When changing over the jig to accept other parts, it is necessary to select and install a supporting bush 11 with an orifice which is smaller than the external diameter of the boss, but larger than the diameter of the hole which is to be drilled in the part. An appropriate exchangeable disc 7, which centres the boss of the part, must also be fitted. The requisite exchangeable jig insert 6 is selected and fitted in the plate 5, and the height of the plate is adjusted to suit the height of the boss of the part to be machined by means of the exchangeable discs 12.

In considering questions of the effectiveness of using group-adaptable jigs, it should be noted that the wide use of such jigs and their mechanization and automation not only considerably reduce the expenditure of time and money on preparations for production, but also considerably increase the productivity of labour. Particularly great effectiveness is achieved by the adoption of a comprehensive solution of the problem, whereby group-adaptable jigs are used on correspondingly modernised machine tools: that is to say, when integrated group manufacturing processes are introduced.

Special features of the design of equipment for production operations

Cold stamping

The group method of cold stamping is based on the classification of parts into groups for the manufacture of which a single type of quickly adaptable equipment, that is to say, group-adaptable (universal) die assemblies with exchangeable working parts, together with versatile presses, can be used.

Group stamping can be used both for individual operations and in the manufacture of groups of parts involving a sequence of operations. This latter fact creates favourable conditions for the use of group-adaptable automatic lines.

One-off or series production of cold stamped parts can be arranged in two ways:

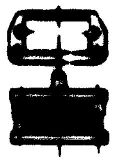
1. By preparing universal and simplified dies;
2. By preparing group-adaptable (universal) die assemblies with exchangeable punch and die sets.

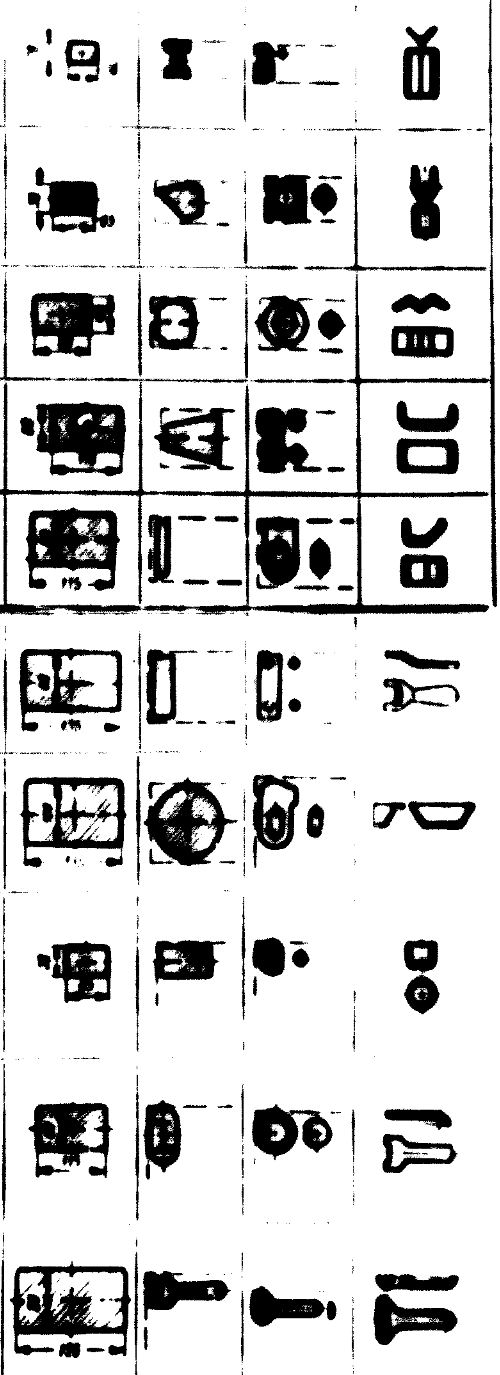
In conditions of one-off and short-run production stamping operations can advantageously be carried out one operation at a time, using universal punches and dies and a dial press. Stamping by this system is also recommended where there are frequent changes in the design of parts, as such design changes do not then necessitate changes in the universal punches and dies.

It is usually most advantageous to use group-adaptable (universal) die assemblies with exchangeable punch and die sets in short-run and series production, although they can also be used in a number of cases in long-term production.

The use of the group method necessitates work on the classification of parts, the development of a group manufacturing process, and the design of group-adaptable tooling.

Classification of group operations in cold stamping

Number of group	Description of operation	Characteristics of universal (group-adaptable) die units	Characteristics of material: Type material	Characteristics of material: Type blank	Thickness of material	Maximum dimensions of parts in group	Typical parts: Simple blanking	Typical parts: Progressive blanking	Typical parts: Bending or drawing
1	Blanking, punching, bending, drawing.	 Die units: 1) With diagonally disposed guide posts 2) With closed-type die units with two guide strips 3) With a closed height of not less than 215-230 mm	Aluminium, leather, rubber, cardboard, etc. steel, brass	Material: uniform strip blanks	0,5 3				
2					0,5 3				
3					0,5-4				
4					0,5-4				
5					0,5 6				
6				Material: sheet or cut-out blanks	0,5 6				
7					0,5 6				
8		 Die sets: 1) With guide posts disposed on one side 2) With semi-open type die units 3) With a closed height of not less than 150-165 mm		Material: uniform strip blanks	0,1 3				
9					0,1 4				
10					0,1-6				



Classification of parts

The basis of the group method of stamping is the classification of parts. In the group method, the parts are classified according to the way they are manufactured: i.e., distinctions are drawn between parts which are manufactured by cutting, bending, drawing, moulding, and pressing in dies on stamping equipment (Figure 16).

The main objective of this classification is to define the groups of parts which can be manufactured on a single machine with a single set of production equipment.

In classifying parts, account must be taken of their shape and dimensions, their method of manufacture, the required accuracy and surface finish, the need for economy in laying out the material strip, and the number of parts to be manufactured.

At the same time, the most efficient type of equipment and the most advantageous tool design must be selected. Thus, for example, in grouping flat parts which are to be stamped with punch and die sets fastened in group-adaptable (universal) die assemblies, the main feature as far as classification is concerned will be the dimensions of the part, which determine the size of the die sets and the strength of the press required for stamping. In this particular case, the shape of the parts will not be significant.

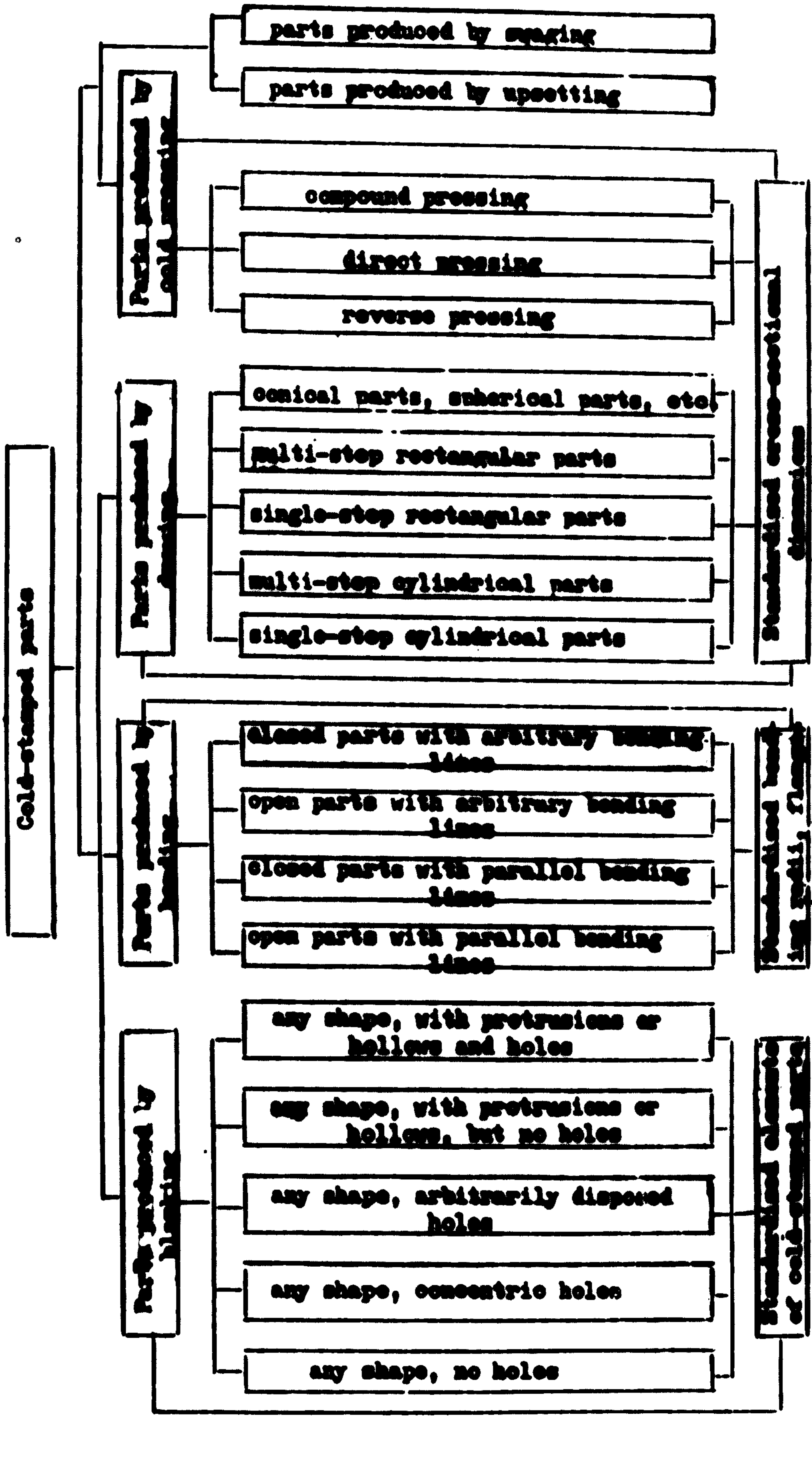
Table 1 gives a classification of group operations based on the classification of parts according to their dimensions, their method of manufacture, and the nature of the blank used. The table also gives details of the universal group-adaptable blocks used in the stamping of parts of each group.

In stamping one operation at a time with universal exchangeable-component dies, it is necessary to single out as grouping features those operations which are to be carried out on a single press fitted with either a fixed die set or a group-adaptable base with exchangeable punch and die sets.

In stamping one operation at a time on a dial press, the grouping features are those characteristics of the part which determine the selection of tools fitted in a single setting to the dial head. When changing over from the manufacture of one batch of parts to another, it is sufficient to change the master pattern or programme (when the press is fitted with a programme device), which takes up much less time than resetting the tool.

Figure 16

Classification system for cold-stamped parts



Grouping is somewhat more difficult in this type of stamping, as the number of types and dimensions of the elements of all the parts making up the group must not exceed the number of stations on the dial head

A characteristic feature of stamping one operation at a time is the absence of any stable groups, not only as far as the whole manufacturing process is concerned, but also as far as the separate operations are concerned, as it is mostly small batches of parts which are manufactured by this means, and some of these parts are not repeated at all (experimental parts), while others are repeated only infrequently, as for example once a quarter. The groups must therefore be reviewed each month, according to the types of parts to be produced under the monthly production programme.

As grouping must involve the minimum of resetting of the dies (or of the tools in the dial head of the press), it can most advantageously be carried out with a computer into which punched cards with coded information on the grouping features are fed, or else by means of a manual punched card system.

The possibility of using various production equipment for the manufacture of different groups of parts (taken into account when classifying the parts) is shown in Table 2.

One of the main conditions for the achievement of high effectivenees in the use of universal dies is the unification of the stamped parts and their design elements Work on unification should therefore be carried out side by side with the classification of parts. The elements of stamped parts (holes, grooves, radii, curves, etc.) must be standardized in order to reduce the number of different varieties of them.

The correct choice of the geometrical forms of design elements in this standardization process creates the most favourable conditions for the use of effective production processes involving the minimum amount of equipment.

The successful introduction of the group method of stamping and its further improvement through mechanization and automation depends to a considerable extent on the level of unification and standardization achieved.

The design of group-adaptable equipment

One of the most important conditions for the effective utilization of the group method in stamping is the correct selection of the types and designs of dies.

Group-adaptable dies must be of simple design, of universal application, safe and convenient in operation, and capable of ensuring an adequate level of productivity in stamping.

In selecting the type and design of dies, it is necessary to take account of the volume of production and the length of each production run, the production capabilities of the enterprise, the features of the equipment, the plan of operations for the group process, and the special features of the parts making up the group.

In designing group-adaptable (universal) dies, the designer is faced with more complicated requirements than in designing special (individual) dies. Group-adaptable (universal) dies are designed on the basis of analysis of the design and manufacturing characteristics of the parts making up the group in question, the range of dimensions, the nature of the mounting surfaces of the parts, and the means of fastening the parts.

The basic design data are:

1. Drawings of all the parts in the group, a card index of the drawings, and comprehensive tables of the standardized geometrical shapes of the design elements of the parts which are to be stamped;
2. An outline or details of the production process to be used;
3. Details of the press for which the group-adaptable die is being designed;
4. Details of the existing designs of dies and their production capabilities.

Types of groups into which parts cold stamped from sheet may be classified

Type of production equipment used	Means of adaptation of equipment	Grouping features	Differentiating features and limitations
Fixed dies	Exchangeable punches	Parts are of identical dimensions and outside shape	Different numbers of holes
Universal (group adaptable) die sets	Exchangeable punches and dies	Dimensions and thickness of material of parts are within certain limits for a given die set	Parts of any shape with over-all dimensions up to 250 mm
Universally adaptable dies	Adjustable and exchangeable stops	Parts have similar stamped elements, the dimensions of which must be within certain limits for a given die	Parts of any shape with dimensions over 70 mm
Universal (group-adaptable) bases	Exchangeable die sets and adjustable stops	Parts have identical stamped elements (holes, grooves, etc)	Parts of any shape, provided that the holes to be punched are located not more than ... mm from the edge of the blank
Dial blocks (dial presses)	Exchangeable tool units and displacement of the blank in given directions	Parts have identical stamped elements or else elements which can be stamped without re-tooling the dial head	Parts of any size and shape for the stamping of holes, or parts with a maximum diameter of 70 mm for cutting-out

The design of universal dies must be such as to ensure the greatest simplicity in their setting up and adjustment, maximum universality in their utilization, long working life, minimum cost, convenience of servicing, and maximum utilization of standardized die components.

Let us now consider the design of group-adaptable (universal) dies used for the stamping of various groups of parts.

Universal (group-adaptable) die sets with exchangeable punches and dies

This equipment is widely used for the short-run and series production of parts. The following types of universal die sets, which differ in the means of attachment of the exchangeable punches and dies, are used:

(a) Sets with mechanical fastening of the punch and die;

(b) Sets with electro-magnetic fastening of the punch and die;

(c) Sets with combined electro-magnetic/mechanical fastening of the punch and die.

The most widely used die sets are those with mechanical fastening of the punch and die (Figure 17). The advantages of these sets are their simplicity of construction, their universality, the possibility of using them for the stamping of parts of a wide range of dimensions and thicknesses, and the possibility of carrying out all types of stamping operations with them. They enable various arrangements for the mechanization of the stamping process to be used, without requiring any special equipment on the press.

The punch and die units installed in group-adaptable die sets with mechanical fastening are essentially ordinary blanking, progressive or combined units without any means of connexion with the press (punch holder and die holder), locating means (such as guide posts and bushes) or punch shank. Where the material to be cut is not very thick (up to 1 mm), punch and die units have their own additional fittings for locating the working parts relative to each other, but with thick materials such location is carried out by the die set.

Some varieties of punch and die units for die sets with mechanical fastening are shown in Figure 18. A simple blanking punch and die unit with a solid stripper plate (Figure 18a) consists of a die 1 with a stripper plate 2 fastened to it by screws and pins. The punch 3 is pressed into the punch holder 4.

Figure 17

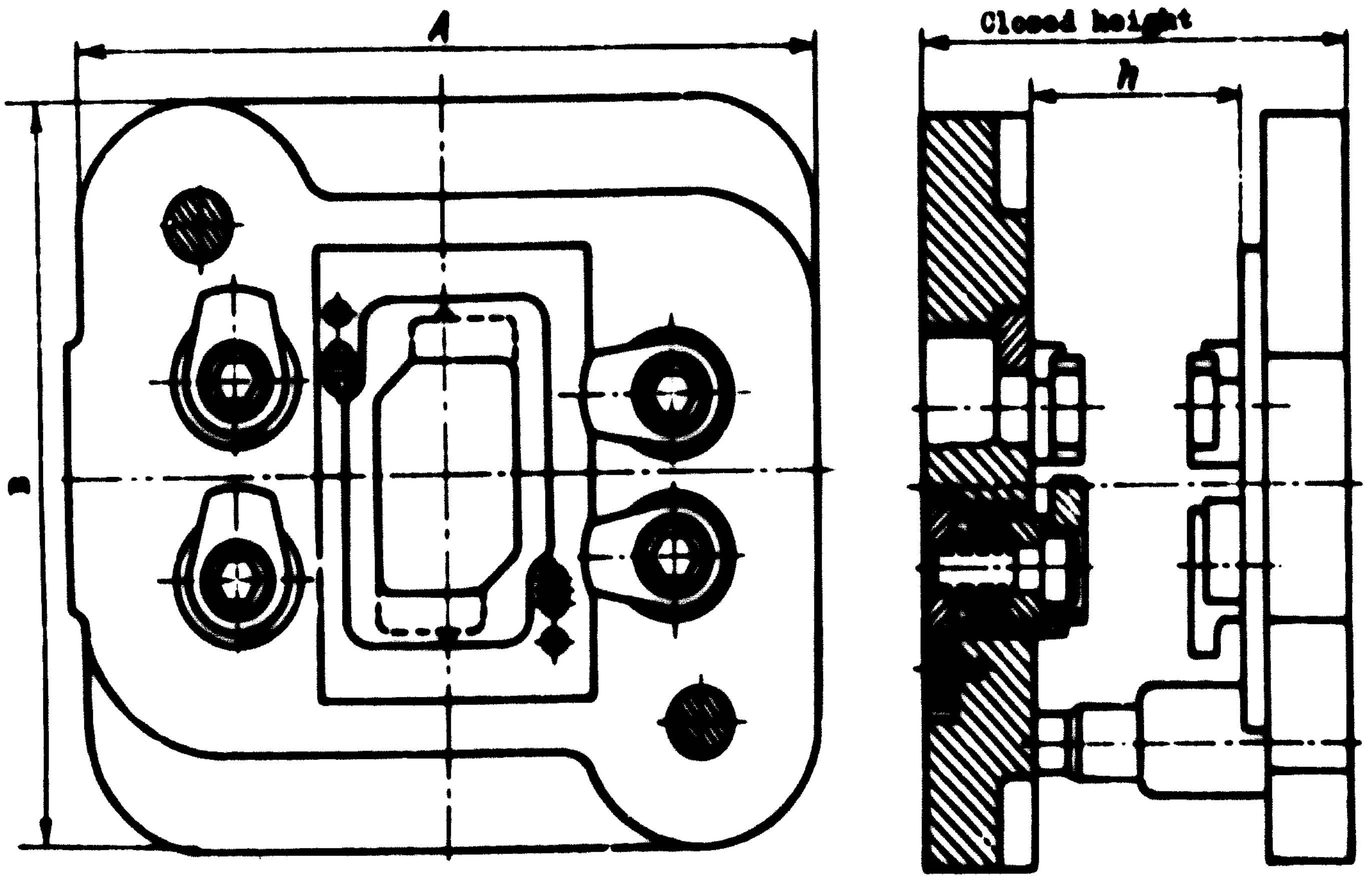
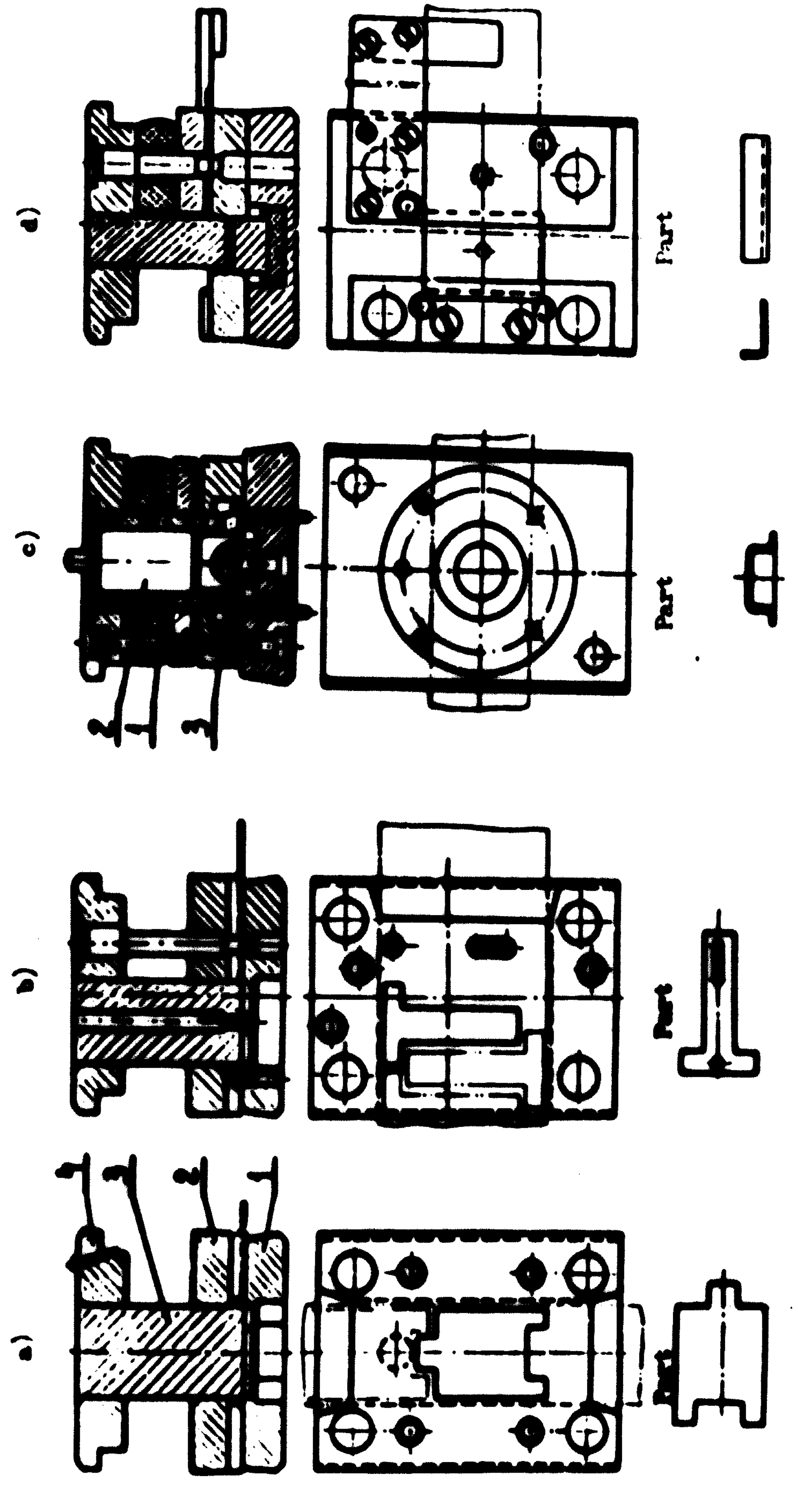


Figure 18



The design of a progressive-action blanking die unit, shown in Figure 18b, is in no way different from that of an ordinary die. The design of a compound die unit for blanking and drawing (Figure 18c) is also identical in its main principles with the basic design. In order, however, to bring about removal of the part from the drawing die 1 by the knockout 2, and to return the lower pusher 3 to its original position, there are devices in the upper and lower parts of the group-adaptable block which are actuated by the slide and the lower buffer of the press, respectively.

Another design of a compound die unit for the cutting and bending of parts is shown in Figure 18d. The provision in the lower unit of a resilient ejector working independently of the die set makes the set more universal and facilitates the setting up of the exchangeable dies.

Universal blocks with electro-magnetic fastening of the punch and die units (Figure 19) offer few technological possibilities and are used for the cutting, perforating, simple bending and shallow drawing of thin sheet metal parts (up to 3-4 mm thick). Their main advantage is the fact that they can use the units of simple design which can quickly be installed in the die set without the use of additional locating devices (by the straightforward matching-up of the cutting parts of the punch and die). This makes possible high accuracy of location of the punch and the die relative to each other, which is particularly important in the cutting and perforation of thin materials. Plate-type single or compound dies are used for electro-magnetic die sets. The first types of dies carry out one stamping operation (such as blanking) for each stroke of the punch, while the second simultaneously carry out several different operations (such as blanking and perforation) for a single stroke of the punch.

Die sets with electro-magnetic/mechanical fastening of the die units (Figure 20) offer considerable technological possibilities. They can be used with advantage for various types of stamping of both small and large parts out of thin or thick material.

__Universal exchangeable-component dies__

These dies are intended for the stamping of parts by elements; various broken-down operations can be carried out by means of them.

Figure 19

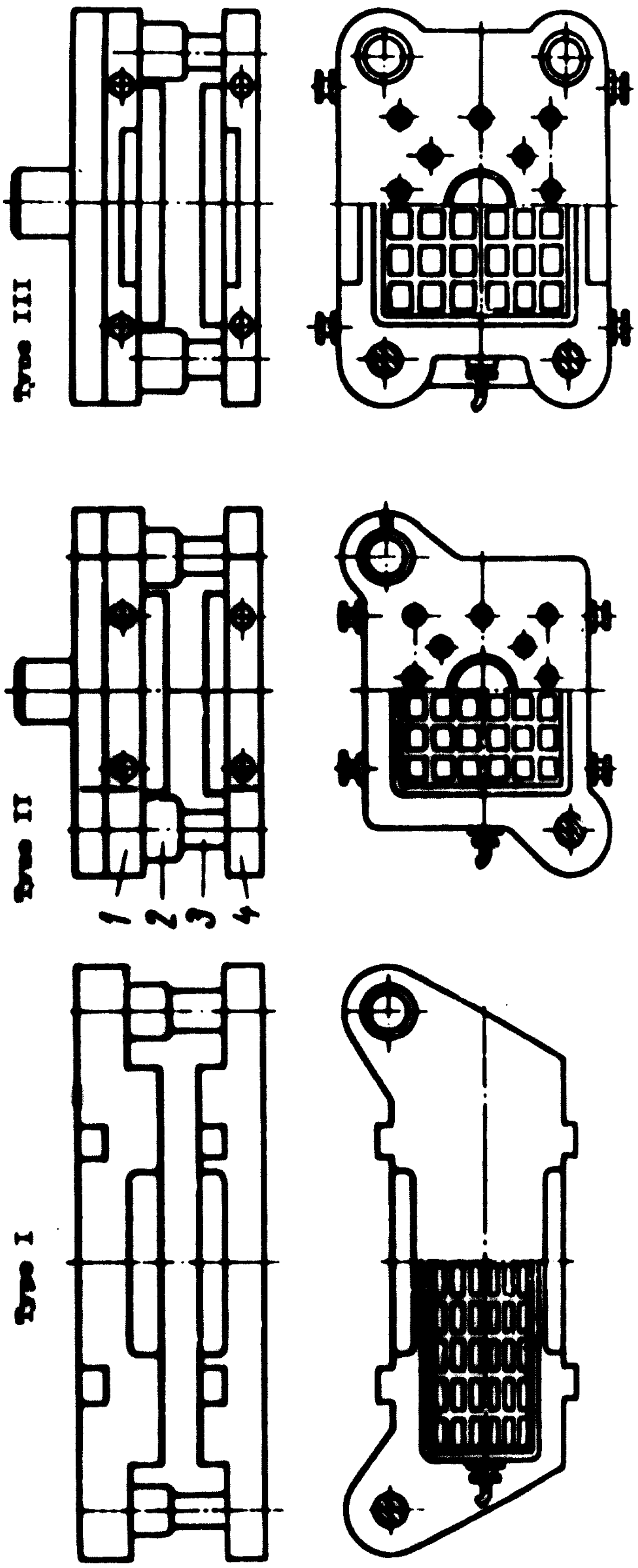
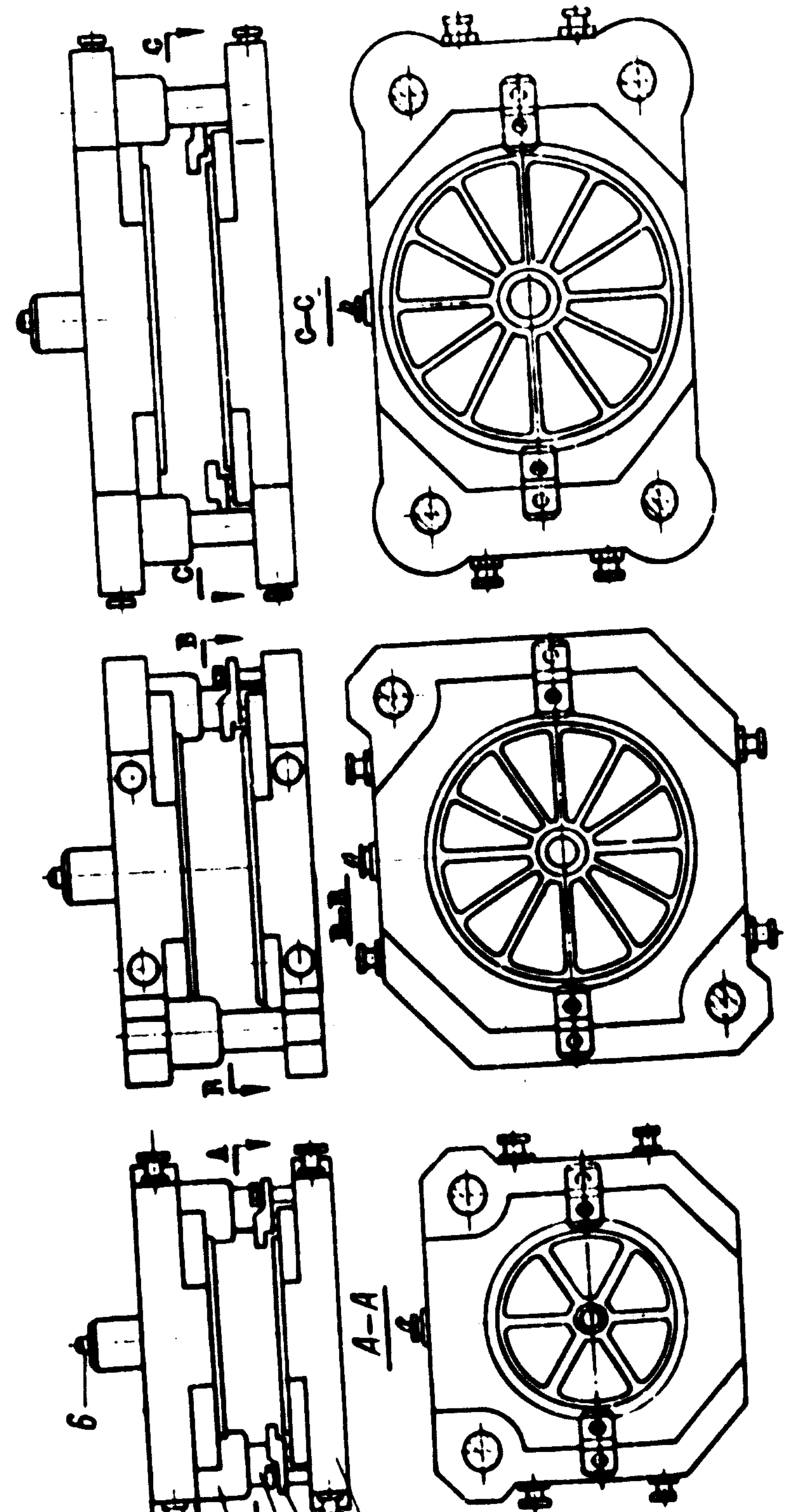


Figure 20



Dial-plate dies

These are being used more and more widely for group stamping by elements. They can most advantageously be used for punching holes of various shapes in flat parts such as plates, panels, etc., of dimensions up to 300 mm, as well as for the blanking of parts with dimensions which do not exceed those of the die holder aperture.

Dial-plate dies are divided into two types:

(a) Those mounted on a single axis with discs (with solid connexion of the upper and lower discs);

(b) Those located in a C-shaped body in the die set (in this case, the upper and lower discs of the dial plate are not solidly connected to each other).

Dies of the first type are used for stamping parts out of strip up to 120 mm wide. The wider production capabilities of dies of the second type, which have separate fastening of the upper and lower discs of the dial plate, enable them to be used for punching holes in sheet blanks up to 300 mm wide with a single setting.

Vernier tables are used to line up the blanks with the axis of the punch when the latter is in its working position.

Dial presses

In enterprises producing short runs of parts, effective use is made of dial presses, which represent one of the most vivid illustrations of the principle of the concentration of operations in cold stamping. A dial press can take the place of a line of several universal presses with exchangeable-component dies in the stamping of parts by elements.

The concentration of stamping operations and the wide capabilities provided by the use of the group method enable the cost of stamping operations to be reduced and the productivity of labour in the stamping of different parts by elements to be increased.

Depending on the design of the press, from 16 to 36 exchangeable sets of tools can be installed on the dial plate of a press at the same time.

The presses are equipped with vernier tables on which the sheet blanks are fastened. The blank can be lined up with the set of exchangeable tools, when the latter is in the working position, by the following methods:

1. Establishment of given co-ordinates on the reading scale with a vernier or optical micrometer;
2. Lining up the blank with a template;
3. Lining up the blank automatically in accordance with a given programme.

Dial presses are used for sheet metal parts such as panels, plates and frames with dimensions of up to 700 x 1,000 mm. An accuracy of up to ± 0.1 mm in the dimensions between the centres of holes can be achieved.

The maximum diameter of a part which is cut out or a hole which is punched with a single stroke varies from 50 to 100 mm, depending on the design of the press.

In order to cut down the time needed for auxiliary operations, some designs of presses are equipped with automatic remote control devices for the rotation and locking of the dial plate.

Group-adaptable automatic lines

The group working method opens up wide possibilities for the automation of the process of cold stamping. Thus, for example, parts from a number of groups which are manufactured by cutting out or perforation can be produced by means of single or progressive dies with automatic feed of the material. Such presses, if provided with special equipment, can be substantially equivalent to a straightforward automatic line.

In the case of production processes involving a number of operations it is worth considering the possibility of setting up special automatic lines which can produce parts belonging to a given group with only a small expenditure of time on resetting.

At the present time, special automatic machines with quickly-exchangeable components and multi-purpose group-adaptable automatic lines are being used more and more widely in industry.

The selection of the best type of production process

When there are two or more otherwise equally attractive production processes available, the process selected is usually that which gives the lowest production cost. The following formula is used for calculating the production cost C_T:

$$C_T = M + Z + O + Y + E$$

Where:

M is the cost of the material from which the part is made, taking into account the cost of waste material;

Z is the wages of the stamping operatives and (if necessary) other production operatives, with additional payments and deductions;

O is the expenditure on the operation and amortization of the punches and dies and other equipment;

Y is the expenditure on the setting up and adaptation of presses and dies; and

E is the expenditure on the operation of the presses (overhaul of the presses and the cost of the electric power used).

This formula can be used for separate operations, for several operations together, or for a whole production cycle. All the components of the formula refer to the manufacture of one part (or, if preferred, 100 parts). Their values for different methods of group stamping are determined either from generally known standard figures (cost of materials, wages) or from the assembly of available technical and economic figures.

The cost of the operation and amortisation of the punches and dies is calculated by means of the formula:

$$O = \frac{F + P}{N}$$

Where:

F is the cost of making the die unit;

P is the expenditure on the overhaul and reworking of the die unit;

N is the number of parts manufactured with the die unit before it is written off.

The cost of making a die unit can be determined approximately according to the formula:

$$F = (K_T + K_C)(A + B) + D$$

Where:

K_T is a coefficient depending on the type of die unit, its value varying from 0.08 to 0.2;

K_C is a coefficient depending on the complexity of the working surface of the die unit, its value varying from 0.06 to 0.2;

A and B are the dimensions of the die and the punch in millimetres; and

D is the cost of the die set (for group-adaptable die units, D = 0).

The expenditure on the overhauling and reworking of a die unit generally averages 40-60 per cent of the cost of its original manufacture.

The number of parts which can be manufactured with a die unit before it is written off is taken as being equal either to the life of the unit until it is completely worn out, T, or (if the number of parts required is less than T) to the number of parts which are to be manufactured with the unit in question.

From the formula for the calculation of C_T it is possible to determine the quantitative limits for the effective use of various means of producing actual parts (the so-called "critical batch size").

<u>The production of parts from plastics</u>

Group operations for the production of parts from plastics are worked out in two stages:

1. The classification of the parts and the formation of groups.
2. The development, for each group of parts, of designs for group-adaptable die units with exchangeable die inserts (mould inserts).

1. Classification of parts

The classification of parts which are to be manufactured out of plastics must be carried out with an eye to the design and production features of the parts, as well as the design features of the dies. The main features determining the group to which a part belongs are:

(a) The type of materials and the dimensional accuracy required for the part;

(b) Its over-all dimensions;

(c) The means of pressing, taking into account the process features of the material;

(d) The means of ejection and the location of the ejectors in the die;

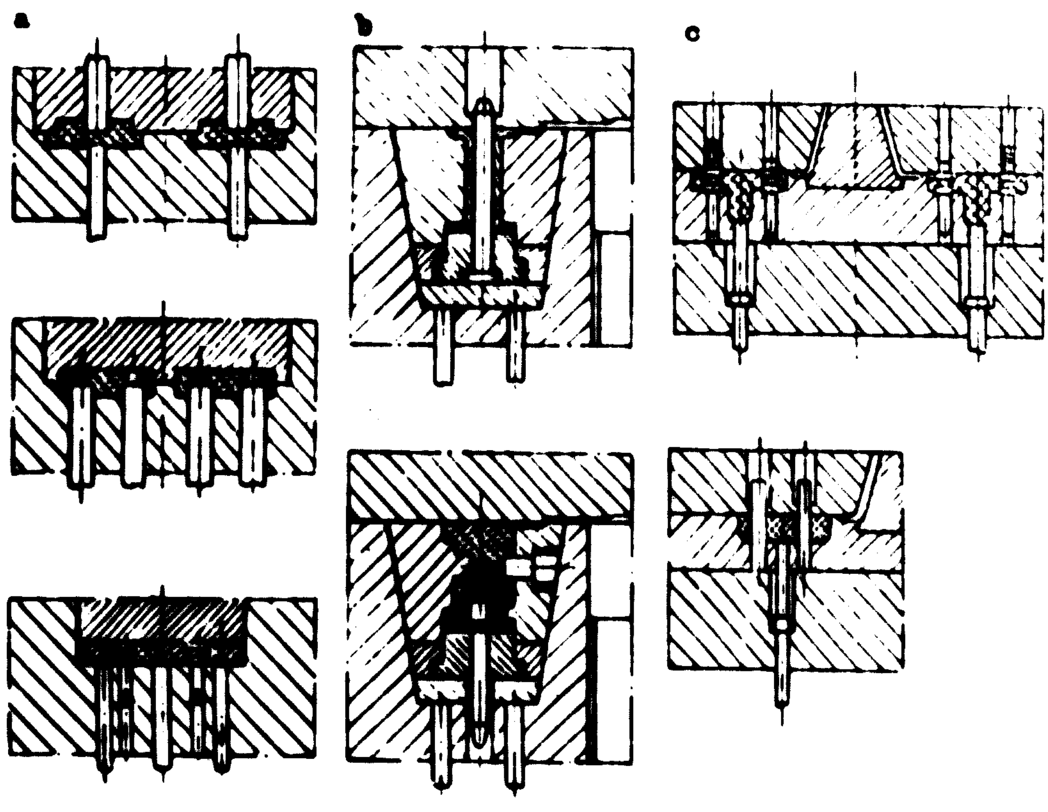
(e) The number and location of the break lines of the die;

(f) The number of inserted fittings, their shape and the way they are laid out in the part.

Let us now consider a number of examples of the classification of parts into groups in accordance with the features enumerated above.

Figure 21 shows several possible layouts of parts in dies which determine the group to which the part belongs.

Figure 21



Group 1: single horizontal break line in die; part ejected from die; fittings can be cast in the part only if placed in the die; accuracy of dimensions perpendicular to the plane of break line cannot be higher than the fifth class of accuracy; this group may include parts such as plates, blocks, panels, handles, etc.

Figure 21a shows examples of parts produced in a mould with a single break line; the bottom drawing shows a part with a cast-in insert located in the bottom part of the mould during pressing.

Group 2: moulds have 2 or more break lines (one of them vertical and the remainder permitting the disassembly of the mould components in the horizontal direction); after disassembly of the mould in the horizontal plane, the parts remain in the inserts and are disassembled outside the press; parts can be manufactured with any cast-in fittings which do not hinder the disassembly of the mould inserts; this group includes parts such as spools, shells, plugs with cast-in fittings and so on.

Figure 21b shows examples of the manufacture of parts where both horizontal and vertical mould break lines are required. In this case, the mould is wedge-shaped, the parts are produced by die-casting, and the working pressure is downwards.

Group 3: the mould has one horizontal break line; ejection of parts from the die is downwards; parts with cast-in fittings running right through them can be produced; the accuracy of dimensions perpendicular to the break line is not higher than the fourth class of accuracy.

Figure 21c shows examples of parts such as blocks, plates, etc. incorporating a large number of cast-in fittings located both in the lower and the upper half of the mould. This means that it is necessary to use the die-casting method and to design the moulds accordingly.

2. The design of group-adaptable moulds

The basis of the design of group-adaptable moulds is the principle of designing a standard group-adaptable (universal) mould block with exchangeable mould inserts.

The first step in the design process consists of the determination of the main operating characteristics of the mould which is to be designed:

(a) The method of stamping the parts;

(b) The layout of parts giving the most efficient stamping;

(c) The number and direction of break lines needed;

(d) The method of operation of the mould (whether it is to be a fixed or removable mould);

(e) The method of ejecting the finished part and the location of the ejectors;

(f) The type of feed chamber to be used;

(g) The number of sockets;

(h) The layout of the pouring system (if die-casting is to be used).

At the present time, a very wide variety of designs of group-adaptable (universal) mould units are in use, because of the different means of pressing parts used and the clearly insufficient standardisation work done so far.

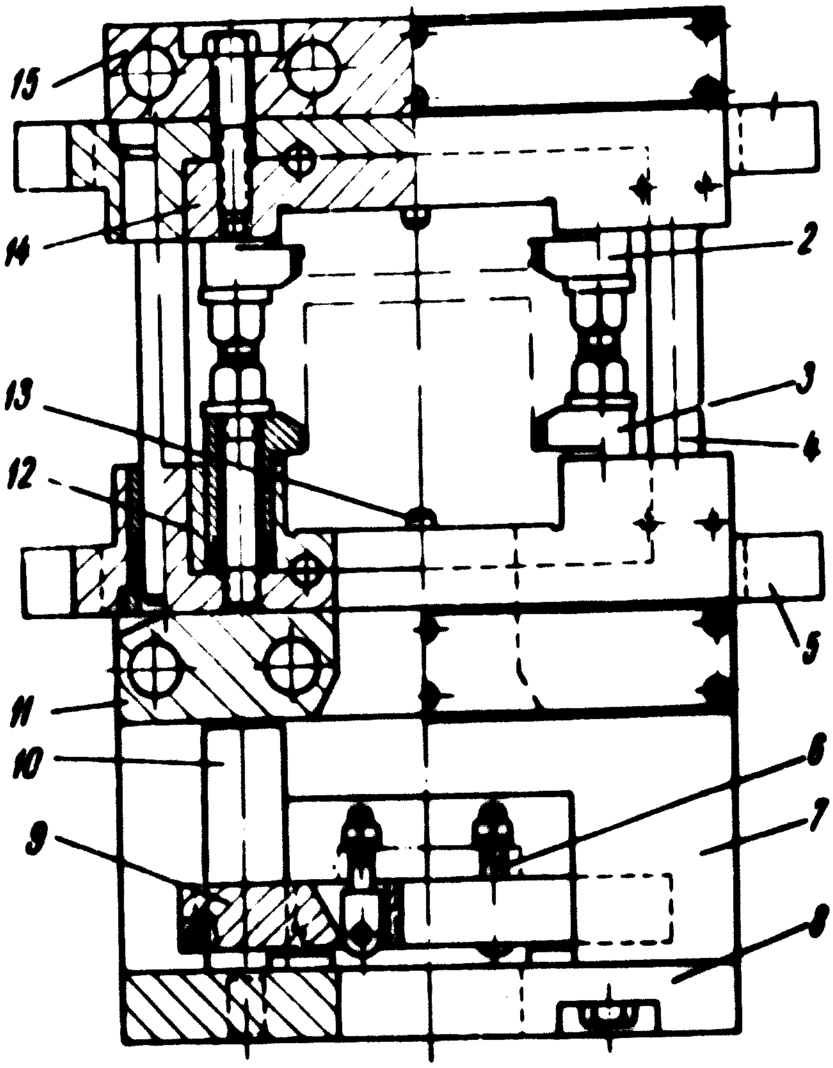
Let us consider a number of examples of the use of the group method in the manufacture of parts from plastics. Groups including parts such as panels, plates, rings and so forth can be produced from thermoplastics by straightforward pressing in a mould with a single horizontal break line. The finished part is then ejected from the mould by the ejector.

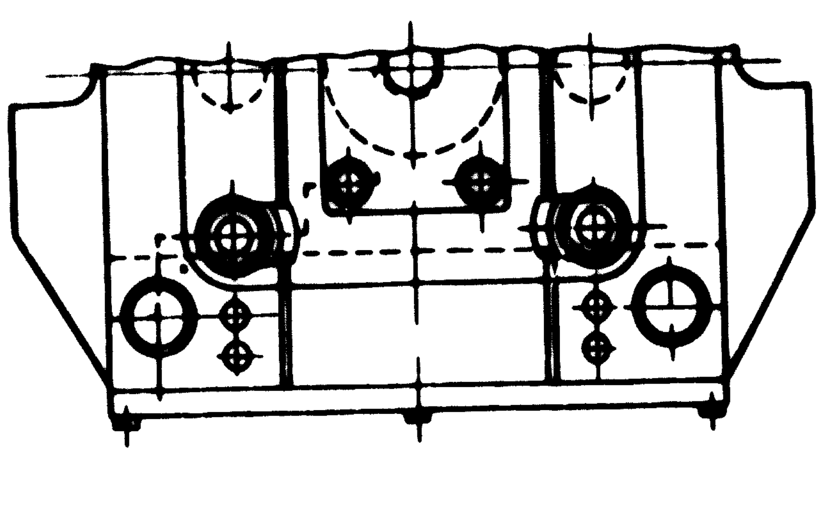
Figure 22 shows the design of a group-adaptable unit for direct pressing with exchangeable mould inserts. The unit consists of two parts: a lower part and an upper part; the lower part is fastened to the bolster plate of a hydraulic press, while the upper part is fastened to the ram.

The upper part consists of a punch holder 1 running on guide posts 4, a heating plate 15, clamping lugs 2 and an insert 14. The lower part consists of the die holder 5 with clamping lugs 3 and a lower insert 12, a heating plate 11 mounted on beams 7, a bed plate 8 and an ejection mechanism 9 which moves on pillars 10 and has a threaded hole under the press ejector.

The unit uses the slide-in system of fastening the mould inserts, so that the inserts can be changed without taking the unit out of the press. Both parts of the unit have rectangular grooves cut in them in which the exchangeable mould inserts are slid up to the stops 13 and are then fastened with the clamping lugs 2 and 3. The insert plates are connected with the ejectors by pivoted

Figure 22





links 6 mounted on the ejector plate 9 which is connected by a shaft with the corresponding mechanism on the press. The design of the exchangeable mould inserts for this unit is shown in Figure 23.

The mould insert consists of an upper plate 1 with a punch 9, buffers 2, guide posts 8, a lower plate with a chamber 3, the die 4 with the mould design cut in it, a base plate 6 and plates 10 and 11 carrying the ejector 7.

In the case under consideration, because of the small dimensions of the parts, the mould inserts are inserted in the slide-in components. Where the parts to be made are of large dimensions, however, the mould inserts may be rectangular (i.e., their dimensions and shape may correspond with those of the slide-in components.

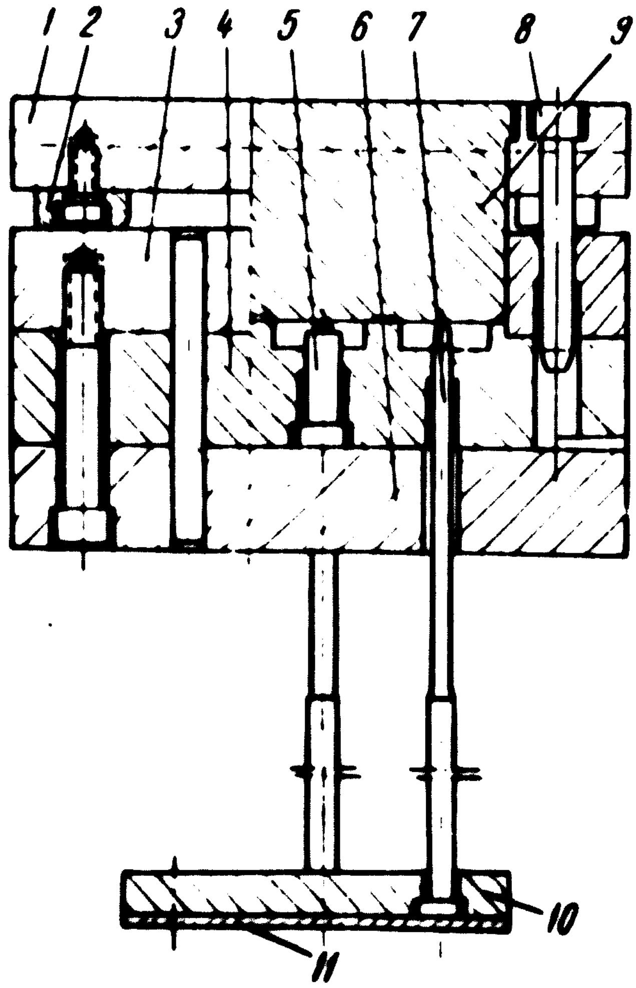
The advantage of this design is that as the unit is not taken out of the press and therefore does not cool down, the mould inserts can quickly be changed and work can proceed on the manufacture of other parts of the same group.

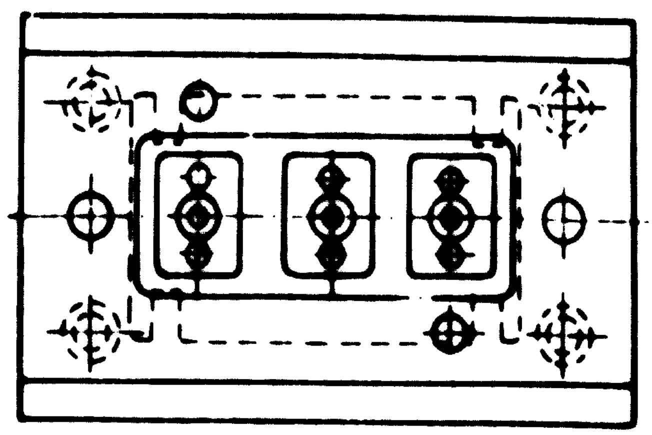
A different design of unit is used for pressing groups of parts (Figure 24) where both vertical and horizontal break lines are required in the mould inserts. Figure 25 shows a general view of such a group-adaptable wedge-type unit, while Figure 26 shows the mould inserts for it.

The unit consists of a die holder 8, spacers 5, heating plates 1 and 3, a surrounding plate 11, guide posts 2 and knockout plates 6, 7 which slide on posts 9 and have threaded holes under the ejector of the press. The mould insert (Figure 26) consists of a base 7 with a plate 8, locating pins 9, wedge-shaped half-moulds 6, a punch holder 2 with a plate 1 and a punch 3, and punch pins 4 and 5.

The mould inserts are attached to the unit in the following manner: the upper part of the mould insert is inserted in a groove in the punch holder of the unit and fastened there, while the lower part of the mould insert is fastened in the die holder of the unit. In the manufacture of parts, the loading of the material to be pressed and the pressing operations are carried out in the normal manner, the locating fingers of the unit mating with grooves in the half-moulds at the moment of pressing (Figure 26).

Figure 23





<u>Figure 24</u>

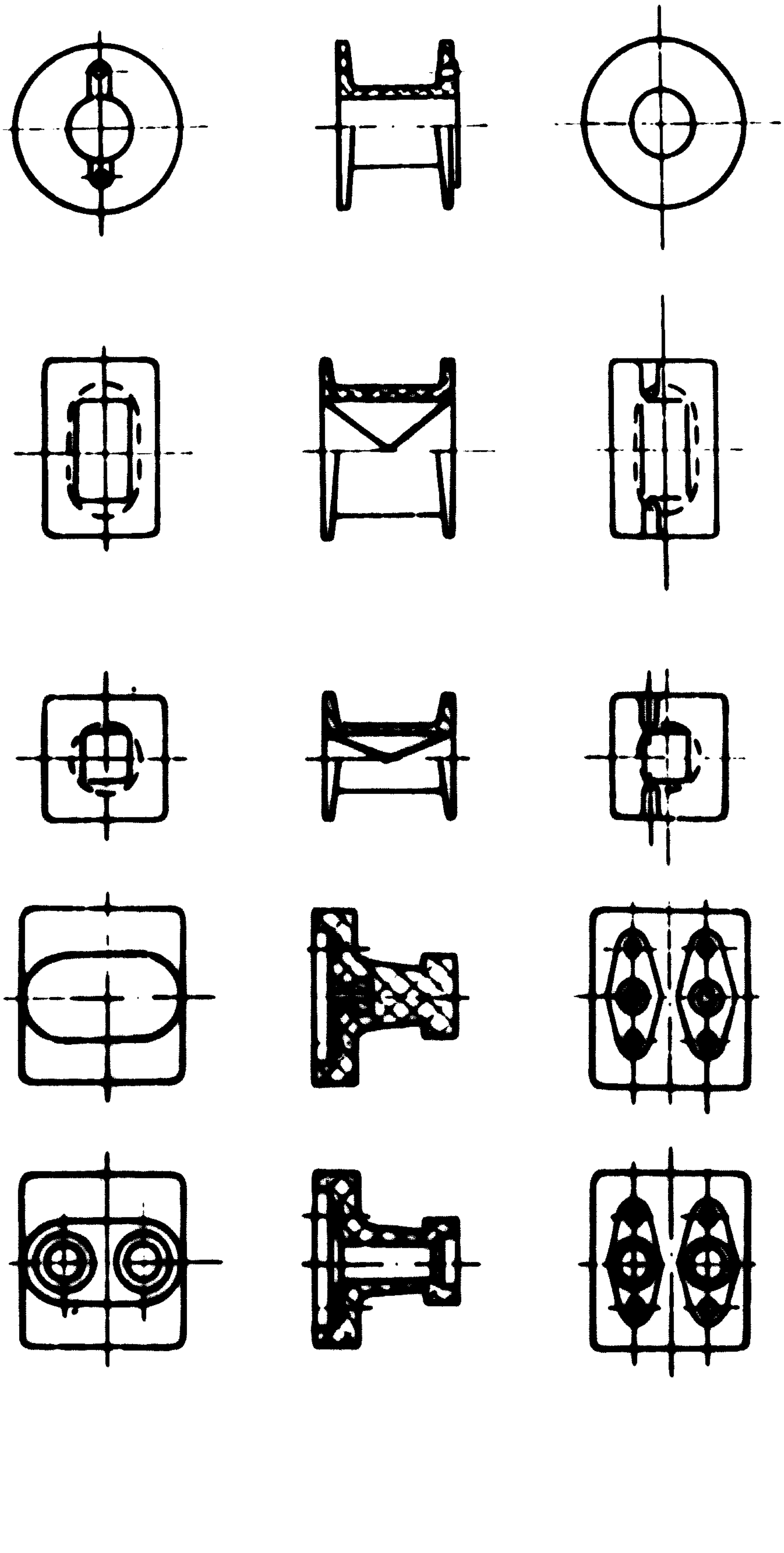


Figure 25

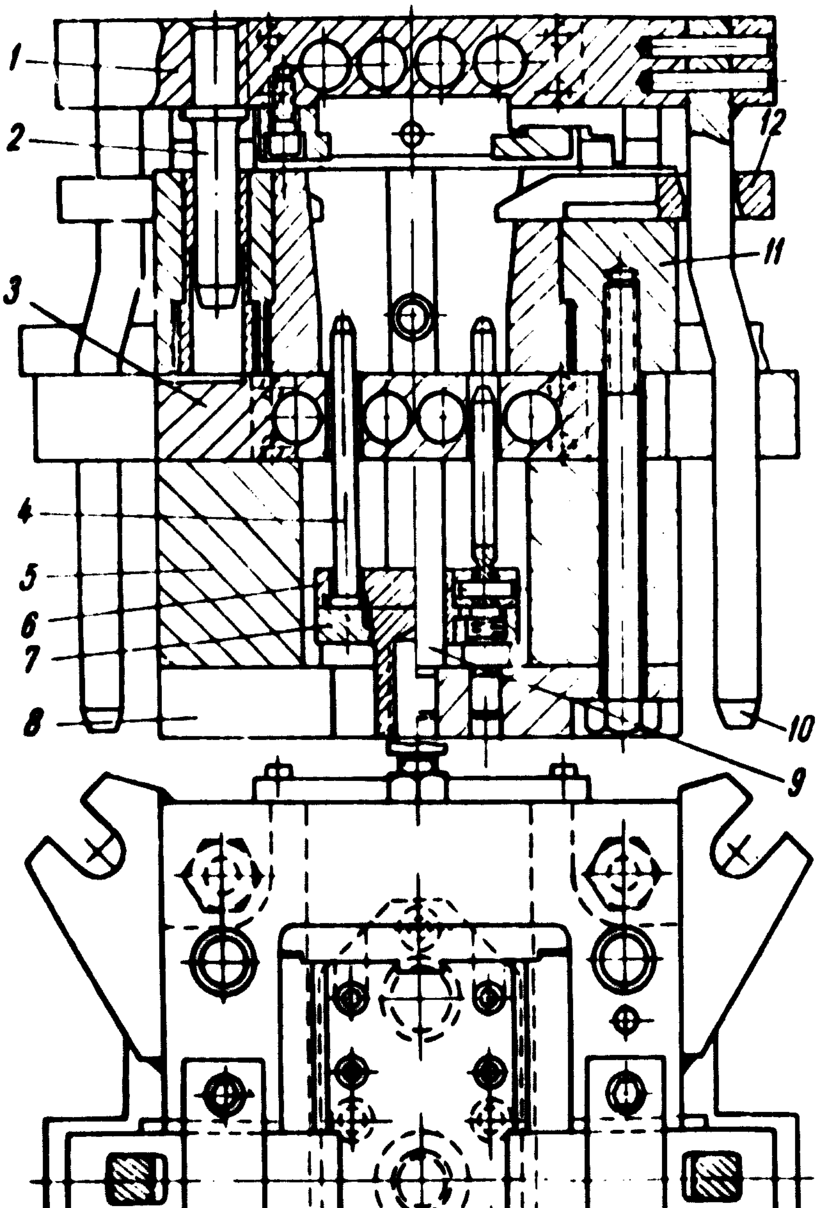
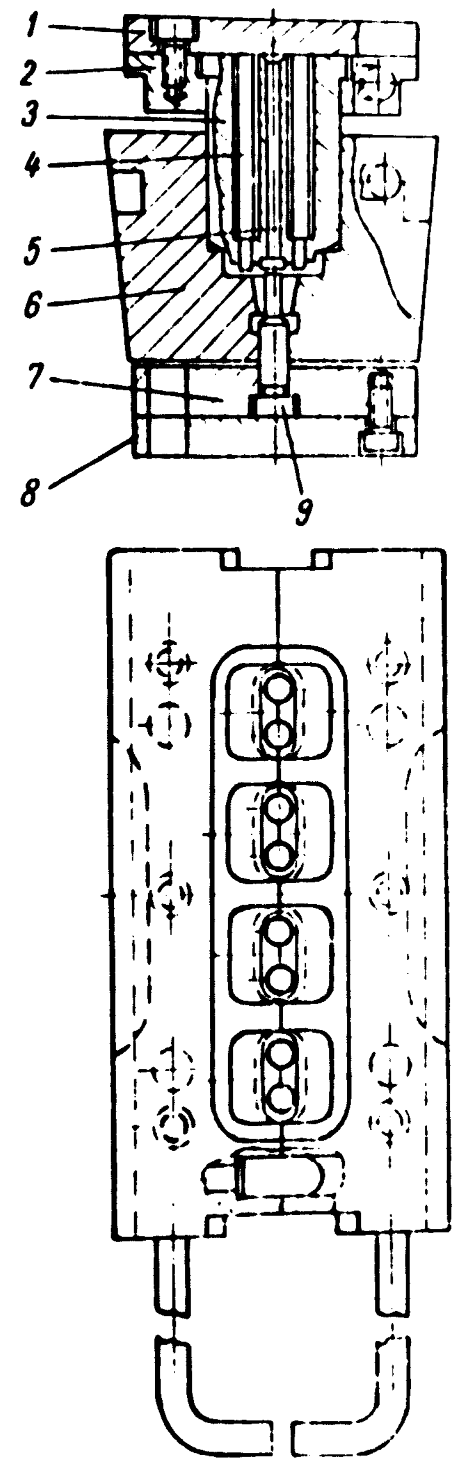


Figure 26



3. Group-adaptable units for die casting

Die casting and appropriate group-adaptable moulds must be used in cases where (1) the parts to be manufactured have fittings running right through them which are located in several of the detachable mould inserts; (2) when the shape of the part to be made necessitates additional dismantling of the mould inserts, and (3) when the dimensions of the parts in a plane perpendicular to the break line of the mould must be of a high degree of accuracy (up to the fourth class).

Group-adaptable die casting moulds are divided into moulds with working pressure from below and those with working pressure from above. Moulds with working pressure from below can have wedge-shaped mould inserts with vertical break lines.

Figure 27 shows the design of a die casting mould unit incorporating mould inserts with one or two horizontal break lines. The design of the unit enables the mould inserts to be taken apart directly under the press, using the force of the lower cylinder, without the use of additional pressing-out equipment.

The lower part of the unit consists of a plate 1, two beams 3, a heating plate 5 lying on beams, and two guides 6. The middle part of the unit consists of the feed chamber 13 located within the plates 8 and 9 which are screwed to the two beams 7, two tension rods 4 and a movable plate 2 with a shaft 16 actuated by the lower cylinder of the press. The upper part of the unit consists of a plate 12, the punch holder 11, the punch 10 and the guide posts 15.

This design of die casting unit can be used for pressing various types of parts up to 35 mm high, using moulds of minimum weight. The casting holes can be located anywhere in the area of the feed chamber, so that the casting channels can be of minimum length, thus improving the quality of the parts cast. Moreover, with such a design two mould inserts can be used and they can quickly be exchanged for different ones. By using such a design of mould unit, it is possible to do without splitters and emptying equipment, thus freeing a considerable production area.

A typical design of mould insert for this die casting unit is shown in Figure 28. Depending on the design, configuration and dimensions of the part

Figure 27

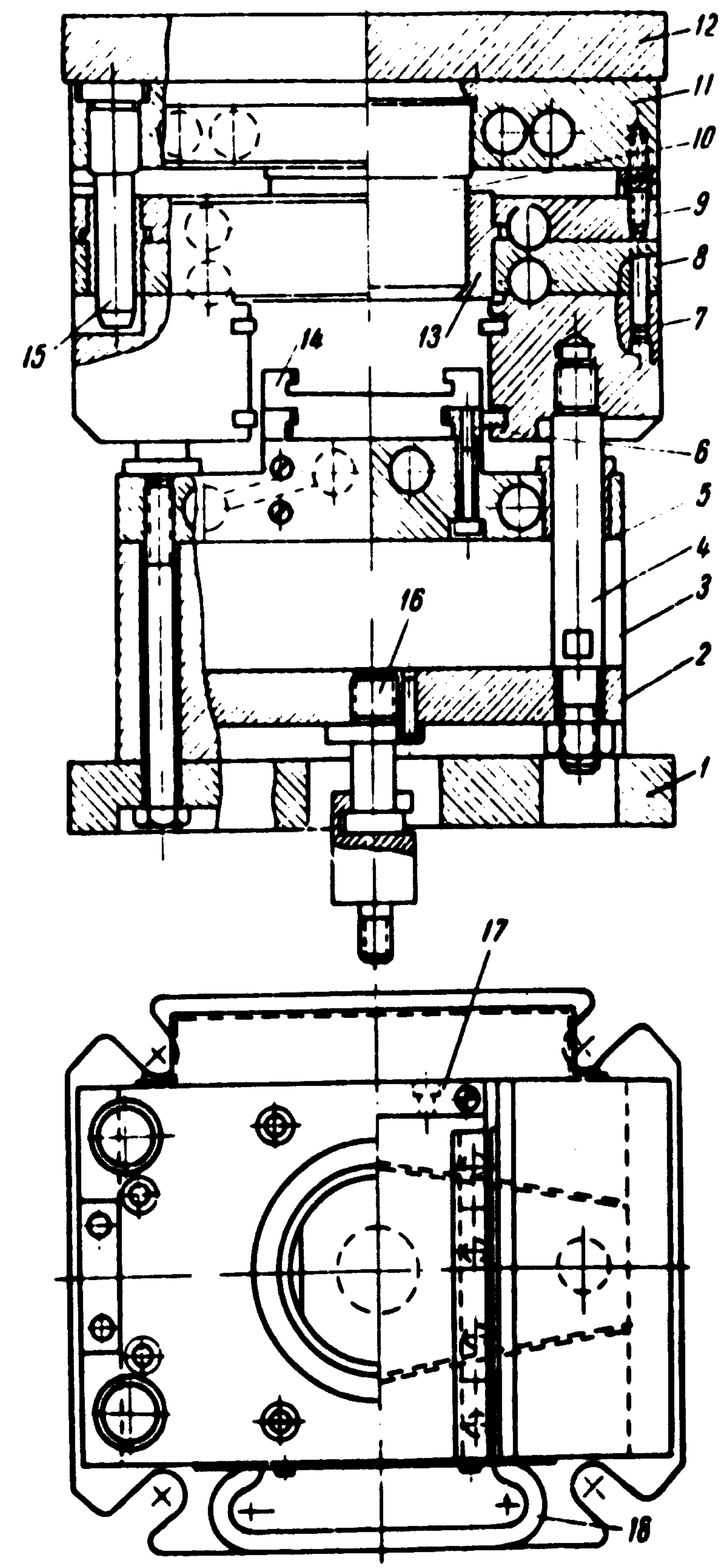
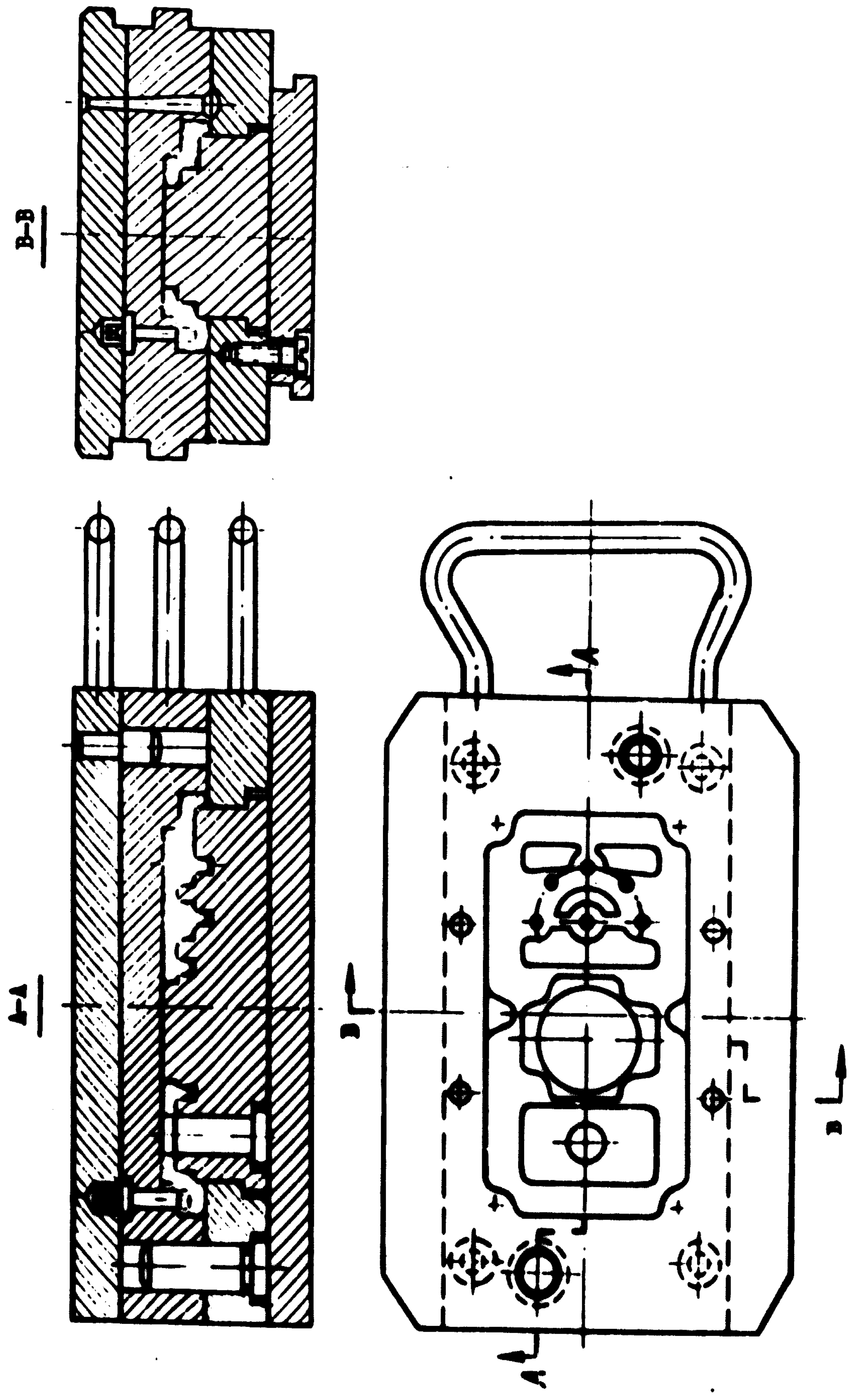


Figure 28



to be cast, the mould inserts can be of various designs and have different numbers of sockets, but their over-all dimensions and their external shape must be such as to fit in the mould unit.

4. A group-adaptable unit for pressure casting

Group-adaptable units for the pressure casting of parts from thermoplastics in casting machines are usually of the fixed type.

Figure 29 shows the design of a mould unit for pressure casting. The unit consists of a fixed plate 5 with a pouring bush, guide posts 4 which serve to ensure the precise location of the mould inserts, and a movable plate 1 with guides 3. The mould inserts are set up by moving them along the guides up to the stop 2, and they can be changed without moving the unit.

The mould inserts (Figure 30) consist of mould halves 1, 2, a pressure plate 4, and a plate 7 with locating pins 5. The accurate mating of the mould halves is ensured by the guide posts 8 and 6. The plate which forms the base for the parts is located by the pin 3 and is sealed up tight without any danger of leakage when the machine is closed. Side cuts are made in the moulds and plates for the purpose of dismantling the mould.

Dismantling is carried out on the bolster plate in the following manner: the upper mould half is removed first, then the lower mould half, from which the part is ejected by means of suitable equipment.

Pressure casting

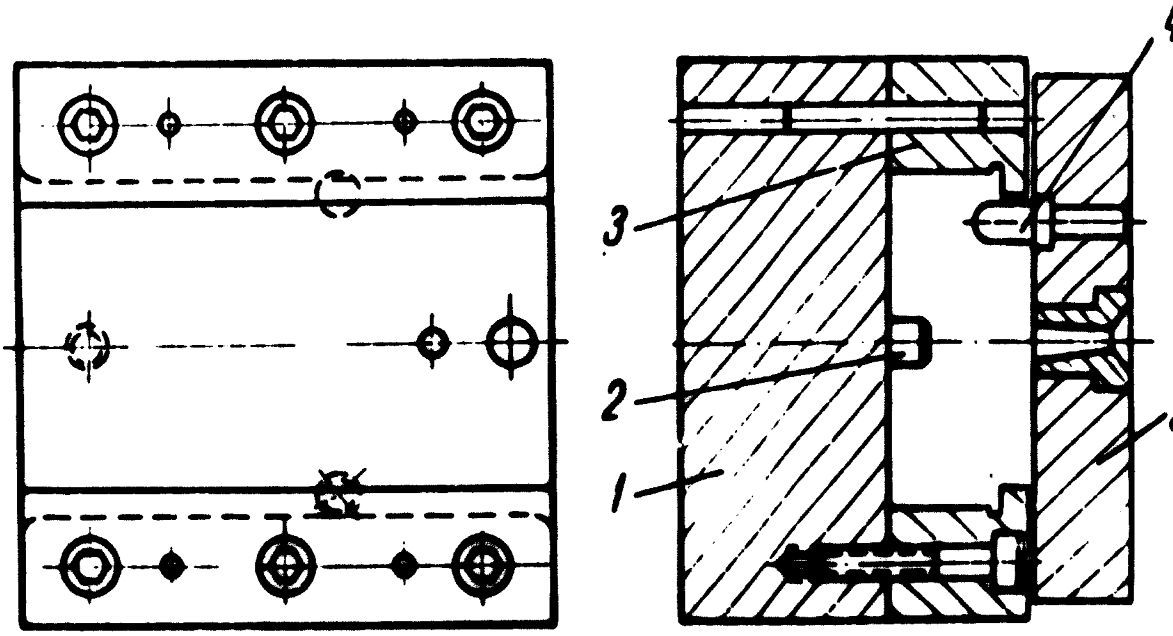
The development of a group-adaptable pressure casting process is divided into two stages:

1. The classification of castings and the establishment of groups;
2. The development of suitable designs of mould units and mould inserts for each group.

In the classification of pressure-cast parts, the main factors determining the groups to which the parts belong are:

(a) The break line of the mould for the production of the casting;
(b) The ejector system in the mould used for producing the casting;
(c) The location of the casting in the moulds (i.e., in the movable mould, in the fixed mould, or in both moulds at once);

Figure 29



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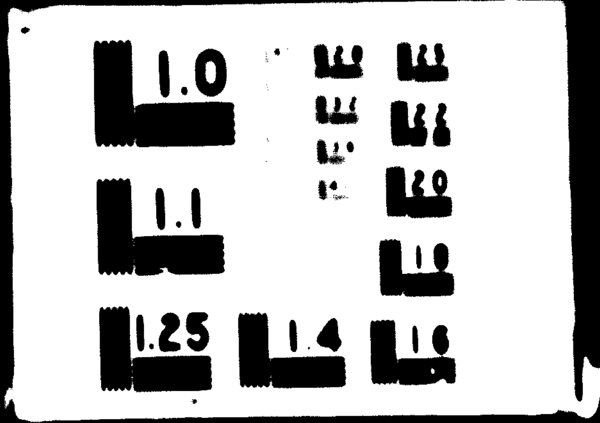
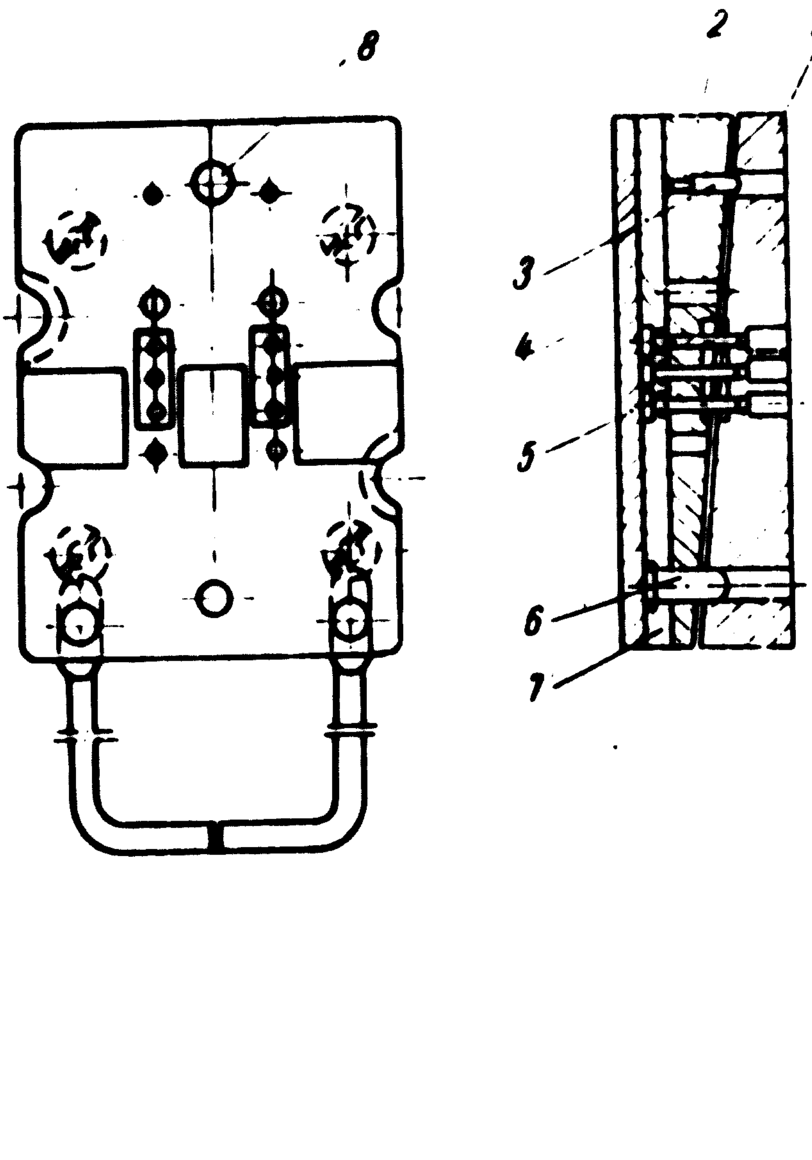


Figure 30



(d) The design of the pouring system;

(e) The presence of side holes in the casting;

(f) The over-all dimension of the cast part.

In practice, the break line of the mould determines the design of the mould unit, the location of the casting in it, and the ejector system used. The break line may be located either at one end of the casting, along its section of maximum dimensions, or along its axis of symmetry.

When a break line running across one end of the cast part is selected, the part is located entirely in one of the moulds. When a break line running along the line of maximum dimensions of the part or along its axis of symmetry is selected, the part is cast in both mould halves.

The ejection system used for removing the casting determines the design of a group-adaptable mould unit. Such systems can be of two types: ejection by a stripper plate and ejection of the part by ejectors.

Stripping by means of a stripper plate is carried out when the outside contours of the casting are formed in a fixed mould. When the internal cores are of large dimensions, however, the use of a stripper plate is undesirable, and it is better to use ejectors.

When the part is cast, in a movable mould or in a mould which is made in two parts, stripping is carried out by ejectors.

<u>The pouring system</u>

Castings made in group-adaptable units can be side-poured or centre-poured.

In selecting the pouring point, the following factors must be borne in mind:

1. Centre pouring of the casting is preferable, as it reduces the dimensions of the mould assembly.
2. The pouring system must be designed with a view to ensuring that the stream of metal entering the mould progressively drives out the air from the spaces within the mould towards the break line.
3. Pouring should preferably be carried out towards a surface of the casting which it is intended to machine later.
4. The thickness of the feeder sed in making the casting should be 25-30 per cent of the wall thickness of the cast part (for cast parts up to 6-7 mm thick).

The dimensions of the casting

The dimensions of the part to be cast influence the determination of the group to which it should belong, as the area of a projection of the casting in the plane of the break line is a basic characteristic in the selection of the type of machinery to be used. The dimensions of the casting do not affect the basic design of the mould assembly, however, but simply determine its dimensions.

Groups of castings are established on the basis of the above considerations. Examples of such groups are shown in Figure 31.

Group 1 consists of parts where the break line surface is a plane coinciding with the end of the part. The outer surface of the part is formed in the fixed section of the mould, the part is removed from the core by a stripper plate, and centre pouring is used in the casting process.

Group 2 differs from Group 1 only in that side pouring is used.

Group 3 consists of parts where the break line surface is located in the plane of greatest cross-sectioned area of the part. The part may be formed in both the movable and fixed parts of the mould, or possibly only in the movable part. The finished casting is removed by means of ejectors, and centre pouring is used in the casting process.

Group 4 differs from Group 3 only in that side pouring is used in the casting process.

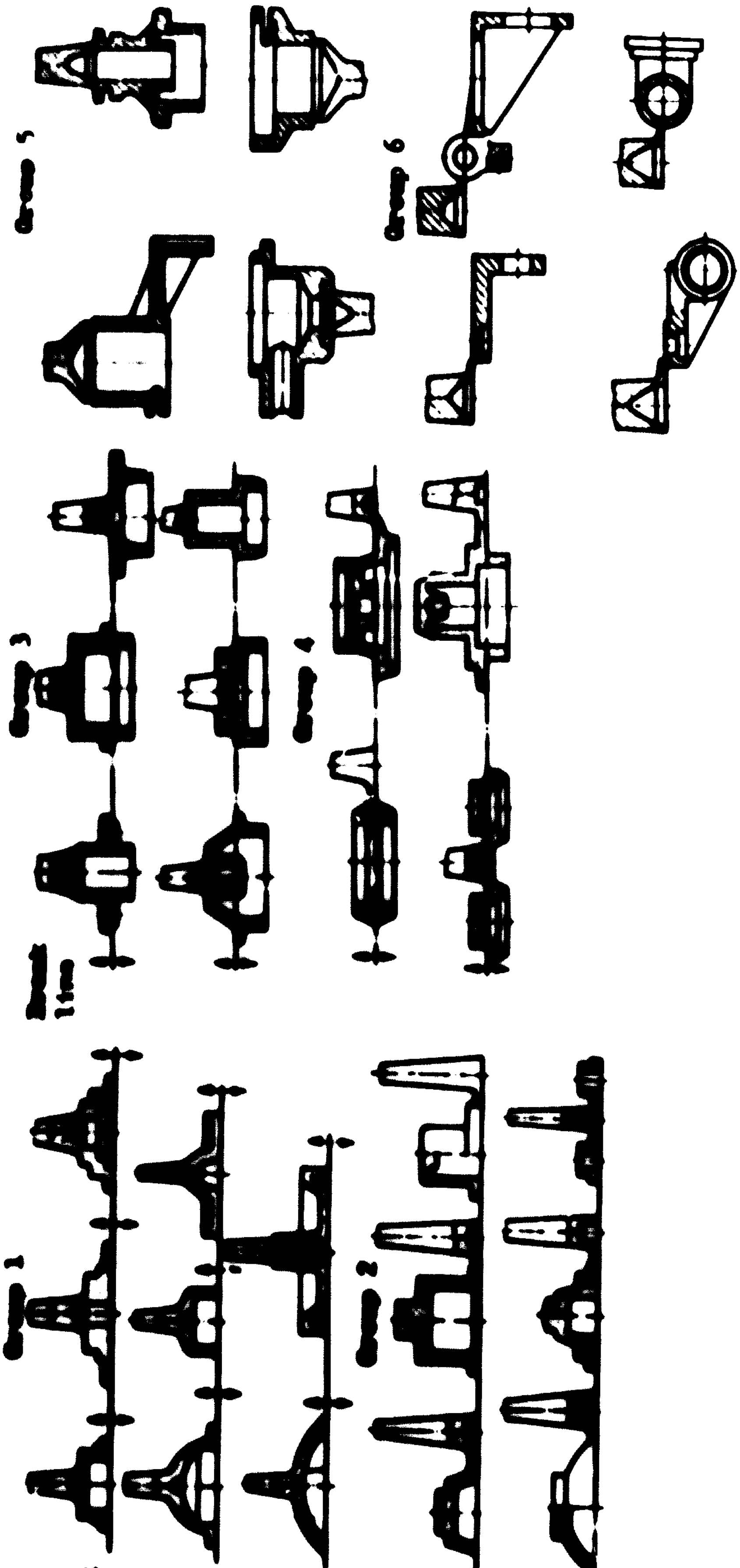
Group 5 consists of parts which have the same features as in Group 3, but where from 1 to 3 side apertures are formed in the casting in 3 mutually perpendicular directions.

Group 6 differs from Group 5 only in that side pouring is used in the casting process.

Principles of the design of group-adaptable mould units and inserts

The principle lying at the basis of the design of such group-adaptable mould assemblies is that of the use of exchangeable mould inserts to form the part. Every effort must be made to ensure that such mould inserts can be changed without removing the mould unit from the casting machine and with the minimum expenditure of time.

Figure 31



The most effective system of fastening mould inserts is the slide-in system, which enables the inserts to be changed without taking the mould unit out of the machine.

Each mould unit consists of two parts. The fixed part is fastened to the stationary part of the machine, while the movable part (together with the stripper devices) is fastened by means of special base to the movable part of the casting machine.

The dimensions of the parts to be cast determine the type of machine, and consequently also the dimensions of the seats of the mould units. Depending on the dimensions of the castings making up the group, mould units may be of different dimensions, although identical in design.

By way of example, let us consider in greater detail one of the designs, of group-adaptable units used to produce castings of Group 1. The parts are actually formed in the fixed part of the mould, as the break line coincides with the end face of the part. Stripping from the cores is carried out by a stripper plate. Centre pouring is used in the casting process. The mould units are designed for use on "Polak 408" and "Polak 600" machines.

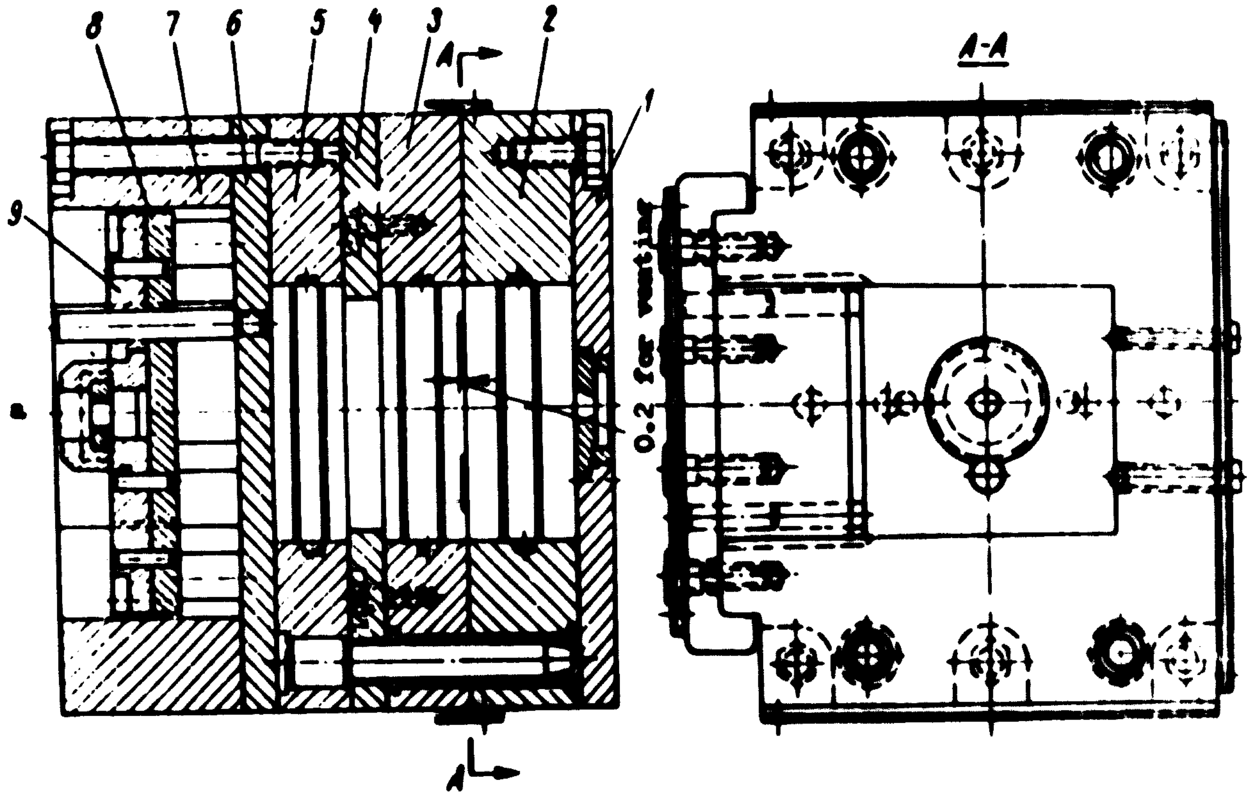
The group-adaptable mould unit (shown in Figure 32) consists of two parts: a fixed part and a movable part. The two halves of the mould are mated by means of four guide posts and bushes which positively locate them during operation. The fixed part consists of a plate 1 fastened by screws to the beam carrying the fixed mould 2, while the movable half of the mould, which incorporates the mechanism for ejecting the part, consists of four plates 3, 4, 8 and 9 fastened together in two sets which can be displaced by means of a hydraulic mechanism relative to the plates 5, 6 and 7.

Both halves have recesses in them in which the exchangeable mould components are inserted and held in place by screw clamps.

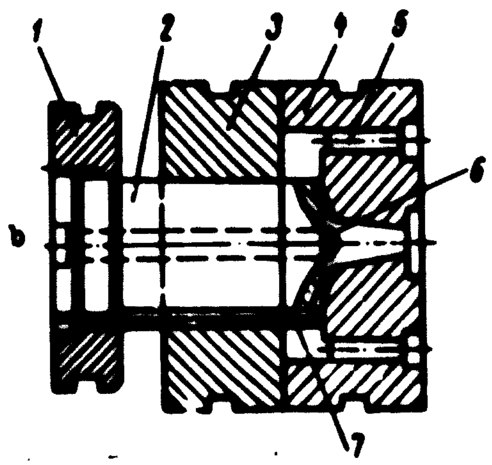
Figure 32 shows the design of an exchangeable mould insert designed for this type of unit The insert consists of plates 3 and 4, moulding cores 2, 5 and 7, a stripper plate 6, and a plate 1 for the fastening of cores 2 and 7.

The mould shown has a centre pouring system located directly in the insert.

Figure 32



Exchangeable insert



The mould inserts can be changed without removing the mould unit from the machine at all. All that it is necessary to do to change the inserts is to remove the pressure strips, take out the inserts from the movable and fixed parts of the unit, and replace them with the new ones needed to produce another type of part in the same group.

Figure 33 shows a group of parts made up of castings, whose break line (rise) runs through their plane of greatest area and which are formed in both the movable and the fixed parts of the mould inserts.

The parts in the group share the characteristic of having co-axial side apertures. The finished parts are stripped from the mould by ejectors, and side pouring is used in the casting process.

The design of a group-adaptable unit is shown in Figure 34a. The unit consists of a fixed plate 1 with wedges 7 which serve to maintain in a fixed position the movable blocks 6 which have shafts 5 connecting them to hydraulic cylinders mounted in the unit. These cylinders actuate the cores which form the apertures and hollow spaces in the casting (Figure 34b, positions 6 and 7).

The movable part of the unit consists of a plate 2 with slots to guide the blocks 6 and a system of plates 4 carrying the ejectors, which are fitted with shafts 3 connected to the hydraulic equipment and which strip the cast part from the hollows in the mould inserts.

The mould inserts 9 and 10 (Figure 34b) are clamped in place on the main plates of the unit.

Figure 34c shows the design of the mould inserts. The inserts consist of a fixed mould 1 with guide posts 5, a movable mould 5 with cores 6 and 7 which are connected with the movable block 6 of the mould assembly (Figure 34a), and a punch 2 and ejector 4 mounted on a plate 3.

<u>Calculation of the economic effectiveness of the use of group-adaptable equipment</u>

The economic effect which can be achieved by the use of a given type of equipment is determined by comparing the cost of manufacturing the equipment in question with the economies on direct wage payments (through reduction of auxiliary, make-ready and clean-up labour requirements) which can be achieved by the use of such equipment.

Figure 33

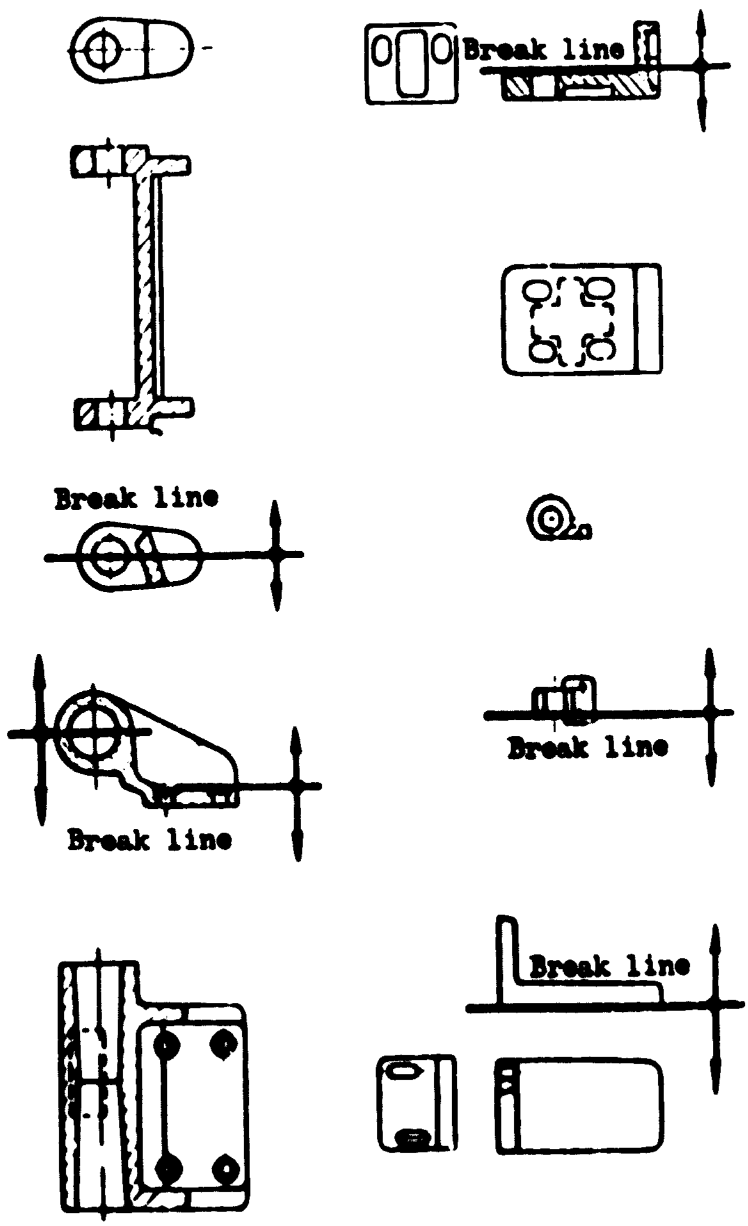
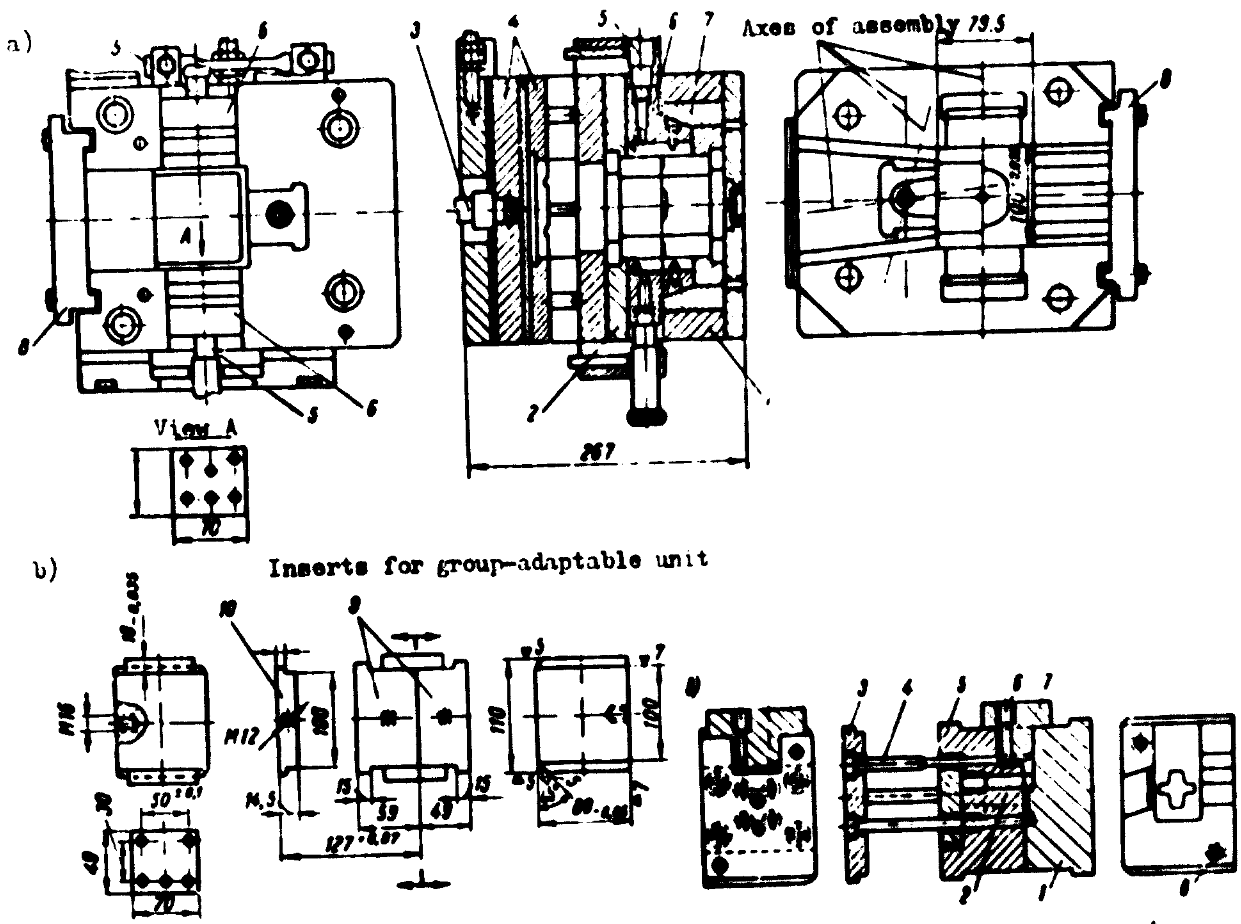


Figure 34


a)
Axes of assembly
79.5
View A
70
267
b)
Inserts for group-adaptable unit
M16
M12
100
110
127
39
49
15
70

The reduction in the labour requirements for one part/operation can be determined by the formula:

$$e' = E_1 - E_2$$

Where:

E_1 is the amount of labour required for one part/operation before the use of the new equipment, and

E_2 is the amount of labour required for the same part/operation when the new equipment is used.

When one type of equipment is replaced with another type of higher productivity, the amount of labour required is determined in a similar manner; in this case, E_1 is the amount of labour required for the manufacture of a part with the previous equipment, and E_2 is the amount of labour required for the same operation with the new equipment.

Economies in direct wage payments, e, achieved through the utilisation of new equipment are expressed by:

$$e = E_1R_1 - E_2R_2$$

Where:

R_1, R_2 are the piece-work rates for the operation in question before and after the use of the new equipment.

The economic advantageousness of the use of new equipment can be expressed as follows:

$$P \leq DN$$

Where:

P is the yearly cost of operating one item of equipment;

D is the economic effect of the use of the new equipment, and

N is the scheduled annual output of parts.

It is assumed in this case that the same basic production machinery is used both before and after introduction of the new equipment.

If the amount of money spent on the production of the new equipment is the same as the amount of the economics made by using it for the production of the volume of parts scheduled in the annual production programme, we have the equation:

$$F = DN$$

This equation determines the maximum permissible annual expenditure on the manufacture of the new equipment for the given production programme.

It follows from this that the minimum production programme N_{min} at which the expenditure on the manufacture of the equipment will be covered, will be:

$$N_{min} = \frac{F}{D}$$

Accordingly, the economic effect which the use of the equipment should bring about in the manufacture of the part in question is:

$$D = \frac{F}{N_{min}}$$

The total economic effect D_{tot} which will be derived from the introduction of one piece of equipment of this type will therefore be equal to:

$$D_{tot} = D (N_r - N_{min})$$

Where:

N_r is the size of the actual annual production programme.

In cases where it is necessary to compare two types of equipment which are different in effectiveness and cost, the following formula can be used:

$$N_K = \frac{P'' - P'}{D'' - D'}$$

Where:

P' and D' are the cost and economy for the "cheaper" type of equipment;

P" and D" are the cost and economy for the more expensive equipment; and

N_K is the critical production schedule for which both the types of equipment being compared are of the same economic effectiveness.

For an annual production schedule greater than N_K the use of the more expensive type of equipment will be more advantageous.

Figure 35 shows graphs comparing cost and economy. The critical production schedule N_K corresponds to the point of intersection of the curves A and A' representing the total economy for the two types of equipment being compared. Curve A corresponds to the economy achieved by the use of the equipment which is "cheaper" in initial cost, but which is less effective in use, while curve A' represents the economy achieved by the use of the more "expensive" equipment.

In order to determine the effectiveness of equipment, a nomogram such as is shown in Figure 36 may be used.

Such a nomogram can be used for the solution of the following problems:

1. Determination of the maximum permissible annual expenditure on a single type of equipment, as a function of the economy achieved by its use;
2. Calculation of the economic effectiveness of using a given type of equipment, for a known annual expenditure on such equipment and a given volume of production of parts;
3. Determination of the minimum saving on direct wage payments through the use of a given type of equipment if the annual expenditure on the equipment, the production schedule for parts, and the level of overhead expenses are known;
4. Calculation of the production schedule for a given part which will cover expenses on equipment and will bring about a given economy on direct wage payments.

The amount of labour needed to produce parts with different equipment can be determined by the standardization of operations.

When group production methods, which permit the utilization of group-adaptable (GPN) and universal (UNP) exchangeable-component equipment, are employed in a plant, it is necessary to calculate the economies achieved with the use of such equipment.

A group may contain different kinds of parts which are produced in different numbers, and it may be profitable to use special equipment for the production of some parts. It is therefore necessary to establish whether or not it would be more advantageous to use group-adaptable equipment in such cases.

Figure 35

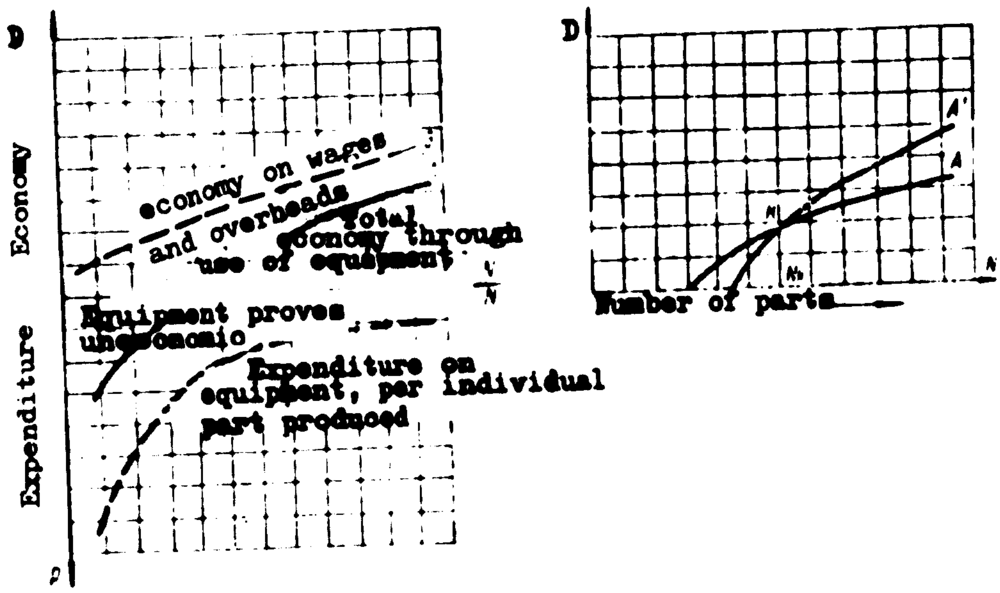
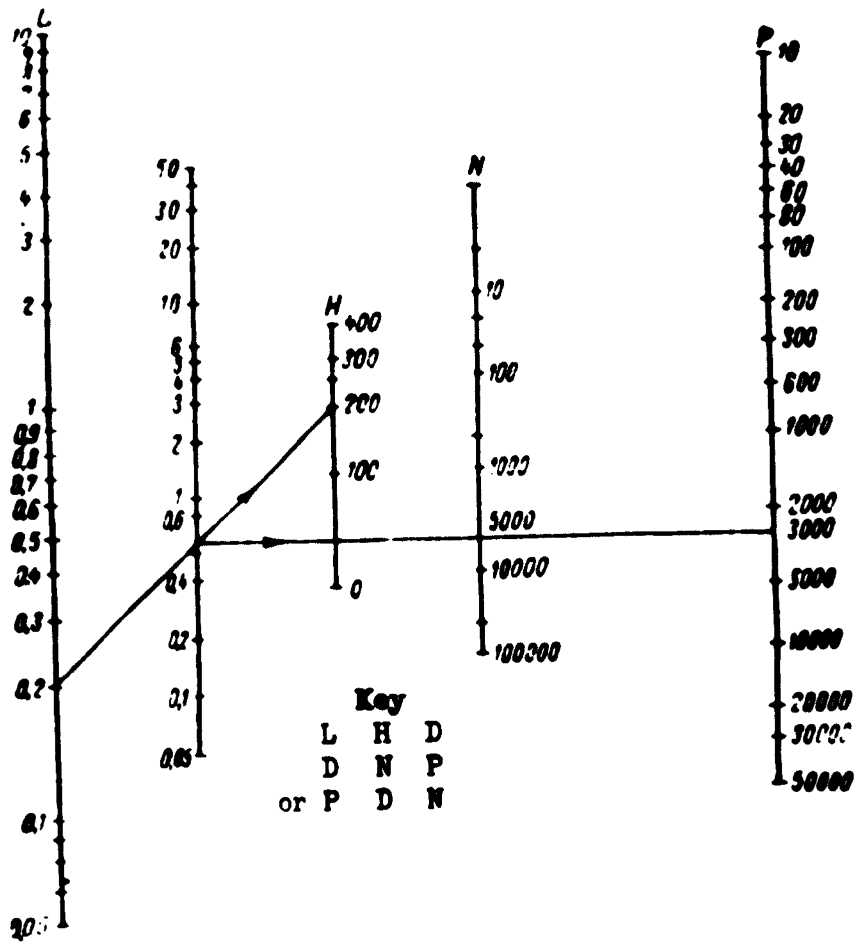


Figure 36

Nomogram for determining the effectiveness of equipment



The settlement of this question amounts basically to the comparison of the economic results achieved by the use of special equipment with the results achieved by the replacement of such special equipment with group-adaptable or universal equipment with special exchangeable components. The following inequality may be used for this calculation:

$$\left\{D_{gr} - \left[(A^a_{gr} + A^D_{gr})\, S_{gr} + (A^a_N + A^D_N) \sum_1^m S_N\right]\right\} \gtrless \left\{D_S - (A^a_S + A^D_S) \sum_1^m S_s\right\}$$

Where:

D_{gr} is the total economic effect achieved through the production of an entire group of parts with group-adaptable equipment;

A^a_{gr}, A^D_{gr}, A^a_S and A^D_S are the coefficients of amortization and operation corresponding to group-adaptable and special equipment;

A^a_N, A^D_N are the coefficients of amortization and operation of the exchangeable components;

S_{gr} is the cost of group-adaptable equipment;

S_N is the cost of a single exchangeable component;

D_S is the total economic effect achieved with the use m of special equipment for the production of the entire given number of parts; and

S_S is the cost of a single item of special equipment.

In the case in question, each of the three expressions:

$$(A^a_{gr} + A^D_{gr})\, S_{gr} \;;\; (A^a_N + A^D_N) \sum_1^m S_N \;;\; (A^a_S + A^D_S) \sum_1^m S_s$$

represents the total of the corresponding expenditure for one year of operation.

The values of the coefficients A^a and A^D must be selected on the basis of practical factory experience.

In short-run production, there is no advantage in preparing complicated special equipment. Parts are therefore frequently manufactured either with universal equipment or with the use of simple mounting and clamping elements such as clamps, blocks, etc. In such conditions, however, the use of group-adaptable equipment would be much more advantageous, as such equipment is specifically designed for the production of a whole group of parts rather than one batch of identical parts above.

In the case in question, the total yearly production schedule N will consist of the outputs N_1, N_2, etc. of each part in the group:

$$N = \sum_{1}^{m} N_n$$

In the graph in Figure 37, the cost of special equipment for a single part in a given production schedule is represented by a straight line parallel to the horizontal axis of the graph. If such parts are manufactured with group-adaptable equipment with exchangeable components, however, the picture changes.

The cost of group-adaptable equipment for a single part will be equal, when a large number of types of parts, and consequently also a larger quantity of parts are to be produced, the cost of group-adaptable equipment will amount, for each individual part, to:

$$P_{gr} = \frac{S_{gr} + \sum_{1}^{m} S_N}{N_{tot}}$$

Where:

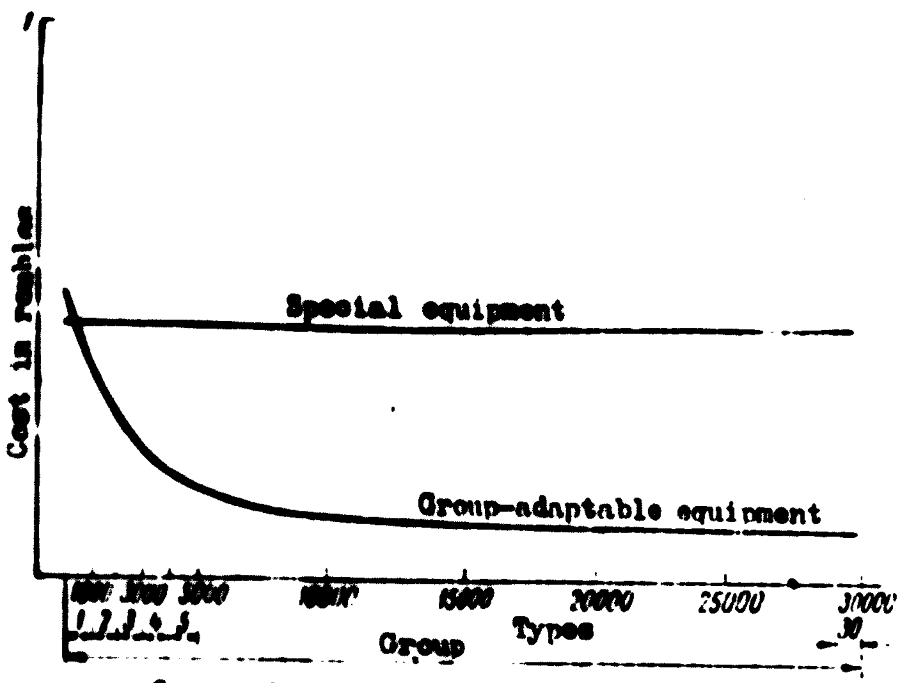
P_{gr} is the cost of group-adaptable exchangeable-component equipment per individual part;

S_{gr} is the cost of the group-adaptable equipment; and

S_N is the cost of the exchangeable components.

Figure 37 clearly shows how expenditure on group-adaptable equipment varies with increase in the total production schedule of all types of parts in a group.

Figure 37



Comparative cost of equipment, per individual part produced

It should be noted that in introducing group-adaptable equipment the throughput capacity of such equipment should be also taken into account. If a group contains a considerable number of types of parts, it is sometimes necessary to put into operation not just one, but several duplicate items of equipment.

Furthermore, in order to unify the equipment, it is necessary to standardize the basic (fixed) components of group-adaptable dquipment. If this is done, the series production of such standardized components can be undertaken. This not only considerably reduces the cost of the components, but also reduces the amount of time and money needed to start production of the parts which the equipment is designed to manufacture.

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