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Setting–up and Operating of Horizontal or Vertical Milling Machines – Course: Techniques for Machining of Material. Trainees' Handbook of Lessons

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Setting−up and Operating of Horizontal or Vertical Milling Machines – Course: Techniques for Machining of Material. Trainees' Handbook of Lessons

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1. Purpose and importance of milling

The milling technique is used to machine and produce workpieces made of free−cutting material.

Milling is a metal cutting operation with the cutting done by a single−edged or multi−edged tool, the milling cutter.

The milling cutter performs a rotary movement (primary motion) and the workpiece a linear movement (secondary motion).

The milling technique is used to produce, mainly on prismatic components, flat, curved, parallel, stepped, square and inclined faces as well as slots, grooves, threads and tooth systems.

There are two basic milling methods: plain (or cylindrical) milling and face (or end) milling. Either method may be up−cut (or conventional) milling or down−cut (or climb−cut) milling. Plain milling and face milling differ with respect to the milling cutters or cutting edges (teeth) used in the cutters, respectively, and to the direction of feed.

Plain milling (cylindrical milling)

The peripheral teeth are cutting.

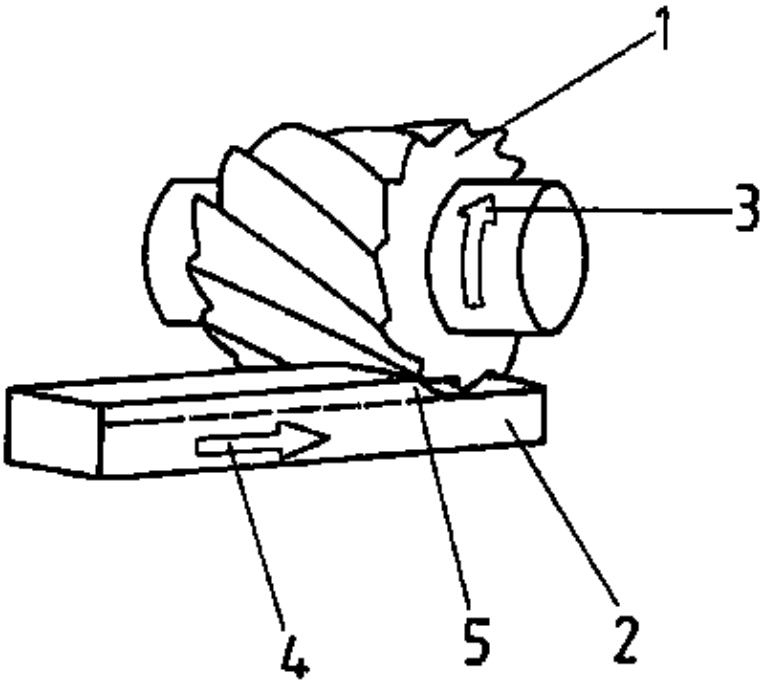

Figure 1. Working motions of plain milling

1 plain milling cutter, 2 workpiece, 3 direction of rotation, 4 feed direction, 5 cross–sectional area of cut

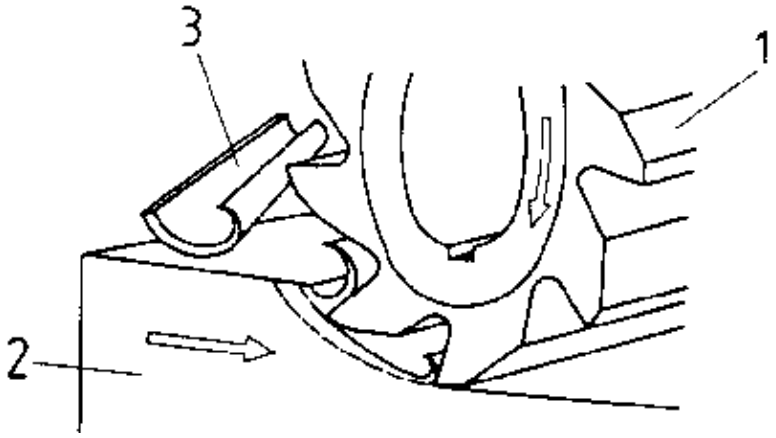

Figure 2. Plain milling cutter in action

1 plain milling cutter, 2 workpiece, 3 comma–shaped chip

Face milling (end milling)

The radial and peripheral teeth are cutting.

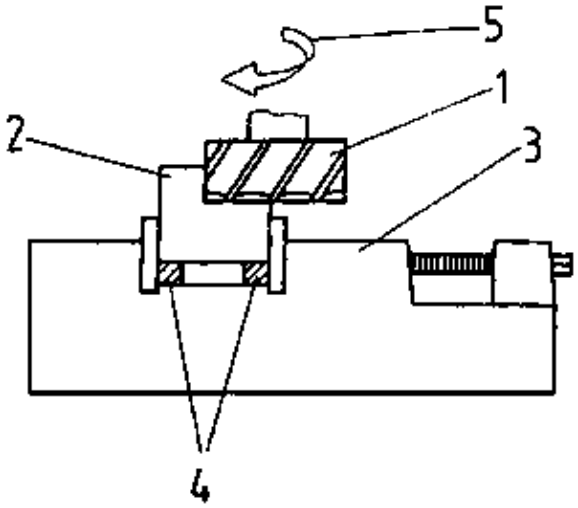

Figure 3. Face milling cutter (face milling of a stepped face)

1 face milling cutter, 2 workpiece, 3 machine vice, 4 parallel blocks, 5 direction of rotation of cutter

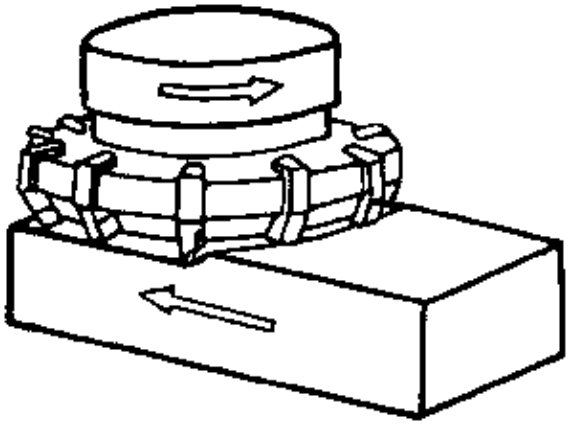

Figure 4. Face mill during face milling

Up–cut milling (conventional milling)

The primary motion of the milling cutter and the secondary motion of the workpiece are in opposite directions.

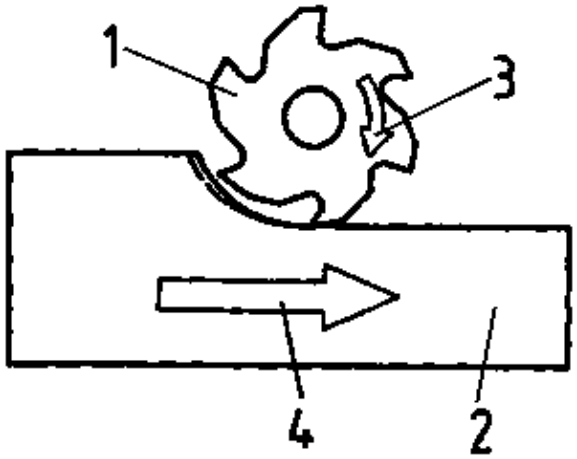

Figure 5. Up–cut milling

1 milling cutter, 2 workpiece, 3 direction of rotation of cutter (primary motion), 4 feed direction of workpiece (secondary motion)

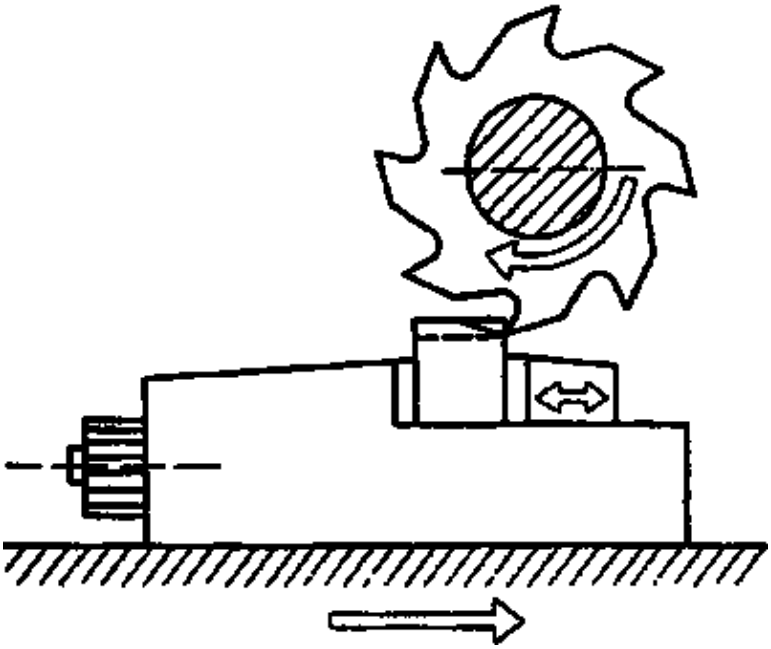

Figure 6. U–cut milling (workpiece clamped in machine vice)

Down–cut milling (climb–cut milling)

The primary and secondary motions (cutter and workpiece motions) are in the same direction.

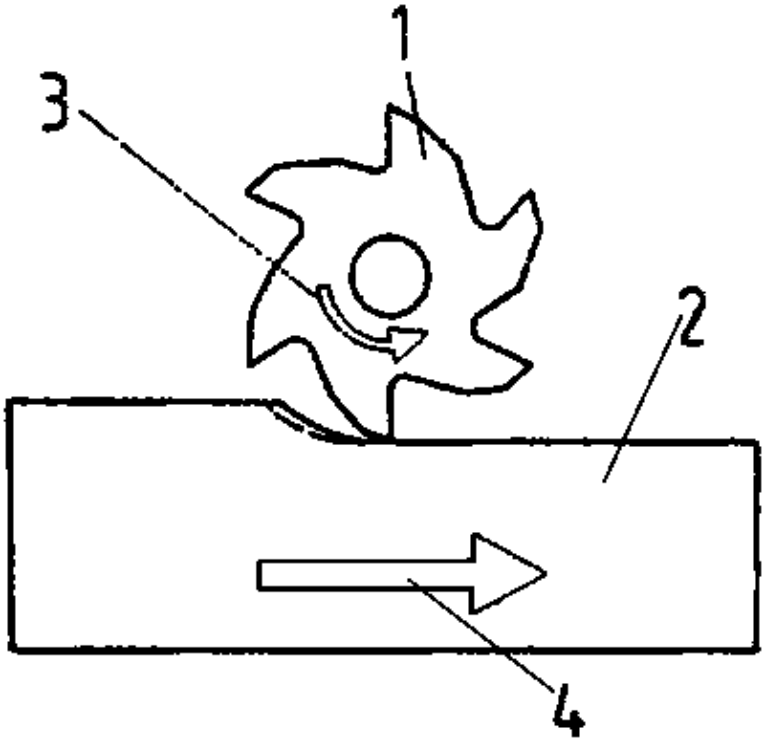

Figure 7. Down–cut milling

1 milling cutter, 2 workpiece, 3 direction of rotation of cutter (primary motion), 4 feed direction of workpiece (secondary motion)

Down–cut milling calls for the following technical prerequisites:

– For elimination of the backlash between the machine table screw and screw nut, a climb–milling attachment (backlash eliminator) is necessary.

– The increased cutting values of down–cut milling (1.5 times the cutting values of up–cut milling are possible) necessitate a low–vibration bearing of the cutter arbor (two counter bearings are recommended for plain milling on the horizontal milling machine) and the

workpiece must be additionally secured in the direction of feed.

– Milling cutters with small wedge angle and relatively big rake angle reduce the cutting impacts and extend the cutter life. The cutting teeth are in action on the maximum thickness of chips.

Down–cut milling is possible only on milling machines with climb–milling attachment.

For down–cut milling the workpiece and workpiece clamping device must be fixed so that the workpiece cannot be pulled to the cutter jerkily. (Danger of accidents/tool breakage).

What is the difference between plain milling and face milling?

_____
_____
_____
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What are the technical prerequisites absolutely necessary for down–cut milling?

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What is the difference between up–cut and down–cut milling?

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2. Types and design of milling machines

The types of milling machines or their names, respectively, are attributable to their application or construction.

Basic types:

– Knee–type milling machines (horizontal or vertical)
– Ram–type (or saddle–type) milling machines
– Piano–milling machines
– Keyway and slot milling machines
– Form copying and engraving millers
– Thread milling machines
– Gear milling machines
– Special milling machines.

Knee–type milling machines are the most popular machines among the above–mentioned types since, in conjunction with additional attachments, they have a wide field of application. For example, the following additional attachments are available: vertical milling head, universal milling head, rotary indexing table, universal indexing head, slotting attachment.

Knee–type milling machines consist of three main units:

– Frame: base plate, column, overarm, counter bearing, knee, saddle and machine table.

– Drive: milling/spindle drive, feed drive and other drives for special attachments between milling cutter and workpiece.

– Control: elements and devices to control the relative movements between the cutter and workpiece.

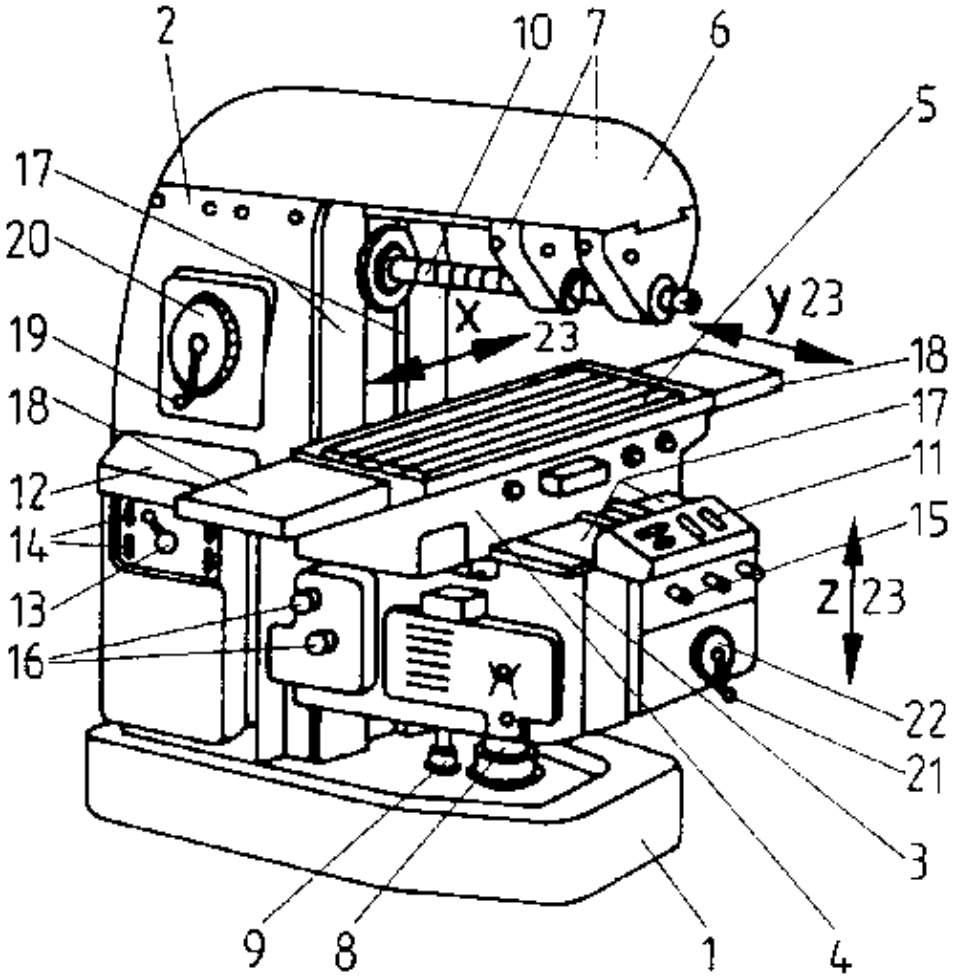


Figure 8. Horizontal milling machine

1 base plate, (base) 2 column, 3 knee, 4 saddle, 5 machine table (table), 6 overarm, 7 counter bearing, 8 screw nut for knee movement, 9 coolant return line, 10 cutter arbor (long arbor), 11 main control console (control panel), 12 auxiliary control console, 13 main switch, 14 selector switch, 15 main hand adjustment, 16 auxiliary hand adjustment, 17 guideways, 18 guideway covers, 19 speed selector lever, 20 speed dial scale, 21 feed selector lever, 22 feed dial scale, 23 directions movements (X, Y, Z axes)

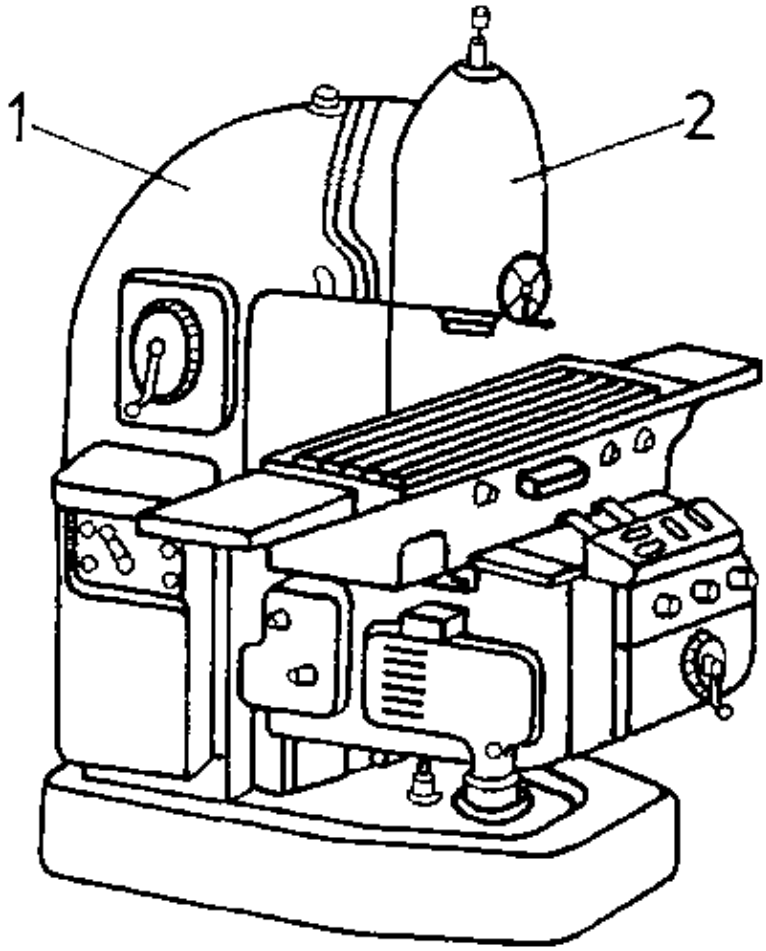


Figure 9. Vertical milling machine

1 top of column (angled towards the front), 2 milling spindle head (swivel type)

Up to the A–B–C plane the frame of the vertical milling machine is similar to that of the horizontal milling machine.

Above that level, the column (1) is angular towards the front and provided with a mount for the swivel–type milling spindle head (2). Thus the milling spindle head can be swivelled to the left and right by 45 degrees each.

3. Preparation for setting–up and operation of horizontal or vertical milling machines

Prior to operating the milling machines, all tools and accessories are to be placed at disposal properly and conveniently and within easy reach observing the following rules:

– Working tools must not lay one above another.

– Measuring and testing tools are to be stored on suitable supports (soft supports: rubber and felt supports).

• Hammer and file handles must be firmly fixed and not be damaged.

• Spanners (open–ended, box and ring spanners), hand and vice cranks must be free from burrs and have the proper size for the purpose of use (bent up openings at spanners and too big spanners/cranks must not be used).

• Clamping tools (machine vices, fixtures, clamping elements) must be suitable for the purpose of locating and fixing.

• Clamping tools for milling cutters (cutter arbors, chucks, collets) must be complete and not be damaged (arbor collars, feather keys, bushings, cap nuts, etc.).

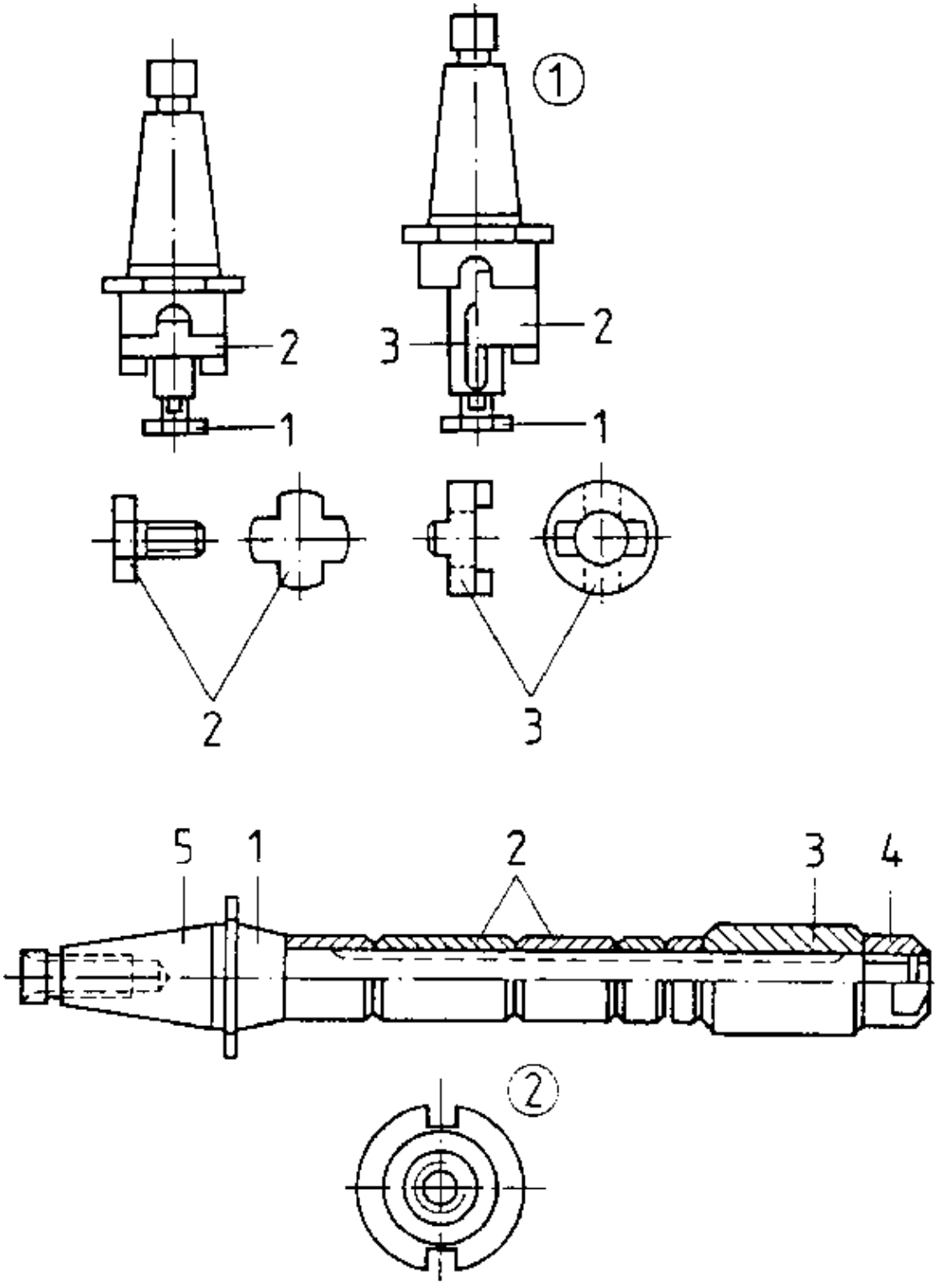


Figure 10. Clamping tools for milling cutters

(1) stub arbor (short arbor) 1 cross screw, 2 driver, 3 feather key

(2) cutter arbor (long arbor) 1 arbor, 2 arbor collars, 3 bush, 4 arbor nut, 5 machine taper (steep taper)

• Tools are to be stored in clean condition.

• All auxiliaries necessary are to be selected according to the work to be done and to be kept ready on proper supports.

Milling of workpieces necessitates firm fixing of the workpieces and cutters. Fixing of workpieces and cutting tools is called “clamping”.

Clamping of workpieces for milling

Clamping of workpieces serves two purposes:

– locating the workpiece, and
– fixing the workpiece.

Locating the workpiece means defining the position and direction of the workpiece depending on the cutter and on the dimensions and datum faces shown in the working drawings.

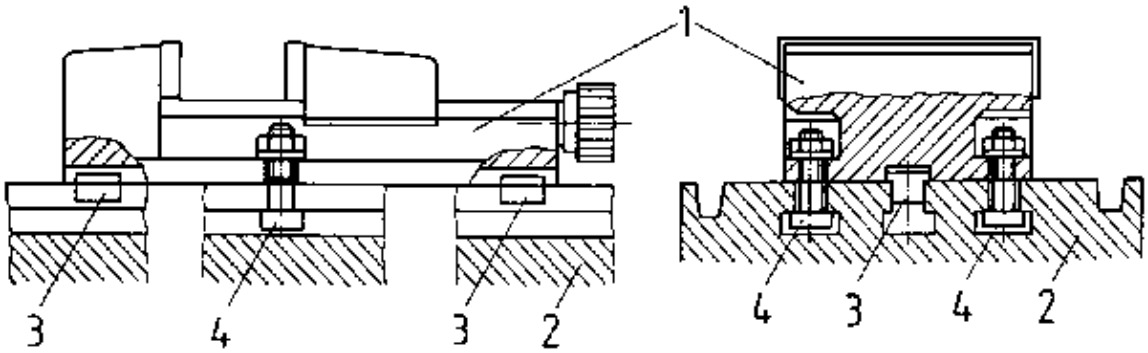


Figure 11. Machine vice located by sliding blocks

1 machine vice, 2 milling table (machine table), 3 sliding blocks, 4 clamping screws

Fixing of the workpiece serves the purpose of holding (retaining) the workpiece during milling in the position where it has been located.

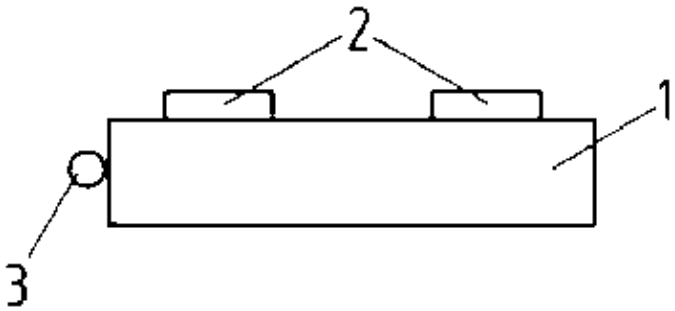


Figure 12. Workpiece located by sliding blocks and stop

1 workpiece, 2 sliding blocks, 3 stop

There are several possibilities for clamping of workpieces which depend on various factors, such as:

– the geometrical form (e.g. cylindrical or prismatic) and the size of the workpiece and its rigidity (thin–walled, hollow casting or square steel part),

– the position of the face of the workpiece to be machined,

– the number and frequency of the workpieces to be machined,

– the selection of clamping tools available and the type of the milling machine used (horizontal or vertical milling machine).

Mostly used clamping facilities include:

– Machine vice (available in various versions).

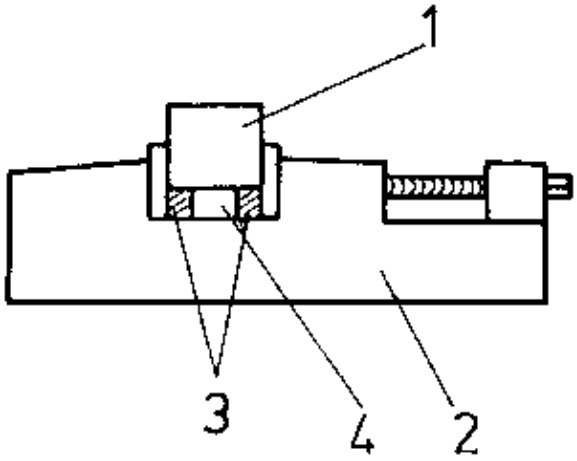


Figure 13. Clamping in machine vice

1 workpiece, 2 machine vice, 3 parallel blocks, 4 machined surface

– A variety of holding clamps, clamping screws and set–up blocks.

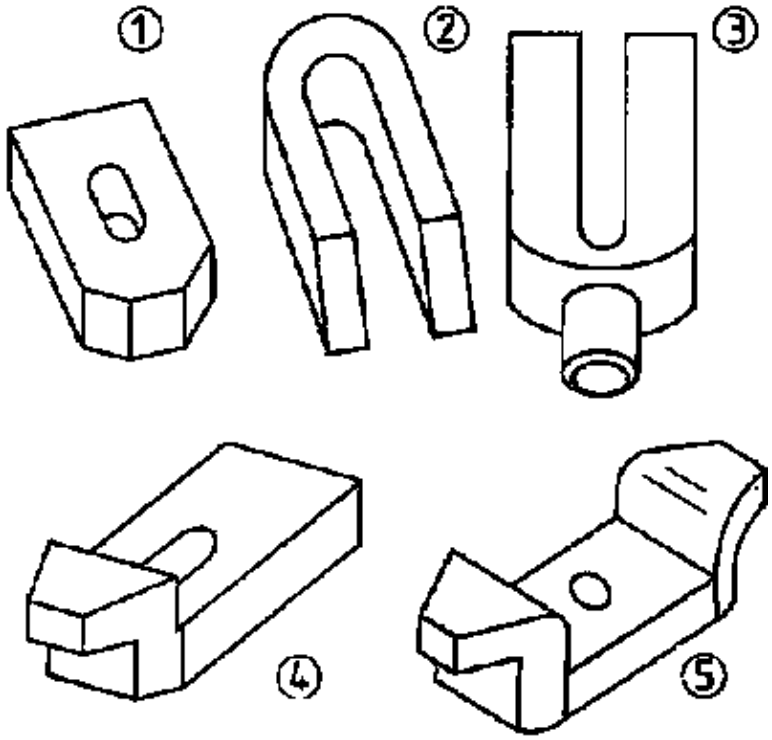


Figure 14. Holding clamps

(1) flat clamp, (2) channel–type, (3) fork–type, (4) offset at one end, (5) offset at two ends

– Sliding blocks, for locating machine vices or directly locating workpieces.

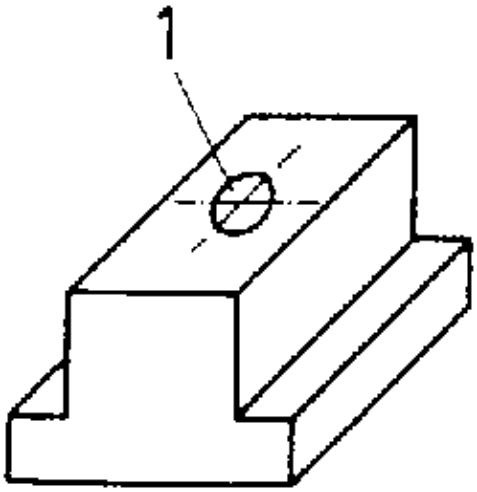


Figure 15. Sliding blocks

1 sliding block with hole for fixing screw

– Angle plates of solid, rotary and swivelling types.

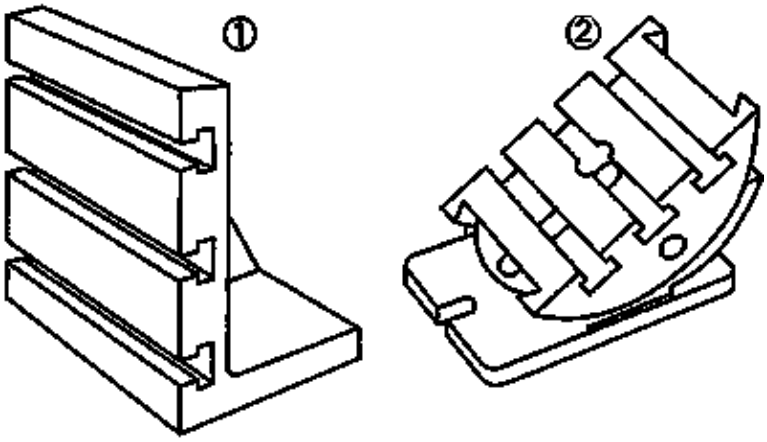


Figure 16. Angle plates

(1) angle plate (90°), (2) angle plate (clamping table), rotary and swivelling

– Chuck jaws with or without rotary base plate.

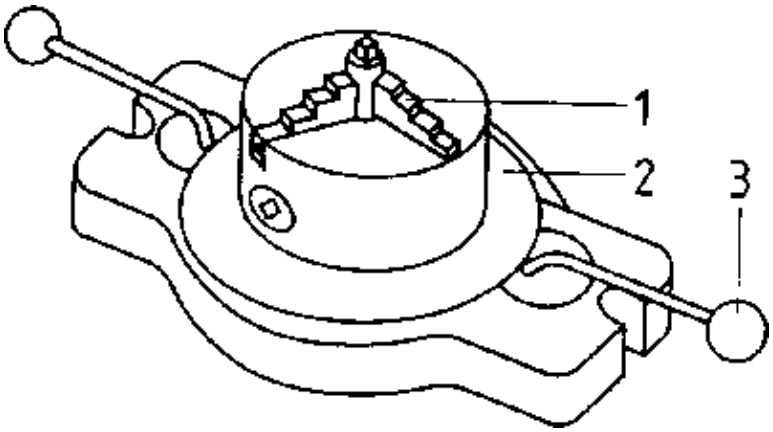


Figure 17. Jaw chuck

1 three–jaw chuck, 2 base plate with scale, 3 control lever

– Workholding fixtures for single or multi–component set–ups.

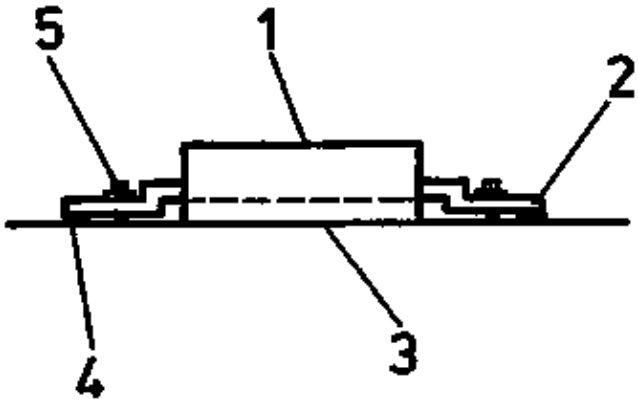


Figure 18. Workholding fixture in direct table clamping

1 workpiece face to be machined, 2 holding clamp, 3 first face machined, 4 support, 5 clamping screw with nut and washer

– Indexing attachments, direct–indexing attachments, universal indexing attachments, rotary indexing tables.

– Clamping auxiliaries, such as stop bars, Vee–jaws, pre–clamping angle plates and clamping mounts for rotary–table indexing.

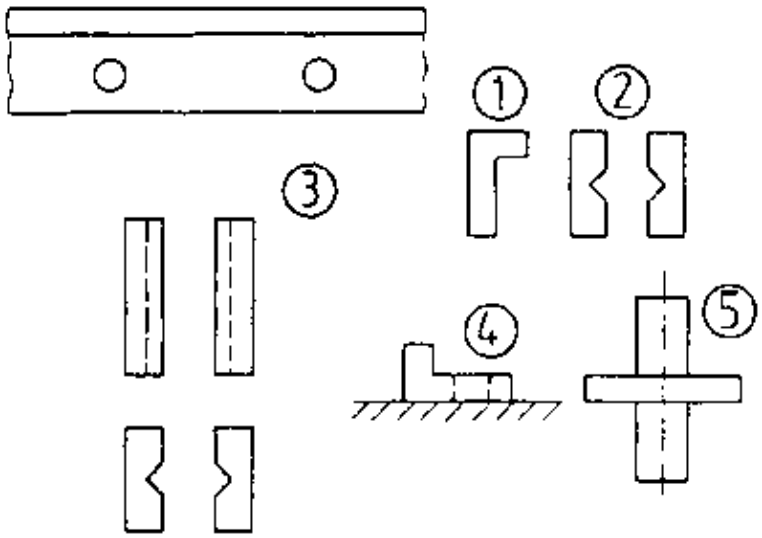


Figure 19. Clamping accessories

(1) stop bar with holes for fixing screws, (2) Vee–jaws (horizontal vee), (3) Vee–jaws (vertical vee), (4) pro–clamping angle plates, (5) clamping mount for rotary indexing table and locating hole in workpiece

Workpiece clamping tools and auxiliaries must serve the following purposes:

– Firm holding (fixing) of the workpiece to secure them against displacement by forces applied during milling.

– Exact and definite location of the workpiece.

– Ensuring sufficient stability and rigidity to permit full utilization of the machine and cutter.

– Quick and easy change of workpieces without any danger.

When clamping the workpieces it is to be made sure that the workpieces, clamping auxiliaries (e.g. jaws of the machine vice) and clamping supports are clean and free from burrs.

Any impurities and burrs will result in deviations from the location and, consequently, from the dimensions of the workpiece and in damage to the workpiece surface.

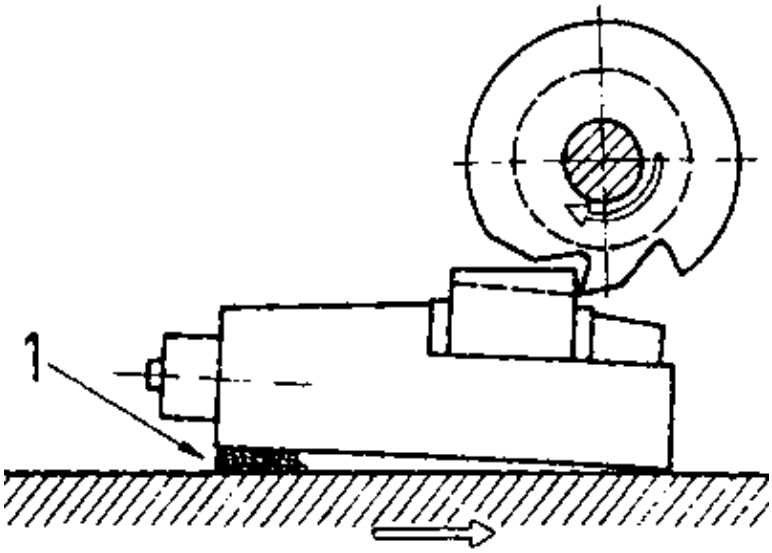


Figure 20. Impurities in clamping

1 chip under machine vice

When clamping thin–walled or instable components it is to be made sure that the clamping force will not deform the workpiece so that it becomes unusable.

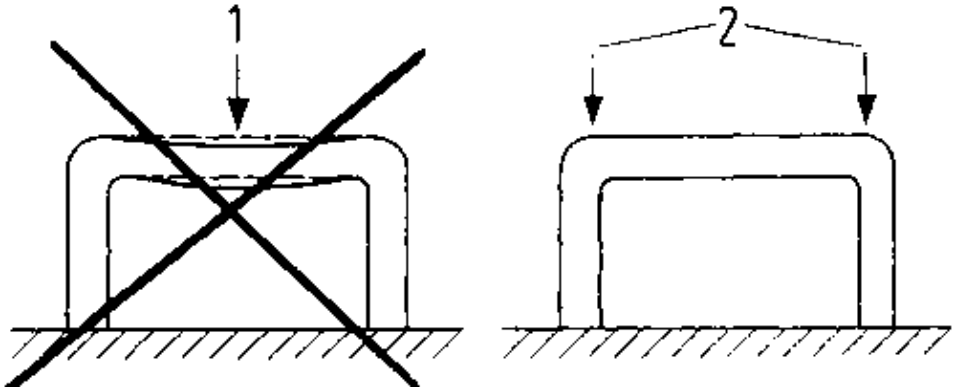


Figure 21. Thin–walled, instable workpiece

1 wrong clamping area – workpiece becomes deformed, 2 favourable clamping areas

Why is it necessary to use serviceable tools and auxiliaries only?

_____
_____
_____

What are the criteria for the selection of workpiece clamping tools?

_____
_____
_____
_____

Clamping of milling cutters

Clamping tools for milling cutters differ with respect to the purpose of use and geometrical form:

– Cutter arbors, long or short (stub arbors)
– Cutter chuck, for straight–shank cutters

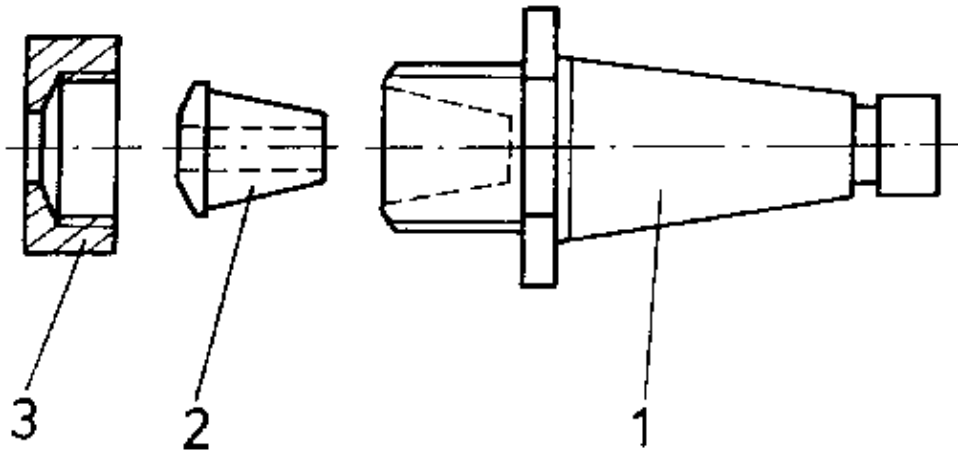


Figure 22. Clamping tools for milling cutters

1 cutter chuck, 2 collet, 3 cap nut

Figure 23. Straight–shank cutter (shank–type milling cutter)

– Cutter adaptor, for taper–shank cutters

Figure 24. Taper–shank cutter (shank–type milling cutter)

– Direct mounting of cutters on the milling spindle

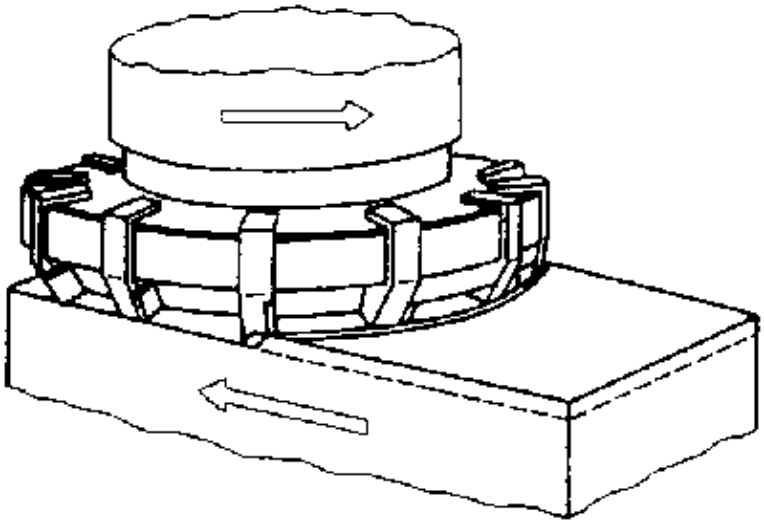


Figure 25. Cutter directly clamped on milling spindle (face milling cutter)

Cleanliness must be ensured when clamping the milling cutters in the clamping tools. Impurities (e.g. chips, dust, sand, etc.) on the contact faces or between the arbor collars will adversely affect the cutting process by radial or axial runout.

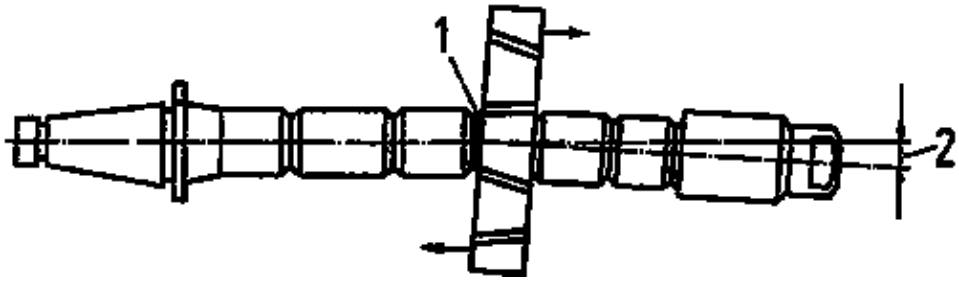


Figure 26. Impurities between cutter and arbor collar

1 impurities, 2 radial runout

– When using long arbors on the horizontal milling machine, the counter bearing is to be placed as close to the cutter as possible to prevent or reduce vibrations generated during milling

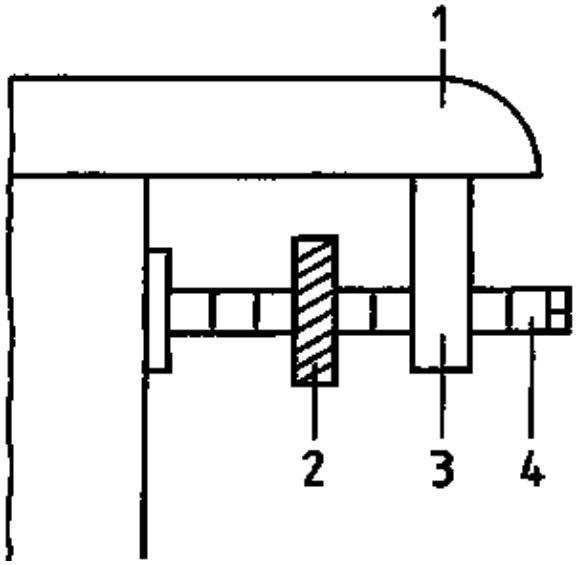


Figure 27. Counter bearing directly at the cutter

1 overarm, 2 cutter, 3 counter bearing, 4 cutter arbor

Vibrations during milling result in deterioration of the surface finish of the workpiece, reduction of the feed rate and early wear of the cutter. The use of a second counter bearing (at the front and rear of the cutter) offers an additional possibility of further reducing vibrations generated, particularly in cases where thick chips are to be

removed.

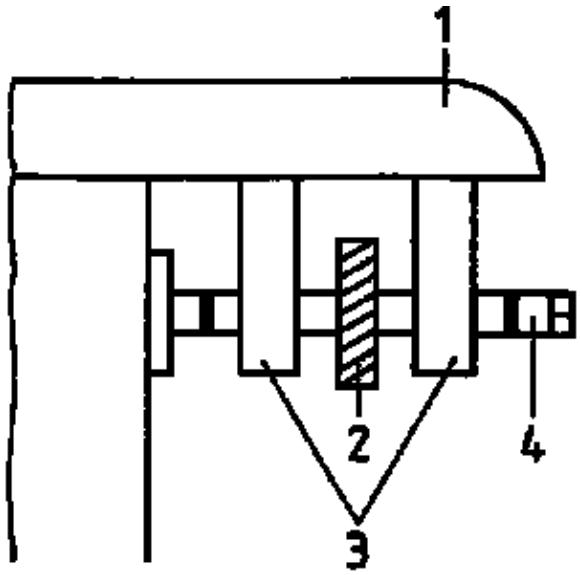


Figure 28. Use of two counter bearings

1 overarm, 2 cutter, 3 counter bearings, 4 cutter arbor

What can be done to reduce vibrations during milling with a long arbor?

_____
_____
_____
_____
_____
_____

4. Setting–up and operation of horizontal or vertical milling machines

Setting–up of milling machines means the preparation of the milling machines for milling. The selection of the clamping tools for the cutters, of the clamping tools for the workpieces and setting of the cutting values, speed rate, feed rate and depth of cut, are necessary prior to milling.

Proper setting–up and operation of the milling machine are prerequisites for carrying out the milling operation successfully. Errors, such as the selection of an unfavourable way of clamping or sequence of the individual steps, will result in defects in quality of the workpieces machines. The amount of work will be considerably increased.

Setting–up and operation of horizontal or vertical milling machines involves the following steps:

1. Planning the work cycle.

2. Making available the cutting tools, measuring and testing tools as well as clamping tools.

3. Checking the cutting tools, measuring and testing tools and clamping tools for serviceability.

4. Checking the milling machine for proper working order:

– existence and state of controls (switches, push–buttons, crank handles),
– oil level (bubble glasses and sight glasses) as well as identified lubrication points,
– existence of safety facilities on the milling machine (covers, hoods, cutter guards).

5. Making available sufficient and adequate coolant.

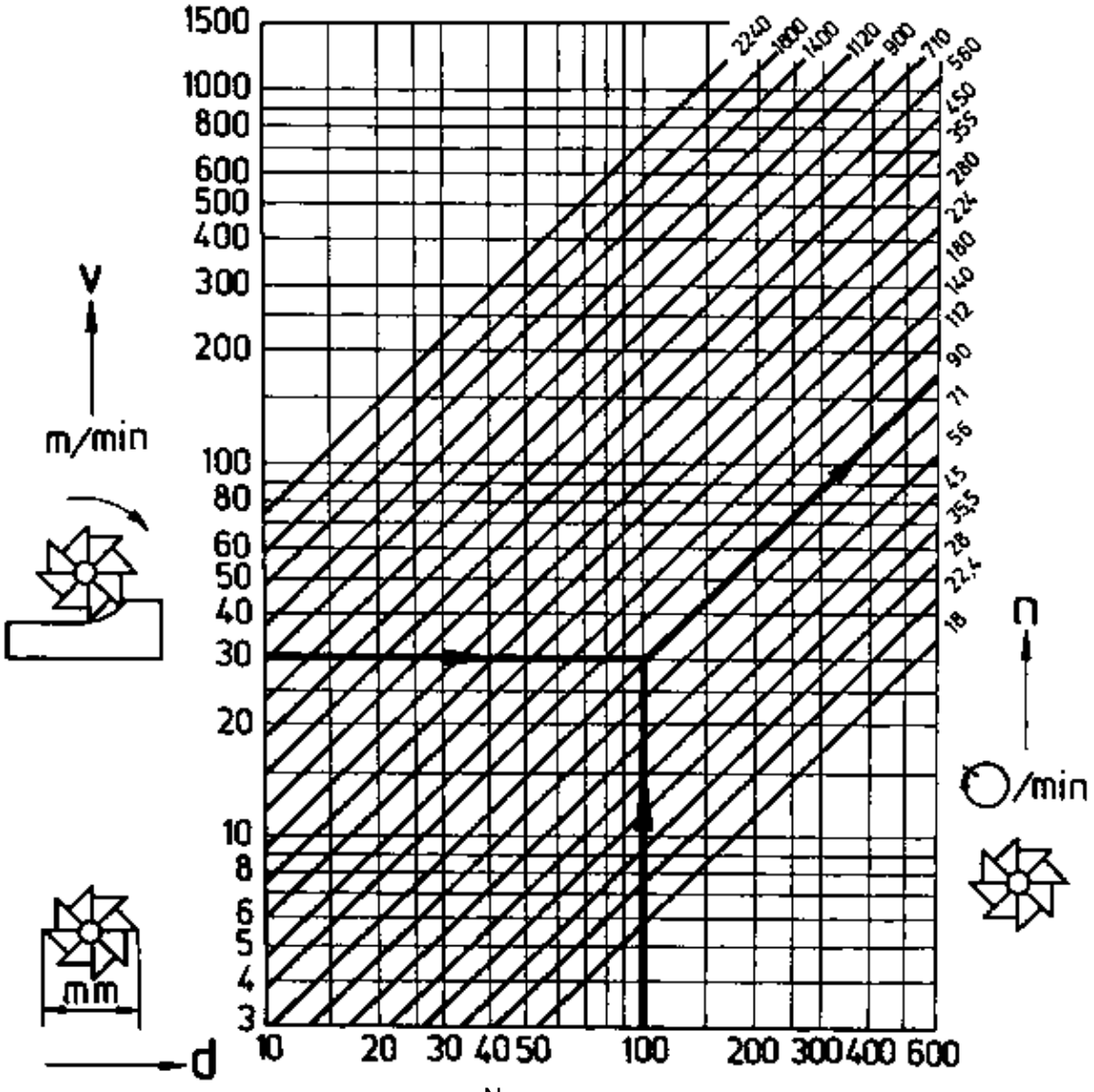
6. Checking for existence and serviceability of end stops on the milling table, knee and saddle.

Any defects found with the milling machine are to be reported immediately to the serviceman in charge to arrange for immediate repair.

If any additional or special attachments are to be used, such as vertical milling heads, universal milling heads, slotting attachments or power driven rotary indexing tables, they are also to be checked for serviceability and safety in operation prior to putting them into operation.

Defective additional attachments are to be replaced. The defective attachment is to be reported for repair.

– The cutting values (cutter speed and feed rates, number of cuts and the relevant depth of cut) are either to be read from the attached documents or to be calculated. They can also be read from the nomogram of the milling machine.



Nomogram

Example

The necessary rotational speed is to be determined for a cutter of 100 mm diameter (d) at 30 m/min cutting speed.

v = 30 m/min (value from table of cutting speeds for milling)

d = 100 mm

Reading for rotational speed (n) = 90 r.p.m.

The rotational speed read from the nomogram is to be set at the milling machine (see Fig. 8 in section 2, 19 – speed selector lever).

• The values determined are to be set by means of the relevant control elements of the milling machine (speed selection lever, feed selection lever and hand adjustment by means of the crank handle).

• For setting the machine table with the clamped workpiece into working position at the cutter, coarse adjustment of the knee, saddle and machine table is made by rapid traverse and fine adjustment by hand.

• The coolant unit is to be positioned and set so that the coolant jet is directed directly on the cutting area. The coolant return line to the coolant tank in the base of the machine must be free from impurities.

– Functions of the coolant:

• Reducing the heat generated by friction between the cutter and workpiece (cooling and lubricating effect), and flushing away the chips from the immediate cutting area.

If necessary, a splash guard and chip guard are to be fitted.

– The cutting value (depth of cut) is set after the “first scratch”. When the cutter is running, the milling table is moved by hand adjustment (crank handle) into the position where the cutting edges of the cutter take the first cut (first scratch).

– After the first milling pass (first cut) it is necessary to check the size and surface finish achieved (comparison with the data on the working drawing).

– After further setting of the depth of cut (until the final size is reached) and finish–milling and subsequent checking of

• the specified dimensions (tolerances),
• the accuracy of shape and position (flatness, parallelism, squareness)
• surface finish (roughness),

machining of the first workpiece is completed.

– For workpiece change (unclamping and clamping) the cutter must be stopped to prevent accidents (hand injuries).

– Metal chips must not be removed by fingers or cleaning rags (danger of injury by sharp–edged or pointed chips). A chip brush or hand broom is to be used.

Note

When chips are removed by means of compressed air, safety goggles are to be used to avoid injuries to the eyes.

For proper fulfillment of the work order it is necessary to observe and follow the specified steps (technological sequence) for setting–up and operating horizontal or vertical milling machines, including maintenance and servicing.

How are the cutting values for milling be determined?

_____
_____
_____
_____

_____
_____
_____

What steps are required in setting–up and operating a milling machine?

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____

What are the functions of the coolant in milling?

_____
_____
_____
_____
_____

5. Maintenance and servicing of milling machines

Like any other machine, milling machines are subject to wear and tear. The physical wear is a result of the use of the machines and of the abrasion caused by friction during use. Such wear can be reduced by regular maintenance and servicing of the milling machine by the operator:

The degree of wear depends on:

– maintenance and servicing of the milling machine,

– properties of coolants and lubricants,

– environmental conditions (dust, temperature variations, etc.)

–operating conditions (single or multi–shift operation, volume of metal removed, proper operation).

Servicing cycle of milling machines:

Kind of servicing work	**Interval**
1. Cleaning of guideways	daily
2. Inspection of oil level (sight glasses)	daily
3. Lubrication as per lubrication chart	as per instructions on lubrication chart
4. Oil renewal	semi–annually/annually
5. Inspection and, if necessary, refilling of coolant tank	weekly
6. Thorough cleaning of the machine	weekly
7. Inspection of slackness of bearings	annually
8. Inspection of electrics (contactors, limit switches, cable connections)	every 3 months
9. Inspection of lubrication pump	semi–annually
10. Coolant renewal	semi–annually

For lubrication of a machine the following basic rule applies:

The specified lubricant is to be applied to the relevant lubricating point in the specified quantity and at the specified time!

It is absolutely necessary to observe the safety regulations for setting–up and operation as well as for maintenance and servicing in order to avoid accidents and interruptions of the production. Any defects found at the lubricating points of the milling machine are to be reported to the serviceman in charge. Repairs, particularly on the electrics, control elements and lubricating points, must be done by authorized specialists only.

For handling and storing lubricants, coolants, etc. the respective fire protection regulations (such as “no smoking” within 5 m; flash points of oil and grease) are to be strictly adhered to in order to prevent fire.

> For setting–up, maintenance, servicing and repair work on the milling machine the main switch must always be in “OFF” position – danger of accidents!

What can be done to reduce the physical wear of the milling machine?

_____
_____
_____
_____
_____

What is to be observed for handling (storing and using) oil and lubricants?

_____
_____

What is the basic rule to be observed for setting–up, maintenance and servicing work in the interest of labour safety?

_____
_____
_____
_____
_____

Setting–up and Operating of Horizontal or Vertical Milling Machines – Course: Techniques for Machining of Material. Instruction Examples for Practical Vocational Training

Table of Contents

Setting–up and Operating of Horizontal or Vertical Milling Machines – Course: Techniques for Machining of Material. Instruction Examples for Practical Vocational Training

Institut für berufliche Entwicklung e.V.
Berlin

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“Einrichten und Bedienen von Waagerecht– oder Senkrechtfräsmaschinen”

Author: Dieter Frank

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Order No.: 90–33–3301/2

Introduction

The present booklet contains 4 selected instruction examples which are intended to help practising and consolidating knowledge and skills acquired in the setting–up and operation of milling machines.

In order to facilitate the preparation and execution of the work, the necessary materials, working, measuring and testing tools and accessories are stated for each instruction example. For the instruction examples 2 and 3 the steel is specified according to the value of its tensile strength in the unit “Megapascal” (MPa).

We also recommend knowledge required in addition to knowledge of setting–up and operation of milling machines, which should be repeated before starting with the work.

Explanations to the working drawings are given before the specification of the technological sequence.

The specified sequence of operations for the individual instruction examples gives the steps necessary for the production of the relevant workpiece. This sequence of operations should be strictly observed if good quality is to be achieved.

For the instruction examples 2 and 3 a working drawing is attached showing the required shapes and dimensions of the work–pieces. The admissible deviations for sizes with no indication of tolerances may be taken from the table below.

Nominal size	Admissible deviation in mm
0.5 – 6	± 0.1
6 – 30	± 0.2
30 – 120	± 0.3
120 – 315	± 0.5

The admissible surface roughness Rz is given in µm (0.001 mm).

Instruction example 1.1.: Operation of the control elements

This example serves to practise the operation of the control elements of a horizontal milling machine and to understand their functions.

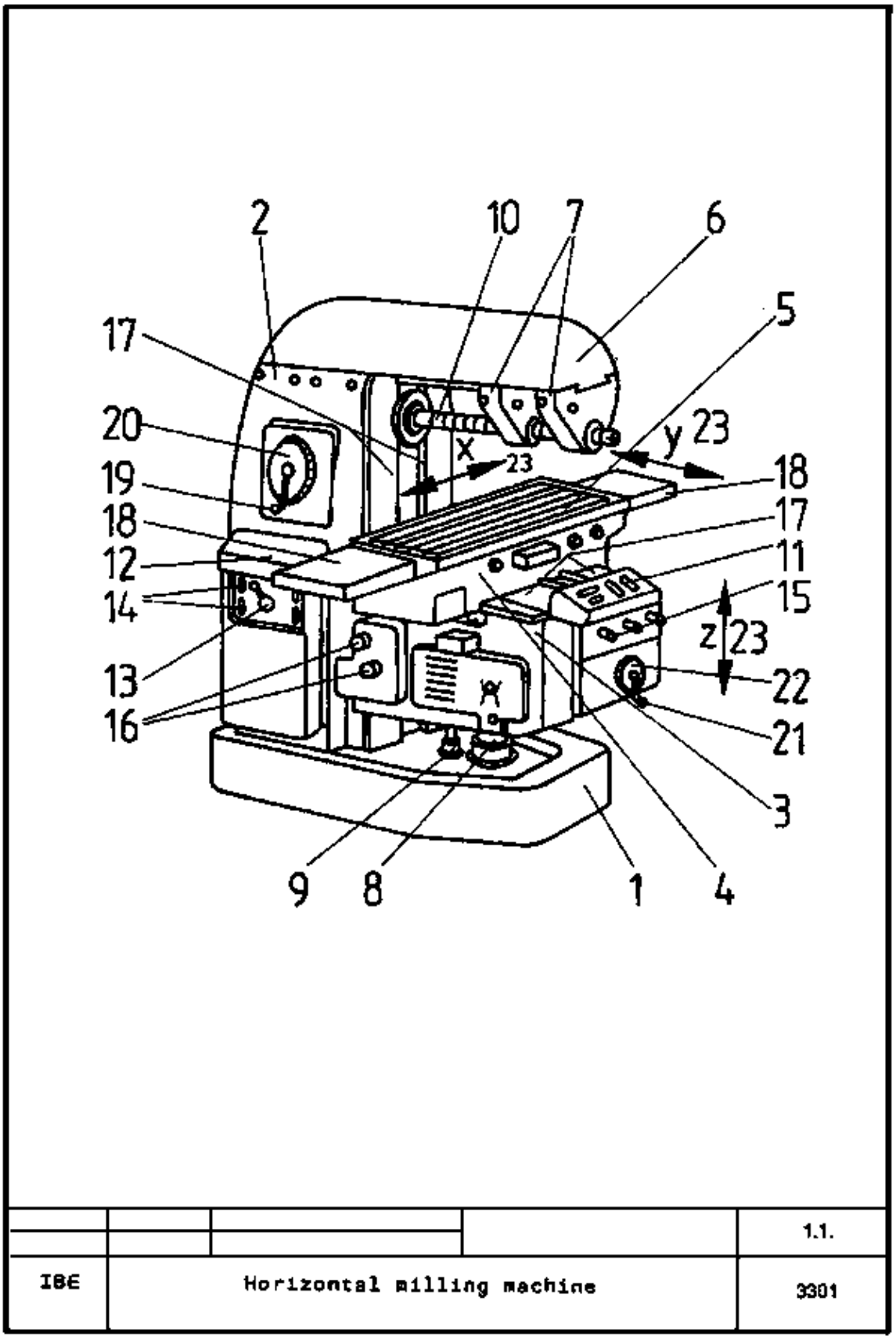
Required previous knowledge

Reading of drawings, design and operating principle of the horizontal milling machine, use and field of application of the milling machine, labour safety regulations.

Explanations to the working drawing

The attached working drawing shows the design of the horizontal milling machine. The individual parts are numbered. In the sequence of operations the number (s) of the control element to be operated is (are) given in brackets.

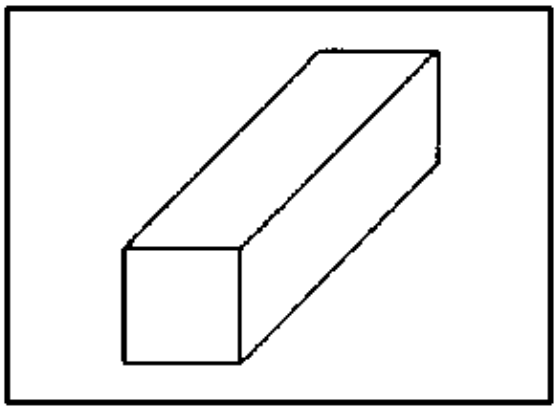
Sequence of operations	Remarks
1. Familiarization with the milling machine – selection of speed (19, 20)	Study the construction and control elements of the milling machine – practise the actuation of the speed selection lever. Operate the lever only when the milling spindle is stopped!
2. Selection of feed (21)	Read the table to determine the feed rate.
3. Operation of the knee (3, 15, 16)	Vertical direction of motion, up and down (Z direction). Vertical motion may be operated manually by the crank handle (moving into position) and mechanically by feed and rapid motion.
4. Operation of the saddle (14, 15, 16)	Horizontal direction of motion on the knee (Y direction). Horizontal motion may be operated manually by the crank handle (moving into position) and mechanically by feed and rapid motion.
5. Operation of the machine table (milling table) (5, 15)	Longitudinal direction of motion in X direction. Longitudinal motion may be operated manually by the crank handle and mechanically by feed and rapid motion. Electro–mechanical stops are used to set and limit the milling travel and the power return travel of the milling table after the milling operation.
6. Operation of the control panel (11, 12)	Familiarization with the functions of the symbols. Location of the main switch and of the circuit breakers and emergency switches. Speed and feed selector switches. Function of the table rise and fall mechanism. Up–cut and down–cut milling. Coolant switch. Operation of rapid motion, feed motion and creep feed motion. Oil lubrication (centralized lubrication, oil level inspection) .
7. Switching the machine ON and OFF (13)	Main switch, emergency switch and control buttons of the main control panel. Check for serviceability prior to putting into operation. On completion of the work order or when leaving the machine, switch off the main switch! Repeat and practise the operation of the milling machine.



Horizontal milling machine

Instruction example 1.2.: Selection of the working tools

The example of a strip to be machined serves to practise the selection of suitable working tools.



Material

St 60 (structural steel with a tensile strength of 600 MPa)

Dimensions

150 x 42 x 38

Machine tool

Vertical milling machine

Working tools

Face milling cutter, cutter arbor (short), machine vice, sliding blocks, clamping screws, spanner, hammer, flat file.

Measuring and testing tools

Vernier caliper

Accessories

Chip brush, hand broom, cleaning rag, parallel pieces, T–slot cleaner

Required previous knowledge

Reading of drawings, types and application of clamping tools and accessories

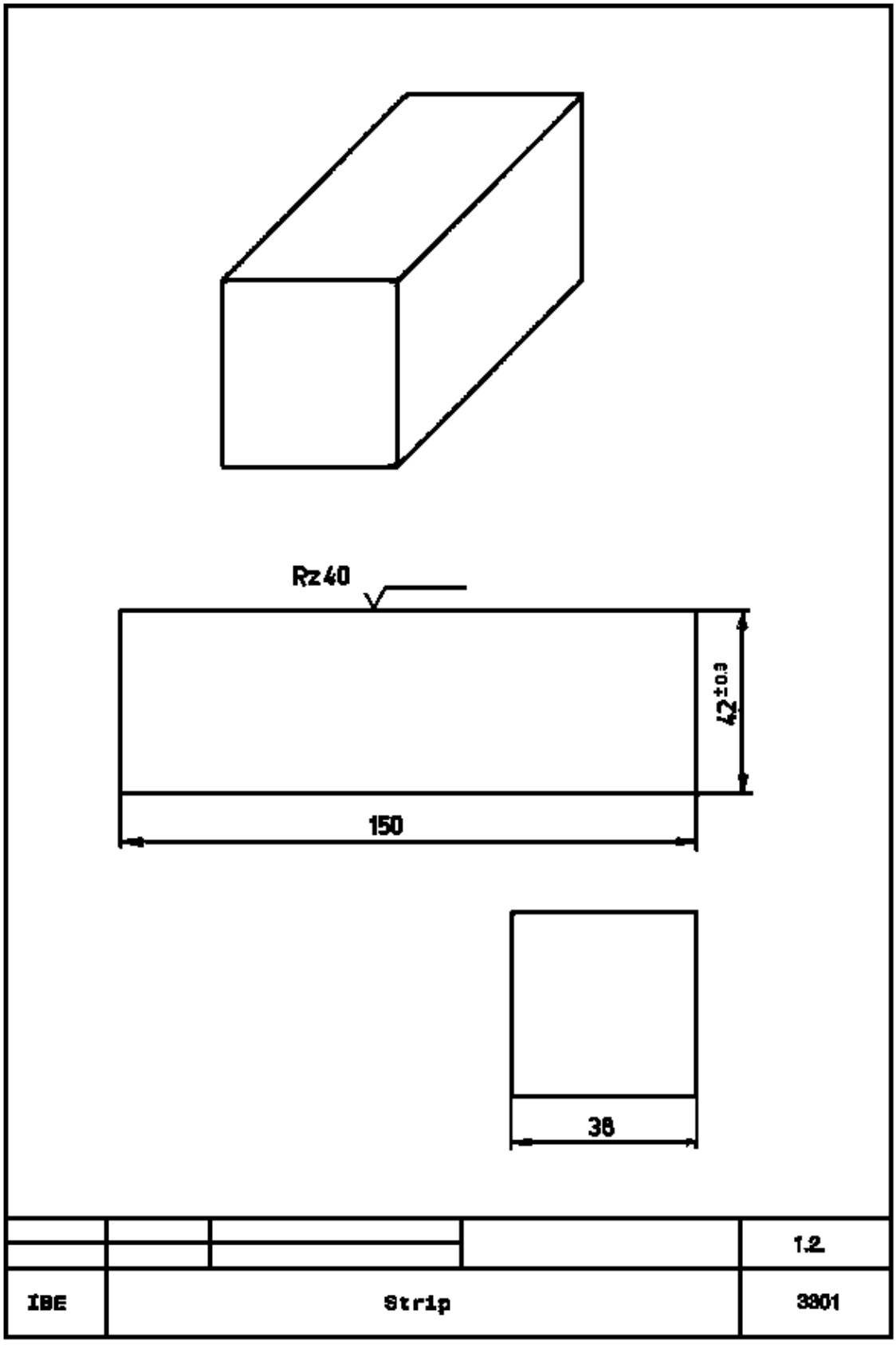
Explanations to the working drawing

Rz 40 : Average roughness of the surface machined = 40 µm (0.04 mm)

Size $40^{\pm 0.3}$: Range of tolerance 39.70 – 40.30 admissible

Sequence of operations	Remarks
1. Inspection of blank sizes	Compare with the details on the accompanying documents.
2. Functional test and lubrication of the milling machine	Lubricate and check oil level as per lubrication chart of the milling machine
3. Clamping the machine vice on the machine table	Locate the machine vice by means of sliding blocks.
4. Selection of milling cutter face milling cutter – (dia. 80 × 40 × 32)	Because of material of workpiece (steel), milling cutters of super high–speed steel or carbide can be used.
	Pay attention to cleanliness when clamping!

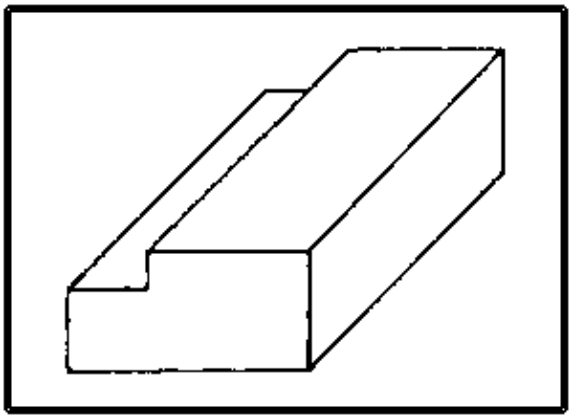
5. Clamping of cutter and mounting of cutter arbor in milling spindle	
6. Clamping of workpiece in machine vice and hammering onto clamping support (parallel pieces)	The workpiece is to be clamped in the vice as deep as possible (safe clamping). In case of small machining allowance a support (e.g. of aluminium) is to be used for hammering to protect the surface from damage by hammer blows.
7. Setting of cutting values for face milling (speed and feed rates)	Values to be taken from tables/standards or to be calculated.
8. Moving the workpiece in machining position (setting the knee, saddle and machine table)	Move knee, saddle and machine table into working position by rapid motion.
9. Scratching (starting cut) of rotating cutter on the workpiece surface and setting of required depth of cut	Machining of steel by a milling cutter of super high−speed steel necessitates the use of coolant.
10. Milling of the first side of the workpiece, inspection of accuracy to size and surface finish	After machining the table is returned in rapid motion with the table rise and fall mechanism in operation.
11. Deburring, cleaning and storing the workpiece on the workbench and machining of the remaining workpieces	Constant checking of the size 42 mm and of surface roughness and correction, if necessary.



Strip

Instruction example 1.3.: Clamping and aligning of workpiece and tool

The example of the production of a strip terminal serves to practise clamping and aligning of workpiece and tool.



Material

GGL 25 (grey cast iron, unalloyed, tensile strength 250 MPa)

Dimensions

500 × 120 × 60

Machine tool

Vertical milling machine

Working tools

Offset holding clamps, clamping screws, spanner, sliding blocks, pressure jaws, locators, face cutter (carbide tipped), cutter arbor (short), flat file.

Measuring and testing tools

Vernier caliper, depth gauge, micrometer depth gauge

Accessories

Chip brush, hand broom, cleaning rag, T–slot cleaner, parallel pieces.

Required previous knowledge

Reading of drawings, measuring and testing, types and application of clamping tools and accessories.

Explanations to the working drawing

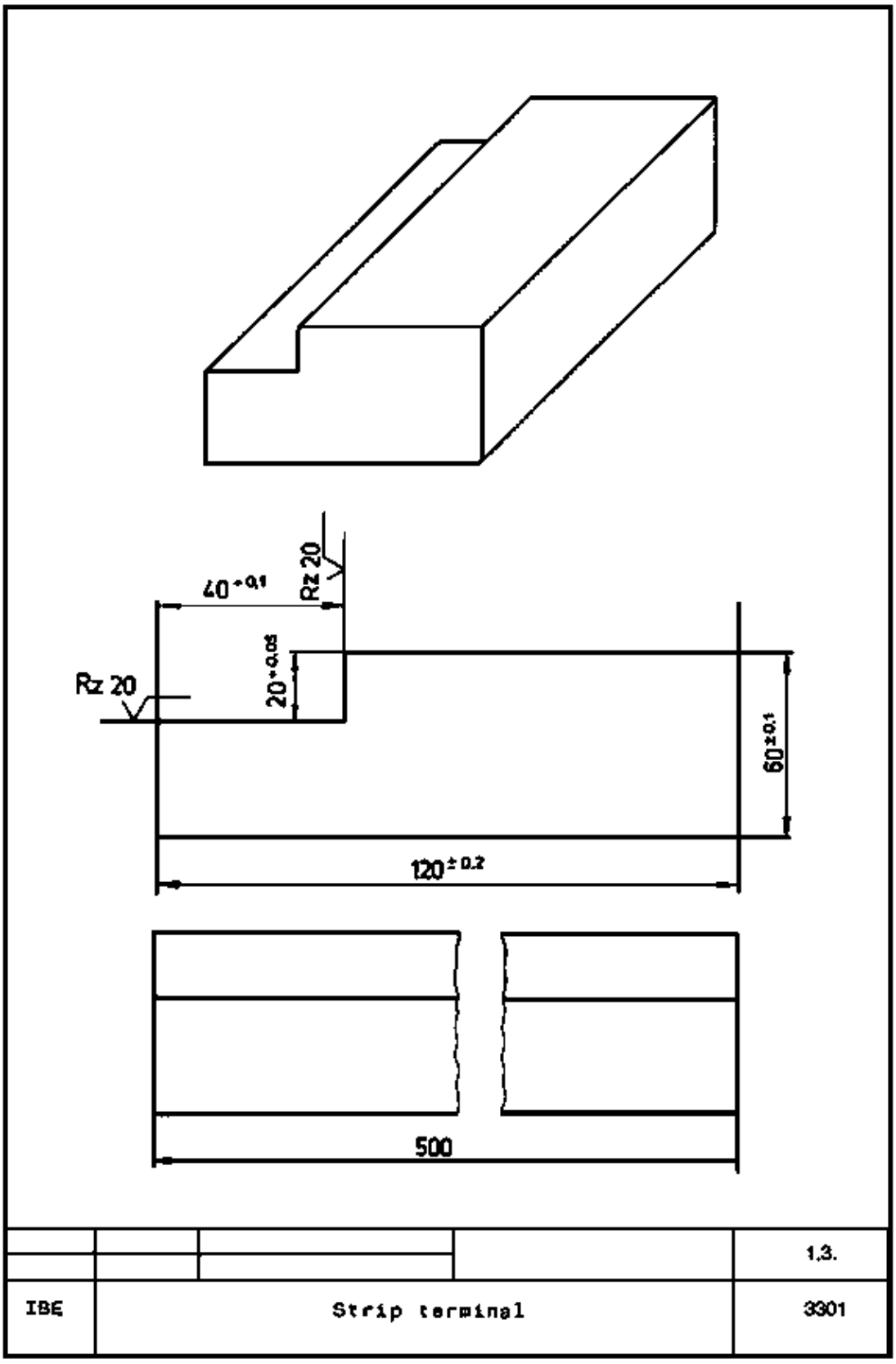
Rz 20 : Average roughness of the surface machined – 20µm (0.02 mm)

size $20^{+0.05}$: Range of tolerance 19.95 – 20.05 mm permissible

size $40^{+0.1}$: Range of tolerance 40.00 – 40.10 mm permissible

Sequence of operations	Remarks
1. Inspection of dimensions	Compare with the details on the accompanying documents.
2. Functional test and lubrication of the milling machine	Lubricate and check oil level as per lubrication chart.
3. Selection of holding clamps, clamping screws, sliding blocks, pressure jaws and locators	Locate the workpiece by location against sliding blocks by means of pressure jaws and locators. Fix the workpiece preferably by using offset holding clamps.

4. Clamping of workpiece on machine table, checking for good contact and support (location)	Pay attention to cleanliness of contact and supporting faces of workpiece!
5. Clamping of face cutter on short arbor (dia. 32) and mounting of cutter arbor in milling spindle	Pay attention to cleanliness when clamping the cutter on the cutter arbor and the cutter arbor in the milling spindle, otherwise there will be radial or axial runout.
6. Setting of cutting values (speed rate n and feed rate v)	Values to be taken from table or to be calculated. $n = \frac{v \cdot 1000}{d \cdot \pi}$ (r.p.m.) v_f =sz • z • n (mm/min) sz = feed per cutting edge of cutter (mm) z = number of cutting edges of cutter ? = 3.14 For workshop use the approximate formula is recommended: $n = \frac{v \cdot 320}{d}$
7. Scratching (starting cut) and milling (roughing) of the shoulder, dimensional inspection and milling of the shoulder to final size ($40^{+0.1} \times 20^{+0.05}$)	Prior to dimensional inspection deburring by the flat file might be necessary.
8. Dimensional and surface inspection	Labour safety note: Never use compressed air for cleaning the machine table – risk of eye injury!



Strip terminal

Instruction example 1.4.: Maintenance and servicing of the milling machine

This serves to practise maintenance and servicing on a horizontal milling machine.

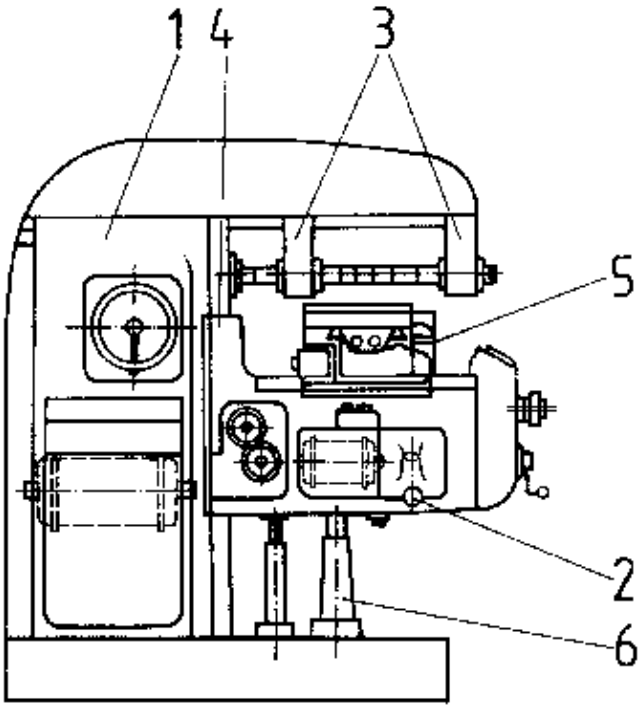
Required previous knowledge

Properties of lubricants and process materials (lubrication chart of the relevant machine), reading of drawings, reading of the instruction manual of the relevant milling machine, labour safety and fire protection regulations when handling lubricants and process materials

Explanations to the working drawing

The drawing shows the following lubricating points: 1 bubble glass (speed gear), 2 sight glass (feed gear), 3 sight glasses (counter bearings), 4 lubricating point (saddle and machine table), 6 lubricating point (screw, screw nut)

Sequence of operations (Kind of servicing/maintenance work)	**Remarks (Cycle/interval)**
1. Cleaning of guideways	daily
2. Inspection of oil level (sight glasses)	daily
3. Lubrication as per lubrication chart	as per instructions on lubrication chart
4. Oil renewal	semi–annually/annually
5. Inspection and, if necessary, refilling of coolant tank	weekly
6. Thorough cleaning of the machine	weekly
7. Inspection of slackness of bearings	annually
8. Inspection of electrics (contactors, limit switches, cable connections)	every three months
9. Inspection of lubrication pump	semi–annually
10. Coolant renewal	semi–annually



				1.4.
IBE	Lubricating points of the horizontal milling machine			3301

Lubricating points of the horizontal milling machine

Milling of End Face – Course: Techniques for Machining of Material. Instruction Examples for Practical Vocational Training

Table of Contents

Milling of End Face – Course: Techniques for Machining of Material. Instruction Examples for Practical Vocational Training

Institut für berufliche Entwicklung e. V.
Berlin

Original title:
Lehrbeispiele für die berufspraktische Ausbildung
"Fräsen von Stirnflächen"

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Order No.: 90–33–3303/2

Introduction

This manual features four selected instruction examples concerning the application and consolidation of the knowledge required for milling end faces.

The necessary materials, tools, measuring, testing and accessory means have been cited for each instruction example in order to facilitate preparations and the actual operations.

In the instruction examples 1 to 4 the steel has been designated in accordance with the tensile strength value in the unit "Megapascal" (MPa).

Basic knowledge requirements which are needed in addition to skills in milling end faces have also been indicated.

We recommend a recapitulation of the said basic knowledge prior to commencing work operations.

Explanations in respect of the working drawings precede the given sequence of operations. The sequence of operations in point incorporates the sequence of steps for yielding a commensurate workpiece. Moreover, this sequence must be adhered to in order to attain sound quality.

Each instruction example is accompanied by a working drawing which indicates the desired shape and dimensions of the work–piece. The admissible deviations for dimensions without tolerance parameters may be taken from the table below:

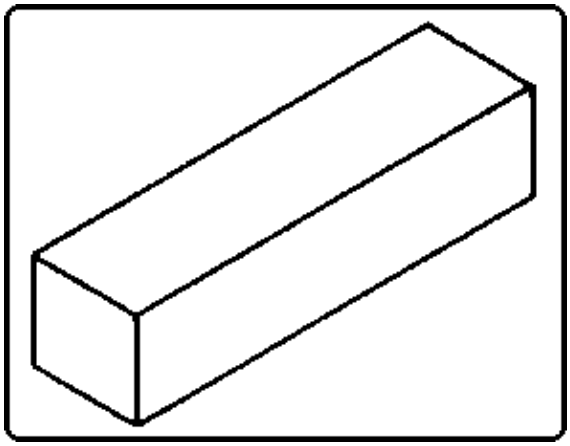
Nominal size	Admissible deviation (in mm)
0.5 – 6	± 0.1
6 – 30	± 0.2
30 – 120	± 0.3
120 – 315	± 0.5

Instruction example 3.1. Backing material

End face milling is practised on the horizontal milling machine when turning out backing material.

Material

Steel 50 (mild steel with 500 MPa tensile strength)



Dimensions

280 x 80 x 80

Machine tool

Horizontal milling machine

Tools

End face mill, stub cutter arbor (short), machine vice, tongues for machine vice, chucking screws, chucking wrench, flat file, try square.

Measuring and testing tools

Vernier caliper, thickness gauge

Accessories

Stop, chip brush/hand broom, rags. T–slot cleaners

Required previous knowledge

Reading of drawings, measuring and testing, setting–up and operating horizontal and vertical milling machines.

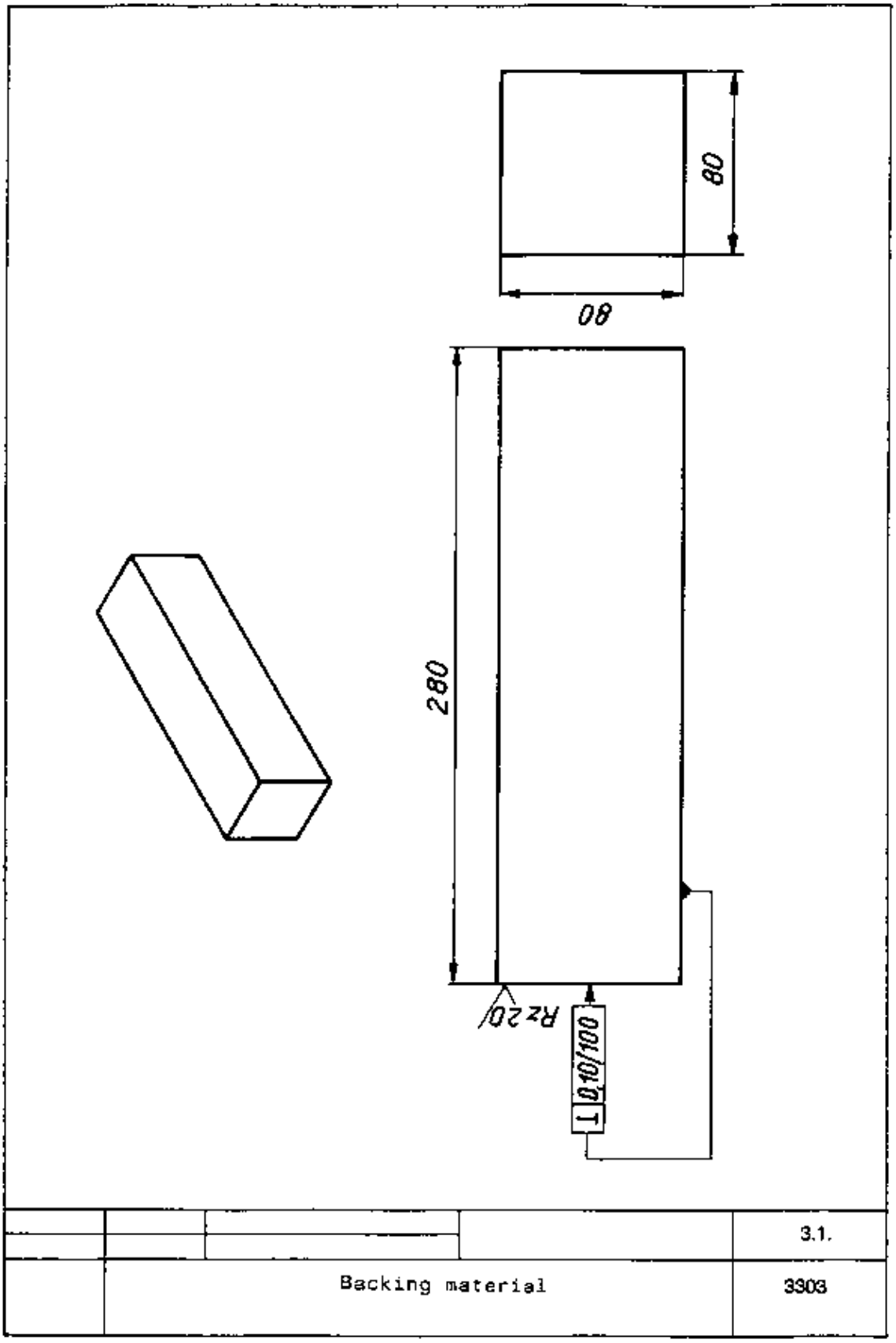
Explanations to the working drawing

Rz 20: average roughness of the surface machined = 20 ?m (0.020 mm)

?	0.10/100	: maximum positional deviation from squareness = 0.10 mm over 100 mm length

Sequence of operations	**Remarks**
1. Batch–quantity control and rough dimensions.	Comparison with work accompanying data sheets.
2. Functional test and milling machine lubrication.	Lubrication, oil level control according to lubrication plan.

3. Clamping and alignment of the machine vice on the machine table.	Chuck the machine vice longitudinally on the machine table with tongues (align).
4. Clamping the end face mill on the stub collar arbor and clamping in the milling spindle of the milling machine,	A hard metal−tipped milling head is also possible.
5. Setting−up the coolant unit and the milling protective device.	When using milling tools of super high−speed steel (SHSS) cooling must ensue during milling (if workpieces are of steel).
6. Clamping the workpiece in the machine vice and clamping a stop to positionally fix the workpiece in its longitudinal direction.	Ensure cleanliness and burr−freeness of the workpiece. Stop ensures the uniform positioning of the workpiece .
7. Setting the cutting values (rotational speed and rate of feed) on the milling machine.	Derive values from the nomogram or calculate them.
8. Position the workpiece for processing.	Knee, saddle and machine table should be set in the X−Y−Z rapid traverse in the processing position.
9. Scratching with the rotating miller on the workpiece surface (end face) and adjusting the milling depth (about 2 – 2.5 mm).	Scratching ensues by means of the manual adjustment of the saddle.
10. Rough milling of the end face utilising the coolant.	The coolant jet shall be aimed directly at the chip removal point,
11. Dimensional control (longitudinal dimension 280 mm), setting the final value and final end face milling.	After final milling – prior to rapid traverse reverse −set the scale to zero to mill the other workpieces according to "position".
12. Unclamping, deburring and cleaning the workpiece.	Risk of accident if damaged file handles are used.
13. Controlling the dimensions and surface condition (roughness) of the end face.	Careful handling of measuring and testing means is necessary, Correction in case of deviations of the required dimensions and angularity to be undertaken on the workpiece clamping means,
14. Continue milling the end face alongside constant control of the processed workpieces.	In case of deviation from the given surface quality the rate of feed shall be reduced or the miller exchanged.
15. Terminate the work assignment and move the workpiece on to the next processing stage, clean the workplace.	Only move the workpieces on in a controlled and clean condition.



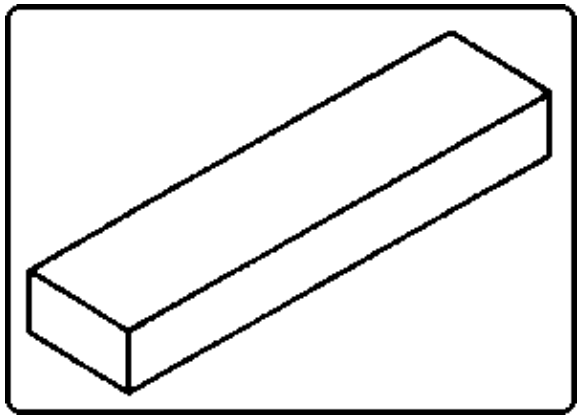
Backing material

Instruction example 3.2. Strip

The trainees practise the milling of two end faces (one after the other) whilst turning out a strip on a horizontal milling machine.

Material

C 35 (high temperature–resistant steel with a tensile strength of 500 to 650 MPa)



Dimensions

540 x 80 x 22

Machine tool

Horizontal milling machine

Tools

Milling bed, stop strip, chucking screws, clamp, chucking supports, chucking wrench, flat file

Measuring and testing tools

Vernier caliper, bevelled edge square, thickness gauge, dial gauge with stand

Accessories

Chip brush, hand broom, rags, chip catch. T–slot cleaners, stop for longitudinal measure

Required previous knowledge

Reading of drawings, measuring and testing, setting–up and operating horizontal and vertical milling machines

Explanations to the working drawing

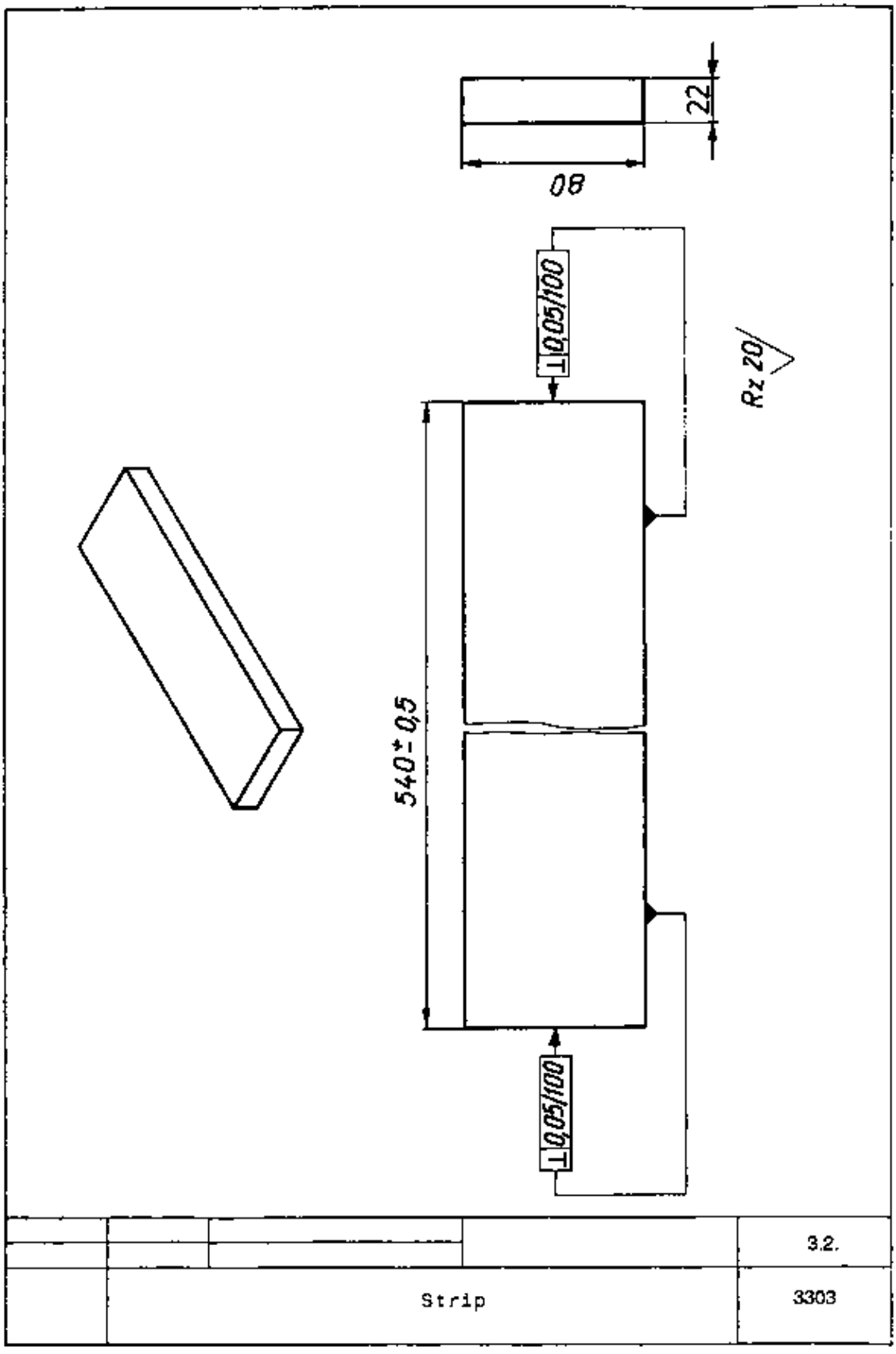
Rz 20: average roughness of end faces = 20 ?m (0.020 mm)

?	0.05/100	: maximum positional deviation from squareness =0.05 mm over 100 mm length

540 ± 0.5: admissible deviation from length (tolerance range 539.5 – 540.5 mm)

Sequence of operations	**Remarks**
1. Check batch–quantity and rough dimensions.	Comparison with work accompanying data sheets.
2. Functional test and milling machine lubrication,	Lubrication, oil level control according to lubrication plan
3. Clamping and alignment of the stop strip on the machine table (transverse).	Alignment with a dial gauge (maximum deviation 0.03 mm on the length of the stop strip). Heed cleanliness when clamping.

4. Clamping the milling head on the stub cutter arbor and clamping in the milling spindle of the milling machine.	
5. Clamping the workpiece to the machine table.	Workpiece must nudge directly to the stop strip. Heed clean bearing and supporting surfaces.
6. Clamp the workpiece longitudinal stop.	Stop is fixed to the opposite end face.
7. Set the cutting values (rotational speed and rate of feed).	
8. Position the milling protective device and set up the chip catch.	Danger of eye injuries through flying chips.
9. Position the workpiece for processing, scratch the workpiece surface and set the cutting depth for rough milling.	Proceed in X–Y–Z directions in rapid traverse (scratching ensues through manual setting).
10. Rough milling of the first end face, dimensional inspection, adjust the remainder (size 542) and complete first end face milling.	Heed admeasure for the second end face.
11. Chuck, deburr the cutting edges and clean the workpiece.	Wear protective gloves to avoid accidents when handling sharp–edged workpieces.
12. Check the size accuracy, angularity and surface properties (roughness) of the first end face.	Check the angle deviation (light slit) with the bevelled edge square and the thickness gauge. If the admissible deviation is exceeded stop strip realignment becomes necessary. The plane surface of the work–piece must be milled again (about 0.3 mm milling depth).
13. Continue milling the first end face.	Milling according to "position" and constant control of attained quality necessary. Ensure cleanliness of the bearing and supporting surfaces during all workpiece exchanges.
14. Reset the workpieces and mill the second end face to end size 540 ± 0.5 mm.	Milling to end size also ensues according to "position" (zero position of the saddle scale).
15. Terminate the work assignment and move the workpiece on to the next processing stage, clean the workplace.	Only move the workpieces on in a controlled and clean condition.



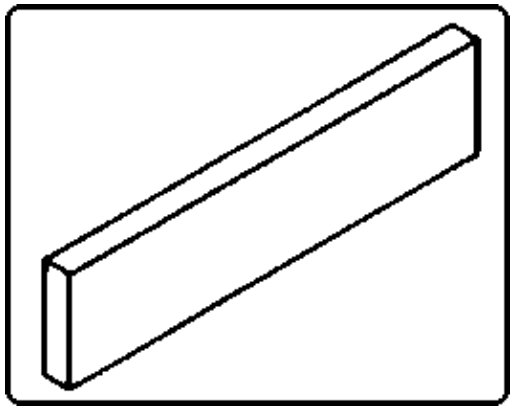
Strip

Instruction example 3.3. Cover plate

Multi−piece clamping (package clamping) is employed in the machine vice for exercising milling of end faces with the milling head.

Material

19 Mn 3 (mild steel, low−alloyed, tensile strength 470 MPa)



Dimensions

240 x 60 x 14

Machine tool

Horizontal milling machine

Tools

Milling head, machine vice, chucking screws, chucking wrench, tongues, flat file

Measuring and testing tools

Vernier caliper, bevelled edge square, thickness gauge

Accessories

Chip brush, hand broom, rags, chip catch, T−slot cleaners, stop for longitudinal measure

Required previous knowledge

Reading of drawings, measuring and testing, setting−up and operating horizontal and vertical milling machines

Explanations to the working drawing

Rz 10: average roughness of end faces = 10 ?m (0.010 mm)

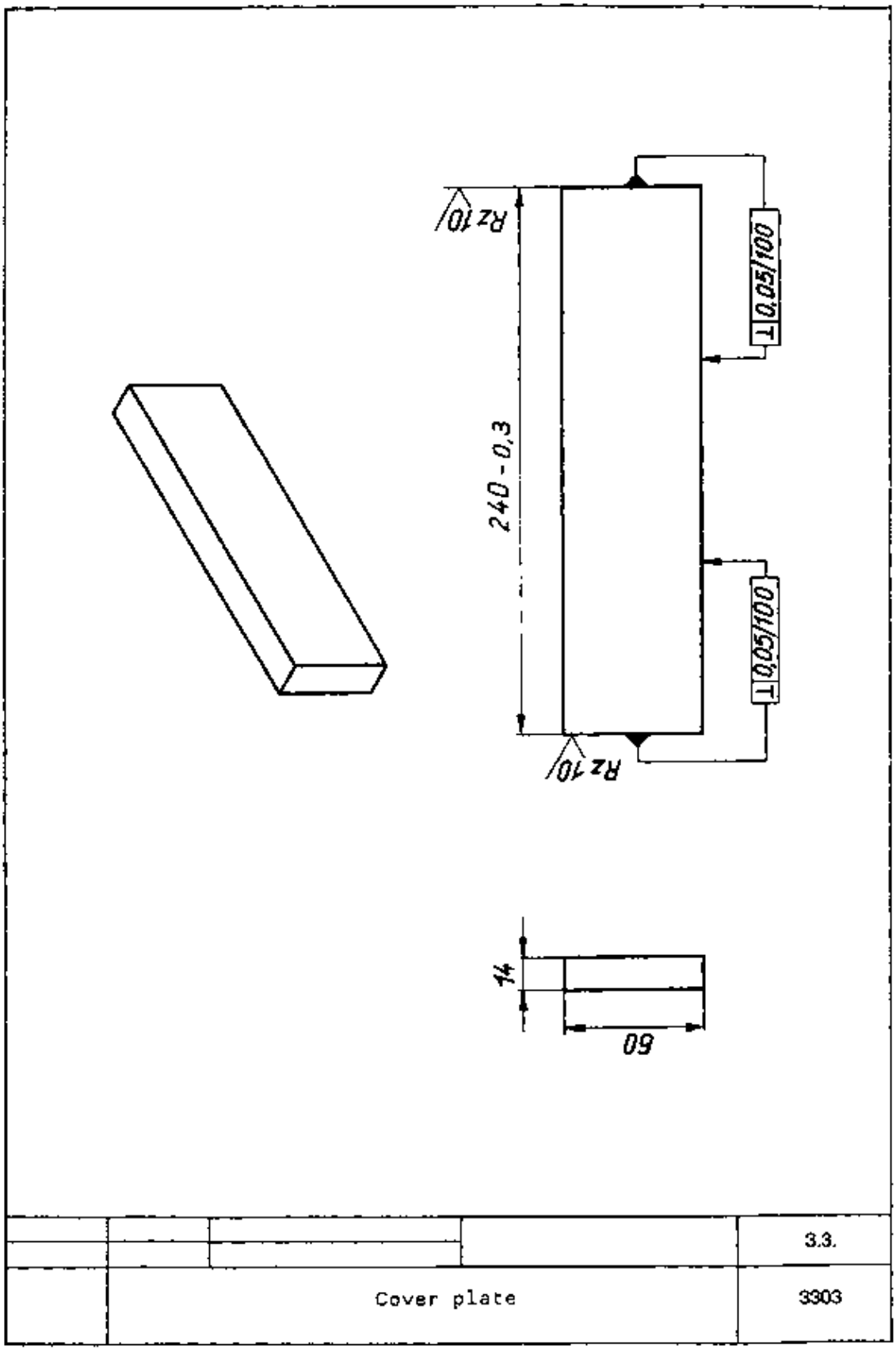
?	0.05/100	: maximum positional deviation from squareness = 0.05 mm over 100 mm length

$240^{-0.3}$: admissible deviation from length (tolerance range 239.7 – 240.0 mm)

Sequence of operations	**Remarks**
1. Control batch−quantity and rough dimensions.	Comparison with work accompanying data sheets,
2. Functional test and milling machine lubrication.	Lubrication and oil level control according to lubrication plan.
3. Clamping and alignment of the machine vice (lengthwise).	Alignment of the machine vice with tongues.
4. Clamping the milling head on the stub arbor collar and clamping to the milling spindle of the milling	

machine.

5. Clamping of 10 workpieces edgeways in the machine vice (package chucking).	Workpieces must be clean and deburred and aligned to a longitudinal stop (stop must be aligned in a longitudinal direction).
6. Setting the cutting values, position workpieces in processing readiness and align the milling protective device, set up the chip catch.	Derive cutting values from the nomogram, position the workpieces in rapid traverse in X–Y–Z direction.
7. Scratching, rough milling of the first end face, dimensional inspection, adjust and final milling to size 242 mm.	Heed size for the second end face (zero position on the saddle scale.
8. Unclamp, deburr and clean the workpieces of the first package, dimensional inspection, angularity and surface controls.	Check angularity with the bevelled edge square and the thickness gauge (light slit method).
9. Mill the first end face of the remaining workpieces.	Undertake constant size and angle controls. Mill according to "position". Take care when unclamping and deburring – danger of accidents from burrs at the cutting edges.
10. Reset the workpieces and mill the second end face to finished size 240 – 0.3 mm.	Mill according to "position". Ensure a clean workpiece support in the machine vice and proper bearing at the longitudinal stop.
11. Terminate the work assignment and move the workpieces on to the next processing stage, clean the workplace.	



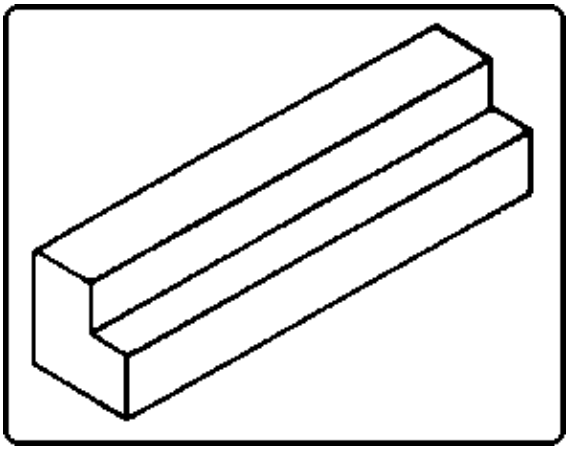
Cover plate

Instruction example 3.4. Elbow

The milling of end faces is exercised by employing a gang cutter on a horizontal milling machine.

Material

GGL 25 (250 MPa tensile strength, 1000 MPa compressive strength, unalloyed with lamina graphite)



Dimensions

225 x 50 x 48

Machine tool

Horizontal milling machine

Tools

Two cylindrical cutters (gang cutters, hard metal tipped or of super high−speed steel), machine vice, chucking screws, chucking wrench, tongues, flat file

Measuring and testing means

Vernier caliper, bevelled edge square, thickness gauge

Required previous knowledge

Reading of drawings, measuring and testing, setting−up and operating horizontal and vertical milling machines

Explanations to the working drawing

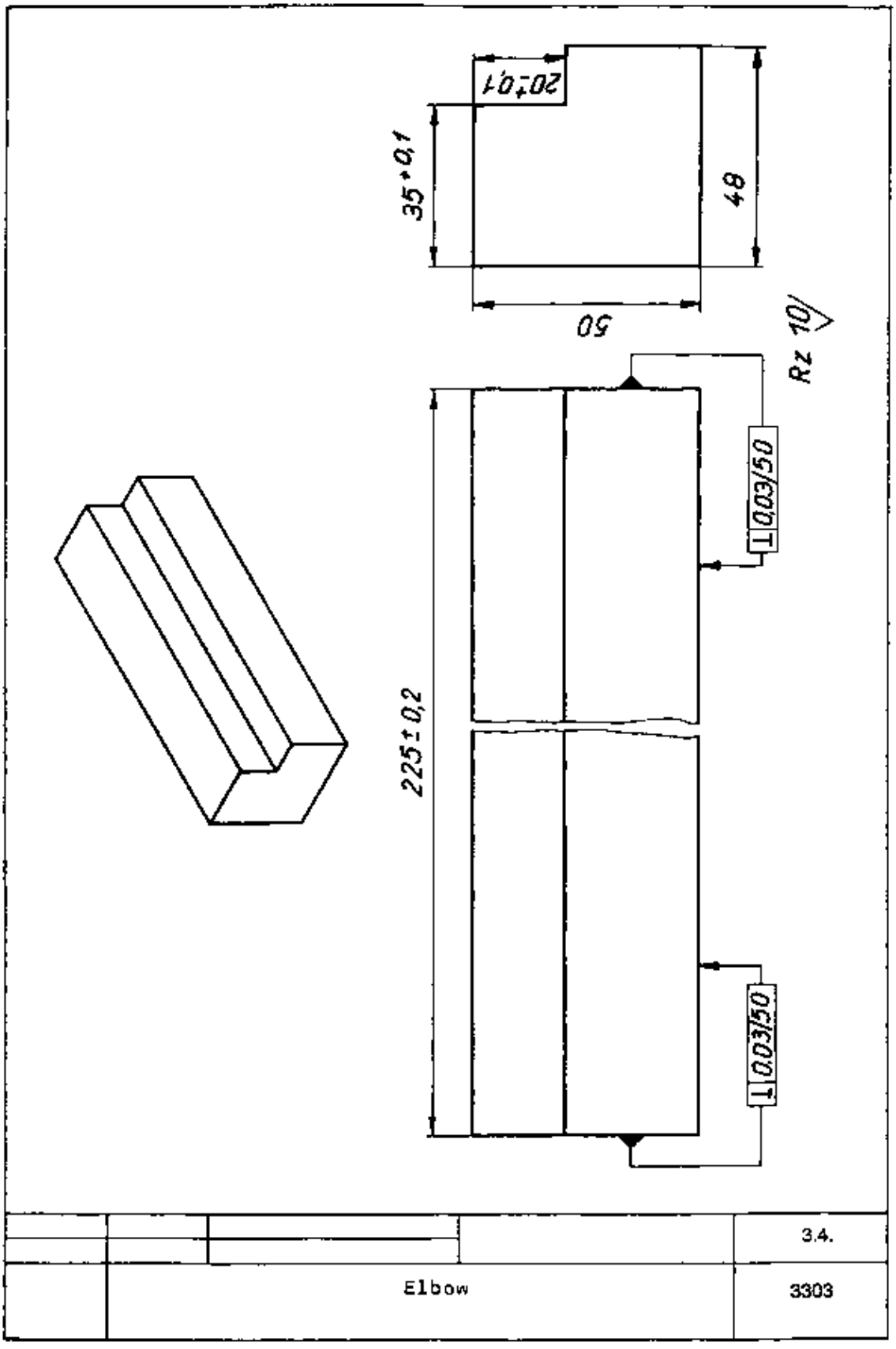
Rz 10: average roughness of end faces = 10 ?m (0.010 mm)

?	0.03/50	: maximum positional deviation from squareness = 0.03 mm over 50 mm length

225 ± 0.2: admissible deviation from length (tolerance range 224.8 – 225.2 mm)

Sequence of operations	**Remarks**
1. Check batch−quantity and rough dimensions.	Comparison with work accompanying data sheets.
2. Functional test and milling machine lubrication.	Lubrication, oil level control according to lubrication plan.
3. Clamping and alignment of the machine vice (lengthwise).	Alignment of the machine vice with tongues and the dial gauge to 0.03 accuracy.
4. Clamping and setting of the cylindrical cutter to the gang cutter (internal distance 225 ± 2 mm).	Distance 225 ± 2 is attained by means of the cutter arbor and spacers.

5. Setting the cutting values, positioning the workpieces and the milling protective device, control the longitudinal dimension 225 ± 0.2 mm and the angularity.	Derive cutting values from the nomogram, position the workpieces in rapid traverse in X–Y–Z direction.
6. Clamp test piece (left over or waste material) and undertake test cut, control longitudinal dimension 225 ± 0.2 mm and the angularity.	Given deviations from the final size. correct by removing or adding spacers. Control angularity with the bevelled edge square and the thickness gauge.
7. Clamp at least two workpieces to mill both end faces to finished size in one operation and end face milling.	The number of workpieces to be simultaneously clamped depends on the maximum clamping width of the machine vice. Uniform positioning of the workpieces in the machine vice by employing a movable stop piece (i.e. a parallel piece is positioned to the processed side surface of the vice – workpieces are positioned to the parallel piece).
8. Unclamp, clean, control dimensional angle and surface.	Control angularity of the end faces in respect of all longitudinal sides,
9. Continue milling of end faces in conjunction with regular quality controls.	Pay attention to cleanliness when clamping the workpieces. Avoid surface damage through chips between the workpieces.
10. Terminate the work assignment and move the workpieces on to the next processing stage, clean the workplace.	Clean both the machine and the workplace but do not use compressed air – danger of eye injuries.



Elbow

Milling

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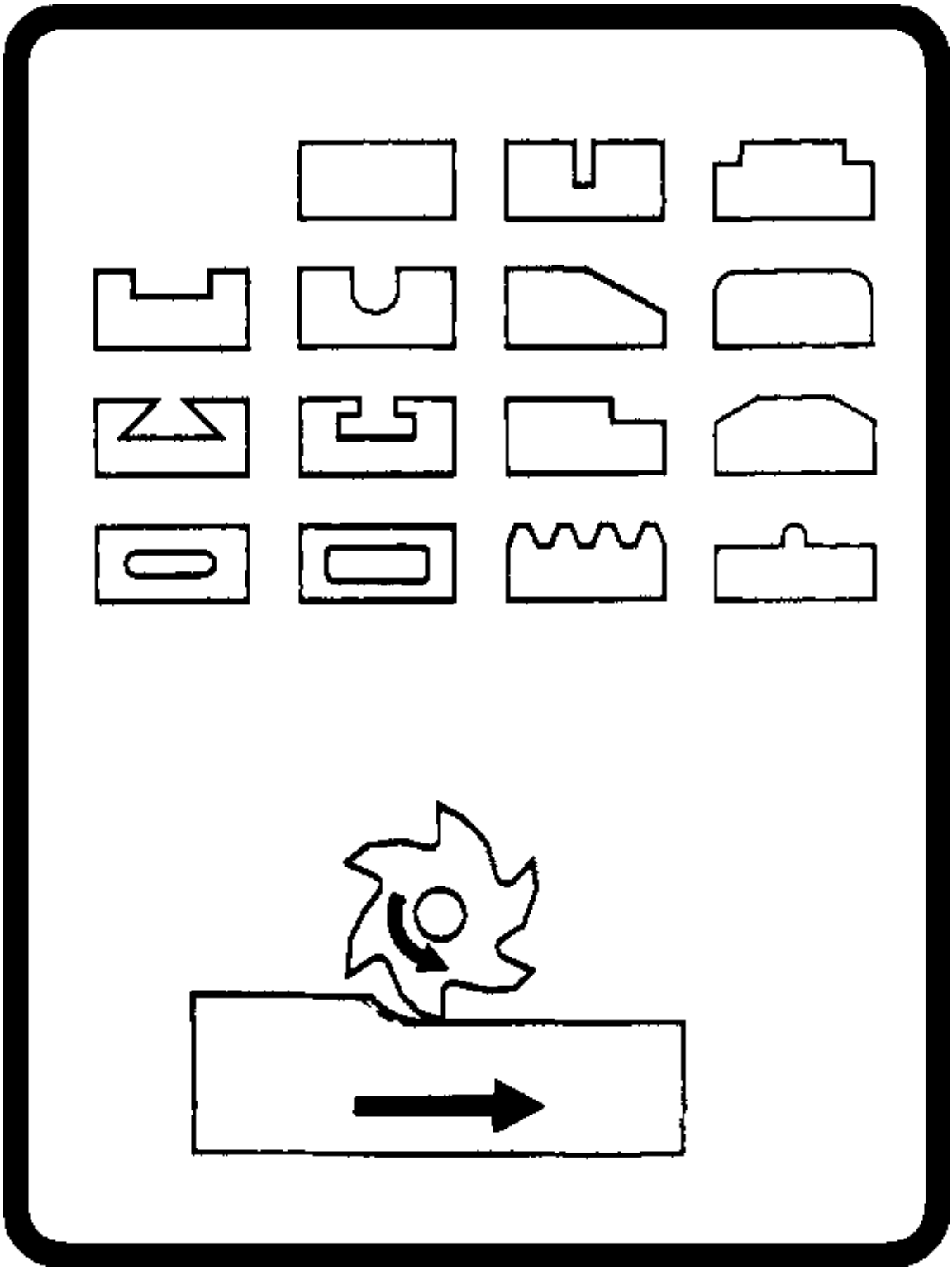

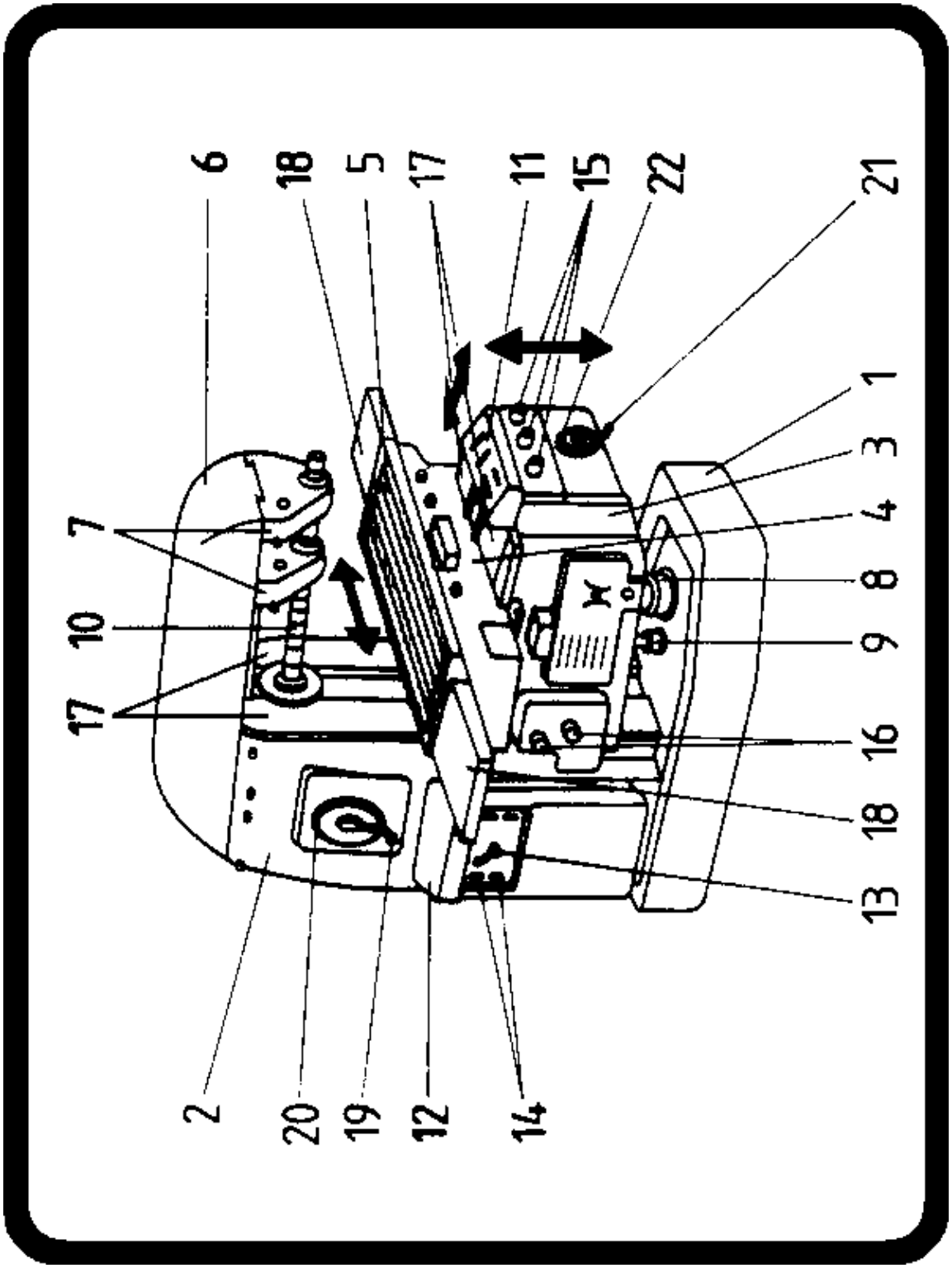
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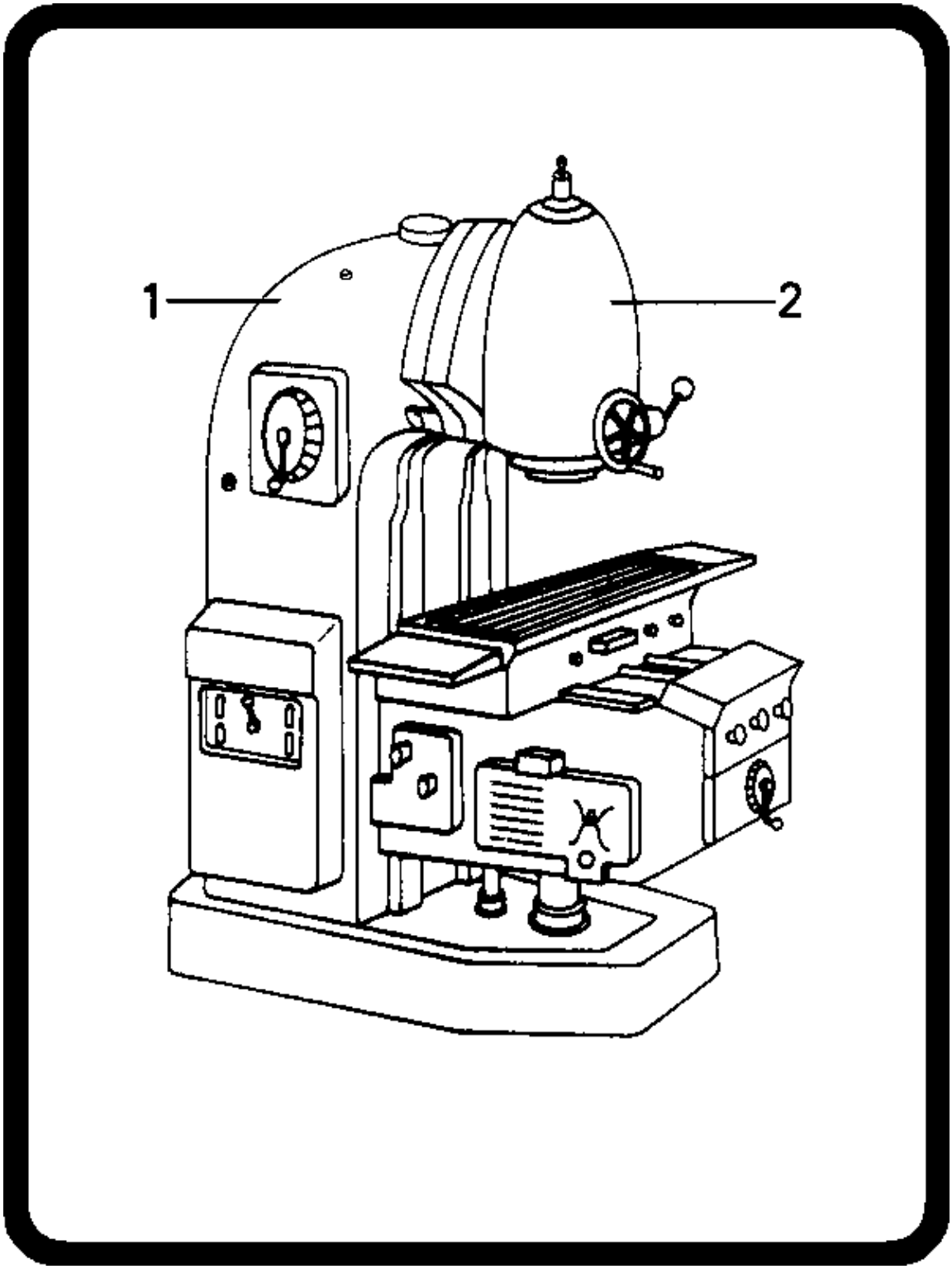
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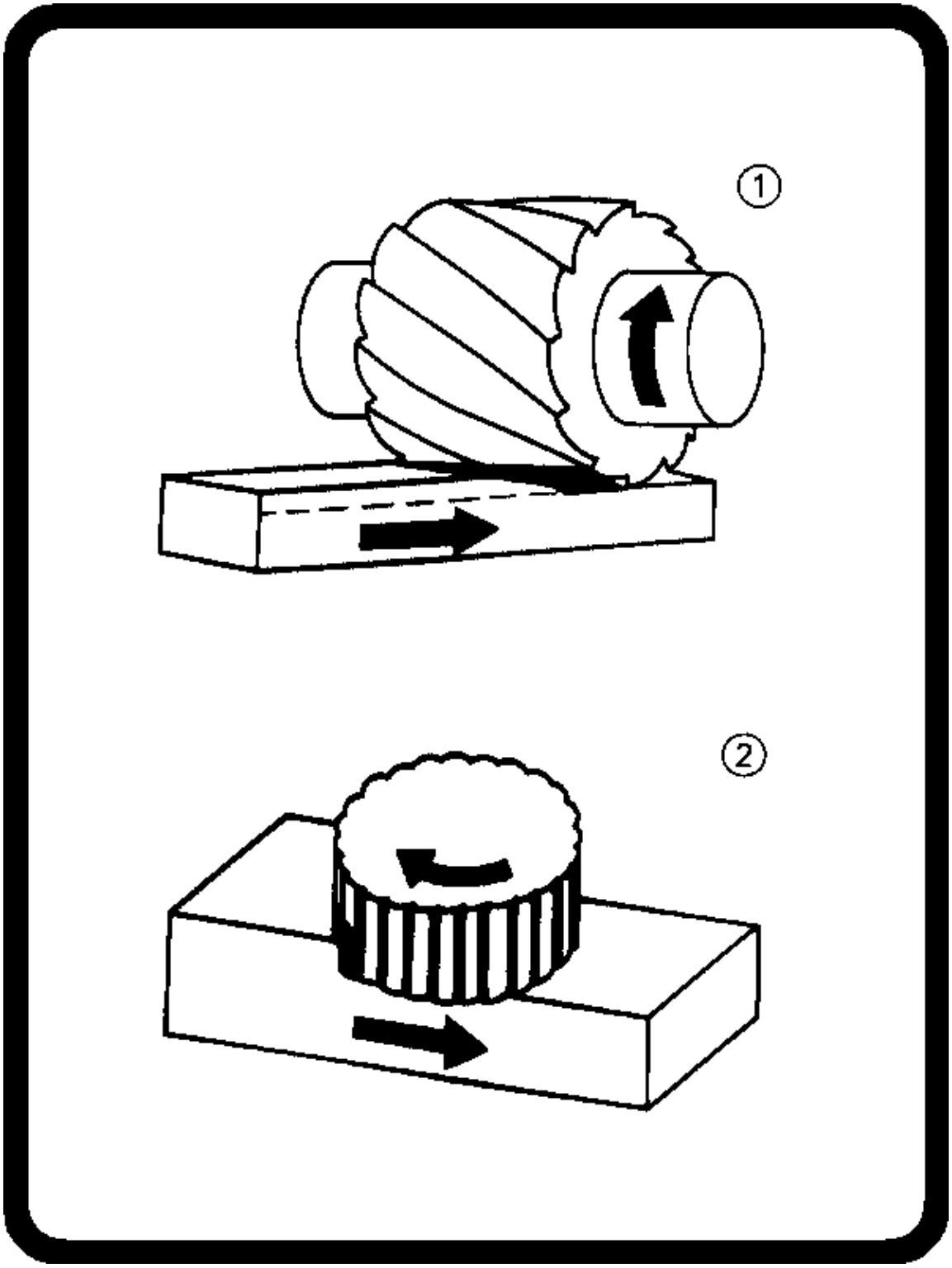
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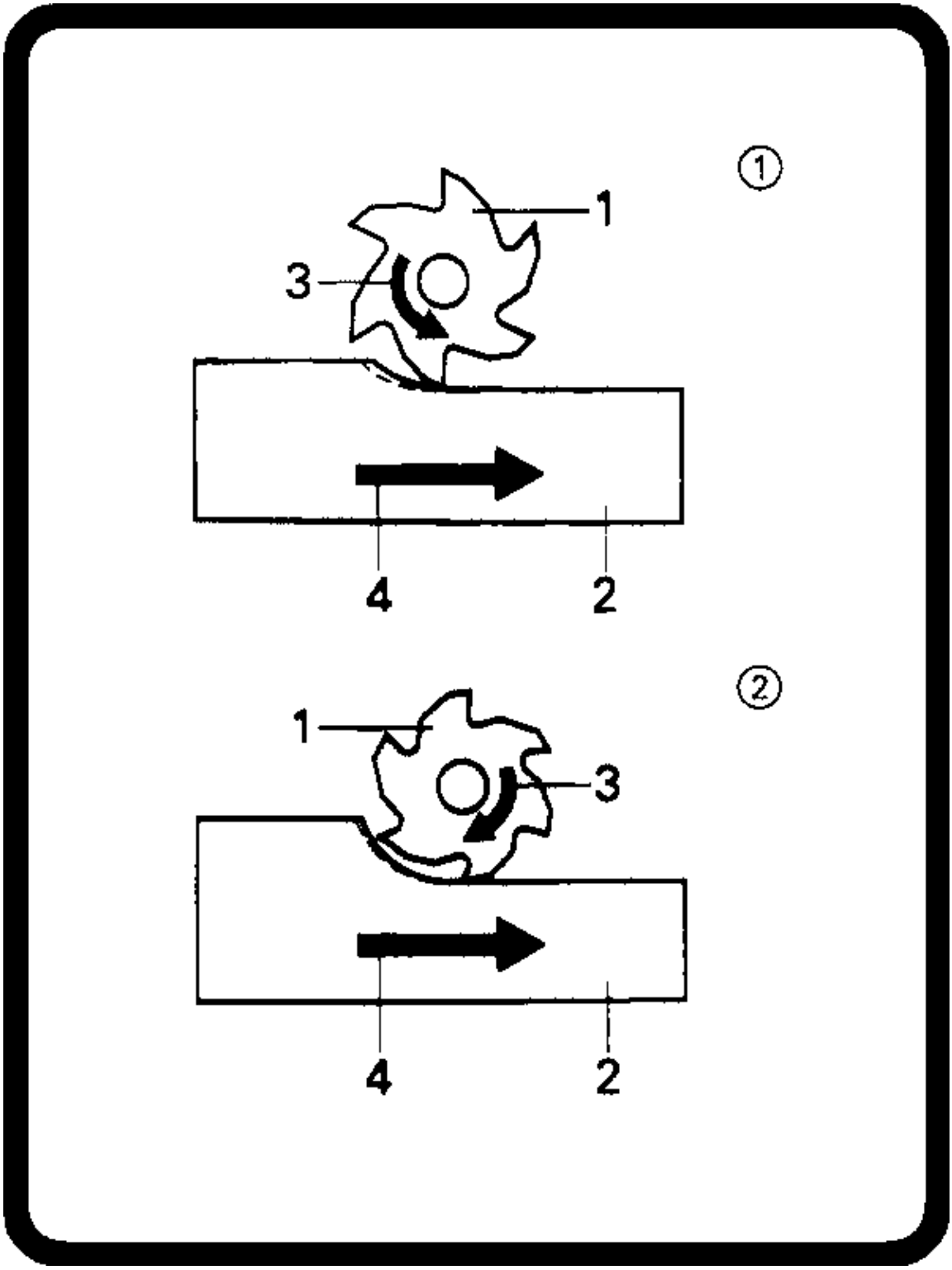
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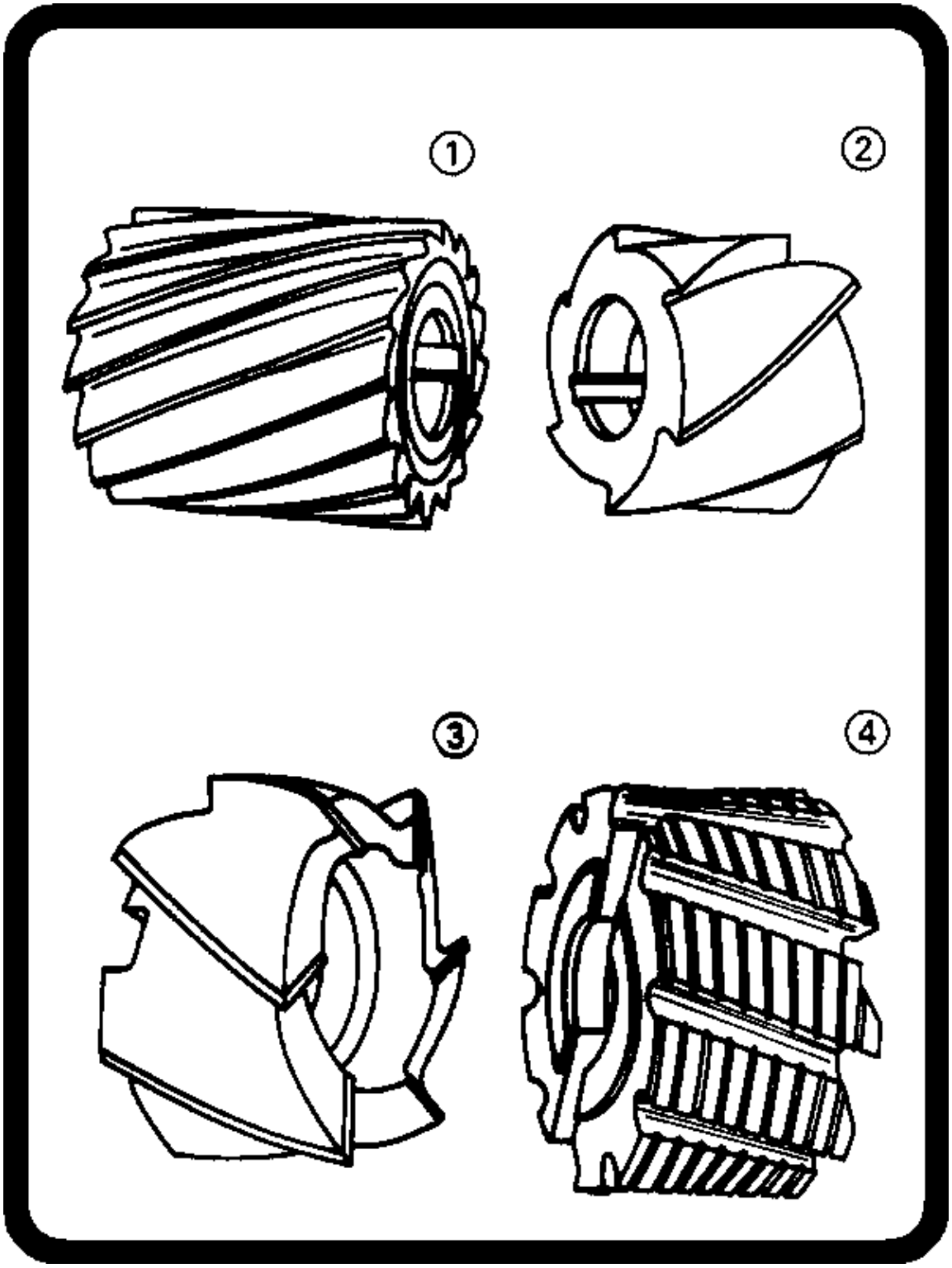
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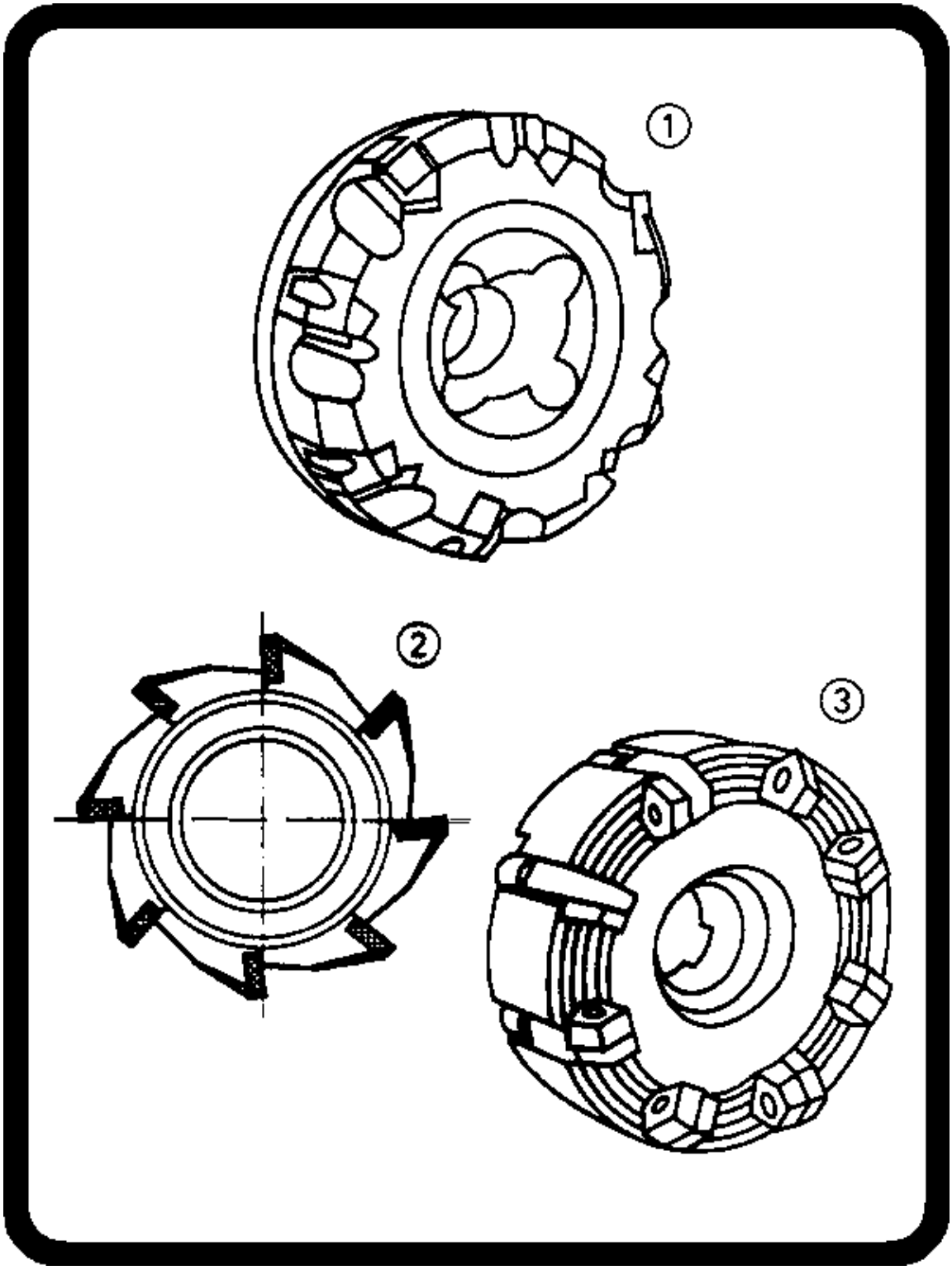
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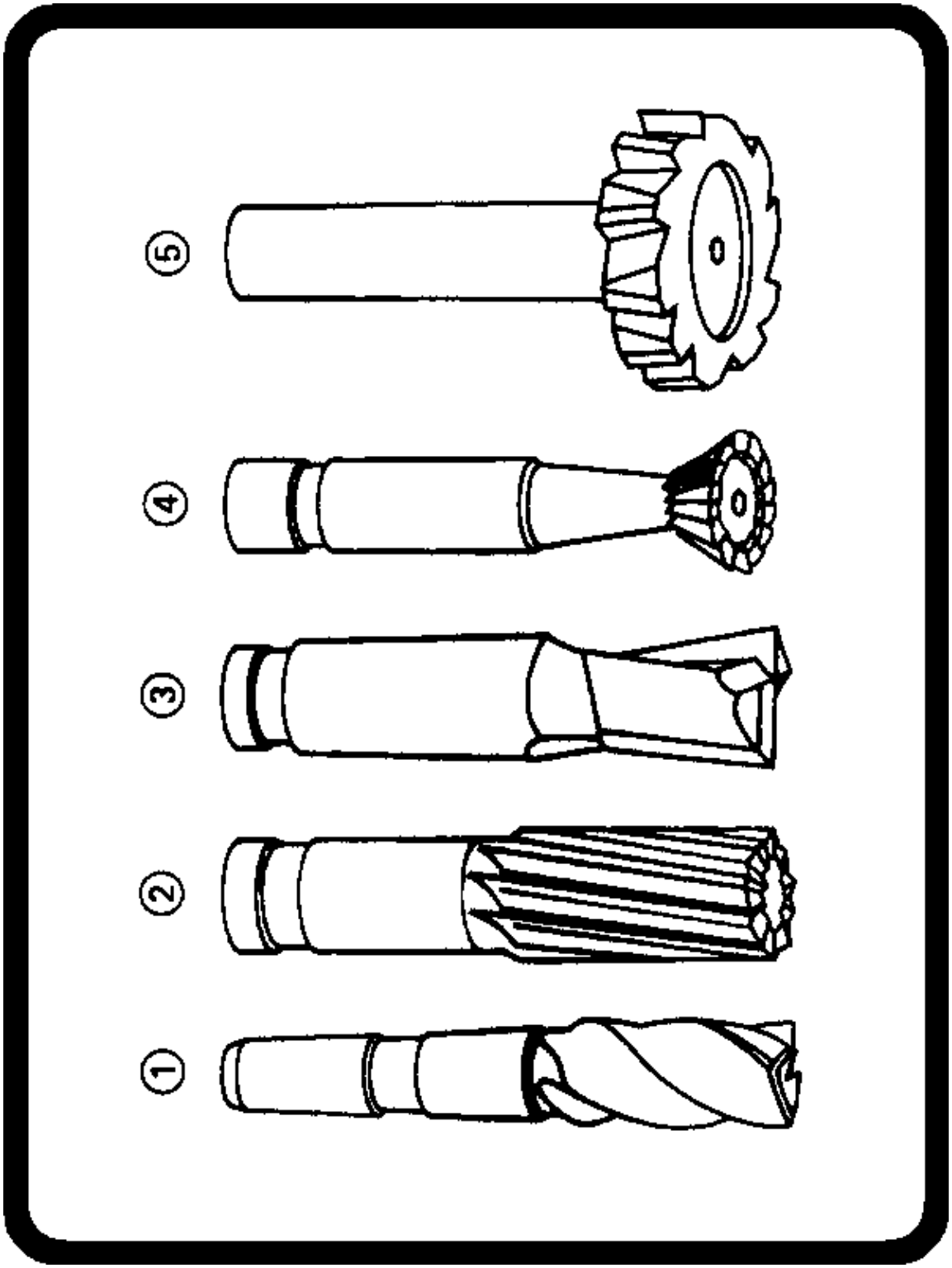
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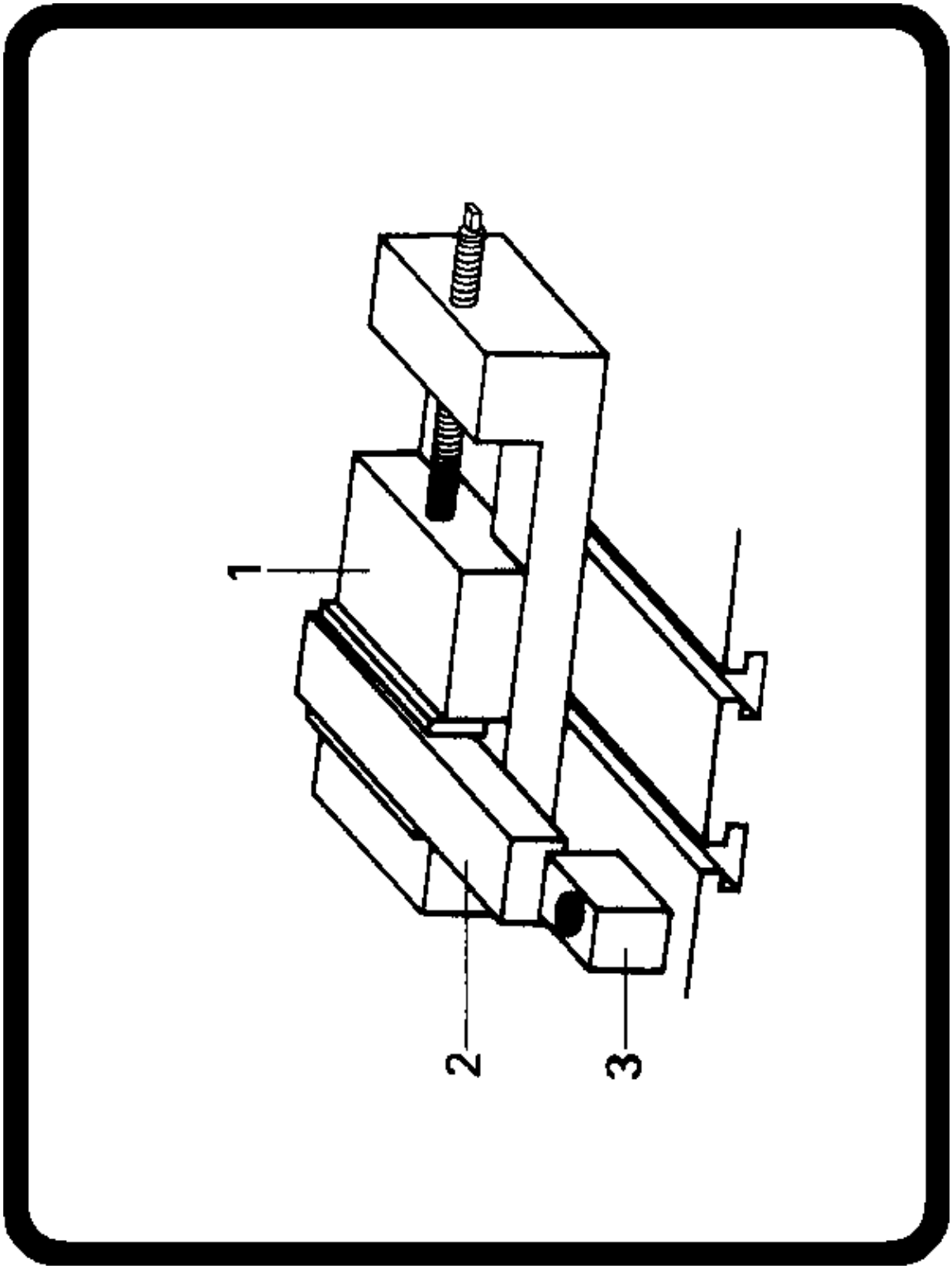
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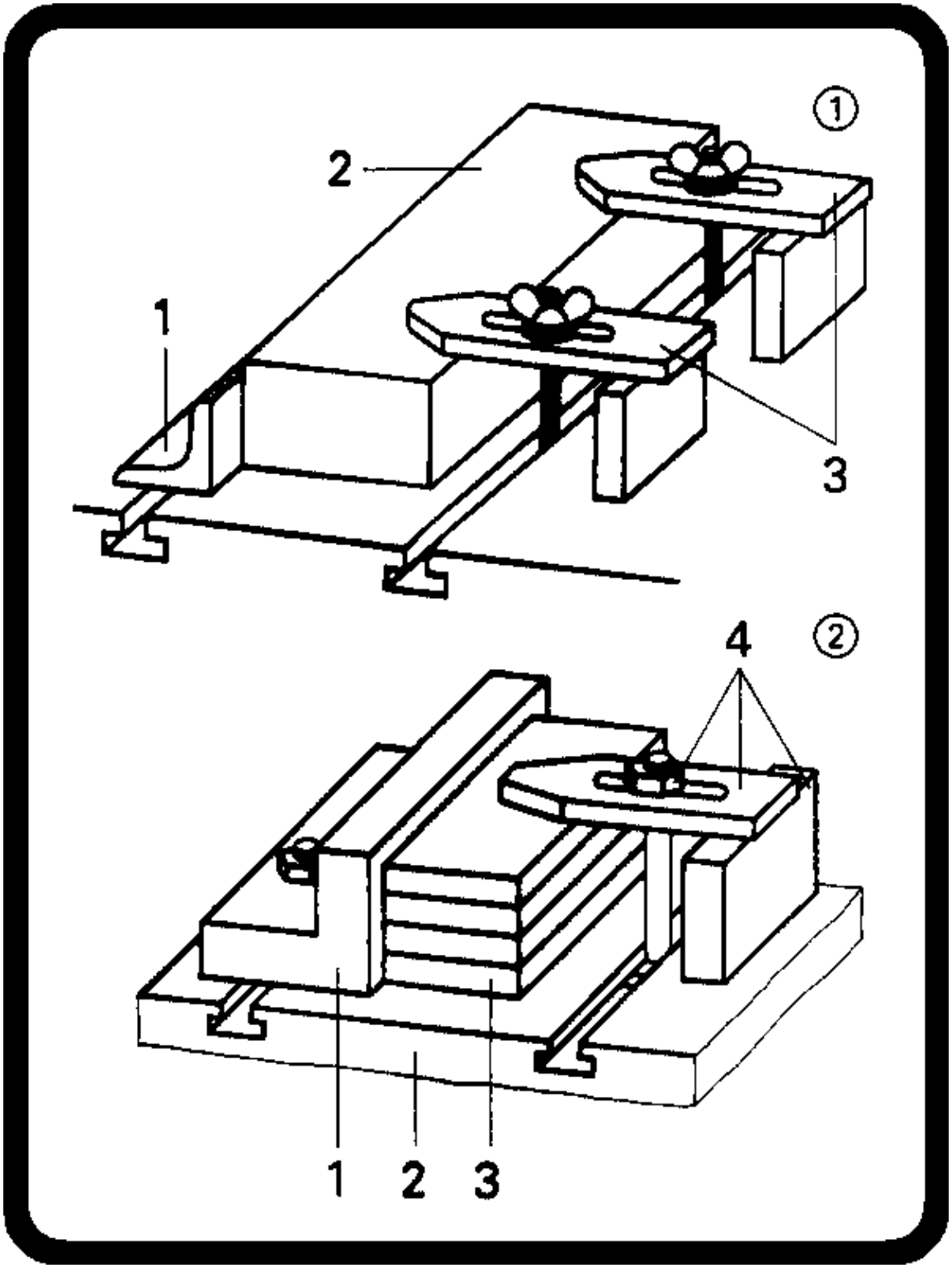
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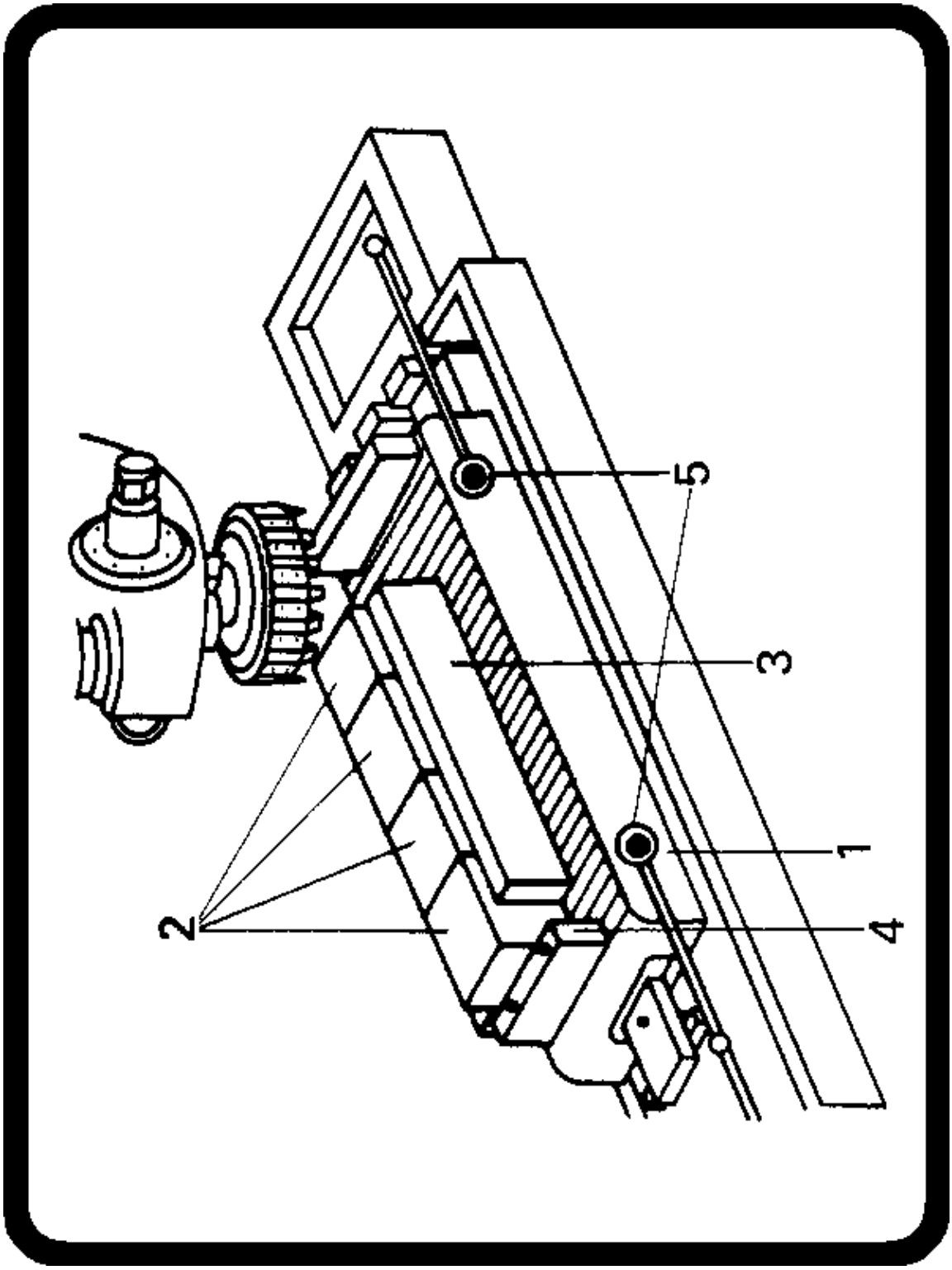
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Pinned Joints – Course: Techniques of Fitting and Assembling Component Parts to Produce Simple Units. Trainees' Handbook of Lessons

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Pinned Joints – Course: Techniques of Fitting and Assembling Component Parts to Produce Simple Units. Trainees' Handbook of Lessons

Institut für berufliche Entwicklung e.V.
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Preliminary Remarks

This material has been drawn up for the training in occupations which require a good command of assembling work, as well as basic knowledge of manual and mechanical techniques of metal working.

This material contains descriptions of the types of different joints which can be made with pins and considers these in the context of their technical function.

The main steps of making and undoing pinned joints are also described.

The questions at the end of each section are intended to help the trainees check their acquired knowledge.

Hints on Labour Safety

Generally, for accident and damage prevention those labour safety rules are valid which are also binding on the techniques of boring, drilling, countersinking and reaming. The following points, however should be emphasized:

– Use only clean, undamaged and sharp tools.

– Use hammers and punches that are in proper condition.

– Clamp workpieces securely and tightly. But never apply excessive pressure. This may damage the work.

– Drive in pins only when the component parts are securely clamped and cannot slip.

– When loosening a pinned joint, rest the workpiece on a suitable support which does not allow the components to slip.

– Put all measuring and testing means down at their proper places. Use pads, supports and the like, in order to protect them against impact, shock and corrosion.

– It is regarded as good workmanship to keep one’s workplace tidy and in good order and always to place individual parts next to their matching components.

1. The Purpose of Pinned Joints

Pinned joints are detachable joints consisting of two or more individual component parts with latter being connected with each other in different was, by means of standardized fasteners, such as pins.

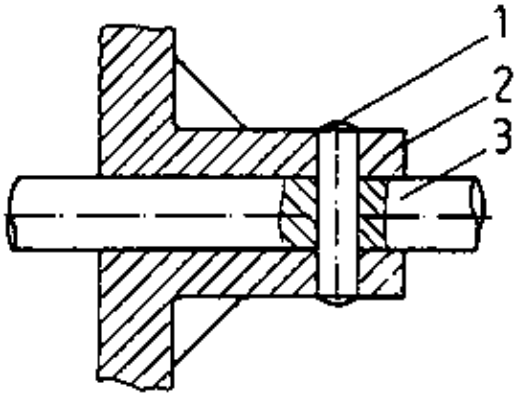

Figure 1 Pinned joint

1 pin, 2 wheel, 3 shaft

Pinned joints are made, in order

- to keep the component parts in a desired position to each another,
- to prevent the component parts from accidental loosening,
- to protect the component parts from overloads,
- to produce firm and tight joints of component parts,
- to produce joints for rotary motions.

Pins are also used to produce hinged connections, hold springs or limit the path of a moving part.

What are pinned joints?

_____
_____
_____

2. Types of Pins

Pins should be harder than the component parts which they join. Pins which are not supposed to wear should be hardened.

- Cylindrical pins

Cylindrical pins are made of bright–drawn constructional steel having tensile strength of approximately 500 MPa.

Cylindrical pins which are not hardened will be deformed permanently and cannot be used again.

There are different types of cylindrical pins. Some are hardened, some are not. There are two grades of unhardened pins with different tolerance zones, viz. m 6 and k 9. Outwardly you can know them by the shapes of their heads. A close fit of pins can be achieved by reaming the bore hole.

Sample designation: Cylindrical pin ø 6 m 6 × 20

- Nominal diameter 6 mm
- Tolerance zone m 6
- Pin length 20 mm

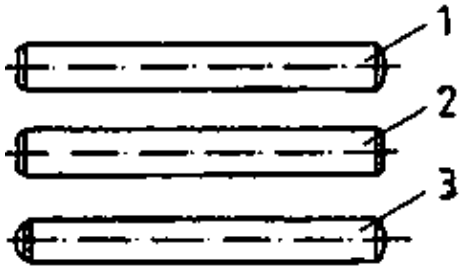

Figure 2 Cylindrical pins

1 *with ISA tolerance zone m 6, 2 with ISA tolerance zone h 9, 3 with ISA tolerance zone m 6–hardened*

– Taper pins

Taper pins are generally made of mild steel having tensile strength of approximately 500 MPa. Taper pins can be used several times. Their taper per unit length is mostly 1: 50. Most taper pins are inserted into tapered holes to provide safe and firm pinning. The tapered hole (which has a taper per unit length of 1:50) is produced with a taper reamer. The nominal diameter of a taper pin is measured at its narrow end. Some taper pins have external or internal threads at their opposite end.

Sample designation: Taper pin ø 6 × 20

– Nominal diameter 6 mm (at thin end)
– Taper pin length 20 mm

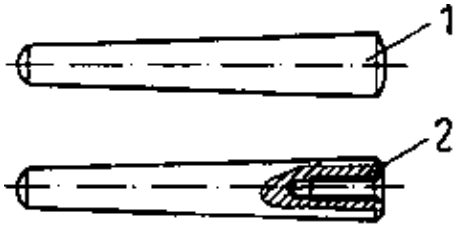

Figure 3 Tapered pins (1: 50)

1 standard design, 2 pin with internal thread

– Grooved pins

Grooved pins are made of blank–drawn steel having tensile strength of 600 to 700 MPa. Grooved pins have three grooves arranged lengthwise at distances of 120 degrees along the circumference. Different types of grooved pins are known by the shape of their grooves.

Grooved pins are driven into simple, unreamed bore holes. A tight fit is obtained by the deformation of the edges along the grooves. Grooved pins can be used as many as 20 times.

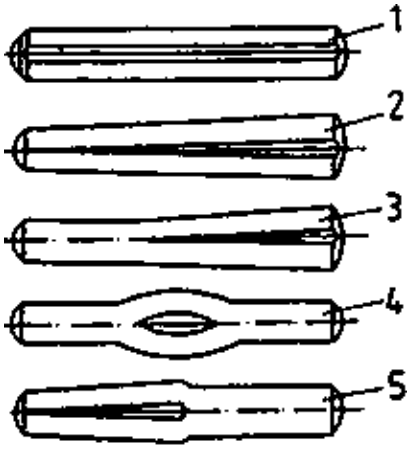

Figure 4 Grooved pins

1 cylindrical grooved pin, 2 grooved taper pin, 3 close–tolerance grooved pin, 4 center–grooved dowel pin, 5 *half length reserve taper grooved dowel pin*

– Grooved drive studs

Grooved drive studs are a special variety of grooved pins. They are made of steel having tensile strength of about 400 MPa, or of copper, brass or light metal. Grooved drive studs are identified by the shape of their heads.

Sample designations: Grooved drive stud, round head ø 4 × 20

– Nominal diameter 4 mm
– Length without the head 20 mm

Grooved drive stud, countersunk ø 4 × 20

– Nominal diameter 4 mm
– Length with the head 20 mm

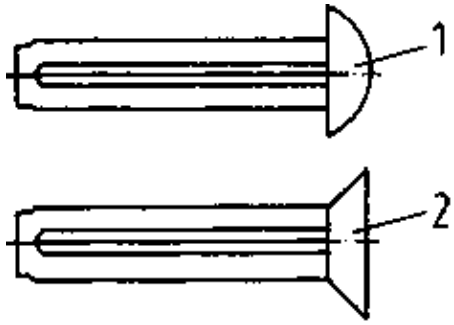

Figure 5 Grooved drive studs

1 grooved drive stud, round head, 2 grooved drive stud, countersunk

– Dowel pins (taper sleeve)

Dowel pins are made of rolled and hardened spring steel strip. They have very high strength. Oversize dowel pins are driven into simple bore holes where they respond to elastic shocks.

Dowel pins can be used as often as needed.

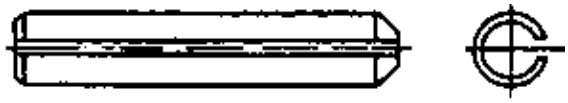

Figure 6 Dowel pin

Name the main types of pins used.

_____
_____
_____

3. Types of Pinned Joints

Pinned joints are specified below as to the function the pin serves in a joint.

– Pinned joint for fastening

Pinned joints for fastening hold together two or more component parts without frictional connection. A good example of a pinned joint for fastening is a toothed wheel on a shaft where only low torques are to be transmitted. All types of pins can be used in joints for fastening.

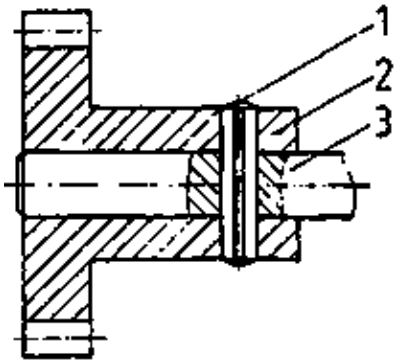

Figure 7 Pinned joint for fastening

1 pin, 2 gear wheel, 3 shaft

– Pinned joint for driving

One part of a machine drives another part, such as in switchgears or couplings which are shifted when at rest. Cylindrical pins, close–tolerance grooved pins and dowel pins can be used in joints for driving.

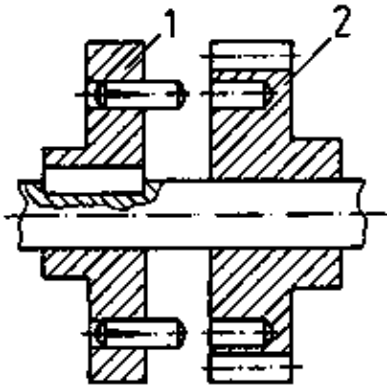

Figure 8 Pinned joint for driving

1 fixed component (feather key joint) with drive pins, 2 driven component

– Pinned joint for holding

Pinned joints of this type hold one component part to another component part. Cylindrical pins and grooved pins can be used in joints for holding.

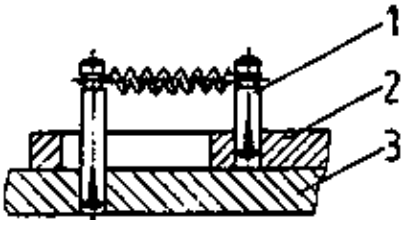

Figure 9 Pinned joint for holding

1 holding pins with spring, 2 movable part, 3 fixed part

– Pinned joint for swivelling

Pinned joints of this type connect two or more movable or rotary component parts. Cylindrical pins, grooved cylindrical pins and center–grooved dowel pins can be used in joints for swivelling.

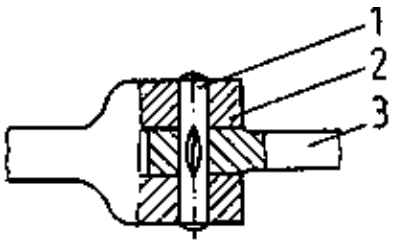

Figure 10 Pinned joint for hinging

1 hinge pin, 2 hinged component I, 3 hinged component II

– Pinned joint for fitting

Pinned joints of this type fix two component parts in a definite position relative to one another. Taper pins, close–tolerance grooved pins and cylindrical pins can be used in joints for fitting.

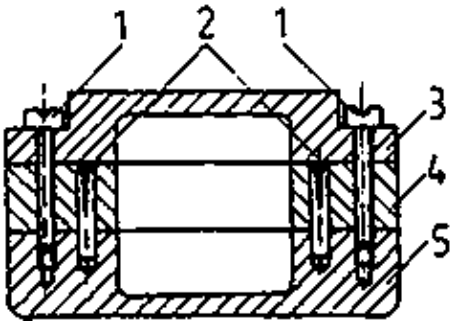

Figure 11 Pinned joint for fitting

1 screwed joint of the three component parts, 2 fitting pins, 3 component part I (lid), 4 component part II (spacer ring), 5 component part III (casing)

– Pinned joint for securing

Pinned joints of this type prevent parts of machines from becoming loose inadvertently under dynamic loads (vibration). Cylindrical pins, taper pins and grooved pins can be used in joints for securing.

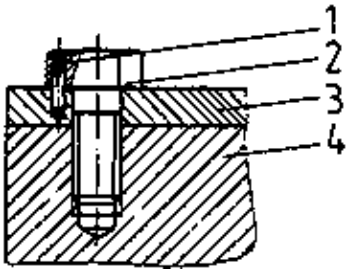

Figure 12 Pinned joint for securing

1 securing pin, 2 screw, 3 component part I, 4 component part II

– Pinned joint for shearing

Pinned joints of this type secure parts of machines which are connected directly with each other, from overloads. The pin in the joint will break when the load becomes too heavy. Thus, the component parts of the joint will not be damaged. Cylindrical pins can be used in joints for shearing.

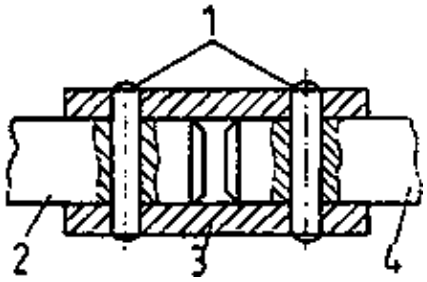

Figure 13 Pinned joint for shearing

1 shearing pins, 2 shaft I, 3 sleeve, 4 shaft II

How are pinned joints specified?

_____
_____
_____

What types of pinned joints are produced?

_____
_____
_____

What is typical of a pinned joint for holding?

_____
_____
_____

What is typical of a pinned joint for fitting?

_____
_____
_____

4. Stresses in Pinned Joints

Pinned joints are positive joints. The pin engages a snugly fitting pre–worked bore hole. It is kept in place by the friction that is generated between the walls of the bore hole and the pin.

External forces, if any, that act on the component parts of a joint will be transmitted from the wall of the bore hole to the surface of the pin. The pin is exposed to shearing stress by the parts of the joint. When the force is too strong, the pin will shear off just where the parts are joined.

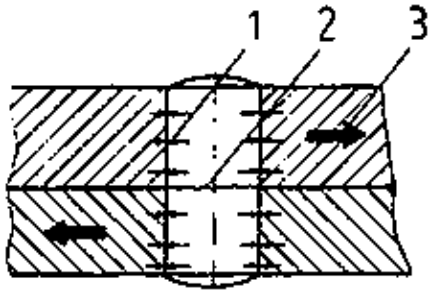

Figure 14 Stresses in Pinned Joints

1 friction, 2 shearing, 3 external forces

Identify stresses to which pins in joints are exposed.

_____
_____
_____

5. Tools and Auxiliary Accessories

– Drills, countersinks, reamers

Various types of drills, spiral countersinks and 90° included angle countersinks, as well as cylindrical and taper reamers are used for preparing pinned joints.

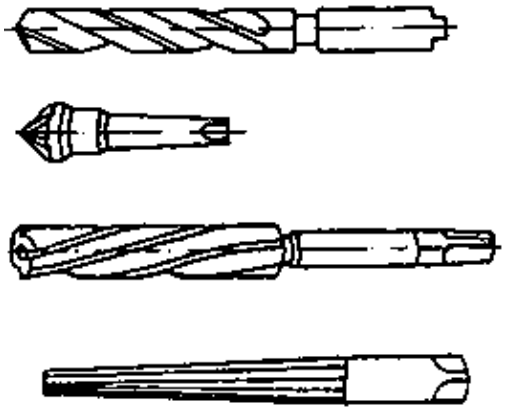

Figure 15 Drills, countersinks, reamers

– Locksmith's hammers

The pins are driven into the bore holes by means of hand–held hammers of 200 grams to 400 grams weight. Very small pins are driven in with a riveting hammer of 50 grams to 200 grams weight.

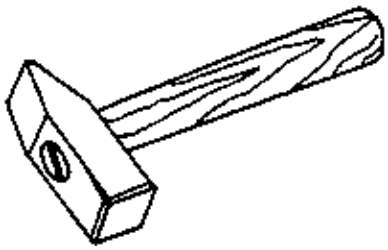

Figure 16 Locksmith's hammer

– Light–metal hammers

Aluminium hammers are used to drive in pins which might be damaged if other hammers were used.

Aluminium hammers will not cause permanent deformations to cylindrical pins or taper pins.

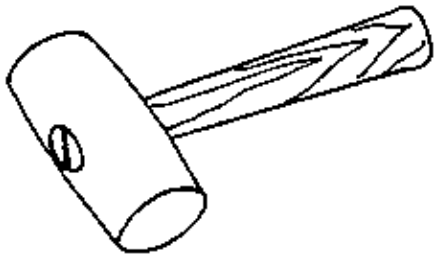

Figure 17 Light–metal hammer

– Non–ferrous metal punches

Cylindrical punches made of copper or brass are used to drive in pins which might be damaged if a locksmith's hammer were used. Punches are mostly used where access to pins is difficult.

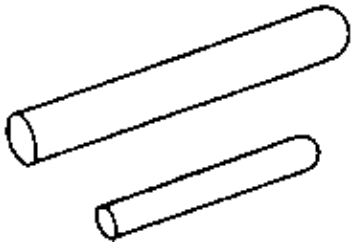

Figure 18 Non–ferrous metal punches

– *Drifts*

Cylindrical drifts made of non–ferrous metal or steel are used to drive pins out of their holes.

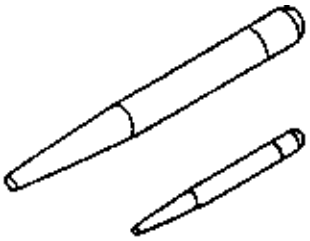

Figure 19 Drifts

– Clamping devices

Several types of clamping devices are used to clamp the component parts before and during joining operations.

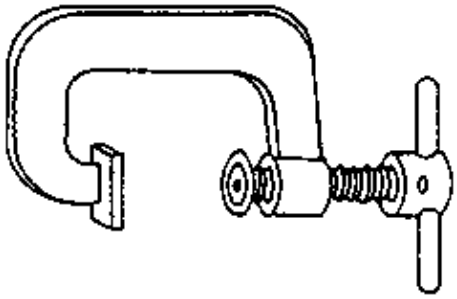

Figure 20 Clamping device

– Supports

Any kind of unhardened steel plate can be used as a support for driving in or driving out pins.

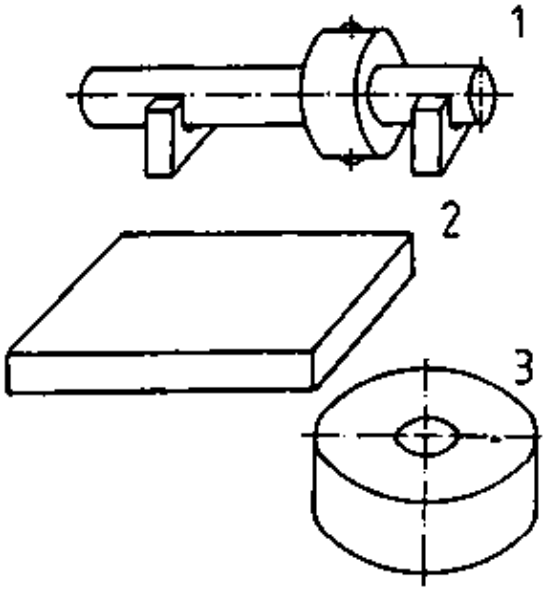

Figure 21 Supports

1 for cylindrical parts, 2 for flat parts, 3 for undoing pinned joints of flat component parts

6. The Technological Steps of Making Pinned Joints

The technological steps of making pinned joints are different for the various types of pins used.

6.1. Joints Using Cylindrical Pins or Taper Pins

– Setting up and clamping

Clean the component parts and fit them together. Set them up and clamp them in a suitable device. While being held in the device, the component parts are to be mounted in the work–holding fixture of the boring machine.

– Drilling

Produce an undersize bore hole for cylindrical pins. The amount of undersize is removed by reaming. In general practice, the following amounts of undersize are employed for the respective nominal bore hole sizes in steel.:

N in mm	U in mm
up to 5	0.1 – 0.2
5 – 20	0.2 – 0.3
21 – 32	0.3
33 – 50	0.5

Allow a greater amount of undersize for bore holes in tough material and light metals.

N = nominal diameter
U = amount of undersize

• Use the following formula to calculate the drill diameter:

$$D = N - U$$

D = drill diameter

Remember the following points for bore holes over 20 mm diameter:

1. Rough–drill using drills which satisfy the following formula: D = N – 2 mm
2. Countersink with a twist countersink. Use this formula: D = N – U

• Produce bore holes for taper pins to the nominal diameter of the taper pin: D = N

• Read the drill speed from the respective table or calculate it, using the following general formula:

$$n = \frac{V \bullet 1000}{D \bullet 3.14}$$

• For producing large bore holes for taper pins, taper reamers of the appropriate size are used. The bore holes are produced stepwise.

n = speed (min^{-1})
V = cutting speed (m/min)
D = diameter of drill (mm)

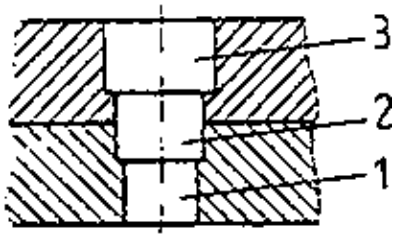

Figure 22 Drilling steps (1–2–3)

Stepped bore holes:

Calculate the diameter of the drill from the taper per unit length:

A taper per unit length of 1:50 means that the diameter is reduced by 1 mm for every 50 mm of length.

Example:

Produce a joint of two component parts having on overall thickness of 150 mm, use a taper pin of 20 mm diameter.

What steps will you drill?

Answer	Diameter	Depth
1st bore hole	ø 20 mm	150 mm through hole
2nd bore hole	ø 21 mm	100 mm
3rd bore hole	ø 22 mm	50 mm

What holes will you drill for a cylindrical pin having a diameter of 26 mm?

_____
_____
_____

How will you produce bore holes for taper pins?

_____
_____
_____

– Countersinking

Using a 90° included angle countersink, countersink the bore hole on both ends 0.2 mm larger than the nominal diameter. This removes the burr from the hole.

$D_S = N+0.2$ mm

where

Ds = Countersunk diameter

– Reaming

Make the bore hole larger by reaming. Use a cylindrical or taper reamer that fits the type and size of the pin which is to be used.

When reaming a hole for a taper pin joint, test the fit of the pin before you drive it in.

With the force of your thumb, push the taper pin into the reamed hole. Clean the hole before you insert the pin. The upper edge of the pin should stick out above the edge of the hole by a length that depends on the nominal diameter of the pin. Where the size is that specified in the table below, apply two or three blows with a hammer to drive in the pin.

Testing the fit of taper pins having taper per unit length of 1: 50

Nominal diameter of the taper pin (mm)	Size for testing the fit (mm)
5	3
6	4 – 5
8	5 – 6
10	8

Remember:

The length of the taper pin you want to use must be 2 mm shorter than the thickness of all parts of the proposed joint.

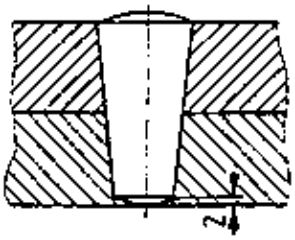

Figure 23 Accurate fit of a taper pin

Thus, the pin can be driven out with a drift from the opposite end. The drift will not slip and the one end of the pin cannot be mistaken for the other.

The upper edge of the pin is flush with the edge of the bore in the upper component part.

Where no taper pin of the required size is available, saw a longer pin to the dimension you need. Always saw off the thicker end of the pin. Do not change the nominal diameter of the pin. Produce a new head by filing.

What type of countersink will you use to deburr a bore hole?

_____
_____
_____

What should be taken into consideration when reaming a taper pin hole?

_____
_____
_____

What condition must be satisfied with respect to the length of a taper pin?

_____
_____
_____

How will you shorten the length of a taper pin?

_____
_____
_____

– Cleaning the bore hole

Use compressed air or a brush to remove chips and any remaining fluid from the bore hole after reaming.

– Pinning

Apply a thin film of grease to the pin and drive it in by several blows with an aluminium hammer. Proceed from the end at which you applied the reamer.

Use a non–ferrous metal punch and a locksmith’s hammer to drive the pin in when access to its location is difficult.

– Checking

Check the pin for tight fit in the hole and that the upper edge of the pin is Gush with the surface of the component part of the joint.

How should a pin fit the hole?

_____
_____
_____

What are the steps of producing a joint using a cylinder pin?

6.2. Joints Using Grooved Pins and Dowel Pins

– Setting up and clamping

Clean the component parts and fit them together. Set them up and clamp them in a suitable device.

While being held in the device, the component parts are to be mounted in the work–holding fixture of the drilling machine.

– Drilling

Produce a bore hole equal to the nominal diameter of the pin.

D = N

– Countersinking

Use a 90–degree included angle countersink and countersink the bore hole at both ends or remove the burr with a triangular reamer.

Ds = N + 0.2 mm

– Cleaning the bore hole

Use compressed air or a brush to remove chips and any remaining fluid from the bore hole.

– Pinning

Apply a thin film of grease to the pin and drive the pin in by several slight blows with a hammer. Proceed from the end at which you applied the drill.

– Checking

Check the pin for tight fit in the hole and that the upper edge of the pin head is flush with the surface of the component part of the joint.

What are the differences in the sequences of operations when producing a joint by means of a grooved pin on one hand and a cylindrical or taper pin on the other hand?

_____
_____
_____

7. Undoing Pinned Joints

Pins in through holes can be driven out by several blows onto a drift (of a nominal diameter somewhat smaller than that of the pin). Apply the blows in the opposite direction of driving in the pin. Make sure that there is a larger hole in the support through which the pin can slip.

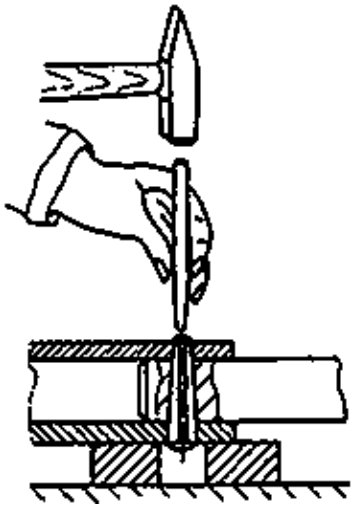

Figure 24 Undoing a pinned joint with a drift

Pins that are flush with the surface of the workpiece and have seized up or pins in blind bores must be removed by drilling. Use a drill of the nominal diameter of the pin.

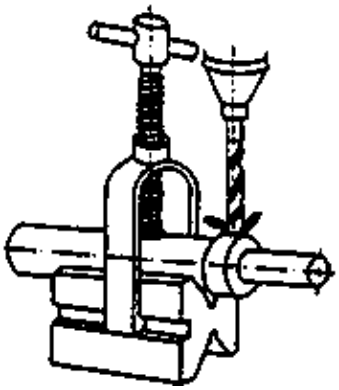

Figure 25 Removing pins with a drill

To remove grooved drive studs, apply a flat chisel sideways between the head of the grooved drive stud and the surface of the component part, and by a few hammer blows, lift the drive stud and remove it with a pair of tongs.

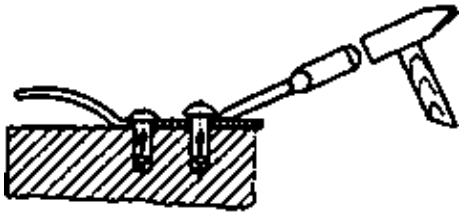

Figure 26 Undoing a grooved drive stud joint

When you remove pins from joints, make sure always to place the joint on a pad or other support that will not slip.

How can you remove a pin from a through hole?

_____
_____
_____

Riveting – Course: Technique for Manual Working of Materials. Methodical Guide for Instructors

Table of Contents

Riveting – Course: Technique for Manual Working of Materials. Methodical Guide for Instructors

Institut für berufliche Entwicklung e.V.
Berlin

Original title:
Methodische Anleitung für den Lehrenden
"Nieten"

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Order No.: 90–32–3111/2

1. Objectives and contents of the practical vocational training in the working technique of "Riveting"

By concluding their training the trainees shall have a good command of the working technique of "Riveting". Therefore, the following objectives have to be achieved:

Objectives

– Knowledge of purpose and application of the riveting technique.

– Proper command of the various working techniques of riveting and capability of joining workpieces in a workmanlike way.

– Capability of selecting the appropriate tools and accessories and of using them properly.

– Capability of evaluating the quality of their own work.

The following contents have to be imparted to the trainees:

Contents

– Purpose of riveting
– Kinds of rivets and riveted joints
– Tools and accessories for riveting
– Calculations for choosing rivets
– Technological process of riveting
– Detachment of riveted joints and riveting faults

2. Organizational preparations

In order to guarantee a trouble–free development of the instructions, exercises and practical work it is necessary to prepare this training properly.

This includes the following steps:

2.1. Preparations for instructions in labour safety

Prior to the exercises the trainees have to be given a brief instruction in the proper use of tools and equipment. This comprises hints for accident–free work, too.

The main emphasis is similar to that of the working technique of "Drilling and Counterboring/Countersinking". The respective hints have to be repeated, and some supplementary points concerning the new working technique have to be added.

These are the main points:

– Use flawless and well–fixed hammers only!
– Use suitable riveting supports only!
– Watch out for flying rivet heads during chiselling–off work – prepare protective screens or gratings!

Familiarity with these hints has to be confirmed by the trainees' signatures in a control book.

2.2. Provision of teaching aids

– For demonstration purposes a vice and suitable riveting supports should be installed at the place of instruction.

– The "Trainees' Handbook of Lessons – Riveting" has to be handed out to the trainees in sufficient numbers.

– When using the transparencies series of "Riveting", check whether the series is complete (transparencies nos. 11.1.–11.3.) and whether the overhead projector is in proper working order.

(Check the operating conditions at the place of instruction and make sure of the proper mains supply!)

– Surveys etc. which are to be written on the blackboard have to be completed prior to the instruction.

– All the tools and accessories mentioned in section 3 should be kept ready for illustrating the riveting technique.

2.3. Provision of working tools and materials

– Sufficient copies of the "Instruction examples for practical vocational training – "Riveting"" roust be handed out to the trainees to provide them with the theoretical foundations for the exercises to be carried out.

– The initial materials necessary for these exercises have to be prepared and laid out in sufficient numbers – based on the materials mentioned in the "Instruction examples ...".

– Each trainee has to be provided with a workbench at which a vice is firmly installed (check the proper height of this vice!).

– The trainees' workbenches have to be fully equipped with tools and accessories – based on the planned exercises.

Recommended basic equipment:

– steel rule, try square, vernier caliper
– steel scriber, marking gauge, punch
– locksmith's hammer, aluminium hammer
– hand hacksaw
– bastard and smooth files 250 mm (flat)
– C–clamps
– rivet set and header for rivet diameters of 3 to 5 mm.

– Bench– or column–type drilling machines and the necessary –clamping tools (machine vices, holding clamps, C–clamps) must be provided for the required preliminary work (drilling and counterboring/countersinking).

– Prior to the start of the exercises the working order of the drilling machines has to be checked in compliance with the regulations on labour safety.

2.4. Time schedule

Time planning is recommended for the following training stages:

– introduction to the working techniques in the form of instructions
– necessary demonstrations
– job–related instructions to prepare the exercises
– carrying out the exercises
– recapitulations and tests.

The necessary time share depends on the respective training conditions. Most of the time is to be allocated to the exercises.

3. Recommendations for practical vocational training in the working technique of "Riveting"

The following paragraphs comprise proposals on conducting trainee instructions, demonstration of working techniques as well as on exercises and tests. Two course variants are recommended:

Variant no. 1

This variant should be chosen for trainees with previous knowledge and generally good achievements and receptiveness.

1.1. Introductory instruction with demonstrations based on the "Trainees' Handbook of Lessons".

1.2. Exercises in riveting based on the "Instruction examples 11.1. – 11.5.".

1.3. Final test of theory knowledge based on the "Examples for recapitulation and tests".

Variant no. 2

This variant should be chosen for trainees with little previous knowledge or poor achievements.

2.1. Introductory instruction with demonstrations based on the "Trainees' Handbook of Lessons".

2.2. Exercises in the technique of countersunk–head riveting based on the "Instruction examples 11.1. and 11.2." with subsequent evaluation.

2.3. Additional instruction in the subject of "button–head riveting" based on the "Trainees' Handbook of Lessons".

2.4. Exercises in riveting of button–head rivets based on the "Instruction examples 11.3. – 11.5." with subsequent evaluation.

2.5. Final test of theory knowledge based on the "Examples for recapitulation and tests".

Practical skills should be checked after handing over the completed workpiece immediately. Theory knowledge can be checked constantly. However, it is recommended to have a final test written (item 1.3. to 2.5.) after the exercises.

3.1. Introductory instruction

If possible, this instruction should be conducted in a classroom.

Make sure that the trainees put down necessary and supplementary notes or answers to questions in their "Trainees' Handbook of Lessons". Based on the main points contained in the "Trainees" Handbook of Lessons", the instructor can deal with the subject of instruction.

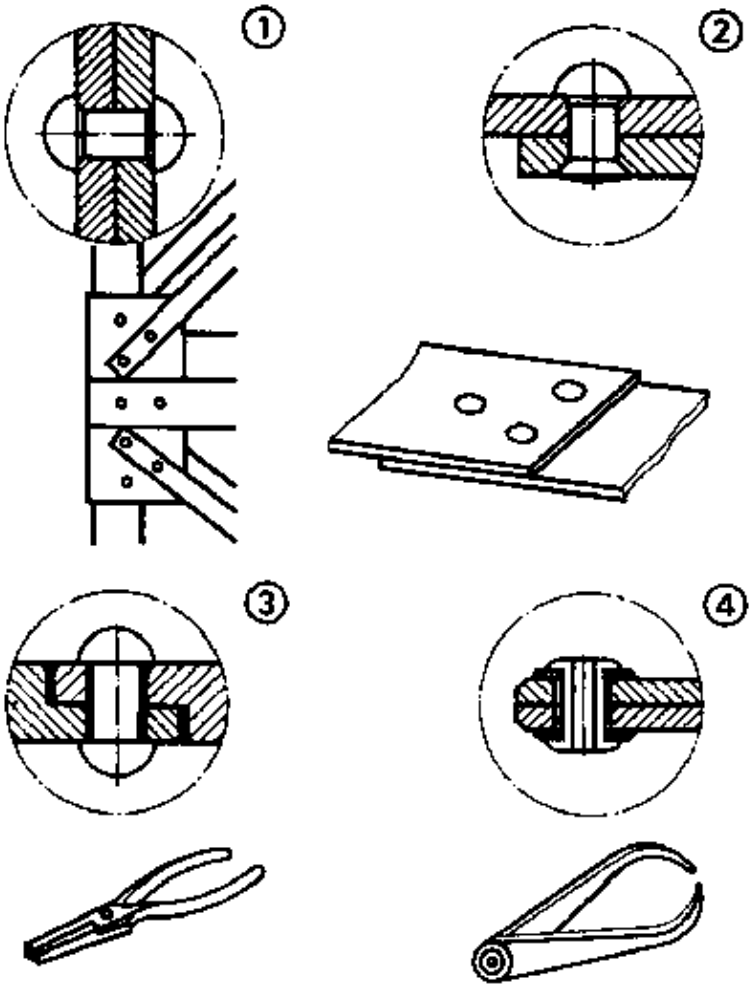
The instruction in the field of tools and accessories must be greatly supported by all the teaching aids available.

Purpose of riveting

The instruction begins with comments on kinds of joints of workpieces.

This instruction is to show riveting as a technique which is still in use in various industrial and craftmen's establishments, but which is mainly replaced by other material– and time–saving techniques, e.g. welding and glueing.

The instruction can be supported by transparency no. 11.1.



Transparency 11.1

Kinds of rivets and riveted joints

The description of these kinds should follow the list contained in the "Trainees' Handbook of Lessons".

- button–head rivet
- countersunk–head rivet
- oval–head countersunk rivet
- boiler rivet

– explosive rivet
– strap rivet
– hollow or pipe rivet
– pin–type rivet (spigot).

This list should be supplemented by additional comments on the fields of use of the rivets. The comments can be based on the detailed hints contained in the "Trainees' Handbook of Lessons". When speaking about the different kinds of riveted joints, the instructor is recommended to deal with the following points:

– kind of joint:	butt joint or lap joint
– number of rows:	single row or multiple row
– rivet arrangement:	parallel or zigzag

Tools and accessories for riveting

The following tools for cold riveting have to be introduced and explained to the trainees:

– riveting hammer
– rivet set
– rivet header
– riveting supports (fixed and adjustable)
– clamping tools.

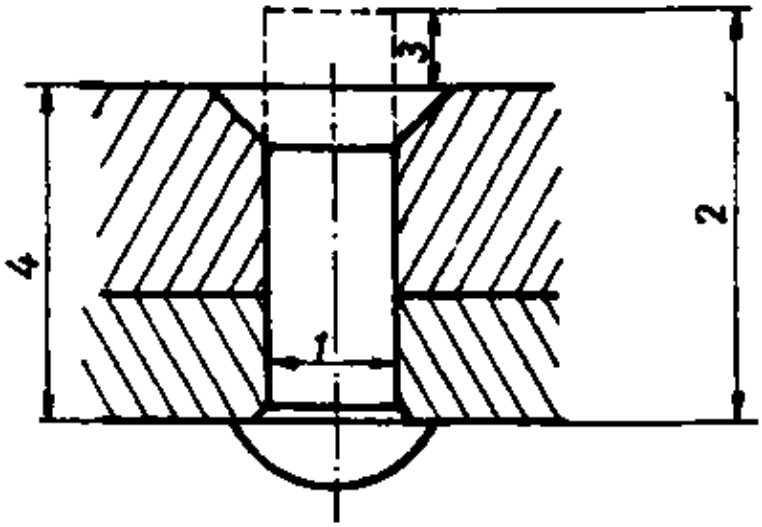
The following items have to be added when speaking about the hot–riveting process:

– forge fire
– riveting block
– riveting tongs.

Calculations for choosing rivets

This subject is to be explained by commenting on the following terms:

– rivet shank diameter (1)
– rivet shank length (2)
– allowance (3)
– thickness of plates being joined (4).



This instruction should be supported by this figure as large–size representation on the blackboard.

The trainees have to learn that it is not always possible to get data on the rivets to be used. Very often there are no drawings available when repairwork has to be done. Thus, the trainees have to learn how to calculate

the dimensions etc. of rivets to be used.

These calculations are to be based on the hints contained in the "Trainees' Handbook of Lessons".

The following formulae shall be used:

$D = 1/4 \times s$

$L = s + A$

D = diameter of rivet shank
s = thickness of plates being joined
L = length of rivet shank
A = allowance.

The trainees have to understand the differences between countersunk–head riveting and button–head riveting operations in order to see why the differences in allowances occur in the following survey:

Allowances for button–type closing heads

– in steel construction:

up to rivet shank diameters of 20 mm
$A = 1.5 \times D$

rivet shank diameters exceeding 20 mm
$A = 1.6 \times D$

– in boiler construction:

up to rivet shank diameters of 20 mm
$A = 1.7 \times D$

rivet shank diameters exceeding 20 mm
$A = 1.8 \times D$

Allowances for countersunk closing heads:
$A = 0.5 \times D$

The instructor has to teach the trainees that the calculated value has to be rounded off to the next standard rivet shank diameter.

The standard sizes are to be taken from the relevant tables.

The trainees have to practise the use of these formulae by calculating several arithmetical examples (as contained in the "Trainees' Handbook of Lessons").

Technological process of riveting

The individual operations should be discussed in detail in the following order:

– clamping/drilling	– upsetting
– deburring/countersinking	– preforming/heading
– insertion/drawing–in	– finish–forming of button head (closing head).

These steps are described in detail and illustrated in the "Trainees' Handbook of Lessons". The following recommended values for drilling and countersinking should be written on the blackboard:

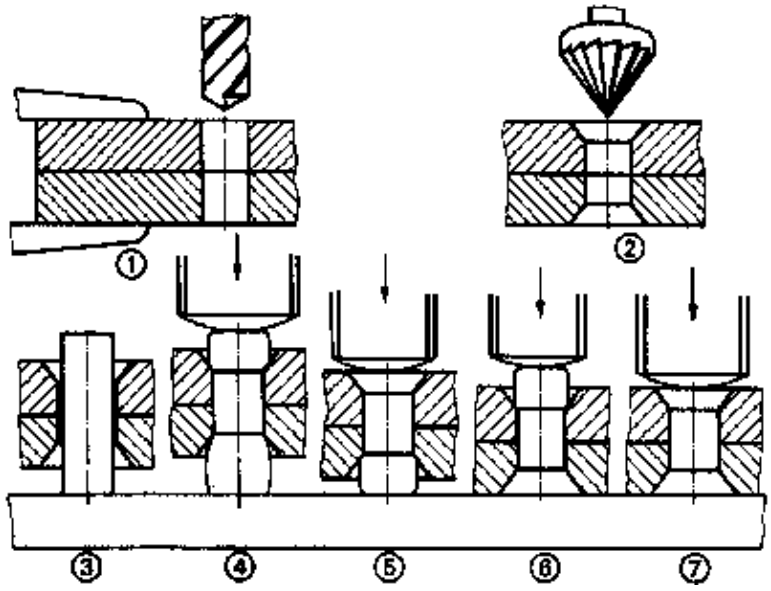
diameter of rivet	diameter of drilled hole	diameter of countersunk hole
(D)	(D_B)	(D_S)
1	1.1	1.8
2	2.2	3.5
3	3.2	5.2
4	4.3	7
5	5.3	8.8
6	6.4	10.3
8	8.4	14

After having explained this theoretical content of the subject, the instructor demonstrates these practises. He performs a simple and rigid countersunk riveted joint of two steel sheets of about 4 mm thickness by a countersunk–head rivet of a diameter of 4 mm. Subsequently, the trainees are shown the button–head riveting technique (same size).

The trainees have to watch the individual steps carefully. One of the trainees has to repeat this practice immediately after–wards. Mistakes he makes have to be revealed and corrected at once. The instructor must not forget to give the following hint:

> Manual riveting of cold rivets is applied for steel rivets up to 8 mm diameter.
> Thicker rivets must be riveted in a red–hot state.

The instructor has to mention the peculiarities of riveting with rivet bolts, too. He has to demonstrate how to preform a die head. Transparency no. 11.2. can serve to illustrate this process.

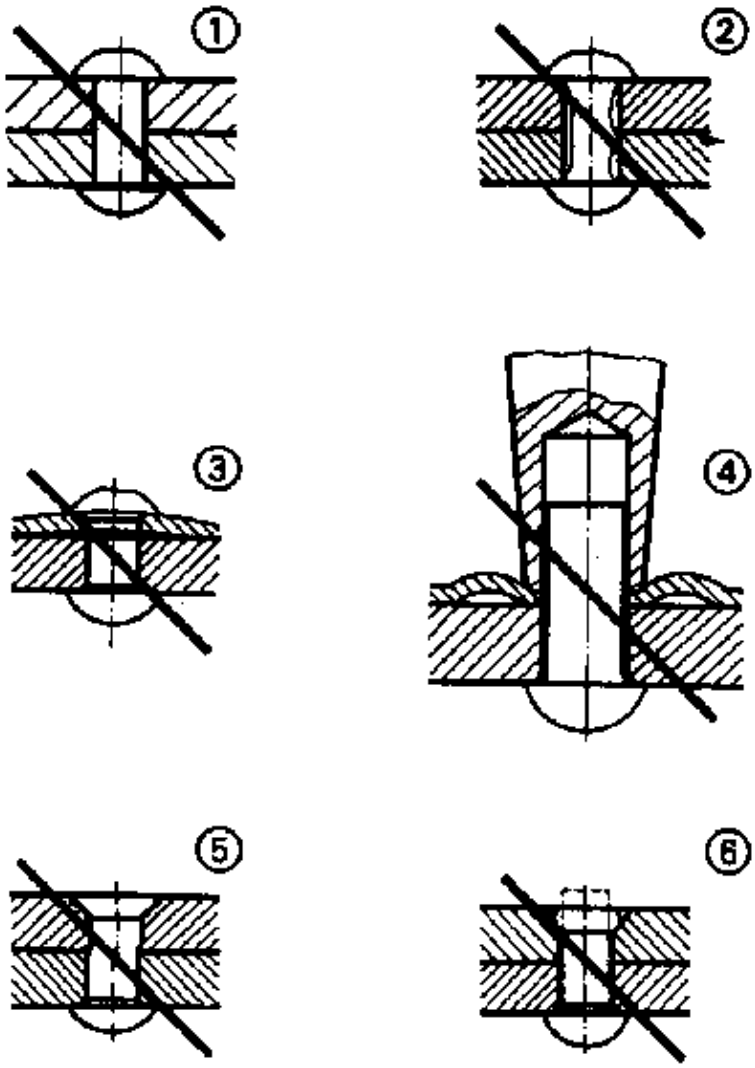


Transparency 11.2

Detachment of riveted joints and riveting faults

Chiselling off, drilling and grinding off are to be mentioned as methods of destroying rivets. This work has to be carried out in compliance with the labour safety regulations.

Subsequently, the instructor mentions the features of frequently occurring riveting faults. The figures and descriptions contained in the "Trainees' Handbook of Lessons" or transparency no. 11.3. should be used as teaching aids.



Transparency 11.3

3.2. Exercises

If it has not been possible to include the individual demonstrations in the instructions, this should be done right now before the start of the exercises.

If the trainees avail of only little practical skill, they should do some preliminary exercises on any small–size work–pieces:

- small countersunk–head riveted joints on flat material
- smaller–scale button–head riveted joints on flat material

However, it is also possible to begin with the first exercises contained in the "Instruction examples for practical vocational training".

But it is necessary to prepare every individual exercise by a brief "job–related instruction", during which the trainees will be shown a finished workpiece in order to illustrate the objectives and crucial points of this exercise.

> The instructor must have completed such a workpiece himself in order to be familiar with all the problems which might arise in producing such a workpiece.

Thus, the instructor is capable of clearly defining the main points of evaluation and of assessing the achievements. During these instructions the sequences of operations and the working drawings of the "Instruction examples" should be placed on the desks so that the trainees can make additional notes therein. The trainees can carry out all the exercises simultaneously in the mentioned order, if sufficient tools etc. are available.

If this is not the case, the trainees have to be grouped – based on the main subjects of the tasks and number of tools available:

group no. 1 – production of countersunk–head riveted joints
group no. 2 – production of button–head riveted joints.

The following hints for operating the drilling machines must be borne in mind:

The trainees must not operate the drilling machines before they are familiar with the function of the control elements!

The instructor has to check whether the trainees had been given the instruction in operating drilling machines (based on the entries in the control book of labour safety instructions). If this is not the case, this must be done now.

During the exercises the instructor must permanently supervise the trainees: No practice without supervision!

Special attention must be drawn to the production of holes. It is recommended to always check the clamping tools for firm clamping.

It is also advisable for the instructor to demonstrate again the operation of the machine, the clamping of the workpiece and the drilling operation. Special emphasis is to be laid on the process of centring (alignment of hole and work spindle), if the work–piece had been undamped between the stages of drilling and countersinking.

As it will not be possible to provide each trainee with a drilling machine, the instructor has to determine the proper succession in which the trainees will operate the machines already during the job–related instruction (instruction examples).

During the exercise the instructor has to make sure that only one trainee operates the machine. Several trainees at one machine could distract each other from working and increase the danger of accidents I

Trainees who cannot begin with riveting work should do some other work in the workshop in the meantime: selection and preparation of initial materials, control of and minor repair work on working tools etc. under the supervision of the instructor, However, it is also possible to carry out additional and consolidating exercises of working techniques acquired earlier.

3.3. Examples for recapitulation and tests

This section comprises questions which are to consolidate and test the acquired knowledge and skills. Each question is provided with the respective answer. Questions which are also contained in the "Trainees' Handbook of Lessons" are marked with the letter "A".

1. What is the purpose of riveting?

(Production of a permanent connection of two or more work–pieces.)

2. What properties can riveted joints have?

"A" (They can be rigid, movable, tight, rigid and tight.)

3. Why is riveting a connection which cannot be detached again?

"A" (Because the rivet as a connecting element must be destroyed, if the connection is to be detached.)

4. What are the materials rivets are made of?

"A" (They are made of tought steel; copper, brass, aluminium.)

5. What is the main property which these materials roust have?

"A" (They must be tough, flexible – well formable.)

6. Which kinds of rivets do you know?

(Button–head rivets, countersunk–head rivets, oval–head countersunk rivets, boiler rivets, strap rivets, hollow rivets.)

7. When do we employ button–head rivets?

"A" (Button–head rivets are used to make particularly tight or rigid connections, which are not affected by the projecting rivet head.)

8. When do we employ countersunk–head rivets?

"A" (Countersunk–head rivets are used when the surface must not have irregularities and the planned joints are not too highly stressed.)

9. What are the criteria for differentiating firm rivet connections?

(Kind of joint, number of rows, arrangement of rivets.)

10. Which tools and accessories are necessary for cold riveting by hand?

"A" (Riveting hammer, rivet set, rivet header, riveting support, surface plate, clamping tools.)

11. What is the function of a rivet set?

"A" (Pressing of the metal sheets to be riveted and setting the die head to the metal sheets.)

12. Which rivet can be used for joining three metal sheets of 5 mm thickness each with a countersunk–head rivet?

"A" (Countersunk–head rivet 4 x 17.)

13. Which values do we have to calculate, if the kind of riveting is not given in detail on the drawing?

(Diameter of rivet shank, length of rivet shank, diameter of drilled hole, diameter of countersunk hole.)

14. What are the individual steps to be taken when producing a button–head countersunk riveted joint?

"A" (Clamping, drilling, deburring, insertion, drawing–in, upsetting, pre–forming, finish–forming.)

15. What can we do if separately drilled components do not have aligned holes after being put together?

"A" (We must ream them up by means of a taper reamer.)

16. What hole must we drill for a 4 mm thick rivet?

"A" (4.3 mm.)

17. What kind of a countersink do we need in order to prepare countersunk–head riveted joints?

"A" (75° countersink.)

18. What is the diameter of the countersunk hole for a countersunk–head rivet of 4 mm?

"A" (7 mm.)

19. What is the upper limit of steel rivet diameters for cold–riveting?

(About 8 mm.)

20. Why should non−ferrous metal rivets by annealed before the riveting process begins?

"A" (Annealing will increase their elasticity or, resp., plasticity.)

21. Why must we apply only a few but straight blows when we rivet the closing head?

"A" (In order not to cold−harden the rivet and in order to preserve its toughness.)

22. How can we detach riveted joints?

"A" (Destruction of rivet head by chiselling, drilling, grinding.)

23. What riveting faults can have occurred, if we recognize that the closing head is not fully formed?

"A" (Shank of rivet too short, metal sheets are not fully pulled together, drilled hole too big for rivet, rivet header too big, rivet hole is not countersunk.)

4. Application of the working technique of "Riveting"

Based on the variants described in section 3, the exercises can be designed as a single instruction or in several stages of exercises. Based on the "Instruction examples for practical vocational training" the trainees can manufacture 5 workpieces of different degrees of difficulty. These "Training examples ..." also comprise a list of materials (initial materials, hand tools, measuring and testing tools, accessories) as well as the sequence of operations associated with manufacturing of the workpiece.

Also contained is an illustrative working drawing.

Thus, the trainees will avail of all the necessary information to begin their exercise−related work.

If the instructor finds out in the course of the exercises that the quality of the workpieces produced is not sufficient, the trainees must carry out more comprehensive preliminary work. In this case it is recommended that waste components be used. After having practised this skill, the planned workpiece can be produced. The following hint should be taken into account:

> The trainee has to do all the necessary work by himself – from cutting the initial material up to the completion of the workpiece. This is the only way to guarantee a just evaluation of the trainee's achievements.

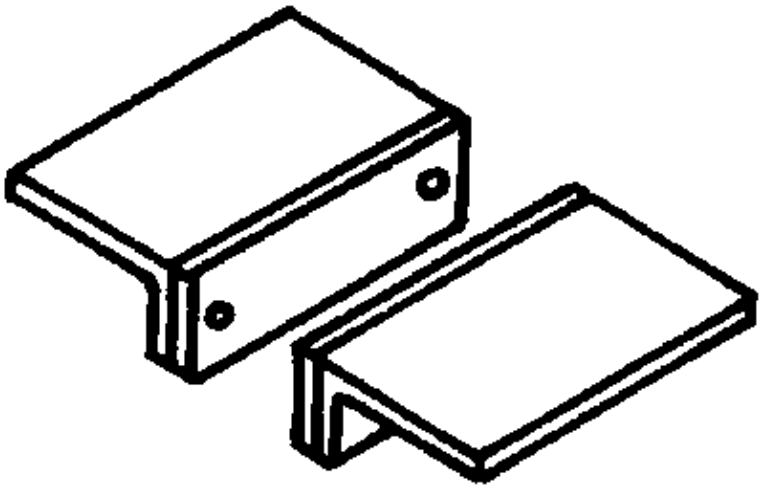
If the proposed "Instruction examples ..." are not included in the exercises, it will be also possible to select other workpieces. In this case the instructor has to make sure of it that all the working techniques mentioned before will be practised with this workpiece.

4.1. Instruction examples

What follows is a brief description of the individual instruction examples in order to give a survey of those workpieces on which the previous knowledge can be practised:

Instruction example 11.1.
Protective jaws

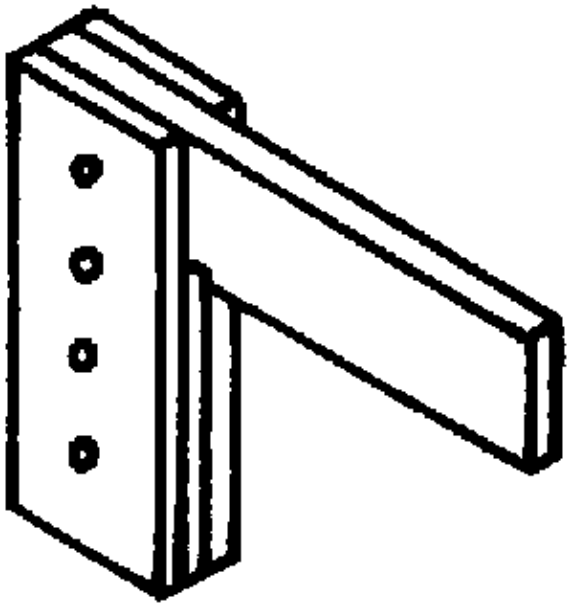
An aluminium sheet and a steel sheet will be rigidly joined by double−sided countersunk−head riveting. The trainees use rivet bolts of 4 mm aluminium wire.



After their completion these protective jaws can be used as accessories for clamping of components with sensitive surfaces in a vice.

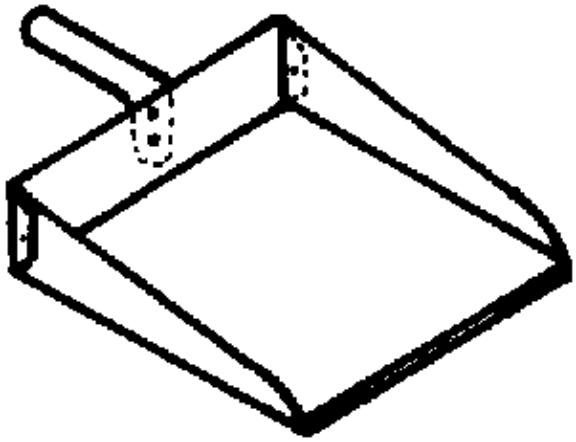
Instruction example 11.2.
Try square

Three steel sheets are firmly joined by countersunk–head rivets in one row. The trainees will use pre–fabricated countersunk rivets of steel (4 mm). After its completion the try square can be used as a testing tool for squareness.



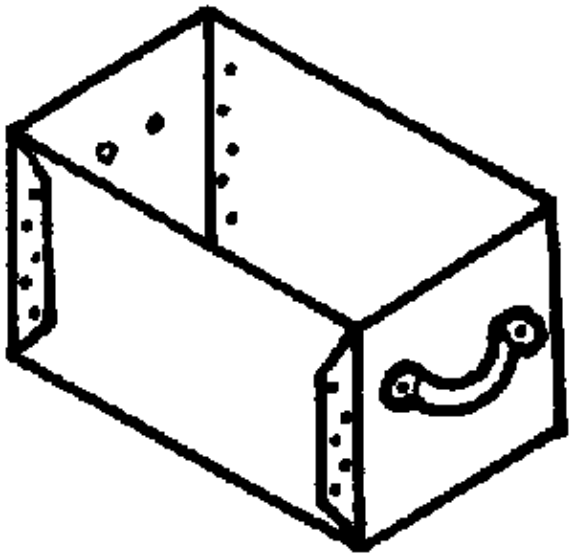
Instruction example 11.3.
Waste shovel

Steel sheets will be rigidly joined by double–sided button–head rivets. The trainees use 4 mm rivet bolts of copper wire. This shovel for waste disposal can be used for cleaning purposes in the workshop.



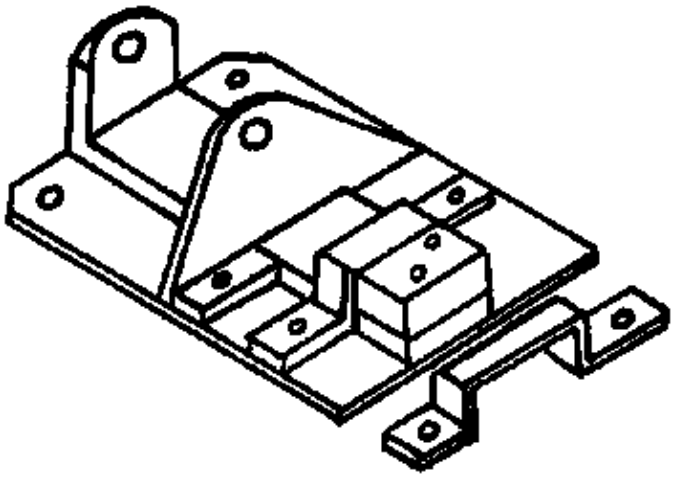
Instruction example 11.4.
Waste bin

The trainees will practise two−row zigzag riveting with button−head rivets of copper and steel in order to rigidly join steel sheets. Its dimensions are chosen to adapt it to the envisaged purpose of use in the workshop.



Instruction example 11.5.
Key−bolt for cabinets

Several components will be joined by combined button−head and counter−sunk rivets. The trainees use button−head rivets of 4 mm and countersunk rivets of steel. This key−bolt for cabinets can be combined with a padlock and form a firm locking mechanism for tool cabinets.



4.2. Criterial for practical training

It is recommended to determine certain points of evaluation and supervision. The following criteria can serve as a guideline:

Preparation

- Did the trainee calculate the rivet dimensions exactly?
- Did the trainee select the appropriate rivet?

Clamping/drilling

- Did the trainee select the appropriate drill?
- Have the workpieces been firmly clamped and drilled jointly?
- Does the trainee properly ream up non−aligned holes?

Deburring/countersinking

- Does the trainee use the appropriate countersink?
- Does the diameter of the countersunk hole comply with the exact tabular value?

Insertion/drawing in

- Does the trainee insert the rivet with the die head at the bottom?
- Does the trainee use the rivet set for tightening the metal sheets?

Upsetting

- Does the trainee hammer exactly into the direction of the longitudinal axis of the rivet?

Pre−forming/heading

- Does the trainee appropriately pre−form the button head by uniform blows around the rivet head?
- Does the trainee hammer the countersunk head cleanly into the countersunk hole?

Finish−forming

- Does the trainee use the appropriate rivet header?
- Does he form the button head cleanly?

5. Captions and legends of the "Riveting" transparencies series

Transparency no. 11.1.	Application of rivet joints
	(1) Rigid rivet joint in steel construction
	(2) Rigid rivet joint of metal sheets (sheet metal rivet with button head and countersunk head)
	(3) Movable rivet joint (universal joint with button−head rivet)
	(4) Movable rivet joint (universal joint with hollow rivet)
Transparency no. 11.2.	Working operations for double−sided countersunk riveted joint with rivet bolts
	(1) Drilling of the clamped metal sheets
	(2) Countersinking on both sides with 75° countersink

(3) Insertion of rivet bolt and setting up on riveting support

(4) Upsetting of shank

(5) Forming of upper countersunk head

(6) Turning over of metal sheets – upsetting of closing head

(7) Forming of closing head

Transparency no. 11.3.

Riveting faults

(1) Rivet hole was not deburred; compression at the hole edge; closing head not fully formed.

(2) Rivet hole too big; bending of shank; closing head not fully formed.

(3) Upper metal sheet not fully tightened; shank compressed between metal sheets; closing head not fully formed.

(4) Rivet joint too tight; upper metal sheet compressed.

(5) Rivet holes offset; notched rivet shank.

(6) Rivet shank too short; closing head not fully formed.

Riveting – Course: Technique for Manual Working of Materials. Instruction Examples for Practical Vocational Training

Table of Contents

Riveting – Course: Technique for Manual Working of Materials. Instruction Examples for Practical Vocational Training

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Introduction

The present documentation comprises 5 selected instruction examples by means of which countersunk–head riveted joints and button–head, riveted joints in various alternatives can be exercised.

The emphasis is laid on the rigid connection between sheet metals.

All workpieces can be used in the workshop after their completion!

Protective jaws and try squares complete the tool outfit of the trainee at his workplace, waste shovel and waste bin are required for cleaning the workshop, tool cabinets can be locked and secured by means of the key–bolt.

To facilitate the preparation and the execution of the work, the materials, hand tools, measuring and testing tools as well as accessories required for each instruction example are given. Moreover, the previous knowledge is mentioned which is required for the individual exercises. On the basis of the working drawings enclosed and the appertaining sequences of operations the workpieces can be manufactured.

Explanations as to material indication:

Marking of the steel is done with the value of tensile strength in the unit of "Megapascal" (MPa).

Instruction example 11.1. Protective jaws

Exercising of double–sided countersunk–head riveted joints as rigid connection between two metal sheets.

Material

– 2 x sheet steel (380 MPa)

Thickness:	2 mm
Width:	82 mm
Length:	122 mm

– 2 x aluminium sheet

Thickness: 10 mm

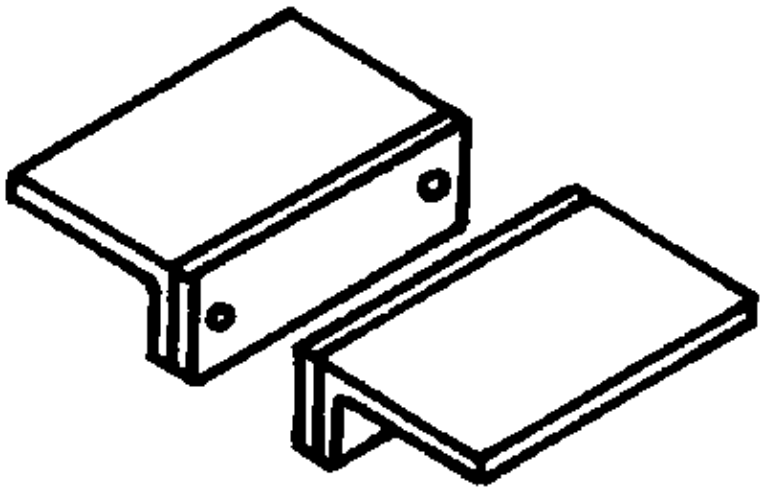
Width: 28 mm

Length: 122 mm

– 4 x aluminium wire (rivet bolts)

Diameter: 4 mm

Length: 16 mm



Hand tools

Steel scriber or marking gauge, centre punch, engineers' hammer, aluminium hammer, hand hacksaw, bastard and smooth file 250 mm (flat)

Measuring and testing tools

Steel rule, try square, vernier caliper

Accessories

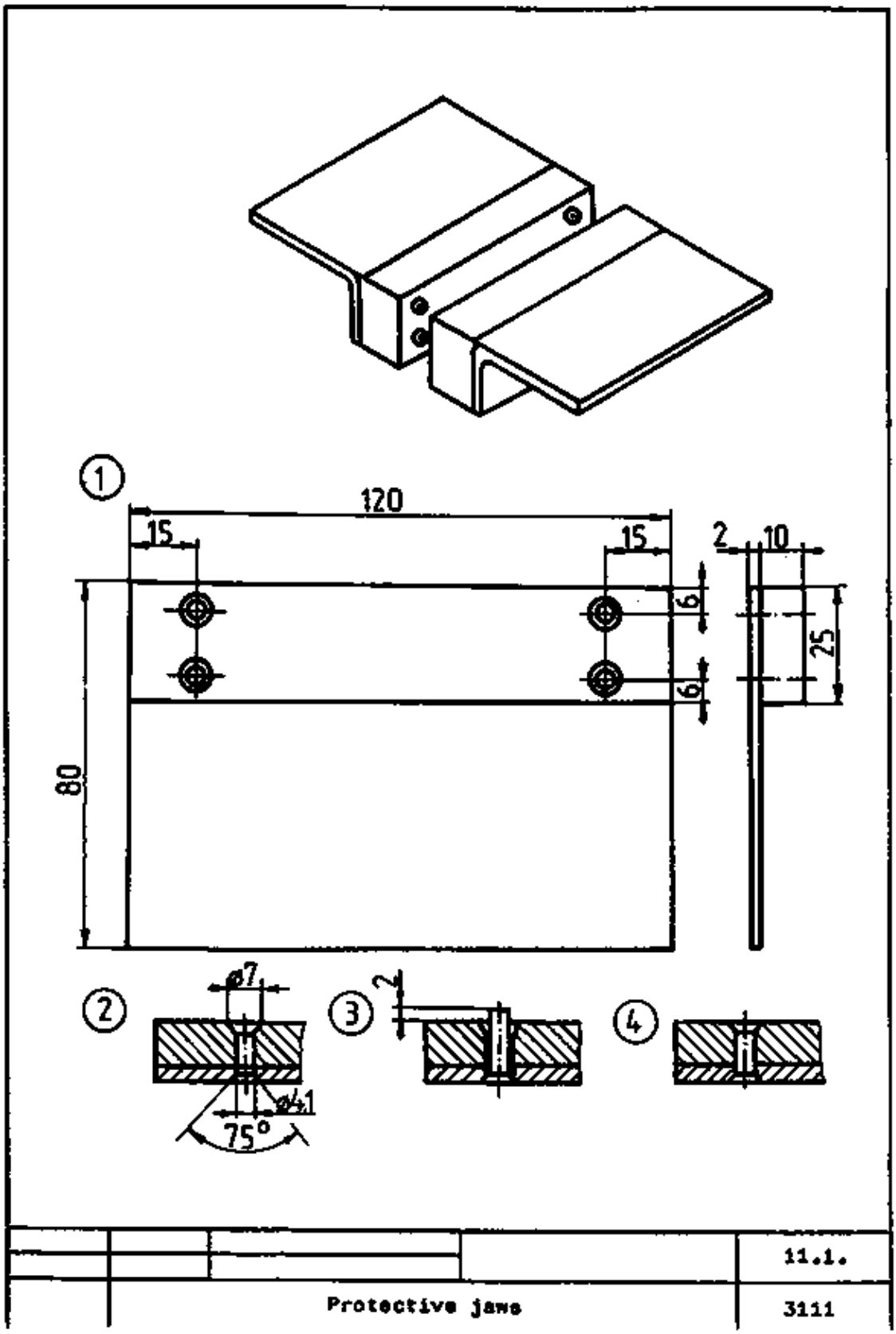
Vice, surface plate, surface plate or anvil, lubricant and coolant (soluble oil), clamp dogs or C–clamps, clamping jaws for round material, rivet set for 4 mm rivets

Required previous knowledge

Reading of the drawings, measuring, testing, scribing. prick–punching, sawing, filing, drilling, countersinking/counterboring

Sequence of operations	**Comments**
1. Arrange workplace, prepare working material	– Check for completeness
2. Preparing the required sizes of the steel sheets and aluminium sheets according to the drawing	– Sawing (shearing) Filing
3. Fixing together of a steel sheet and an aluminium sheet by means of a clamp dog or a C–clamp	– Stage (1) Upper edges and sides to be exactly in alignment!

4. Scribing and punching of the holes; drilling and countersinking	– Stage(2) Drill and countersink the holes as per drawing!
5. Checking of the aluminium wires for their required lengths; fixing them into the vice by clamping jaws for round material	– Wire to project 2 mm over the clamping jaws!
6. Upsetting of the rivet head with uniform and light hammer blows –forming of the die head	
7. Inserting of the upset rivet bolt into the hole of the sheets clamped together, putting of the sheets on the surface plate	– Stage (3) Upset side of the rivet bolt (die head) lies on the surface plate!
8. Pressing together of the sheets by hammer blows on the rivet set, the die head sets to the sheets	– Rivet bolt sits firmly in the hole!
9. Heading of the closing head by light hammer blows, subsequently forming so that the countersunk hole is completely filled out	– Stage (4)
10. Turning of the sheets and checking of the reverse side of the riveted joint (countersunk hole must be completely filled out as well)	– If necessary, rework the countersunk head
11. Making of the second riveting	– Same as operations 7 to 10
12. Riveting of the second steel sheet with the second aluminium sheet	– Same as operations 3 to 11
13. Loosening of the clamping tools	
14. Checking of the rivets for clean, not projecting countersunk heads as well as for rigid connection of the sheets	– If necessary, rework!
15. Fixing of the parts into the vice and tangent bending of the sheets by the aluminium hammer	
16. Final check	– Accuracy to size, appearance



Protective jaws

Instruction example 11.2. Try square

Exercising of single–row countersunk–head riveted joints as rigid connection between three metal sheets.

Material

– Steel sheet (of high–strength or hardenable steel)

Thickness: 5 mm

Width: 75 mm

Length: 115 mm (or from instruction example 4.5.)

– 2 x steel sheet (of high–strength or hardenable steel)

Thickness: 3 mm

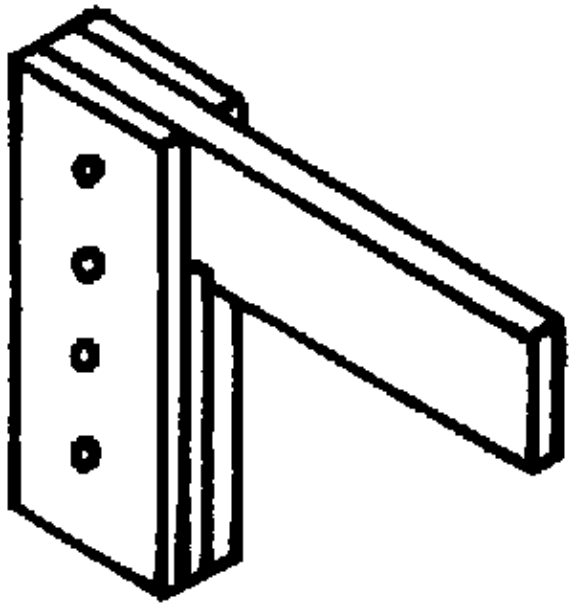
Width: 25 mm

Length: 75 mm

– 4 x countersunk–head rivets (steel)

Diameter: 4 mm

Length: 13 mm



Hand tools

Steel scriber or marking gauge, centre punch, engineers' hammer, hand hacksaw, bastard and smooth file 250 mm (flat), drill 4.1 or 4.3 mm dia.; countersink 75°

Measuring and testing tools

Steel rule, try square, bevelled edge square, vernier caliper

Accessories

Vice, surface plate, surface plate or anvil, lubricant and coolant (soluble oil), clamp dogs or C–clamps, rivet set for 4 mm rivets

Required previous knowledge

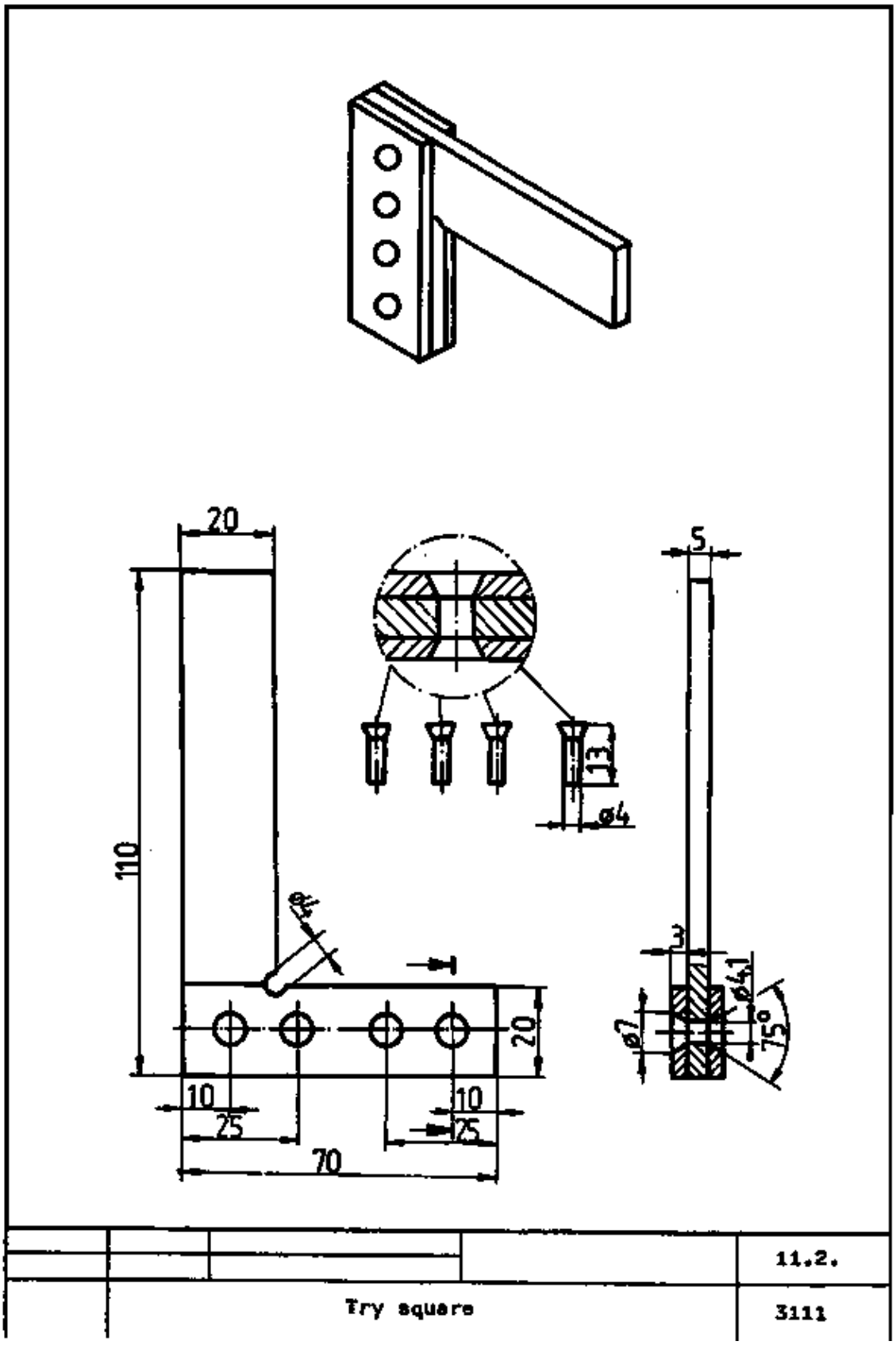
Reading of the drawing, measuring, testing, scribing, prick–punching, sawing, filing, drilling, countersinking/counterboring

Sequence of operations **Comments**

1. Arrange workplace, prepare working material	– Check for completeness
2. Preparing the sizes of the steel sheets as per drawing	– Sawing, filing
3. Clamping together of the steel sheets by means of clamp dog or C–clamp	– Edges to be exactly in alignment
4. Scribing and centre–punching of the holes, drilling and countersinking of all holes as per drawing	– Clamping tools must be reclamped for this operation!
5. Inserting of the first rivet into the hole, putting of the sheets on the surface plate with the countersunk–head side of the rivet, fastening once more with the rivet set (tighten up)	– Sheets can be fastened after drilling with two screws as well, thus the hole alignment is maintained!
6. Upsetting of the closing head with light hammer blows, subsequently forming so that the countersunk hole is completely filled out	
7. Turning of the sheets and checking of the back side (countersunk hole roust be completely filled out as well)	
8. Making of all the other rivetings as well	– Same as operations 5 to 7
9. Loosening of the clamping tools	
10. Checking of the rivets for clean, not projecting countersunk heads as well as for rigid connection of the sheets	– If necessary, rework!
11. Checking of the edges for exact alignment as well as for angularity	– If necessary, rework by filing!
12. Final check	– Accuracy to size, appearance

Completion

Have the inner and outer edges hardened (if hardenable steel is used)



Try square

Instruction example 11.3. Waste shovel

Exercising of double−side button−head riveted joints as rigid connection of metal sheets

Material

– Sheet steel (380 MPa)

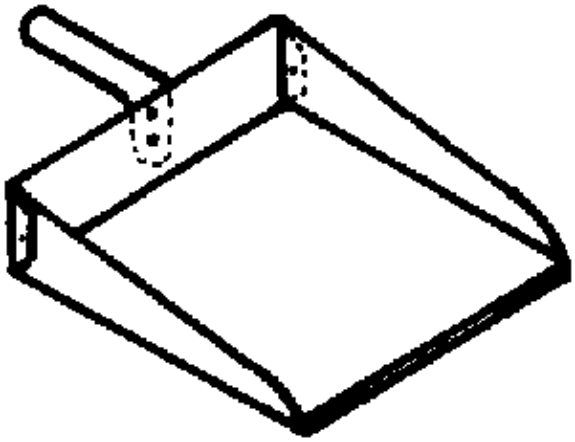
Thickness:	1.5 to 2 mm
Width:	242 mm
Length:	260 mm

– Steel pipe (380 MPa)

Diameter:	22 mm
Length:	160 mm

– 4 x copper wire (rivet bolt)

Diameter:	4 mm



Hand tools

Steel scriber, centre punch, engineers' hammer, hand hacksaw, smooth file 250 mm (flat), drill 4.3 mm dia., header for 4 mm rivets, taper reamer

Accessories

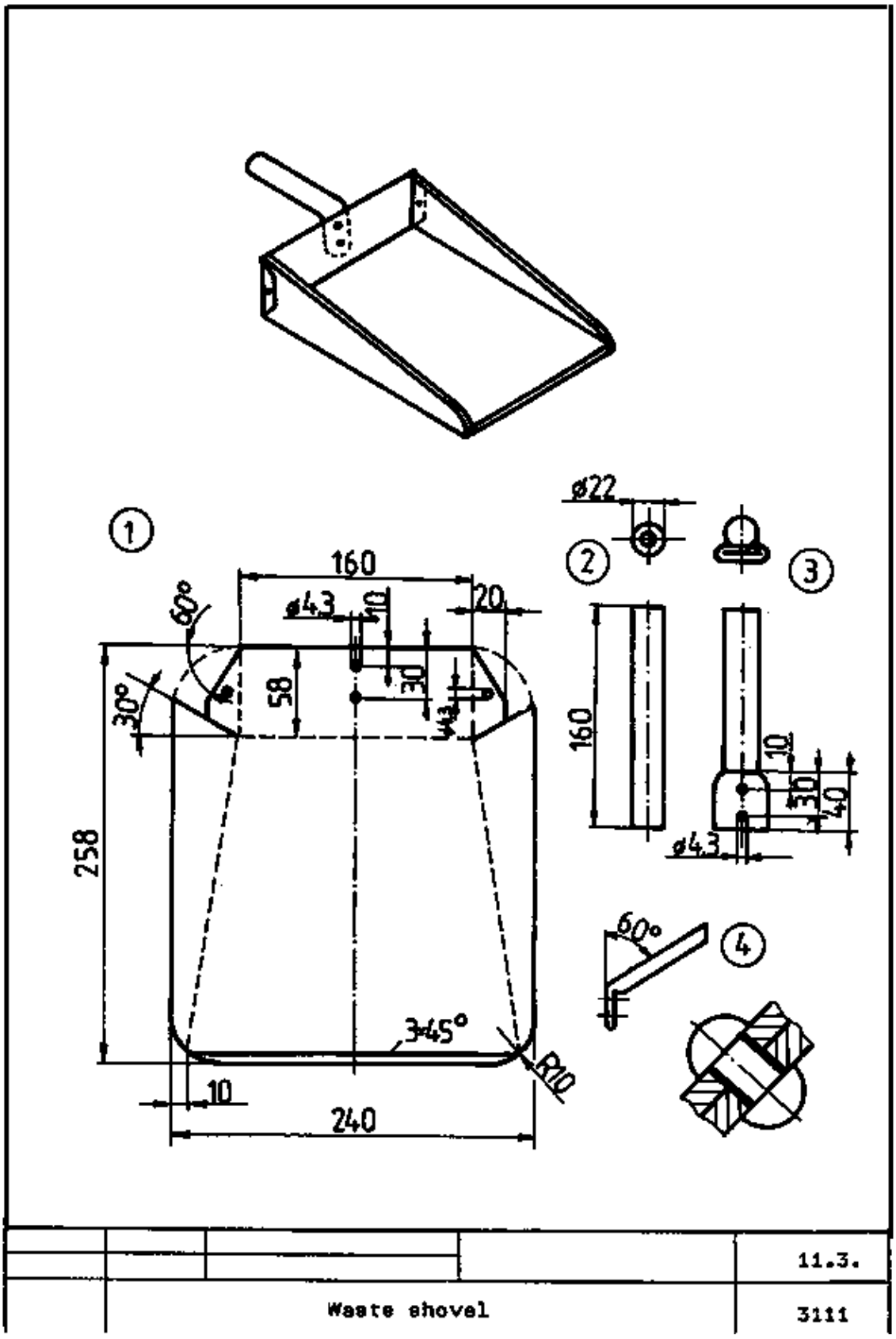
Vice, surface plate, surface plate or anvil, lubricant and coolant (soluble oil), C–clamps, rivet set for 4 mm rivets, holder or riveting support for 4 mm rivets, clamping jaws for round material, tap wrench

Required previous knowledge

Reading of the drawings, measuring, testing, scribing, prick–punching, sawing, filing, drilling, countersinking/counterboring, hammering

Sequence of operations	**Comments**
1. Arrange workplace, prepare working material	– Check for completeness
2. Preparing the size of the sheet steel according to the drawing, scribing of the holes, centre punching and drilling	– Stage (1) Deburr exactly the sheet edges and holes
	– Stages (2) (3) (4)

3. Hammering out of the steel pipe from one side to a length of 40 mm, scribing of the holes, punching and drilling, subsequently bending in the vice	
4. Fixing of the copper wire (rivet bolt) into the vice by means of clamping jaws for round material	– Wire projects 6 mm over the clamping jaws!
5. Heading of the rivet head with uniform light hammer blows; finish–forming of the head by means of the header	
6. Providing of all the other rivets with button heads as well	
7. Bending of the sheet steel; the holes of the side parts have to be situated one upon the other	– If necessary, ream with the taper reamer!
8. Determining of the length of the rivet shank; sawing of the rivet to the required length; inserting it into the deburred hole, placing on the holder; fastening with the rivet set	– Length of the rivet for sheet riveting is not identical with that of the sheet–pipe riveting!
9. Heading of the rivet head, finish–forming of the closing head by means of the header	
10. Making of all rivetings in this manner	
11. Checking of the rivets for clean, uniform button heads, checking of the sheet connection for rigidity	
12. Final check	– Accuracy to size, appearance



Waste shovel

Instruction example 11.4. Waste bin

Exercising of two−row zigzag riveted joints by means of button−head rivets as rigid connection

Material

– Sheet steel (380 MPa)

Thickness: 1 to 1.5 mm

Width: abt. 900 mm

Length: abt. 1100 mm

– 2 x Steel pipe (380 MPa)

Diameter: 16 mm

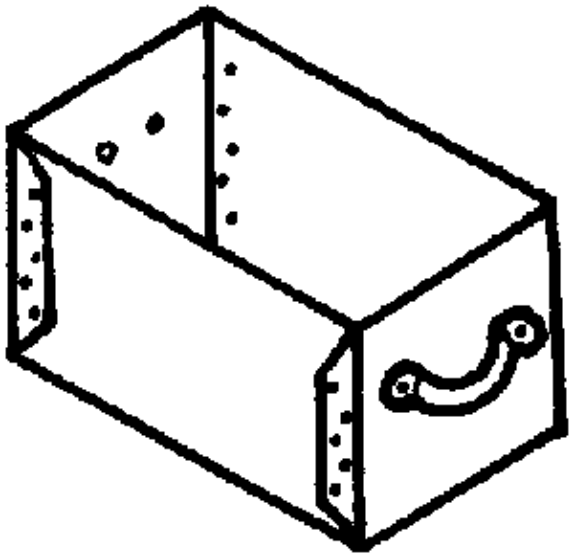
Length: abt. 260 mm

– Button–head rivets (copper)

Diameter: 3 mm

– 4 x button–head rivets (steel)

Diameter: 5 mm



Hand tools

Steel scriber or marking gauge, centre punch, engineers' hammer, aluminium hammer, hand hacksaw, smooth file 250 mm (flat), drills 3.2 mm dia. and 5.3 mm dia., header for 3 mm rivets and for 5 mm rivets

Measuring and testing tools

Steel rule, thin steel square, vernier caliper

Accessories

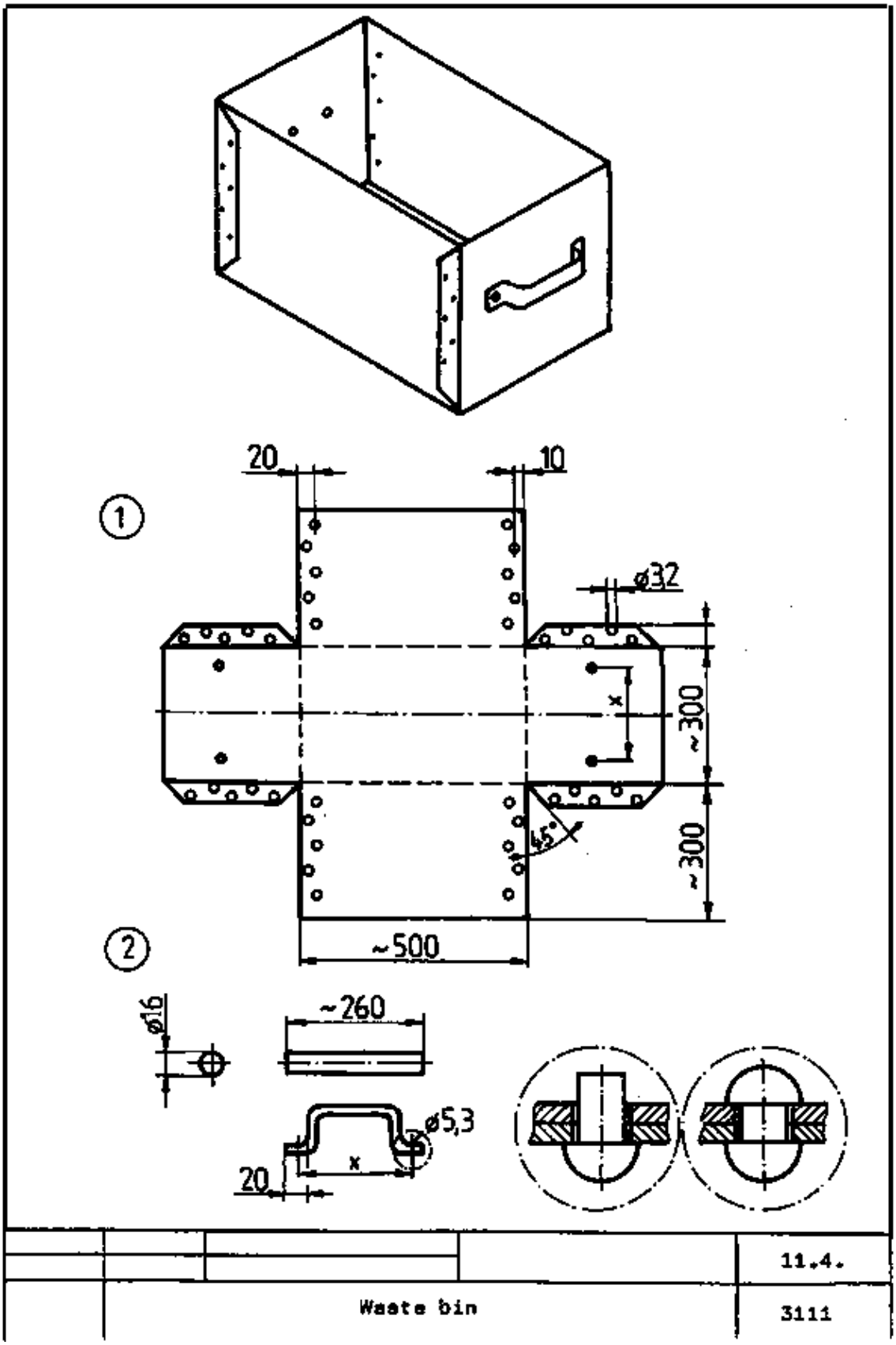
Vice, surface plate, lubricant and coolant (soluble oil), C–clamps, rivet set for 3 mm and 5 mm rivets, holder or riveting support for 3 mm and 5 mm rivets

Required previous knowledge

Reading of the drawings, measuring, testing, scribing, prick–punching, sawing, filing, drilling, countersinking/counterboring, hammering

Sequence of operations **Comments**

1. Preparing of the workplace, laying out of the working material	– Check for completeness
2. Preparing the size of the steel sheet according to the drawing	– Stage (1) Sawing, shearing
3. Scribing and punching of the holes (number depends on the size specified) in a zigzag course	– The number of holes is stipulated by the instructor!
4. Drilling and deburring	
5. Bending of the sheet metal, fixing together of overlappings	– Rework offset holes with a taper reamer!
6. Determining of the length of the rivet shank, sawing of the rivets to the required length	
7. Inserting individually the rivets from outside into the holes; tightening up by means of the rivet set and finish–forming of the closing head on the holder by means of the header	– Finish–form the closing head inside of the bin!
8. Free bending of the steel pipes in the vice as handles, hammering out 20 mm from the ends, scribing, punching and drilling	– Stage (2)
9. Scribing of the handle holes on the bin sides, drilling by the hand drilling machine, deburring	
10. Riveting of the handles with the bin	– Same as operations 6 and 7
11. Checking of the rivets for faulty rivetings, checking of the overlappings for close contact and strength	
12. Final check	– Accuracy to size, appearance



Waste bin

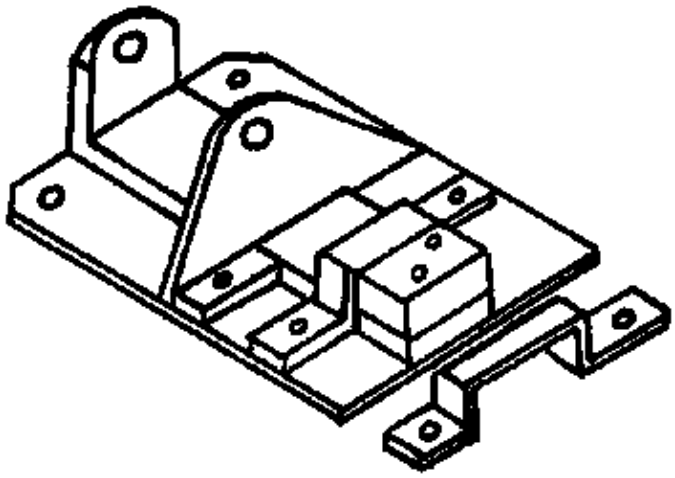
Instruction example 11.5. Key–bolt for cabinets

Exercising of combined button–head and countersunk–head riveted joints as rigid connection between metal sheets

Material

– Steel sheet (380 MPa)

Thickness:	4 mm
– Part (1)	22 x 130 mm
– Part (2)	52 x 62 mm
– Part (3)	12 x 70 mm or 8 x 12 x 52 mm
– Part (4)	22 x 27 mm
– Part (5)	52 x 92 mm
– Part (6)	12 x 80 mm or 12 x 12 x 52 mm
– Part (7)	countersunk–head rivet 4 mm
– Part (8)	button–head rivet 4 mm



Hand tools

Surface gauge, centre punch, engineers' hammer, hand hacksaw, bastard files and smooth files, drills 4.3 mm and 10 mm dia., countersink 75°

Measuring and testing tools

Vernier caliper, try square

Accessories

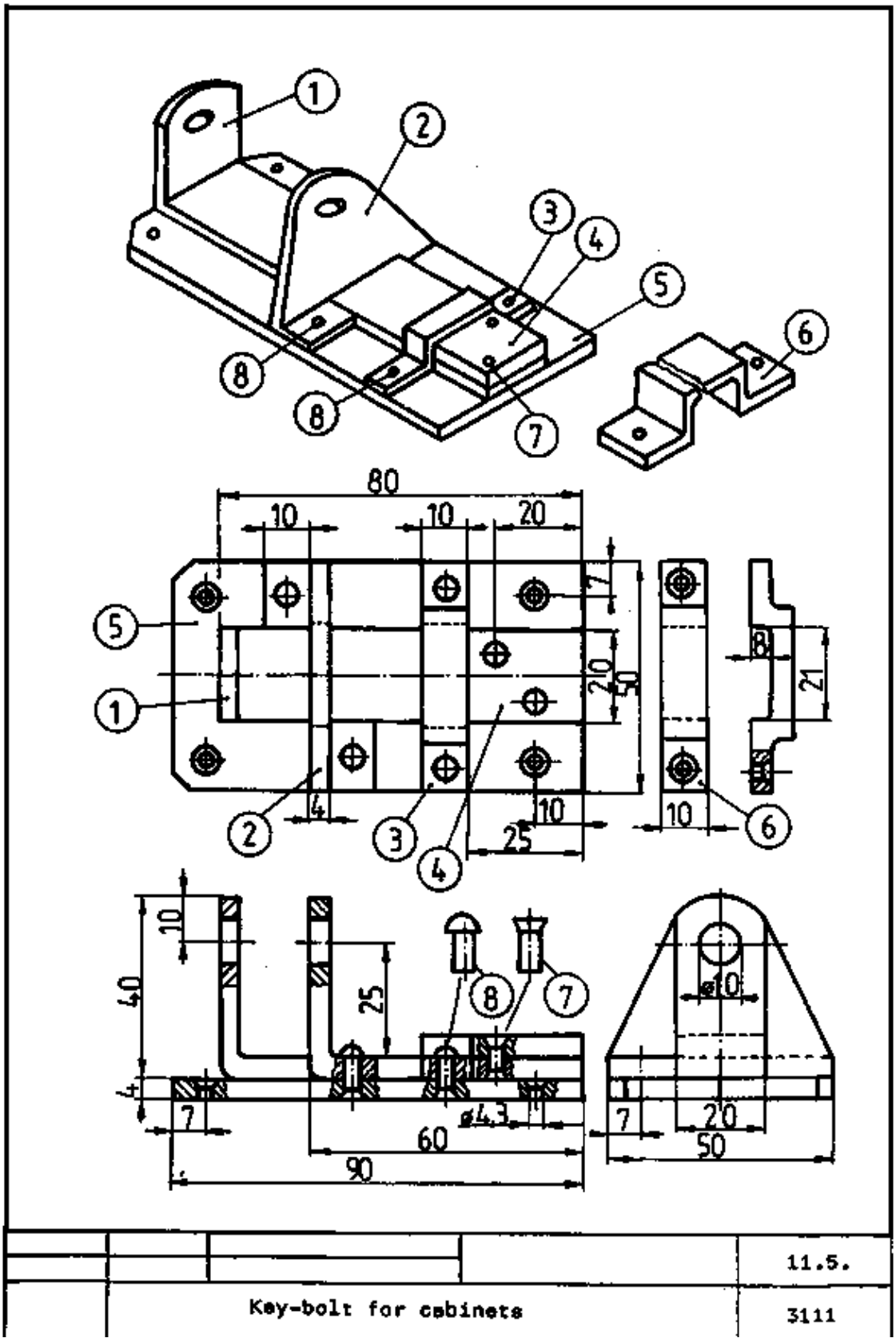
Vice, surface plate, surface plate or anvil, lubricant and coolant (soluble oil), clamp dogs or C–clamps, rivet set for 4 mm rivets, holder for 4 mm rivets

Required previous knowledge

Reading of the drawings, measuring, testing, scribing, prick–punching, sawing, filing, drilling, countersinking/counterboring

Sequence of operations	**Comments**

1. Preparing of the workplace, laying out of the working material	– Check for completeness
2. Preparing the sizes of the individual parts (1) to (6) as per drawing	– Sawing, filing, bending
3. Separately drilling and deburring of the parts (2), (3) and (6)	
4. Fastening of part (1) with part (4), scribing, punching, drilling, countersinking and riveting through part (s)	– Countersunk rivet heads to be exactly in alignment with the surface!
5. Placing of parts (2) and (3) on part (5) and drilling of the rivet holes, countersinking of part (5) from below	
6. Firmly riveting of parts (2) and (3) with part (1) inserted on part (5) through part (8)	
7. Checking of part (1) for easy sliding, checking of the rivet joints for cleanliness and strength	
8. Drilling and countersinking of holes on part (8) for screwing	
9. Final check	– Accuracy to size, appearance



Key–bolt for cabinets

Riveting – Course: Technique for Manual Working of Materials. Trainees' Handbook of Lessons

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Riveting – Course: Technique for Manual Working of Materials. Trainees' Handbook of Lessons

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1. Purpose of riveting

Riveting is the permanent connection of two or more workpieces the rivet being put as a joint in a predrilled bore hole and formed on one or both ends.

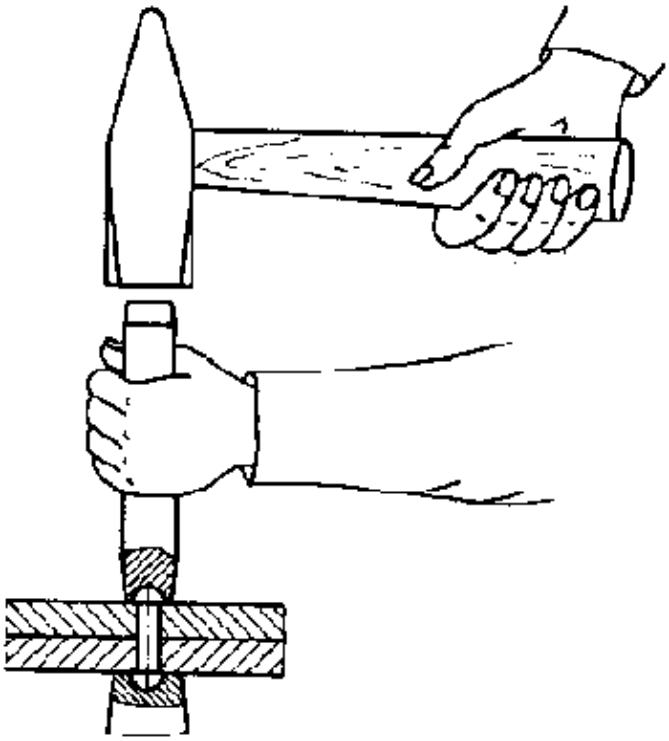

Figure 1 – Riveting

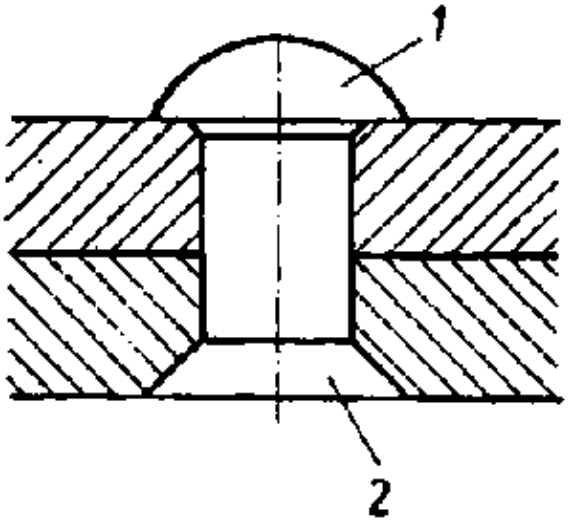

Figure 2 – Riveted connection

1 – Closing head (button head)
2 – Set head (countersunk–head)

The riveted parts can be connected in a movable, fixed, close or fixed and close manner. Shall the connection be undone, the rivet must be removed by destroying one of the two rivet heads.

Note:

When considering the kind of connection, check up if the material can be glued or welded – these techniques replace the method of riveting and are more economical as to time and material.

What characteristics can riveted joints have?

_____
_____

Why is riveting a permanent connection?

_____

2. Kinds of rivets

Rivets consist of tough steel (340 MPa), copper, brass and aluminium.

– Button head rivets:

They are used in components, where the projecting head does not disturb and are especially suitable for fixed and close joints, because a strong clamping effect is achieved by them.

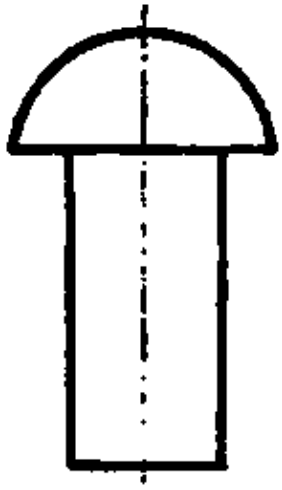

Figure 3 – Button head rivet

– Countersunk–head rivet:

This is used in components or parts the surfaces of which must not become uneven by projecting rivet heads; it is not suitable for highly stressed connections.

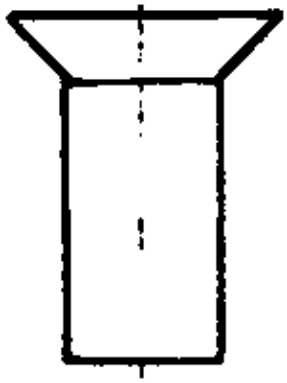

Figure 4 – Countersunk–head rivet

– Oval head countersunk rivet:

They are used for such parts where the surface is rough and uneven and where no special demands are made on the quality of the surface or – on the contrary – an uneven surface shall be achieved (gangways, steel stairs – nonskid property).

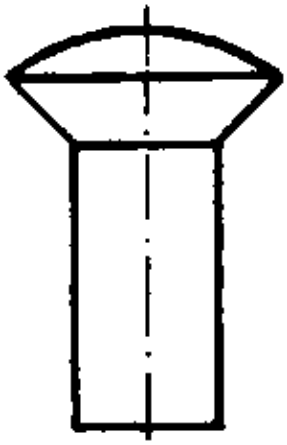

Figure 5 – Oval head countersunk rivet

– Boiler construction rivet:

A button head rivet with conical shank, which can be easily put into not quite accurately aligned bore holes. This rivet is used in the construction of pressure vessels and boilers. By

caulking the plate edges and rivet heads, close and fixed connections are achieved.

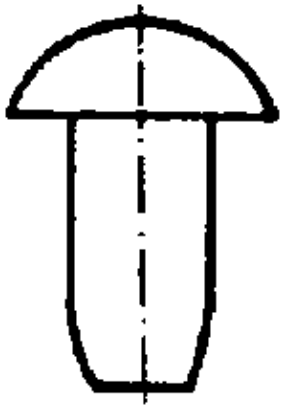

Figure 6 – Boiler construction rivet

– Explosive rivets:

These are used, if the components are accessible only from one side (light metal construction, aircraft manufacture). The explosive charge is electrically ignited thus widening the rivet shank.

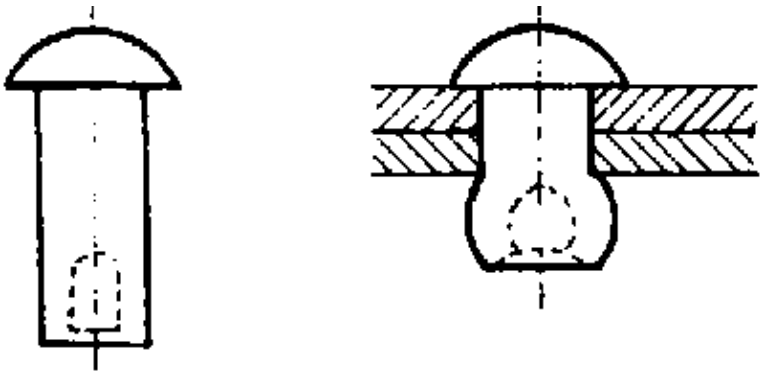

Figure 7 – Explosive rivet

– Belt rivet:

The belt rivet is used for connecting soft materials such as leather, rubber, felt.

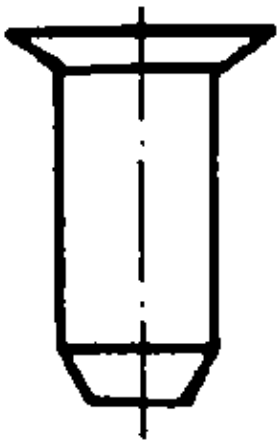

Figure 8 – Belt rivet

– Hollow civet or tubular rivet:

This kind of rivet is used to connect delicate materials – the hammering ofthe rivet head requires only little force.

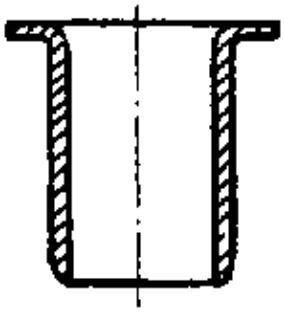

Figure 9 – Hollow rivet

– Pin:

Components used in precision mechanics are sometimes equipped with a pin the projecting end of which can be worked like the shank of a rivet.

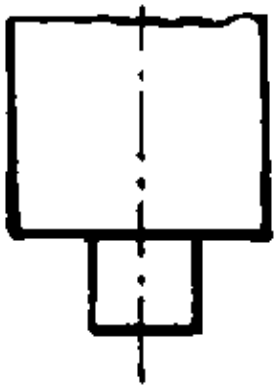

Figure 10 – Pin

What materials are rivets made of?

_____

What qualities must these materials have?

_____

When do you use button–head rivets?

_____

_____

When do you use countersunk head rivets?

_____

_____

3. Kinds of riveted joints

Movable rivetings are always made in the form of individual rivetings; the parts can be moved against one another after being riveted.

Fixed rivetings are mostly made in the form of riveted seams at plates.

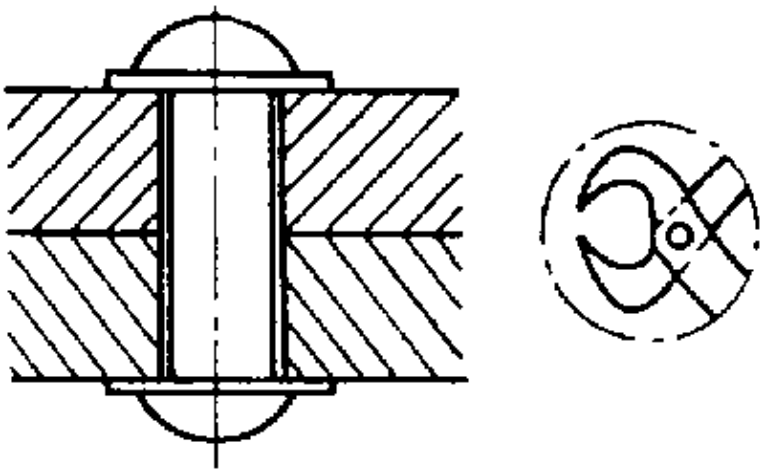

Figure 11 – Movable riveting (example: tongs)

We distinguish between:

– Kind of joint – butt joints, lap riveted joints

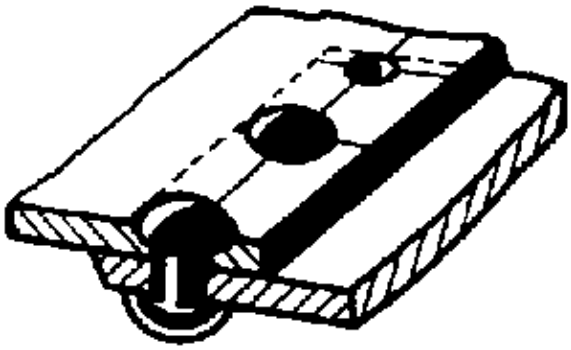

Figure 12 – Single–row lap riveted joint

– Number of rows – single–row, multirow

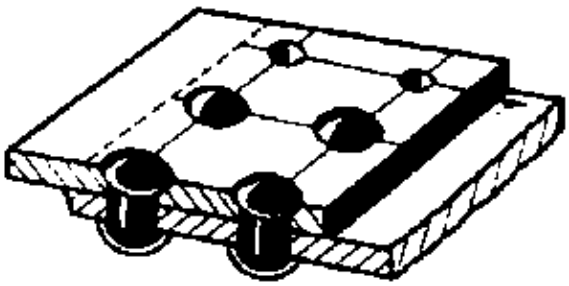

Figure 13 – Double–row parallel lap riveted joint

– Arrangement of rivets – parallel, zigzag

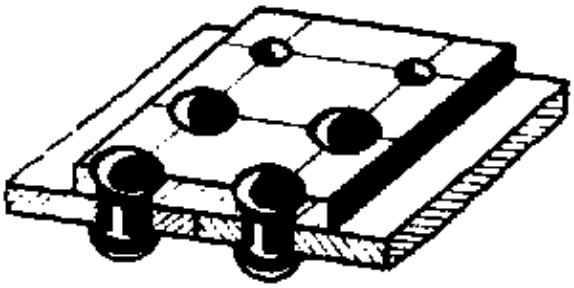

Figure 14 – Double–row parallel butt riveted joint

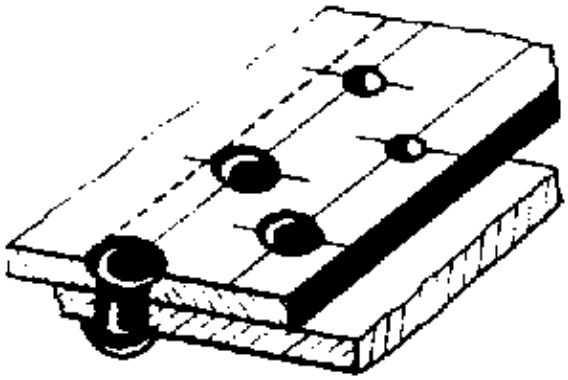

Figure 15 – Double–row zigzag butt riveted joint

4. Tools and auxiliary means for riveting

– Riveting hammer:

These are locksmith's hammers of a weight between 50 g and 200 g. Hand hammers of a weight between 200 g and 400 g are also used.

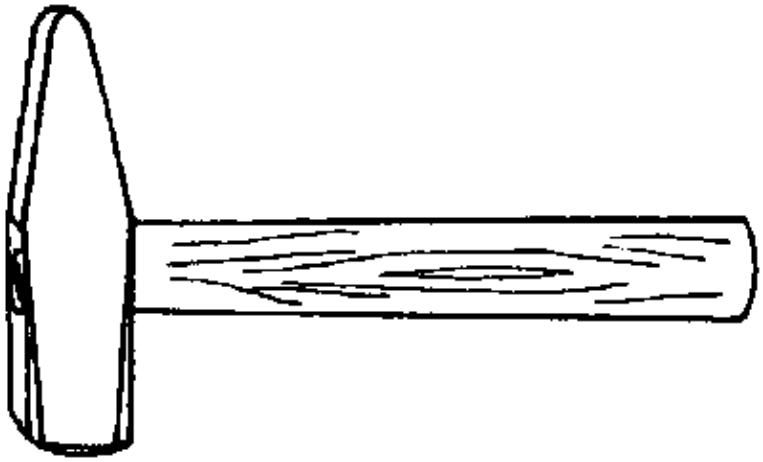

Figure 16 – Riveting hammer

Rivet setter:

It serves for setting the set head to the workpiece and for pressing on the plates to be riveted. The head bore side is hardened.

Figure 17 – Rivet setter

– Rivet header:

It serves for finish–forming the closing head of button head rivets after it had been preshaped by the hammer. The head recess is hardened and polished.

Figure 18 – Rivet header

Rivet support (counter holder):

This receives the set head of a button head rivet and is equipped with a head recess. There are fixed rivet supports for clamping in a vice as well as adjustable ones.

The latter are placed under big workpieces and adjusted with the help of a screw.

For countersunk–head riveting, a surface plate or anvil can be used as rivet support.

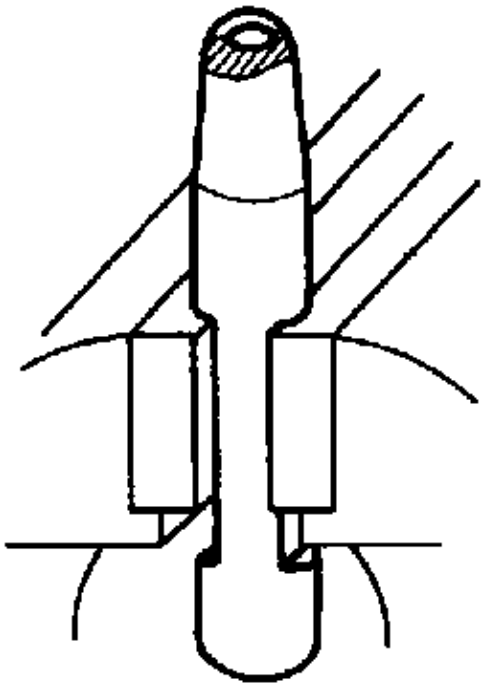

Figure 19 – Fixed riveting support

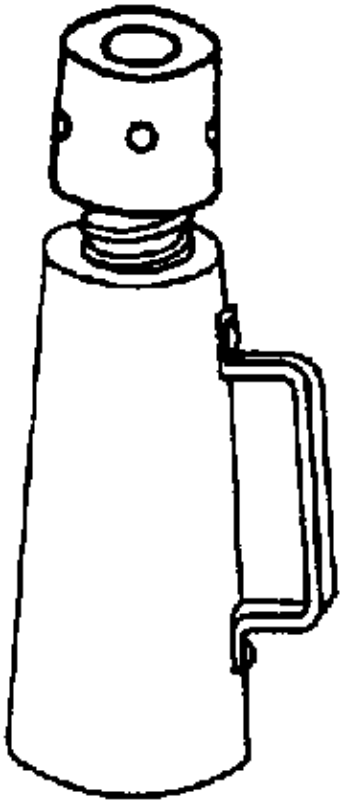

Figure 20 – Adjustable riveting support

– Clamping tools:

Various clamps or clamp dogs may be used for clamping the plates; in clamping jaws for round material, rivet bolts can be preformed.

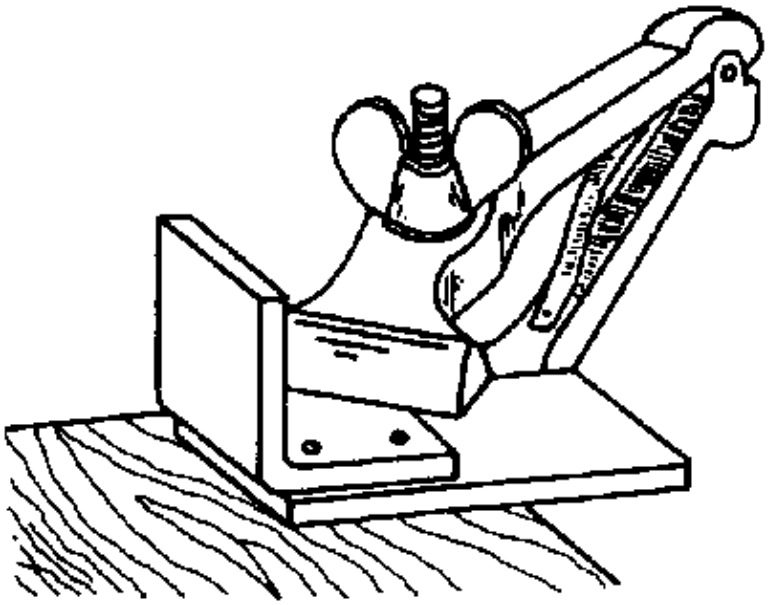

Figure 21 – Clamping by hand vice

For hot–riveting, the following is required additionally:

– smith's fire (for heating up the rivets)
– rivet clamp (for holding the hot rivets)
– rivet tongs (for taking the rivets out of the fire)

For mechanized riveting, the following equipment is used:

– pneumatic riveter
– hydraulic riveter

Which tools and auxiliary equipment are used for cold–riveting by hand?

_____
_____

What is the task of the rivet setter?

_____
_____

5. Calculations for the selection of rivets

If on the workingdrawing no details on the rivet are indicated, the following hasto be taken into consideration:

The diameter of the rivet shank shall be at least one quarter of the thickness of all plates to be riveted – formula:

$$D = \frac{1}{4} \times s$$

D = diameter of the rivet shank
s = thickness of all plates to be riveted (clamping length)

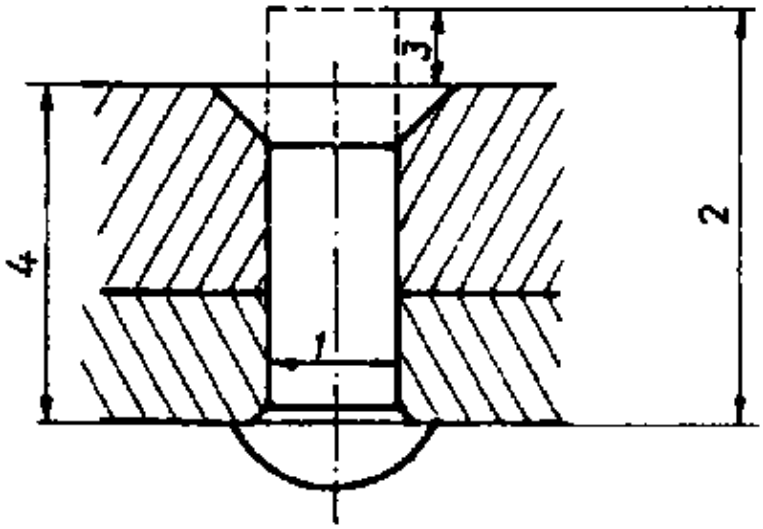

Figure 22 – Riveted joint:

1 – Diameter of the rivet shank
2 – Length of the rivet shank
3 – Allowance
4 – Clamping length

The length of the rivet shank has to be calculated on the basis of the thickness of all plates to be riveted:

The rivet shank must be longer than the thickness of all plates to be riveted by the measure of the "allowance" – formula:

$$L = S + z$$

L = length of the rivet shank
S = thickness of all plates to be riveted
Z = allowance

The allowance depends on the kind of rivet and on the field of application:

– Button closing heads in steel construction:

For rivets of diameters of the rivet shank up to 20 mm –

$$Z = 1.5 \times D$$

For rivets of diameters of the rivet shank of more than 20 mm –

$$Z = 1.6 \times D$$

– Button closing heads in boiler construction:

For rivets of rivet shank diameters up to 20 mm –

$$Z = 1.7 \times D$$

For rivets of rivet shank diameters of more than 20 mm –

$$Z = 1.8 \times D$$

– Countersunk closing heads in general:

$$Z = 0.5 \times D$$

Rivets which are too long must be cut – the right length of the rivet shank is the precondition of the quality of the closing head.

Calculating example:

A button head rivet shall be calculated in order to connect two plates of 4 mm in thickness in steel construction:

1. Diameter of the rivet shank:

$$D = \frac{1}{4} \times S = \frac{1}{4} \times 8\ mm$$

D = 2 mm

selected: 3 mm

2. Length of the rivet shank:

L = S + Z

Z = 1.5 x D = 1.5 x 3 mm Z = 4.5 mm

L = 8 mm + 4.5 mm L = 12.5 mm

selected: 12 mm

Result: A rivet with the designation button head rivet 3 x 12 can be used for the intended connection.

Exercise:

A countersunk riveting of three 5 mm thick plates shall be made What rivet can be used for this purpose?

_____

_____

6. Technological process of riveting

On principle, the following sequence of operations is necessary for a riveted connection:

6.1. Clamping/drilling:

All plates to be riveted must be clamped with one another as tightly as possible and be drilled together.

With separately drilled parts, attention has to be paid that misaligned holes are reamed by a structural reamer.

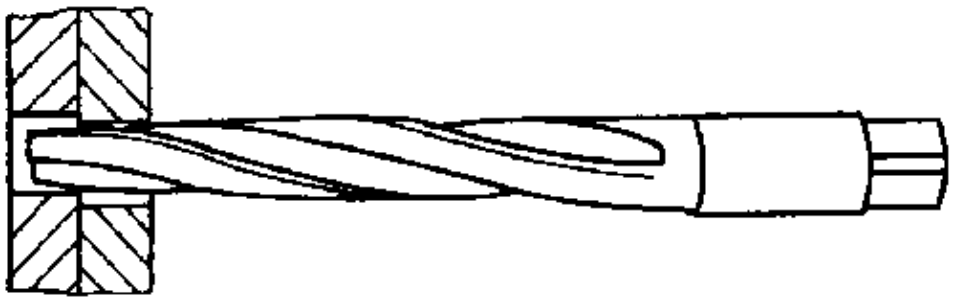

Figure 23 – Reaming of misaligned bore holes

Rivet holes have to be drilled a little larger the diameter of the rivet shank:

For rivets thicker than indicated in the table, the bore holes are made by 1 mm larger than the diameter of the rivet shank.

Recommended values

D	D_B
1	1.1
2	2.2
3	3.2
4	4.3
5	5.3
6	6.4
8	8.4

D = diameter of the rivet shank
D_B = diameter of the bore hole

6.2. Deburring/countersinking:

Rivet holes are always debarred with the help of a countersinking cutter; for countersunk–head rivets, countersinking must be made by the 75° countersinking cutter. For this, the recommended values are to be found in the marginal table:

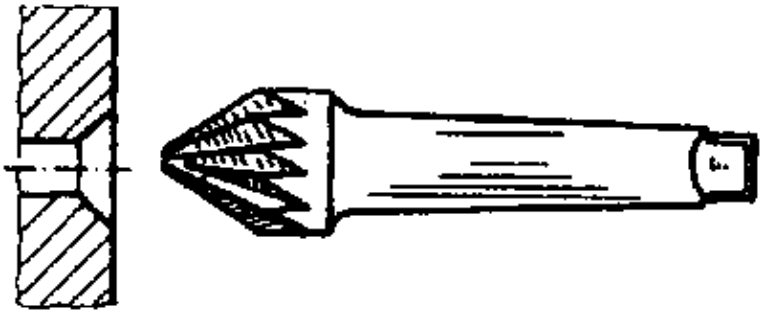

Figure 24 – Deburring/countersinking

Recommended values	
D	D_S
1	1.8
2	3.5
3	5.2
4	7
5	8.8
6	10.3
8	14

D = diameter of the rivet shank
D_S = countersinking diameter

6.3. Inserting/setting

The rivet is inserted into the bore hole, the workpieces are placed on the riveting support in such a way that the set head is underneath. By hammer blows on the rivet setter, the plates are pressed together and the set head draws itself to the workpiece.

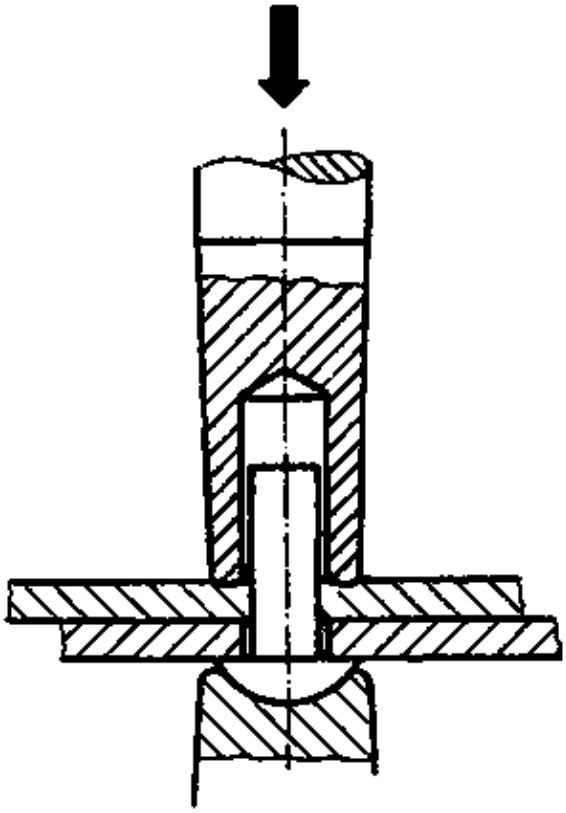

Figure 25 – Inserting/setting

6.4. Upsetting

By a couple of hammer blows accurately in the direction of the longitudinal **axis,** the rivet is upset – until it fills up the bore hole completely.

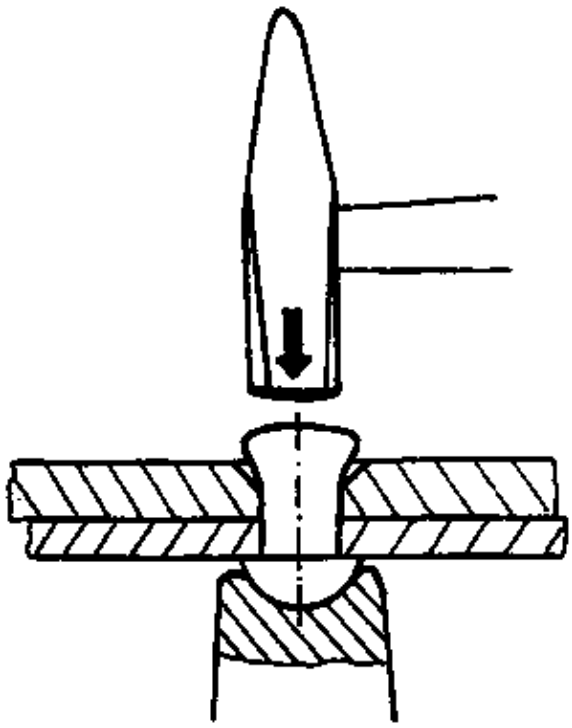

Figure 26 – Upsetting

6.5. Preforming/heading

By even and steady blows around the rivet head, the rivet head is preformed, if a button head riveting shall be made.

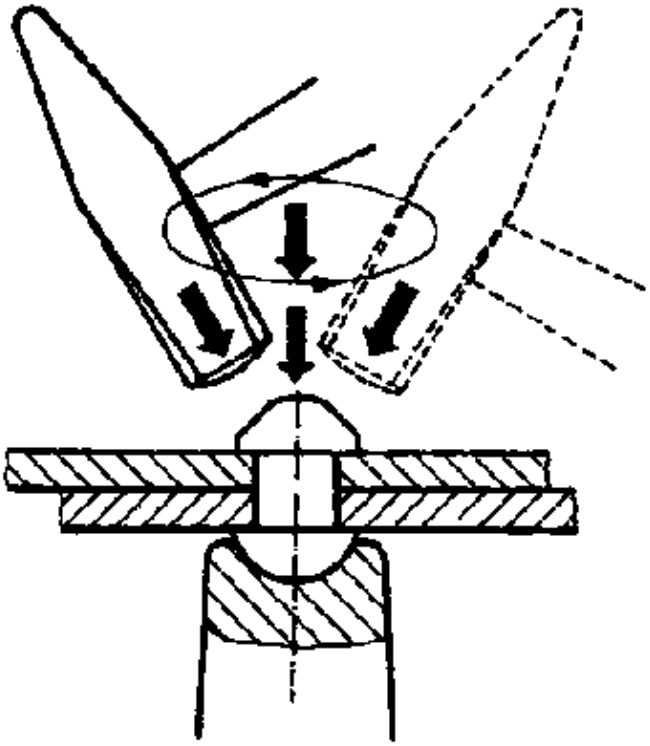

Figure 27 – Preforming

With countersunk–head rivetings, the rivet head can be driven into the countersinking immediately.

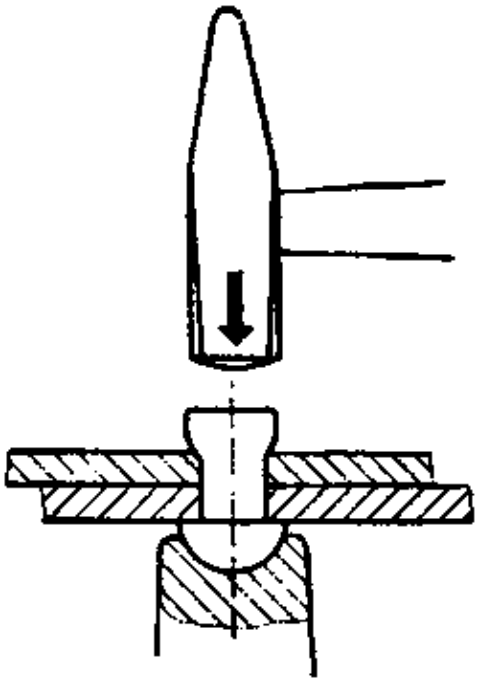

Figure 28 – Heading

6.6. Finish–forming of the button closing head

If the closing head has been preformed sufficiently, the head is finish–formed by the rivet header.

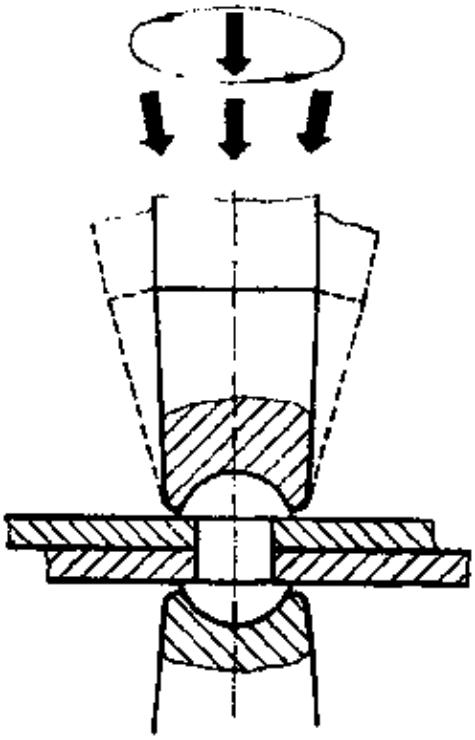

Figure 29 – Finish–forming

Note:

– Riveting by hand can be carried out in cold condition of the steel rivet up to approximately 8 mm diameter – thicker rivets must be worked in red–hot condition.

– Non–ferrous metal rivets are worked in cold condition after having them annealed before.

With every cold working of steel or non–ferrous metal, the material becomes hard and brittle, especially if it is formed by many hammer blows. In order to keep the material as tough and elastic as possible, the rivet should be shaped by a few, well–aimed blows.

Peculiarities of the technological process

– If no prefabricated button head rivets or countersunk–head rivets are at disposal, steel or non–ferrous metal wires may also be used as rivet bolts.

In this case, the rivet bolt has to be clamped in clamping jaws for round material with a set head to be preformed.

If no clamping jaws for round material are at hand. the rivet bolt must be preheaded in the rivet hole, the set head is formed, then the workpiece is turned and the closing head is shaped.

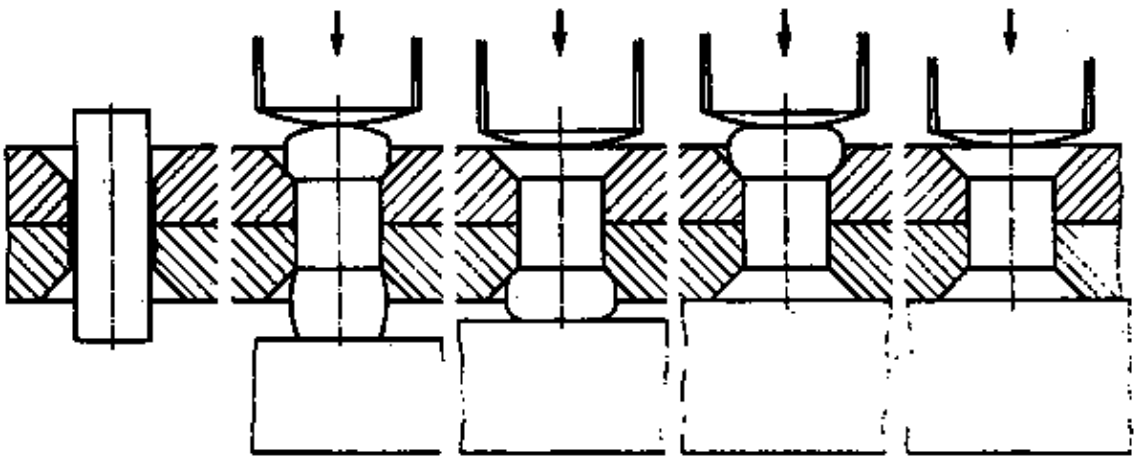

Figure 30 – Sequence of operations for a double–strap countersunk–head riveting with rivet bolt

– If hollow rivets shall be used, an allowance has to be calculated as it is done with countersunk–head rivets; the rivet –after having been inserted – is to be expanded by a centre punch and to be upset by two short blows.

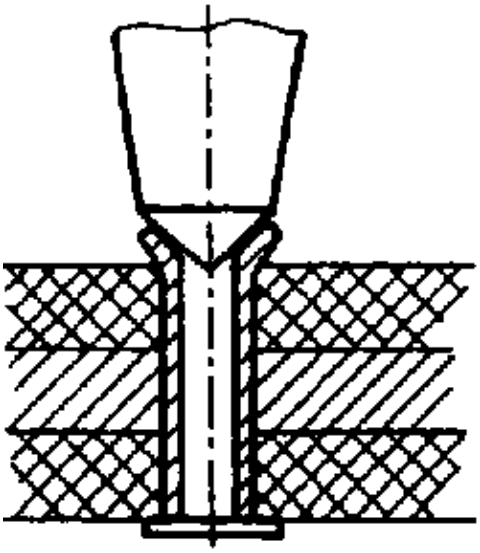

Figure 31 – Hollow rivet expanded by a centre punch

What individual steps are required for making a button head riveting?

_____
_____

What is to be done, if individually drilled parts – when being put together – show misaligned holes?

_____
_____

What hole must be drilled for a 4 mm thick rivet?

_____

What countersink do you use to prepare countersunk–head riveted joints?

_____

How must the countersinking diameter be for a 4 mm countersunk–head rivet?

_____

7. Loosening of a riveted connection

A riveted connection can be undone only by destroying the rivet.

For this purpose, one rivet head has to be chiselled off by a flat chisel, and the rivet has to be driven out of the hole with the help of a drift pin.

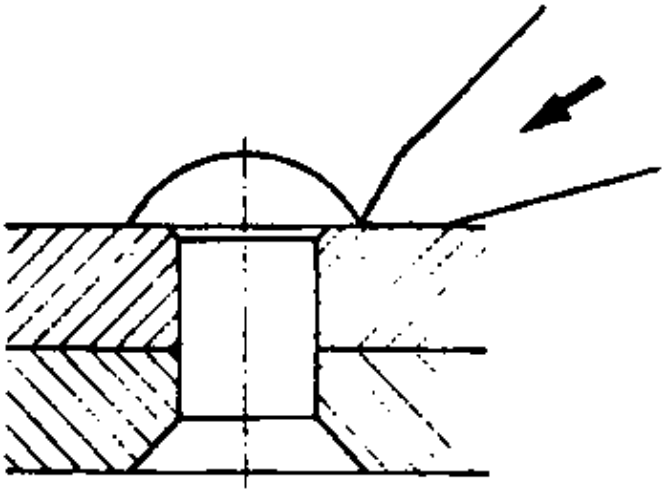

Figure 32 – Chiselling–off of rivet heads

Beware of splitting off rivet heads – put up a safety lattices or safety guards.

Rivets can be destroyed also by drilling or grinding–off of the rivet heads.

8. Riveting faults

– If the rivet shank is too long. the superfluous material forms a wreath at the head of the closing head.

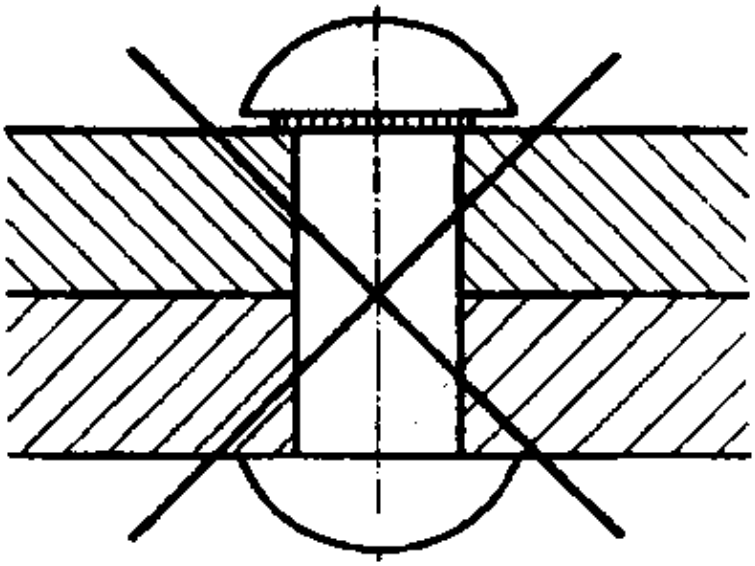

Figure 33 – Riveting faults

– If the rivet shank is too short, the closing head is not sufficiently formed,

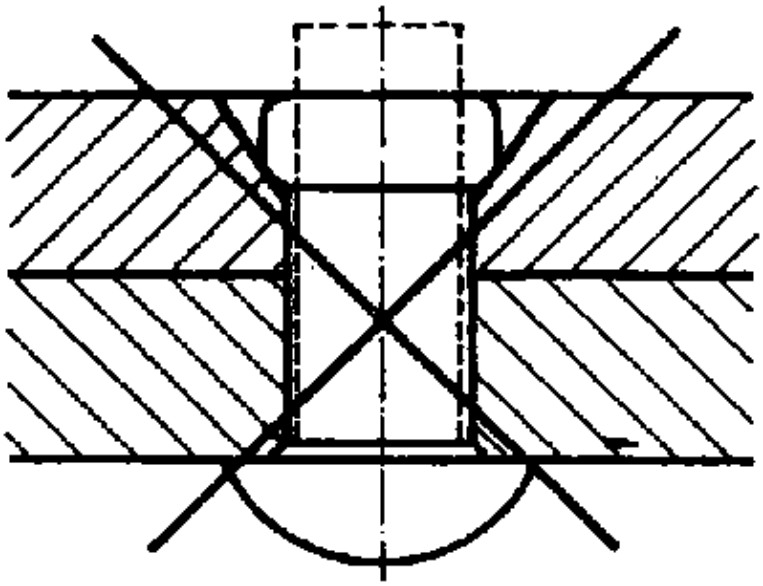

Figure 34 – Riveting faults

– If the plates are not enough tightened by the rivet setter, the shank is squeezed between the plates, a wreath appears and the closing head is not correctly formed.

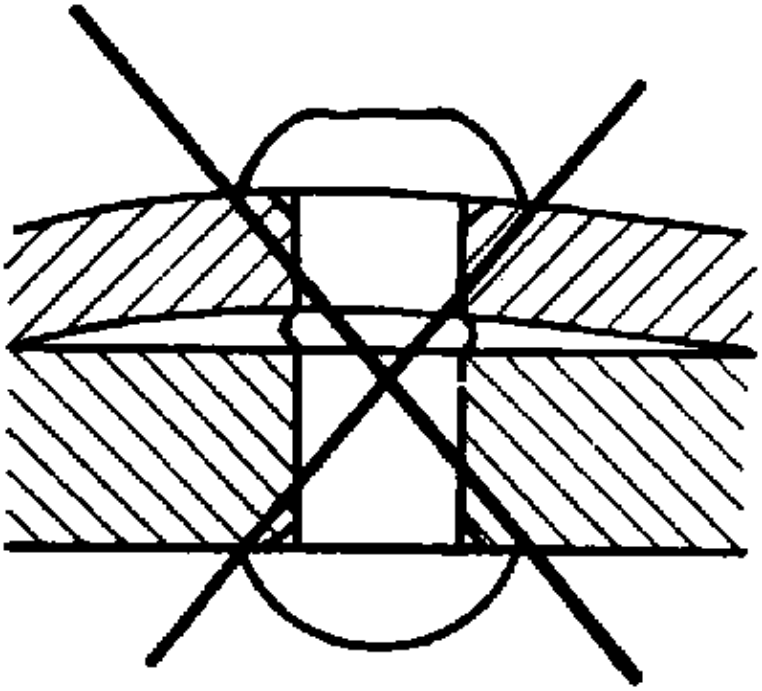

Figure 35 – Riveting faults

– If the hammer blows on the rivet setter are too strong, the upper plate is squeezed too much and bows.

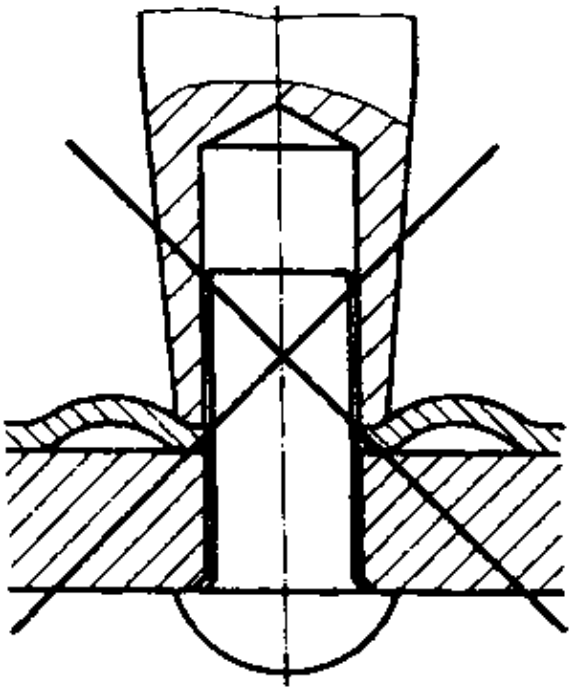

Figure 36 – Riveting faults

– If the bore holes are heavily misaligned, the rivet shank will be notched, so that the rivet cannot stand high shearing loads.

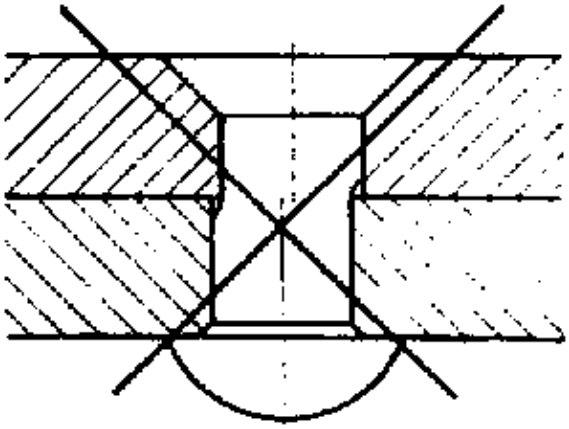

Figure 37 – Riveting faults

– If the rivet hole is too large, the rivet shank bends, the closing head is not formed.

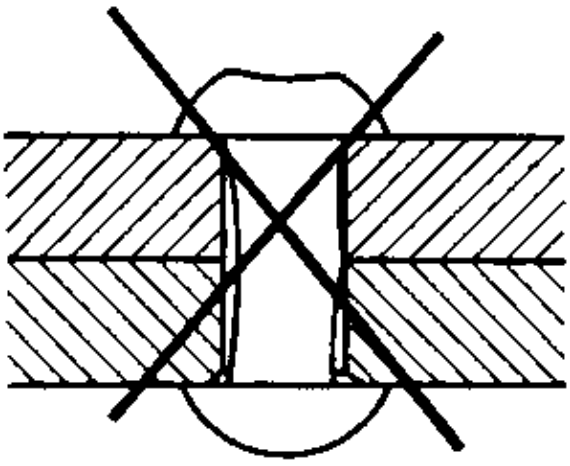

Figure 38 – Riveting faults

Note:

Use the corresponding rivet setter and rivet header for the rivet you have chosen,

Why shall only a few, well−aimed blows be made when riveting the closing head?

_____
_____

How can riveted joints be undone?

_____
_____

What kinds of riveting faults could have been made if it is to be seen that the closing head is not formed correctly?

_____
_____

Riveting

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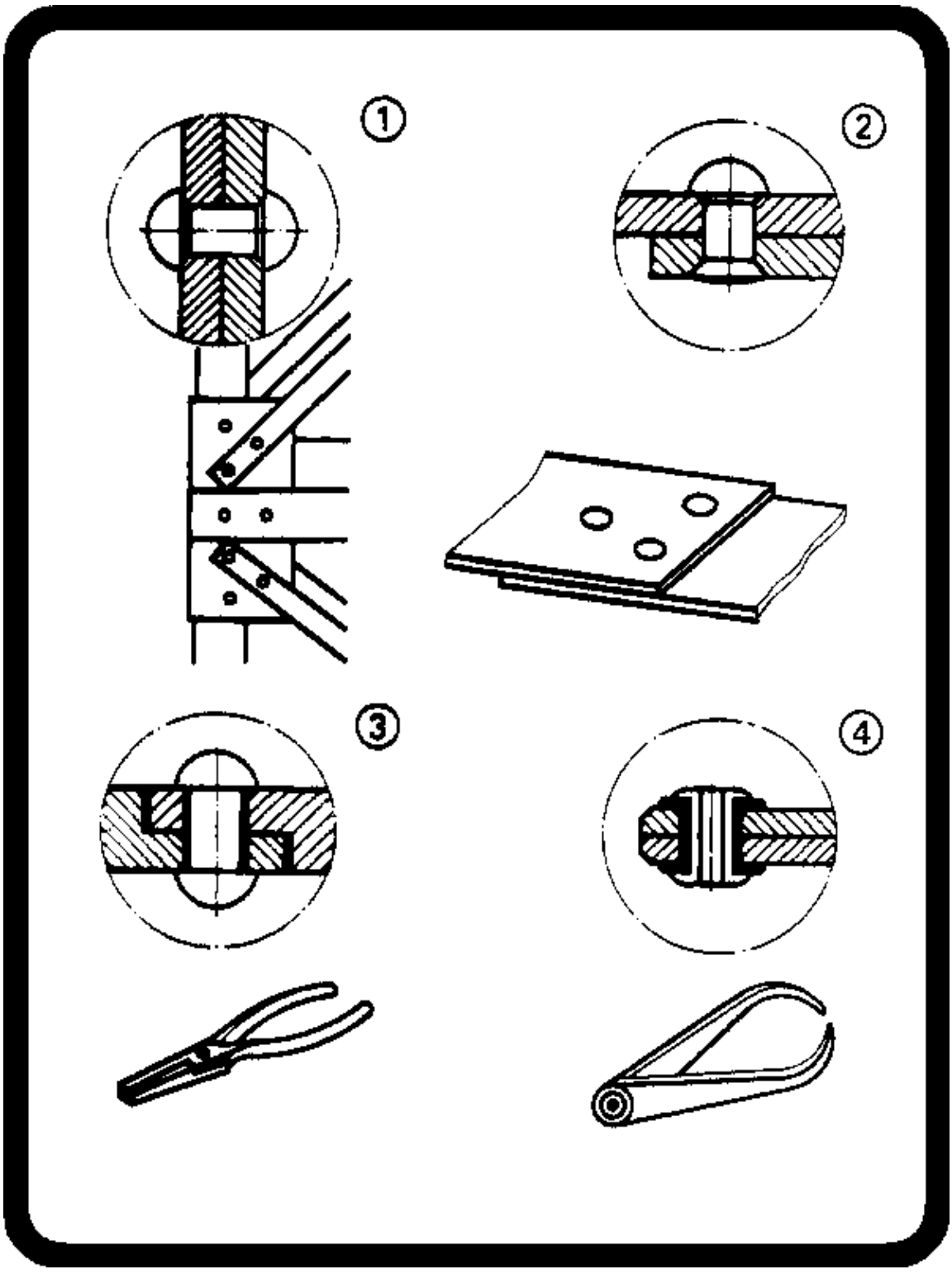
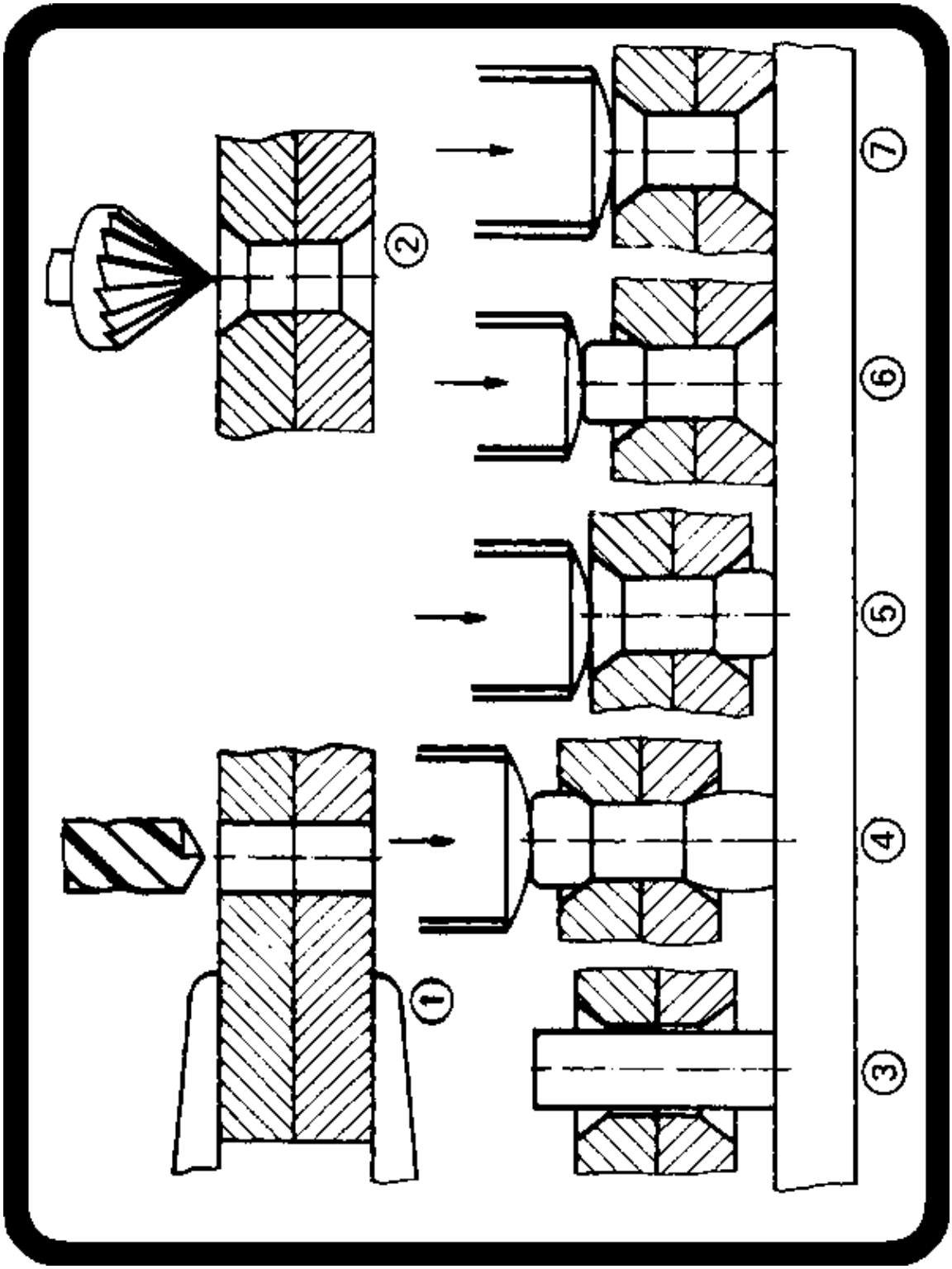
Riveting

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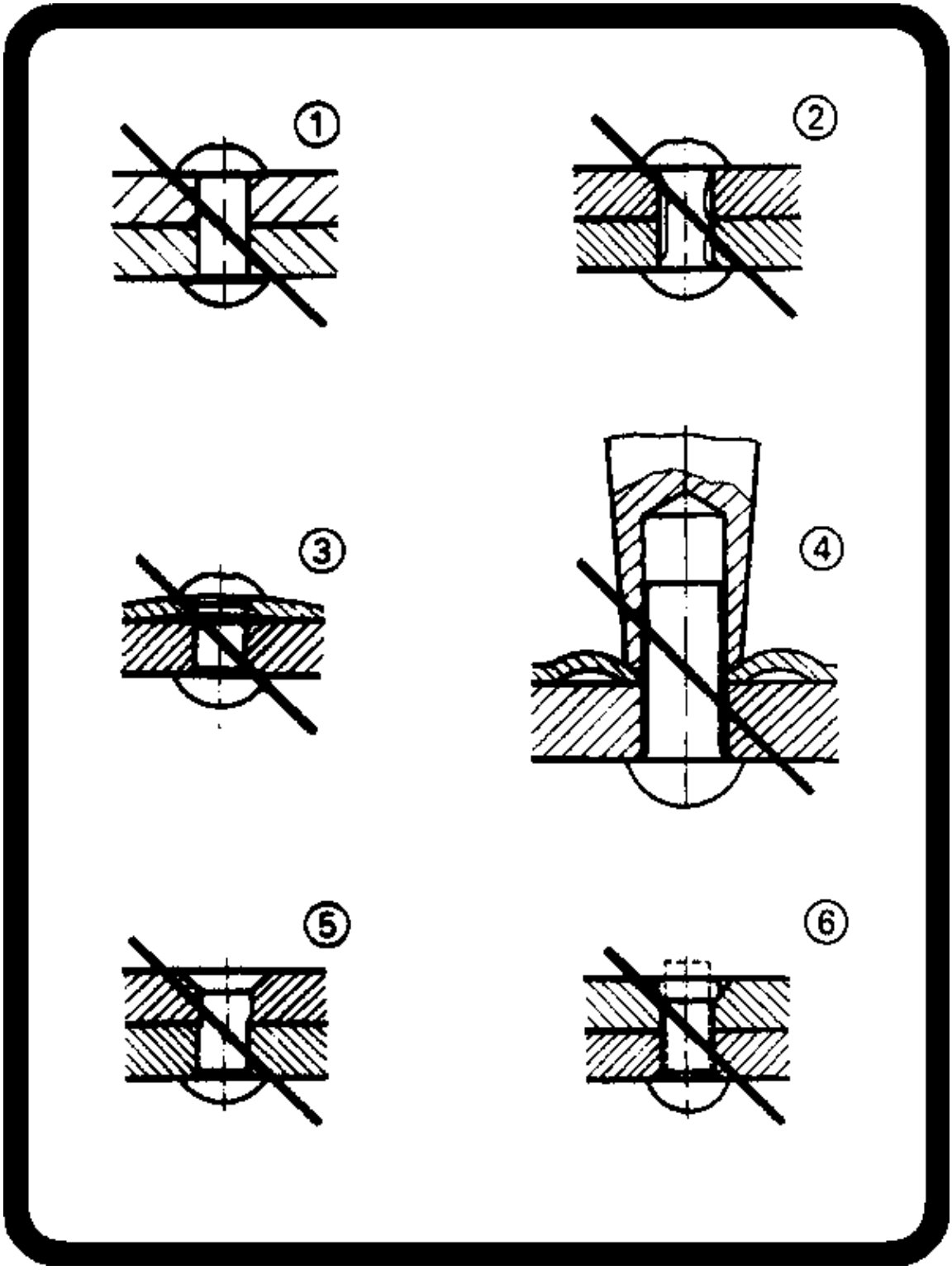
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Scraping of Plane Surfaces – Course: Technique for Manual Working of Materials. Trainees' Handbook of Lessons

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Scraping of Plane Surfaces – Course: Technique for Manual Working of Materials. Trainees' Handbook of Lessons

Institut für berufliche Entwicklung e.V
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Original title:
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Author: Frank Wenghöfer

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1. Purpose of scraping

Scraping is fine finishing of largely rough–finished in order to smooth them, to correct defects of the form or to provide them with a pattern.

Scraping is highly qualified manual work and is applied only if the respective material cannot be fine–finished by machines.

Figure 1 – Scraping

Normally, plane surfaces should be finished by surface grinding, curved surfaces and bore holes by precision boring or honing. By scraping mainly sliding parts of machines are worked such as carriages and slide bearings which must show a high surface quality. With sliding surfaces, the recesses achieved have a positive effect since they enable an accumulation of lubricating oil.

An even lubricant film is required to reduce friction at these surfaces. By scraping also oil grooves are placed in domed brasses.

What kinds of workpieces are mainly treated by scraping?

_____

When is the method of scraping applied?

_____

2. Tools for scraping

Scrapers consist of high–grade, mostly alloyed tool steel; after drawing–out they are hardened, ground and whetted. The selection of the scraper depends on the shape of the surfaces to be worked.

Flat scrapers

Pushing scrapers for pre–scraping and spot scraping of plane surfaces, suitable for removing larger quantities of chips;

Figure 2 – Flat scraper

Pulling scrapers

Scrapers for finishing and pattern scraping of plane surfaces, suitable only for removing smallest quantities of chips.

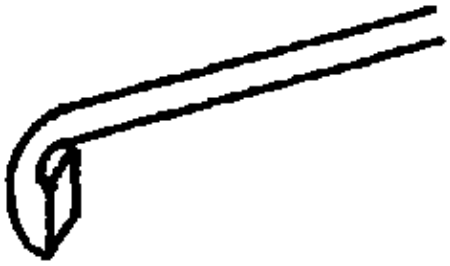

Figure 3 – Pulling scraper

Half–round scrapers

Tools in the form of solid or hollow scrapers for scraping curved surfaces or bore holes.

Figure 4 – Half–round scraper

Three–square scrapers

Tools in the form of solid or hollow scrapers for scraping curved surfaces or bore holes as well as for deburring edges

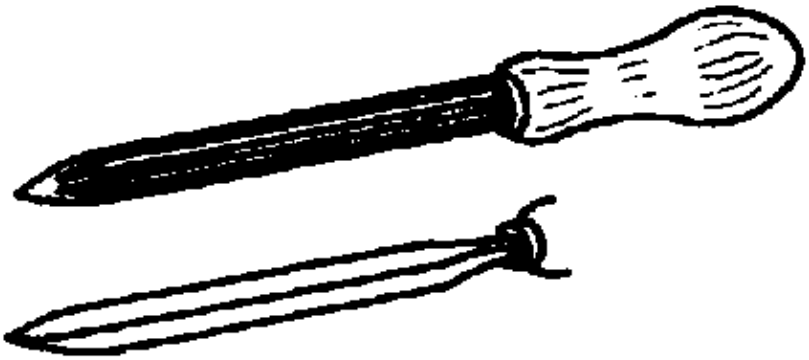

Figure 5 – Three–square scraper

Note:

The cutting–wedge angle of the scraper has to be ground according to the material; it is between 70° and 90°.

After having been given an angle by grinding the scraper must be deburred on an oiled whetstone, so that it remains sharp for a longer time and does not become dull too soon.

In doing so, the scraper has to be drawn over the oilstone from either side of the cutting edge alternately and in an inclined position till the burr – which this way is bent for several times – is neatly removed.

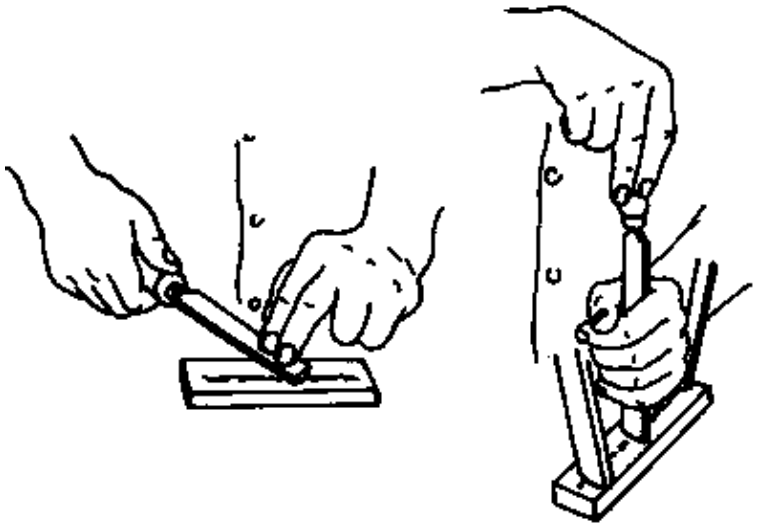

Figure 6 – Whetting of a flat scraper

What is the flat scraper used for?

_____

_____

What is the pulling scraper used for?

_____

_____

What has to be done after scraping?

_____

What happens if one fails to carry out this last operation?

_____

3. Purpose of inking

Inking is the technique of testing the quality of scraped surfaces by checking them against roaster plates. With the help of roaster plates and ink, unevennesses and faults of shape are made visible on the surface of the workpiece. Inking and scraping alternate with each other. The combination of inking and scraping characterizes the actual working process and is called “planing”.

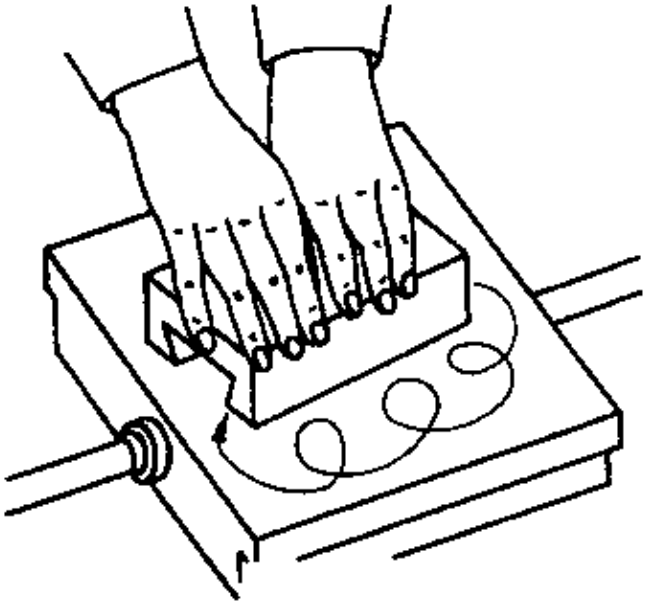

Figure 7 – Inking of a workpiece

4. Testing and auxiliary equipment for inking

Master plates are made of wear–resistant, dense grey cast iron. The testing faces are of highest accuracy, the bottom sides mostly being equipped with stiffening ribs in order to make the roaster plate rigid and unbendable.

Surface plate

Large plate on which small to medium–size workpieces are checked; the workpiece is moved over the plate.

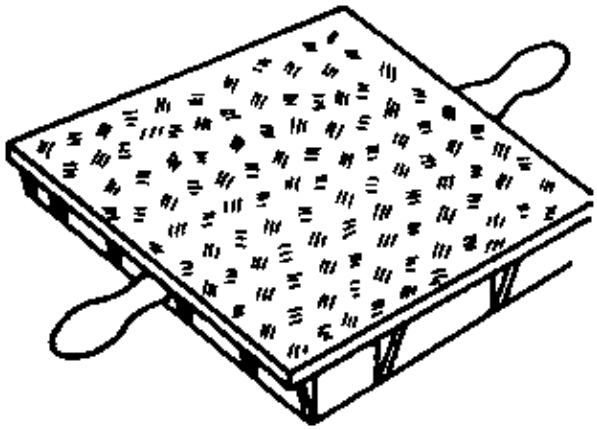

Figure 8 – Surface plate

Straight edge

Instrument for checking long and narrow workpiece surfaces, the instrument being moved over the workpiece.

Figure 9 – Straight edge

Planing bar

Instrument for checking prismatic guideways. Here, two testing faces have the same angle to which the prismatic guide shall be planed. The instrument is moved in the prismatic guide.

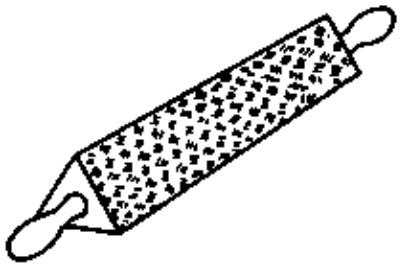

Figure 10 – Planing rod

Planing instrument for slideways

Specially shaped instrument for inking slideways of machines – the sliding faces are shaped corresponding to the machine bed. The instrument is moved over the bedways of the machine.

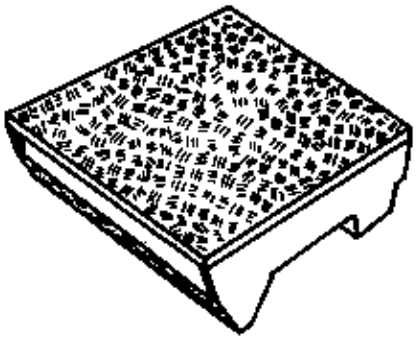

Figure 11 – Planing device for guides

Ink or inking paste:

Colouring agent for making visible the unevennesses on worked surfaces

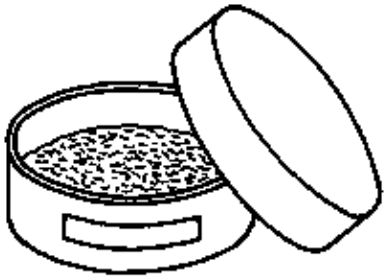

Figure 12 – Inking paste

The paste consists of pine black, clay or red–lead and oil – for use in light rooms. With unfavourable light conditions, red ink (powdered iron oxide) is used for preinking and black ink for reinking. With spot scraping,

the use of blue ink (iron cyanide compound) is recommended.

Inking block

Block of wood covered by cloth that does not unreval or by leather for distributing the ink.

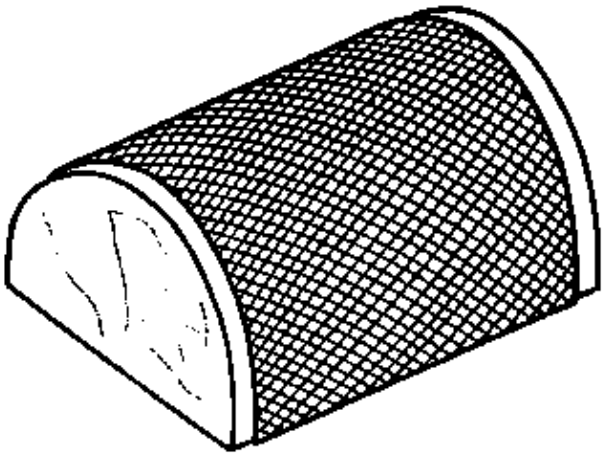

Figure 13 – Inking block

What is understood by planing a surface?

_____
_____

When do you use surface plates and straight edges? Explain the difference.

_____
_____

What is the task the ink has to fulfill?

_____

5. Operation of scraping

The scraper is moved over the workpiece by the pushing or puling power of the hand. The chips are removed not by cutting but by squeezing, because the scraper is applied to the workpiece by an angle of inclination of approximately 45° which results in a cutting angle of more than 90°.

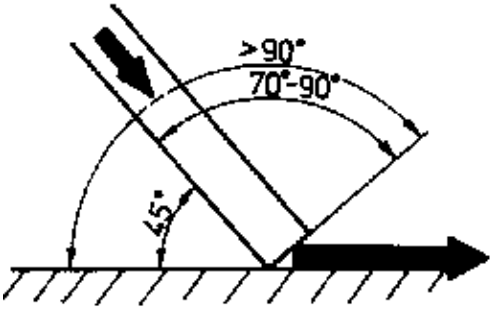

Figure 14 – Angles with push–scraping

6. Technological process of planing a plane surface

6.1. Prescraping

By prescraping, the working traces on the rough–finished work–piece surface are eliminated and the surface is smoothed. The surface is scraped by long, strong strokes, the flat scraper has to be applied in an inclined position to the existing working traces using the sides alternately.

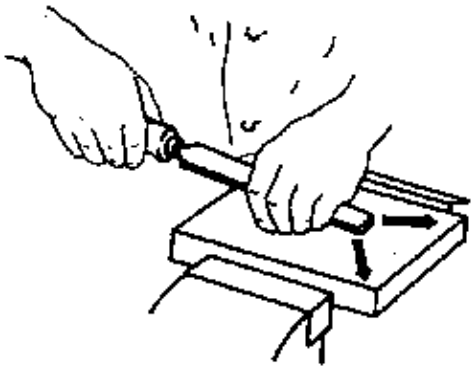

Figure 15 – Prescraping

Each scraping stroke must be carried out by increasing and decreasing manual pressure, so that no ledges occur on the surface. The scraper is drawn back without pressure in order to save the cutting edge.

6.2. Inking

By the inking block, the inking paste is spread on the inking device extremely thin and rubbed.

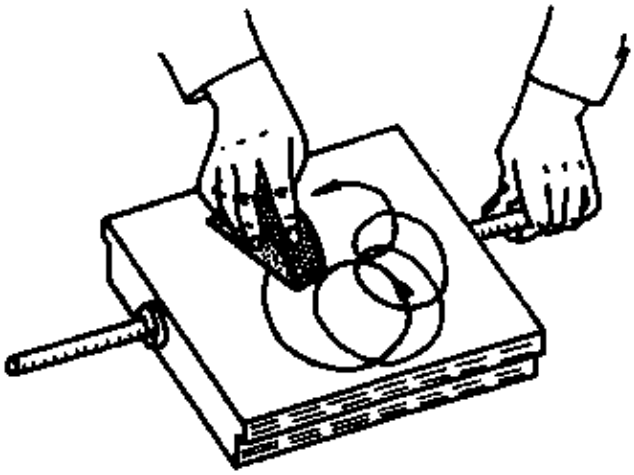

Figure 16 – Spreading of inking paste

Small workplaces are moved slowly and in circles on the inked surface plate; on large workpiece surfaces, the straight edge is drawn over the surface.

At places where surfaces get in touch with one another, ink is rubbed down, whereas in deeper places, ink is accumulated. Extremely deep spots are not touched by the ink.

Figure 17 – Surface appearance

A surface appearance is created this way:

Slightly coloured spots:	highest points
Strongly coloured spots:	medium position
Noncoloured spots:	deepest points

6.3. Spot scraping

In order to achieve closely adjacent surfaces, the highest points (slightly coloured) are scraped with frequent change of direction and checked against a master plate until there are three times as many highest points in comparison with deepest points.

In this process, the flat scraper is pushed over the highest points in short curves.

Figure 18 – Prescraping

6.4. Finishing and pattern scraping

If the quality of spot scraping does not lead to a satisfactory result, the surface is reworked with the help of the pulling scraper which is drawn over the highest point with slight pressure by the hand.

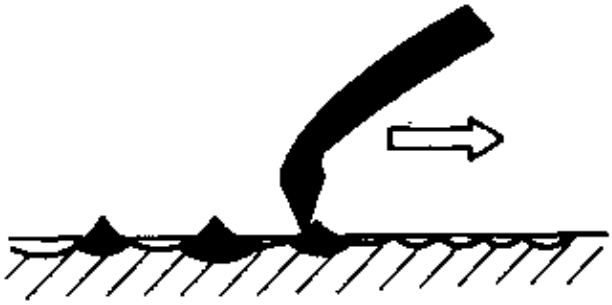

Figure 19 – Finishing

The pulling scraper may be used for making a pattern if it is drawn over the workpiece in regular movements. Common patterns are stripes and plaited patterns.

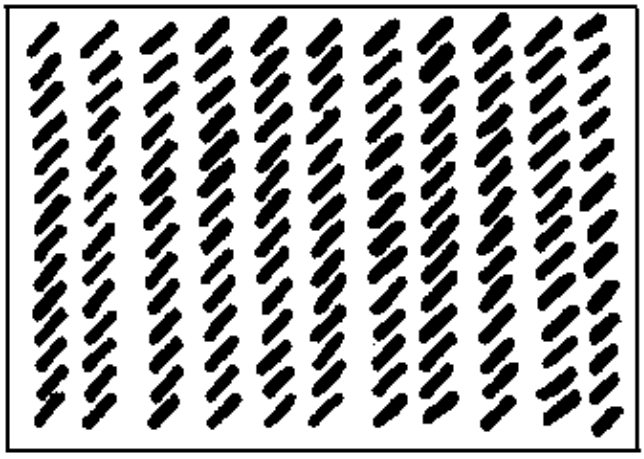

Figure 20 – Striped pattern

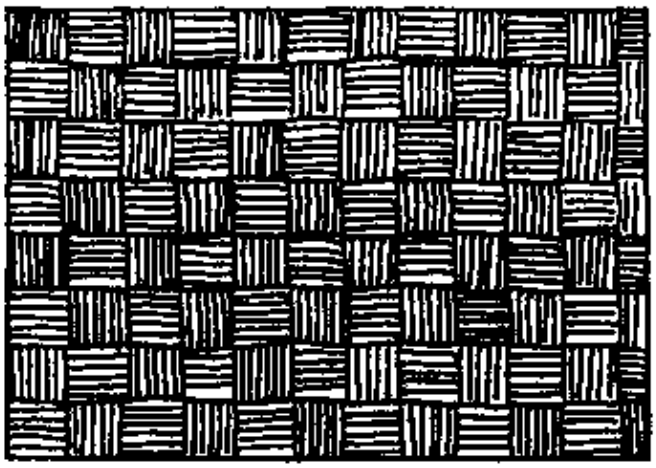

Figure 21 – Plaited pattern

Patterns are scraped if:

– workpieces shall look better;
– the adherence of the greasing film shall be guaranteed with sliding surfaces;
– the abrasion of guiding surfaces shall be controlled (in case of wear the pattern disappears).

What sequence of operations characterizes the planing of a plane surface?

_____
_____

What characterizes the prescraping?

_____
_____

What characterizes the spot scraping?

_____
_____

What characterizes the finishing operation?

_____
_____

7. Additional recommendations

– Do only use properly whetted scrapers.

– Workpieces have to be clamped that way, that they do not distort under the clamping force.

– Spread the ink extremely thin and evenly.

– Protect the surfaces of roaster plates against damages, prevent them from rusting by oiling them after use.

Scraping of Plane Surfaces – Course: Technique for Manual Working of Materials. Instruction Examples for Practical Vocational Training

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Scraping of Plane Surfaces – Course: Technique for Manual Working of Materials. Instruction Examples for Practical Vocational Training

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Author. B. Zierenberg

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Introduction

The present material includes 5 selected instruction examples by means of which the essential operations of scraping of plane surfaces can be practised. For that purpose, rough and finish–scraping as well as pattern scraping in connection with scraping and checking against master plates of known accuracy will be practised with an increasing degree of difficulty.

In addition to the pure exercise on the V–block, the finished workpieces: steel straight–edge, try square and centre square can be used in the workshop after surface hardening; the lathe bed can only be planed at adequate local and material conditions.

In order to facilitate the preparation and execution of works, the required materials, hand tools, measuring and testing tools as well as accessories are given for each of the instruction examples. Furthermore, the previous knowledge is mentioned that is necessary for executing the exercises.

Apart from the working drawing attached, the sequence of operations has been described in a favourable order.

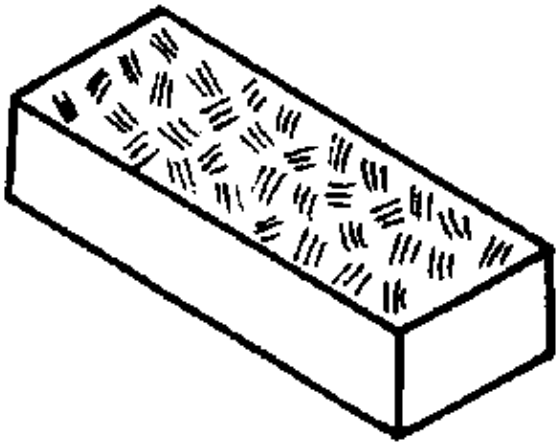
Explanation to material data:

Steel grading is as to the value of tensile strength given in the unit “Megapascal” (MPa).

Instruction example 6.1. V–block

Practise flat scraping of a flat surface without having given the size.

Material



flat material steel (600 MPa)

thickness:	approx. 20 mm
width:	approx. 35 mm
length:	approx. 70 mm

Hand tools

Bastard file of 300 mm (flat), wide flat scraper

Measuring and testing tools

Steel rule, bevelled steel straight−edge, surface plate

Accessories

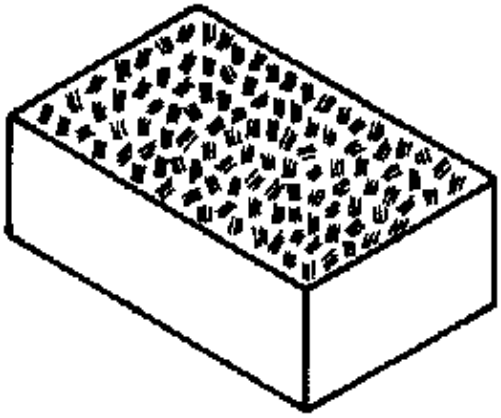
Vice, checking ink or paste, inking block

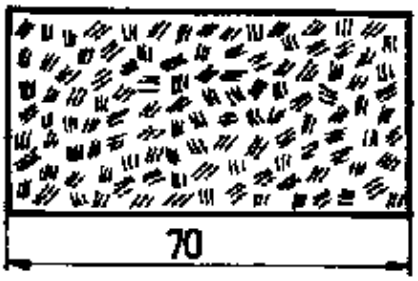
Required previous knowledge

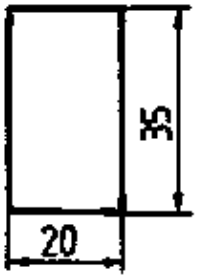
Reading of drawings, measuring, testing, sawing, filing

Sequence of operations	**Comments**
1. Arrange workplace Prepare working material	– Check for completeness
2. Check rough dimensions of workpiece; if necessary, prepare true−to−size as to drawing; rough cover surface in diagonal stroke	– (sawing, filing) roughly check surface for flatness by means of bevelled steel straightedge
3. Rough−scrape cover surface in long strokes by means of flat scraper until working marks of filing disappear	– Powerful cutting by push−scraping!
4. Rub surface plate with a wafer−thin layer of checking ink	
5. Rub workpiece with the rough−scraped cover surface onto the surface plate by applying a slight pressure	– Circular moves!

6. Take off workpiece and rough−scrape surfaces covered with checking ink	– If there are great surface differences noticeable, the entire contact area must be scraped again in long strokes!
7. Ink and rub workpiece again, take off and check colour spots	– When the colour spots are evenly distributed over the entire surface, begin with spot−scraping
8. Clamp workpiece and rough and spot−scrape surfaces (spots) surrounded with checking ink, change direction of stroke after each procedure of scraping	– Work with short and slightly arched pushes by applying increasing and declining working pressure
9. Steadily change scraping and checking until the ratio between high and low areas is 3: 1	
10. Final check	– flatness, uniformity of surface appearance





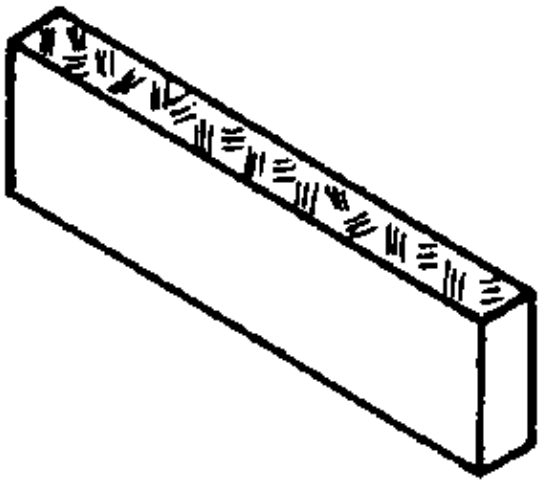


				6.1.
	V-block			3106

Instruction example 6.2. Steel straight–edge

Practise scraping of two narrow surfaces with emphasis on parallelism to each other

Material



flat material made of heat–treatable steel

thickness:	6 mm
width:	approx. 35 mm
length:	approx. 200 mm

Hand tools

Smooth file of 300 mm (flat), flat scraper, pull–type scraper

Measuring and testing tools

Vernier caliper, bevelled steel straight–edge, surface plate, dial gauge

Accessories

Vice, tripod for dial gauge, checking ink or paste, inking block

Required previous knowledge

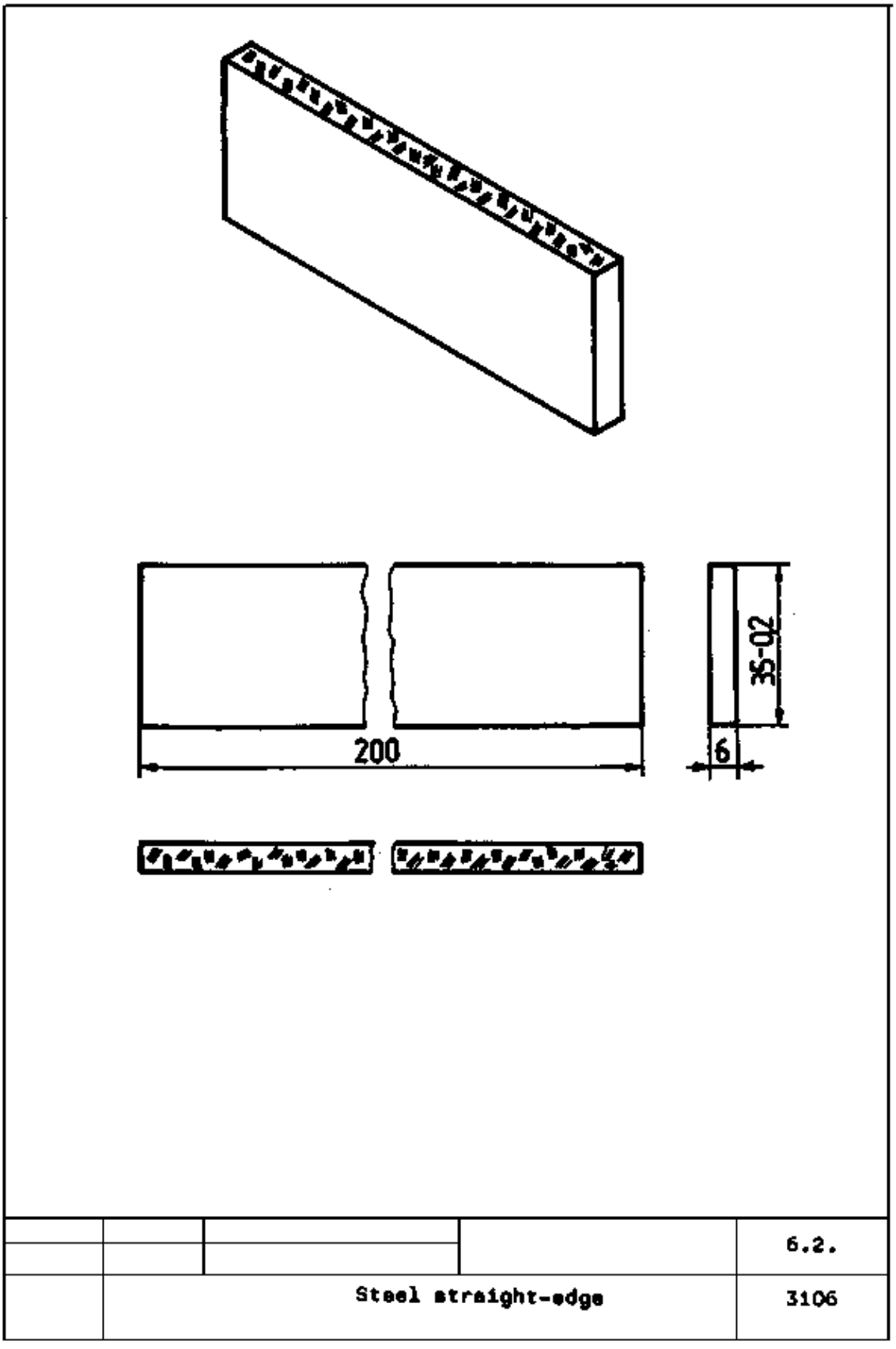
Reading of drawings, measuring, testing, sawing, filing

Sequence of operations	**Comments**
1. Arrange workplace Prepare working material	– Check for completeness
2. Check rough dimensions of workpiece; if necessary, prepare true–to–size as to drawing	– (Sawing, filing)
3. Smooth the two longitudinal surfaces (of 6 mm width) in longitudinal stroke	– Roughly check surfaces for parallelism by means of vernier caliper
4. Rub surface plate with a wafer–thin layer of checking ink	
	– Circular moves!

5. Rub workpiece with a smoothed longitudinal surface onto surface plate by applying a slight pressure	
6. Take off workpiece and rough and spot–scrape surfaces surrounded with checking ink	– Scrape diagonally to working marks of filing
7. Ink and rub workpiece again, check colour spots	
8. Finish–scrape contact points by means of pull–type scraper	
9. Work 2nd longitudinal surface repeating 5th till 8th operation, check continuously for parallelism	– Check parallelism by means of dial gauge
10. Final Check	– Parallelism, flatness, surface appearance

Finishing

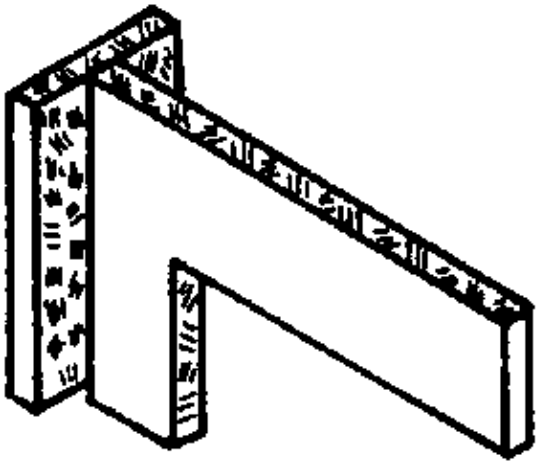
Surface hardening of functional surfaces



Instruction example 6.3. Try square

Practise scraping of two or three narrow surfaces lying in parallel to each other maintaining the specified size and parallelism.

Material



– steel sheet made of heat–treatable

steel thickness:	5 mm
width: approx.	67 mm
length: approx.	92 mm

– flat material made of heat–treatable steel

thickness:	9 mm
width:	15 mm
length:	approx. 67 mm

– 2 off countersunk screws M 3 x 12

Hand tools

Hand hacksaw, surface gauge, marking–out and centre punches, locksmith's hammer, bastard and smooth files 300 mm (flat), drills of 2.5. 3.0 and 3.2 mm dia., countersink – 90°, tap M 3, screw driver, flat scraper, pull–type scraper

Measuring and testing tools

Vernier caliper with depth gauge, dial gauge, bevelled edge square, surface plate, levelling straight–edge

Accessories

Clamping tools (C–clamps and vice, machine vice), tap wrench, cutting oil, checking ink or paste, inking block, tripod for dial gauge

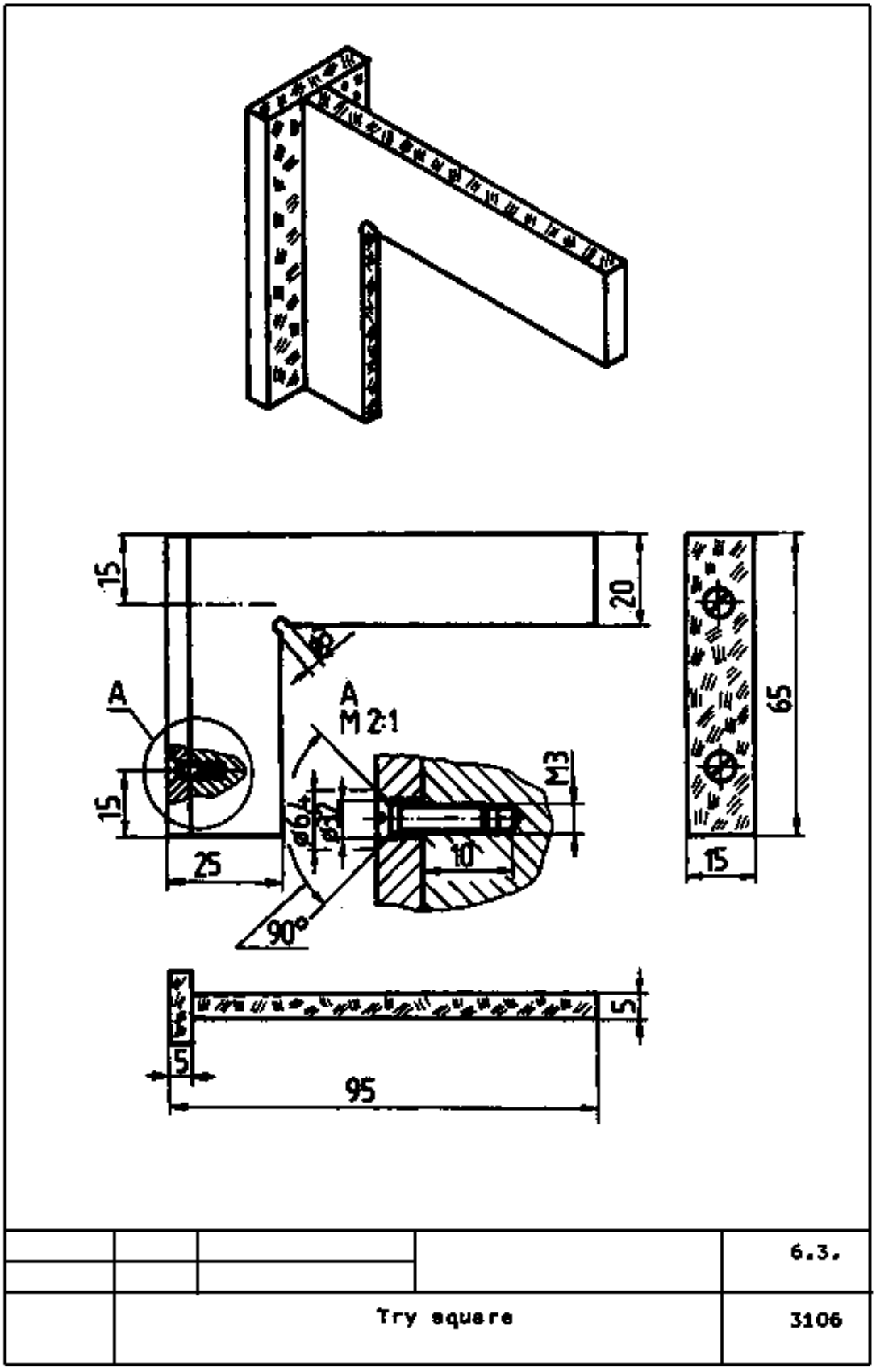
Required previous knowledge

Reading of drawings, measuring, testing, scribing, prick–punching, sawing, filing, drilling, countersinking, thread cutting

Sequence of operations	**Comments**
1. Arrange workplace Prepare working material	– Check for completeness

2. Work single parts true–to–size as to drawing dimensions; smooth all surfaces; drill in clamped position; subsequently, countersink and cut thread; bolt by means of countersunk screws M 3 x 12	– (Sawing, filing)
3. Ink and check outer surface of contact face (15 x 65); subsequently, rough and spot–scrape	– Use surface plate!
4. Ink and check the two inner surfaces of contact face; subsequently, rough and spot–scrape, check parallelism to outer surface	– Use levelling straightedge! Check parallelism by means of dial gauge!
5. Ink and check inner surface of short jaw; rough and spot–scrape; check parallelism to outer surface of contact face and pay attention to dimensions (25 – 0.2)	– Use levelling straightedge!
6. Ink and check outer and inner surface of long jaw; rough and spot–scrape; check parallelism of both surfaces and pay attention to given dimensions (20 – 0.2)	
7. Pattern–scrape all functional surfaces by means of pull–type scraper	– (Stripe pattern)
8. Final check	– Flatness, parallelism, appearance of pattern

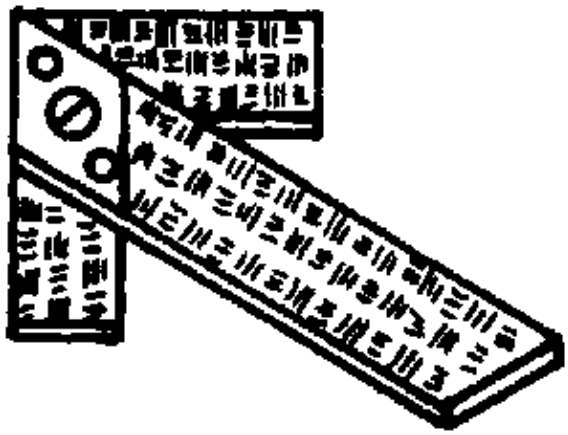
Finishing: Surface hardening of functional surfaces



Instruction example 6.4. Centre square

Practise pattern–scraping (irregular braiding pattern)

Material



– steel sheet made of heat–treatable steel

thickness: 4 mm

width: approx. 82 mm

length: approx. 82 mm

– flat material made of heat–treatable steel

thickness: 4 mm

width: 20 mm

length: approx. 162 mm

– countersunk screw M 3 x 8

– 2 off straight pins Ø 3m6, length: 8 mm

Hand tools

Hand hacksaw, steel scriber, marking–out and centre punches, hammer, bastard and smooth files of 250 mm (flat), drills of 2.5, 2.8, 3.2, 4.0 mm dia., hand reamer Ø 3 K 7, pull–type scraper, aluminium hammer, screw driver

Measuring and testing tools

Vernier caliper, bevelled edge square

Accessories

Clamping tools (C–clamps, machine vice, vice), tap wrench, cutting oil

Required previous knowledge

Reading of drawings, measuring, testing, scribing, prick–punching, sawing, filing, countersinking, thread cutting, reaming

Sequence of operations	**Comments**
1. Arrange workplace Prepare working material	– Check for completeness
	– (Do not drill yet)

2. Work single parts true−to−size as to given drawing dimensions; smooth all surfaces; check parallelism and angularity

3. Scrape a braiding pattern onto both faces of the two single parts by means of pull−type scraper

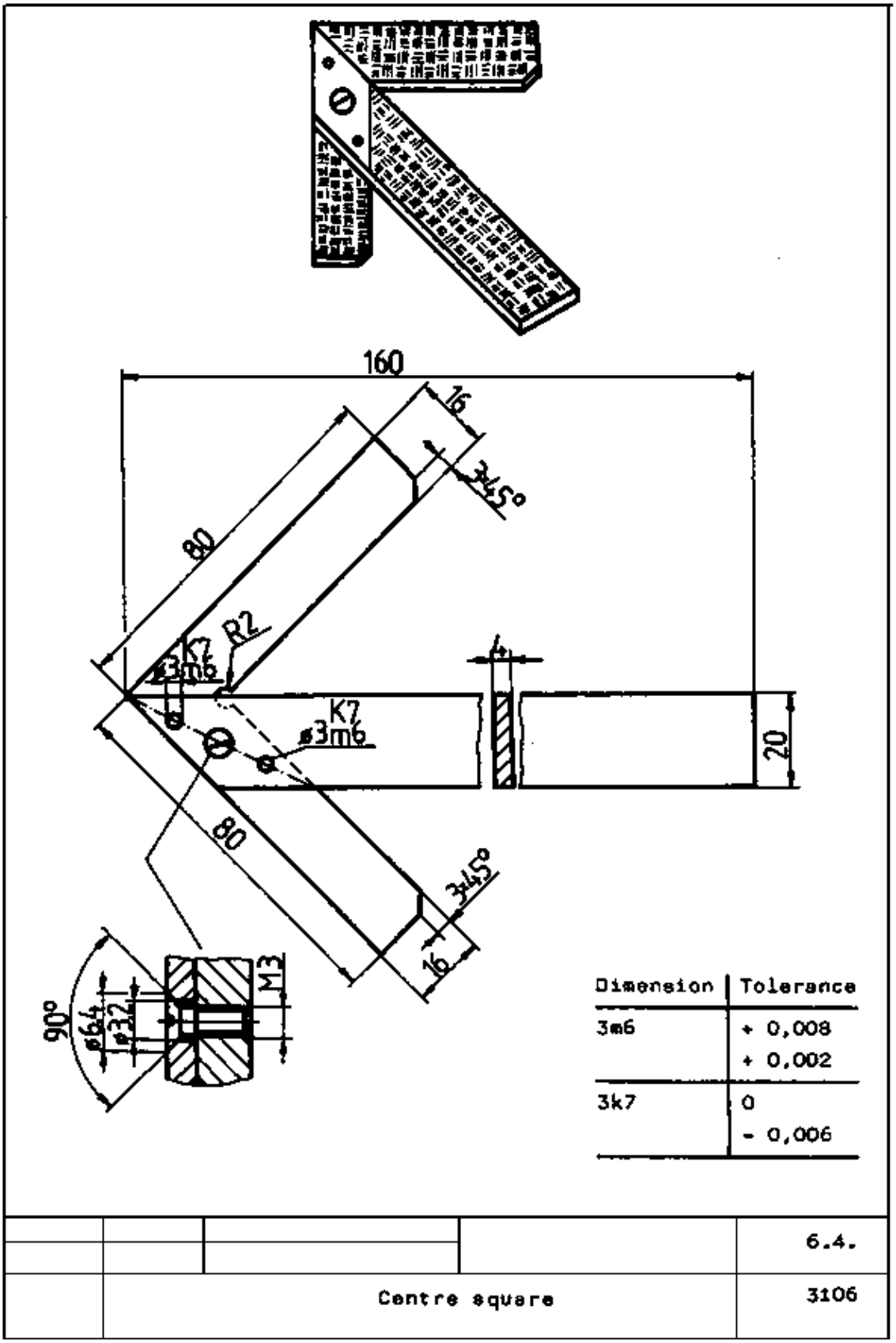
4. Check – Appearance of pattern

Finishing:

– Clamp parts and drill as to free marking, countersink and ream; after unclamping, cut thread (M 3) into the square

– Mount square (secure by screws and pins)

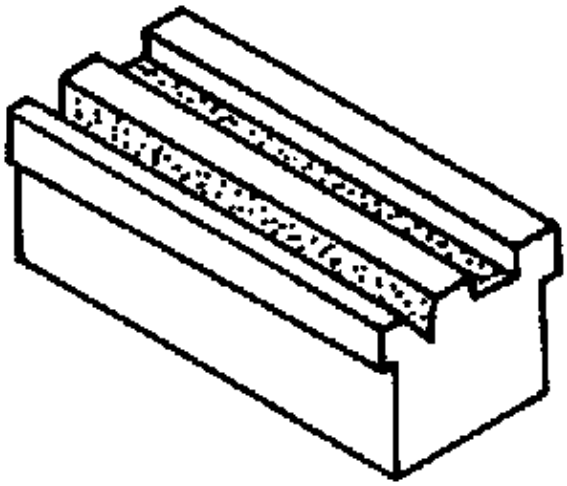
– Surface hardening of functional surfaces



Instruction example 6.5. Lathe bed

Practise planing of lathe bed

Material



lathe bed (base)

Hand tools

Wide and narrow flat scraper

Measuring and testing tools

Water–level (bubble level), measuring microscope, planing straight–edge, surface plate, if necessary, mating machine slide, locksmith's hammer

Accessories

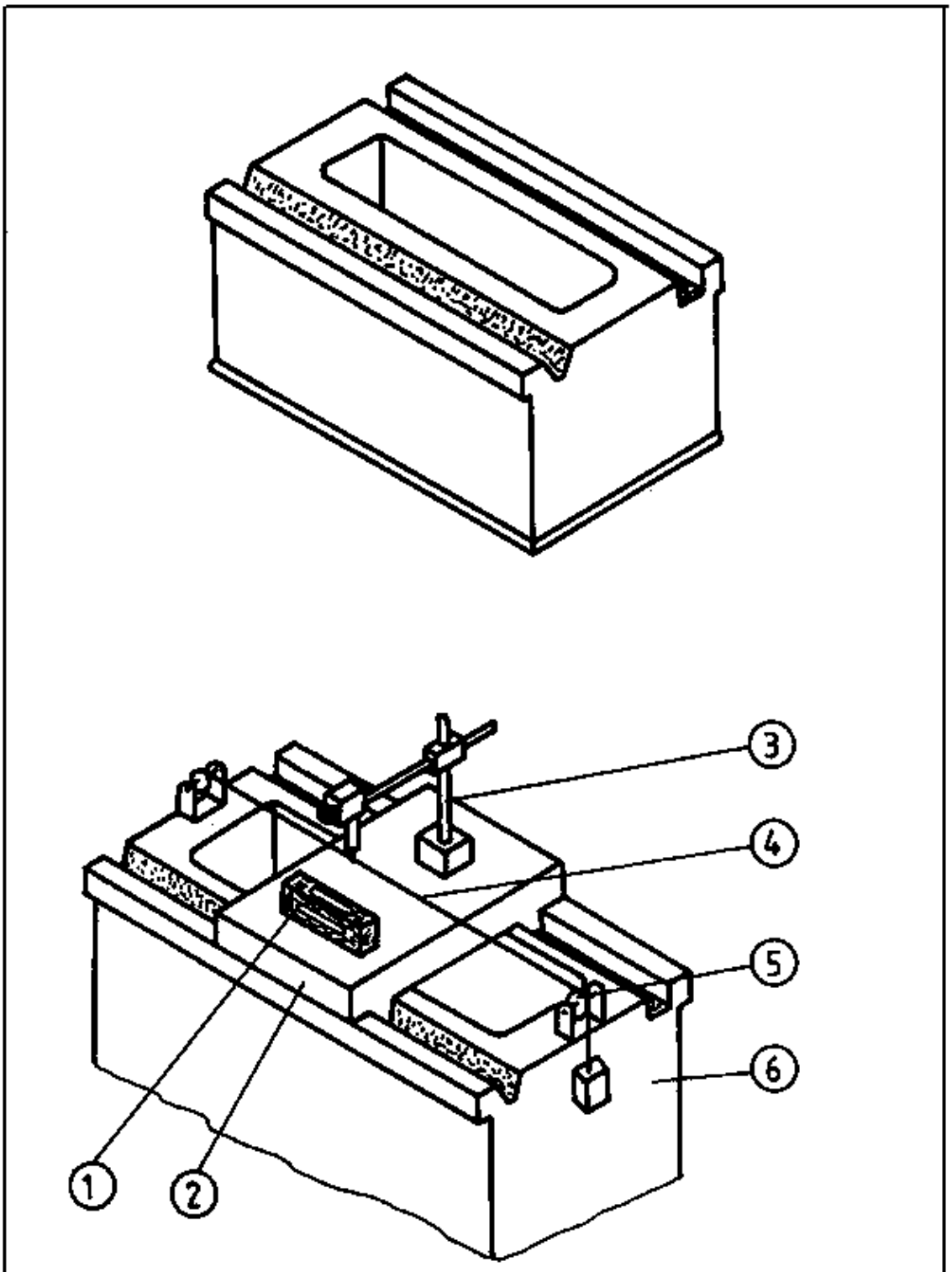
Measuring bridge, long bars (lever), various steel wedges, measuring wire Ø 0.1 mm with mounting, checking ink (black, red), inking block

Required previous knowledge

Testing, measuring

Sequence of operations	**Comments**
1. Arrange workplace Prepare working material	– Check for completeness
2. Remove planing marks from slideway by means of wide flat scraper (powerful rough–scraping)	– Work in long powerful strokes at right angles to planing direction until planing traces disappear
3. Align lathe bed (6) by water–level (1) – place a suitable measuring bridge (2) onto lathe bed; check cross and longitudinal direction by water–level without displacing the measuring bridge; to correct position, arrange steel wedges	– Guideways must exactly lie in parallel and horizontally – Lift lathe bed by means of levers, mount steel wedges
4. Check plane ways in order to realize variations from the horizontal – mark variations at the base	– Move measuring bridge and level in longitudinal direction, measure in longitudinal and cross direction!

5. Check lateral bendings (variations) of guideways:	– Place front and end in same position to guides!
– tension a steel wire (4) of 0.1 mm dia. along the bed centre (rigid mounting (5!))	– Cross hairs matches the wire
– mount measuring microscope (3) onto the measuring bridge and adjust to wire	– Read dimension of variation from microscope
– move measuring bridge with measuring microscope along the bed – in case of variations the microscopic image is laterally displaced from wire	
– Mark variation point at the base	
6. Remove measuring wire and measuring bridge, rub planing straight–edge or surface plate with a wafer–thin layer of black or red checking ink and slowly rub over the guideways (finished machine slide can also be used for checking)	– Avoid oil blotches on guideways!
7. Take off checking device and rough–scrape the entire surface having contact points – subsequently, remove variations (found in operations No. 4 and No. 5)	– Change scraping and checking until even contact points are reached!
8. Spot–scrape contact points in changing direction by means of narrow scraper until you can see enough contact points after checking	– First begin with spot–scraping when you had sufficiently rough–scraped!
9. Final check	– Function test with machine slide



				6.5.
	Lathe bed			3106

Scraping of Plane Surfaces – Course: Technique for Manual Working of Materials. Methodical Guide for Instructors

Table of Contents

Scraping of Plane Surfaces – Course: Technique for Manual Working of Materials. Methodical Guide for Instructors

Institut für berufliche Entwicklung e.V.
Berlin

Original title:
Methodische Anleitung für den Lehrenden
“Schaben ebener Flächen”

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1. Objectives and contents of practical vocational training in the working technique of “Scraping of Plane Surfaces”

By concluding their training, the trainees shall have a good command of the working technique of “Scraping of Plane Surfaces”. Therefore, the following objectives must be achieved:

Objectives

– Knowledge of purpose and application of scraping and checking against master plates.

– Good command of the various working techniques of scraping and surfacing as well as capability of planing workpieces.

– Capability of selecting the appropriate tools and accessories and of using them properly.

– Capability of making decisions on quality independently.

Therefore, the following contents have to be imparted to the trainees:

Contents:

– Purpose of scraping
– Scraping tools
– Purpose of checking against master plates
– Testing tools and accessories for checking against master plates
– Action of scraping
– Technological process of planing flat surfaces.

2. Organizational preparations

In order to guarantee a trouble–free development of the instructions, exercises and practical work it is necessary to prepare this training appropriately.

2.1. Preparations for instructions on labour safety

Prior to the exercise a brief instruction in the proper use of working tools has to be given. This comprises also

hints for accident–free work. The main emphasis is to be laid on:

– Flawless scrapers must be used only

– The scraper handles roust not show any cracks

– Workpieces roust be clamped in such a way that they do not become distorted by the clamping forces

– Scraped surfaces must be protected from damage – they must be covered

– Surfaces of tools for checking against master plates must be protected from damage – to be oiled after use!

Familiarity with these hints has to be confirmed by the trainees' signatures in a control book.

2.2. Provision of teaching aids

– For the purpose of demonstrations during the instructions a small surface plate has to be installed at a workbench, and a vice should also be at the site.

– The "Trainees' Handbook of Lessons – Scraping of Plane Surfaces" is to be handed out to the trainees in sufficient numbers.

– When using the transparencies series of "Scraping of Plane Surfaces", check whether they are complete (transparencies nos. 6.1. – 6.3.) and whether the overhead projector is functional. (Check the operation conditions at the place of work and make sure of the proper mains supply I)

– Surveys etc. which are to be written on the blackboard have to be completed prior to instruction.

– All the tools and accessories mentioned in section 3 should be kept ready for illustration purposes.

2.3. Provision of working tools and materials

– Sufficient copies of the "Instruction Examples for Practical Vocational Training – Scraping of Plane Surfaces" must be handed out to the trainees to provide them with the theoretical foundations of the exercises to be carried out.

– The initial materials necessary for the exercises have to be prepared and laid out in sufficient numbers according to the materials mentioned in the "Instruction Examples...".

– Each trainee is to be provided with a workbench at which the respective clamping devices and surface plates are firmly fixed and which is sufficiently lit.

– The trainees' workbenches have to be fully equipped with tools and accessories according to the envisaged exercises.

Recommended basic equipment:

– steel rule, bevelled steel straight–edge, vernier caliper

– bastard and smooth files 200 – 300 mm (flat)

– hand hacksaw

– locksmith's hammer, aluminium hammer

– flat scraper, pull–type scraper

– checking ink, inking block, levelling straight–edges

– bench–type or column–type drilling machines with the appropriate clamping devices (machine vice, holding clamps, C clamps) for necessary preparations (drilling) in certain exercises.

– Before the exercises are carried out, the drilling machines' compliance with the requirements of labour safety has to be checked.

2.4. Time schedule

Time planning is recommended for the following training stages:

– introduction to the working techniques in the form of instructions
– necessary demonstrations
– job–related instructions for preparing the exercises
– carrying–out the exercises
– recapitulations and tests.

The necessary time share depends on the respective training conditions. Most of the time is to be allocated to the exercises.

3. Recommendations for practical training in the working technique of "Scraping of Plane Surfaces"

The following paragraphs comprise proposals on conducting trainee instruction, the demonstration of working techniques as well as the exercises and tests. The following sequence of stages is recommended:

– Introductory instruction with demonstrations from the "Trainees' Handbook of Lessons".

– Exercises in scraping according to the "Instruction Examples 6.1. – 6.5.".

– Final test of theory knowledge based on the contents of "Examples for Recapitulation and Tests".

Practical skills should be evaluated immediately after handing over the finished workpieces. Knowledge of theory should be constantly checked. However, it is recommended that a final test paper should be written after concluding the exercises.

3.1. Introductory instruction

If possible, this instruction should be conducted in a classroom, Make sure that the trainees put down necessary and supplementary notes or answers to questions in their "Trainees' Handbook of Lessons".

Instruction can be carried out on the basis of the main points contained in the "Trainees' Handbook of Lessons".

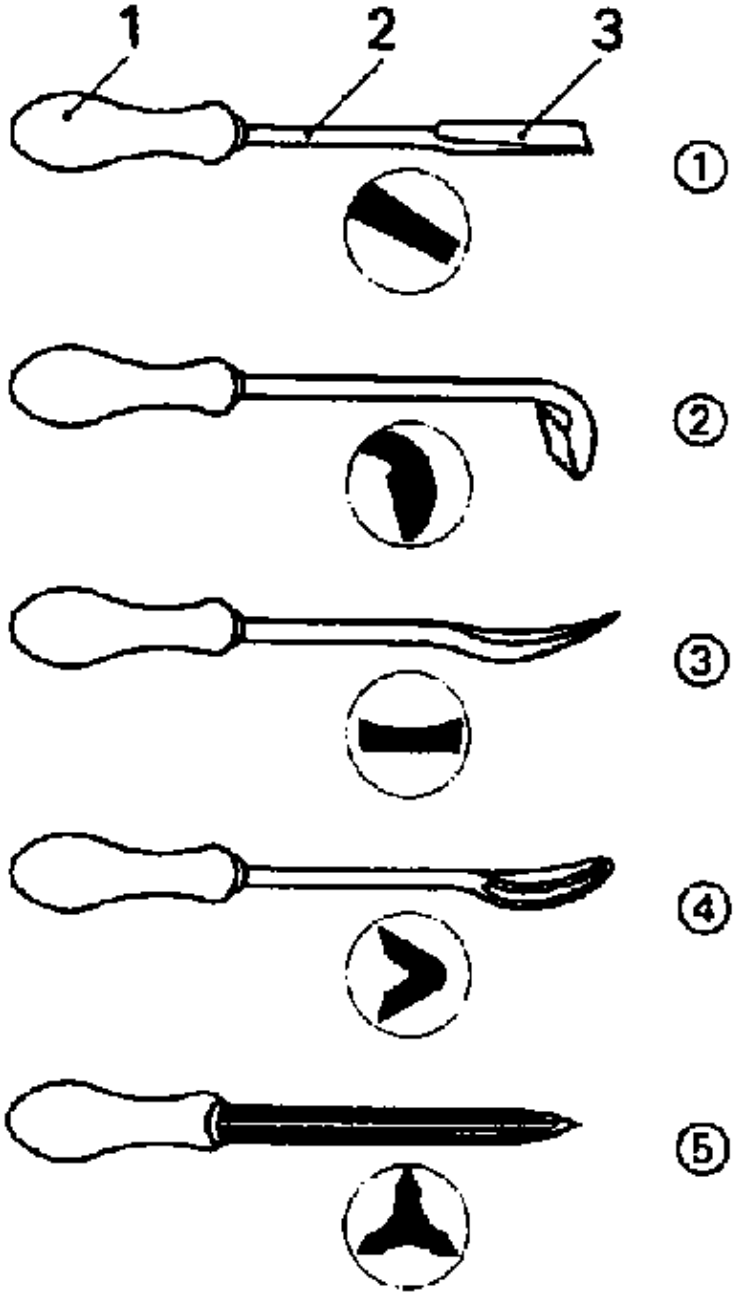
Purpose of scraping

This subject can be explained to the trainees by way of a short lecture. The instructor has to emphasise that manual scraping ranks among the high–grade manual techniques and that this working technique is mostly replaced by machine processes in modern industry. However, the trainees have to understand that machine processes cannot be employed everywhere and that they are not always worth while.

Scraping tools

The following tools and their use should be introduced by showing some original tools and illustrations contained in transparency no. 6.1.

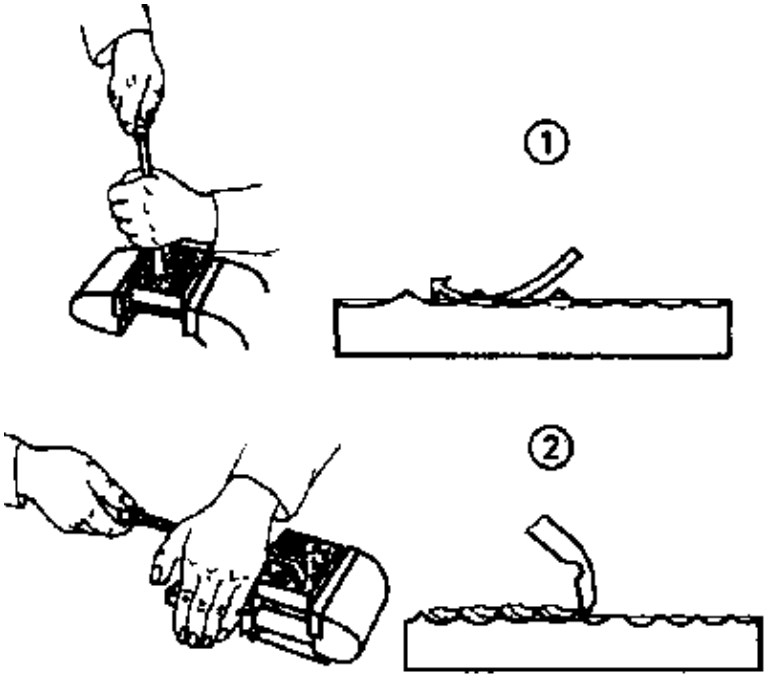
– flat scraper (push–type scraper)
– pull–type scraper
– curved bearing scraper (half–round scraper)
– three–square scraper.



Transparency 6.1

Transparency no. 6.2.

can illustrate the use of flat and pull–type scrapers. Subsequently, it has to be stressed that these tools have to be ground absolutely sharp and whetted clean. The whetting has to be demonstrated, because it is rather difficult to give a clear–cut description of the motions involved.



Transparency 6.2

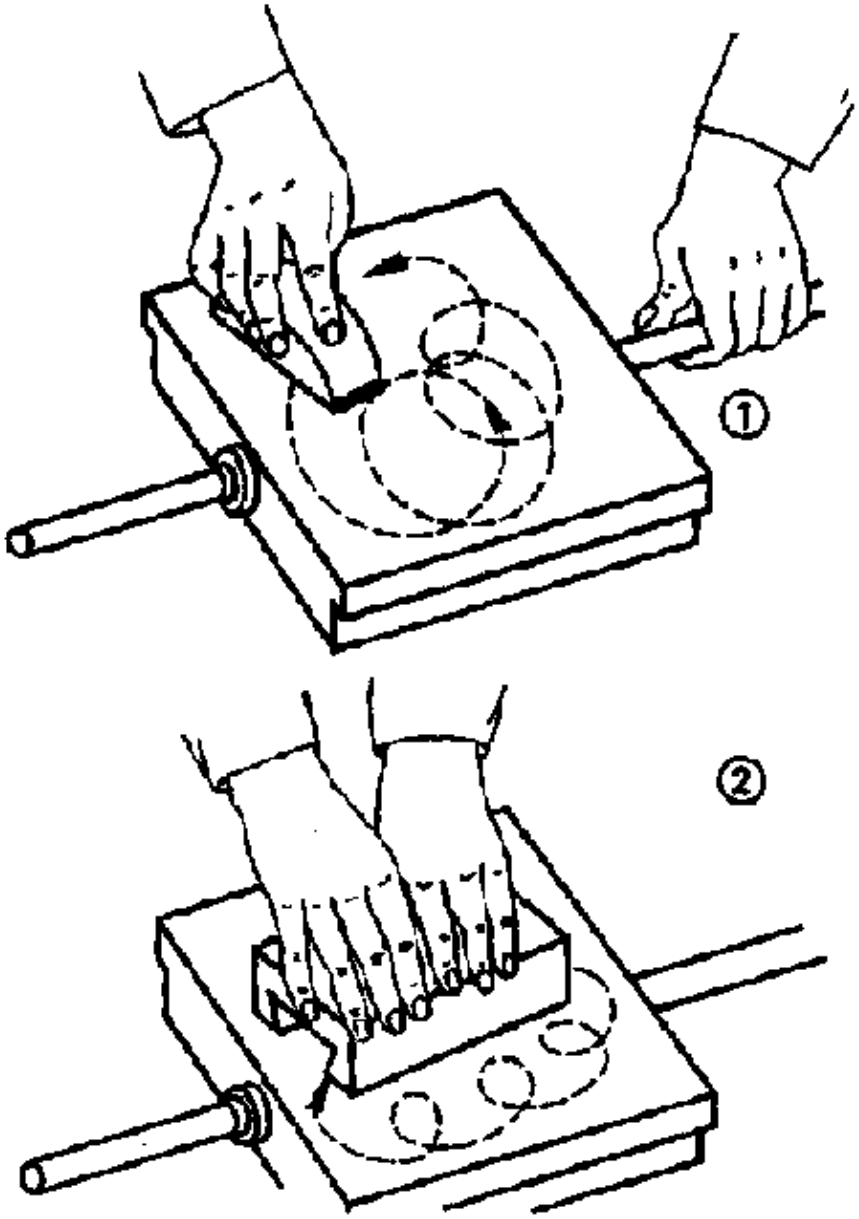
Purpose of checking against roaster plates

It is necessary to explain this quality checking technique to the trainees.

The instructor clearly points out that scraping and checking against master plates are two interactive processes.

Transparency no. 6.3.

will illustrate this working method.



Transparency 6.3

Testing tools and accessories for checking against master plates

- surface plate
- levelling straight–edge
- planing straight–edge
- planing tool for slide guides.

The following accessories are to be mentioned:

- checking ink
- inking block.

If the original tools are not available, the illustrations contained in the "Trainees' Handbook of Lessons" can support and supplement the instruction.

Action of scraping

Transparency no. 6.2. and the illustration contained in the "Trainees' Handbook of Lessons" supplement the instruction of this major topic. This includes a demonstration of the proper angle of inclination (45 degrees) as well as the characteristic movements of the hand when working with the scraper.

Technological process of planing flat surfaces

First, the individual steps of the process must be described and – if possible – they will be followed by demonstrations then.

This demonstration includes the following steps:

1. rough–scraping (pre–scraping)
2. checking
3. spot–scraping
4. finish–scraping and pattern–scraping

The "Trainees' Handbook of Lessons" contains a detailed description of these steps. The trainees must avail of a good theoretical knowledge of these processes before they can begin their practical work. Therefore, it is advisable that the trainees should answer the questions contained in the "Trainees' Handbook of Lessons".

3.2. Exercises

If it has not been possible to include the individual demonstrations in the instructions yet, this shall be done prior to the beginning of the exercises.

Subsequently, it will be possible to commence with the first exercises contained in the "Instruction Examples for Practical Vocational Training". However, it is necessary to prepare every individual exercise by a brief "job–related instruction" during which the trainees are shown a finished workpiece in order to demonstrate the objectives and purpose of this exercise.

> The instructor must have finished such a workpiece by himself in order to be familiar with all the problems which might arise in producing such a workpiece.

Thus the instructor can mention the main points of evaluation as well as all the problems involved in manufacturing such a workpiece. During these instructions the Sequences of operations and the working drawings should be placed on the desks so that the trainees can make some notes therein.

All the trainees can carry out these exercises simultaneously, if the necessary material is available (availability of a sufficient number of working tools etc.). This being the case, all the individual exercises should be carried out by the individual trainees without being pushed by time limits.

If there are not enough tools available, the trainees have to be grouped in teams depending on the application of the various tools:

team no. 1 – single–piece work according to the working drawings
team no. 2 – scraping exercises according to the "Instruction Examples 6.1 – 6.4."
team no. 3 – planing of the lathe bed – Instruction Example 6.5. (maximum: 3 trainees).

If there are still trainees who cannot participate in the exercises, they shall be given a task to consolidate their skills in previously learned working techniques.

3.3. Examples for recapitulation and tests

This section comprises questions which are to consolidate and test the acquired skills and knowledge. Each question is provided with the respective answer. Questions which are also contained in the "Trainees' Handbook of Lessons" are marked with the letter "A".

1. What is the purpose of scraping?

   (To perform a smooth finishing of pre–worked surfaces: they have to be smoothed, deviations of form have to be removed or patterns have to be created.)

2. What kinds of workpieces are mainly worked by scraping?

"A" (Sliding machine components – tool carriages, slide bearings.)

3. When is it useful to employ scrapers?

"A" (When fine finishing cannot be done by machines.)

4. Which are the scraping tools?

(Flat scraper, pull−type scraper, curved bearing scraper, three−square scraper.)

5. When is it useful to employ flat scrapers?

"A" (They are used for pre− and spot−scraping of plane surfaces, for removing bigger amounts of chips.)

6. When is it useful to employ a pull−type scraper?

"A" (It is used for finishing and pattern scraping of plane surfaces and for removing minimum amounts of chips.)

7. What is to be done after having ground a scraper?

"A" (Whetting of the cutting edge for removing burrs.)

8. What happens, if you omit this process?

"A" (The burrs will break off during the scraping action and this will result in notches on the cutting edge which, in turn, will make the cutting edge useless quickly.)

9. How is whetting to be performed?

(Both sides of the cutting edge of the scraper have to be alternately pulled over the whetstone in inclined position until the burrs are removed.)

10. What is the purpose of checking against master plates?

(It is a technique for checking the quality of scraped surfaces optically.)

11. What does "planing of a surface" mean?

"A" (Planing means a permanent alternation of scraping and checking against master plates until the surface is finished.)

12. Which testing tools and accessories do we need for checking against master plates?

(Surface plate, levelling straight−edge, planing straightedge, planing tool for slide guides, checking ink, inking block.)

13. How does the use of surface plates and levelling straightedges differ?

"A" (Surface plate: used for small− and medium−sized workpieces which are moved over the plate

levelling straight−edge: used for long and narrow surfaces of workpieces; the straight−edge is moved over the workpiece.)

14. What is the purpose of using checking paste?

"A" (Checking paste will make visible irregularities on the worked surface.)

15. How are the chips removed when scraping?

    (This is a squeezing process during which the material will be removed at a cutting angle of more than 90°.)

16. Which are the characteristic stages of planing a flat surface?

"A" (Pre−scraping, checking, spot−scraping, checking, finish−scraping.)

17. What is typical of pre−scraping processes?

"A" (Long and powerful pushes with a flat scraper over the whole surface and diagonal to the tool marks are typical of the pre−scraping processes.)

18. What is typical of spot−scraping processes?

"A" (short and curved pushes with a flat scraper over the peaks of the surface with frequent changes of directions are typical of spot−scraping processes.)

19. What is typical of the finish−scraping processes?

"A" (Gentle pulling of the pull−type scraper over the peaks of the surface is typical of finish−scraping processes.)

4. Application of the working technique of "Scraping of Plane Surfaces"

The sequence of exercises can follow the order of the 5 exercises mentioned in the "Instruction Examples for Practical Vocational Training − Scraping of Plane Surfaces".

These "Instruction Examples..." also comprise a list of materials (initial material, hand tools, measuring and testing tools, accessories) and a sequence of operations as well as an illustrative working drawing.

Thus, the trainees avail of the necessary information to begin their exercise−related work.

Should the quality of the produced workplaces be considered insufficient, the trainee has to carry out comprehensive preliminary exercises. To do so, any waste parts will do. If the respective skill has been practised sufficiently, the envisaged workpiece can be produced.

The following hint should be taken into consideration:

> Scraping can be practised on pre−worked parts. The production of component parts and their assembly can be done by other trainees earlier.

Should the proposed "Instruction Examples..." not be used in the exercises, then it is also possible to select other work−pieces.

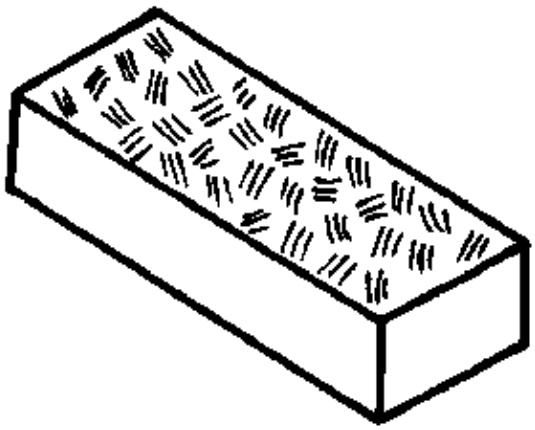
In this case all the working techniques described earlier should be also practised when working these parts.

4.1. Instruction Examples

What follows is a brief description of the individual instruction examples in order to give a survey of those workpieces on which the previously acquired knowledge can be verified:

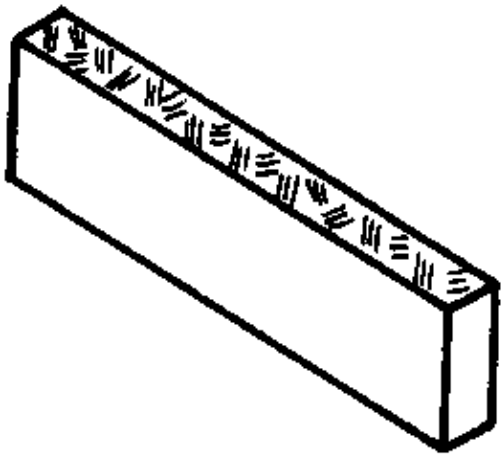
Instruction Example 6.1. V–block

The trainees will practise the flat–scraping process on a flat steel surface (without given dimensions). Flat scrapers will be employed only.



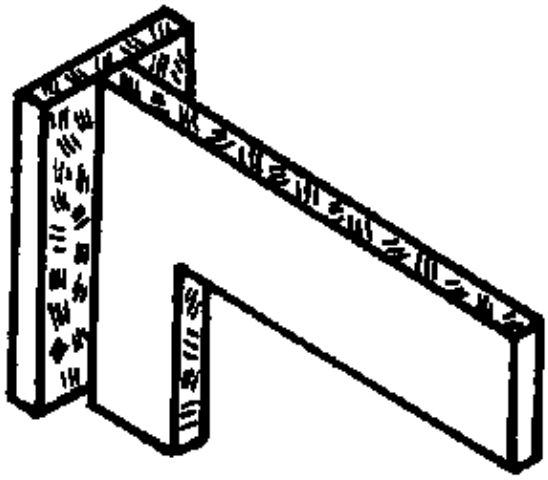
Instruction Example 6.2. Steel straight–edge

Two parallel, narrow surfaces of flat steel are worked with the flat scraper first and with the pull–type scraper then. After hardening the surface, the straight–edge can be used in the workshop.



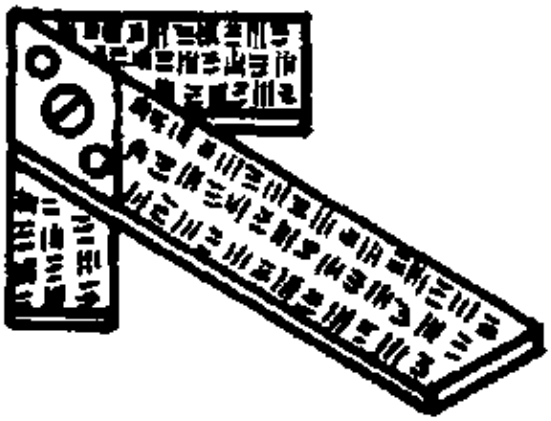
Instruction Example 6.3. Try Square

Two or, resp., three narrow surfaces of flat steel are worked in such a way that they are parallel to each other – in accordance with given dimensions. Parallelism will be checked by using dial gauges. After hardening the surfaces, the try square can be used in the workshop.



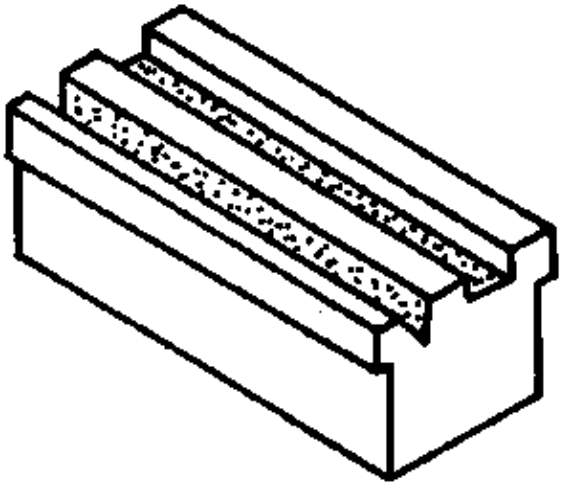
Instruction Example 6.4. Centre Square

After the production of the components, this device can be used to practise pattern scraping of braiding patterns on steel sheets, After hardening the surfaces this centre square can be used in the workshop.



Instruction Example 6.5. Lathe bed

Planing will be practised at an available lathe bed employing all the necessary techniques of scraping and checking against master plates.



4.2. Criteria for practical training

It is recommended to determine some major points of observation and evaluation of the work to be performed.

The following criteria can serve as a guideline:

Pre–scraping process

– Does the trainee employ long and powerful pushes which run diagonal to the working marks?
– Does the trainee apply the scraper with varying scraper positions?
– Does the trainee exert an increasing pressure?

Checking against master plates

– Does the trainee apply very thin films of the checking ink?
– Does he spread the checking ink evenly over the whole surface?
– Does the trainee recognise the surface appearance, and is he in a position to interpret it?

Spot–scraping

– Does the trainee apply the flat scraper in short, clearly defined curves?
– Does the trainee persistently work the peaks?
– Does he check regularly?
– Does he achieve the ratio of three peaks to one valley?

Finish–scraping and pattern scraping

– Does the trainee apply the pull–type scraper correctly?
– Is the trainee in a position to produce a regular pattern?

5. Captions and legends of the "Scraping of Plane Surfaces" transparencies series

Transparency no. 6.1. Kinds of scrapers

(1) Flat scraper

1 – handle

2 – shank

3 – blade

(2) Pull–type scraper

(3) Half–round scraper (solid)

(4) Half–round scraper (hollow)

(5) Three–square scraper (hollow)

Transparency no. 6.2. Kinds of finish–scraping

(1) Scraping with pushing actions

(2) Scraping with pulling actions

Transparency no. 6.3. Checking against master plates

(1) Spreading the checking ink over the surface plate using an inking block

(2) Rubbing of the workpiece on the surface plate