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

Table of Contents

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

Institut für berufliche Entwicklung e.V.
Berlin

Original title:
Methodische Anleitung fur den Lehrenden
“Sägen von Hand”

Author: Frank Wenghöfer

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1. Objectives and contents of practical vocational training in the working technique of “Manual Sawing”

By concluding their training the trainees shall have a good command of the working technique of “Manual Sawing”. Therefore, the following objectives are to be achieved:

Objectives

– Knowledge of the purpose and application of manual sawing.

– Mastery in handling the saw and capability of carrying out true−to−size sawing cuts of any kind.

– Capability of selecting the proper tools and accessories and their proper use.

– Capability of evaluating the quality of their own work.

The following contents have to be imparted to the trainees:

Contents

– Purpose of sawing
– Tools and accessories
– Effects of sawing and handling of saws

2. Organizational preparation

To guarantee a trouble−free development of instructions, exercises and practical work it is necessary to prepare this training properly.

The following steps have to be taken:

2.1. Preparation of instructions on labour safety

Prior to the exercises a brief instruction on the proper use of tools and materials has to be given. This comprises hints for accident−free work.

The main emphasis is to be laid on:

– Hand hacksaws with crackless handles must be used only I
– Fixing components must not protrude at the side of the clamp dog!
– The guide hand must not work in the range above the vice I

Familiarity with these hints is to be confirmed by the trainee's signature in a control book.

2.2. <u>Provision of teaching aids</u>

For demonstration purposes during instruction, a vice has to be installed at the place.

The "Trainees' Handbook of Lessons – Manual Sawing" is to be handed out to the trainees.

When using the transparencies series of "Manual Sawing", check whether they are complete (transparencies nos. 4.1. – 4.3.) and whether the overhead projector is functional.

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

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

All the tools and accessories mentioned in section 3 (for sawing purposes) should be kept ready for demonstration.

2.3. <u>Provision of working tools and materials</u>

The "Instruction Examples for Practical Vocational Training –Manual Sawing" must be handed out to the trainees in sufficient copies to provide them with the theoretical foundations for the exercises to be performed.

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

Each trainee is to be provided with a workbench with a stationary vice (check the proper working height of the vice).

The trainees' workbenches have to be fully equipped with tools and accessories according to the exercises planned. Do not forget to check this!

Recommended basic equipment:

– steel rule, try square, protractor
– steel scriber, prick–punch, dividers
– locksmith's hammer
– hand hacksaw with various types of saw blades
– bastard and smooth files – 200 mm and 250 mm (flat and half round)
– vee clamps.

2.4. <u>Time schedule</u>

Time planning is recommended for the following training stages:

– introduction to the working technique in the form of instructions
– necessary demonstrations
– job–related instructions in performing the exercises
– performing the exercises
– recapitulation 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 “Manual Sawing”

The following paragraphs comprise proposals on conducting trainee instruction, the demonstration of the working techniques as well as exercises and tests. We recommend the following way of conducting the course:

Introductory instruction with demonstrations from the “Trainees’ Handbook of Lessons”.

Exercises in sawing from “Instruction Examples 4.1. – 4.6.” and subsequent evaluation.

Final test of theory knowledge based on the contents of the “Examples for Recapitulation and Tests”.

The exercise associated with “Instruction Example 4.7.” can follow later as a complex work, because it is necessary to acquire other working techniques first.

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

3.1. Introductory instruction

If possible, this instruction should be given in a classroom. Make sure that the trainees put down necessary supplementary hints 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”. The main subjects of “Purpose of Sawing” and “Tools and Accessories for Sawing” are to be taught with the employment of all the teaching aids available.

Purpose of sawing

This subject should be illustrated by presenting workpieces which were cut by sawing or which show kerfs. The trainees should recognize the single–piece nature of this work.

Tools and accessories

Transparencies nos. 4.1. and 4.2. can support the demonstration of original tools and accessories. The design of a hand hacksaw and the fixing of the saw blade is to be explained.

Vice

Most important clamping device for any locksmith work. It consists of a fixed part screwed onto the work bench and a movable part.

By means of a handle the movable part (clamping Jaw) is screwed towards the fixed clamping jaw (both jaws are hardened). The clamping jaws may be of flat or vee type.

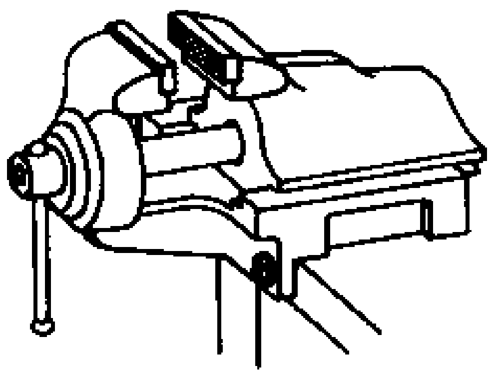


Figure 7 Vice

Vee clamps

Vee–shaped attachments for the vice permitting horizontal clamping of cylindrical workpieces.

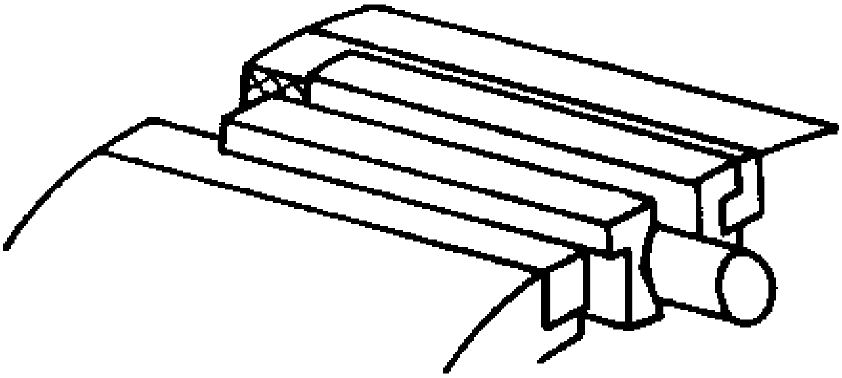


Figure 8 Vee clamp

Angle clamps

Simple angles to be vertically attached to the vice permitting long metal sheets to be firmly clamped.

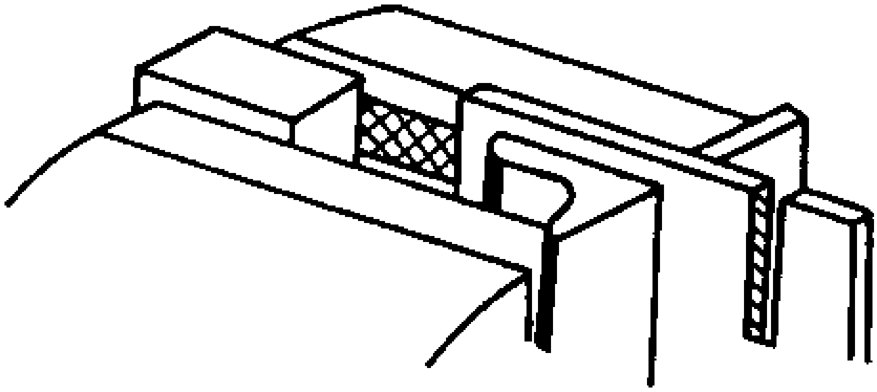


Figure 9 Angle clamp

Protective jaws

Soft–metal attachments for the vice to protect coated or sensitive surfaces of workpieces from damage when being clamped.

Saw blades for different cross sections of workpieces and degrees of material hardness

Type of saw blade	**cross section of workpiece**	**material hardness**	**tooth pitch (number of teeth on 25 mm)**
coarse	– solid sections (round, square and hexagonal steels)	soft steel, non–ferrous metals	14
normal	– normal sections (angles, sectional steel) – thick sheet metal	steel of normal hardness, harder light metals	22
fine	– light–steel sections – thin sheet metal	harder steel, cast iron	32

The instructor has to stress the importance of the free cutting action of saw blades.

For the purpose of demonstration one trainee is to be given the task to perform a sawing cut on any workpiece using a saw blade with free cutting action first, and then a saw blade without (or with poor) free cutting action. The trainees have to register the required times for sawing and to draw the necessary conclusions.

They will recognize that more time and energy is necessary for the use of saw blades without or with poor free cutting action due to the frequent jamming.

Subsequently, the trainees have to answer the questions contained the "Trainees' Handbook of Lessons".

The following order is recommended when introducing the accessories:

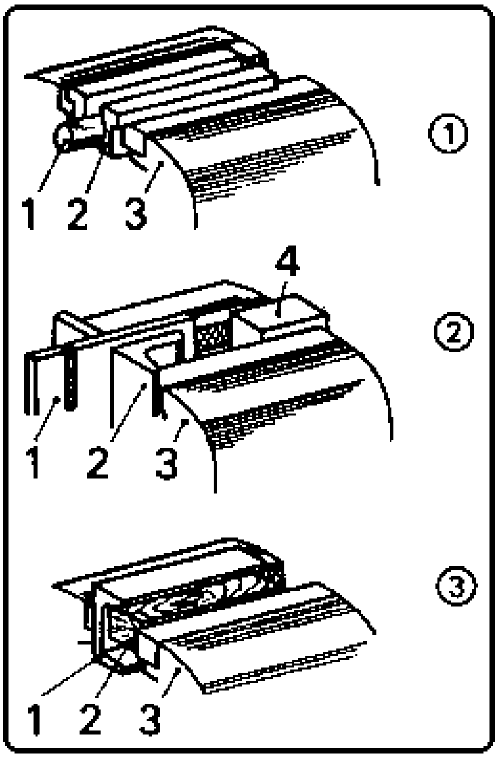
- vice
- vee clamps
- angle clamps
- protective jaws.

It must be stated quite clearly why these accessories have to be used – this should be supplemented by employing transparency no. 4.3.

If some of these tools and accessories should not be available as originals, the respective illustrations in the "Trainees' Handbook of Lessons" could supplement the instruction.

Effects of sawing, posture and
saw guidance

Demonstrations should show these effects when cutting a broad and a narrow workpiece each. The trainees will see that the saw will cut better when many teeth are cutting at the same time. This requires a different handling of saws.



In this context the trainees should be shown the proper posture and guidance of the saw.

The "Trainees' Handbook of Lessons" contains specific hints for this subject which must be taken into account.

How to handle the saw

The trainees have to be shown the close connection between a vertical guidance of the cut and the proper clamping of the workpieces. The following examples need particular explanation:

- Clamping of flat workpieces for sawing on their broad side.
- Clamping of sheet metal and sawing with upward pushing direction.

– Clamping and repeated re–clamping when sawing tubes.
– Fixing of angle sections and sawing on the broad side only.
– Sawing of deep cuts with the saw frame swivelled by 90°.

These facts should be further illustrated when working in the workshop.

3.2. Exercises

If it was not possible to include the individual demonstrations into the instructions, they should be performed right now before the exercises.

If the trainees avail of only little practical skills, they should do some preliminary exercises on any small workpieces:

– simple cutting of flat and square steel
– cutting of tubes and angle sections
– sawing of straight and angular recesses.

But it is also possible to begin with the first exercises contained in the "Instruction Examples for Practical Vocational Training" at once.

However, it is necessary to prepare any individual exercise by a brief "job–related instruction". Within this context the trainees are shown a finished workpiece in order to make them familiar with the aim and purpose of this exercise.

> The instructor must have completed such a workpiece by himself so as to know the problems involved in manufacturing it.

This makes it possible to determine the main points in evaluating the trainees' performance and to advise the trainees on problems involved.

During these lessons of special instruction the trainees have to place the sequences of operations and working drawings of the training examples on their desks so that they can make notes therein.

All the trainees can carry out these exercises simultaneously, if the required number of working tools is available. If this is not the case, the trainees will be divided into groups based on the respective tasks and the number of the working tools available.

Those trainees who cannot start their practice of sawing immediately should do some other jobs in the workshop first:

– selection and preparation of the initial materials.

– checking and minor repair work on working tools under supervision of an instructor; other exercises can reinforce the skills of working techniques acquired earlier.

3.3. Examples for recapitulation and tests

This section comprises questions for consolidating and testing 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 sawing?
(Cutting of workpieces in a narrow saw kerf in order to divide them or to provide them with slots or cuts.)

2. How do the various types of saw blades differ?
"A" (Design of angles at the saw tooth, number of teeth on a length of 25 mm.)

3. What saw blade do we use when sawing steel of normal hardness?
(Saw blade with medium tooth pitch and cutting–type chip formation.)

4. Why is the free cutting action necessary for saw blades?
“A” (This is to prevent them from jamming in the kerf.)

5. Which are the common design−based ways of achieving the free cutting action?
(Raker−setting of saw teeth, wave−setting of teeth.)

6. What is to be taken into consideration when clamping a workpiece for sawing purposes?
“A” (The workpiece is to be clamped in a way that allows a vertical sawing cut and prevents the workpiece from springing and slipping.)

7. Which is the most important clamping device for workpieces?
“A” (Vice.)

8. Which types of workpieces have to be clamped in vices by means of protective jaws?
(Workpieces with coated or sensitive surfaces.)

9. Why must we guide the saw in such a way that as many teeth as possible are cutting at the same time?
“A” (If only a few teeth are cutting, there will be the danger of hooking in and breaking out of teeth.)

10. What is to be taken into consideration when sawing off workpieces?
“A” (Immediately before the workpiece is sawn off, the pressure on the saw must be reduced so that the saw blade will not be damaged by a torn off workpiece.)

11. How is the saw to be handled when sawing thin metal sheets?
"A" (Saw must be held slightly upwards in the pushing direction.)

12. How is the saw to be handled when sawing tubes and sectional steel?
“A” (Tubes and steel sections must not be sawn off in one pass, but they have to be reclamped during sawing so that as many teeth as possible will be cutting at the same time.)

4. Application of the working technique of “Manual Sawing”

The sequence of exercises can follow the order of the 7 (or 6)

Workpieces mentioned in the “Instruction Examples for practical vocational training − Manual Sawing”.

These “Instruction Examples...” comprise a list of materials (initial materials, hand tools, measuring and testing tools, accessories) as well as the sequence of operations for manufacturing these workpieces. Thus, the trainees avail of the necessary information to begin their exercise−related work.

Should the quality of the manufactured workpieces be considered insufficient, the trainee has to carry out comprehensive preliminary exercises. To do so, any waste components will do.

If the skill has been practised sufficiently, the envisaged workpiece can be manufactured.

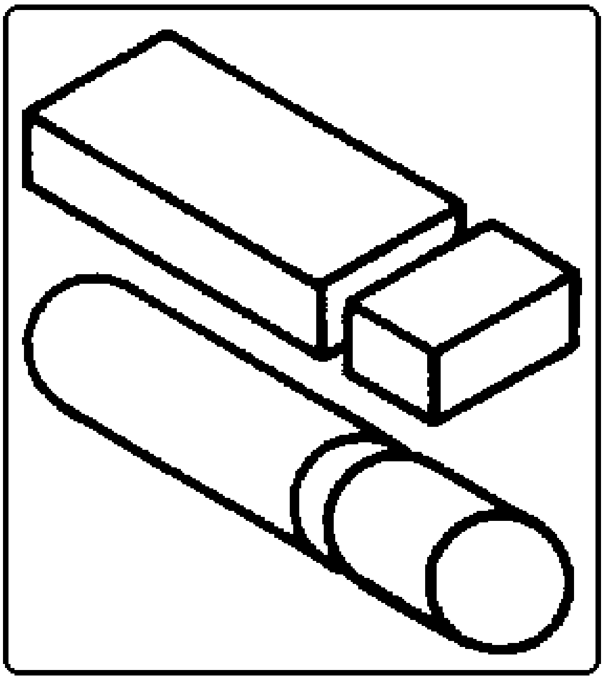
The following hint should be taken into consideration:
The trainee has to do all the work alone − from the very beginning (cutting of initial material) till the completion of the workpiece.

This is the only way to guarantee a just evaluation of the achievements. Should the offered “Instruction Examples...” not be used in the exercises, then it is also possible to select other workpieces. In this case all the working techniques acquired earlier should also be practised with these workpieces.

4.1. Instruction examples

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

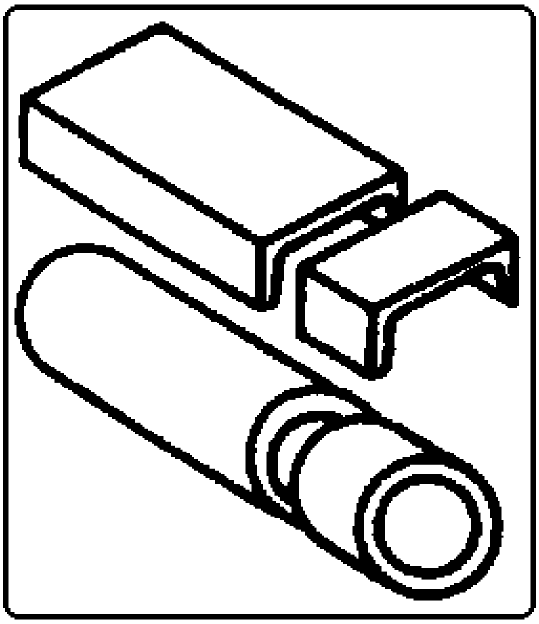
Instruction Example 4.1.
<u>Spacers and Pin Drifts</u>



Flat steel and aluminium sheets as well as round material of copper and brass are used to practise simple, straight saw cuts. The finished parts can be employed as necessary accessories in workshops: spacers for clamping, pin drifts for loosening pin connections.

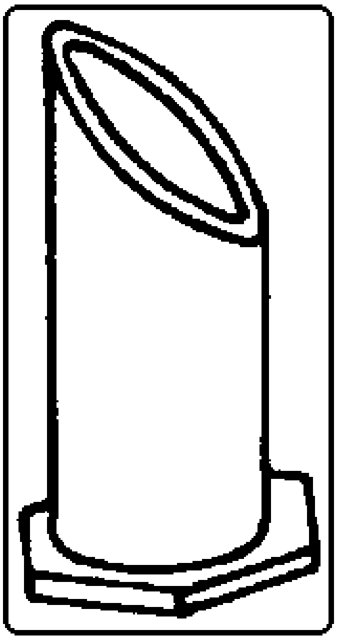
Instruction Example 4.2.
<u>Stands and Supports</u>

Channel sections and steel tubes serve to practise the specific skill of cutt−off sawing. Repeated re−clamping of the workpiece is a must.



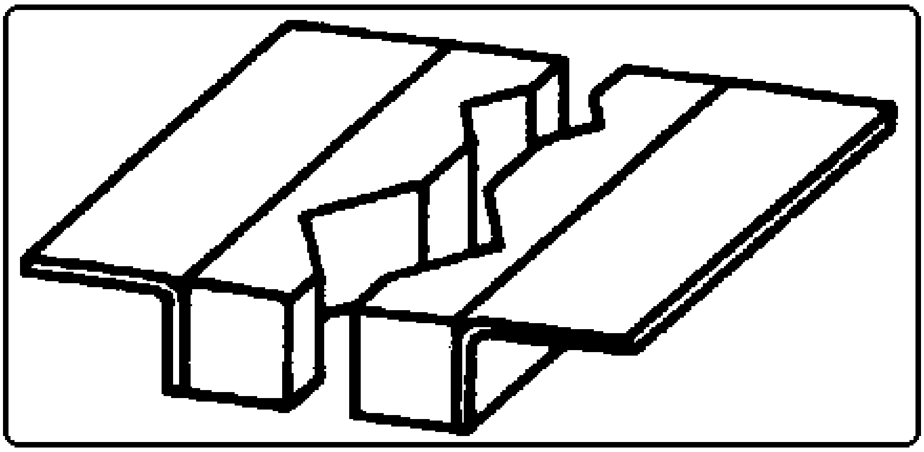
Channel can be further worked in order to manufacture drill stands etc. The instruction examples 2.3. and 7.4. give a description of continuing this work. The tubes can be prepared in such a way that they can serve as supports for instruction example 4.6.

Instruction Example 4.3.
<u>Container</u>



Light metal or steel sheets or tubes will be sawn to given dimensions to practise mitre cuts. After glueing, soldering or welding, these components can serve as containers for pins or scribers.

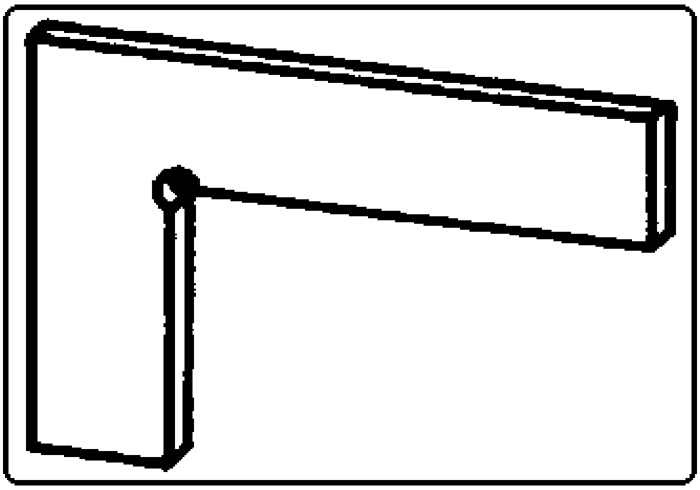
Instruction Example 4.4.
<u>Vee−shaped−Attachment</u>



Steel sheet will be cut to size by long and straight sawing cuts; solid square steel will be sawn by mitre cuts (the required angle will be given by the instructor).

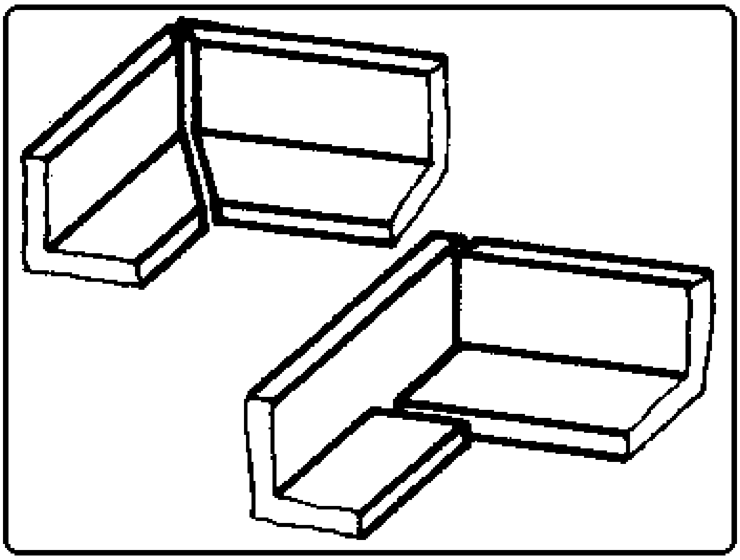
After−having connected these components by bolts or rivets this workpiece can be used as accessory for clamping cylindrical workpieces.

Instruction Example 4.5.
<u>Steel Square</u>



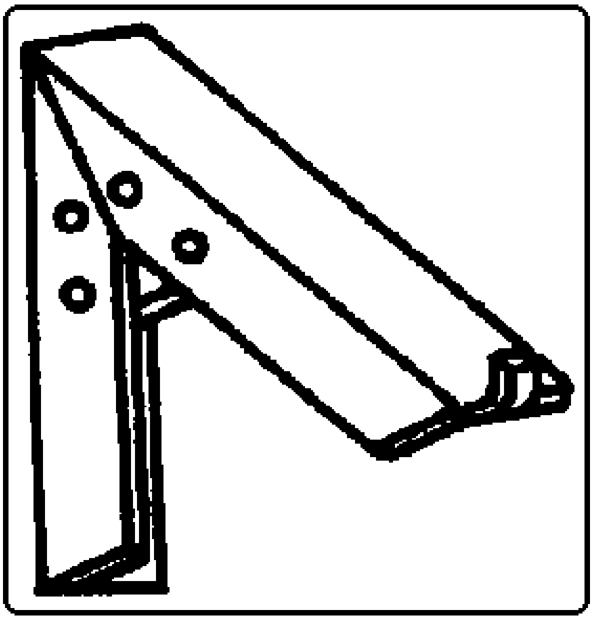
Long and straight sawing cuts of high precision are practised on steel sheets. Once completed, the workpiece can be used in the workshop.

Instruction Example 4.6.
<u>Angle−Steel Frame Table</u>



Straight and mitre cuts serve to practise the technique of joining angle steel to form a frame. Emphasis is to be laid on the peculiarities of straight and mitre cuts. Welded with the supports mentioned in instruction example 4.2., a frame for a table is produced which can be provided with an insert (of steel or wood) so as to form a table for putting down tools etc. in the workshop.

Instruction Example 4.7.
<u>Wall−Shelf−Bracket</u>



Angle steel is used to practise mitre cuts and cut−outs.

When combined with other working techniques, a set of brackets for wall shelves can be produced.

These brackets can be bolted into the wall and provided with a board of any length − and this results in a useful and solid place for laying down workshop accessories.

4.2. Criteria for practical training

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

The following criteria may serve as a guideline:

Does the trainee select the appropriate saw blade?

Does he fix the saw blade in the proper way (in the pushing direction)?

Is the workpiece clamped as required?

Does the trainee use available accessories?

Does the trainee employ cutting oil for sawing?

Does the trainee pay attention to vertical guidance of the saw?

Does the trainee re−clamp sections during sawing or does he saw off in one pass?

Does the trainee pay attention to the fact that there must be as many teeth as possible cutting at the same time even when sawing thin workpieces?

Does the trainee's tool comply with the labour safety requirements?

5. Captions and legends of the "Manual Sawing" transparencies series

Transparency No. 4.1.: Design and operation of a hand hacksaw

(1) Hand hacksaw

1 − handle
2 − fixed clamping dog

3 – retaining pin
4 – saw blade
5 – saw frame
6 – adjustable clamping dog with wing

(2) saw teeth in action

Transparency No. 4.2.: Fixing and free cutting action of saw blade

(1) Fixing of saw blade

1 – clamp dog
2 – rivet or pin
3 – saw blade

(2) action of saw blade with raker−set teeth

(3) action of saw blade with wave−set teeth

4 – free cutting action

Transparency No. 4.3.: How to clamp a workpiece for sawing

(1) Clamping a round workpiece with vee clamp as attachment

1 – workpiece
2 – vee clamp
3 – vice

(2) clamping a metal sheet with angle clamp as attachment

4 – spacer

(3) clamping a channel section with hardwood attachment

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

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Introduction

The present material contains 7 selected instruction examples which are intended to help practising the main techniques of manual sawing with increasing level of difficulties. This includes straight, angular and parallel cuts – from simple cutting–off of flat and cylindrical parts as well as of various sections up to the manufacture of complex parts.

In order to facilitate the preparation and execution of the work, the necessary materials, measuring and testing tools, hand tools and accessories are stated for each training example. Moreover, knowledge required in addition to knowledge of manual sawing is mentioned.

The sequence of operations given for each instruction example includes the necessary steps for the production of the relevant workpiece.

For each instruction example a working drawing is attached showing the required shapes and dimensions of the workpiece.

All workpieces produced may be used in the workshop for practical purposes.

Spacers and Vee–shaped attachments are required for various vice work; pin drifts of nonferrous metals (copper and brass) are necessary accessories for pinning and drifting work; steel squares may be used by the trainees as testing tools.

Angle–steel frames with inserted steel or wooden plates and provided with supports are suitable tables for storing purposes.

Wall–shelf brackets are necessary supporting elements for the manufacture of wall shelves for the workshop.

Explanation to the specification of material:
Steel is specified according to the value of its tensile strength in the unit "Megapascal" (MPa).

Instruction example 4.1. Spacers and pin drifts

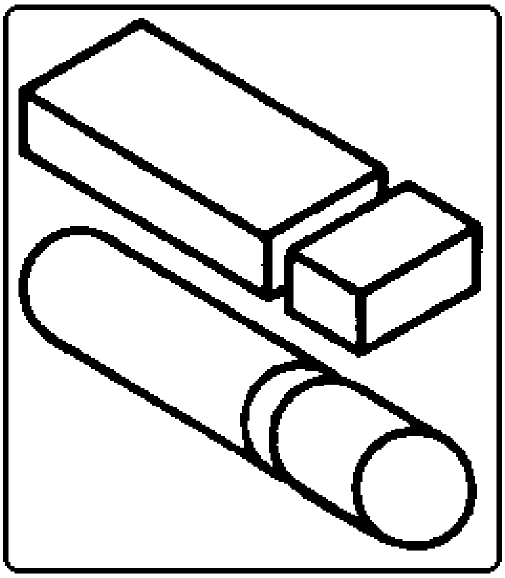
To practise simple cutting–off of sectional steel and other materials.

<u>Material</u>

– Flat steel (340 MPa)
Thickness: 15 mm
Width: 25 mm

– Flat aluminium bars
Thickness: 5 mm
Width: 40 ram

– Round copper and brass bars e.g. 6 and 10 mm diameter, any length.



Hand tools

Steel scriber, mark–out punch, engineers' hammer, hand hacksaw with various saw blade types (coarse and normal tooth pitch), smooth–cut file 200 mm (flat).

Measuring and testing tools

Steel measuring tool, try square.

Accessories

Vice, cutting oil, horizontal Vee–shaped attachments.

Required previous knowledge

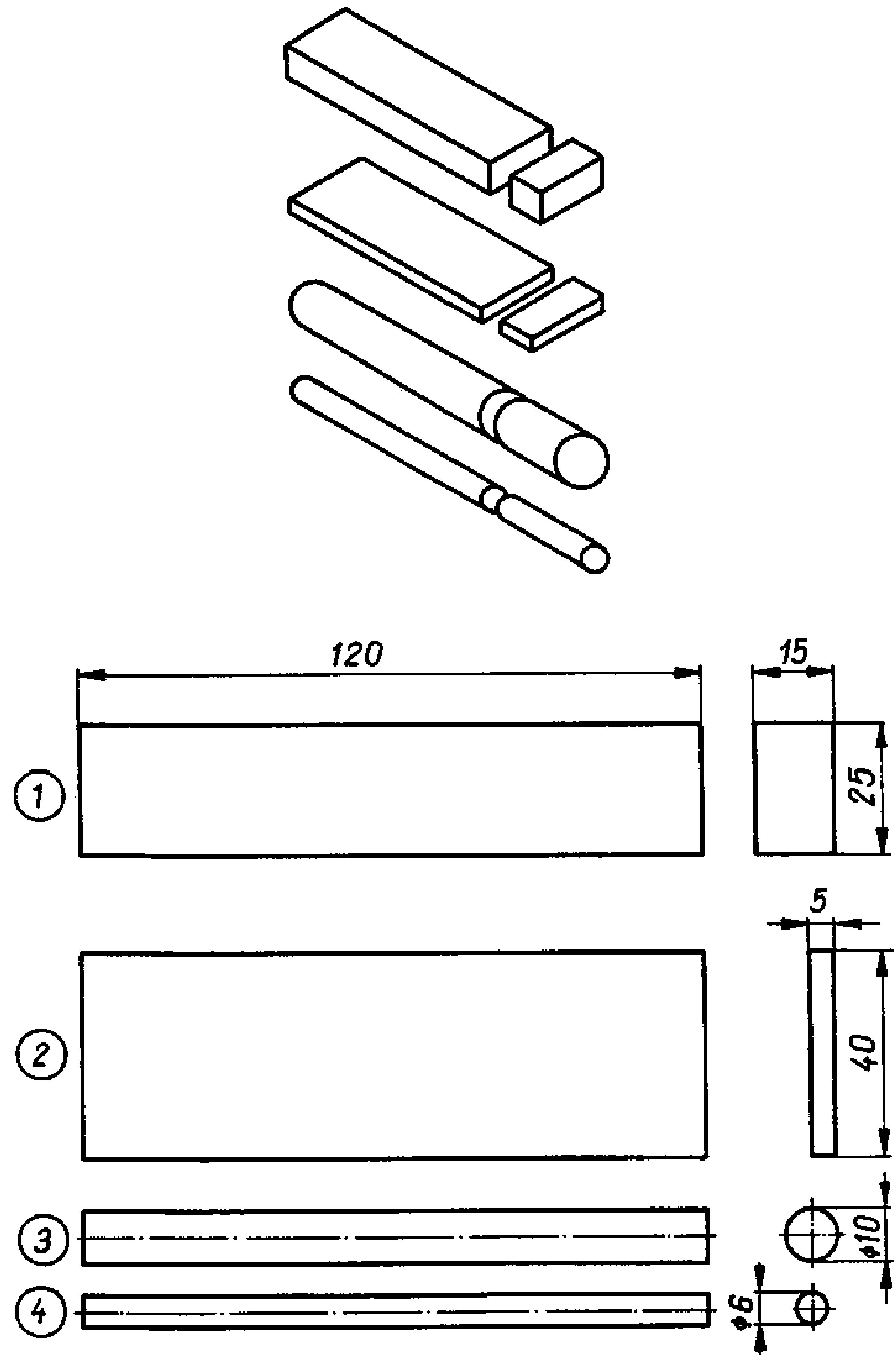
Reading of drawings, measuring and testing, scribing and prick–punching.

Sequence of operations	**Comments**
1. Arrange the working place, prepare the working materials.	– Check for completeness.
2. Scribe and prick–punch flat steel to 120 length.	– Part (1) Datum edge to be flat and at right angle (try square).
3. Clamp workpiece in vice and start sawing with small starting–cut sawing angle.	– Use saw blade with normal tooth pitch. – File guiding kerf, it necessary.
4. Saw–off with constant cutting movement, then remove burrs.	– Provide saw blade with cutting oil. – Use total length of saw blade.
5. Prepare and saw–off flat aluminium bar in the same manner.	– Part (2) – Use saw blade with coarse tooth pitch.

6. Scribe round copper and brass bars and clamp them in vice.	– Parts (3) and (4) – Use suitable attachments for horizontal clamping.
7. Saw–off at scribed line in one pass and remove burrs.	
8. Final inspection.	– Straightness of cut.

To continue practising, if necessary

Saw–off other flat stock and round bars of different diameters.



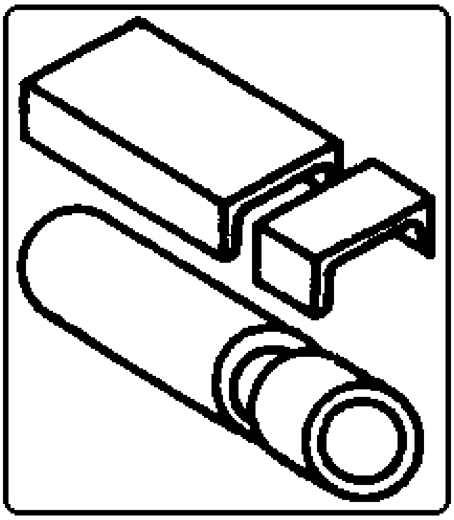
				4.1.
5	Spacers and pin drifts			3104

Instruction example 4.2. Stands and supports

To practise straight saw−off cuts in several steps on U−sections and tubes. U−sections may be used as basic bodies for drill stands, tubes as supports (table legs), training example 4.6.

Material

U−sections of steel (340 MPa)
Web width: 80 mm
Flange height: 45 mm
Steel tube (340 MPa)
25 mm diameter



Hand tools

Steel scriber, hand hacksaw (saw blade of normal tooth pitch), smooth−cut file 200 mm (flat), mark−out punch, engineers' hammer.

Measuring and testing tools

Steel measuring tool, try square.

Accessories

Vice, surface plate, spacer (wooden block) for clamping of U−section, horizontal Vee−shaped attachment suitable for tube diameter, cutting oil.

Required previous knowledge

Reading of drawings, measuring and testing, scribing and prick−punching.

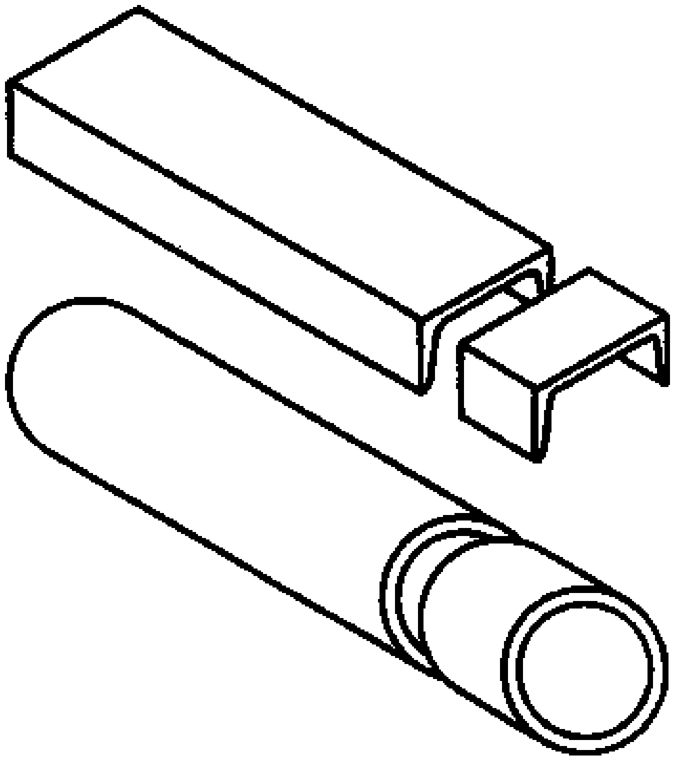
Sequence of operations	Comments
1. Arrange the working place, prepare the working materials.	– Check for completeness.
2. Scribe U−section for 120 mm length using try square and steel measuring tool, prick−punch scribed line.	– File datum edge, if end face is not flat.
	– Part (1)

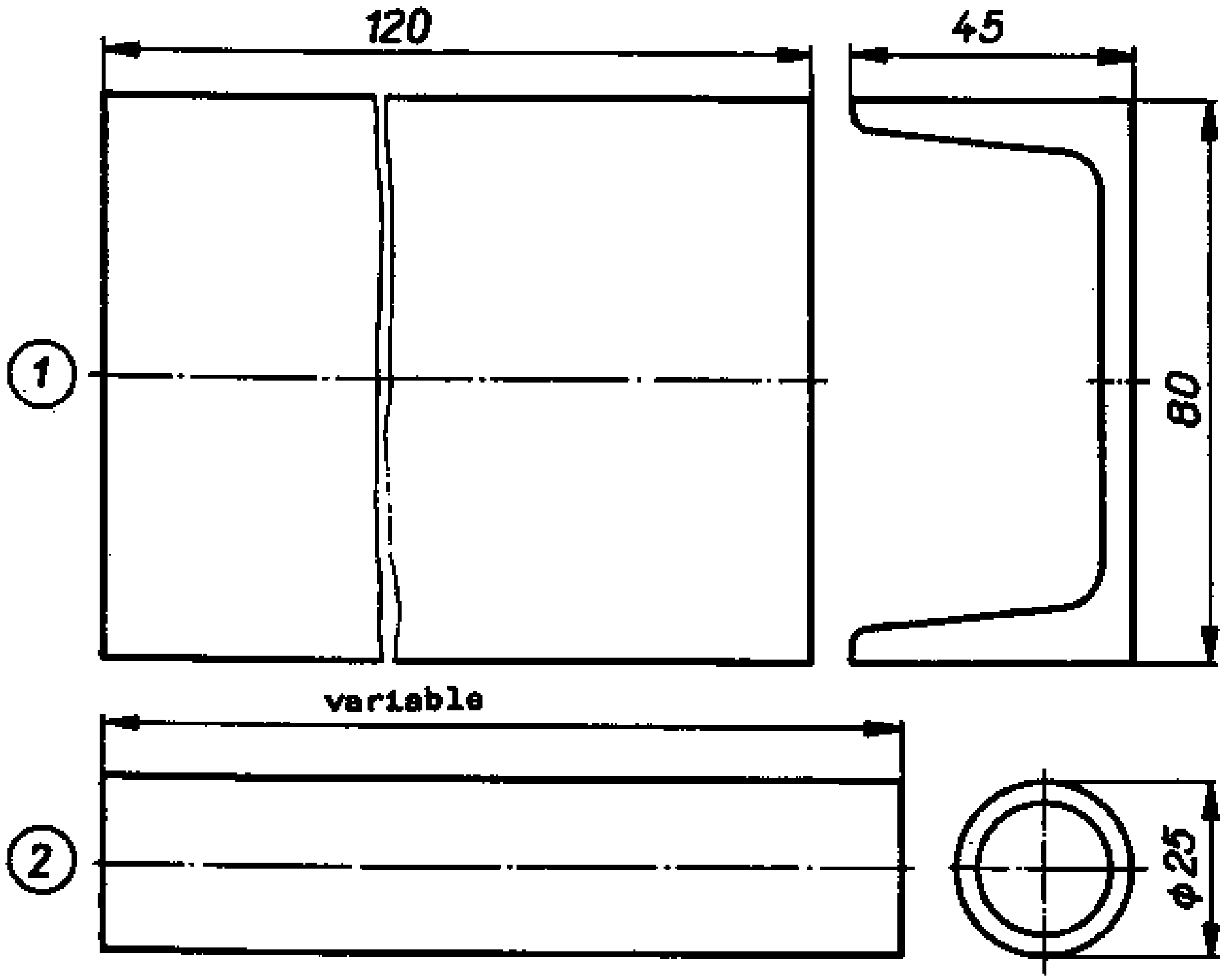
3. Clamp workpiece in vice at web using suitable attachment and file guiding kerf at upper face (flange).	
4. Saw until upper face (flange) is cut off, then re−clamp and saw web, then re−clamp and saw off other flange, remove burrs.	– Use total length of saw blade.
5. Clamp steel tube in vice in horizontal position using Vee−shaped attachment. Scribe length as specified and file guiding kerf.	– Length to be specified by the instructor.
6. Saw until saw blade cuts off inner wall, then slightly turn tube and continue sawing.	– Part (2)
7. Saw off the tube constantly turning it.	
8. Final inspection.	– Straightness of cut.

To continue practising, if necessary

Prepare several U−sections for different drill stands (training examples 2.3 and 7.4).

Saw off additional tubes for supports (training example 4.6).





				4.2.
9	Stands and supports			3104

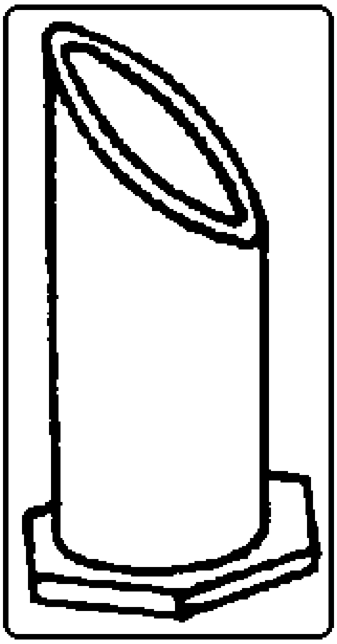
Instruction example 4.5. Container

To practise mitre cuts on tubes and sheets of steel or light metal to specified size.

Material

– Steel or aluminium tube
45 dia. x 100 mm long
(wall thickness 2.5 mm).

– Steel sheet or aluminium sheet
Thickness: 4 mm
Width: 70 mm
Length: 70 mm.



Hand tools

Steel scriber, mark–out punch, engineers' hammer, dividers, hand hacksaw, smooth–cut file 200 mm (half–round).

Measuring and testing tools

Steel measuring tool, protractor, try square.

Accessories

Vice, Vee–shaped attachment to suit tube diameter, surface plate, cutting oil.

Required previous knowledge

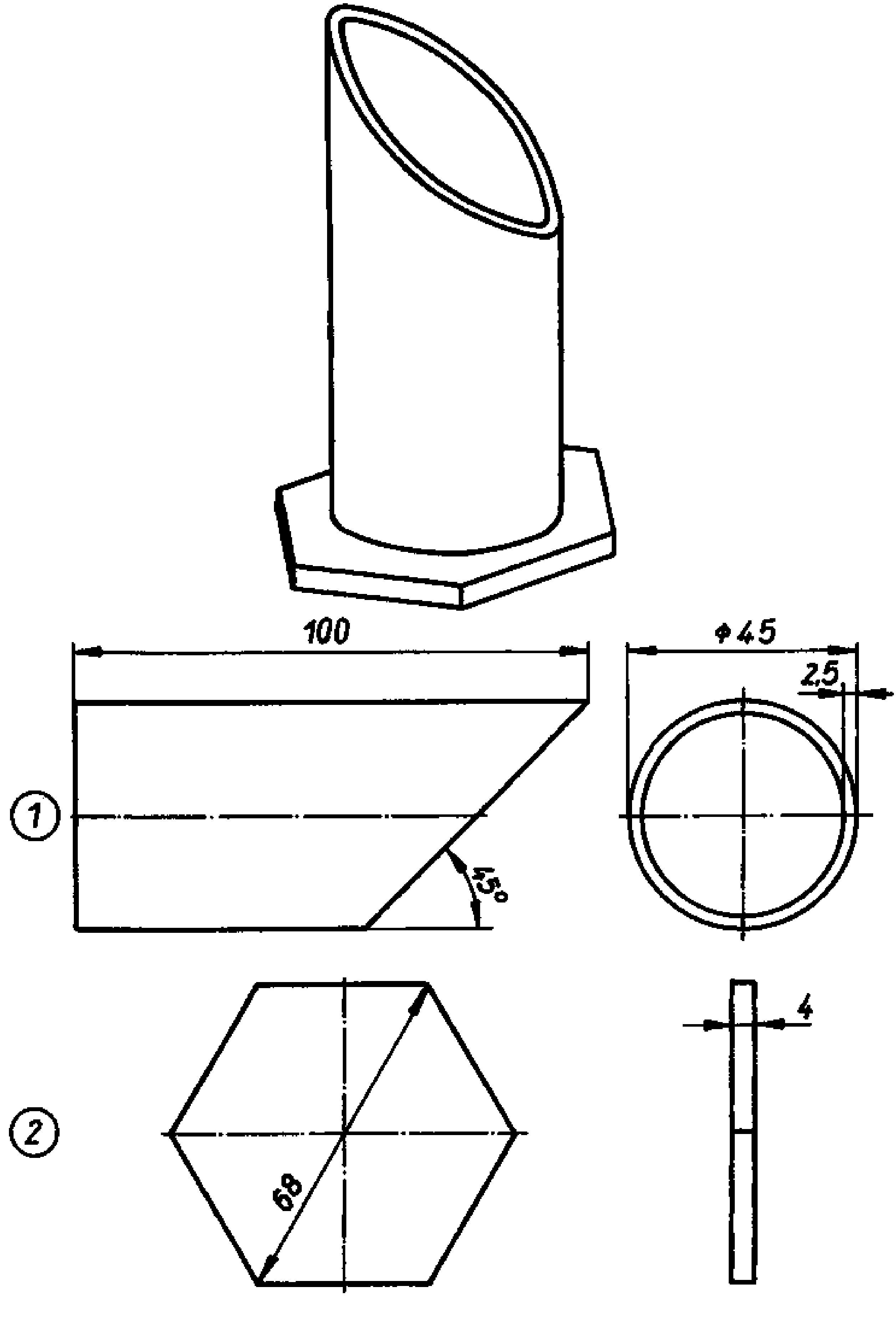
Reading of drawings, measuring and testing, scribing and prick–punching.

Sequence of operations	Comments
1. Arrange the working place, prepare the working materials.	– Check for

	completeness.
2. Clamp steel tube horizontally in vice using Vee−shaped attachment, scribe one end face with protractor (45° setting) and steel scriber.	– Part (1)
3. File guiding kerf and saw off tube in one pass, remove burrs (inside and outside).	– Provide saw blade with cutting oil.
4. Scribe 100 mm length and saw off other face end with straight cut (check with try square), remove burrs*	
5. Prick−punch sheet at centre, use punch mark as supporting point for dividers and draw circle of 68 diameter. Use same setting of dividers to mark step by step the six points on the circle, connect such points.	– Part (2)
6. Clamp sheet vertically in vice and saw at scribed line, remove burrs.	– Use small starting−cut sawing angle!
7. Final inspection.	– Dimensions and straightness of cut.

Completion

Glue, solder or weld tube onto metal sheet.



				4.3.
13	Container			3104

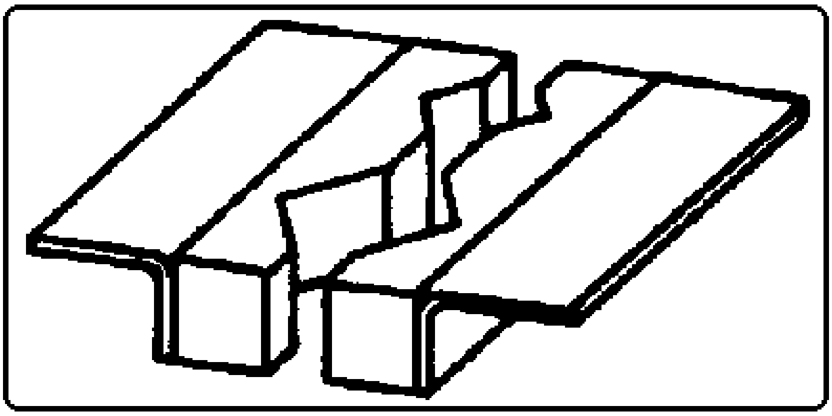
Instruction example 4.4. Vee−shaped attachment

To practise straight long cuts on sheet metal and angular cuts on solid square bar steel.

Material

− 2 x sheet steel (380 MPa)
Thickness: 2.5 mm
Width: 85 mm
Length: 125 mm

− 2 x square bar steel (420 MPa)
Thickness: 30 mm
Length: 125 mm



Hand tools

Steel scriber, mark−out punch, engineers' hammer, aluminium hammer, hand hacksaw (saw blade with normal tooth pitch), smooth−cut file 250 mm (flat).

Measuring and testing tools

Steel measuring tool, protractor, try square.

Accessories

Vice, surface plate, cutting oil.

Required previous knowledge

Reading of drawings, measuring and testing, scribing and prick−punching.

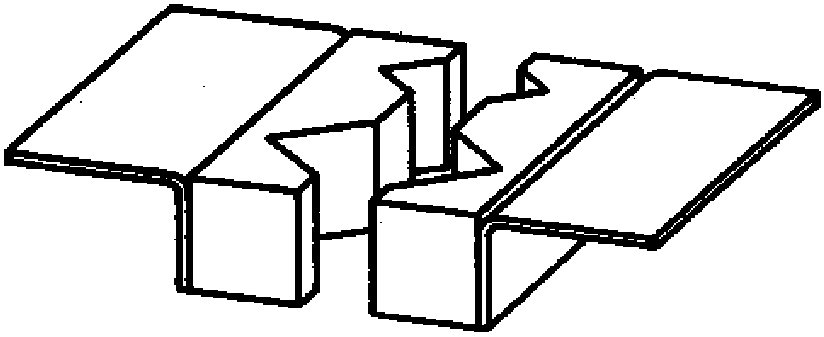
Sequence of operations	**Comments**
1. Arrange the working place, prepare the working materials.	− Check for completeness.
2. Scribe sheet steel and saw to length and width, smooth edges with file.	− Part (1) Check for squareness (try square).
3. Saw square bar steel to length, smooth and face with file.	− Check for squareness.
4. Scribe, prick−punch and saw out angles.	− Part (2)

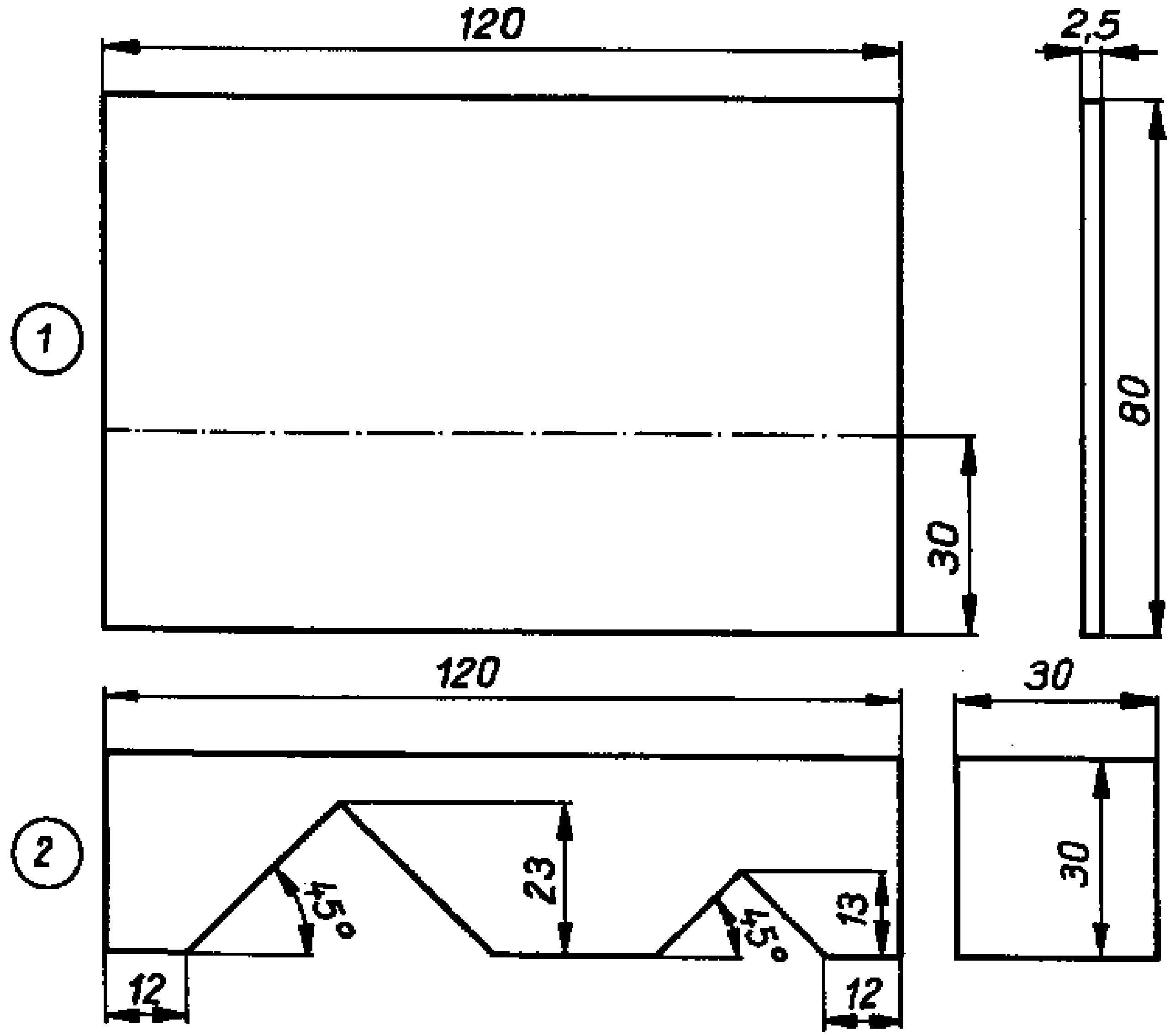
	Provide saw blade with
5. Smooth inner angle faces with file, chamfer all edges.	cutting oil.
6. Final inspection.	– Dimensions, appearance.

<u>Completion</u>

Connect sheets with square steel by screwing or rivetting
(to be specified by the instructor).

Clamp parts in vice and bend sheets by hammering with aluminium hammer.





				4.4.
17	Vee-shaped attachment			3104

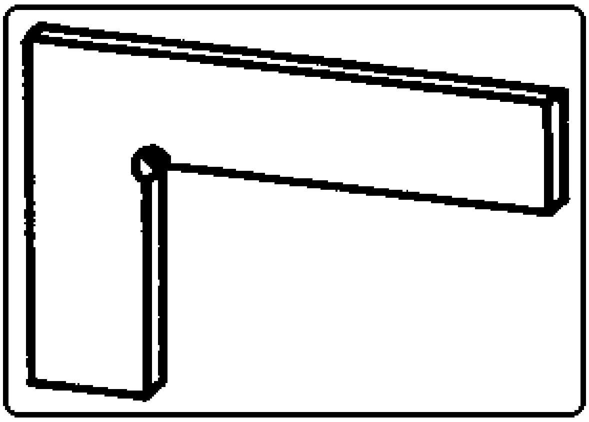
Vee−shaped attachment

Instruction example 4.5. Steel square

To practise straight long sawing cuts of high precision on sheet steel.

Material

Sheet steel (higher−strength or hardenable steel)
Thickness: 5 mm
Width: 80 mm
Length: 120 mm



Hand tools

Steel scriber, prick punch, engineers' hammer, 4 mm dia. drill, hand hacksaw (saw blade of normal tooth pitch), smooth−cut file 250 mm (flat).

Measuring and testing tools

Steel measuring tool, try square.

Accessories

Vice, surface plate, copper sulphate solution, cutting oil.

Required previous knowledge

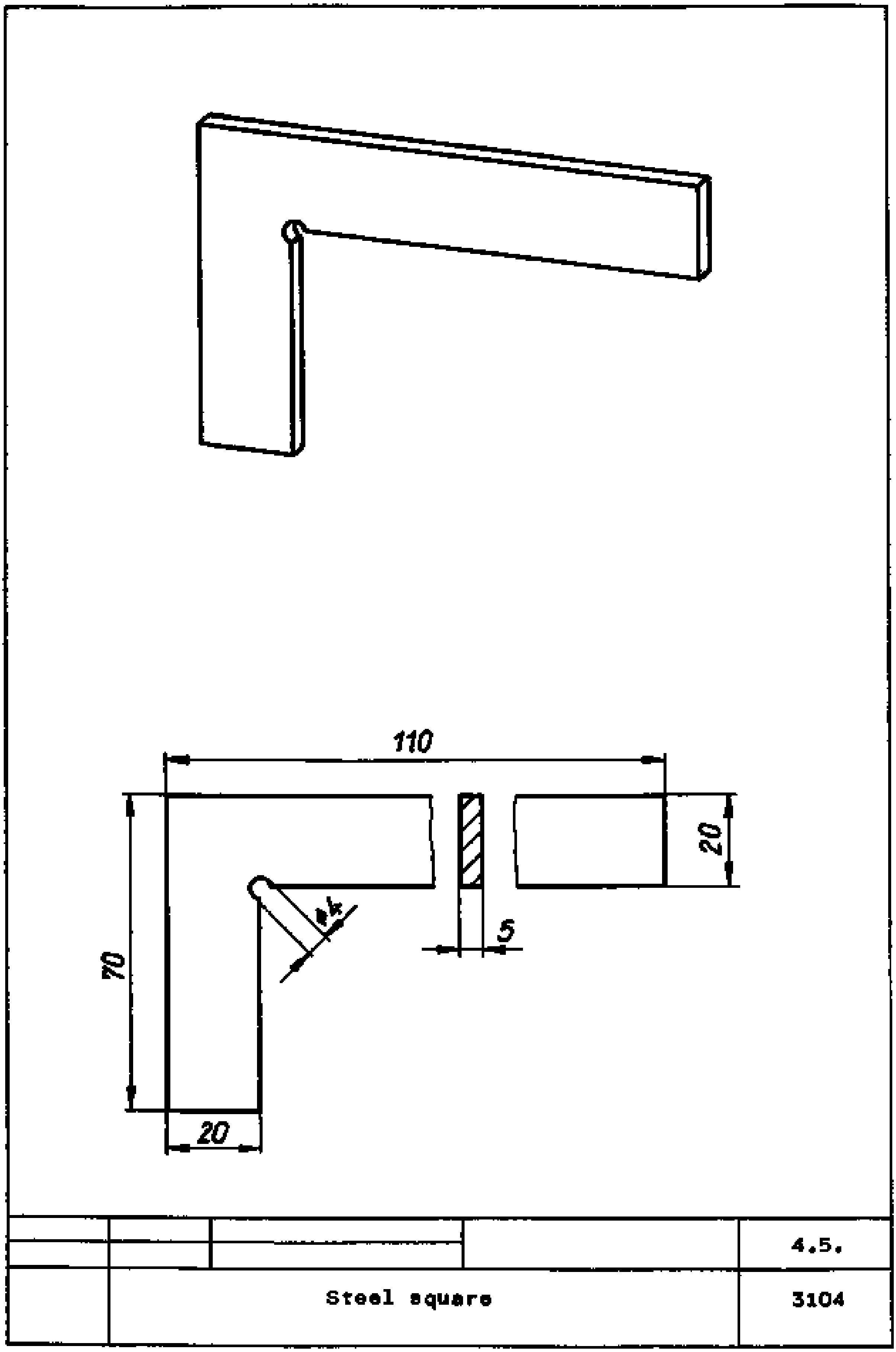
Reading of drawings, measuring and testing, scribing and prick−punching.

Sequence of operations	**Comments**
1. Arrange the working place, prepare the working materials.	− Check for completeness.
2. File steel sheet at one longitudinal side and one end side flat and at right angle to each other to serve as datum edges.	
3. Coat sheet with copper sulphate solution, after drying scribe inside edges and provide with check punch marks.	− Danger! Copper sulphate solution is toxical!
4. Prick−punch point of intersection of inside edges and drill with 4 mm dia. drill, remove burrs.	− 1400 r.p.m. speed Drill under supervision of

	instructor only!
5. Clamp sheet in vice so as to permit vertical sawing cut. At a distance of 1 mm to the scribed line saw out inside edges first and then end faces of the workpiece.	– Provide saw blade with cutting oil.
6. Final inspection.	– Dimensions and straightness of cut.

<u>Completion</u>

Produce final form by filing, check with bevelled edge square, have inside and outside edges hardened.



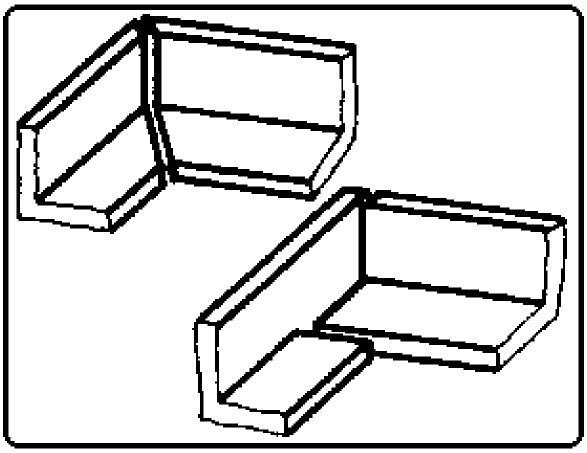
Steel square

Instruction example 4.6. Angle−steel frame table

To practise straight and mitre cuts on angles for angle splices to specified size.

Material

- − Angles of 25 x 25 x 5 thick, length depending on table size.
- − Steel tube of 25 mm diameter, length depending on table size (or to suit training example 4.2.).



Hand tools

Steel scriber, mark−out punch, engineers' hammer, hand hacksaw (saw blade With normal tooth pitch), smooth−cut file 250 mm (flat).

Measuring and testing tools

Measuring tape, try square, protractor or centre square.

Accessories

Vice, whiting, cutting oil

Required previous knowledge

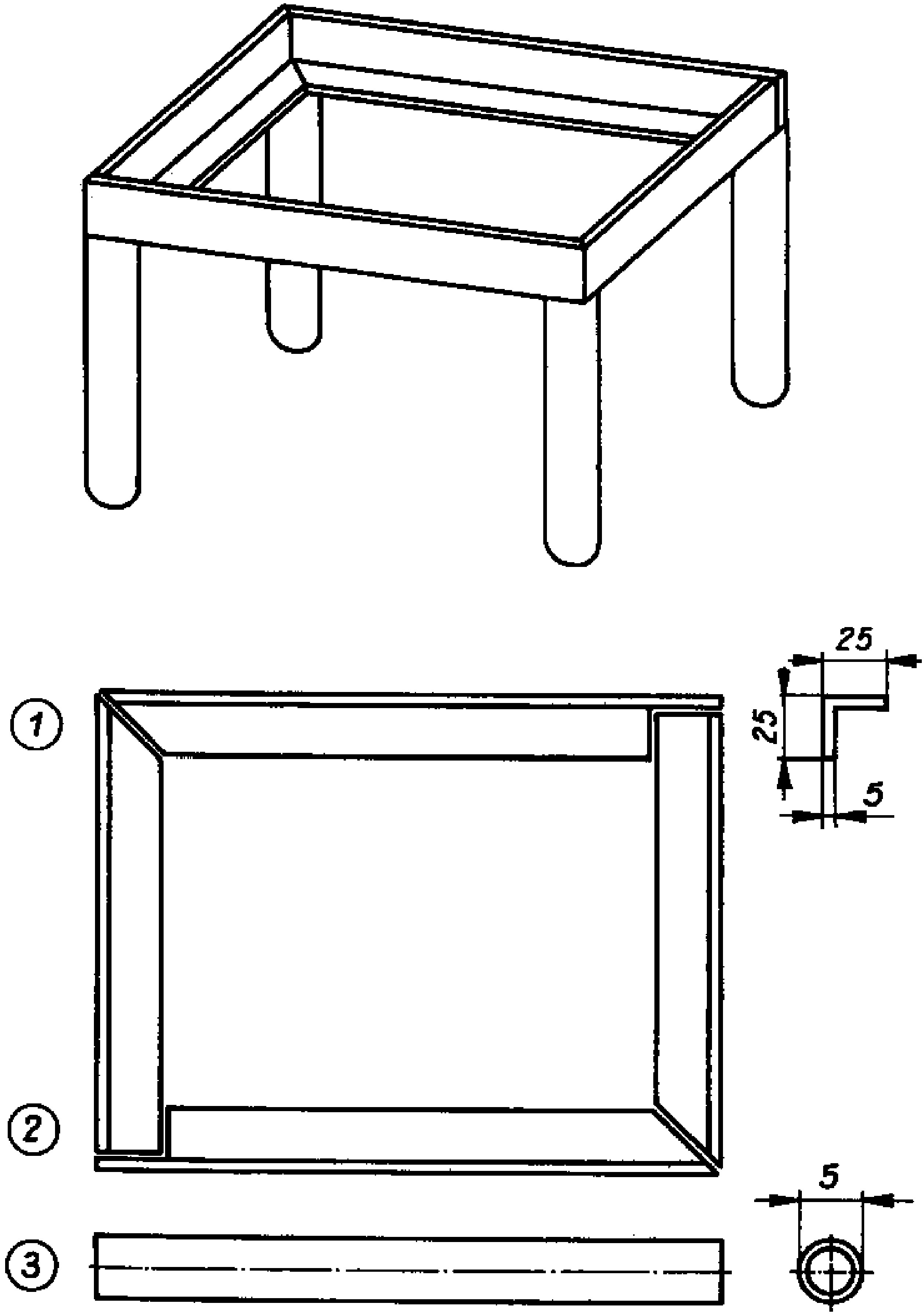
Reading of drawings, measuring and testing, scribing and prick−punching.

Sequence of operations	**Comments**
1. Arrange the working place, prepare the working materials.	− Check for completeness.
2. Saw 4 angles roughly to specified length (5 − 10 mm longer than specified).	− Length to be specified by the instructor.
3. Coat all end faces with whiting after drying scribe and prick−punch the 45° angle for the mitre cut, saw the mitre.	− Stage (1) Scribe on the outside face.
4. Scribe the exact length from the mitre side, mark and prick−punch the cutout (square)/straight cut at this end face.	− Stage (2) Mitre cut, cutout and straight cut to be specified as per drawing (straight cut to be scribed outside, cutout to be scribed inside)
5. Saw 4 steel tubes to specified length (depending on table height), constantly turn the tubes while	− Stage (3)

sawing 1	
6. Final inspection.	– Quality of mitre cut and straight cut.

Completion

Deburr the cut edges, put individual parts together and have them welded together. Insert a steel plate or wooden plate.



		4.6.
	Angle-steel frame table	3104

Instruction example 4.7. Wall−shelf bracket

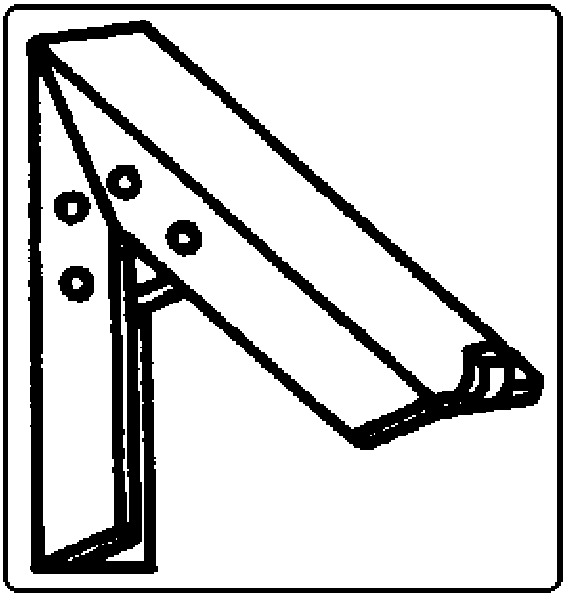
To practise mitre cuts with increased level of difficulties and bevel cuts and cutouts on angles.

Material

− Unequal−leg angles of any steel 20 x 30 x 4 thick, approx. 1000 mm long.

− Sheet steel
70 x 70 x 2.5 thick.

− 4 button−head rivets
4 mm diameter
(of copper or aluminium).



Hand tools

Steel scriber, mark−out punch, engineers' hammer, hand hacksaw (saw blade with normal tooth pitch), 4.1 mm dia. and 5.5 mm dia. drills, 75° countersink, smooth−cut file 250 mm (flat).

Measuring and testing tools

Steel measuring tool, try square.

Accessories

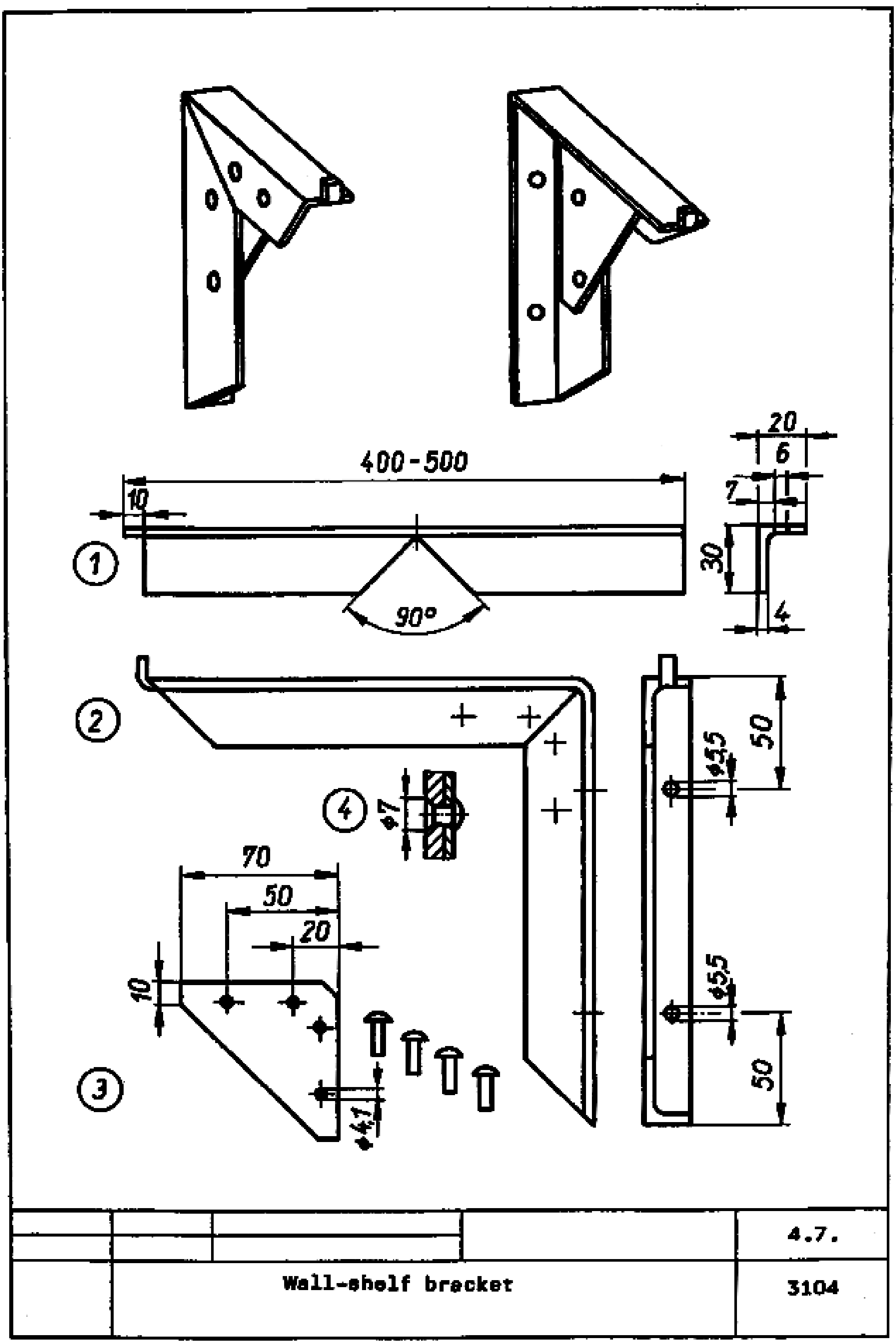
Vice, surface plate, levelling plate, rivet set for 4 mm dia. rivets, rivet header for 4 mm dia. rivets, pin vice.

Required previous knowledge

Reading of drawings, measuring and testing, scribing and punch−marking.

Sequence of operations	Comments
1. Arrange the working place, prepare the working materials.	− Check for completeness.

2. Scribe the angles and saw to initial length. Saw out the pivot at one end face 6 x 10, remove burrs with the file.	– Determine length by width of shelf! – Note: left–hand and right–hand wall–shelf bracket.
3. Scribe centre and 90° mitre angle (inside), saw out the angle, remove burrs.	– Stage (1) Clamp angle so that sawing cut will be vertical!
4. Bend the angle in the vice by means of the engineers' hammer, bend the pivot (upward).	– Stage (2) Check for right–angularity by means of try square.
5. Saw out the steel sheet to specified size, remove burrs.	– Stage (3)
6. Inspection of cuts.	
<u>Completion</u> – Scribe holes on steel sheet, prick–punch and drill with 4.1 mm dia. drill.	– Drill under supervision of the instructor with steel sheet clamped in pin vice. Speed: approx. 1400 r.p.m.
– Insert the drilled sheet inside the bent angles and prick–punch the angles through the holes of the sheet, drill with 4.1 mm dia. drill.	– Use sheet as stencil!
– Scribe and prick–punch the 5.5 mm dia. holes, drill all scribed holes.	– Pay attention to specified sizes!
– Countersink 4.1 mm dia. holes from the outside of the angles with 75° countersink.	– Speed: approx. 350 r.p.m. Countersink diameter: 7.0 mm
– Clamp angle and sheet together in pin vice, then rivet together	– Stage (4)



Wall–shelf bracket

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

Table of Contents

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

Institut für berufliche Entwicklung e.V.
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1. Purpose of sawing

Sawing is cutting of workpieces in a narrow kerf by many chisel−type teeth on a saw blade arranged one after the other for the purpose of cutting off or of providing workpieces with slots or recesses.

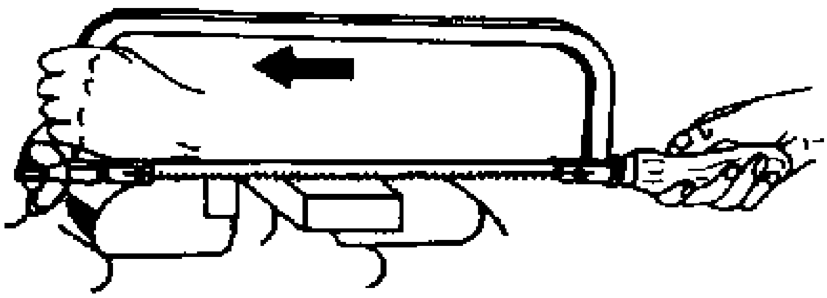


Figure 1 Sawing

Manual sawing is used only in single−piece production and repair work on small−section workpieces because it is hard and time−consuming manual work.

For bigger cuts hacksawing, circular sawing (slitting) and band sawing machines are used.

2. Sawing tools

Tools for sawing are saw blades with teeth on one or two edges which are clamped in a hand hacksaw frame.

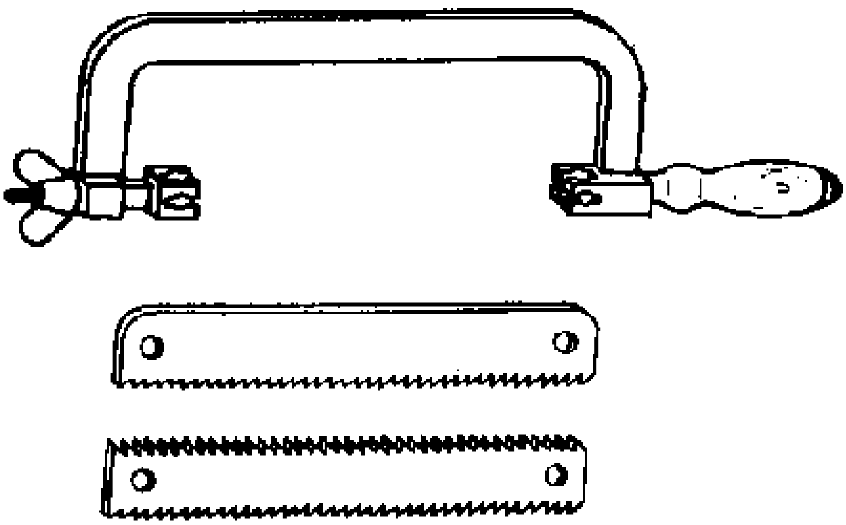


Figure 2 Hand hacksaw and saw blades

Different types of saw blades are used depending on the hardness of the material to be cut and on the type of cross−section of the workpiece.

The blades differ with respect to the saw tooth angles and the number of teeth on a fixed length of 25 mm (tooth pitch – 1).

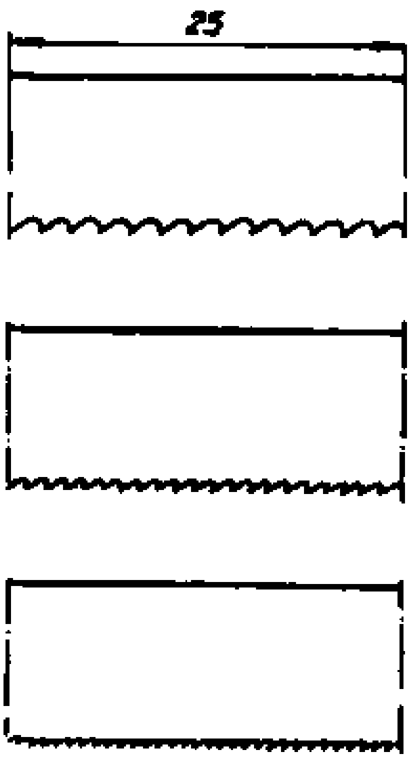


Figure 3 Saw blades with different tooth pitch

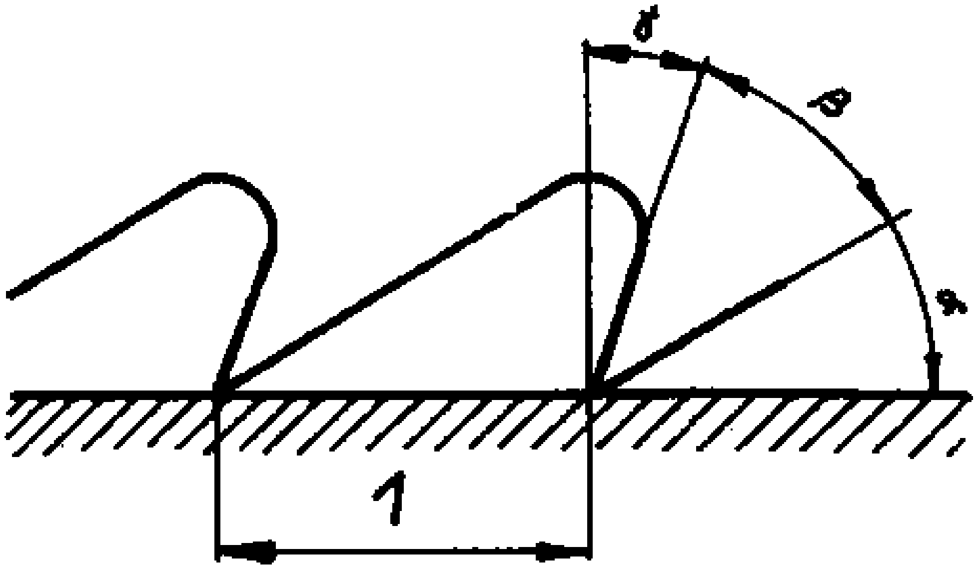


Figure 4 Angles at the saw tooth

Saw blades for different hardness of material:

Hardness of material	Formation of chips at the saw tooth	Clearance angle (?)	Lip angle (?)	Rake angle (?)
Hard	Shaving –small quantity of chips	40°	50°	0°
Normal	Cutting –small quantity of chips	20°	65°	5°
Soft	Cutting –big quantity of chips	30°	50°	10°

Saw blades for different workpiece cross–sections and hardness of material

Type of saw blade	Cross–section of workpiece	Hardness of material	Tooth pitch (number of teeth on 25 mm)
Coarse	– Solid Sections (rounds, squares, hexagons)	Soft steel, brass and bronze	14
Normal	– Normal sections (angles, sectional steel) – Thick metal sheets	Steel of normal hardness, harder light metals	22
Fine	– Light–steel sections – Thin metal sheets	Harder steel, cast iron	32

Free cutting action of saw blades

Saw blades must not jam when penetrating into the kerf, therefore the width of the kerf must be bigger than the thickness of the saw blade.

Free cutting of the saw blade is achieved by:

– raker–set teeth or
– wave–set teeth of the saw blade.

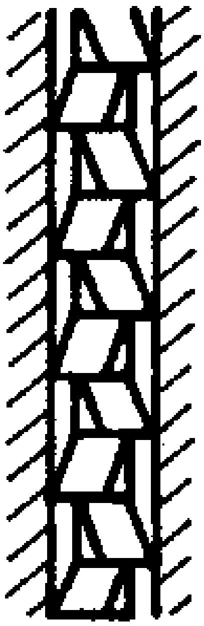


Figure 5 Raker−set teeth

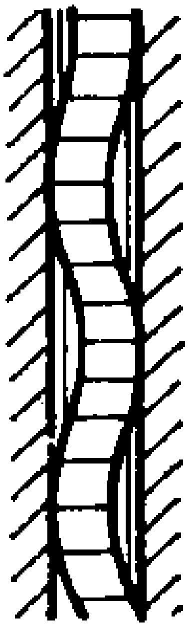


Figure 6 Wave−set teeth

After long use of saw blades the teeth will become dull and the free cutting facilities will also wear out.

Therefore, it is often not sufficient to sharpen the saw blade but restoring the free cutting facilities will also be necessary.

What makes the difference between the different types of saw blades?

____

Which type of saw blade is used for sawing of steel of normal hardness?

____

Why is the free cutting action necessary for saw blades?

____

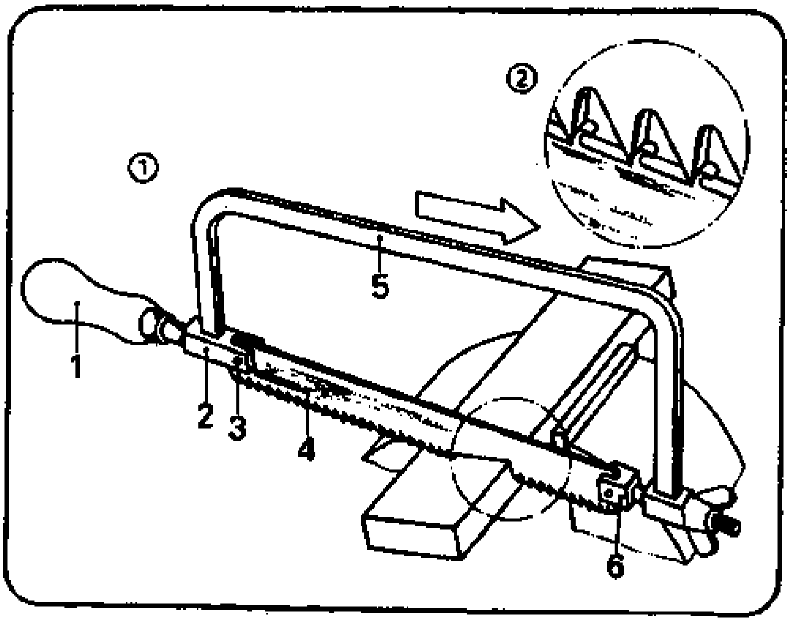
3. Auxiliary means for sawing

Auxiliary means for sawing are clamping devices which are to be selected according to the purpose of clamping the relevant cross–section of the workpiece.

Requirements:

The workpiece is to be clamped so that the sawing cut is always vertical.

The workpiece is to be clamped as firmly and deeply as to eliminate any springiness and displacement of the workpiece during sawing.



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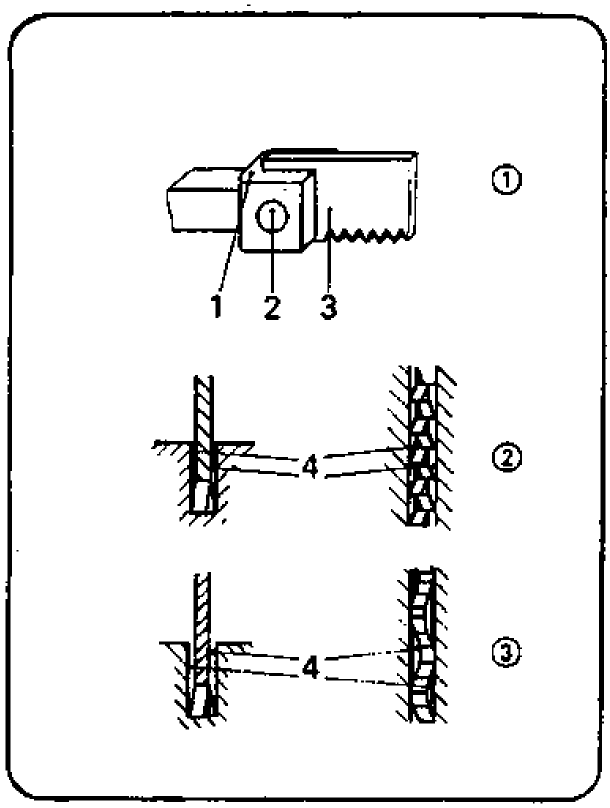

6.2

The following surveys should support the introduction to saw blades:

Saw blades for different material hardness

Hardness of material	chip formation	angle of clearance	wedge angle	rake angle
hard	shaving – small amount of chips	40°	50°	0°
normal	cutting – small amount of chips	20°	65°	5°
soft	cutting – large amount of chips	30°	50°	10°

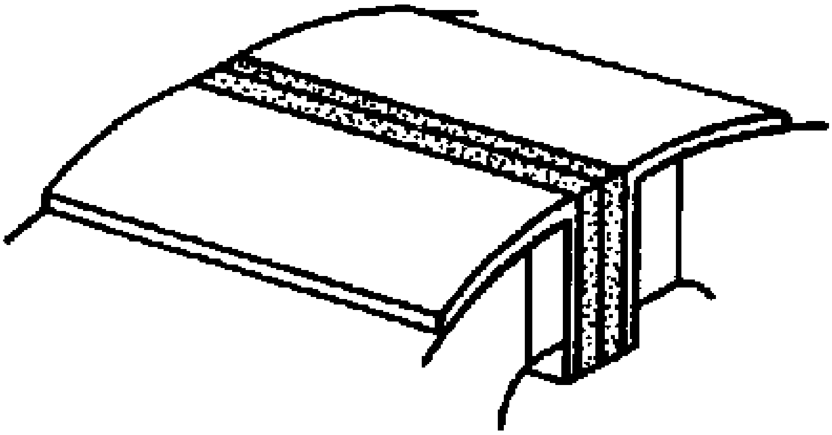

Figure 10 Protective jaws

Which requirements must be met when clamping workpieces for sawing?

____

What is the most important auxiliary means for clamping of workpieces?

____

4. Operation of sawing

When pressing the saw blade onto the workpiece and vigorously pushing it at the same time, the teeth are cutting into the material removing chips.

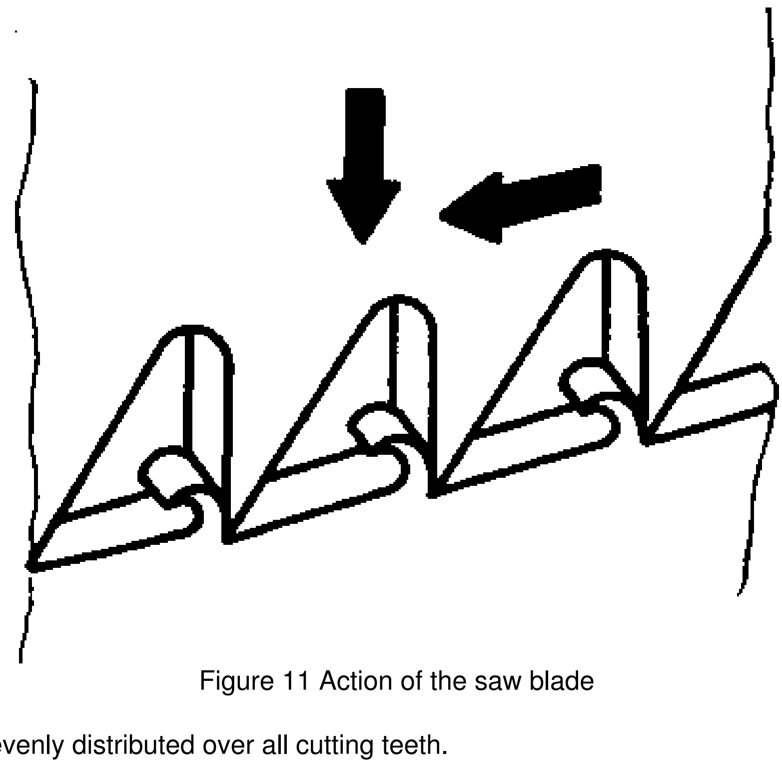

Figure 11 Action of the saw blade

The force applied is evenly distributed over all cutting teeth.

If only a few teeth are cutting (thin workpieces) there is a danger of hooking and breaking away!

Therefore, the saw is to be guided so that many teeth are cutting at the same time!

5. Standing position and guiding of the saw

Before beginning to saw make sure that the height of the vice is correct and that the workpiece is firmly clamped!

Procedure:

– The weight of the body is resting on one leg while the other leg is always straightened with both feet firmly on the ground.

– The saw is moved with the arms and such movement may be slightly supported by the upper part of the body.

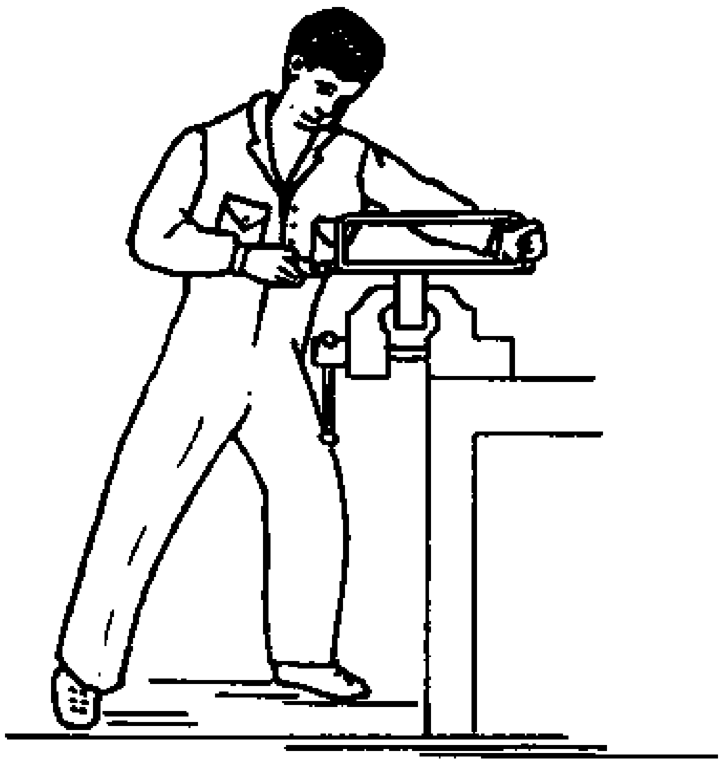

Figure 12 Standing position

– When pushing the saw is pressed onto the workpiece, pulling back is without exerting any pressure!

– Shortly before the workpiece is sawn off the pressure is to be released so as to avoid the workpiece to be pulled away by the saw which might damage the saw blade I

Notes

– The total length of the saw blade is to be utilized when sawing.

– Cutting oil is to be slightly applied to the sides of the sawing blade before use to minimize friction!

– Right–handed persons have to stand on the left of the vice so that the guiding hand will not be pulled over the vice – danger of injury!

Why should the saw be guided so that many teeth are cutting at the same time?

____

What is attention to be paid to when sawing off workpieces?

6. Handling of the saw

The saw blade is to be clamped so that the teeth are showing into the pushing direction.

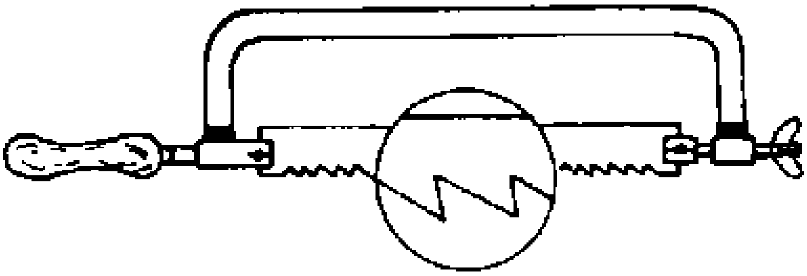

Figure 13 Correctly clamped saw blade

Before starting to saw it is useful to file a guiding groove beside the scribed line so that the saw will not slip off when starting.

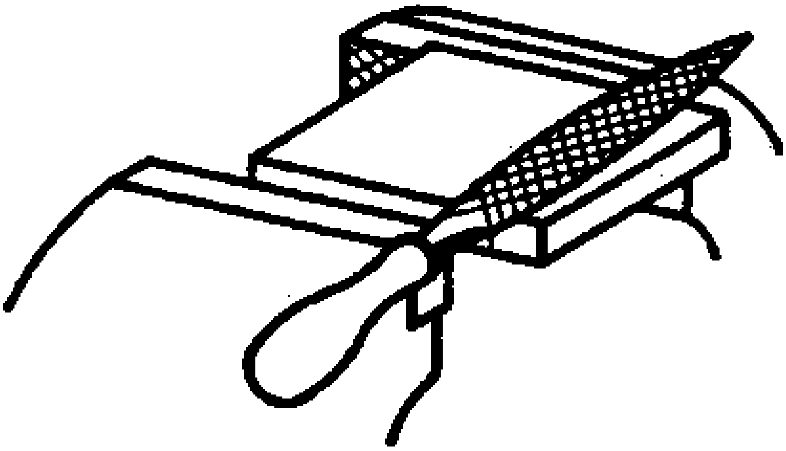

Figure 14 Filing of the guiding groove

Flat workpieces are to be sawn on their wide face. This will achieve better guidance for the saw blade and a more accurate cut since many teeth are cutting at the same time.

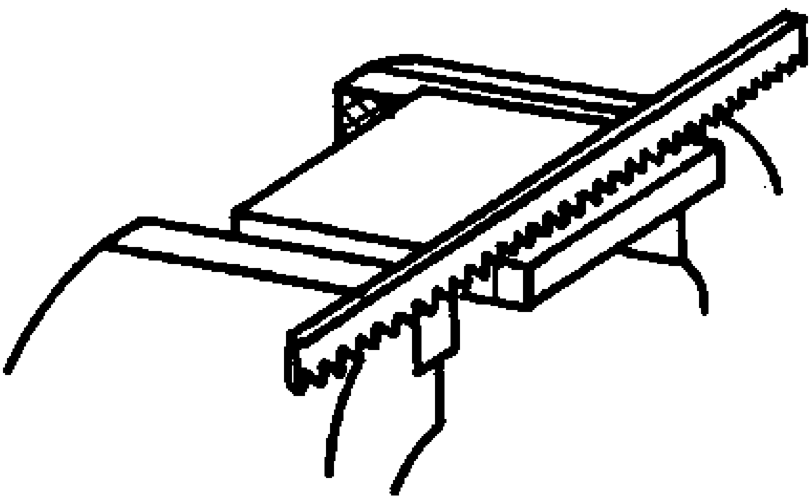

Figure 15 Sawing of flat parts on their wide side

When sawing metal sheets the saw is to be positioned so that the cut in pushing direction will be slightly upwards so that many teeth are cutting at the same time.

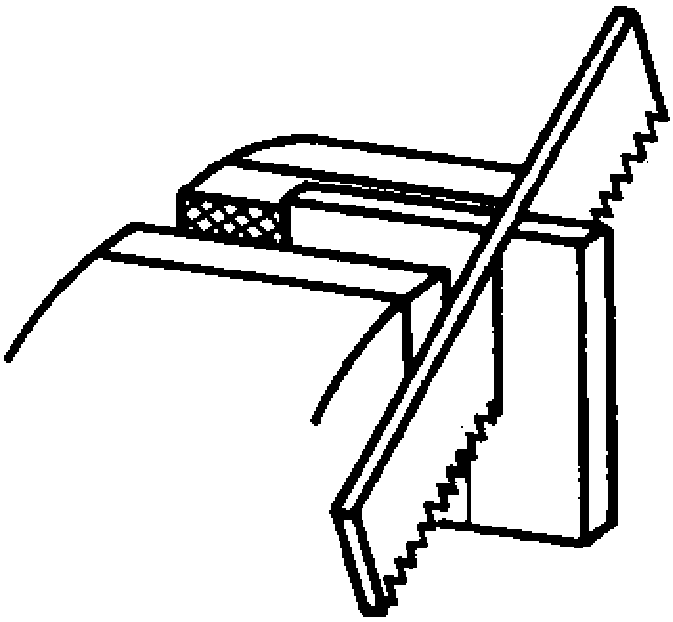

Figure 16 Sawing of sheets in upward pushing direction

Tubes are not be sawn off in one pass because the teeth might hook at the inner tube wall and break away.

Therefore, proceed with sawing until the inner tube wall is reached and then constantly turn the tube in pushing direction while sawing until the tube is sawn off.

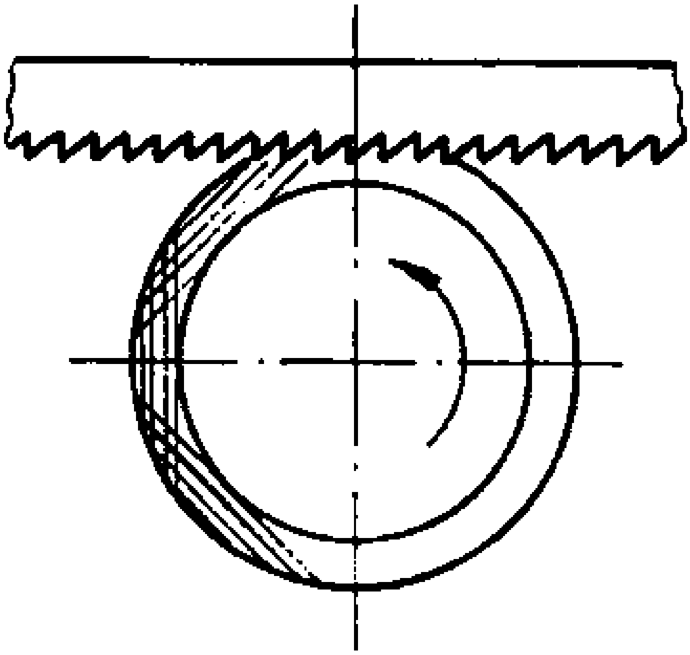

Figure 17 Sawing of tubes with multiple re−clamping

Angle sections are always to be sawn on the wide face which necessitates re−clamping after the first sawing cut.

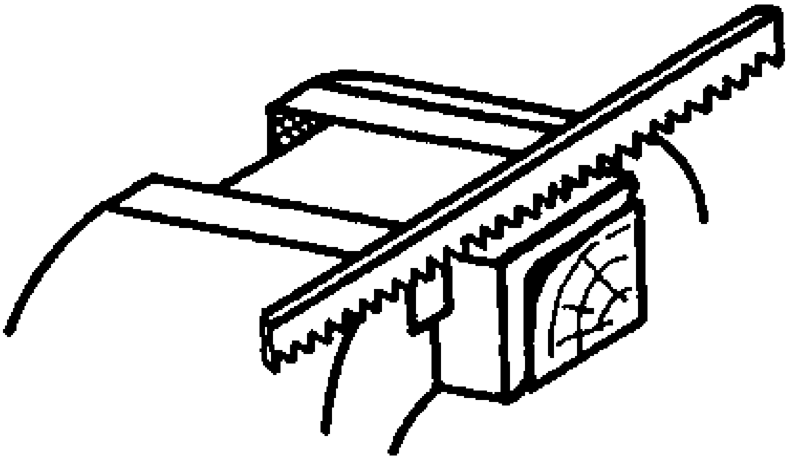

Figure 18 Sawing of angle sections on their wide side

Deep cuts are to be sawn with laterally swivelled frame. Therefore, the saw blade is to be clamped at an angle of 90 degrees compared to the normal position.

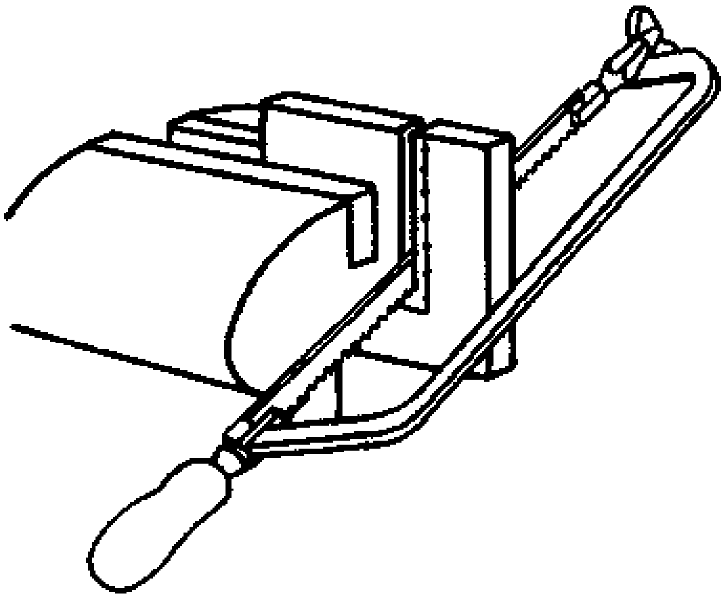

Figure 19 Sawing of deep cuts with laterally swivelled frame

How is the saw to be handled when sawing thin metal sheets?

___

How is the saw to be handled when sawing tubes and sections?

___

7. Labour safety recommendations

– Use hand hacksaws with crackless handle only – otherwise danger of injury!

– Fastening elements of the saw blade roust not protrude at the side of the clamp dog – danger of injury!

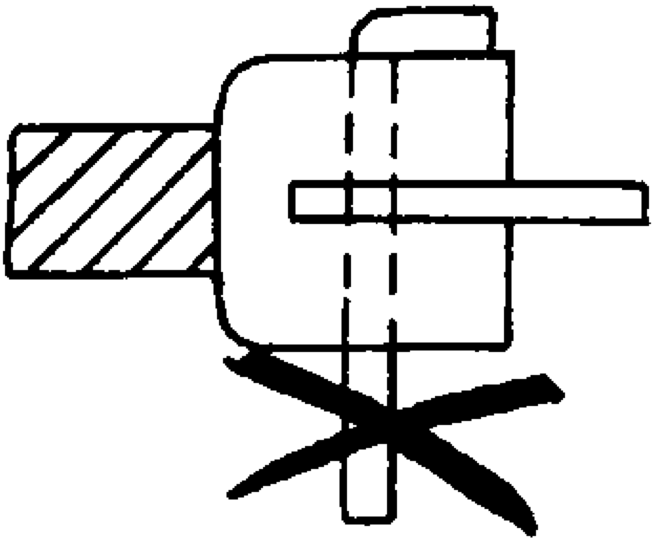

Figure 20 Protruding fastening elements of the saw blade, a source of injuries

– Always guide the saw so as to pass by the vice – never work with the guiding hand above the vice – danger of injury when slipping off!

Marking and Punch Marking – Course: Technique for Manual Working of Materials. Trainees' Handbook of Lessons

Table of Contents

Marking and Punch Marking – Course: Technique for Manual Working of Materials. Trainees' Handbook of Lessons

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

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1. Purpose of marking and punch marking

Marking means laying off the shape and size of a workpiece from data in the manufacturing drawing onto the blank.

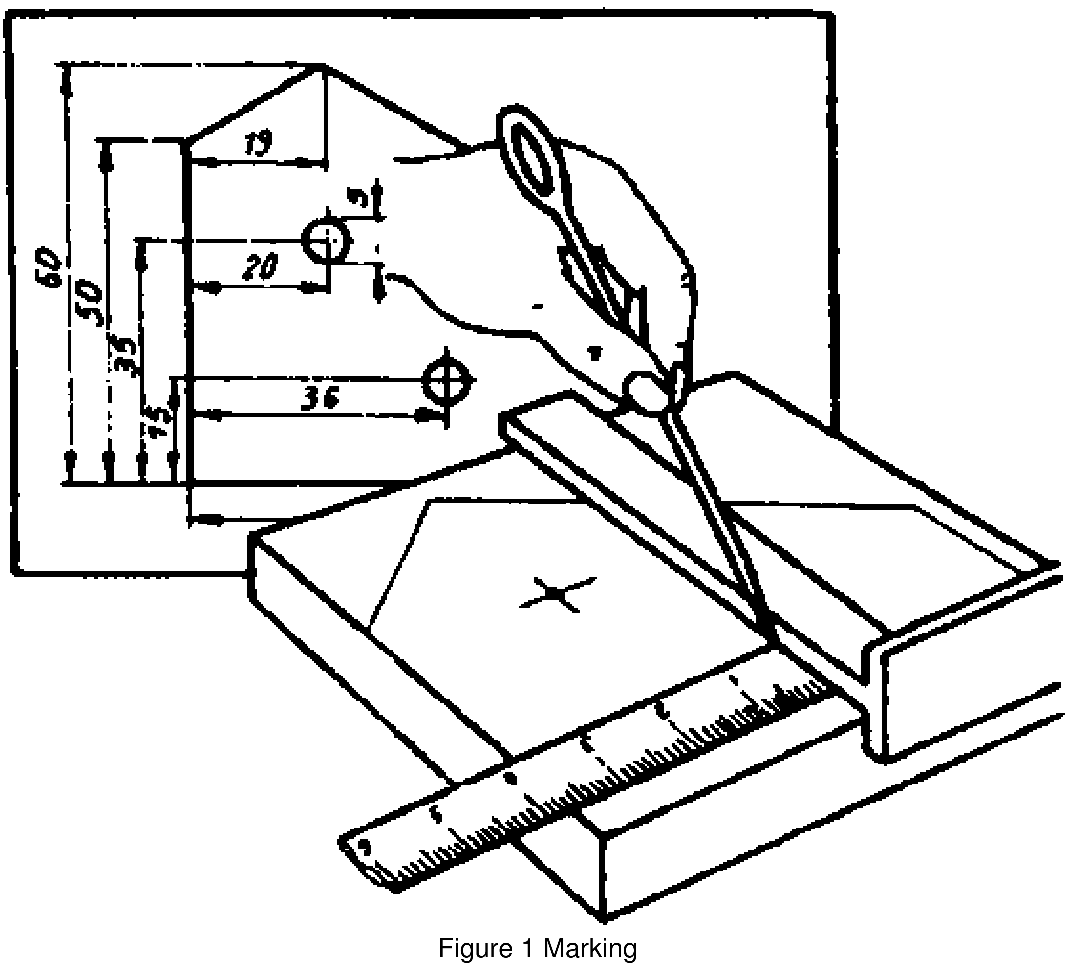

Figure 1 Marking

This is done by scribing, with special scribing tools, lines on the workpiece which must remain visible during the period of manufacture.

Punch marking means impressing conical marks for permanent marking of the scribed lines by means of a special tool – the prick punch. Punch marks are also applied as a guide for dividers points or drills.

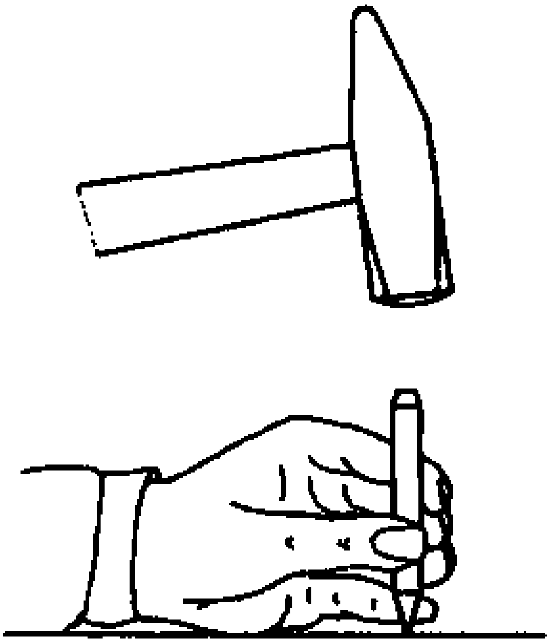

Figure 2 Punch marking

Marking and punch marking are necessary preparatory operations for subsequent working operations, such as cutting, forming and joining in single–piece production.

Careful and accurate scribing, easily visible during the entire manufacturing process is essential for the dimensional accuracy of the finished product.

In batch and mass production, scribing is of minor importance since tools and workpieces are guided so that the required dimensions are necessarily maintained during the working process.

2. Marking tools

Scribed lines are produced by tools which are either slightly notching the surface of the workpiece or leaving a thin line by wearing themselves,

Steel scriber

Widely used scribing tool with hardened or carbide points which are straight or angular. It is used for rough or rough–machined steel parts and leaves a fine notch.

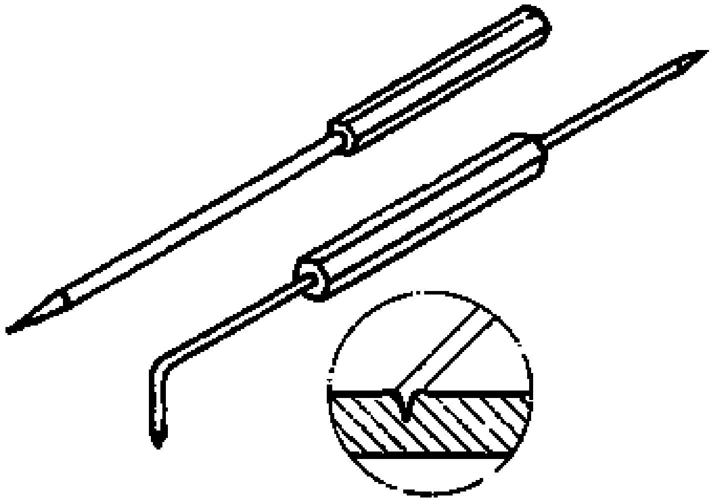

Figure 3 Steel scriber

Notch−sensitive materials and borders of thin sheet metal to be bent must not be scribed with steel scribers.
Risk of breakage!

Brass scriber

Scribing tool of brass wire with filed point. It is used for scribing on finished surfaces only and applied a thin yellow line − no notching effect I

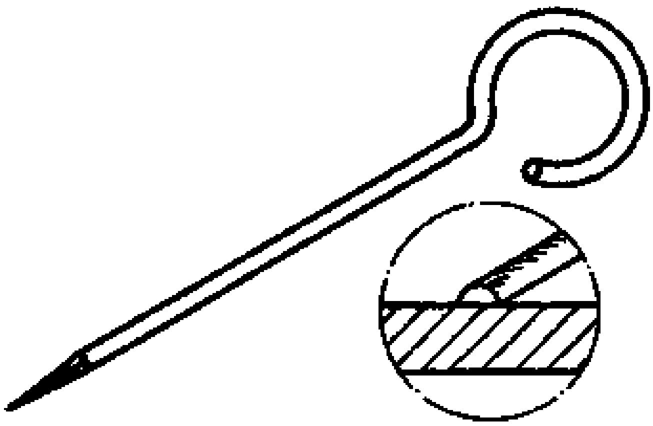

Figure 4 Brass scriber

Soft pencil

Scribing tool for thin, notch−sensitive as well as surface−refined or very soft workpieces. It applies a black line − no notching effect!

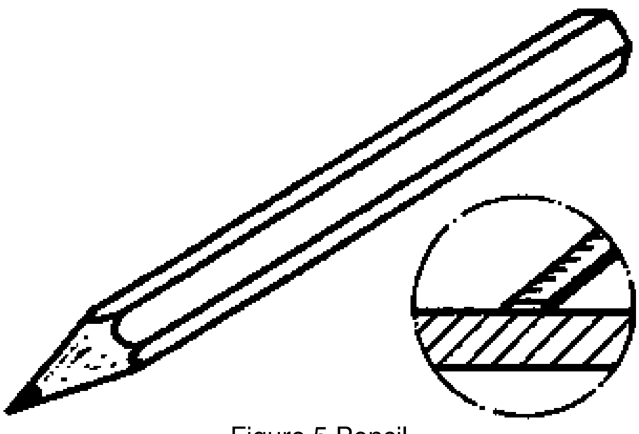

Figure 5 Pencil

Dividers

Scribing tool for scribing circular arcs and curvatures. The use of dividers always necessitates a punch mark for the guiding point. It leaves a fine notch!

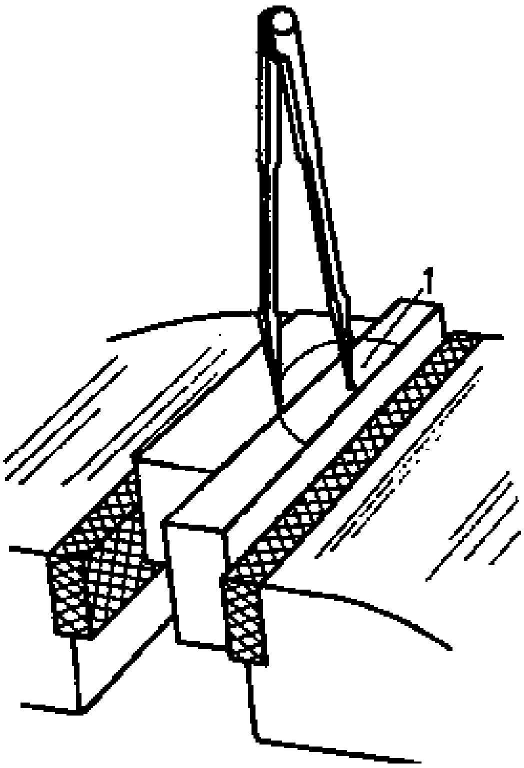

Figure 6 Scribing with toolmakers' dividers using an insert (1)

Customary dividers are toolmakers' dividers with or without lockable legs, tool–makers' dividers with adjustable points for scribing on stepped faces and beam trammels for very big curvatures.

For the use of dividers an insert may be required, if the supporting point is outside the workpiece,

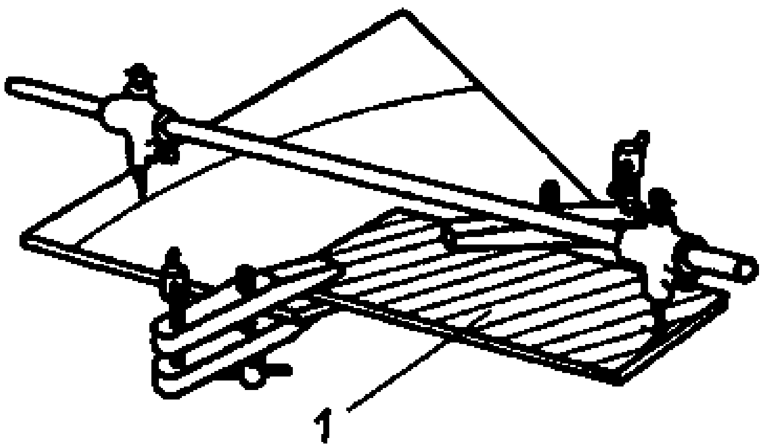

Figure 7 Scribing with beam trammels using an insert (1)

Scribing blocks

Adjustable scribing tools used for scribing of parallel lines along datum faces or edges.

Customary scribing blocks are caliper gauges for quick scribing in the hand and height gauges for extensive or very accurace scribing (0.1 mm measuring accuracy) from a datum plane – the surface plate.

Scribing blocks may have graduations or not.

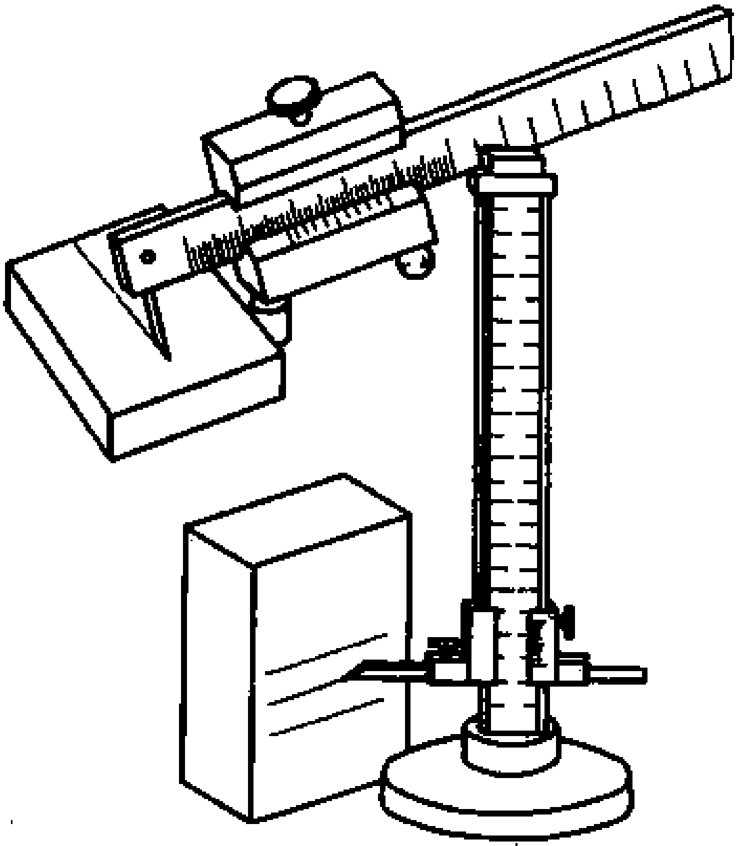

Figure 8 Caliper gauge scriber and height gauge scriber

Scribing of parallel lines necessitates accurately machined datum faces or edges!

Prick punches

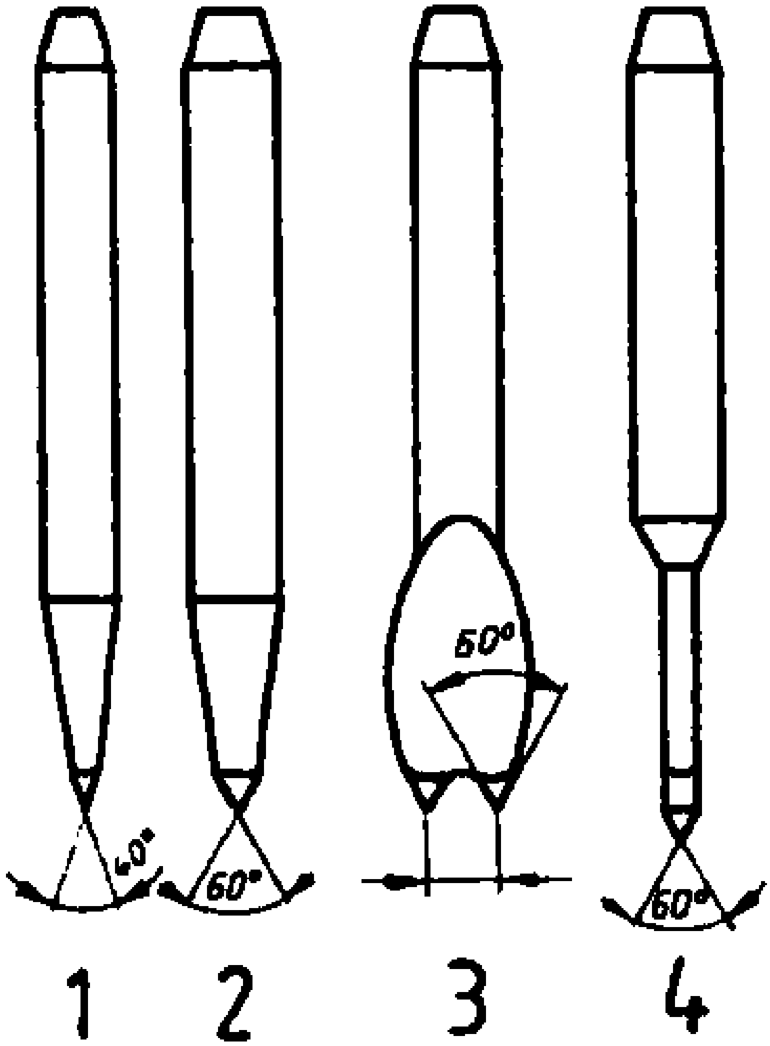

Figure 9 Prick punch types

Tools of various types producing punch marks:

Marking–out punch (1)	– Angle of taper 40°, for prick–punching of scribed lines,
Centre punch (2)	– Angle of taper 60°, to produce punch marks for holes to be drilled.
Double–point punch (3)	– Punch with two points, for symmetric prick–punching of marks for bore lines.
Stencil punch (4)	– Angle of taper 60° with very slender point, for prick–punching of holes to be drilled through stencils.

Which requirements must be met by scribed lines?

____

Which effects must be produced by scribing tools?

____

What makes the difference in the use of steel scribers and brass scribers?

____

Which requirements must be met by workpieces for which scribing blocks shall be used?

____

3. Accessories

Scribing should be done at a clean and well−lighted place. The support must be flat and big enough to permit storing of the workpiece and accessories and scribing without hindrance.

Surface plate

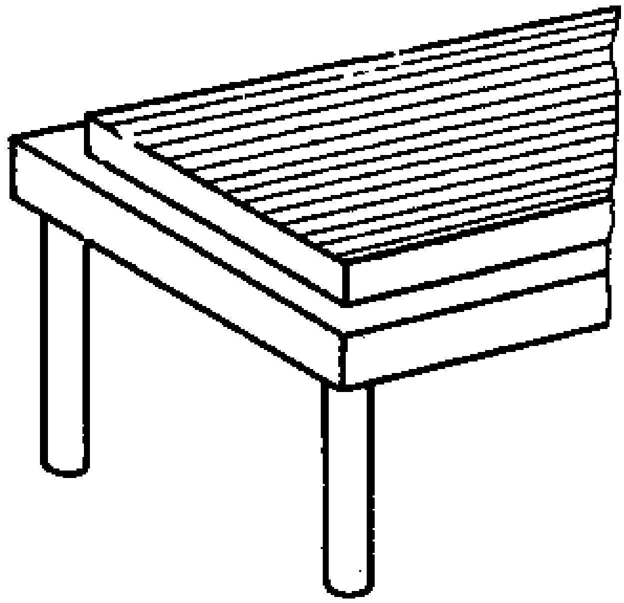

Figure 10 Surface plate

Flat, usually planed cast−steel plate or granite plate used as support for scribing work, preferably with height gauges.

> Note: Surface plates must not be damaged by hammering, chipping or straightening of workpieces.

Angle plate:

Steel angle with flat base and vertical locating face provided with T−slots for clamping of parts by means of locking screws (particularly of parts which don't have datum faces or edges).

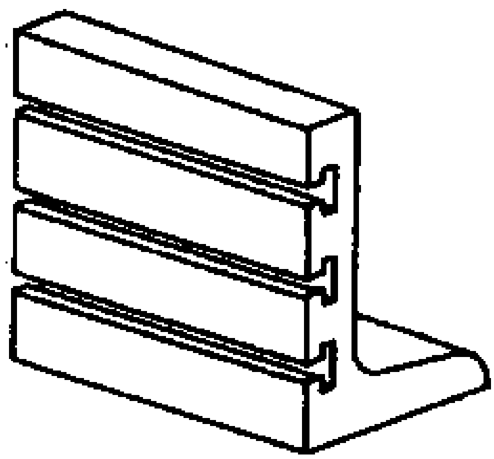

Figure 11 Angle plate

Big steel−parallels

Equally flat testing tools of different sizes used here as support for flat workpieces for scribing with height gauges.

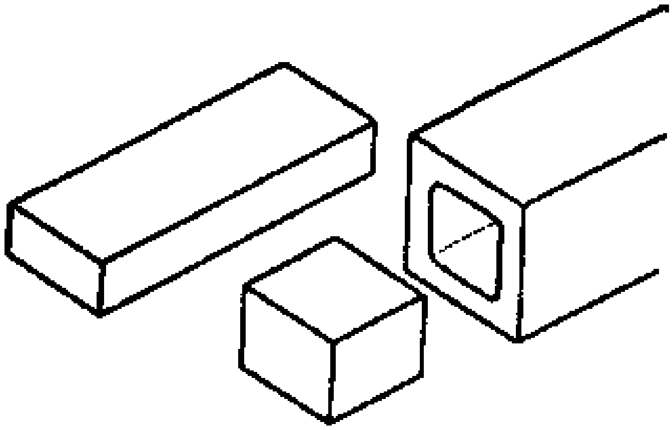

Figure 12 Steel parallels

Vees

Supports for cylindrical workpieces to prevent them from slipping or rolling away.

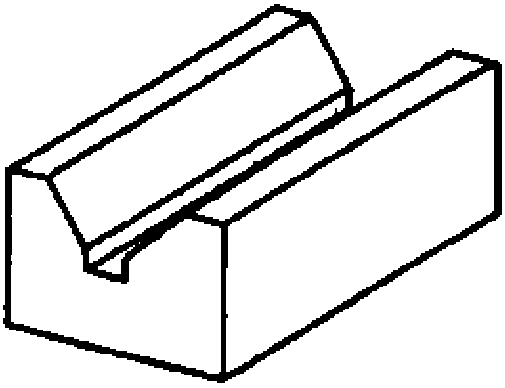

Figure 13 Vees

Stencils

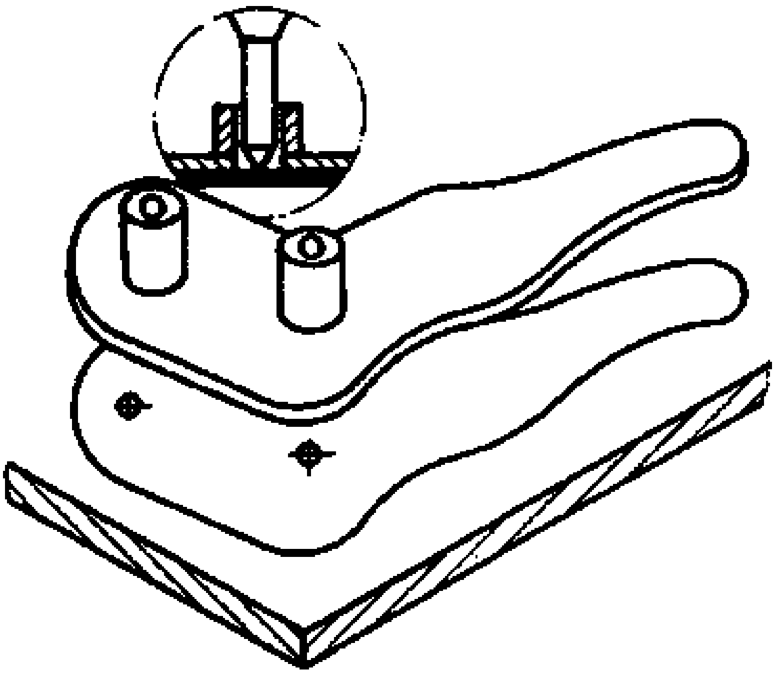

Figure 14 Stencils

Accessories for scribing and prick−punching of larger batches or intricate shapes which eliminate the need for measuring the workpieces shape. Prick−punching is made by means of the stencil punch applied through hardened bushings. Further accessories are measuring and testing tools the design of which permits the scriber to be located and guided, such as: steel gauge, steel straight edge, try square.

T−square and centre square

Special squares for locating cylindrical workpieces to permit scribing of centres or lines on end faces.

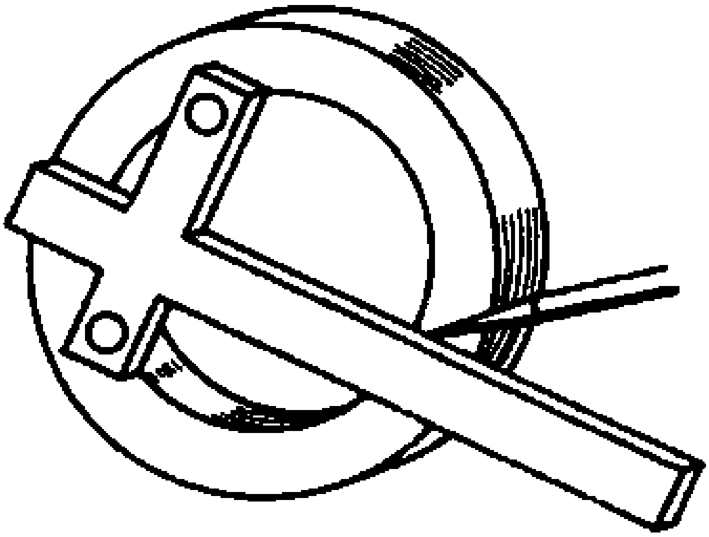

Figure 15 Use of the T−square

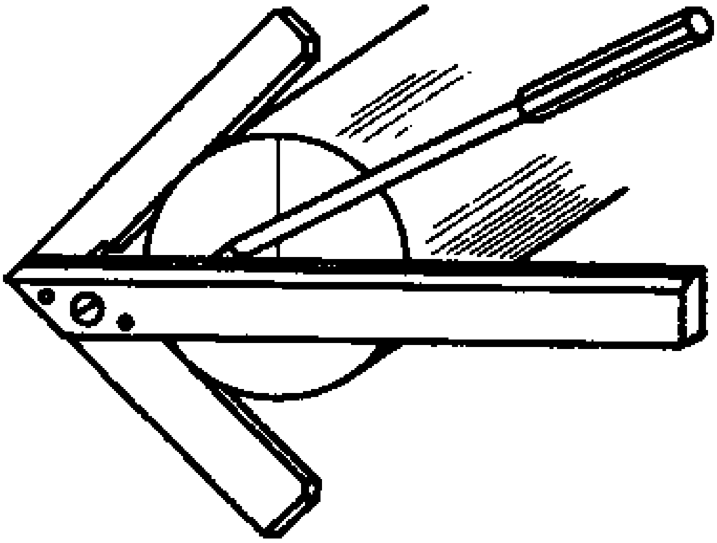

Figure 16 Use of the centre square

Scratch gauges

Adjustable stops permitting the scriber to be guided along flat datum edges or faces. The size is set by means of a steel gauge.

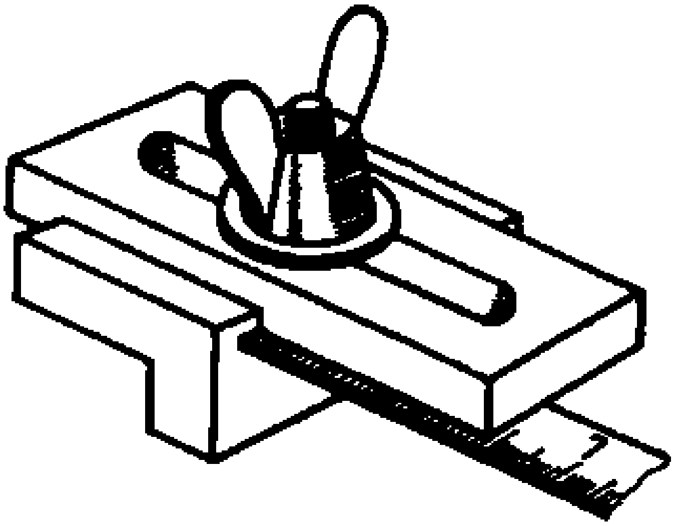

Figure 17 Setting of the scratch gauge

Which requirements must be met by the scribing place?

____

What makes the difference between the use of centre squares and try squares?

____

4. Preparation of the workpiece surface

The condition of some workpiece surfaces does not permit easily visible scribed lines.

Such surfaces must be coated with special paint.

Workpiece surface	**Paint coat**
Rough, big−pore surfaces of castings and forgings	To be coated with whiting mixed in water adding a bit of linseed oil.
Hard and scaled steel parts	To be coated with copper sulphate solution ($CuSO_4$) −danger − toxical!
Big pre−machined surfaces and light metal	To be coated with shellac or scribing varnish.

The workpiece must have pre−scribed lines, pre−machined edges and faces from where further layout out of dimensions can be done with various possibilities of datum:

Datum faces and datum edges

Usually pre−machined faces or edges which are flat and partly perpendicular to other faces or edges. They are used as location for measuring tools or as supporting face on surface plates. When datum faces or edges are used, scribing is mostly done by means of scribing blocks.

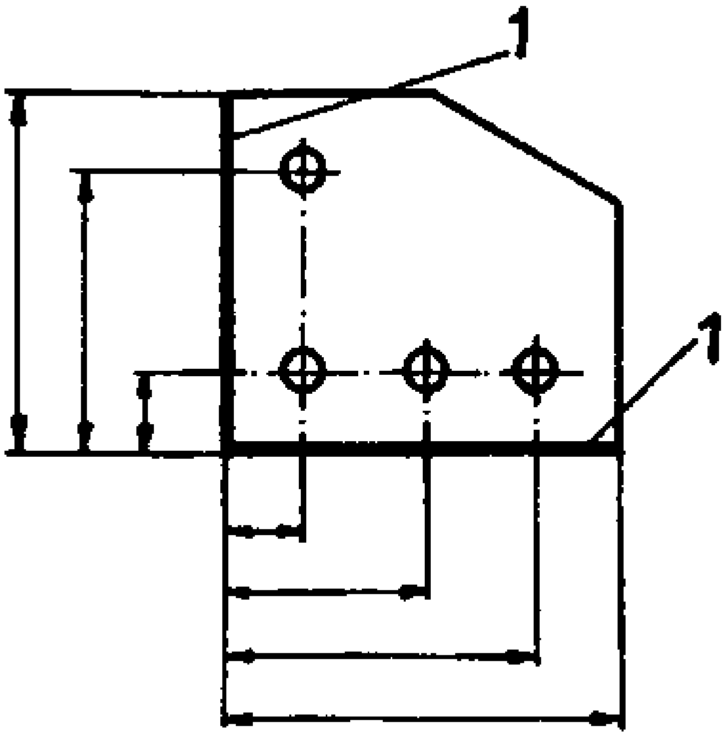

Figure 18 Scribing based on two datum faces or edges

1 datum faces or edges

Datum lines

On symmetrical parts or parts with indefinite shape, lines or centre lines are marked which are used as datum for further scribing.

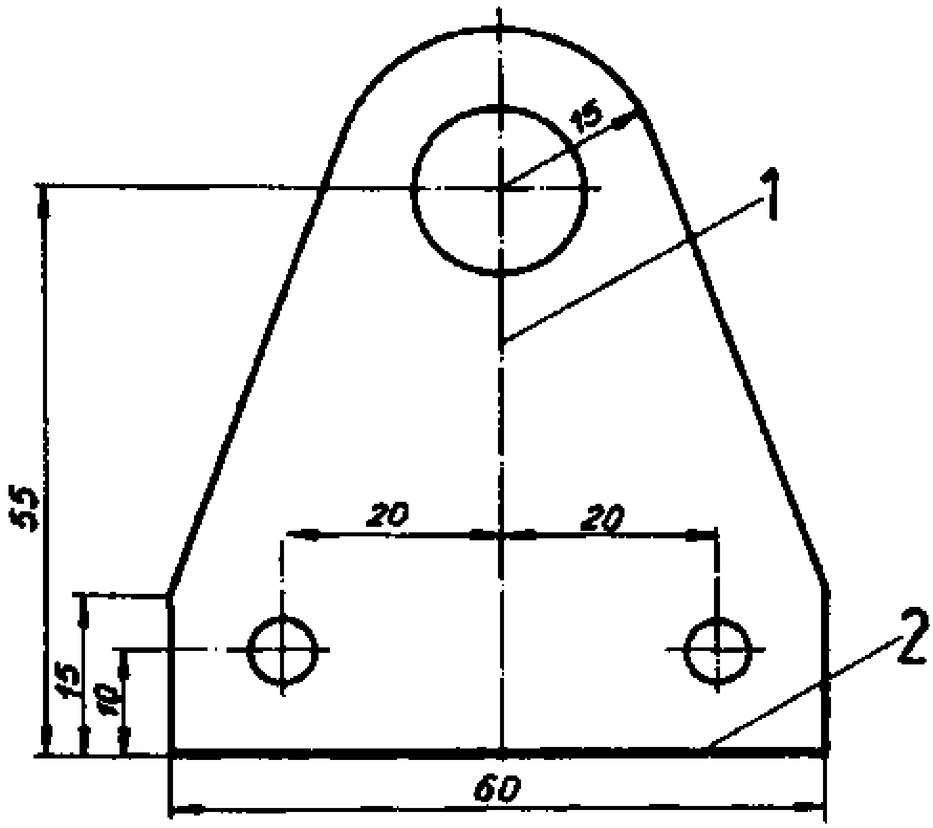

Figure 19 Scribing based on one datum line (centre line) and one datum edge

1 datum line
2 datum edge

Why must certain workpiece surfaces be coated prior to scribing?

____

Which possibilities of datum for scribing are there?

____

5. Selected working techniques of marking and punch marking

5.1. <u>Marking with steel scriber and steel straight edge</u>

1. Prepare the surface to be scribed and a datum face.

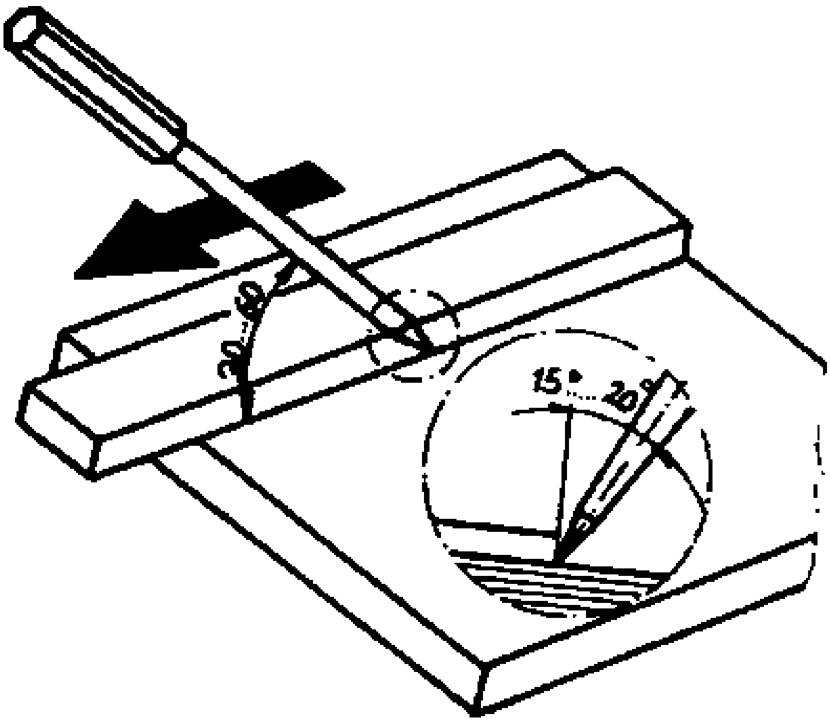

Figure 20 Scribing with steel scriber and steel straight edge

2. Mark the parallel measures by dashes by means of steel gauge and scriber.

3. Put the steel straight edge to the dashes and connect the dashes by drawing the scriber directly along the edge of the steel straight edge (Draw the scriber to your body slightly inclined and with the scriber point trailing).

5.2. <u>Marking with steel scriber and try square</u>

1. Prepare the surface to be scribed and one or two datum faces.

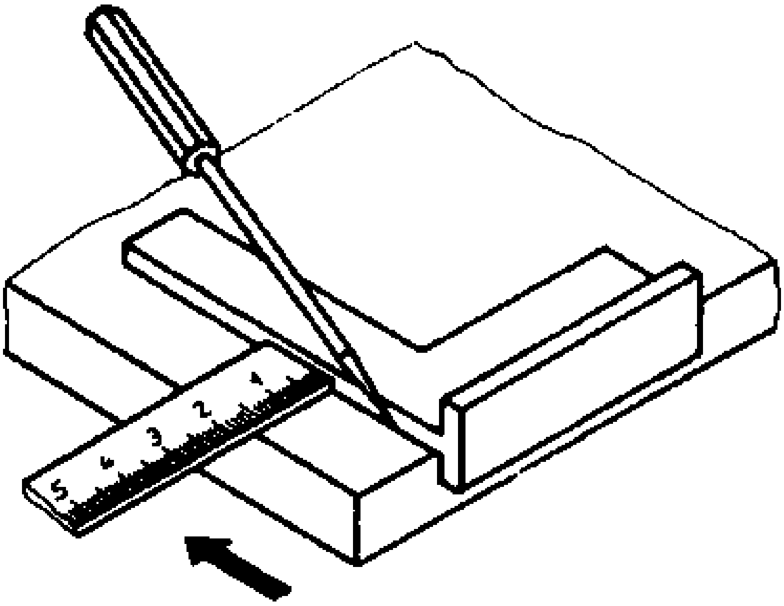

Figure 21 Scribing with steel scriber and try square

2. Mark the measure by dashes from one datum face by means of steel gauge and steel scriber.

3. Put the try square to the other perpendicular datum face and draw the scriber directly along the edge of the long leg.

5.3. <u>Marking with dividers</u>

Prepare the surface to be scribed and:

1. Mark and prick–punch the centre as supporting point for the dividers.

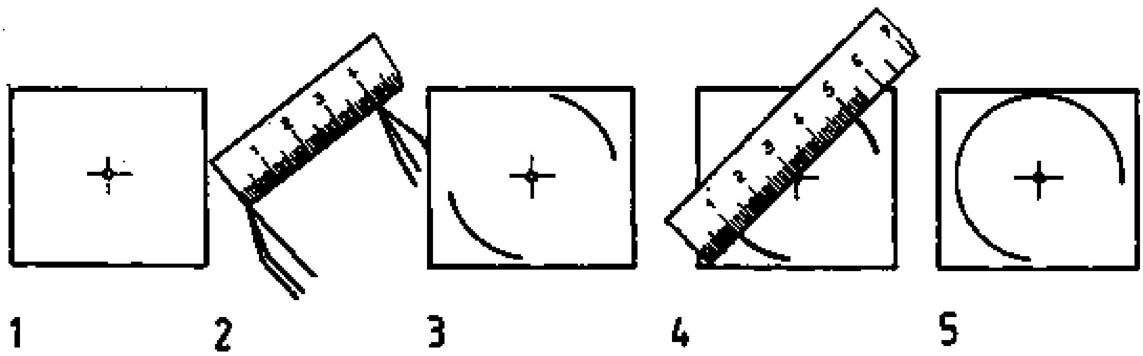

Figure 22 Steps when scribing with dividers

2. Set the measure at the dividers by means of steel gauge.

3. Scribe check curvatures.

4. Check the radius or diameter.

5. Correct or finish–scribe the circular arc.

> If straight connection lines between circular arcs are required, the arcs are to be scribed first and then the lines!

Figure 23 Correct connections between straight lines and circular arcs

5.4. Marking with height gauge scriber

1. Prepare the surface to be scribed and a datum face.

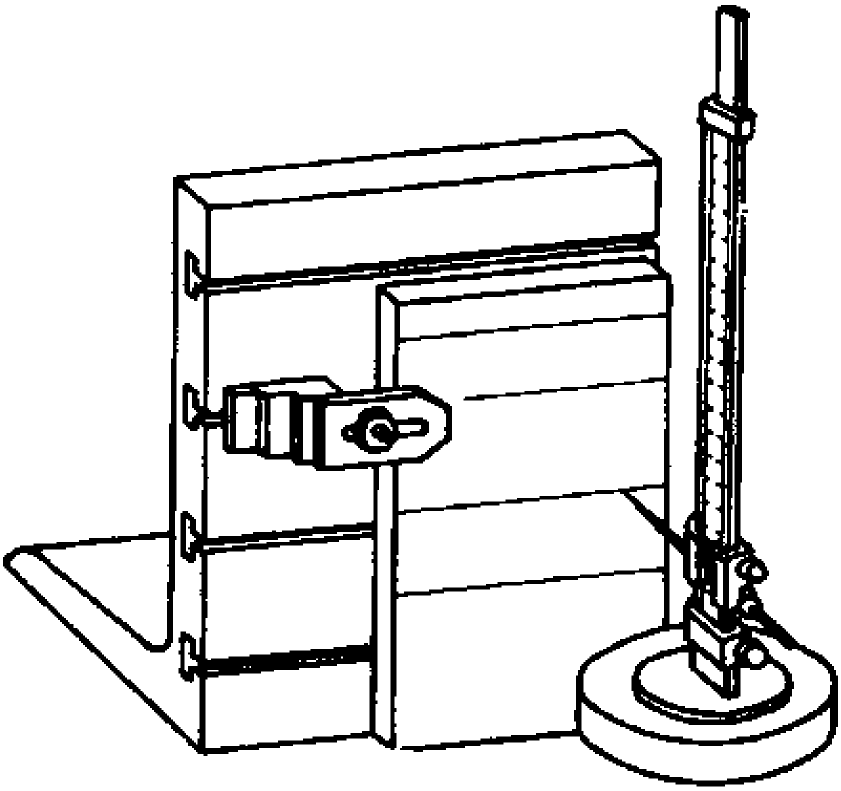

Figure 24 Scribing with height gauge scriber

2. Put the workpiece with the datum face onto the surface plate.

3. Set the scriber of the height gauge to the measure at the height scale.

4. Grip the height gauge at the base plate and draw it along towards your body with massive workplaces held directly and smaller workpieces pressed against the angle plate,

Notes

- Parallel scribing necessitates exactly machined datum faces or datum edges!

- For height gauge scribers without scale, the measure is to be set by means of special height scales or gauge blocks.

- For height gauge scribers which are not starting from the zero position of the scriber on the surface plate plane, a steel parallel is to be used as support for the workpiece. The height of the steel parallel is to be taken into account when setting the measure.

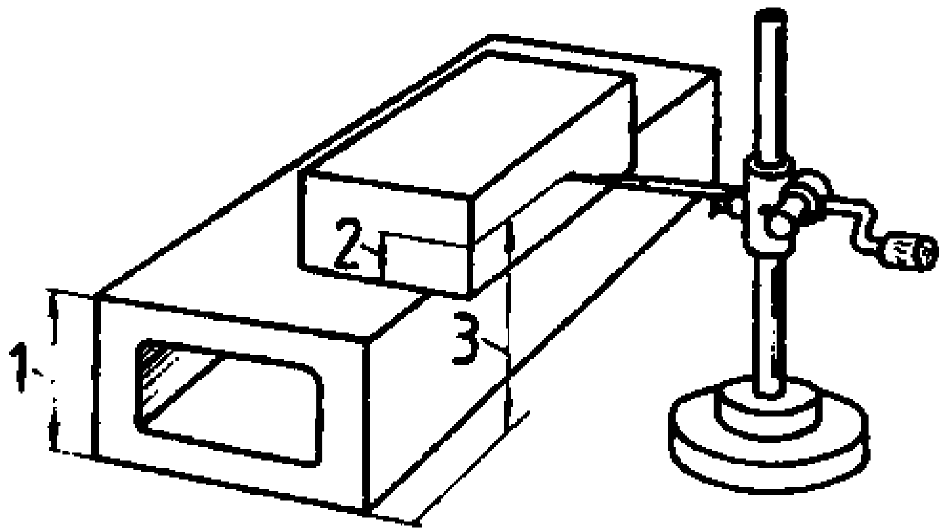

Figure 25

1 height of the steel parallel
2 measure to be marked on the workpiece
3 measure to be set at the height gauge

How is the scriber to be drawn along the steel straight edge or try square?

What intermediate step is necessary for scribing with dividers?

Which accessories are required for scribing with the height gauge scriber?

5.5. Punch marking after scribing

Check punch marks are necessary after scribing if the scribed lines may be wiped out in the subsequent working process or would not be easily visible because of poor conditions of visibility during the manufacture or of bad workpiece surface.

Placing

The prick punch is placed onto the point in inclined position, then set to vertical position with a hand on it and blown!

Guidelines for check punch marks

– Spacing on straight sections: 7 – 10 mm
– Spacing on curved sections: 3 – 4 mm.

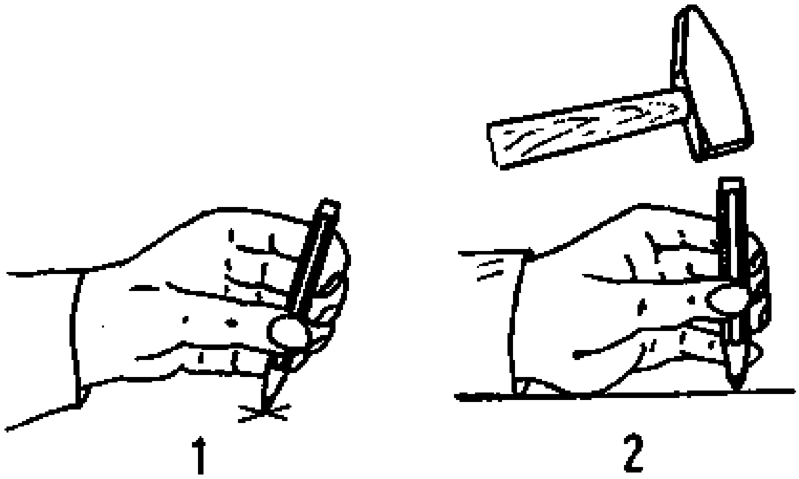

Figure 26 Placing of the prick punch

1 placing
2 setting to vertical position

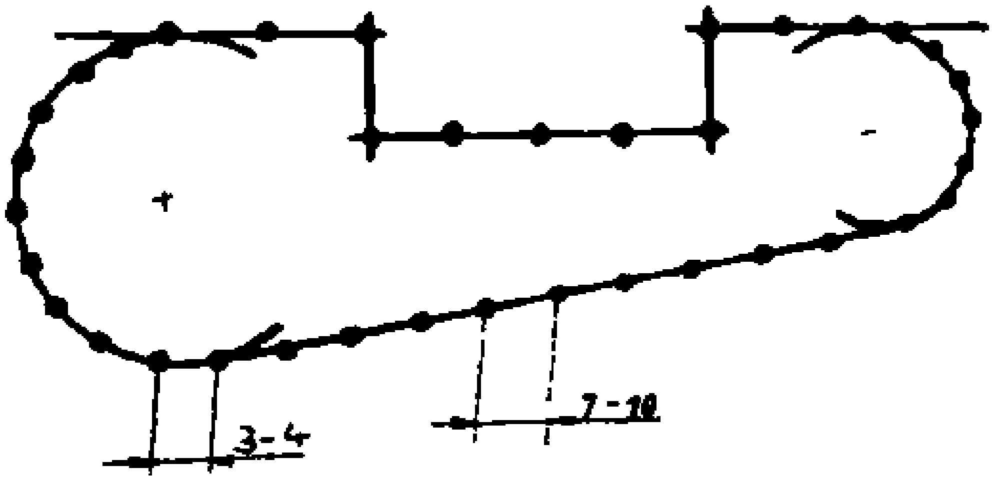

Figure 27 Correct spacings for check punch marks

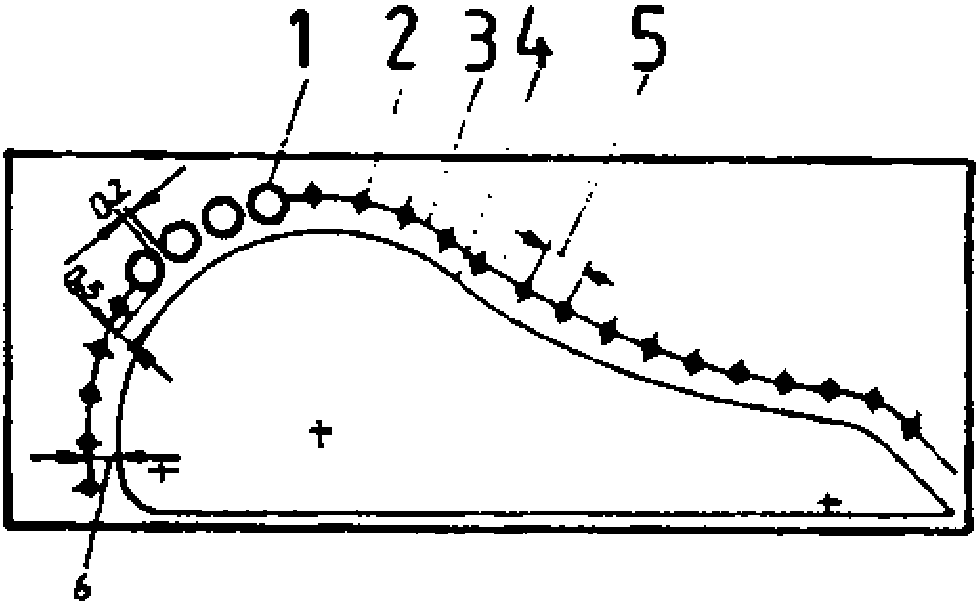

Figure 28 Producing a bore line

1 bore (D), 2 punch mark, 3 bore line,
4 scribed line – working line,
5 double–point punch width (y).

6 distance between bore line and scribed line (x)

The use of the double−point punch is necessary for prick−punching of bore lines to have a minimum of reworking for workpieces drilled. Scribing of the bore lines is to be done after scribing of working lines with the following requirements to be met:

$D = y - 0.2$ mm
$x = D/2 + 0.5$ mm

D = drill diameter
y = double−point punch width
x = distance between bore line and scribed line

Note

After the first blow, one point of the double−point punch is to be put into the last preceding punch mark, then the punch is set into vertical position and blown − a new punch mark is produced!

This will result in symmetrical punch mark spacing.

Then the punch marks are repunched with a powerful blow on the centre punch I

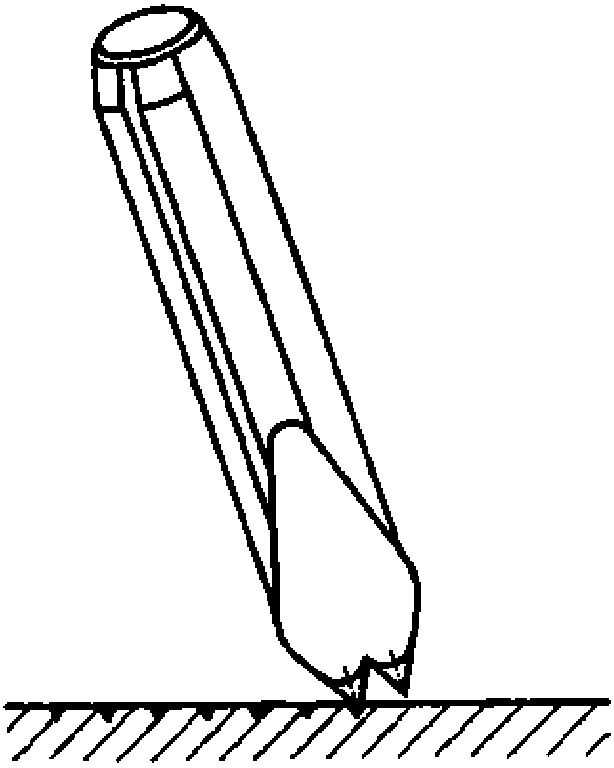

Figure 29 Correct placing of a double−point punch

What makes punch marking of scribed lines necessary?

____

What size is of prime importance for bore line marks?

____

6. Labour safety recommendations

− Points of scribers, dividers and prick punches are to be protected by putting on cork or plastic caps!

– Do not put scribing tools with protruding points into pockets of clothing!

– Store height gauge scribers with the point showing to the rear!

– Do not use damaged or dull scribing tools!

– Copper sulphate solution is toxical!

It should be stored in properly marked containers only and kept closed! Skin contact is to be avoided!

Marking and Punch Marking – Course: Technique for Manual Working of Materials. Instruction Examples for Practical Vocational Training

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Marking and Punch Marking – Course: Technique for Manual Working of Materials. Instruction Examples for Practical Vocational Training

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Introduction

The present material contains 7 selected instruction examples which are intended to help practising main techniques of scribing and prick−punching with increasing level of difficulties. The examples represent scribing of simple straight, angular and parallel lines as well as of curved lines and lines with check marks.

For selected materials special importance is attached to the preparation of scribed lines applying special coating agents (copper sulphate solution and whiting).

On completion of the workpieces by the operations additionally specified for completion in the sequence of operations, all workpieces produced may be used in practice:

The open−end wrench, drill stand, angle gauge and clamp may be immediately used in the workshop, the bow for a C clamp needs to be completed by other parts.

The dimensions of the door lock panel may be modified as specified by the instructor according to the requirements. The base plate may be used to support a work lamp.

In scribing, cleanness and uniformity of the scribed lines are essential. Check marks should be punched slightly only.

In order to facilitate the preparation and execution of the work, the necessary materials, measuring and testing tools, hand tools and accessories are stated. Moreover, knowledge required in addition to knowledge of marking and punch−marking is mentioned.

Working drawings are attached and the sequence of operations is given in a favourable order.

Explanation to the specification of material:

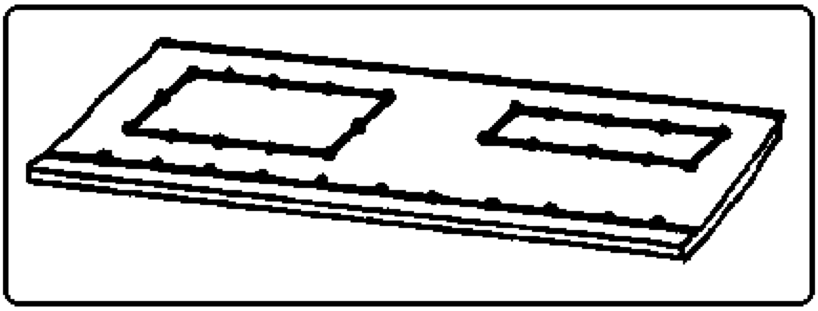
The steel is specified according to the value of its tensile strength in the unit “Megapascal” (MPa).

Instruction example 2.1. Door lock panel

To practise scribing of straight and parallel lines with steel measuring tool, steel straight edge and steel scriber based on datum edges.

<u>Material</u>

Sheet steel (approx. 380 MPa), rolled
Thickness: approx. 2 mm
Width: approx. 30 mm
Length: approx. 240 mm
(One longitudinal edge and one end edge to be flat and at right angle)



<u>Hand tools</u>

Smooth−cut file 300 mm (flat), steel scriber, prick punch, engineers' hammer

<u>Measuring and testing tools</u>

Steel measuring tool, steel straight edge, try square

<u>Accessories</u>

Surface plate, copper sulphate solution, brush

<u>Required previous knowledge</u>

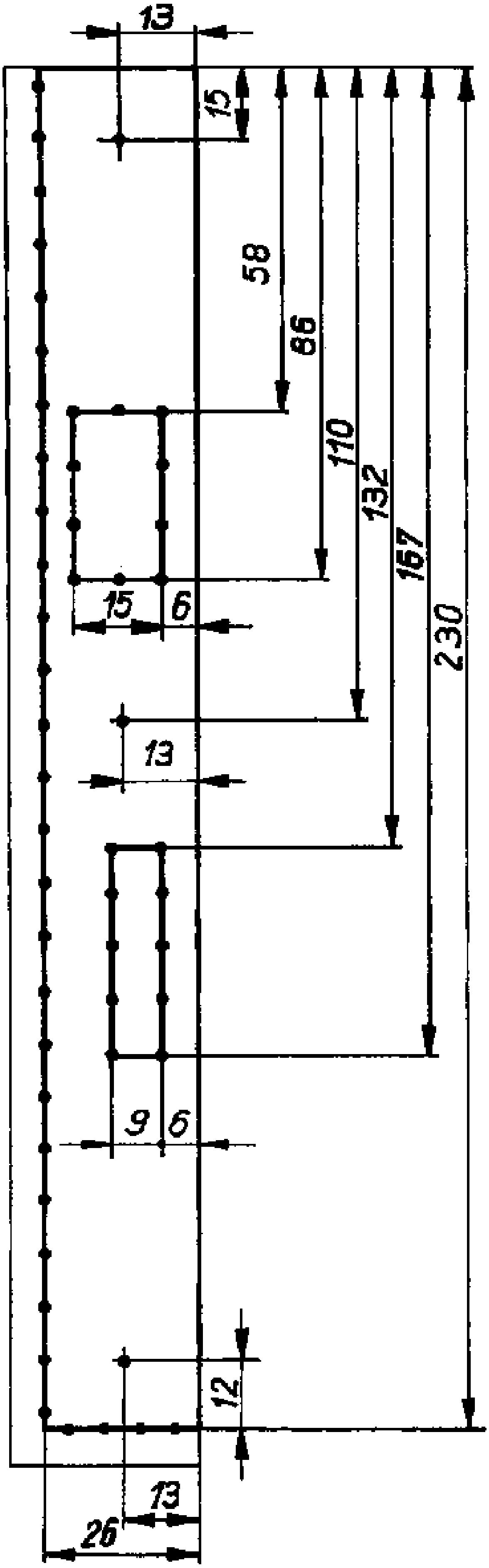
Reading of drawings, measuring, testing.

Sequence of operations	**Comments**
1. Arrange the working place, prepare the working materials.	– Check for completeness.
2. Check the edges for flatness and squareness, if necessary file one longitudinal edge and one end edge flat and at angle of 90°.	– Check with try square (upper edge – right−hand longitudinal edge)
3. Coat steel sheet surface with copper sulphate solution and let it dry.	– Danger: copper sulphate solution is toxical.
4. Lay off with steel measuring tool 3 measuring points (size 26 mm) over the length of the pre−worked longitudinal side (right−hand datum edge) and mark with steel scriber.	
5. Line up the measuring points with steel straight edge and connect such points with scriber.	– Hold steel straight edge firmly in place.
6. Lay off with steel measuring tool 2 measuring points (size 230 mm) on pre−worked end side (datum edge on top), mark and connect them.	
7. Scribe all other inner contours as described above, always based on the two datum edges.	
8. Prick−punch check marks over all scribed lines at 7 – 10 mm distances.	– Prick−punch just slightly'

9. Final inspection.	– Dimensions and cleanness of scribed lines.

Completion

Drill and file to size the rectangular inner contours. Cut the outer edges by saw or shear. Slightly chamfer all edges. Drill the 3 holes for fixing to the door frame.



			2.1.
5	Door lock panel		3102

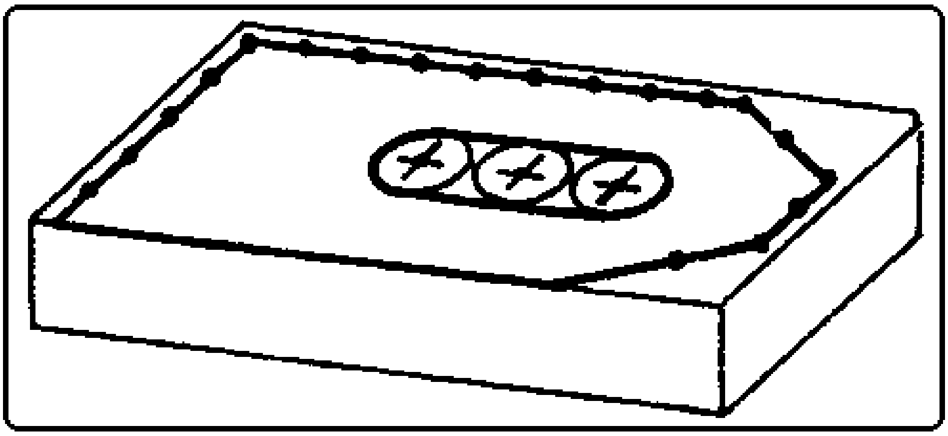
Door lock panel

Instruction example 2.2. Holding Clamp

To practise scribing of straight and angular lines by means of try square and protractor, based on one datum edge and on datum lines.

Material

Sheet steel
Thickness: approx. 20 mm
Width: approx. 50 mm
Length: approx. 110 mm
(One longitudinal edge to be flat)



Hand tools

Steel scriber, dividers, prick punch, centre punch, engineers' hammer.

Measuring and testing tools

Steel measuring tool, try square, universal protractor, steel straight edge.

Accessories

Surface plate,

Required previous knowledge

Reading of drawings, measuring, testing.

Sequence of operations	**Comments**
1. Arrange the working place, prepare the working materials.	– Check for completeness.
2. Check flatness of one longitudinal side, if necessary prepare one longitudinal side as datum edge.	
3. Scribe left–hand and right–hand end sides to specified size (100 mm distance) by means of try square and scriber.	
4. Mark second longitudinal side and centre line with steel measuring tool, based on datum edge, and scribe (connect) by means of steel straight edge and scriber.	

5. Lay off the tapered lines (30°) at the right−hand end side by means of universal protractor, based on the longitudinal sides.	– Line up exactly!
6. Mark the end points of the oblong hole on the centre line (steel measuring tool and scriber).	
7. Set the dividers to 8.0 mm by means of steel measuring tool and scribe from the end points of the oblong hole inward. Prick−punch with centre punch and scribe radii with dividers. Mark and prick−punch centre punch mark.	
8. Scribe longitudinal sides of oblong hole by means of steel straight edge and scriber.	
9. Prick−punch check marks on all scribed lines at 7 – 10 mm distances	
10. Final inspection.	– Dimensions and cleanness of scribed lines.

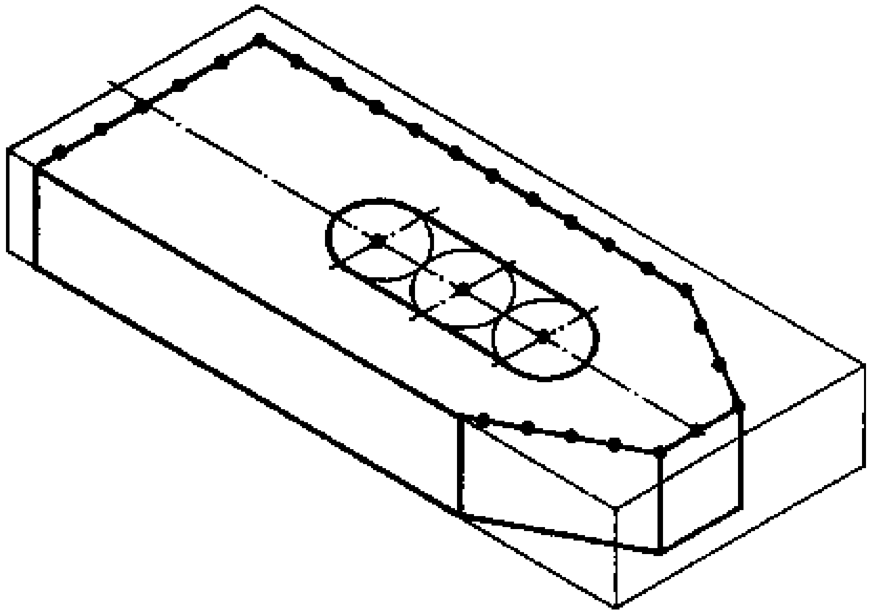
<u>Note</u>

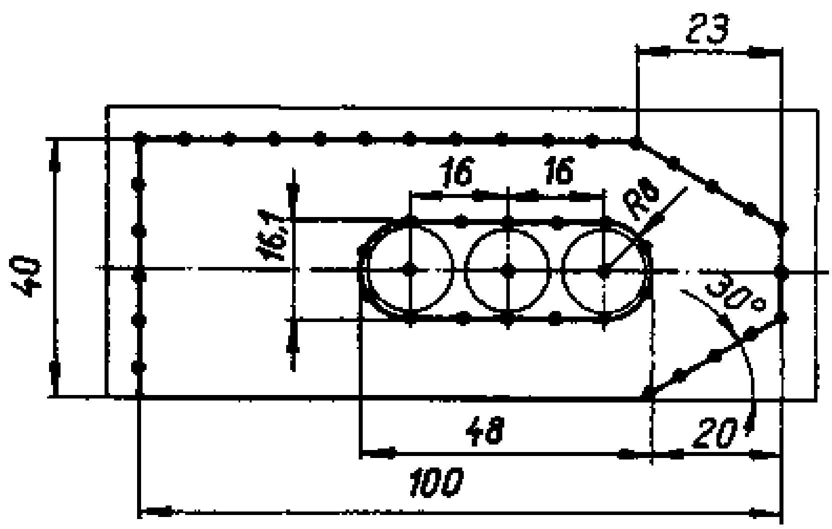
The clamp together with instruction example 5.1. (step block)

5.2. (tenon block)

5.5. (box wrench)

and a bolt M16 with washer and nut M16 form a complete set of clamping tools for an upright drilling machine.





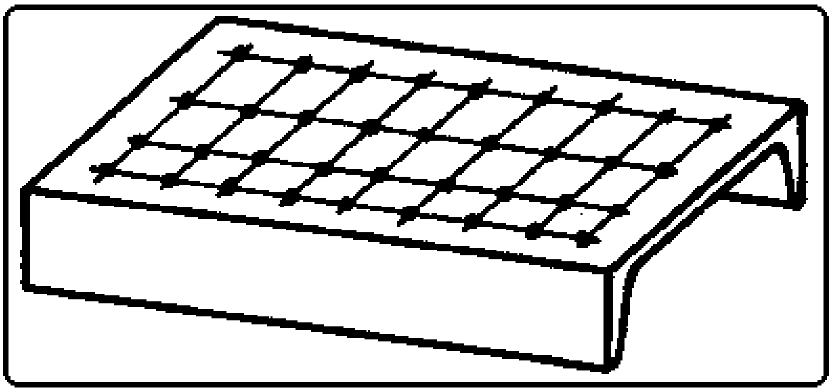
				2.2.
	Holding Clamp			3102

Instruction example 2.3. Drill stand

To practise scribing of straight and parallel lines with scribing blocks, based on datum edges.

Material

U−section (approx. 380 MPa)
Web width: 80 mm
Flange height: 45 mm
Length: 120 mm
(see also training example 4.2.)



Hand tools

Scribing blocks (marking gauge and steel scriber or caliper gauge or height gauge), centre punch, engineers' hammer.

Measuring and testing tools

Steel measuring tool

Accessories

Surface plate, whiting, brush

Required previous knowledge

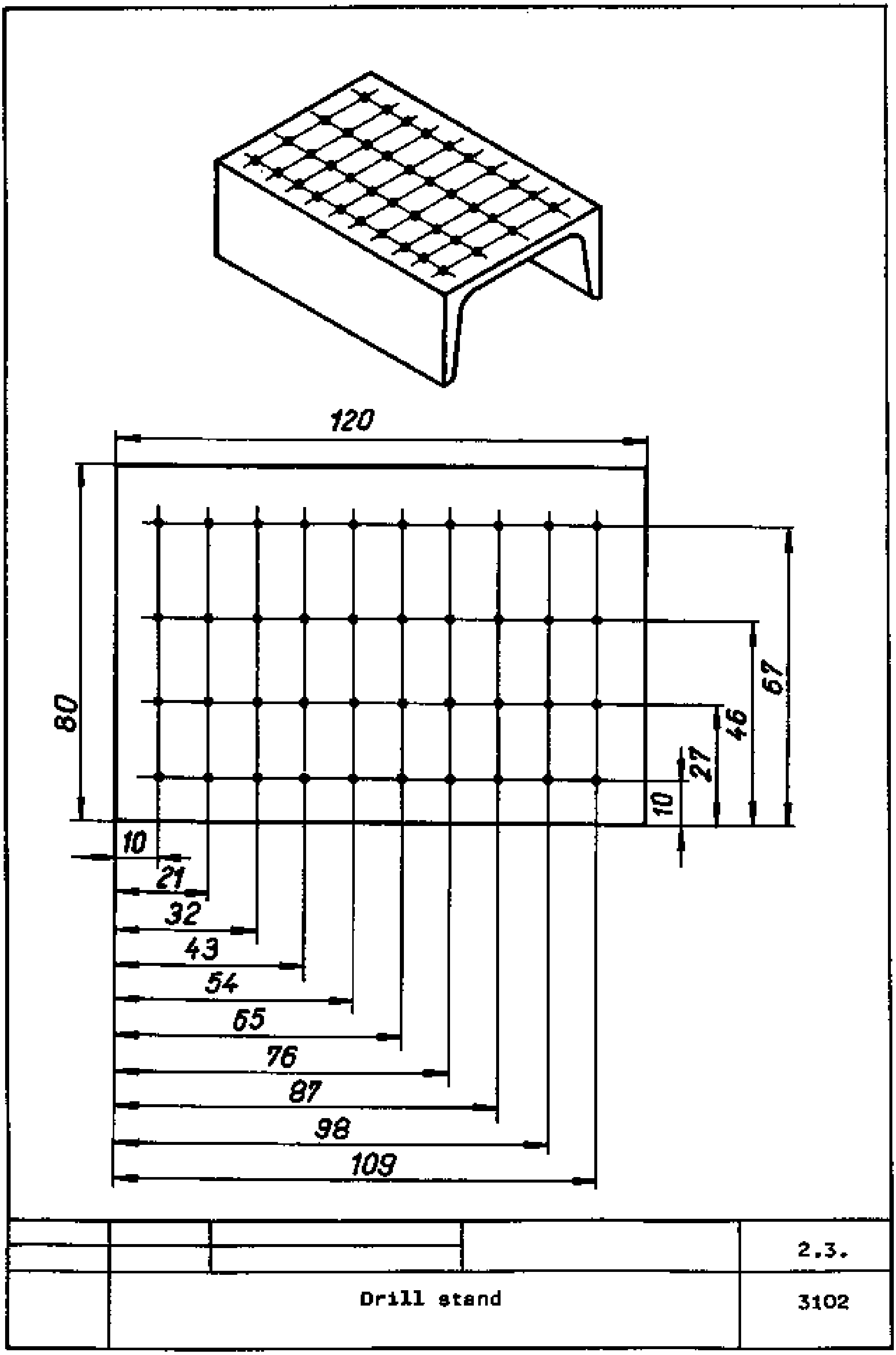
Reading of drawings, measuring

Sequence of operations	Comments
1. Arrange the working place, prepare the working materials.	− Check for completeness.
2. Check datum edges/datum faces for flatness and squareness.	− If necessary re−work(file).
3. Coat surface with whiting and let it dry.	
4.1. For scribing blocks without scale, set the distances according to drawing by means of steel measuring tool and scribe step by step, based on the datum edges.	− Line up exactly with the datum edges! Do not cant!
4.2. For scribing blocks with scale, set the distances according to drawing directly	

at the gauge and scribe step by step, based on the datum edges.	
5. Prick–punch points of intersections of scribed lines heavily by means of centre punch	
6. Final inspection.	– Dimensions, parallelism and cleanness of scribed lines.

Completion

Drill the holes with drill diameters as required (to be specified by the instructor or as per instruction example 7.4.). Produce a stringer plate to support the tools to be inserted. Clean the surface and mark for identification.


120
80
67
46
27
10
10
21
32
43
54
65
76
87
98
109
2.3.
Drill stand
3102

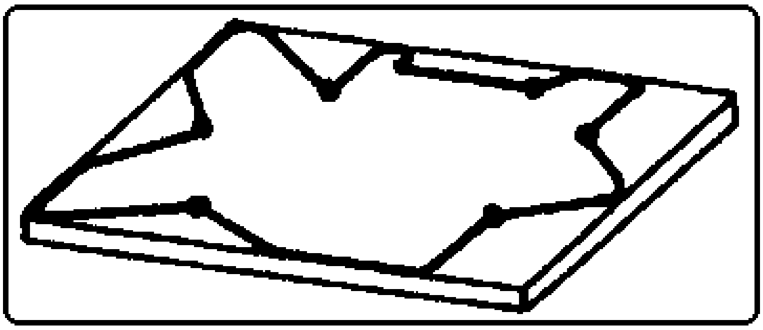
Drill stand

Instruction example 2.4. Angle gauge

To practise scribing of angular lines by means of protractor, based on datum edges.

Material

Sheet steel, bright
(approx. 380 MPa)
Thickness: approx. 2.5 mm
Width: approx. 40 mm
Length: approx. 70 mm
(Edges to be flat and at right angles to each other).



Hand tools

Smooth-cut file 200 mm (flat), caliper gauge, steel scriber, centre punch, engineers' hammer.

Measuring and testing tools

Bevelled edge square, universal protractor

Accessories

Surface plate, scribing varnish, brush

Required previous knowledge

Reading of drawings, measuring, application of the mathematical law of the sum of interior angles (? + ? + ? = 180°), use of the universal protractor.

Sequence of operations	Comments
1. Arrange the working place, prepare the working materials.	– Check for completeness.
2. Check for size and squareness of outer edges. Coat the surface with scribing varnish.	
3. Scribe the hole centres with the caliper gauge and punch with centre punch.	– Proceed step by step, based on the outer edges!
4. Scribe all angles, based on outer edges, by means of universal protractor (locate the try square and scribe with scriber from the punch mark outward). Example: angle 90. Bisector bisects 90° into two 45° angles forming 90° angle with outer edge, angle to be set on universal protractor, therefore: 45°. (45° + 90° + 45° = 180°).	– Calculate the complementary angles by means of the law of the sum of interior angles I
5. Final inspection.	– Dimensions and cleanness of scribing.

Completion

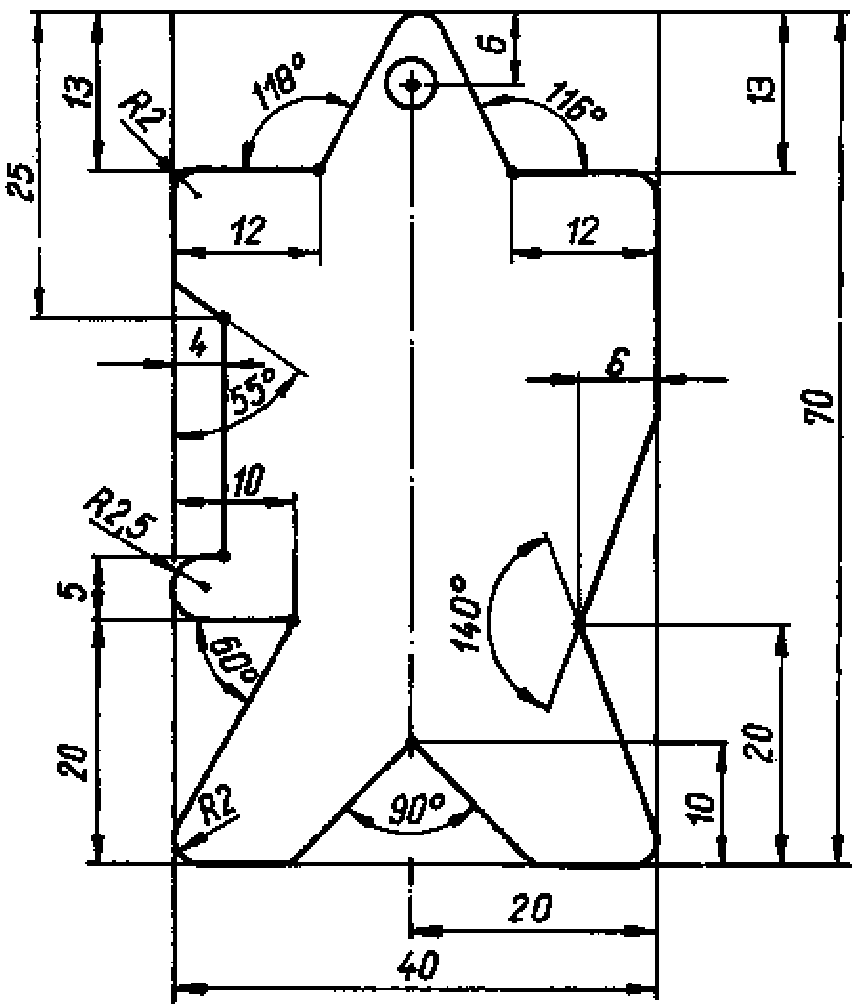
Drill the punched centres of angles with 1.5 mm diameter.

Saw out the angles. File to size and chamfer inner edges.

Mark angles. – Explanation:

116 – 118°	point angle of drill (normal material)
90°	point angle of drill (hard material)
140°	point angle of drill (soft material)
55°	chisel edge angle of drill
60°	wedge angle of chisel, prick–punch.

Drill 4 mm dia. hole at size 6 mm (punch mark on top)



				2.4.
	Angle gauge			3102

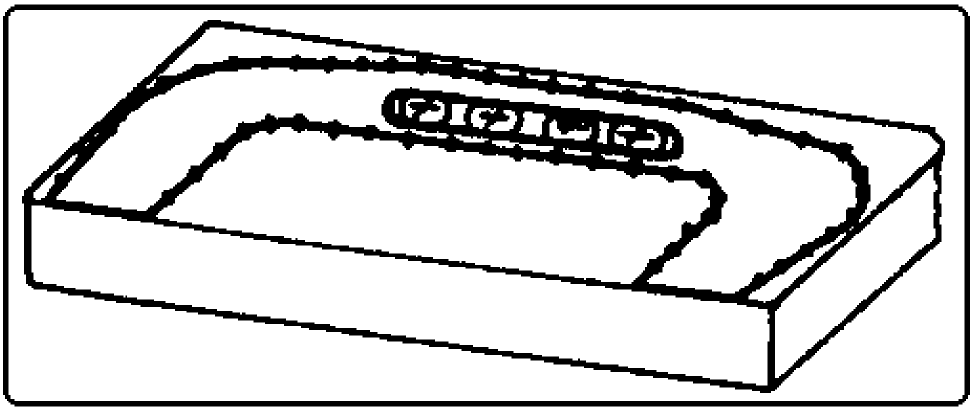
Angle gauge

Instruction example 2.5. Bow for C clamp

To practise scribing of lines with height gauge and dividers, based on datum edges and one datum line and producing a bore line.

Material

Sheet steel (approx. 380 MPa)
Thickness: approx. 8 mm
Width: approx. 80 mm
Length: approx. 115 mm
(One longitudinal side and end side to be flat and at right angle)



Hand tools

Smooth−cut file 300 mm (flat), height gauge, steel scriber, dividers, marking−out punch, centre punch, double−point punch, engineers' hammer.

Measuring and testing tools

Steel measuring tool, steel straight edge, bevelled edge square.

Accessories

Surface plate, angle plate, steel parallel as support (if height gauge cannot be started at zero level).

Required previous knowledge

Reading of drawings, measuring, use of the height gauge, application of simple mathematical equations.

Sequence of operations	Comments
1. Arrange the working place, prepare the working materials.	– Check for completeness.
2. Check the two datum edges (one longitudinal side and one end side to be flat and at right angle).	– File and check with bevelled edge square, if datum edges are not meeting the requirements.
3. Put the steel sheet on the worked end−side edge and set the scriber of the height gauge to "zero" level.	– If the height gauge cannot be set to zero level because of foot height, an adequate steel parallel is to be used as support for the workpiece.
4. Scribe the centre line (size 55 mm above zero). Set the height gauge to the level of the centre line.	– Choose an even number for reference.
5. Scribe the sizes from the datum line up and down.	

6. Put the steel sheet on the worked longitudinal edge and set the height gauge to “zero” level.	
7. Scribe the sizes in this plane.	
8. Prick−punch the guide marks for the dividers. Scribe the radii according to specified size.	
9. Scribe the oblique tines between radii and corner points by means of steel scriber and steel straight edge.	
10. Scribe the check circles in the oblong hole by means of dividers (radius 5.0 mm).	
11. Prick−punch check marks on all scribed lines.	
12. Calculate the bore line based on specified width of double−point punch.	− Equations: $d = y - 0.2$ mm $x = d/2 + 0.5$ mm
13. Scribe the bore line by means of steel scriber and steel measuring tool. Prick−punch by means of double−point punch.	
14. Final inspection.	− Dimensions and cleanness of scribing,

Completion

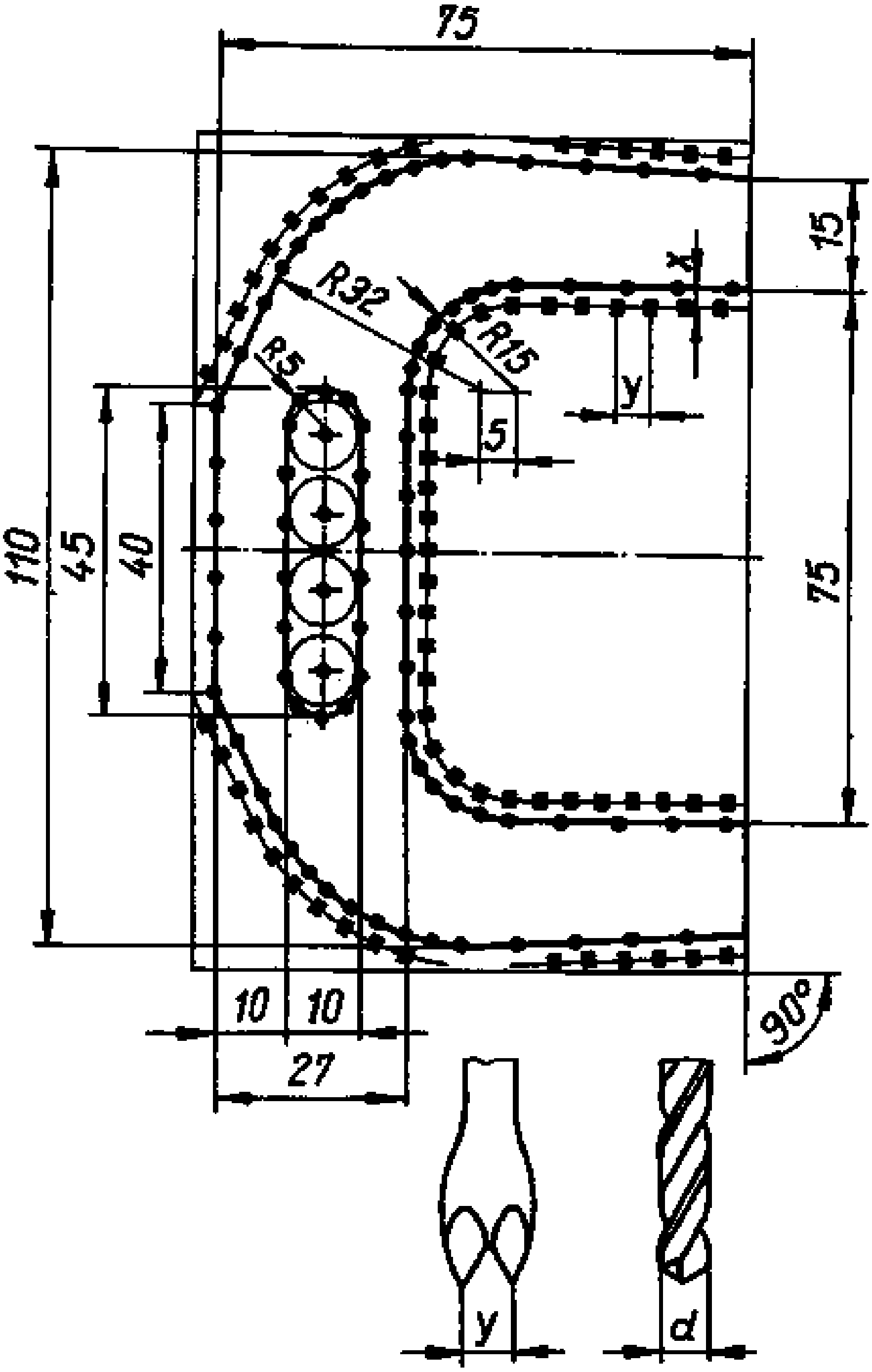
− Drill and chip the bow; file all edges.

− Weld threaded rings to it (Instruction example 9.5.).

− Insert a lead−screw (Instruction examples 9.5 and 8.2) into one threaded ring,

− Pin together a head−piece and the lead−screw (Instruction example 7.6.).

− Insert a hexagon−head screw M10 x 15 as counterpart for the lead−screw into the other threaded ring.



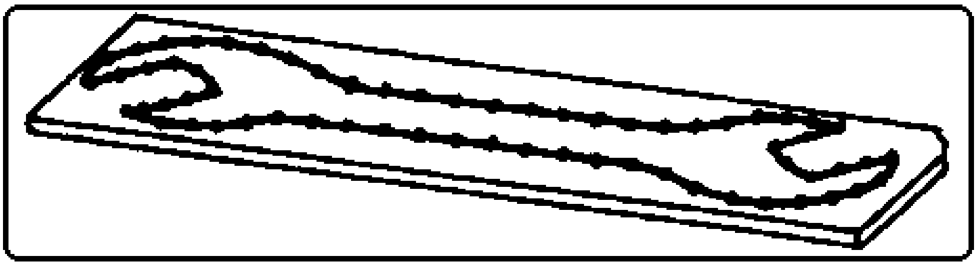
				2.5.
	Bow for C Clamp			3102

Instruction example 2.6. Open−end wrench 19/24

To practise scribing of curved and straight lines, based on datum lines, and producing a bore line.

Material

Cold work sheet steel with 1 – 1.1 % carbon content
Thickness: 6−8 mm
Width: approx. 50 mm
Length: approx. 230 mm



Hand tools

Steel scriber, dividers, mark−out punch, double−point punch, centre punch, engineers' hammer.

Measuring and testing tools

Steel measuring tool, universal protractor.

Accessories

Surface plate, copper sulphate solution, brush, steel−sheet insert of equal thickness.

Required previous knowledge

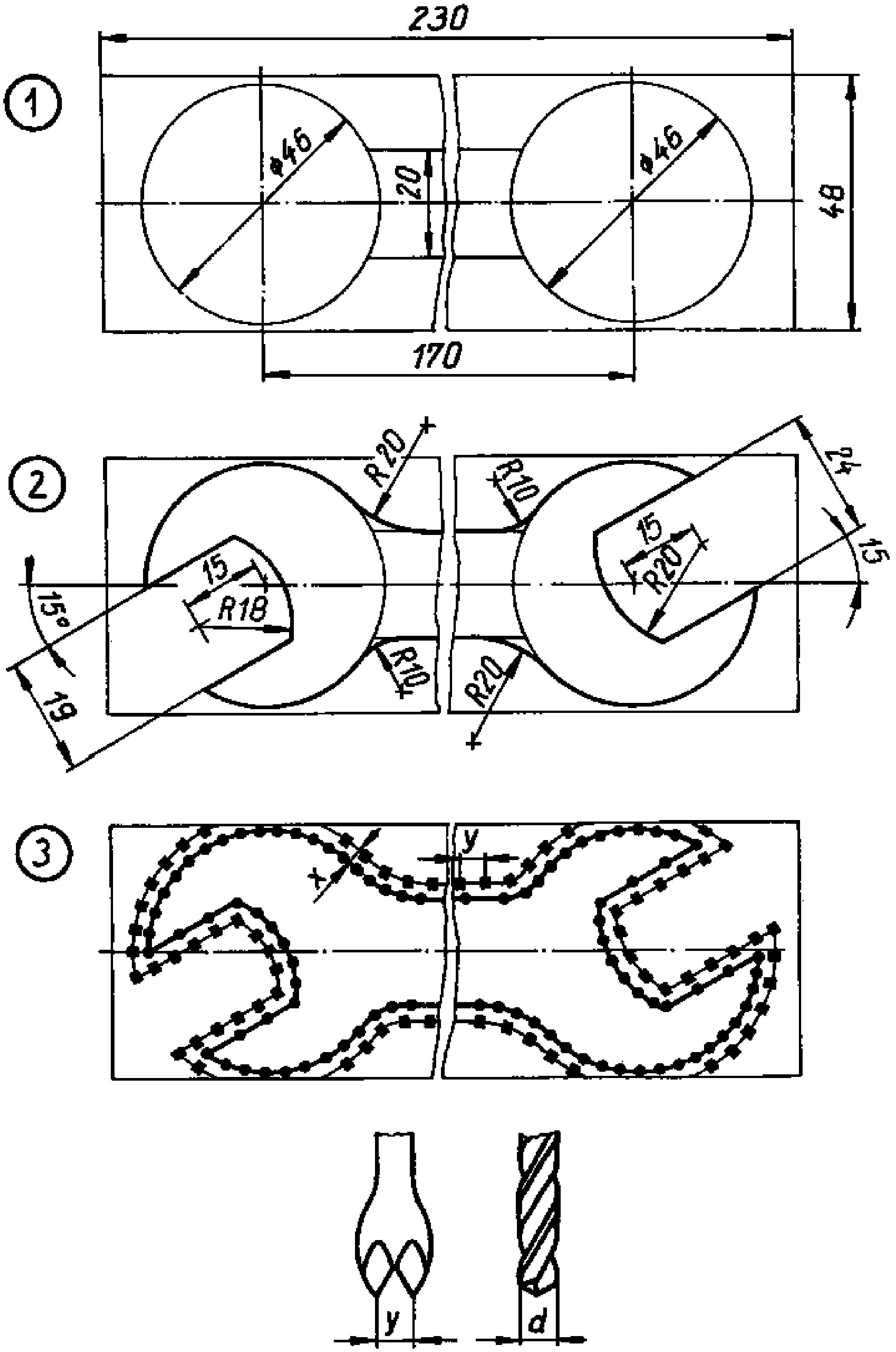
Reading of drawings, measuring, application of simple mathematical equations.

Sequence of operations	**Comments**
1. Arrange the working place, prepare the working materials.	– Check for completeness.
2. Coat surface with copper sulphate solution. Scribe two crossing centre lines.	– Stage (1)
3. Scribe datum lines (170 mm distance) for centres of circles.	
4. Prick−punch supporting points for the dividers and scribe circle lines and web lines (size 20 mm).	
5. Scribe 15° inclined datum lines for openings of the wrench by means of universal protractor. Scribe and prick−punch the supporting points for the dividers for all radii.	– Stage (2) For 20 mm radii use insert (supporting points are outside the workpiece).
6. Finish the contour of the open−end wrench. Provide all outer lines with check punch−marks.	– Punch−mark distances for straight lines: 7 – 10 mm and for curved lines: 3 – 4 mm.

7. Calculate the bore line according to specified width of double−point punch.	− Equations: $d = y - 0.2$ mm $x = d/2 + 0.5$ mm
8. Scribe the bore line and prick−punch by means of double−point punch.	− Stage (3)
9. Final inspection.	− Dimensions and cleanness of scribing.

<u>Completion:</u>

Drill and file. Slightly chamfer all edges. Mark openings of wrench. After hardening the wrench can be used for hexagon−head screws of sizes M



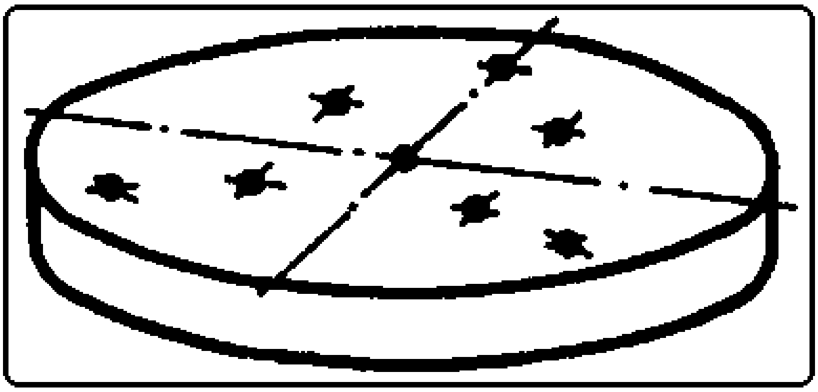
				2.6.
	Open-end wrench 19/24			3102

Instruction example 2.7. Base plate

To practise scribing of circular lines by means of dividers and steel measuring tool and scribing of a bore line.

Material

Sheet steel (approx. 380 MPa)
Thickness: approx. 6 mm
Width: 75 mm
Length: 75 mm



Hand tools

Dividers, centre punch, double−point punch, engineers’ hammer.

Measuring and testing tools

Steel measuring tool, centre square

Accessories

Surface plate

Required previous knowledge

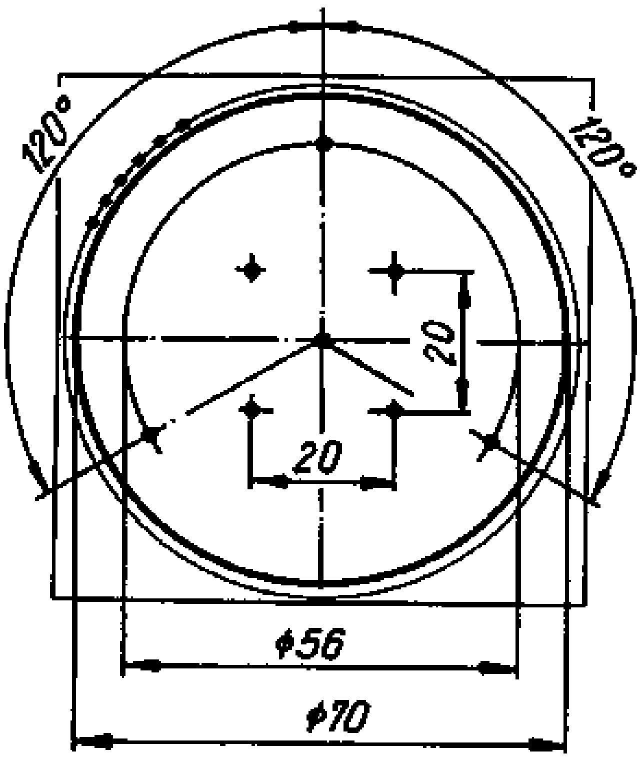
Reading of drawings, measuring

Sequence of operations	Comments
1. Arrange the working place, prepare the working materials.	– Check for completeness.
2. Scribe the centre by means of the centre square and prick−punch by means of the centre punch. Scribe the circumference.	
3. Scribe the crossing centre lines and the hole circle 65 dia. Set the dividers six times on the hole circle to determine 3 points as per sketch for the holes to be drilled. Prick−punch the points. Scribe the bore line.	– Equations: d = y – 0.2 mm x = d/2 + 0.5 mm
4. Scribe the holes at 20 mm distances with reference to the centre−line cross. Prick−punch the points.	
5. Final inspection.	– Dimensions and cleanness of

	scribing.

Completion

Drill according to instructions of the instructor.



				2.7.
	Base plate			31026

Base plate

Marking and Punch Marking – Course: Technique for Manual Working of Materials. Methodical Guide for Instructors

Table of Contents

Marking and Punch Marking – Course: Technique for Manual Working of Materials. Methodical Guide for Instructors

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1. Objectives and contents of practical vocational training in the working techniques of "Marking and Punch Marking"

By concluding their training, the trainees shall have a good command of the working techniques of "Marking and Punch Marking". Therefore, the following objectives are to be achieved:

Objectives

- Knowledge of the purpose and application of the marking and punch marking techniques.

- Mastery of the various working techniques of marking and punch marking and capability of preparing the workpieces for good−quality working.

- Capability of selecting the proper scribing tools and their proper use.

- Capability of making decisions on quality independently.

The following contents have to be imparted to the trainees:

Contents

- Purpose of marking and punch marking
- Types and application of scribing tools and accessories
- Preparation of the surface of the workpiece.

2. Organizational preparation

In order to guarantee a trouble−free development of instruction, exercises and teaching it is necessary to prepare this training properly.

The following steps have to be envisaged:

2.1. Preparation of instruction on labour safety

Prior to the exercises, a brief instruction on the proper use of marking and punch marking tools has to be given.

This comprises hints for accident−free work. Emphasis is to be laid on:

- – Points of scribers and dividers have to be protected by covering them with cork or plastic cases.

- – Never put scribing tools with projecting points in your pockets.

- – Vernier height gauges have to be put down with their points turned away.

- – Never use damaged or blunt scribing tools.

- – As copper−sulphate solutions are poisonous, they have to be stored in marked and sealed vessels; avoid any contact with your skin when handling such solutions.

Familiarity with these hints is to be confirmed by the trainee's signature in a control book.

2.2. <u>Provision of teaching aids</u>

- – For demonstration purposes during instruction, a small surface plate should be installed on the workbench.

- – The "Trainees' Handbook of Lessons – Marking and Punch Marking" is to be handed out to the trainees,

- – When using the transparencies series of "Marking and Punch Marking" (transparencies 2.1. – 2.5.) check whether they are complete and whether the overhead projector is functional. (Check operating conditions at the site of use and make sure of the proper mains supply!)

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

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

2.3. <u>Provision of working tools and materials</u>

- – Sufficient copies of the "Instruction Examples for Practical Vocational Training – Marking and Punch Marking" must be handed out to the trainees to provide them with the theoretical foundations of the exercises to be carried out.

- – The initial materials required for the exercises are to be prepared and laid out in sufficient numbers according to the materials specified in the "Instruction Examples...".

- – Each trainee is to be provided with a plane steel plate, which serves as a surface plate, and ideal lighting conditions.

- – It must be checked that all workbenches are equipped with scribing tools and accessories appropriate to the exercises that are planned,

Recommended basic equipment:

- – steel rule, steel straightedge, try square, bevelled edge square
- – universal bevel protractor
- – steel scriber, dividers, marking gauge, height gauge
- – paint
- – bastard files and smooth files (flat) 200 – 300 mm
- – hammer; marking−out, centre and double−type punches

2.4. <u>Time schedule</u>

Time planning is recommended for the following training stages:

– introduction to the working techniques by way of instruction
– necessary demonstrations
– job–related instructions in preparing the exercises
– carrying out the exercises
– recapitulation 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 techniques of "Marking and Punch Marking"

The following paragraphs comprise proposals on conducting trainee instruction, carrying out demonstrations as well as exercises and tests. We recommend two course variants:

Variant No. 1

This variant should be chosen for trainees with generally good achievements and receptiveness,

1.1. Introductory instruction for the whole subject with demonstrations according to the "Trainees' Handbook of Lessons"

1.2. Exercises in marking and punch marking from the "Instruction Examples..." (2.1. – 2.7.) and subsequent evaluation.

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

Variant No. 2

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

2.1. Introductory instruction for the whole subject of "Marking and Punch Marking" with demonstrations according to the "Trainees' Handbook of Lessons".

2.2. Exercises in marking and punch marking from the "Instruction Examples 2.1. and 2.2." and subsequent evaluation.

2.3. Supplementary instruction for the subject of scribing with scribing blocks.

2.4. Exercises in marking and punch marking from the "Instruction Examples 2.3. – 2.5." and subsequent evaluation.

2.5. Supplementary instruction in the field of boring–line production.

2.6. Exercises in marking and punch marking from the "Instruction Examples 2.6. and 2.7." and subsequent evaluation.

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

Practical skills should be evaluated immediately after the handing in of the finished workpieces. Knowledge of theory should be constantly checked. However, it is recommended that a final test (item 1.3. or resp., 2.7.) should be written after concluding the exercises.

3.1. Introductory instruction

If possible, this instruction should be given in a classroom. Make sure that the trainees put down necessary supplementary hints 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 marking and punch marking

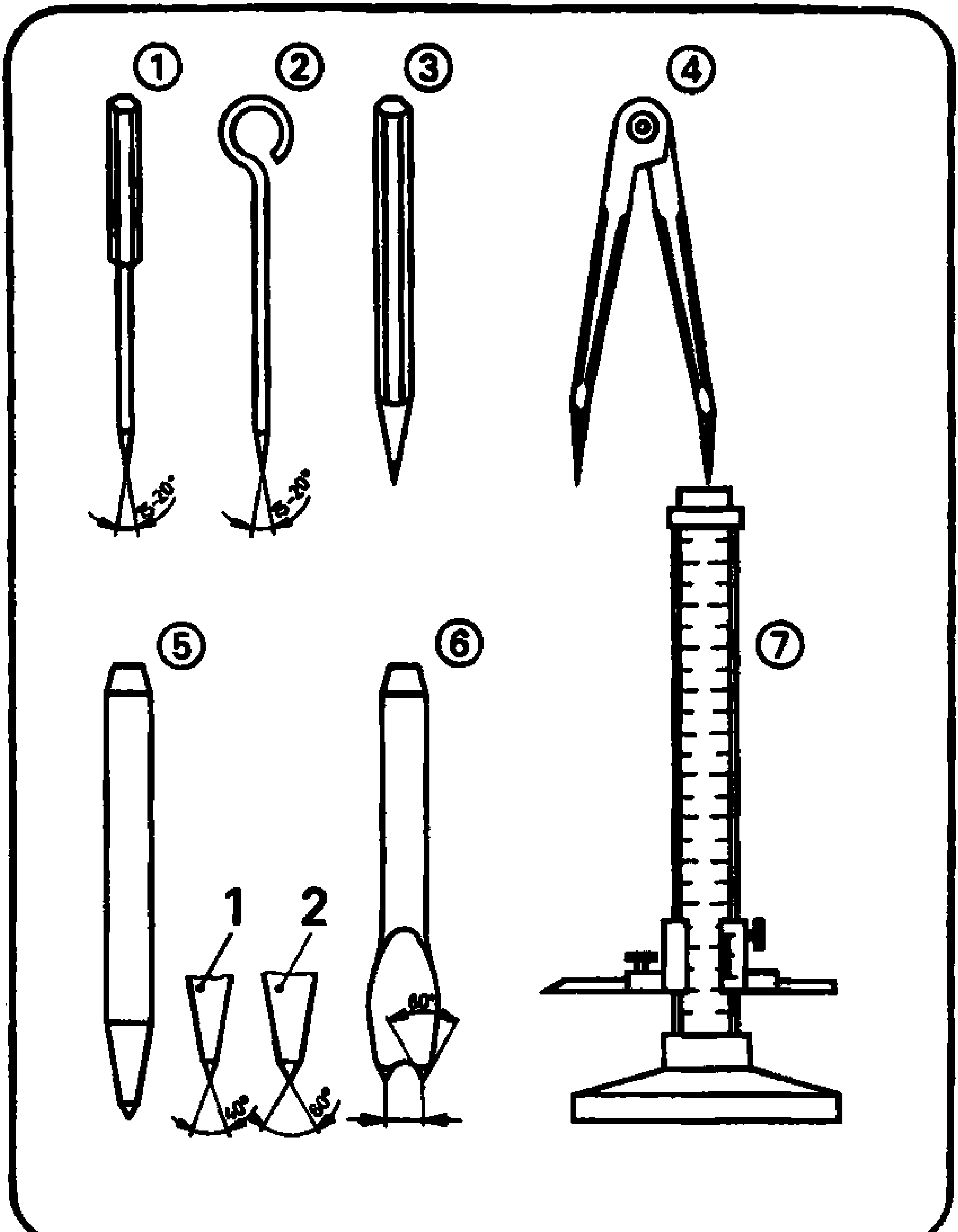
Instruction is to begin with the definition of terms and concepts. This is followed by pointing out the significance of the scribing quality for the accuracy to size of the manufactured workpieces. The trainees should be encouraged to carry out the planned exercises with great care and accuracy.

Scribing tools and accessories

The introduction of scribing tools should follow the list contained in the "Trainees' Handbook of Lessons".

- steel scriber
- brass scriber
- soft pencil
- dividers (various types)
- scribing blocks (caliper gauge or marking gauge; height gauge)
- prick punches (marking−out, centre, double−point and stencil punches)

Demonstrating the original tools may be supported by using transparency no. 2.1.



2.1

The trainees must learn how and when to use the individual tools. They must be able to select the appropriate scribing tool necessary for completing the tasks and depending on the kind and surface of materials. The instruction in the field of accessories has to lay emphasis on the respective fields of application:

–surface plate
– angle plate
– large–size steel parallels
– vees
– stencils.

The instruction has to mention the measuring and testing tools the specific form of which makes it possible to support the motion of the scriber:

– steel rule
– try square
– T–square and centre square.

When dealing with the application of parallel scribing processes the instruction has to mention the mode of using scratch gauges.

Preparing the surface of the workpiece

The trainees should be shown that it is not always possible to produce clearly visible scribed lines on the various surfaces of the workpiece, if the scribing is performed directly on the surface. The trainee has to be instructed in the use of paints.

The following survey can be used to give instructions in employing paints:

surface of workpiece	**paint coating**
rough and big pore surfaces of castings and forgings	coating with whiting prepared in water (a low percentage of linseed oil added)
hard and scaled steel parts	coating with copper sulphate solution ($CuSO_4$) – Caution: poisonous!
large pre–machined surfaces and light metals	coating of shellac or scribing varnish

This survey is also contained in the "Trainees' Handbook of Lessons".

Having dealt with these problems you should mention the problem of reference surfaces and lines. The emphasis is to be laid on:

– datum faces and edges
– datum lines.

You have to point out the significance of these datum possibilities for the accuracy of the scribed line.

Selected working techniques of marking and punch marking

Demonstrations of the working techniques should include:

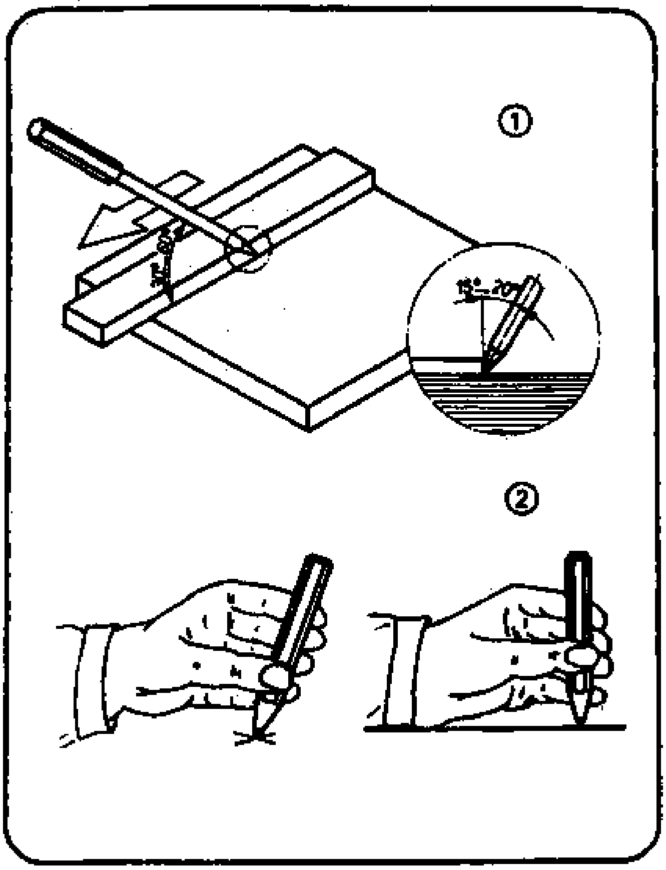
– Scribing with steel scriber and steel straightedge: emphasis is to be laid on the proper position of the scriber.

Transparency No. 2.2. can supplement this demonstration.

– Scribing with steel scriber and try square:

You have to underline that it is necessary to have one or two datum faces/edges in order to lay the try square properly.

Transparency No. 2.3. can be used as a supplement to instructions in the use of centre squares and T–squares.



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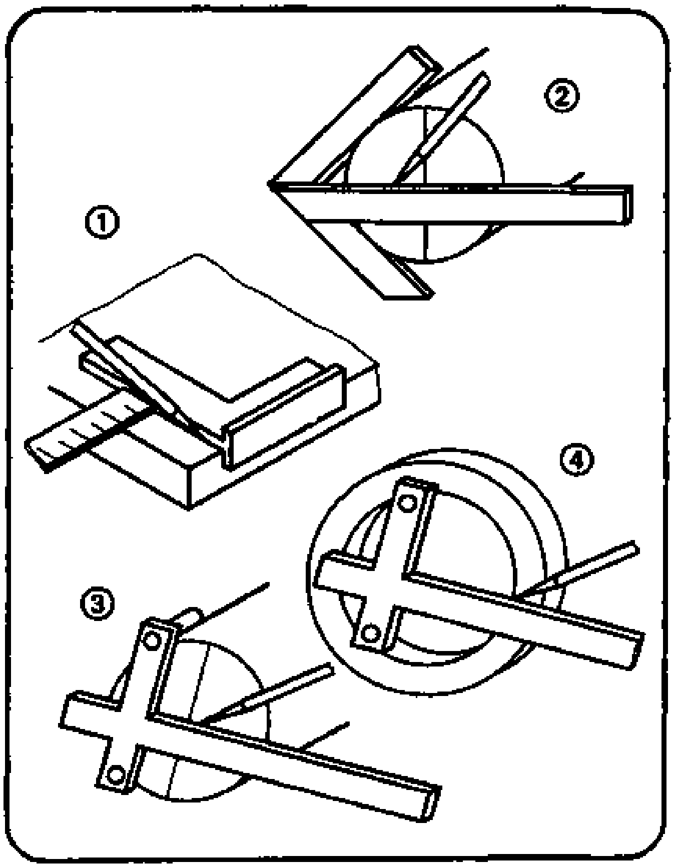

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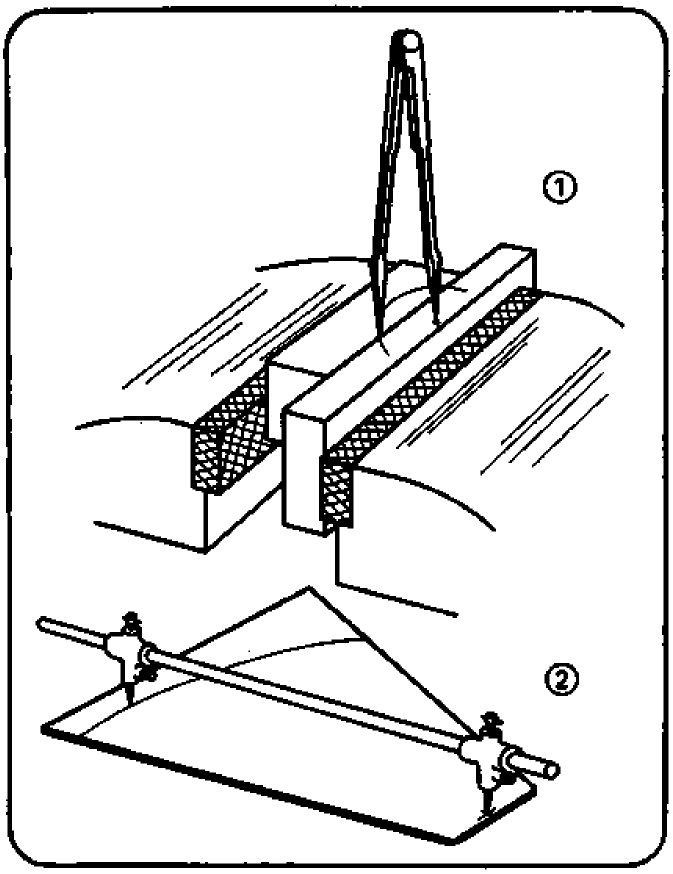

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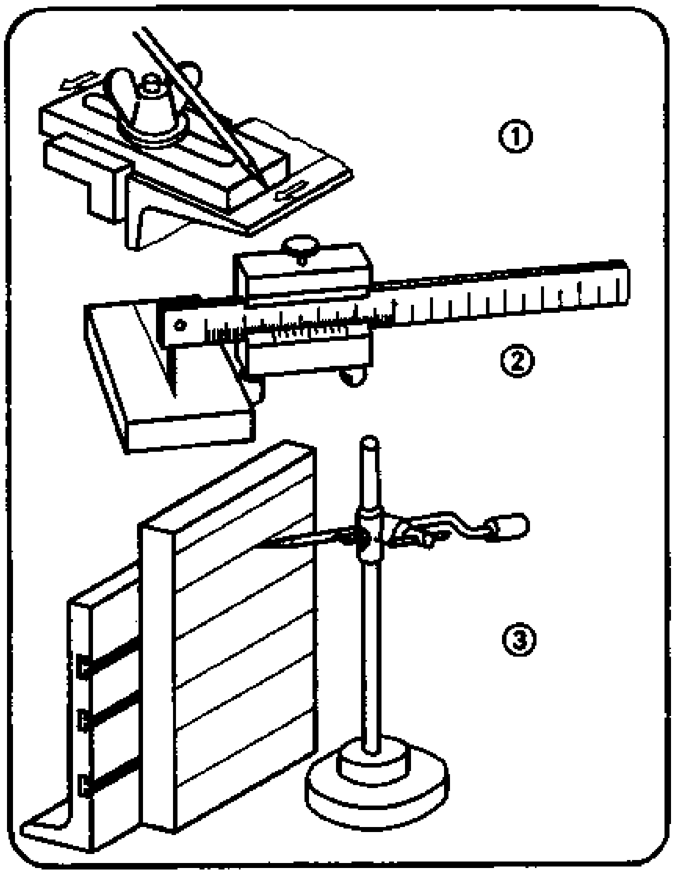


2.5

Scribing with dividers

Special emphasis is to be laid on the working stages of adjusting the dividers and control of the circular arc.

<u>Transparency No. 2.4.</u> will serve to demonstrate working situations in which the supporting point is located outside the work−piece.

Scribing with height gauge scriber

The difference in using the various height gauge scriber techniques has to be shown.

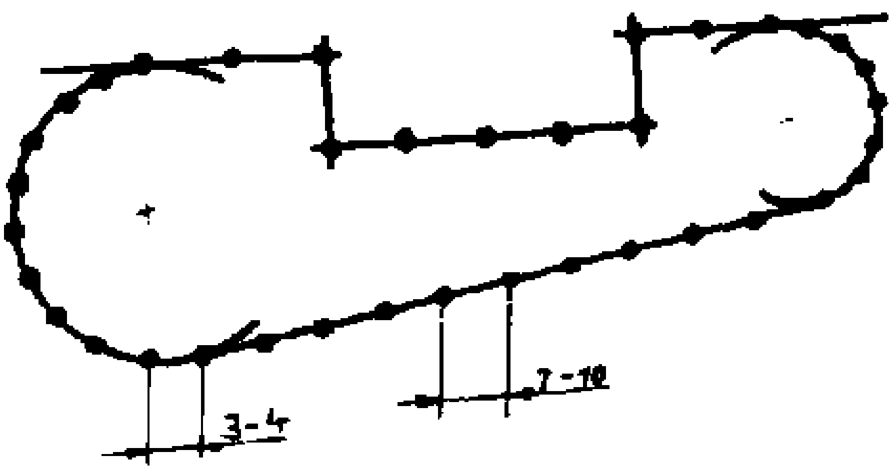
<u>Transparency No. 2.5.</u> can be used additionally to illustrate these techniques.

Punch marking after scribing

Instruction in handling the prick punches is to be supplemented by hints about how to make check punch marks according to recommended values.

The figures and formulas (also in the "<u>Trainees' Handbook of Lessons</u>") supplement the detailed instruction in the use of double−point punches for producing bore lines. Recommended values for check punch marks:

- spacing on straight sections 7 − 10 mm
- spacing on curved sections 3 − 4 mm.



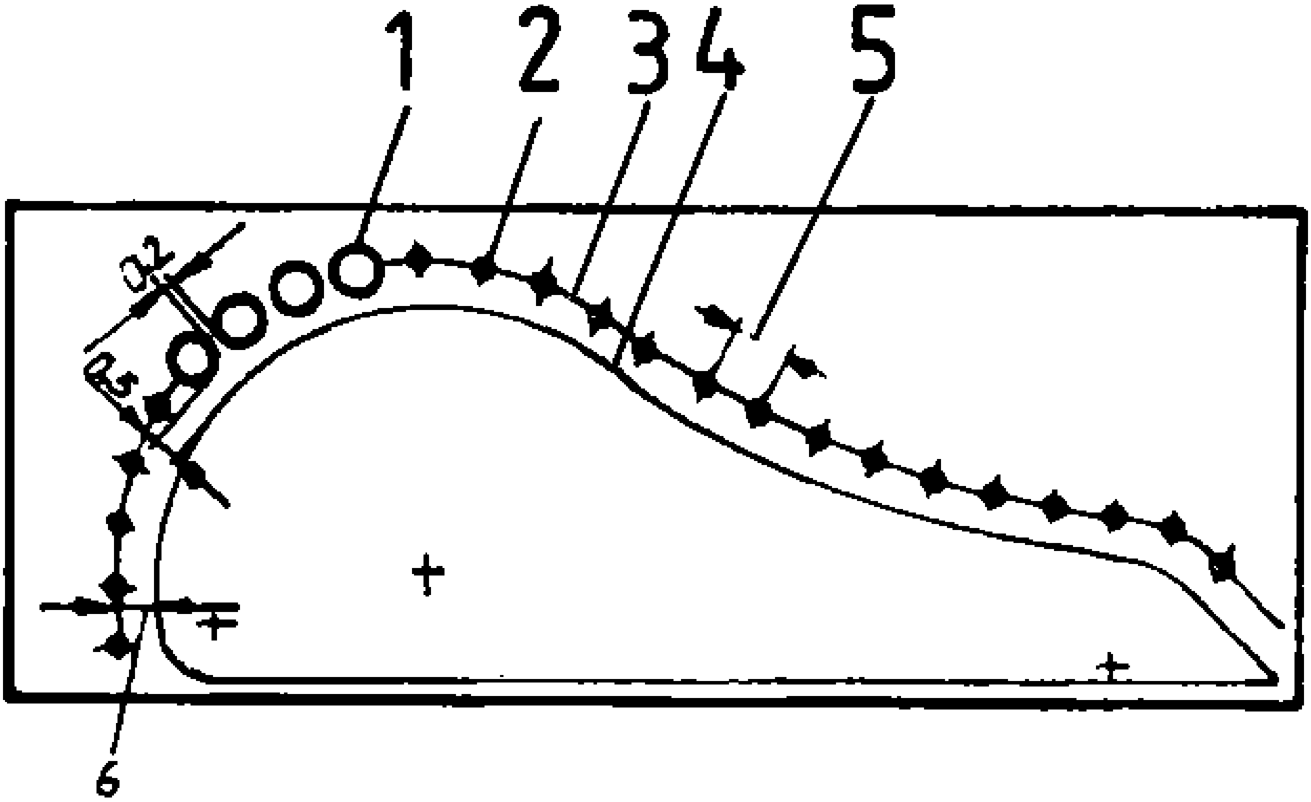
Correct spacings of check punch marks.

Formulas to calculate the boring lines:

D = y− 0.2 mm
x = D/2 + 0.5 mm

Conditions of producing a bore line

1 bore hole (0), 2 punch mark, 3 bore line, 4 scribed line − line of working, 5 width of double−point punch (y), 6 distance between bore line and scribed line (x)



The trainees have to be shown that the compliance with these conditions of producing bore lines guarantees a minimum of additional treatment when finishing the workpiece.

3.2. Exercises

The degree of difficulty with these exercises is to be increased step by step – beginning with very simple scribing techniques. The trainees should start their work with simple and straight scribing operations using a steel scriber. They must know the exact objective of the exercise and that their results might be evaluated.

A short practice to consolidate the use of the tools is to be started with exercises from the "Instruction Examples for Practical Vocational Training". However, it will be necessary to prepare each exercise by "job–related instructions", in which the trainees are shown a finished workpiece to illustrate the objectives and main problems of this exercise.

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

Thus the instructor can mention the major points of evaluation as well as the problems involved. During these lessons of special instruction the sequences of operations and working drawings must be placed on the tables so that the trainees can make notes therein.

All the trainees can carry out these exercises simultaneously, if the appropriate number of scribing tools is available.

This being the case, the trainees can do each exercise by themselves without being pushed by time limits.

If the required number of scribing tools cannot be provided, the group of trainees has to be subdivided according to the various categories of scribing applications:

group no. 1 – scribing with steel scribers
group no. 2 – scribing with scribing blocks
group no. 3 – scribing with dividers and punching with double–point punches

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 accompanied by the respective answers. Questions which are also contained in the "Trainees' Handbook of Lessons" are marked with the letter "A".

1. What is the purpose of scribing?
(Transfer of form and size of workpieces according to the dimensions on the manufacturing drawings to the blanks in order to enable true−to−size working).

2. What is the purpose of punch marking?
(Punching of tapered recesses for permanent marking of scribed lines, for supporting dividers points and drills.)

3. What are the conditions a scribed line has to fulfil?
"A" (Careful finish, accuracy, visibility during the entire manufacturing process.)

4. Which effect must be produced by scribing tools?
"A" (They have to produce clearly visible lines on the work−piece).

5. What makes the difference in the use of steel scribers and brass scribers?
"A" (Their results: steel scribers leave a fine notch; brass scribers plot lines.)

6. When do we use dividers with adjustable points?
(If radii are to be marked on stepped surfaces.)

7. What are the conditions a workpiece has to fulfil, if it is to be marked with scribing blocks?
"A" (They must avail of flat datum faces/edges to lay the scribing blocks.)

8. How do marking−out punch and centre punch differ?
(Marking−out punch: angle of taper 40° for scribed lines; centre−punch: angle of taper 60° for prick−punching of holes)

9. What are the conditions a workplace has to fulfil?
"A" (Clean; well illuminated; spacious enough to put down work−piece and accessories.)

10. What are the accessories to be used?
(Surface plate, angle plate, large−size steel parallels, vees, stencils, some measuring and testing tools.)

11. What makes the difference in the use of centre squares and try squares?
"A" (Centre square: scribing of central points at front sides of cylindrical workpieces; try square: scribing of straight lines on flat surfaces of workpieces.)

12. Why must certain surfaces of workpieces be coated with paint prior to scribing?
"A" (Because the roughness of certain workpieces does not allow a clearly visible scribed line.)

13. What paint is used as a coating for hard or scaled sheet metal (scaled by hot rolling)?
(Copper sulphate solution.)

14. What kinds of datum are there for scribing?
"A" (Datum surfaces, edges and lines.)

15. How do we guide the scriber at the steel straightedge or try square?
"A" (Drawing the scriber point directly along the edge of the straightedge or square with the scriber slightly inclined towards the body.)

16. What is a necessary intermediate step in scribing with dividers?
"A" (Making of check arcs to check the set radius.)

17. What are the accessories necessary for scribing with height gauge scribers?
"A" (Surface plate, angle plate, parallel piece.)

18. What are the conditions under which a parallel piece has to be used as workpiece support when employing height gauge scribers for scribing?
(If the height gauge scriber does not allow a zero−position of the scriber at the level of the surface plate.)

19. What makes punch marking of scribed lines necessary?
“A” (This must be done, if the following treatment will blur these lines or if the visibility during manufacture is restricted or if the surface conditions of the workpiece deteriorate the visibility.)

20. What spacing must be used for check punch marks?
(Straight sections: 7−10 mm)
curved sections: 3 − 4 mm)

21. What size is of prime importance for bore line marks?
“A” (Width of double−point punch /y/ of the double−point punch to be used.)

22. How is punching done with double−point punches?
(One point of the double−point punch has to be placed in the previous punch mark; the punch has to be set upright; punching can be performed now.)

23. What are the dangers associated with the use of scribing tools?
(Danger of injuries by the sharp points.)

4. Application of the working techniques of “Marking and Punch Marking”

The sequence of exercises can focus on one topic each according to the variant mentioned in section 3 or it may be divided into several stages.

The “Instruction Examples for Practical Vocational Training” provide 7 exercises whose degree of difficulty increases gradually.

These “Instruction Examples...” comprise a list of required materials (initial material, hand tools, measuring and testing tools, accessories) as well as the sequence of operations for carrying out the exercise and an illustrative working drawing. Thus, the trainees avail of the necessary information to do their exercises in an objective−related way.

The selection of exercises takes into consideration that such workpieces are scribed which will be used in the further stages of treatment with other working techniques, i. e. that they serve a certain purpose.

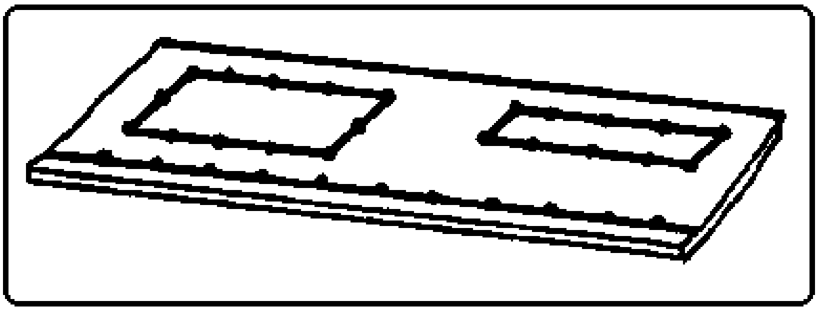
That is the reason why these workpieces should be marked with the trainee’s name in order to finish them at a later stage.

4.1. Instruction Examples

To give a survey of the workpieces on which the prior knowledge shall be verified, the individual training examples are described in brief here,

Instruction Example 2.1.
Door Lock Panel

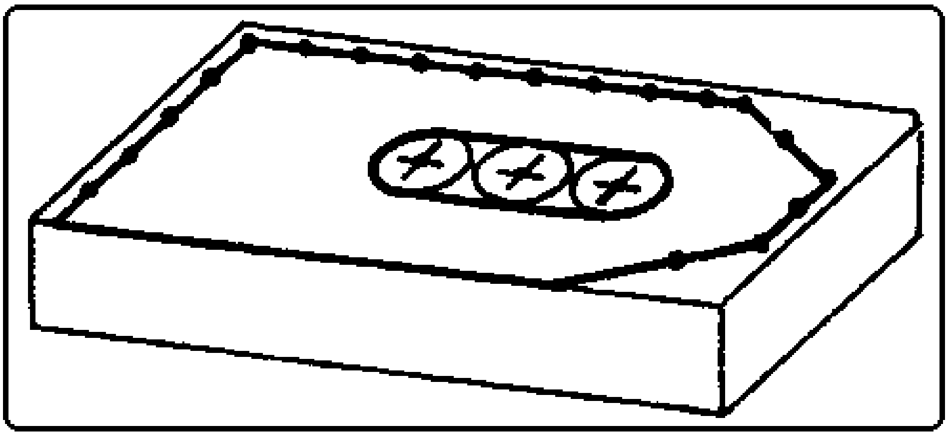
Scribing of straight and parallel lines on steel plates by using the steel rule, steel straightedge and steel scriber starting from datum edges.



The dimensions of the break−throughs can be adapted to local conditions so that this component can be screwed on a door frame after being finished by sawing, drilling and filing.

Instruction Example 2.2.
<u>Holding Clamp</u>

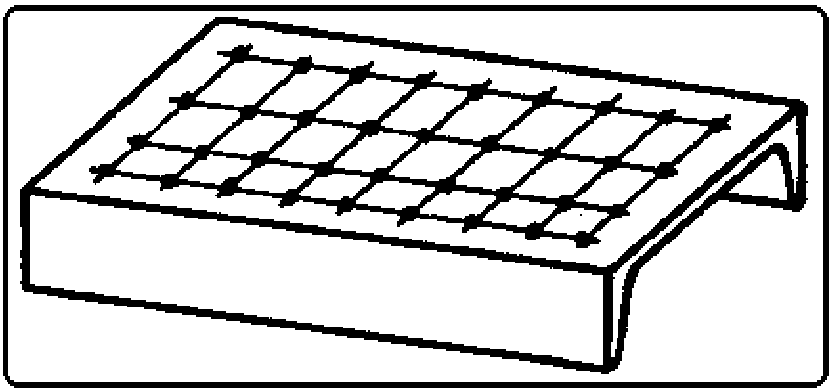
Scribing of straight and angular lines on steel sheet using a try square and protractor as well as a datum edge and a datum line.



Together with the instruction examples 5.1., 5.2. and 5.5. this will constitute a set of clamping tools for an upright drilling machine.

Instruction Example 2.3.
<u>Drill Stand</u>

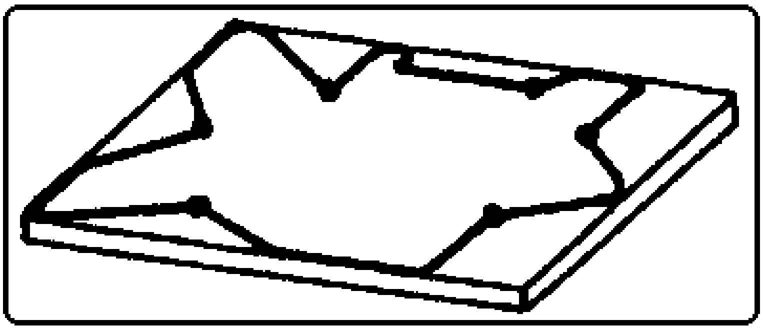
Scribing of straight and parallel lines using scribing blocks on rolled steel channels based on datum edges.



After having finished this part it can be used as support for drills. Instruction example 7.4. describes how to finish this component •

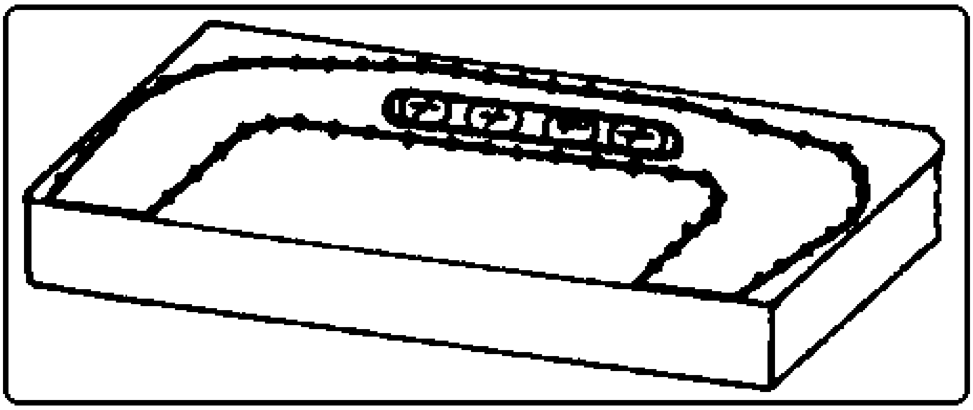
Instruction Example 2.4.
<u>Angle Gauge</u>

The universal bevel protractor is used for scribing angular lines on steel sheet based on datum edges. After having been finished, this instrument can serve as a testing tool in the field of sharpening tools, as this gauge contains the most important angle sizes.



Instruction Example 2.5.
Bow for C Clamp

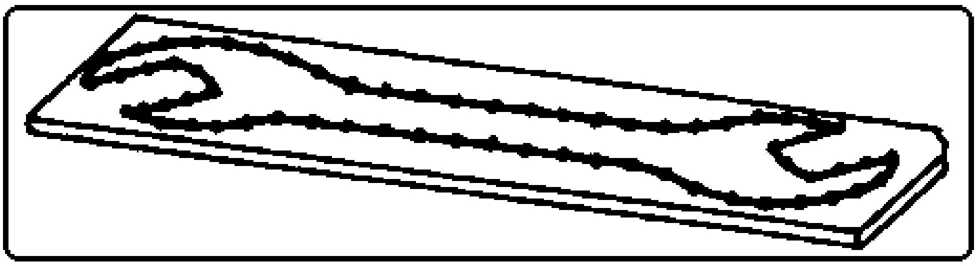
Scribing of lines on steel sheet using height gauge scriber and dividers based on datum edges and a datum line.



Another major point of work refers to marking a bore line according to fixed dimensions. After being completed, this part will be a component of a C clamp which can be used in the workshop. (This comprises also the parts mentioned in the instruction examples 7.6., 8.2. and 9.5.)

Instruction Example 2.6.
Open−end Wrench 19/24

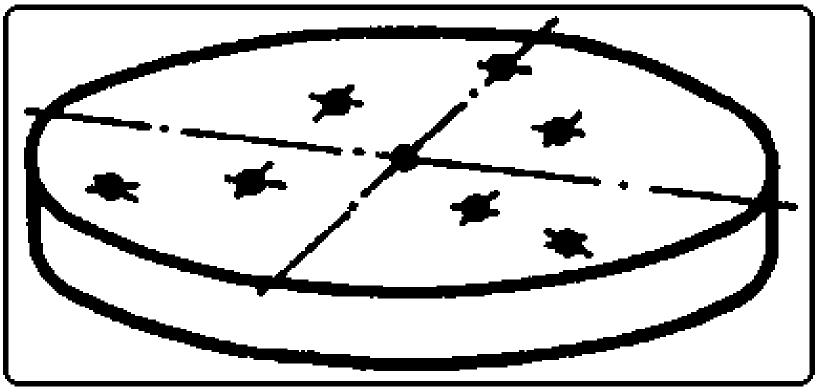
Scribing of symmetrical, curved and straight lines on steel sheet using a datum line as the central line.



Additionally, a bore line will be scribed and punch marked. After finishing this test workpiece it can be used in the workshop to fasten/loosen hexagonal−head bolts and M12 or, resp. M16 nuts.

Instruction Example 2.7.
Base Plate

On a circular steel plate the contour and markings for boreholes will be scribed using a steel rule, dividers and centre square. Then a bore line is to be scribed. When this workpiece has been finished, various devices (e.g. workbench lamp) can be mounted with this base plate on a workbench,



4.2. Criteria for practical training

It is recommended to determine some major points of observation and evaluation when the work is being carried out. The following criteria may serve as a guideline:

– Does the trainee use the scribing tools so that injuries will be avoided?
– Are the surfaces of the workpiece coated with the appropriate paints, if necessary?
– Are the datum lines/edges up to the standards?
– Is the position of the steel scriber correct?
– Are the transitions from straight lines to curved ones clean and without steps?
– Does the trainee draw the necessary lines only or does he produce a maze of lines?
– Are the scribed lines clear and a single line only or are there any double lines?
– Are the supporting points for the dividers sufficiently prepunched?
– Are the scribers of the scribing block exactly adjusted?
– Are the spacings of the check punch marks correct?
– Are the check punch marks exactly on the scribed line or not?
– Are the bore lines correctly scribed and punched according to the given conditions?

5. Captions and legends to the “Marking and Punch Marking” transparencies series

Transparency No. 2.1. Scribing Tools

(1) steel scriber
(2) brass scriber
(3) pencil (soft)
(4) dividers
(5) prick–punches

1 – marking–out punch
2 – centre punch

(6) double–point punch
(7) height gauge scriber with scale

Transparency No. 2.2. Technique of Scribing and Prick–Punching

(1) locating of scriber
(2) placing the punch and upright position for punching.

Transparency No. 2.3. Scribing with Steel Squares

(1) scribing with try square
(2) scribing of shaft centre with centre square
(3) scribing of shaft centre with T–square
(4) scribing of central lines with T–square

Transparency No. 2.4. Scribing with Dividers

(1) scribing with toolmakers' dividers
(using an inset, because the supporting point is located outside the workpiece)

(2) scribing with beam trammel

Transparency No. 2.5. <u>Scribing with Scribing Blocks</u>

(1) caliper gauge
(2) marking gauge
(3) height gauge scriber

Measuring and Testing – Course: Technique for Manual Working of Materials. Methodical Guide for Instructors

Table of Contents

Measuring and Testing – Course: Technique for Manual Working of Materials. Methodical Guide for Instructors

Institut für berufliche Entwicklung e.V.
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1. Objectives and contents of practical vocational training in the working techniques of "Measuring and Testing"

By concluding their training the trainees shall have a good command of the working techniques of "Measuring and Testing". Therefore, the following objectives are to be achieved:

Objectives

– knowledge of the purpose and application of the measuring and testing methods

– mastery of the various basic measuring and testing methods and capability of making decisions on quality independently,

– capability of selecting the proper measuring and testing tools and their proper use.

The following contents have to be imparted to the trainees:

Contents

– purpose of measuring and testing
– types and uses of measuring and testing tools

2. Organizational preparation

In order to guarantee a trouble–free development of instruction. exercises and teaching, it is necessary to prepare this training appropriately.

The following steps have to be taken:

2.1. Preparation of instructions on labour safety

Prior to the exercises, a brief instruction on the proper use of measuring and testing tools has to be given. This comprises hints for accident–free work,

The main emphasis is to be laid on:

– keeping the measuring and testing tools always separate from cutting/working tools;

– carrying measuring and testing tools in cases only and greasing them slightly with acid−free grease to protect them from rust;

– handling measuring and testing tools with care and not exposing them to the risks of shock and dropping.

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

2.2. Provision of teaching aids

For demonstration purposes during instruction a soft support should be provided on a workbench.

The "Trainees' Handbook of Lessons − Measuring and Testing" is to be handed out to the trainees.

When using the transparencies series of "Measuring and Testing", check whether they are complete (transparencies 1.1. to 1.9.) and whether the overhead projector is functional. (Check the operating conditions at the place of use and make sure of the proper mains supply!)

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

All the measuring and testing tools 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 − Measuring and Testing" must be handed out to the trainees to provide them with the theoretical foundations for the exercises to be performed.

The initial materials necessary for the exercises have to be prepared and laid out in a sufficient number of copies, according to the materials mentioned in the "Instruction Examples ...".

Each trainee is to be provided with a workbench with a soft support and appropriate lighting at his workplace. The trainees' workplaces have to be fully equipped with measuring and testing tools according to the exercises planned. Do not forget to check this I

Recommended basic equipment:

– steel rule, tape rule
– vernier caliper, depth gauge
– external micrometers, dial gauge with support
– protractor, universal bevel protractor
– calipers, thickness gauge, hole gauge, block gauges
– limit gauges
– straightedges, squares, angle gauges, radius gauges.

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
– performing 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 techniques of "Measuring and Testing"

The following paragraphs comprise proposals on conducting trainee instruction, the demonstration of working techniques as well as exercises and tests. We recommend two course variants:

Variant No. 1

This variant is to be chosen for trainees with generally good achievements and receptiveness:

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

1.2. Exercises in measuring and testing techniques from the "Instruction Examples 1.1. to 1.8." and subsequent evaluation.

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

Variant No. 2

This variant is to be chosen for trainees with little previous knowledge or poor achievements:

2.1. Introductory instruction for the subject of "Measuring Tools" with demonstrations based on the "Trainees' Handbook of Lessons".

2.2. Exercises in measuring from the "Instruction Examples 1.1. to 1.3." with subsequent evaluation.

2.3. Supplementary instruction for the subject of "Testing Tools" with demonstrations from the "Trainees' Handbook of Lessons".

2.4. Exercises in measuring and testing from the "Instruction Examples 1.4. to 1.8." with subsequent evaluation.

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

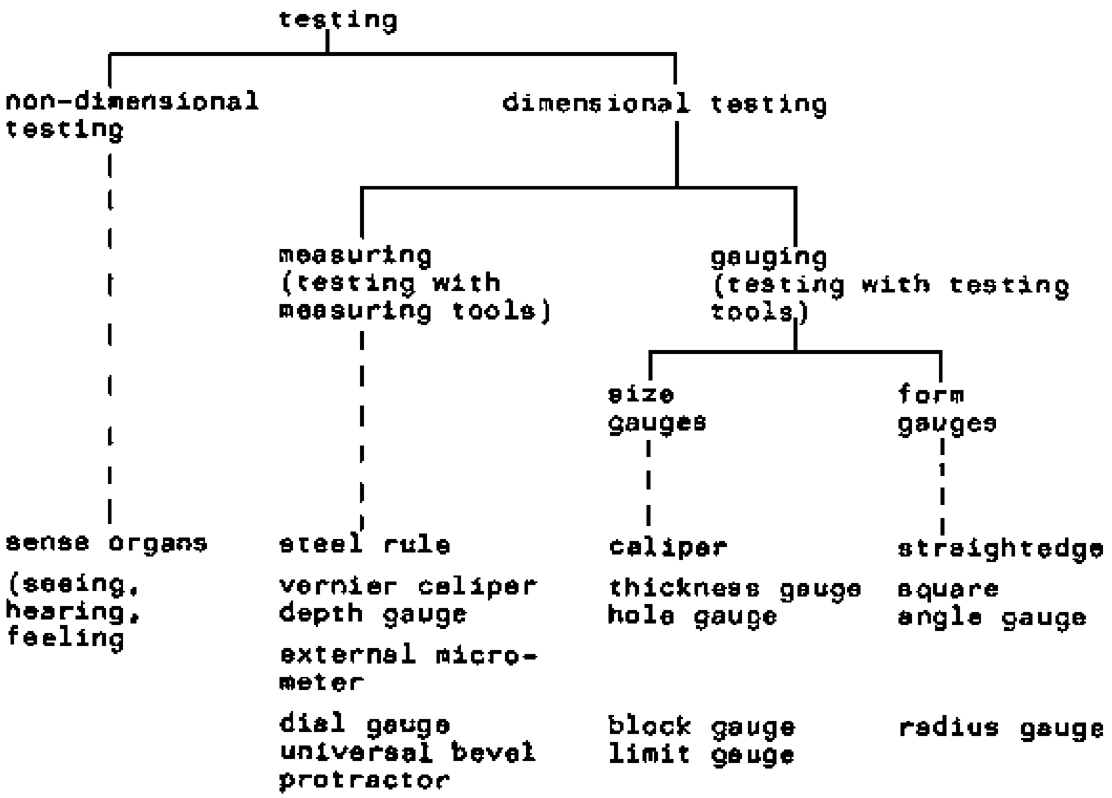
Practical skills should be tested immediately after the evaluation tables contained in the working drawings have been handed in. Knowledge of theory should be constantly checked. However, it is recommended that a final test paper (point 1.3. or, resp., 2.5.) should be written after concluding the exercises.

3.1. Introductory instruction

If possible, this instruction should be given in a classroom. Ensure that the trainees put down necessary supplementary hints 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 measuring and testing

Instruction is to begin with clear–cut definitions of the terms and concepts. The trainees have to learn that there is a distinction between testing procedures with measuring tools (measuring) and testing procedures with testing tools (gauging). The following survey is to facilitate the classification of terms:



It must be made clear to the trainees that dimensions, shapes or surface finish have to be checked after every individual stage of work. The following principle must become their motto of work:

> "Do your work as precisely as <u>necessary</u> and not as precisely as possible!"

<u>Measuring tools</u>

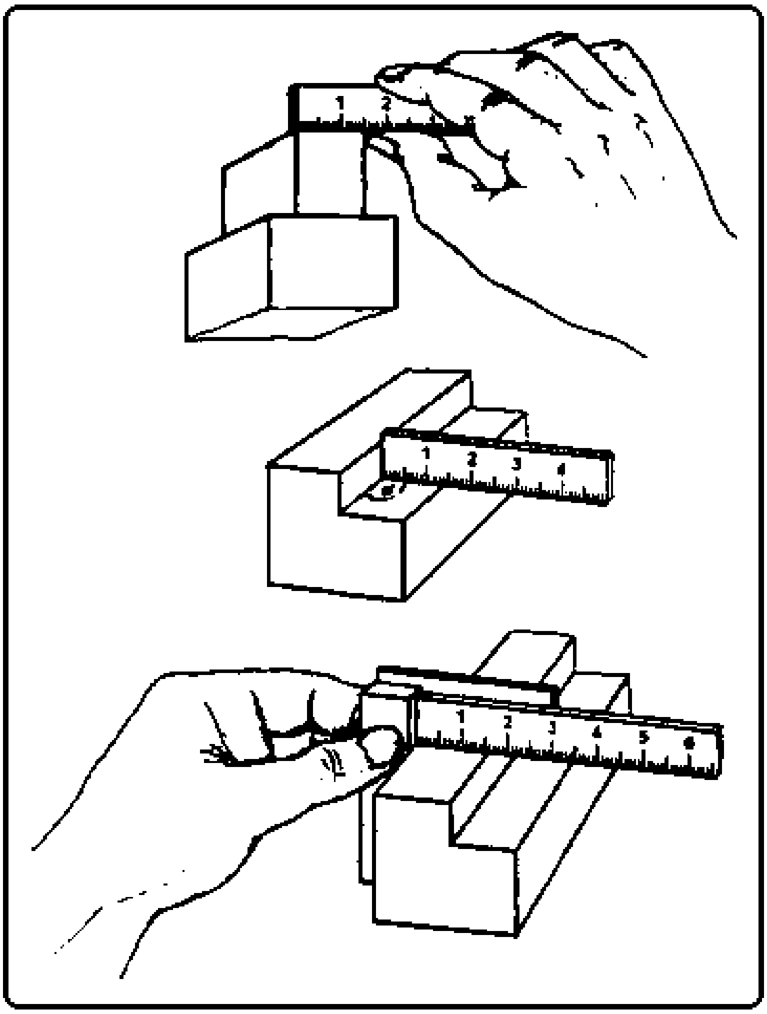
The most common types of measuring tools can be introduced according to the list of measuring tools contained in the <u>"Trainees' Handbook of Lessons".</u> This will be followed by defining their ranges of application and accuracy.

The envisaged order is as follows:

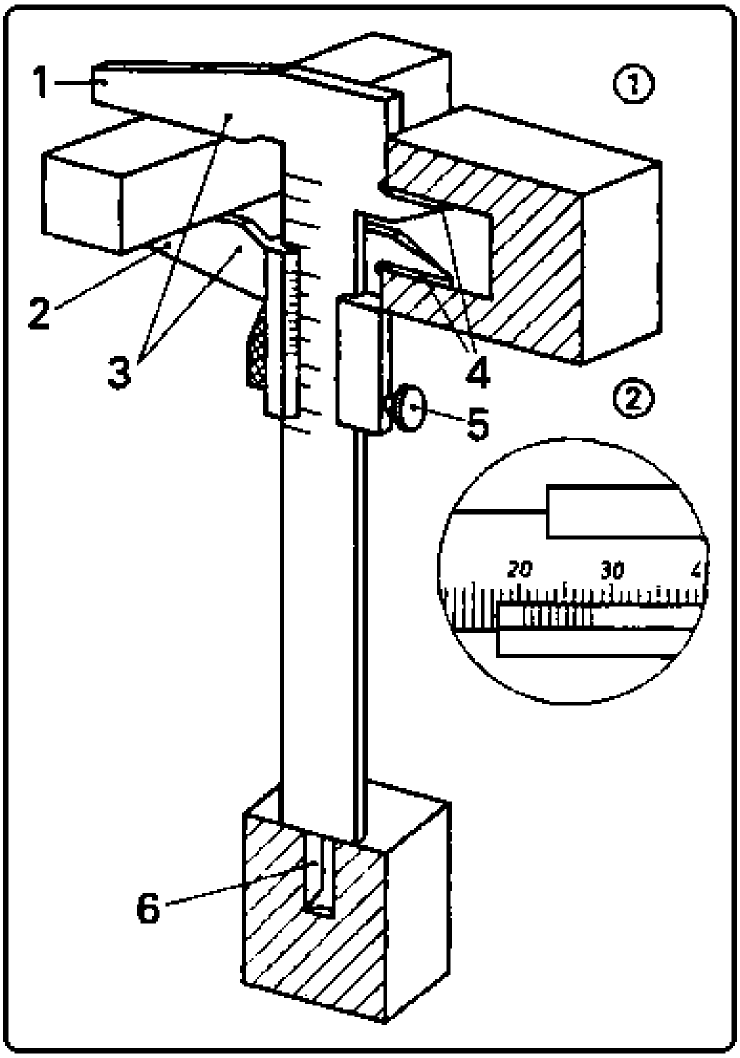
- steel measure, roller–type measuring tape (tape rule)
- vernier caliper
- depth gauge
- external micrometer
- dial gauge
- protractor
- universal bevel protractor.

When describing the first, simple measuring tools the instructor should explain to the trainees that there is a relation between the numerical value and the standardized measuring unit. Therefore, every trainee should have carried out the respective measuring operation at least once (such as the measuring of objects available in the classroom by using a steel rule). The trainees are taught how to read the measuring values correctly. This is to be practised, if necessary.

The <u>transparencies 1.1. and 1.2.</u> may be used to further clarify this subject.



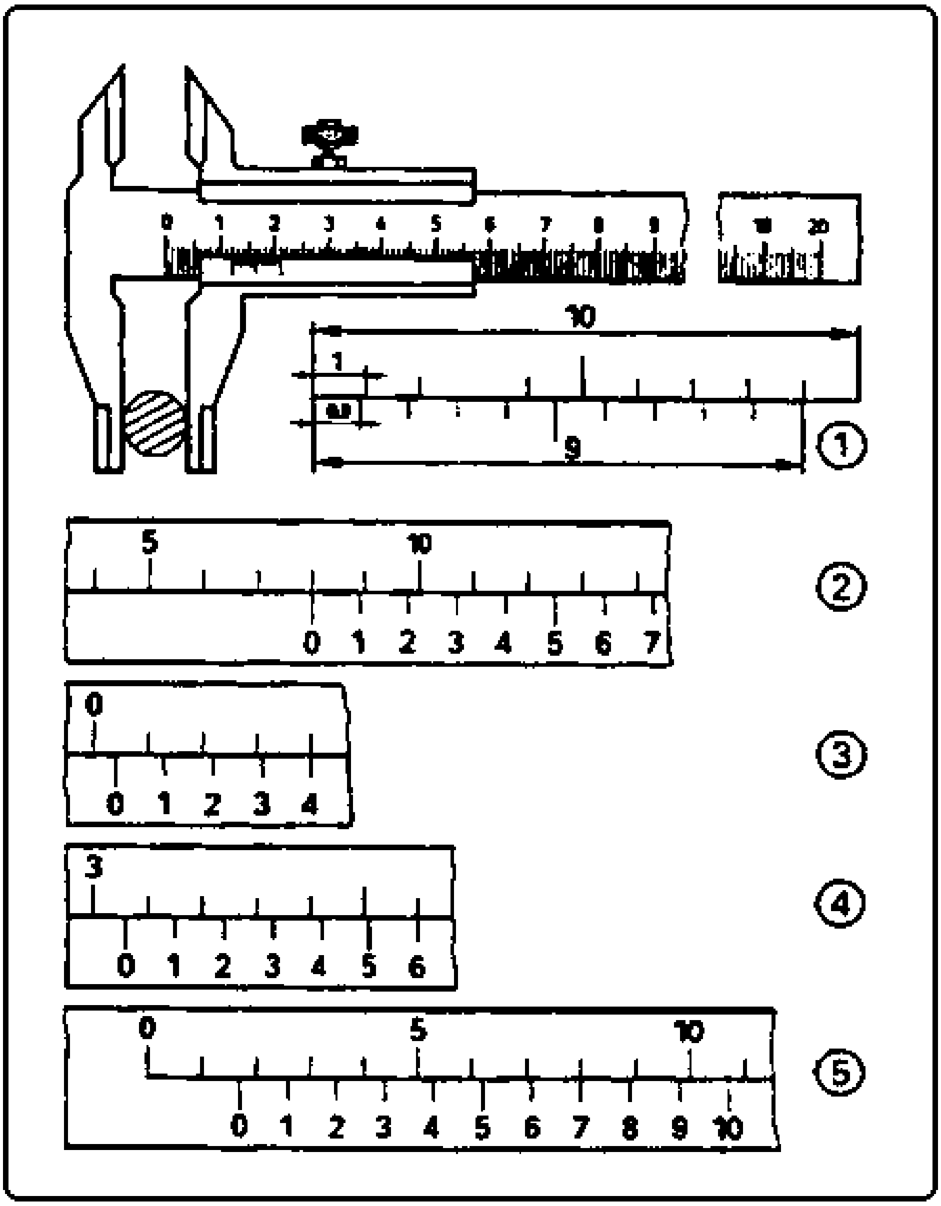
Transparency 1.1.



Transparency 1.2.

Experience shows that trainees find it difficult to handle the vernier caliper at the beginning.

Transparency 1.3. should be used to demonstrate the procedure of reading measuring values at this device.

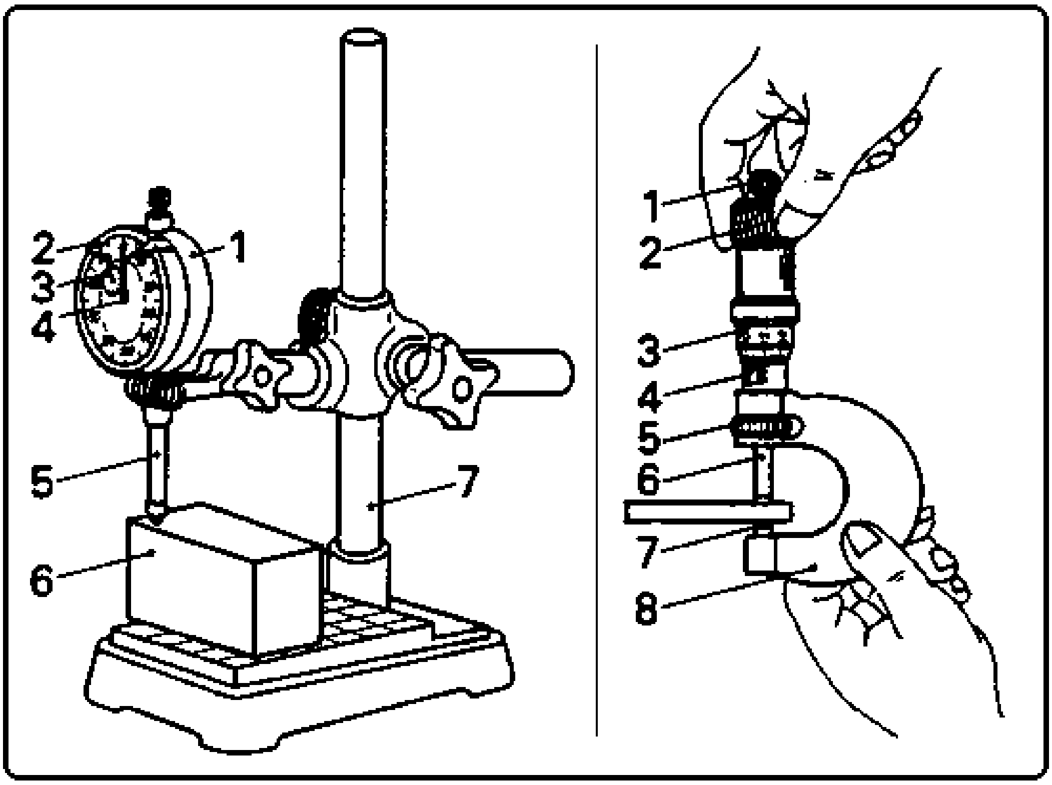


Transparency 1.3.

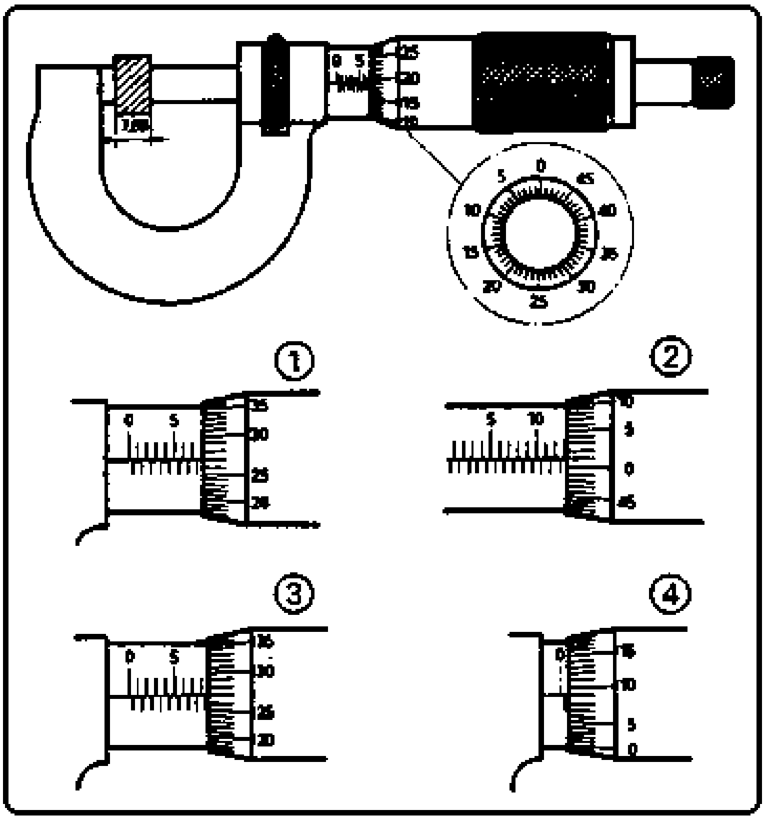
This transparency introduces some setting examples for recognizing the measuring values. The trainees have to put down the settings nos. two to five on a piece of paper and to check the results mutually by exchanging their papers.

This reading test can also be performed without using this transparency. Therefore, the trainee has to read measuring values on the vernier caliper adjusted by the instructor. The vernier caliper has to be given a fixed measure, the fixing screw is to be tightened, and the device is to be passed on to the group of trainees. Every trainee puts down the measured value so that it might be checked afterwards. The following measuring tools should not be introduced before having a good command of handling the vernier caliper.

Transparency no. 1.4. may be used, in addition to the original tools, to introduce the dial gauge and external micrometer precision measuring tools. Exercises in reading the measuring values on the external micrometer may be done similarly to that with the vernier caliper according to transparency no. 1.5. Reading the values on the original tool should also be practised with setting examples.



Transparency 1.4.



Transparency 1.5.

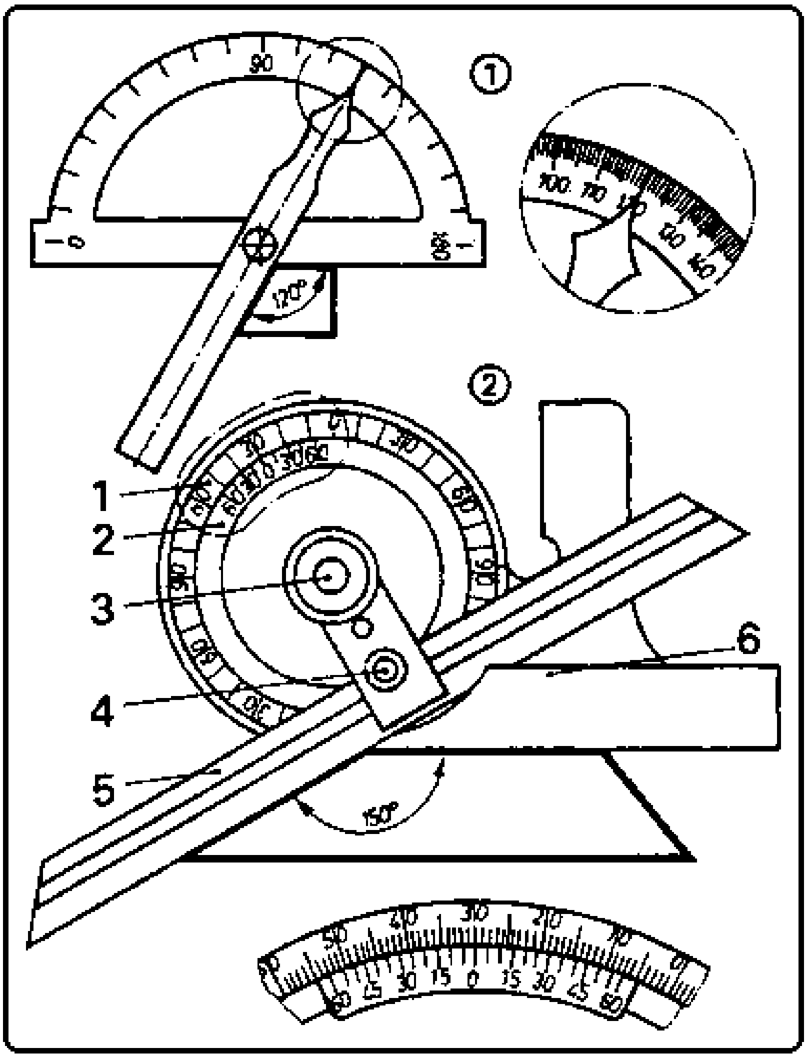
Using the dial gauge may be demonstrated as follows:

The dial gauge rests on its support – a square–shaped workpiece with parallel bottom and top surfaces is to be put under the tracer pin which is slightly thrown in. The dial gauge scale is adjusted to "Zero" and the limit pointers are set at 10/100 mm on the right and left side of "Zero".

Now the workpiece is to be moved to and fro under the tracer pin. The trainees can be shown that the indicator position beyond the limit pointers means that the range of tolerance has been exceeded.

The trainees have to learn what the term "tolerance" means. It is to be made clear to the trainees that an indicator position within the range of tolerance means that the quality is still "good".

When describing the instruments for angular measurement, special emphasis is to be laid on handling the universal bevel protractor, as it guarantees a universal use. Transparency no. 1.6. can be used for further clarification.



Transparency 1.6.

After these instructions, it is recommended that the topic of faulty measurements should be discussed. If possible, the main causes of such faults should be stated clearly:

- fault with the measuring instrument
- fault due to incorrect handling/use
- fault caused by environmental circumstances.

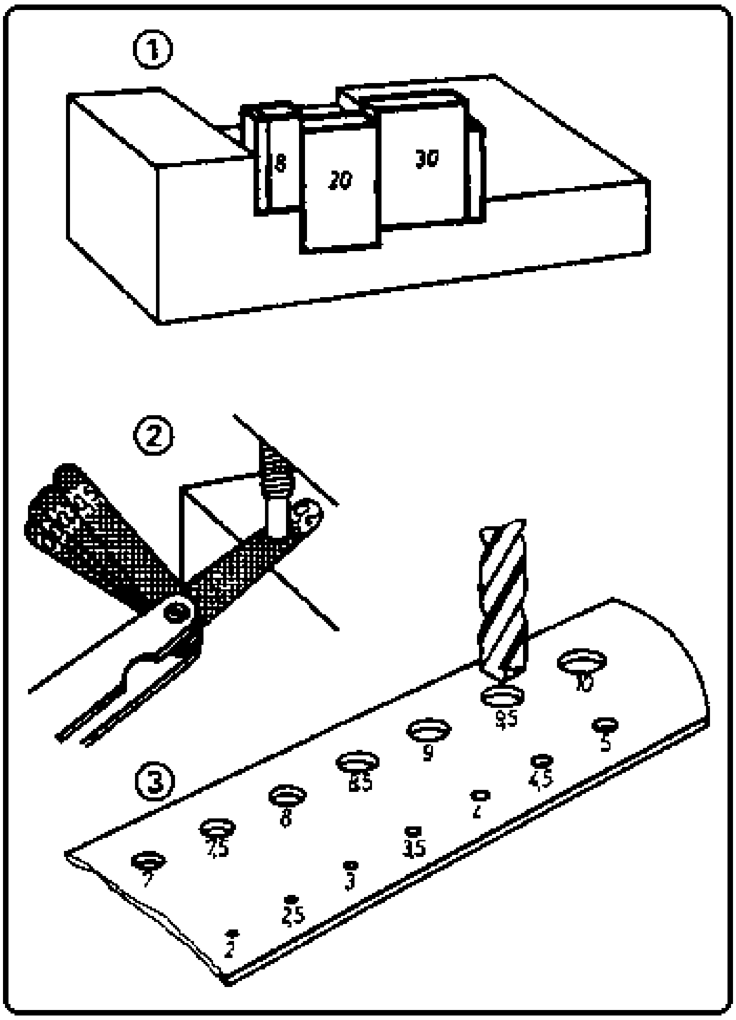
These instructions must be followed by hints for the prevention of such faulty measurements,

Testing tools

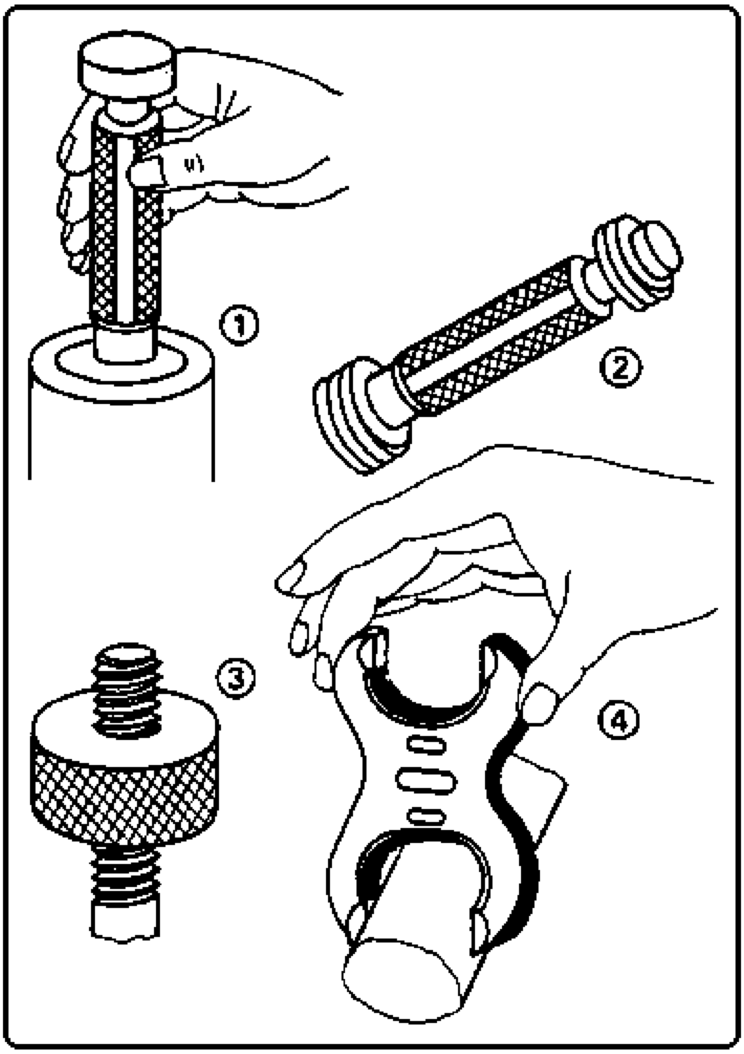
The order of testing tools in the list contained in the "Trainees' Handbook of Lessons" is to be followed when explaining the use of these testing tools. First you should deal with the size gauges and make clear how they differ from form gauges. The definition of the terms contained in the "Trainees' Handbook of Lessons" may be used to explain this difference.

Transparency no. 1.7. can serve to illustrate size gauges

- caliper, thickness gauge, hole gauge. Limit gauges can be seen on transparency no. 1.8.



Transparency 1.7.



Transparency 1.8.

Design and use of limit gauges need detailed information. Experience shows that it is not easy to learn how to handle these size gauges. The trainees have to be given some information on the designation of limit gauges, which is derived from standards.

The trainees will learn that this designation indicates the maximum and minimum values of a standardized range of tolerance.

Comments on the use of limit gauges should be made during demonstrations of prepared test specimens. Thus, the trainees will learn the distinction between the "go" end and the "not go" end of the various kinds of limit gauges.

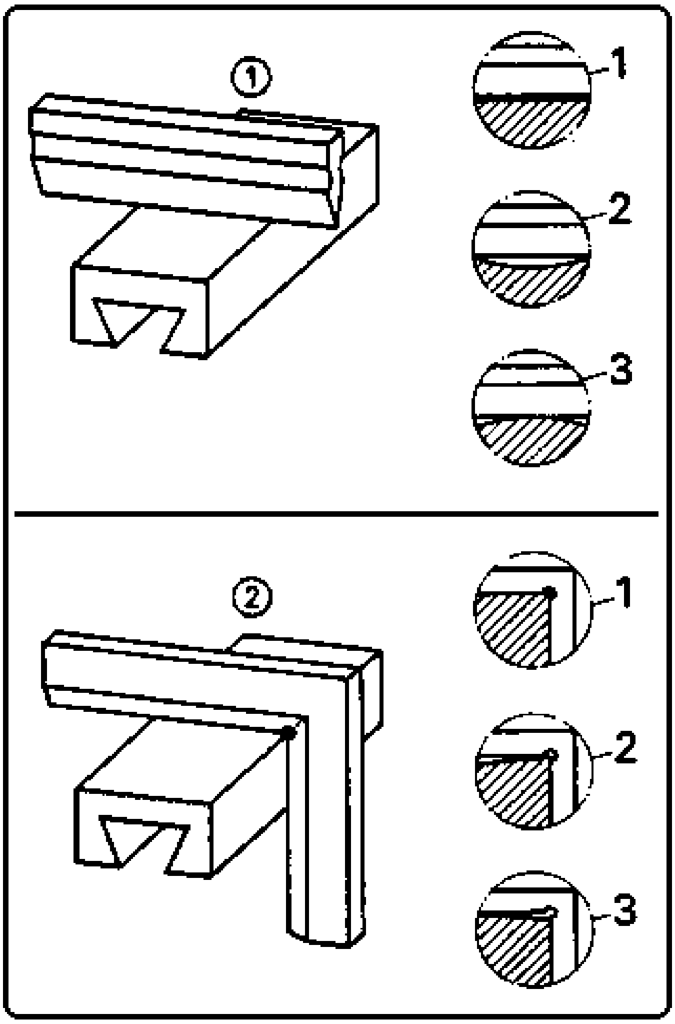
It should be emphasized that the distinction between maximum and minimum values falls within the range of several hundredths of millimeters.

The trainees must realize that testing with these testing tools has to be carried out sensitively and non−violently. When introducing the form gauges the instructor has to mention the light−gap method. The trainee will learn that the form of the gauge serves to make decisions on quality by comparison.

These gauges should be introduced in the following order:

- straightedges (steel straightedge, bevelled steel straightedge)
- squares (flat, try and bevelled edge squares)
- angle gauges
- radius gauges.

Transparency no. 1.9. can supplement this instruction.



Transparency 1.9.

The trainees must learn to evaluate the surface qualities of the object (workpiece) to be tested (checked) by using the light–gap method. It is recommended to illustrate the handling of these testing tools by using test specimens prepared in advance.

3.2. Exercises

The degree of difficulty in these exercises is to be increased step by step beginning with the easiest measuring and testing techniques and ending with the more complicated methods. Instruments for rough measuring should be dealt with first. To practise these measuring and testing techniques any objects available may be used as measuring specimens. The trainees must know the objectives of the exercises and that the results of measurements are subject to evaluation.

A short practice of handling the instruments is followed by exercises from the "Instruction Examples for Practical Vocational Training".

Each of the individual exercises must be preceded by a brief "job–related instruction" in order to show the trainees where the measuring and testing methods have to be applied on the chosen objects.

The instructor can mention the major points of evaluation as well as the problems involved.

During these lessons of special instruction the trainees have to place the sequences of operations and working drawings with the tables to be completed contained in the "Instruction Examples" on their desks so that they can make notes therein.

All the trainees can carry out these exercises simultaneously, if the appropriate number of measuring and testing tools is available.

This being the case, the trainees can do the necessary exercises by themselves without being pushed by time limits. If the required number of tools cannot be provided, the waiting trainees should do other jobs in the workshop. It is a good practice to roughly prepare the initial materials for the subsequent exercises, e.g. selection of materials, sawing and shearing to rough nominal sizes, derusting. deburring etc. These activities need supervision!

3.3. Examples for Recapitulation and Tests

This section contains questions which are to consolidate and test the acquired skills and knowledge. All the exercises are provided with the necessary answers.

Questions which are also contained in the "Trainees' Handbook of Lessons", are marked with the letter "A".

1. What is the purpose of measuring and testing?

(To check dimensions, shape and surface finish of the work−piece during the manufacturing process and to compare the data with the manufacturing drawing.)

2. Which testing methods do you know?

"A" (Dimensional and non−dimensional testing methods.)

3. Which dimensional testing methods do you know?

(Testing with measuring tools and testing with testing tools (gauges).)

4. What is the difference between measuring and gauging?

"A" (Measuring serves to determine the exact sizes and dimensions; gauging serves to find out deviations from dimensions and shapes limited by a certain range of tolerance.)

5. Which measuring tools have a measuring accuracy of 1/10 millimeter?

"A" (Vernier caliper, depth gauge.)

6. Which measuring tools are used for precision measurements of 1/100 millimeter measuring accuracy?

"A" (External micrometer, internal micrometer, depth micrometer, dial gauge.)

7. How do the individual types of instruments for angular measurements differ?

"A" (Protractors with a range of 0 − 180 degrees for rough measurements; universal bevel protractors with a range of 0 − 360 degrees for precision measurements.)

8. Which measuring faults do you know?

(Faulty measuring instrument, faulty handling, environmental influences.)

9. How can we avoid faulty measuring?

"A" (Repeated measuring; use of faultless measuring instruments, proper handling of these instruments; provision of a clean and well−lit workbench; measuring under the same temperature conditions.)

10. What is the difference between measuring and testing tools?

"A" (Measuring tools are provided with scales to read the measuring value; testing tools do not have scales but only the designation of the measure.)

11. What are size gauges?

(Instruments to determine sizes or to check whether or not existing dimensions on an object are within the stipulated limits.)

12. What are the special features of limit gauges compared to simple size gauges?

"A" (They mostly comprise two size gauges for the maximum and minimum size and are used with standardized and very close ranges of tolerance.)

13. Which testing method is typical of using the cylindrical limit plug gauge?

"A" (The "go" end must fit easily into the true−to−size bore hole, the "not go" end must not.)

14. Which testing results do we obtain if we use limit screw plug gauges?

"A" (Result: "go" or "not go", "go" does not say anything about external quality criteria.)

15. What are form gauges?

(Instruments to check flatness, angles and accuracy of radius.)

16. Which testing method is typical of form gauges?

"A" (Light−gap method − comparison of gauge and workpiece through light incidence; light incidence must be uniform.)

17. How do squares and angle gauges differ?

"A" (Squares are used to check the squareness of surfaces or edges/e.g. 90 degrees/; angle gauges are designed for specific angles/e.g. 55 degrees/.)

18. Which are the main principles to be observed when employing measuring and testing tools?

"A" (Keep measuring and testing tools separate from cutting or hand tools, place them on soft pads, protect them shocks and dropping.)

4. Application of the working techniques of "Measuring and Testing"

The sequence of exercises can focus on one subject according to the variant mentioned in section 3 or it may be divided into several stages.

The "Instruction Examples for Practical Vocational Training −Measuring and Testing" provide 8 exercises, the degree of difficulty of which increases gradually.

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

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

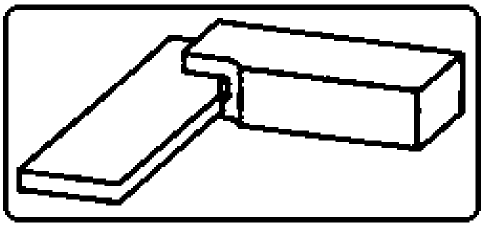
The selection of exercises takes into consideration that in the majority of cases there are no manufactured pieces of work available and that the acquisition of measuring and testing techniques will be the first activities at the beginning of the course for such trainees. That is the reason why we have chosen objects which usually are available at the workbench or in the workshop.

4.1. Instruction Examples

What follows is a short description of the individual training examples in order to give a survey of those objects at which the prior knowledge is to be verified.

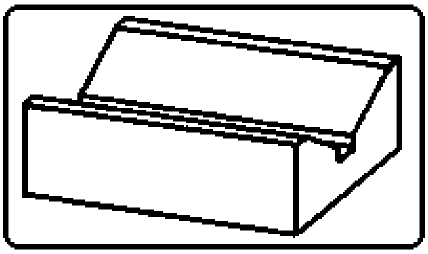
Instruction Example 1.1.
<u>Try Square</u>

This testing tool shall serve as an object for simple rough and precise linear measurements by means of the steel rule, vernier caliper, depth gauge as well as for flatness testing by means of the bevelled steel straightedge.



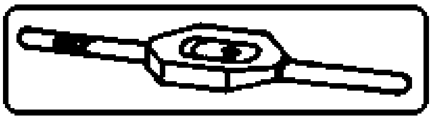
Instruction Example 1.2.
<u>Vee</u>

A vee which is often used in a workshop shall be tested by using the steel rule, caliper, depth gauge and protractor (rough and precise measurements). Bevelled steel straightedge and bevelled edge square shall be used to test the flatness and squareness of faces.



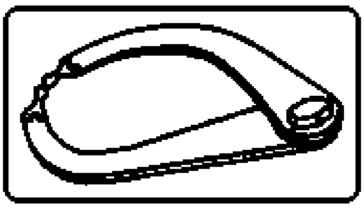
Instruction Example 1.3.
<u>Tap Wrench</u>

This device shall serve as an object to practise linear and angular measurements of a higher degree of difficulty. The exact measuring point will be determined by rough and precision measurements.



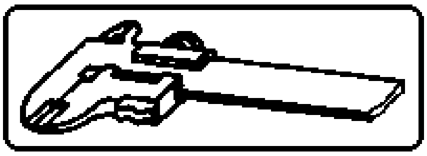
Instruction Example 1.4.
<u>Outside Calipers</u>

This device shall serve to practise simple linear measurements by rough and precision measurements as well as radius measurements of external and internal radii and angles. The light−gap method roust be fully mastered.



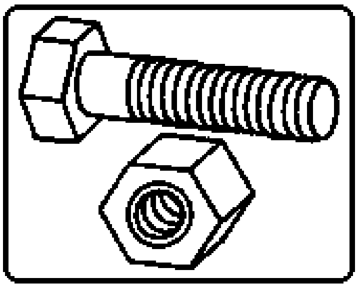
Instruction Example 1.5.
<u>Vernier Caliper</u>

This device shall serve as an object to practise linear and angular measurements as well as radius determinations with a high degree of difficulty. External micrometers for precision measuring will add to the degree of difficulty.



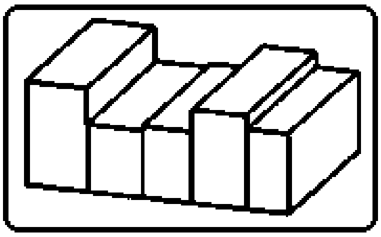
Instruction Example 1.6.
Hexagonal–Head Bolt and Nut

In addition to simple linear and angle measurements, the thread is to be determined by using a limit gauge in order to check whether the external and internal threads are true to size.



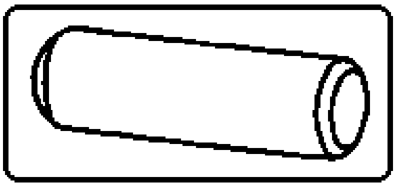
Instruction Example 1.7.
Block Gauge

Some block gauges are arranged side by side so that differences can be measured by using a dial gauge. The skill of handling external micrometers is to be consolidated.



Instruction Example 1.8.
Plain Pins

The external micrometer is used to determine the dimensions of diameters; limit snap gauges shall serve to check true–to–size dimensions and tolerances according to standard values.



4.2. Criteria for practical training

It is recommended to determine some major points of observation and evaluation when the work is being carried out. The following criteria may serve as a guideline:

– Does the trainee handle the measuring and testing tools with care or negligence?

– Does the trainee select the proper measuring tools?

– Are the surfaces to be measured and tested clean or does the trainee use the measuring/testing tool on surfaces which are not clean?

– Does the trainee read the correct measuring value or are there reading errors?

– Does the trainee employ the correct measuring force or does he cause damage by applying too much measuring force?

– Does the trainee use the "go" end and "not go" end of the limit gauges properly?

– Does the trainee put the form gauge on the surface properly or does he cant it?

– Does the trainee see the light gap and can be evaluate it?

5. Captions and legends of the "Measuring and Testing" transparencies series

Transparency No. 1.1: Application of the Steel Rule

Transparency No. 1.2.: Design and Application of Vernier Caliper

(1) Vernier caliper

1 fixed jaw with measuring scale
2 sliding jaw with vernier
3 measuring jaw for external measurements
4 measuring jaw for internal measurements
5 clamping screw
6 depth gauge

(2) Vernier with a set measure of 20.8 mm

Transparency No. 1.3.: Vernier Caliper Setting Examples

(1) Comparison of length of scale units and vernier units in millimeters
(2) Setting of 8 mm
(3) Setting of 0.4 mm
(4) Setting of 3.6 mm
(5) Setting of 1.7 mm

Transparency No. 1.4.: Design and Application of Precision Measuring Tools

(1) Dial Gauge

1 dial gauge
2 tolerance pointer
3 millimeter indicator
4 0.01 millimeter indicator
5 tracer pin
6 workpiece
7 support

(2) External Micrometer

1 tracer screw
2 case
3 dial for 50/100 millimeter indication
4 dial for whole and half millimeters
5 clamping nut (locking)
6 sliding tracer pin (measuring screw)
7 fixed tracer pin (anvil)
8 frame

Transparency No. 1.5. Setting Examples at the External Micrometer

(1) 8.27 mm setting
(2) 13.01 mm setting
(3) 8.77 mm setting
(4) 0.59 mm setting

Transparency No. 1.6. Design and Application of Instruments
<u>for Angular Measurements</u>

(1) Protractor (120 degrees' setting)
(2) universal bevel protractor (150 degrees' setting)

1 scale with 4 x 90 degrees' division
2 vernier
3 locking knob for scale
4 locking knob for measuring jaw
5 adjustable measuring jaw
6 fixed measuring jaw (stop)

Transparency No. 1.7.
<u>Application of Size Gauges</u>

(1) Testing of a stepped groove by block gauges
(2) Testing of a narrow clearance by a thickness gauge
(3) Testing of a drill diameter by hole gauges

Transparency No. 1.8.
<u>Application of Limit Gauges</u>

(1) Testing of a true−to−size bore hole by a cylindrical limit plug gauge
(2) Limit screw plug gauge
(3) Testing a bolt by the ring thread gauge
(4) Testing a shaft diameter by the limit snap gauge

Transparency No. 1.9.
<u>Application of Form Gauges</u>

(1) Testing the flatness by the bevelled steel straightedge

1 flat surface
2 hollow surface
3 crowned surface

(2) Testing of squareness (90) by the bevelled edge square

1 exact angle
2 angle too small
3 angle too big

<u>List of Captions</u>

Figures 1 through 9 according to transparencies 1.1. through 1.9.

Figures 10 through 17 according to instruction examples 1.1. through 1.8.

Measuring and Testing – Course: Technique for Manual Working of Materials. Instruction Examples for Practical Vocational Training

Table of Contents

Measuring and Testing – Course: Technique for Manual Working of Materials. Instruction Examples for Practical Vocational Training

Institut für berufliche Entwicklung e.V.
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Introduction

The present material contains 8 selected instruction examples which are intended to help practising the main techniques of measuring and testing of simple and medium levels of difficulties. This is connected with simple manual operations and practising is possible at any working place without specific requirements (except for good lighting).

Practising the subject working techniques does not require a workpiece to be produced but to check sizes and forms of existing objects which are often used in the workshop and thus to practise handling them.

In order to facilitate the preparation and execution of the work, the necessary materials, measuring and testing tools and accessories are stated. Moreover, knowledge required in addition to knowledge of measuring and testing is mentioned.

For each instruction example a working drawing is attached and the sequence of operations specified giving the most favourable order of steps necessary to achieve the results of measuring and testing.

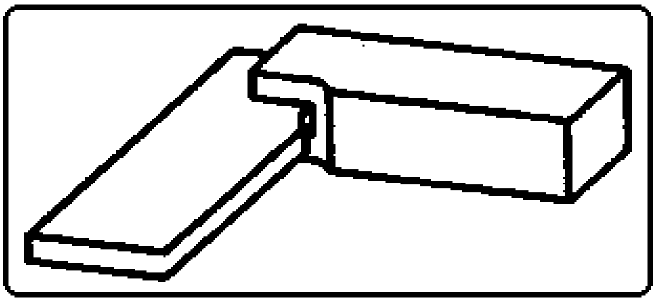
The results of measuring and testing are to be entered in the table on the working drawing for evaluation by the instructor. The order of the instruction examples is given so as to provide for an increasing level of difficulties of measuring and testing. Since measuring and testing tools need to be handled with care, the serviceability of the tools is to be checked prior to starting any measuring and testing, and storing of the measuring and testing tools on a soft support on the work bench is to be ensured.

Instruction example 1.1.: Try square

To practise simple length measurements with common measuring tools, exact reading of measured values on the vernier caliper as well as visual checks according to the light–gap testing method by means of the bevelled steel straightedge.

<u>Material</u>

Common try square of steel of small or medium size



Measuring and testing tools

Steel measuring tool (or tape rule), vernier caliper, depth gauge, bevelled steel straightedge (or bevelled edge square).

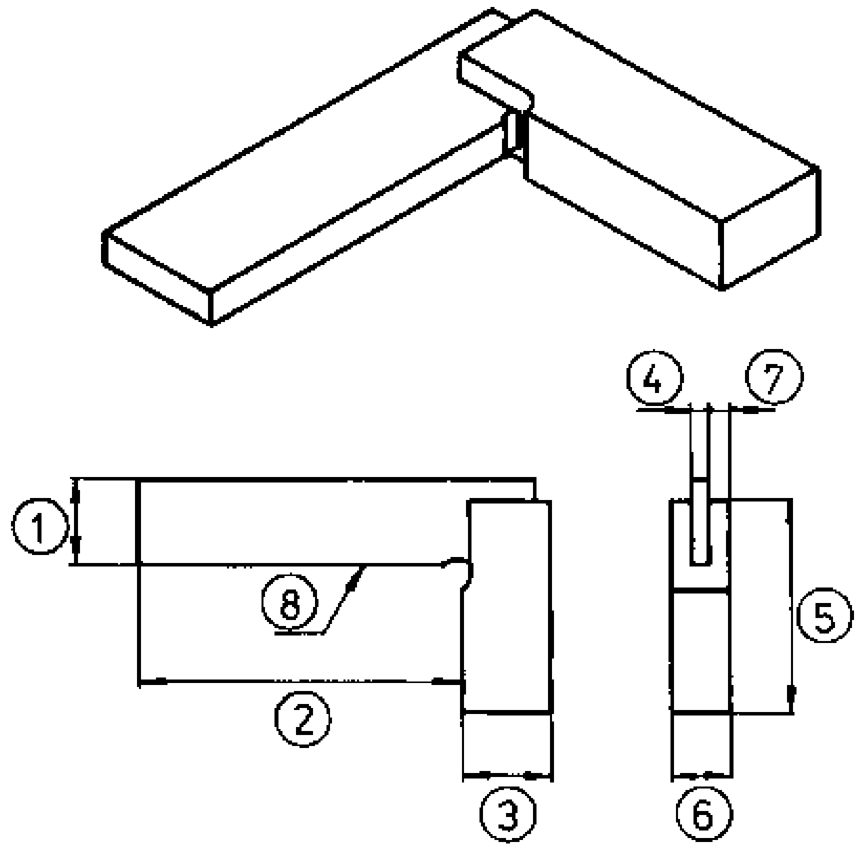
Accessories

Working place with a seat, soft support for measuring and testing tools (rag), well−lighted working area, pencil for entries in the table of values.

Required previous knowledge

Reading of drawings, knowledge of decimal numbers and length units, construction and reading of verniers of vernier calipers and depth gauges.

Sequence of operations	Comments
1. Arrange the working place, prepare the working materials.	− Put measuring and testing tools on soft rag. Lay out pencil, drawing and table in easy reach,
2. Measure sizes no. (1) to (7) with steel measuring tool (or tape rule) and enter values in table of values.	− Entry in column "coarse" in 1 mm measuring accuracy.
3. Measure sizes no. (1) to (6) with vernier caliper and enter values in table of values.	− Entry in column "fine" in 0.1 mm measuring accuracy.
4. Measure size no. (7) with depth gauge and enter in table.	− Entry in column "fine" in 0.1 mm measuring accuracy.
5. Check edge at size no. (8) for flatness with bevelled steel straightedge − light−gap testing method.	− Entry "flat" or "not flat".
6. Measure sizes no. (1) , (3) and (6) with vernier caliper at several points and check for parallelism.	− Entry "parallel" or "not parallel" (first blank space in last line).
7. Check outer and inner angles with bevelled edge square.	− Entry "square" or "not square" (second blank space in last line).
8. Check all faces diagonally for flatness with bevelled steel straightedge or bevelled edge square.	− Entry "flat" or "not flat" (third blank space in last line).



size	coarse	fine	size	coarse	fine
1			5		
2			6		
3			7		
4			8		

	1.1.
Try Square	3101

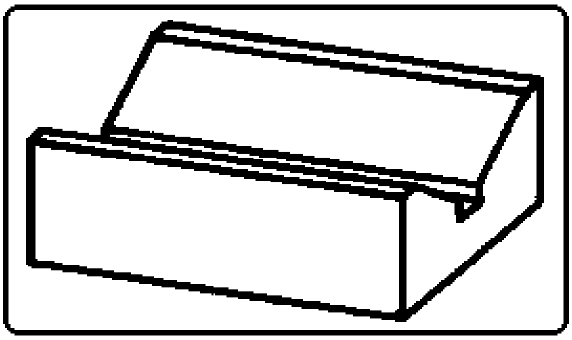
Try Square

Instruction example 1.2.: Vee

To practise simple length measurements with steel measuring tool, vernier caliper and depth gauge, exact reading of measured values for fine measurements, measuring of an angle.

Material

Common Vee as auxiliary means for scribing and drilling of round stock (smaller size).



Measuring and testing tools

Steel measuring tool (or tape rule), vernier caliper, depth gauge, protractor, bevelled steel straightedge (or bevelled edge square).

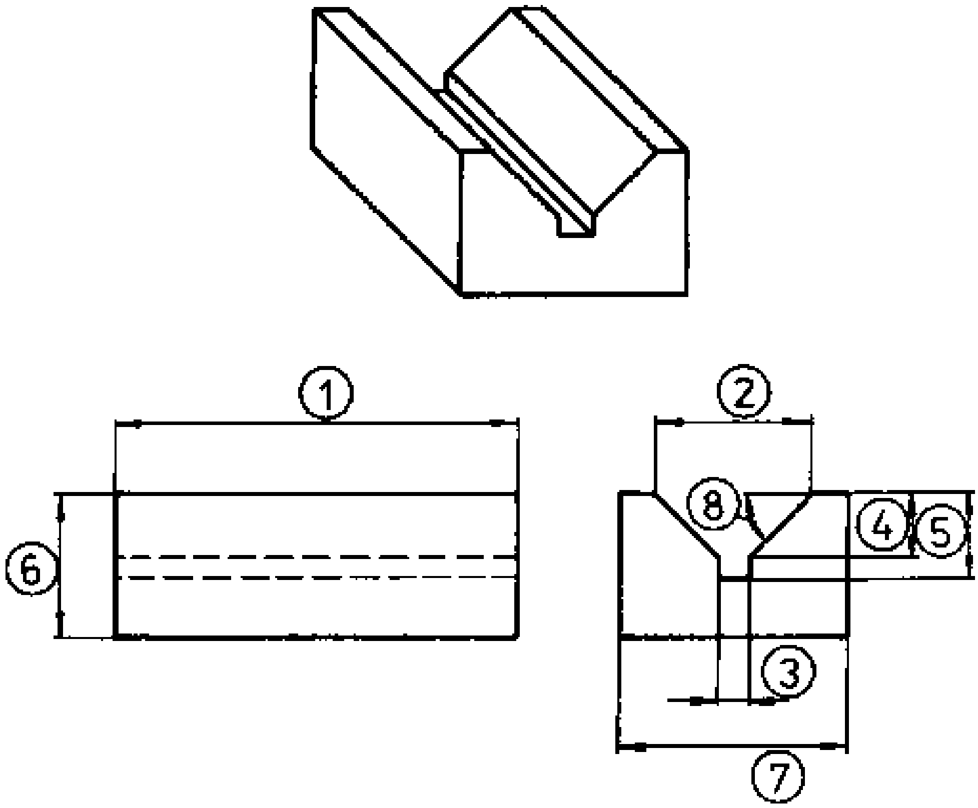
Accessories

Working place with seat, soft support for measuring and testing tools (rag), well–lighted working area, pencil for entries in the table of values.

Required previous knowledge

Reading of drawings, knowledge of decimal numbers and length units, construction and reading of verniers of vernier calipers. depth gauges and of scales of protractors.

Sequence of operations	**Comments**
1. Arrange the working place, prepare the working materials,	– Put measuring and testing tools on soft rag. Lay out pencil and drawing with table in easy reach.
2. Measure sizes no. (1) to (7) with steel measuring tool (or tape rule) and enter values in table of values.	– Entry in column "coarse" in 1 mm measuring accuracy.
3. Measure sizes no. (1) to (3) and (6) and (7) with vernier caliper and enter values in table of values,	– Entry in column "fine" in 0.1 mm measuring accuracy.
4. Measure sizes no. (4) and (5) with depth gauge and enter values.	– Entry in column "fine" with 0.1 mm measuring accuracy.
5. Measure size no. (8) with protractor and enter values.	
6. Check all faces for flatness and squareness with bevelled steel straightedge and bevelled edge square.	– Entry "flat" and "square", respectively, in blank spaces of last line.



size	coarse	fine
1		
2		
3		
4		
5		
6		
7		
8	∢	

		1.2.
	Vee	3101

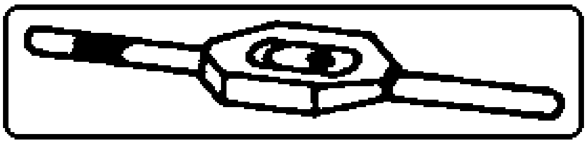
Vee

Instruction example 1.3.: Tap wrench

To practise length measurements of higher level of difficulties with exact finding of measuring points, exact reading of measured values for fine measurements, measuring of an angle.

Material

Common tap wrench of small or medium size.



Measuring and testing tools

Steel measuring tool, vernier caliper. protractor.

Accessories

Working place with a seat, soft support for measuring and testing tools (rag), well−lighted working area, pencil for entries in the table of values.

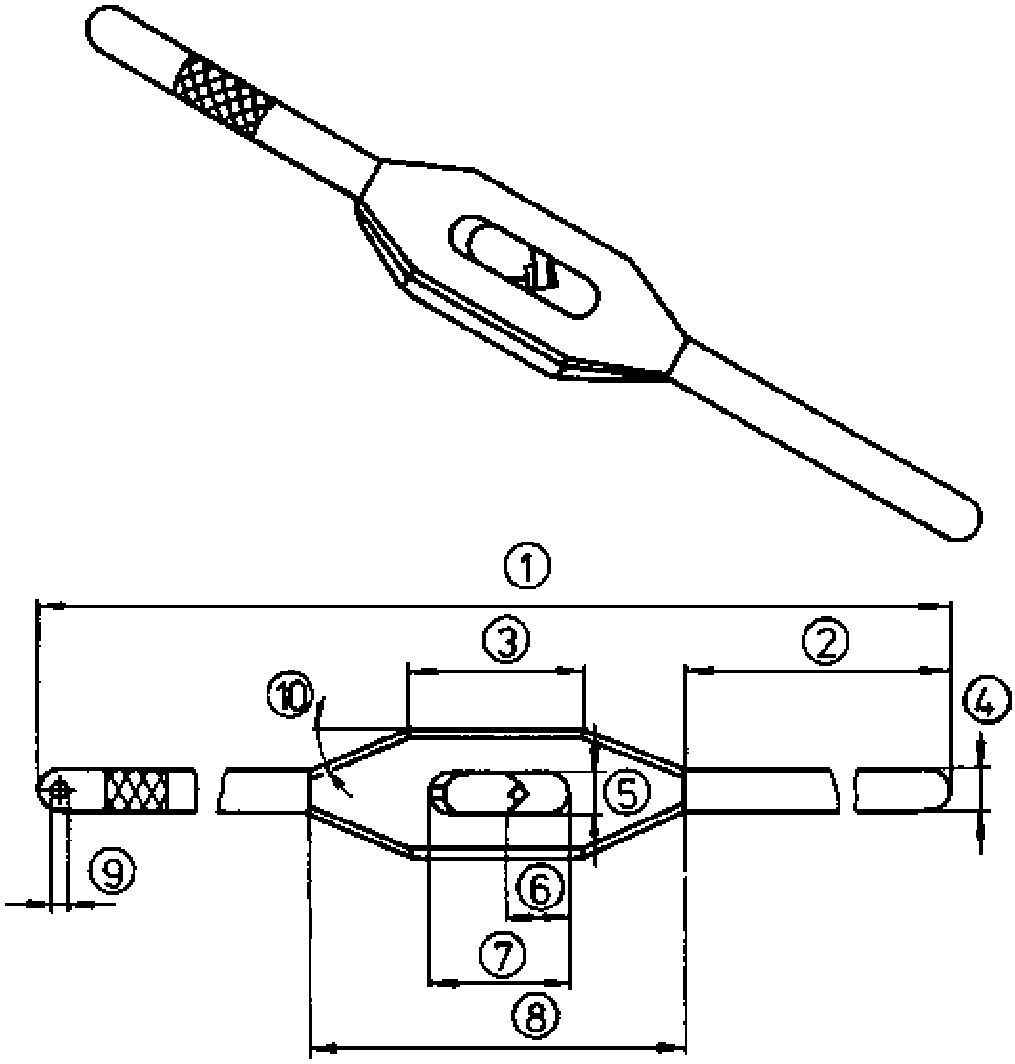
Required previous knowledge

Reading of drawings, knowledge of decimal numbers and length units, construction and reading of verniers of vernier calipers and of scales of protractors.

Sequence of operations	Comments
1. Arrange the working place, prepare the working materials.	− Put measuring and testing tools on soft rag. Lay out pencil and drawing with table in easy reach.
2. Measure sizes no. (1) to (3) and (5) to (8) with steel measuring tool and enter values in table of values.	− Entry in column "coarse" in 1 mm measuring accuracy.
3. Measure sizes no. (1) to (9) with vernier caliper and enter values in table of values,	− Entry in column "fine" in 0,1 mm measuring accuracy.
4. Measure size no. (10) with protractor and enter value in table of values.	

To continue practising, if necessary:

Further sizes to be specified by the instructor and to be measured.



size	coarse	fine	size	coarse	fine
1			6		
2			7		
3			8		
4			9		
5			10		

		1.3.
	Tap Wrench	3101

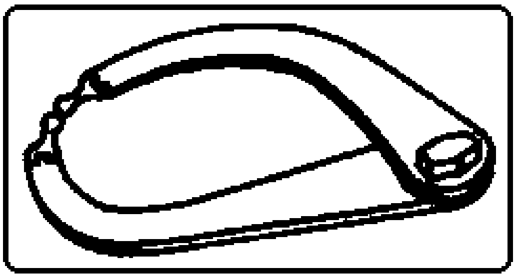
Tap Wrench

Instruction example 1.4.: Outside caliper

To practise simple length measurements and, particularly, roundness tests of outside and inside radii as well as measuring of an angle. The light−gap testing method shall be safely mastered.

Material

Common outside caliper of small or medium size.



Measuring and testing tools

Steel measuring tool (or tape rule), vernier caliper. radius gauges for outside and inside radii, protractor.

Accessories

Well−lighted working place with a seat and soft support for measuring and testing tools, pencil, possibly dividers and paper.

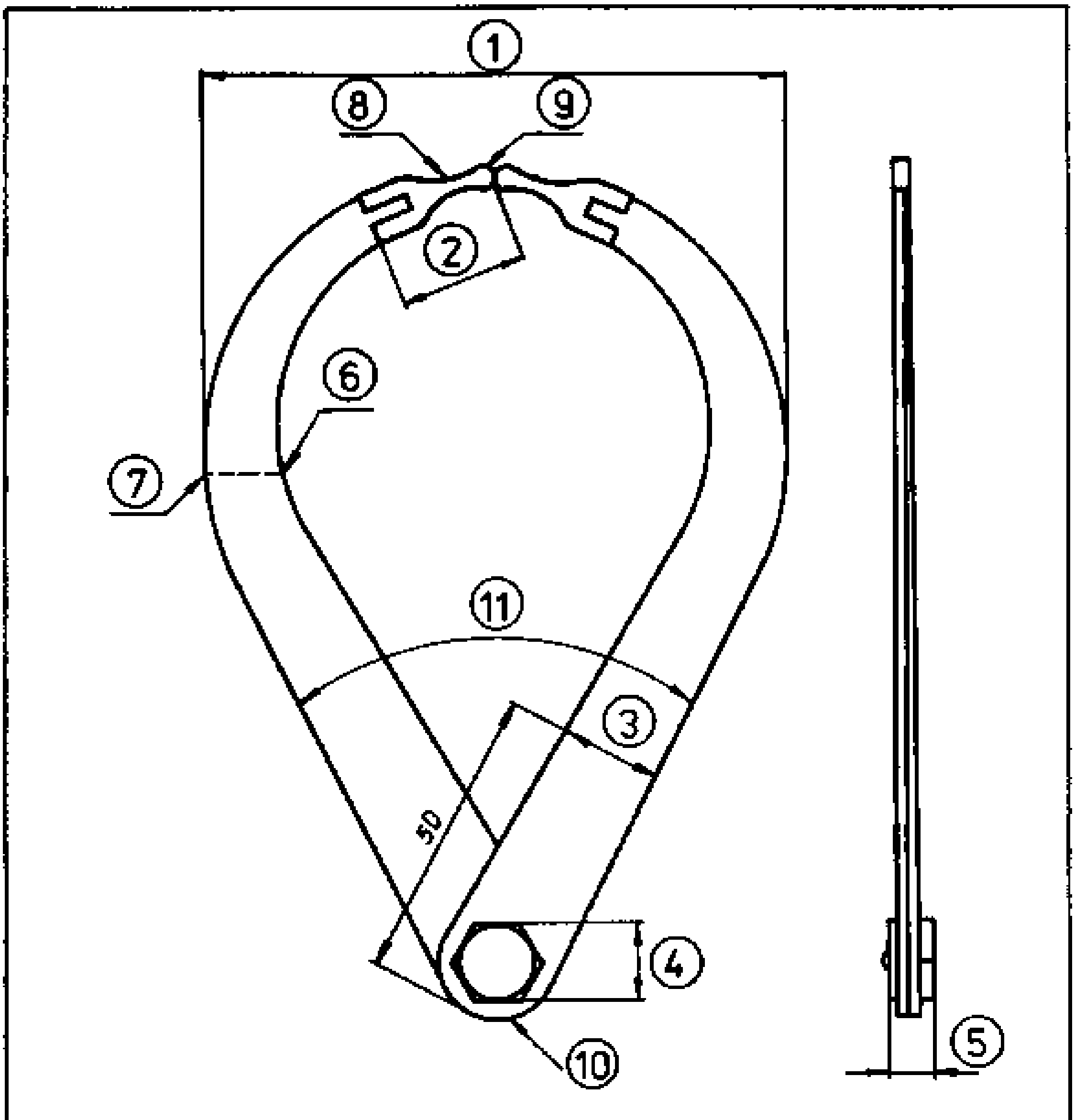
Required previous knowledge

Reading of drawings, knowledge of decimal numbers and length units, term "radius" and knowledge of angle quantities.

Sequence of operations	Comments
1. Arrange the working place, prepare the outside caliper to be tested in folded position.	− Put measuring and testing tools on soft rag, lay out pencil and dividers in easy reach.
2. Measure sizes no. (1) to (4) with steel measuring tool (or tape rule) end enter values in table of values.	− Entry in column "coarse" in 1 mm measuring accuracy.
3. Measure sizes no. (1) to (5) with vernier caliper and enter values.	− Entry in column "fine" in 0.1 mm measuring accuracy.
4. Test sizes no. (6) and (7) with adequate radius gauges, mark the testing point with pencil.	− Test the folded caliper exactly at the widest point (enter values in table).
5. Test sizes no. (8) , (9) and (10) with small radius gauges and enter values in table.	
6. Measure the folded outside caliper with protractor and enter value of size no. (11).	

Note:

If operation 4 cannot be performed because of lack of radius gauges, the radii can be determined indirectly by putting the caliper on paper, drawing the radii with pencil and testing with dividers.



size	coarse	fine	size	
1			7	
2			8	
3			9	
4			10	
5			11	∢
6				

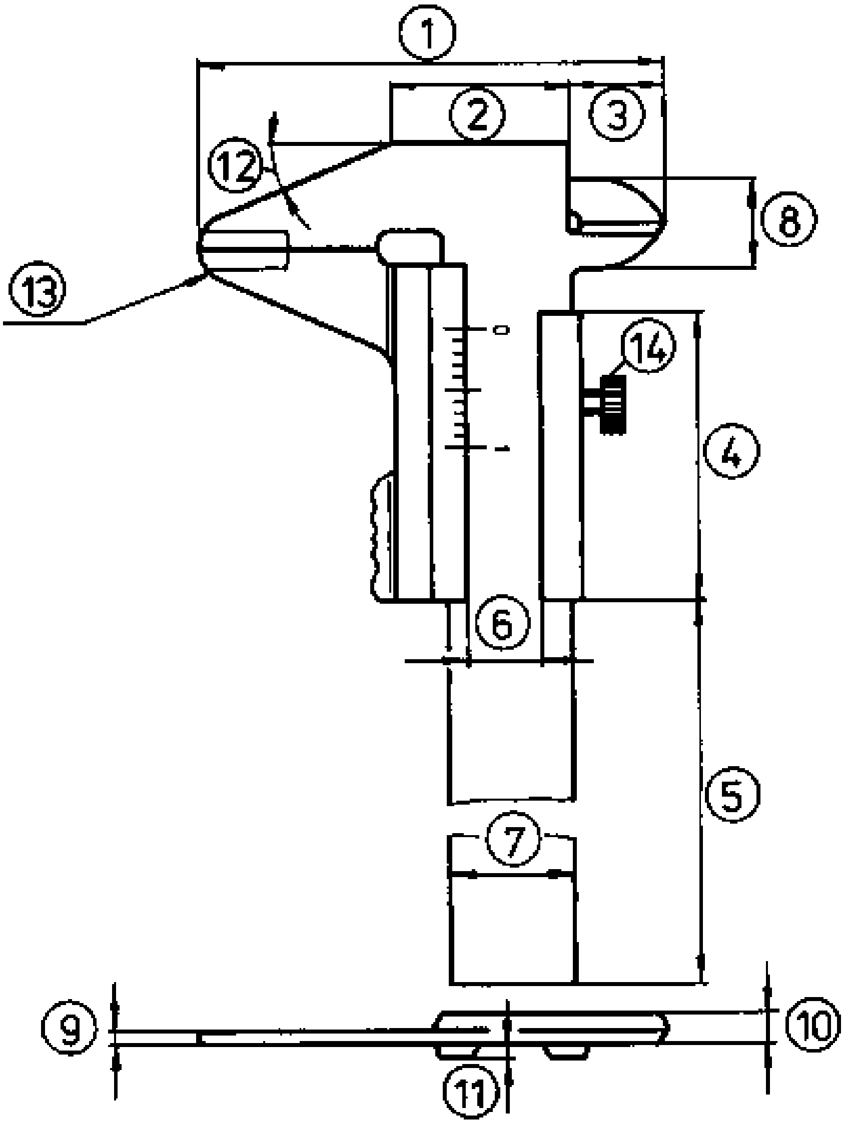
	1.4.
Outside caliper	3101

Outside caliper

(...)

Sequence of operations	**Comments**
1. Arrange the working place, lock vernier caliper to be tested in 0–position.	– Prepare the materials.

2. Measure sizes no. (1) to (10) with vernier caliper and enter values in table.	– Entry in column "coarse" in 0.1 mm measuring accuracy.
3. Measure sizes no. (7), (8), (9), (10) with outside micrometers and enter values in table.	– Entry in column "fine" in 0.01 mm measuring accuracy.
4. Measure size no. (11) with depth gauge and enter value in table.	– Entry in column "coarse in 0.1 mm measuring accuracy.
5. Measure size no. (12) with protractor.	
6. Determine amounts of radii at sizes no. (13) and (14) with radius gauges.	
7. Test the flatness of the slide–ways and of the measuring jaws for inside and outside measurements by light–gap testing methods by means of bevelled steel straightedge.	– Entry directly in the working drawing.
8. Determine the nominal thread meter of the clamping screw by vernier caliper.	– Entry directly in the working drawing.



size	coarse	fine	size	coarse	fine
1			8		
2			9		
3			10		
4			11		
5			12	∢	
6			13		
7			14		

		1.5.
	Vernier Caliper	3101

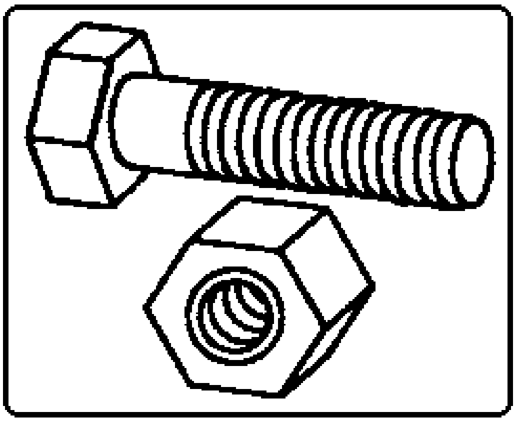
Vernier Caliper

Instruction example 1.6.: Hexagon−head screw and nut

To practise length and angular measurements, in particular determination of threads by means of limit gauges, testing of the accuracy of fit of threads.

Material

Any hexagon−head screw with fitting nut (nominal diameter at least 5 mm).



Measuring and testing tools

Small vernier caliper, small−size outside micrometer, protractor, various limit plug gauges, ring screw gauges, screw pitch gauges,

Accessories

Well−lighted working place with a seat and soft support for measuring and testing tools, pencil.

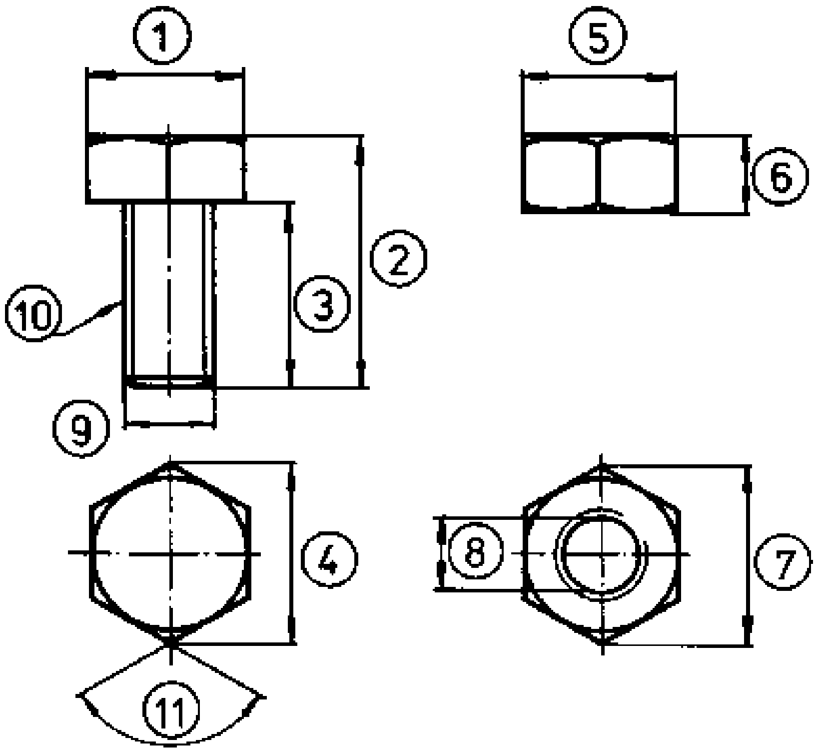
Required previous knowledge

Reading of drawings, knowledge of decimal numbers, construction and operation of the outside micrometer, of the limit plug gauges and screw pitch gauges, knowledge of coarse and fine pitch threads, knowledge of the terms of thread definition.

Sequence of operations	Comments
1. Arrange the working place, keep ready cleaned screws and nuts to be tested,	− Prepare the materials.
2. Measure sizes no. (1) to (9) with vernier caliper and enter values in table.	− Entry in column "amount".
3. Determine the pitch at size no. (10) with screw pitch gauge.	
4. Find out type of thread by means of amounts of sizes no. (9) and (10) , choose the adequate ring screw gauge and test the accuracy of fit of the screw.	− Entry of the type of thread beside the amounts of sizes no. (9) and (10) as well as "fitting" or "non−fitting".
5. Test the accuracy of fit of the nut with adequate limit plug gauge.	− Entry beside amount of size no. (8).
6. Estimate the angle at size no. (11) and then measure with protractor.	− Entry of estimated value and beside entry of measured value.
7. Name the characteristic terms of the screw to valid standards.	− Terms like nominal diameter, minor diameter, depth of engagement, width across flats, width across corners, etc. are to be related to the size numbers.

To continue practising, if necessary

Determine further screws and nuts.



size	amount	further data	terms
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11	∢		

		1.6.
	Hexagon-head Screw and Nut	3101

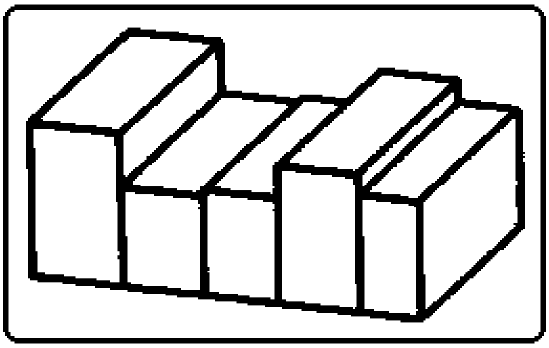
Hexagon–head Screw and Nut

Instruction example 1.7.: Block gauges

To practise differential measurements, setting and reading of values measured at the dial gauge, handling the outside micrometer.

Material

5 block gauges with small differences in length.



Measuring and testing tools Outside micrometer, dial gauge.

Accessories

Flat steel support (surface plate) to bear the dial gauges, magnetic stand for dial gauge, well−lighted working place with seat, soft support for outside micrometer.

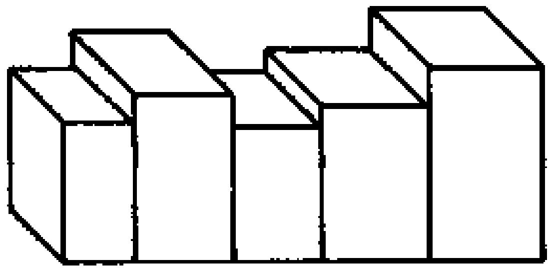
Required previous knowledge

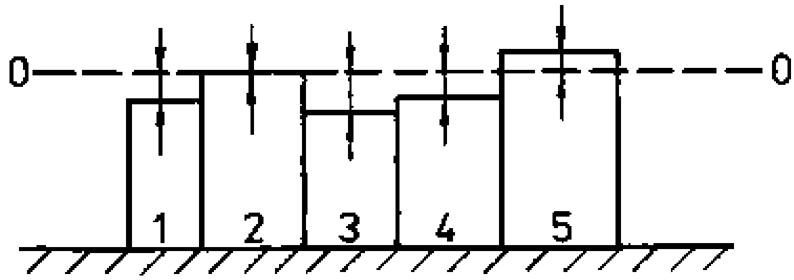
Reading of drawings, construction and operation as well as reading of the dial gauge, functioning and use of block gauges.

Sequence of operations	Comments
1. Arrange the working place.	− Prepare the materials.
2. Wring/push together the block gauges to be measured.	− (Possible in clean condition only)
3. Clamp dial gauge in stand and set to nominal size (0−plane).	− Nominal size to be specified by the instructor (e.g. 2nd test specimen as per drawing)
4. Guide feeler over block gauges and measure step by step.	− Entry in column "variation in nominal size".
5. Measure width and depth of individual block gauges with outside micrometer and enter values in table.	− Entry in columns "width" and "depth".

To continue practising, if necessary:

1. Test block−type bodies with clean surface by means of other measuring and testing tools, such as flat limit gauge for determination of fit.	− Exact objective to be specified by the instructor.
2. Test slot depths and slot widths on any workpiece by means of block gauges.	
3. Join test specimens of any size and measure difference.	





No.	Variation in nominal size	width	depth
1			
2			
3			
4			
5			

		1.7.
	Block Gauges	3101

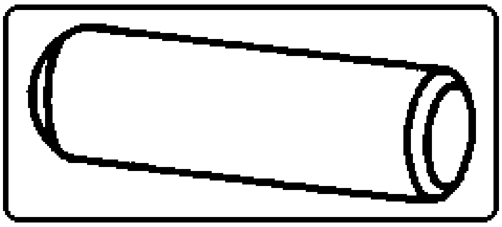
Block Gauges

Instruction example 1.8.: Plain pins

To practise diameter measurements by means of outside micrometer, finding out and calculation of tolerances to standard values,

Material

Common plain pins of small size (examples as per table of sizes).



Measuring and testing tools

Vernier caliper, outside micrometer, limit snap gauges as per plain pins specified in the table of sizes.

Accessories

Well−lighted working place with seat and soft support for measuring and testing tools, holder for outside micrometer, pencil, standard table for shafts.

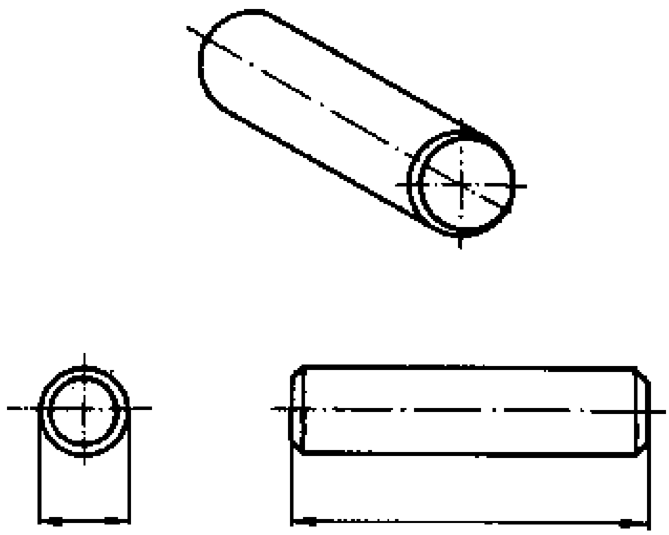
Required previous knowledge

Safe handling of the outside micrometer, knowledge of tolerance terms and application of standards, operation of limit snap gauges.

Sequence of operations	Comments
1. Arrange the working place, keep ready the plain pins to be tested in clean condition.	− Prepare the materials.
2. Coarse check of plain pins by vernier caliper for length and diameter.	− Store in given order (entry not necessary yet).
3. Determine the tolerance for each plain pin to standard table, entry in table of sizes.	− Tolerance = maximum size − minimum size. − Maximum size a nominal diameter + upper deviation. − Minimum size = nominal diameter + lower deviation.
4. Measure the actual diameter by outside micrometer, measure two times to avoid measuring errors.	− Entry in column "measurement 1st and 2nd"
5. Determine the quality of fit by adequate limit snap gauges.	− Entry "go" or "not go" in column "fit".

To continue practising, if necessary:

Test further plain pins or shafts after preceding operation.



Description	Tolerance	Maximum size / Minimum size	Measurement 1st	2nd	Fit
2.5 m 6 x 5					
5h 9 x 7					
6h 9 x 8					
8m 6 x 10					
10m 6 x 12					
12h 9 x 22					

		1.8
	Plain pins	3101

Plain pins

Measuring and Testing – Course: Technique for Manual Working of Materials. Trainees' Handbook of Lessons

Table of Contents

Measuring and Testing – Course: Technique for Manual Working of Materials. Trainees' Handbook of Lessons

Institut für berufliche Entwicklung e.V.
Berlin

Original title:
Arbeitsmaterial für den Lernenden
"Messen und Prüfen"

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13187 Berlin

Order No.: 90–35–3101/2

1. Purpose of Measuring and Testing

After each operation within the manufacturing process, workpieces must be checked for size, shape or surface finish, This is mostly based on the data of a manufacturing drawing. In addition to judgment by the eye, by the ear and tactile sense as possibilities of non–dimensional testing, dimensional testing methods using sensitive measuring and testing tools are predominantly applied in manufacturing processes.

Testing with measuring tools (measuring):

Lengths and angles of any object are determined (measured) by comparison with a measuring instrument where the exact value measured can be read on a scale.

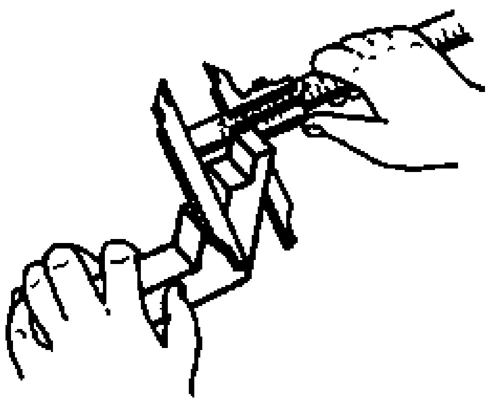

Figure 1 Measuring

Testing with testing tools (gauging):

Deviations in size or shape of any object are determined (tested) by comparison with a gauge.

This will answer the question as to whether the deviations are within or beyond admissible ranges (tolerance ranges) only. There is no need to know the exact value.

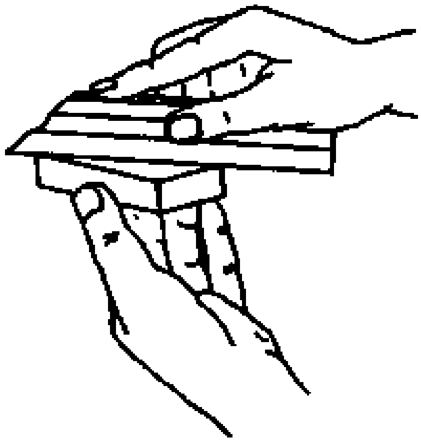

Figure 2 Testing

Which testing methods do you know?

____

What is the difference between measuring and gauging?

____

2. Measuring Tools

Measuring tools are sensitive instruments of surface hardened steel provided with scales of different degree of accuracy. Simple measuring tools are mainly used in single−part production and maintenance work.

Steel rule and tape rule:

Measuring tools of 1 mm graduation mainly used for coarse measurements at easily accessible measuring points with the tool always to be placed at right angles to the locating edge.

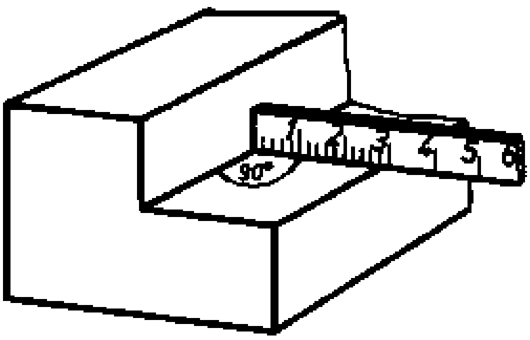

Figure 3 Location of the steel rule

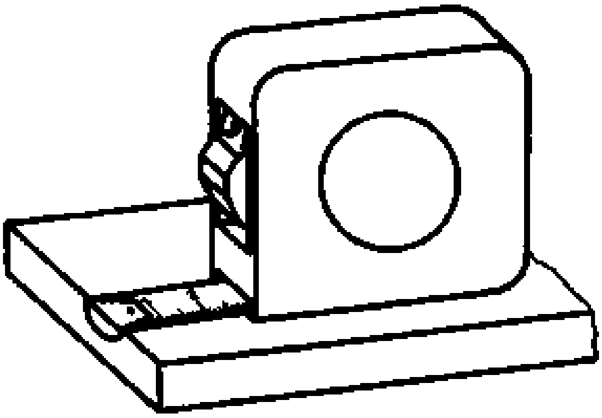

Figure 4 Location of the tape rule

Vernier caliper:

Predominantly used instrument, mostly of 1/10 mm graduation. Specially formed jaws permit outside, inside and depth measurements.

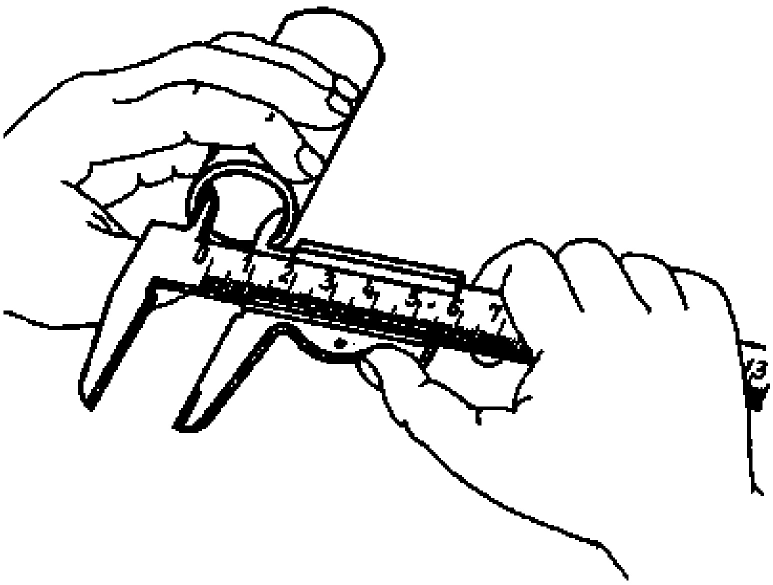

Figure 5 Measuring of inside dimensions by means of the vernier caliper

Depth gauge:

Special instrument of 1/10 nun measuring accuracy for depth measurements of slots, shoulders and bore holes.

Depths of bore holes are always measured at the border (never in the centre!)!

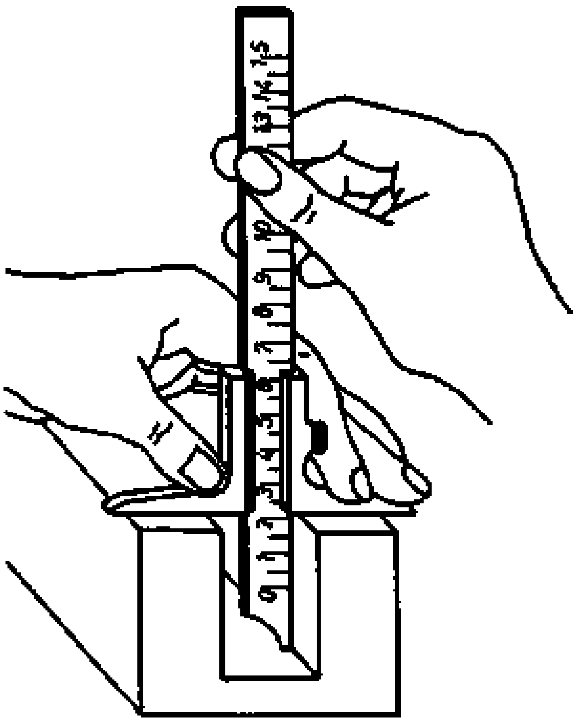

Figure 6 Measuring of a slot depth by means of the depth gauge

Outside micrometer:

Instrument of 1/100 mm measuring accuracy for precision measurement of outside measures in certain measuring ranges. For inside and depth measurements inside and depth micrometers are used.

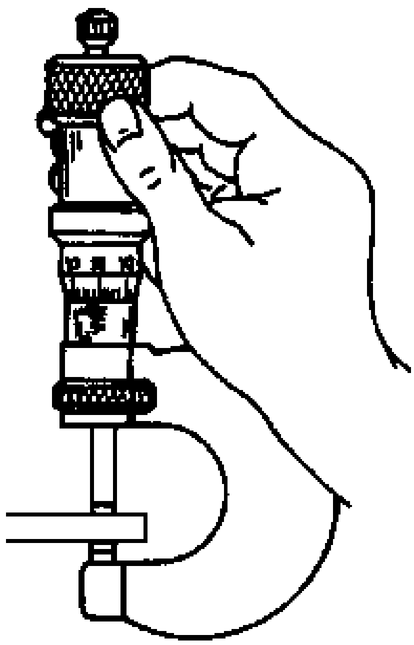

Figure 7 Measuring by means of the outside micrometer

Dial gauge:

Special instrument of 1/100 mm measuring accuracy for precision measurement in differential and concentricity measurements in batch production.

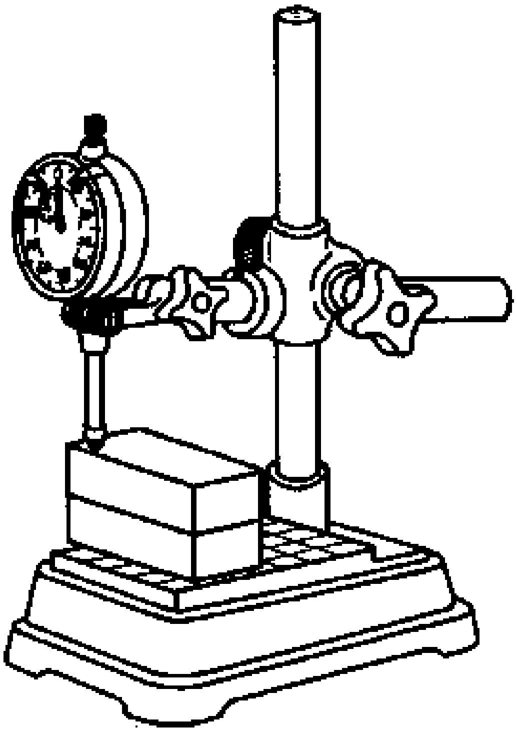

Figure 8 Use of the dial gauge in differential measurements

Protractor:

Instrument for measurement of angles from 0 to 180 degrees with 1 degree graduation, suitable for coarse measurement only.

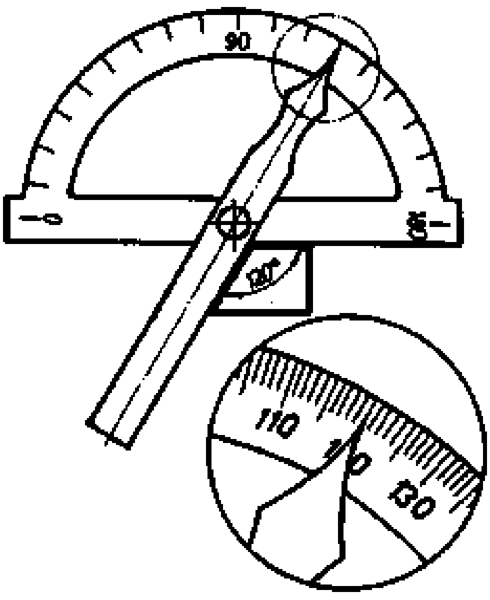

Figure 9 Protractor used for coarse measurements

Universal bevel protractor:

Instrument for measurement of angles from 0 to 360 degrees with 1 degree graduation, with vernier providing for a reading accuracy of 1/12 degree – suitable for precision measurements.

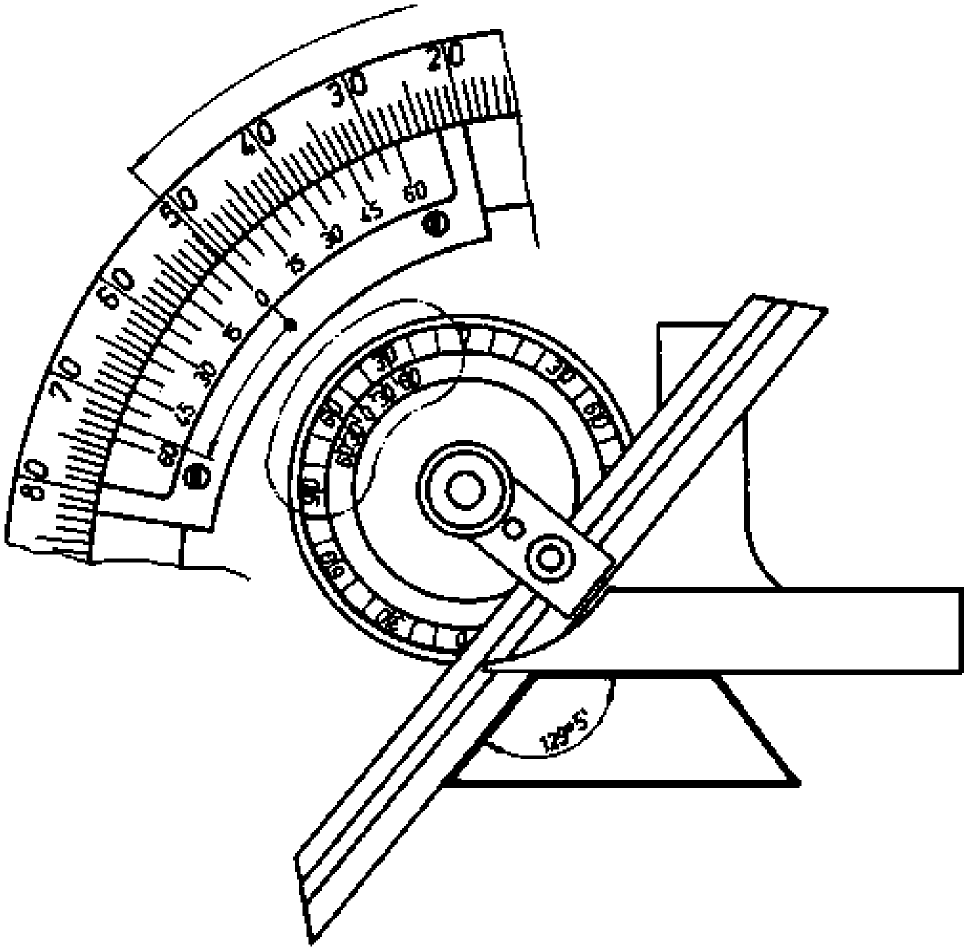

Figure 10 Universal bevel protractor

In the use of measuring instruments faulty measurements may occur as a result of:

– Faults at the measuring instrument (damage):

Check any measuring instrument for serviceability before use (slide vernier caliper into zero position and compare scale and vernier; check for external damage). Inaccuracies of measuring instruments may also be the result of too wide manufacturing tolerances or maladjustments!

– Faults caused by wrong use:

The measuring instrument is to be used for the proper purpose and range of accuracy. Too big measuring forces (deflections), oblique location or location on faces or edges not cleaned or deburred may result in wrong values measured. Moreover, reading errors may be a consequence of inadequate lighting or wrong conversion of the indicated values.

– Faults caused by environmental conditions:

Measuring instruments and workpieces are subject to heat expansion and low–temperature contraction. This may lead to different measuring results for the same object measured. To have a comparative value, measuring and testing tools are mostly adjusted at 20° Celsius.

Notes:

– Avoid faulty measurements, if possible – measure twice at least I
– Use serviceable measuring tools only!
– Handle the measuring instrument properly!
– Ensure good conditions at the place of measurement – adequate lighting and cleanliness!
– Take the measurements at comparable temperatures, if possible I

Which measuring tools have a measuring accuracy of 1/10 mm?

____

Which measuring tools are used for precision measurements of 1/100 mm measuring accuracy?

____

What are the specific features of angle measuring instruments? How can measuring errors be avoided?

____

3. Testing Tools

Testing tools (gauges) are sensitive instruments of surface hardened steel without any graduation. The measure is represented by their shape or size or setting.

Some testing tools have their type of measure engraved on them.

3.1. <u>Size gauges</u>

Size gauges are used to determine sizes or to check whether any dimensions of parts are within admissible limits.

The answer may be:

Yes – the size is within the admissible range.
No – the size is smaller than required.
No – the size is bigger than required.

If the answer is "no", it is to be decided whether (reworking) corrections of the part are possible.

Caliper:

Instrument with movable legs for outside and inside testing which are set to the size of the workpiece or setting of which is done by means of a measuring instrument before use.

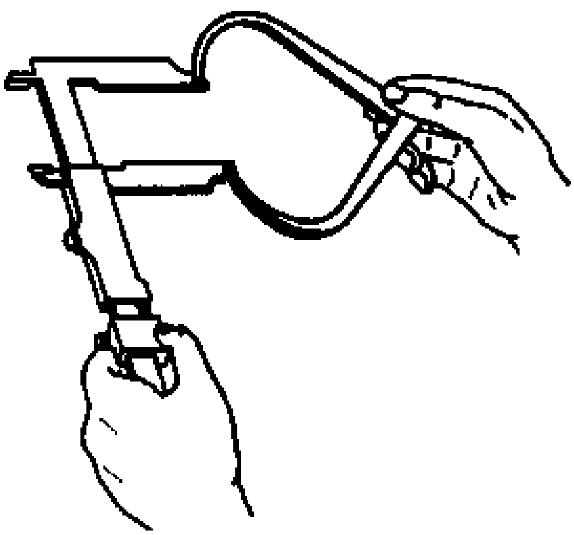

Figure 11 Outside calipering

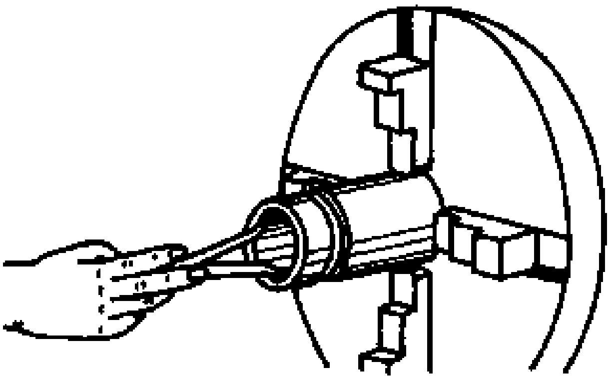

Figure 12 Inside calipering

Thickness gauge:

Instrument which consists of several leaves of different thicknesses (0.05 to 0.1 mm increments) and is used to determine the size of narrow clearances by inserting a leaf into the clearance.

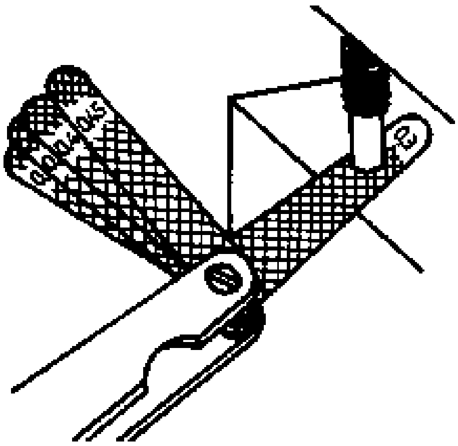

Figure 13 Clearance testing by means of a thickness gauge

Drill and wire gauges:

Instruments with holes on a steel disk in 0.1 mm increments to quickly determine the diameter of drills or wires.

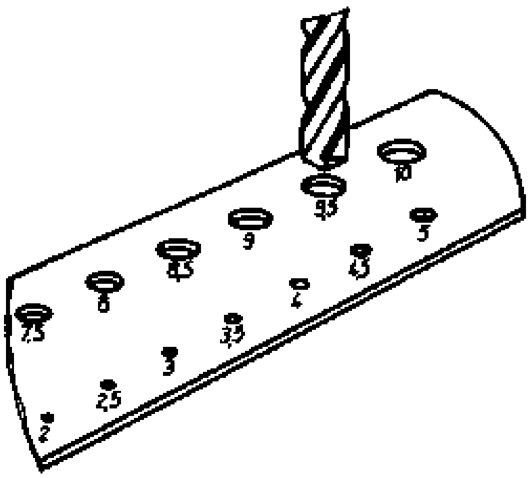

Figure 14 Testing of diameters by means of the drill and wire gauge

Block gauges:

Square, standardized blocks, each representing a very precise measure of length (from 0.1 mm) .They are arranged in sets in boxes and are used for differential or comparative measurements.

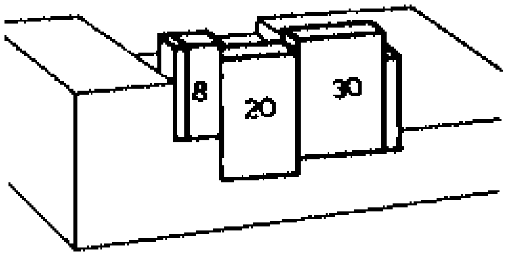

Figure 15 Testing by means of block gauges

Limit gauges:

Instruments representing the maximum and minimum limits of very small, standardized tolerance ranges (such as to the ISA system of tolerances and fits):

– Cylindrical limit plug gauge – for fitting inside diameters

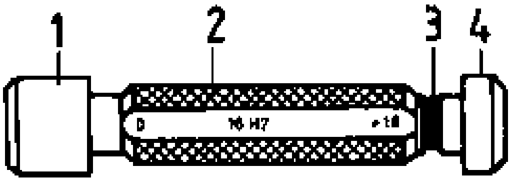

Figure 16 Cylindrical limit plug gauge

1 "go" end (minimum size), 2 handle with designation of fit, 3 marking (red) of "not go" end, 4 "not go" end (maximum size)

– Limit screw plug gauge – for fitting female threads.

Figure 17 Limit screw plug gauge

Testing method:

The "go" end (minimum diameter) must easily go into the bore, the "not go" end (maximum diameter, marked with red colour) must not go into the bore.

– Limit snap gauge – for fitting outside diameters

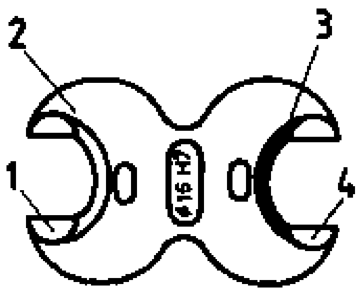

Figure 18 Limit snap gauge

1 "go" end (maximum size), 2 gauge body with designation of fit, 3 marking (red) of "not go" end, 4 "not go" end (minimum size)

Testing method:

The "go" end (maximum diameter) must easily go over the work–piece, the "not go" end (minimum diameter, marked with red colour) must not slide over the workpiece,

– Ring thread gauge – for fitting male threads

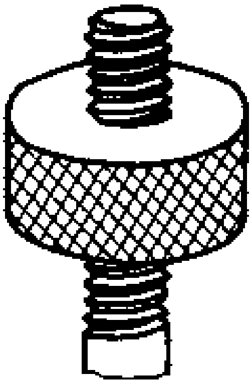

Figure 19 Ring thread gauge

Testing method:

When the ring can be screwed onto the thread, the thread is fitting!

(This does, however, not say whether the thread is possibly skew or dented).

What is the difference between measuring and testing tools?

____

What are the special features of limit gauges compared to simple size gauges?

____

What testing method is typical of the use of cylindrical limit plug gauges?

____

What are the results of testing by means of limit screw plug gauges and ring thread gauges?

____

3.2. <u>Form gauges</u>

Form gauges are used to determine whether the requirements as to flatness, squareness, roundness or other forms are met.

The light–gap testing method is applied:

Place the gauge against the workpiece and hold it against the light! The light gap between the gauge and workpiece must be evenly narrow!

(Form errors from 0.003 mm can be detected)

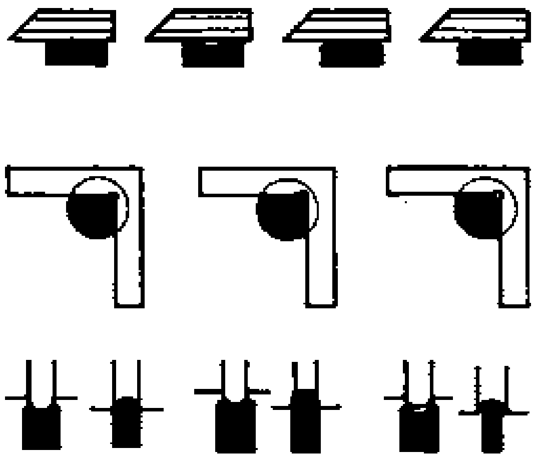

Figure 20 Light–gap testing

Levelling straightedge:

Instrument designed as steel straightedge (with straight reference faces) or as bevelled steel straightedge (with one knife edge) for flatness tests on finished surfaces.

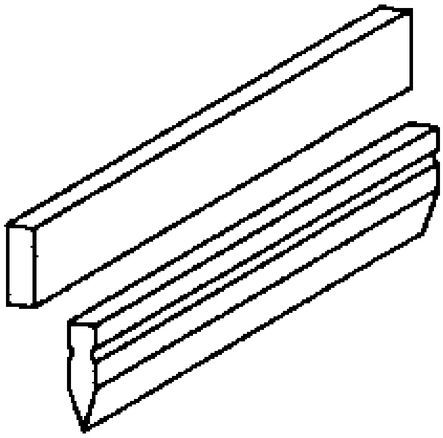

Figure 21 Levelling straightedges

Try square:

Instrument designed as millwrights' steel square (with straight reference faces), back square (with straight reference faces and one reference face designed as stock support) or bevelled edge square (with one knife edge) for flatness tests of faces and angularity tests (mostly 90° degrees) of two faces or edges to each other.

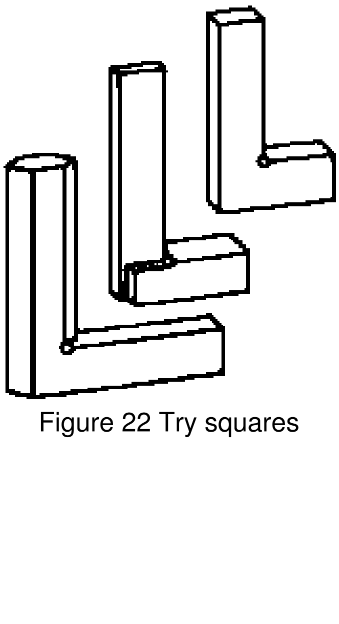

Figure 22 Try squares

Angle gauges:

Instruments for specific angles (60, 120, 55. 118 degrees).

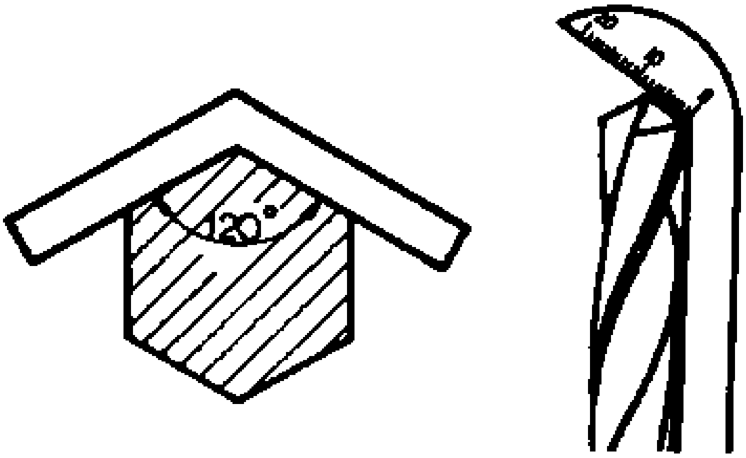

Figure 23 Angle gauges

Radius gauges:

Instruments consisting of one or more specifically radiused leaves (increment of radii 1 mm) for convex or concave radii.

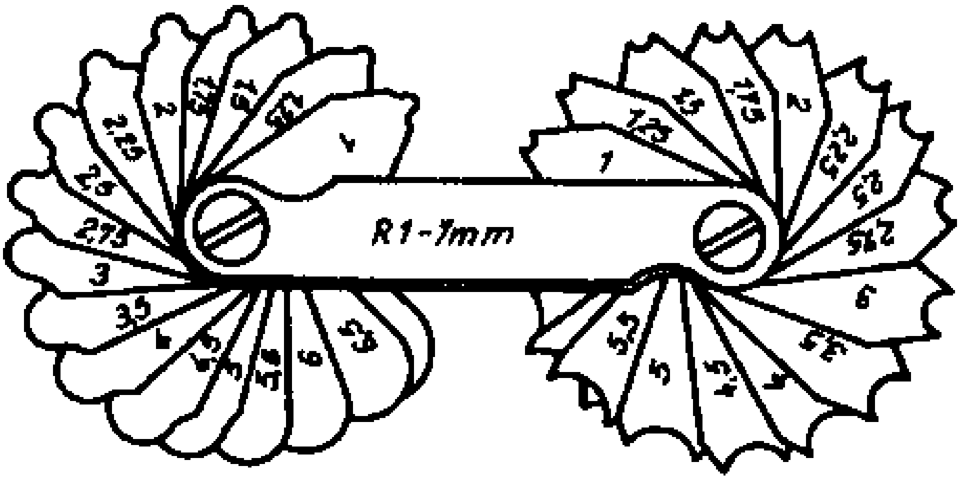

Figure 24 Radius gauge

Which testing method is typical of form gauges?

____

What is the difference between try squares and angle gauges?

____

4. Recommendations for Handling Measuring and Testing Tools

– Store the instruments strictly separate from cutting or hand tools!

– Transport the instruments exclusively in the covers or containers intended for this purpose!

– Deposit the instruments during use on a piece of cloth or in special containers with padding!

– Handle the instruments with care – avoid any damage by shocks or by dropping them!

– Slightly grease the instruments after use with nonacid grease – protect them against rust!

– Have the instruments checked every 6 to 12 months depending on the degree of accuracy!

Machining of Material/Metal – Course: Manual working of metal. Methodical course–guide for instructors

Table of Contents

Machining of Material/Metal – Course: Manual working of metal. Methodical course–guide for instructors

Institut für berufliche Entwicklung e.V.
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First edition © IBE

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Parkstraße 23
13187 Berlin

Order No.: 90–32–0003/2

Introduction

The present guide shall help the instructor to accomplish the practical Locational training by giving practical recommendations as to the

- – preparation,
- – accomplishment and
- – review of the practical vocational lessons.

At the beginning of the methodical guide the instructor is informed of the aims and contents of the course. The guide also states the previous knowledge required for acquiring the working techniques of machining of material. The emphasis is on the recommendations of didactic and methodology of the practical vocational lessons. The recommendations suggest the instructor how to plan and prepare the lessons. Possible forms and methods of accomplishing the instructions and exercises are also explained.

The last section deals with the peculiarities of the individual training units. It also contains a summary of the necessary teaching aids and working tools to facilitate organizing the course.

A methodically arranged complex of questions and answers shall help the instructor to test the know ledge of the trainees.

1. Aims and contents of the course

On completion of this training course the trainees should have the necessary knowledge, abilities and skills to work with

- – engine lathes,
- – horizontal or vertical milling machines,
- – horizontal shaping machines and
- – boring/drilling machines.

This implies that the trainees

- – are able to decide on the purpose and application of the relevant machine and technique,

- – are capable of setting up, operating, servicing and maintaining the machines and know the construction of the machines,

– have knowledge of how to determine the cutting values, such as speeds, feeds and stroke length,

– are able to select the proper tools and accessories for setting up the machines and know the construction of the different types of tools and accessories,

– have knowledge of how to meet the safety requirements in machining of material.

The course comprises the following training units (TU):

1st TU: Fundamentals of Fittings
2nd TU: Pinned Joints
3rd TU: Threaded Joints
4th TU: Feather Key Joints

To successfully acquire the skills of these working techniques, the trainees must have previous knowledge of and master the basic skills in the working techniques of manual working of material. In addition, they should have basic knowledge of engineering drawing to be able to "read" the working drawings.

2. Organizational preparation of training

In order to ensure that the instructions, demonstrations and exercises go off smoothly, the training must be well prepared. The following is to be made available:

Classroom and workshop

Though the instructions could be given in the workshop, it is better to do it in a room where the trainees have adequate facilities to sit and write.

If a daylight projector shall be used, a bright projection area and electric supply are required.

The demonstrations of the working techniques, followed by exercises, are to be done in the workshop directly on the relevant machine. One machine with the necessary cutting and operating tools, measuring and testing tools and accessories should be available for each trainee. The necessary working tools, related to the "Instruction Examples for Practical Vocational Training", are summarized in the "Methodical Guide for Instructors".

Teaching aids

Sufficient copies of the "Trainees' Handbook of Lessons" equalling the number of trainees are to be made available. The "Trainees' Handbook of Lessons" is mainly used in the introductory instruction for introduction and recapitulation. It explains the technical knowledge of one training unit, which is absolutely necessary for mastering the relevant technique, in a clearly arranged and easily conceivable way. Many illustrations add up to better understanding. Tasks and questions are included to recapitulate, strengthen and test the knowledge acquired. But they may also be used by the trainees for acquiring the knowledge by themselves. A summary of all questions is contained in a complex of questions and answers in the present methodical guide in the sub–section of the relevant training unit. Tasks and questions included in the "Trainees' Handbook of Lessons" are marked with "A".

Sufficient copies of the "Instruction Examples for Practical Vocational Training", depending on the number of trainees, are to be made available. They explain the technology for practising the examples, supplemented by working drawings. By means of the "Instruction Examples ..." workpieces can be produced and working algorithms practised to develop essential practical skills. Based on the "Instruction Examples ...", the availability of the materials and necessary working tools can be checked and arranged by the trainees themselves.

The "Instruction Examples ..." of each training unit are arranged with increasing level of difficulty and should be followed in the sequence given.

The textbooks

– “Basic Vocational Knowledge – Working of Metal”
– “Formulas and Tables – Metal”
– “Machine Elements and Assemblies and their Installation”

can be used by the instructor for the instructions to consolidate knowledge and refresh basic knowledge.

The textbook “Formulas and Tables – metal” is particularly recommended for exercises of technical calculations.

All tools and accessories required for the working technique are to be made available as visual and/or demonstration aids. Various workpieces related to the conditions of the relevant factory are also to be made available for demonstration.

Blackboard drawings are to be prepared prior to the instructions.

If further teaching aids are available, the instructor can complete the Methodical Guide for Instructor.

This will give him a comprehensive survey and facilitate the preparations for the instructions.

Working tools and materials

The trainees' working places are to be checked for neatness, serviceability and completeness of the working tools and materials.

The completeness of the required technological documents (drawings, instruction examples for the relevant working technique) is to be ensured. Tests and/or recapitulations are to be prepared. The materials required for the exercises are specified in the relevant “Instruction Examples for Practical Vocational Training” – including the required dimensions. In a few cases the raw materials are to be made available in a certain stage of prefabrication that is to be prepared on advance.

3. Accomplishment of the training

3.1. General recommendations for the procedure of the course

The training course proceeds in the succession of the individual training units. The training units “Setting up and operation” should always be started with, since they will impart the basic knowledge required for the other training units. The training should then proceed with the training units according to the serial number of the training units. The knowledge and skills in the relevant working technique should be taught by an alternation of instructions and exercises. The instructions shall teach the knowledge required for accomplishing the working technique. In the exercises to follow the trainees shall put into practice the theoretical knowledge acquired. Practising of the work routines should take most of the time available for training and go on until a specified level of perfection has been reached. The practical exercises are to be considered the heart of the training. At the end of the exercises each trainee should be informed of the level of skills developed. Therefore, the following procedure of teaching a working technique is recommended to the instructor:

– introductory instruction,
– exercises with accompanying instructions,
– final instruction.

3.2. Introductory instruction

This lesson shall teach the theoretical knowledge required for the relevant working technique. It is to be given by the instructor at the beginning of each training unit. After that instruction the trainees should be able to carry out the exercises properly and with as good results as possible.

Related to the individual training units, the whole group of trainees is to be informed of

– the purpose and meaning of the relevant working technique,

– the construction, maintenance, types of machines, cutting tools, clamping tools, measuring and testing tools,

– the technological flow of work on the respective machine in the relevant working technique.

The instruction should also include labour safety instructions. This is absolutely necessary before each exercise is started in order to avoid accidents. The labour safety instructions should be as vivid as possible explaining accidents and incidents that actually happened in the factory. The trainees should be informed of general rules of labour safety and be referred to further specific hints to be given during the practical work. The trainees must be convinced that accidents cannot be avoided unless the labour safety instructions are strictly followed. A control book is to be prepared to give proof of labour safety instructions given outlining in brief the hints and explanations given to the trainees. Each trainee has to sign in the control book the labour safety instructions for ready reference in the event of any neglect.

General rules of labour safety:

– Wear close–fitting clothes! Loose clothes may be caught and pulled about by rotating machine parts.

– Never work at machines without protective headgear!

– Protect your feet by solid footwear!

– Never remove any protective devices from the machine!

– Do not reach into rotating machine parts! Switch off the machine first!

– Use tools in proper condition only!

– Clamp workpieces and tools safely and firmly!

– Use safety goggles (particularly with short–chip material) to avoid injuries of the eyes!

– Do not remove metal chips by hand! Use a chip hook, chip brush or hand broom!

– Keep naked hands off workpieces with burrs! Use protective gloves or a piece of cloth!

– Cover with sand and remove any oil slicks resulting from oiling of the machine!

– Never do any measuring or testing unless the machine is at rest!

– Do not set the speed or operate any switches unless the machine is at rest!

– Do not open any gear or motor covers until after switching off the main switch!

The introductory instruction may have the form of a lecture or dialogue or combination of these two forms.

The lecture by the instructor shall introduce the trainees into the new working technique and inform them of the aim of the instruction. Moreover, this is a way of teaching unknown knowledge, such as of the construction and operation of the relevant machine, of the construction and type of working tools to be used.

For more vividness of the lecture it is necessary to show and explain, e.g. to demonstrate, all working tools to the trainees. The construction and operation of the machine should be demonstrated in the workshop directly on the respective machine, the engine lathe, for example. The following steps are recommended for the demonstration of a working process:

– Demonstration at normal pace of work.

The instructor mentions the individual steps of work. The trainees get an idea of the entire process.

– Demonstration at decelerated pace

The process is disassembled into single components with the emphasis being on explanations.

– Repetition of difficult steps.

– Demonstration of the entire process at normal pace of work.

– One or two trainees repeat the demonstration of the working process.

– Evaluation of the demonstration.

It is important that all trainees can match the demonstration.

The lecture by trainees should be used as a means of recapitulating and consolidating knowledge already taught. For this purpose the trainees should be requested to deliver a continuous lecture, e.g. about the construction of vertical and horizontal milling machines.

The teaching dialogue shall serve to jointly elaborate (instructor with trainees) new knowledge, e.g. of technological processes. The dialogue is based on existing knowledge which is to be applied to new situations. For example, the dialogue may be preceded by reading some sections in the “Trainees' Handbook of Lessons”.

The elaboration of new knowledge in the dialogue can be considerably supported by the use of various visual aids, such as original cutting, clamping, measuring and testing tools, of the illustrations in the “Trainees' Handbook of Lessons”, of transparencies and models. The dialogue may also be used as a means of recapitulating known knowledge. All trainees can be involved in the recapitulation by the form of questions and answers of the dialogue. So the instructor can easily judge the level of knowledge of the trainees. The questions contained in the “Trainees' Handbook of Lessons” should be included in the teaching dialogue. Immediately upon elaboration of one or more key points, the trainees may requested to answer orally or in writing. In this way, the instructor can find out whether or not the trainees have understood everything. On the other hand, the questions in the individual sections of the “Trainees' Handbook of Lessons” are a means of control if the trainees had been requested to elaborate some technical key points on their own.

3.3. Exercises with accompanying instructions

Immediately before any exercises the trainees should be given specific hints for the workpiece to be practised.

According to the individual instruction examples, the trainees should be provided with information

– on the aim of the exercise,
– on the raw material of the workpiece,
– on the cutting, clamping, measuring and testing tools and accessories immediately required,
– on the steps of work (difficult steps should be demonstrated again),
– on certain dimensions and critical points of the workpiece,
– on criteria for judging the performance at the workpiece and on intermediate controls,
– on the time of the exercise to be kept.

A finished workpiece should be shown to the trainees to make clear the aim and key points of the exercise. It is useful when the instructor has previously made the workpiece himself so as to know the problems connected with its manufacture.

So he can clearly state the performance rating criteria and point out critical points of the workpiece. During such instructions each trainee should have the sequences of operations and the working drawings of the “Instruction Examples for Practical Vocational Training”. The trainees may then add necessary hints under headline “Comments” of the “Instruction Examples...”.

The aim of the exercises is to learn and to develop the skills of important operations in machining of metal workpieces up to an intended level of perfection. Therefore, the exercises must be repeated several times and be carried out purposefully. If the instructor is of the opinion that the first example of any training unit would make too high demands on the trainees' skills, preparatory exercises must be planned in terms of time and availability of material. Such preparatory exercises could comprise:

– Practising of the manipulation for setting up and operating the machines without workpieces.
– Practising of the possibilities of clamping of any blanks desired.

It is also possible to start immediately with the exercises based on the “Instruction Examples for Practical Vocational Training”. If the “Instruction Examples for Practical Vocational Training” offered are not used for the exercises, it is also possible to select other workpieces. In this case, attention should be paid to the fact that the workpieces selected lend themselves to practising of all working techniques already discussed. Before the trainees start practising, the instructor should make sure that the labour safety instructions and the instructions on how to behave in the workshop have been given. If not, they should be given now. For the exercises on lathes, the existing engine lathes should be assigned to the trainees according to their body height. The height of the machine can be compensated by footboards (gratings).

Upon assignment of the working places to the trainees including checking for completeness and serviceability of all cutting, measuring, testing tools and accessories, the trainees should receive their material. Each trainee should produce his workpiece himself, from cutting the blank until completion of the part. This is the only way of fair rating of the trainee's performance. The performance rating criteria are to be made known to the trainees before they start with the exercises. Each trainee should start practising based on the sequences of operations and working drawings.

All trainees should carry out the exercises on the same workpiece in the same sequence!

In this way the instructor keeps control of things. In the event of any difficulties the instructor must find out whether they face individual trainees only or the whole group. Individual trainees may be guided individually. If the whole group is facing the difficulties, the exercises should be interrupted for additional hints to be given to all trainees. The instructor should always walk from one trainee to another one to get exactly informed of the state of machining. He should praise good results and criticize bad results.

The instructor must always keep control of things.
The trainees must not practise unsupervisedly.

If the instructor finds out that the working techniques are carried out wrongly, he must make corrections immediately.

Since the trainees are working with machines, special attention is required. The trainees must not operate the machines unless they have first been instructed in the operation or the controls and in the hazards of injuries. One trainee only should work at the machine at a time.

In the event of waiting times because of occupied machines it is useful to keep the trainees busy with intermediate jobs, such as

– sharpening of worn–out cutting tools,
– repair of damaged working tools,
– refilling of coolant and lubricant.

With increasing level of intricacy of the exercises <u>intermediate controls</u> are recommended. This is an opportunity for the instructor to rate the performance already prior to the completion of the exercise. Workpieces of bad workmanship can be eliminated already in this stage if reworking is required or a good final result cannot be expected any more. This is all the more important if single parts are to be matched and one part cannot be made fit because of pour quality of machining.

It is a waste of time if trainees continue machining of parts which are of no use.

In this case it is more useful if the trainee stops the exercise and starts again with new raw material.

Intermediate controls, which are announced to the trainees in advance, stimulate the trainees and make them feel confident to go on with the exercises.

The instructor should note down the results and observations of the intermediate controls to take them into account for the final control.

Upon completion of each exercise the workpiece must be rated.

It is important that the rating is based on the rating criteria stated before the beginning of the exercise.

In preparation of the control and evaluation of the results the instructor must ensure that

– each trainee is informed of the rating criteria,
– a sheet of paper is prepared to fill in the results of rating.

Experience showed that the trainees are stimulated by seeing and comparing their performances on a rating sheet visible for anybody.

This rating sheet may have the form of a clearly arranged table:

Table 1: Example of a rating chart

Training unit 1

	1st instruction example				**2nd instruction example**				**3rd instruction example**			
Rating criteria	**accuracy to size**	**surface finish**		**time of exercise**	**accuracy to size**	**surface finish**		**time of exercise**	**accuracy to size**	**surface finish**		**time of exercise**
1st name												
2nd name												
3rd name												

The rating sheet should be open to inspection by all trainees. During the controls, whether intermediate or final, the trainees should have the opportunity of self–assessment of their performance. In this way, the trainees learn to exercise self–control. Observations and results of the intermediate controls noted down during the exercises are to be taken into account for the rating. Irrespective of the form of rating (mark, point or percentage system), general rules of rating the quality of the workpieces and the way of working are to be observed. The following rules of rating are recommended:

Very good performance

The workpiece is faultless. All specified sizes have been complied with. The workpiece surfaces are clean. Full use of the workpiece is ensured. The workpiece has been produced within reasonable time and with no additional help by the instructor. The trainee has a good command of the working techniques and properly uses the tools and accessories.

Good performance

The workpiece shows minor faults in terms of compliance with specified sizes and cleanness of the workpiece surfaces. The use of the workpiece is ensured. No reworking is required. The trainee basically works on his own. With certain reservations the trainee has a good command of the working techniques.

Fairly good performance

The workpiece shows several faults which can be removed by reworking, such as deviations from specified sizes, unclean surfaces. The use of the workpiece is ensured.

The trainee works with little help. He has no good command of the working techniques.

Satisfactory performance

The workpiece shows major faults in terms of accuracy to size and quality. It can just be used. Reworking is necessary.

The trainee needs the help of the instructor because he has a poor command of the working technique and doss not always find faults himself.

Unsatisfactory performance

Specified sizes have not been complied with. The workpiece is of no use. The trainee is not able to work on his own. He has no command of the working techniques.

3.4. Final instruction

At the end of each exercise and immediately on completion of each training unit the results must be evaluated. Such evaluation should have the form of discussions with the whole group of trainees to find out:

To which degree did each trainee achieve the aims envisaged? It is recommended to guide the trainees, based on the rating criteria made known before the exercise, to assess their results themselves. The instructor should

– complete the trainees' assessment,
– rate the results,
– generalize the experience gathered by the trainees,
– point out typical faults made by the trainees in their work and the causes,
– show to the trainees ways of removing and avoiding faults in preparation of the next exercise.

The results of the evaluation should be recorded in a table (see table 1). At the end of a training unit it is useful to have a prepared test. In this may the instructor will get a comprehensive survey of the trainees' knowledge actually acquired and of their practical experience. The complex of questions and answers of each training unit (see section 4) facilitates the preparation and evaluation of such tests.

Fundamentals of Fitting

1. Objectives and Subject Matters of the Practical Vocational Training in the Techniques of "Fitting"

On completion of the training the trainees are supposed to have a good command of the manual techniques of fitting component parts, in order to produce simple units. To achieve this, the following is required:

Objectives of training

– The trainees have knowledge of the purpose, types and use of the fitting of component parts and sub−assemblies (units).

– They know the various methods used for manual fitting works in preparation of assemblings.

– They are able to produce the correct type of fit according to the use and function of the component parts and sub−assemblies.

– The trainees are able to properly select the tools and auxiliaries and to suitably apply them by strictly observing the health protection, labour safety and fire protection rules.

To meet these objectives, the instructor or teacher should emphasize the following points of content:

Subject matters of training

Knowledge

– purpose, types and methods of manual fitting works
– types and fields of application of the tools, testing instruments and auxiliaries
– selected basic terms of the ISA System of Fits, representation and designation of fits
– principal technological sequences of fitting works on plane and curved surfaces
– hints on labour safety

Skills

– selection and handling of the tools, testing instruments and auxiliaries for manual fitting works

– selection and implementation of the appropriate technique according to the demands made on the work–pieces:

• narrow, plane surfaces by filing
• broad, plane surfaces by filing and scraping
• curved surfaces by scraping
• bores by reaming
• quality control and function test.

2. Organizational Preparations

All instructions, demonstrations and exercises should be prepared thoroughly and meticulously. This requires the following measures:

2.1. Planning of the Practical Vocational Training in the Techniques of "Fitting"

Draw up a time schedule and set an approximate number of hours in which you expect to complete the instruction on the various techniques of fitting. Plan an appropriate number of hours for the theory instruction on each subject, the practical demonstration, the instruction in preparation of a particular job, especially the exercices, the proper execution of the exercises, for recapitulations and controls.

When elaborating your time schedule, remember the level of know–how of your trainees, the conditions of trainees, the jobs which your trainees will take on in future and the degree of difficulty of the respective training stage.

The mephasis at each stage of training is always on the impartment of high craftsmanship and teaching of mechanical skills with the help of practice–related exercises which should be given the biggest chunk of time your schedule.

2.2. Preparation of the Labour Safety Instructions

A short labour safety instruction should precede every practical exercise, where the main points of the safe handling of all tools, auxiliaries, etc. are explained to avoid injuries.

The directions which are binding on the safe handling of drills, countersinks and reamers should be repeated as they apply to the techniques of fitting. The following focal points should be repeated several times:

– Make sure that all tools are clean, sharp and undamaged.

– Make sure that the workpiece is clamped securely and safely. Never apply excessive force. This may damage the workpieces.

– Put all measuring and testing means aside at their proper place. Use pads, supports, etc. where provided, to protect them against impact, shock and corrosion.

– It is regarded as good workmanship to keep one's workplace tidy and always to put down individual components together with their matching parts.

Have a notebook or file at hand where you keep minutes of these instructions. All trainees shall certify with their signature that they were instructed accordingly.

2.3. Preparing the Teaching Aids

– The "Trainees' Handbook of Lessons – Fundamentals of Fitting" has to be given to each trainee.

– Surveys can be prepared in form of blackboard drawings prior to the beginning of the instructions.

– Component parts, assemblies and models of guides can be made available as demonstration aids.

2.4. Preparing the Working Materials

– Each trainee has to be given the "Instruction Examples for the Practical Vocational Training – Fundamentals of Fitting" as theoretical basis for the exercises to be done.

– The starting material necessary for the exercises has to be prepared with the help of the material contained in the "Instruction Examples..." and made available in a sufficient number.

– The workshop has to be checked for complete equipment with tools, measuring and testing means and auxiliaries according to the planned exercises.

– Recommended basic equipment:

- hand hacksaws, files of various forms, scrapers, hand reamers with and without angular momentum
- steel scriber, pencil, centre punch, hammer, aluminium hammer
- limit gauges for external and internal dimensions
- form gauges and feeler gauges, centre squares
- steel tape, vernier caliper, external, internal and depth micrometers, protractor
- marking devices
- marking colour, chalk, cutting oil, tap wrench, machine grease
- vice with protective jaws, special clamping devices

– A bench or upright drilling machine with pertinent clamping devices is required for the necessary preparatory works (boring and countersinking).

– Prior to the beginning of the exercises, the serviceability of this machine has to be controlled with regard to the aspects of labour safety.

3. Recommendations for the Practical Vocational Training in the Techniques of "Fitting"

The following paragraphs make suggestions for the theory instructions, demonstrations of the techniques of fitting, as well as for checking and assessing the trainees' knewly acquired know−how.

3.1. Introductory Instruction

The trainees should be instructed on the basics of the subjects. For this, use a room where they can sit down and take notes. The trainees should be asked to enter the answers to the questions in the "Trainees' Handbook...". The trainees are supposed to have a good command of the techniques of filing, scraping and reaming before they are instructed in the techniques of fitting. The essentials of these techniques should be repeated occasionally. The contents of the "Trainees' Handbook..." follow the system of the introductory demonstrations and instructions. The focal points in that "Handbook" can be discussed in the order given there.

Purpose, types and methods of manual fitting works

To start with, explain to the trainees the necessity of fitting works in preparation of mounting sub−assemblies. It is advisable, to show examples of interference and clearance fits by means of visual aids available and to explain the use of these types of fits.

Since the methods applied in manual fitting works differ strongly in individual and series production these differences have to be illustrated by examples.

In doing so the manufacturing condition of "exchangeability" of series−manufactured component parts has to be especially pointed out.

Tools, testing means and auxiliaries

Introduce the tools, testing means and auxiliaries, as well as the fields of their application. The trainees will have some knowledge from their instructions on the manual techniques of material working. Discuss these points again with your trainees. Ask them questions to find out what they remember. The following instruments are to be recapitulated:

- files, scrapers, hand reamers
- matching pieces, testing instruments, measuring instruments
- marking devices
- special clamping devices, vice with protective jaws.

Selected basic terms of the ISA System of Fits

The worldwide use of the ISA System of Fits, particularly in countries which have adopted the metric system of units makes it necessary to enable the trainees to work with ISA−standardized sub−assemblies. With the help of the respective section in the "Trainees' Handbook..." basic terms can be explained which have to be known for reading an engineering drawing with fit specifications.

Only selected terms from this extensive field are to be mentioned:

- nominal size and actual size
- dimensional limits, dimensional variations and fit sizes
- tolerance and tolerance zone.

Accordingly, the representations of fits in engineering drawings have to be shown, and "fit specifications with dimensional variations" and "fit specifications with ISA symbols" have to be presented.

Imparting of this knowledge should be aimed at recognizing fit specifications in engineering drawings and deducing their fabrication with corresponding tools and testing means.

For the practical work it is not necessary to calculate the dimensional limits by means of ISA tables. However, the trainees should be shown such a way of determining a dimensional limit by the example of a "fit size symbol".

This focal point has to be concluded with the explanation of the advantages of the ISA System of Fits. It should be especially emphasized how simply precision bores can be worked manually using ISA−standardized hand reamers and testing instruments the dimensions of which have been coordinated accordingly.

Fitting works on plane and curved surfaces

The various techniques are to be explained proceeding from the description of the working surfaces of component parts and sub−assemblies. The “Trainees' Handbook...” contains pertinent examples:

Fitting works on narrow plane surfaces are described by the example of a mitre angle gauge, the working of broad plane surfaces is explained by examples of a square−box wrench and a lock screw. Precondition for this is the good command of the techniques of “filing” and “scraping of plane surfaces”.

When explaining these works the different test methods are to be dealt with. It is important to show the trainees the limits of the light gap test method and to explain to them the drag mark and the touching−up method as supplementary and more exact test methods.

Recommendation:

Here, the instructions can be finished and followed by exercises in the working of plane surfaces (1st and 2nd Instruction Examples).

Subsequently, the instructions have to be continued be the following focal point:

Fitting works on curved surfaces are also described by means of examples.

The fitting in by scraping of a slide bearing and the reaming of a gear bore for the reception of a shaft are explained. The latter example requires the recapitulation of the knowledge of the point “ISA System of Fits” and an explanation of the practical application. It is recommended to determine a fit size as example to designate tools and testing means with concrete specifications.

Hints on labour safety

The main points of safe filing, scraping and reaming should be discussed once more. These main points can be taken from the “Trainees' Handbook of Lessons”.

3.2. Exercises

The necessary hints on labour safety have to be given, on principle, before the beginning of the exercises. Afterwards, the workshop and the available technical equipment are to be shown to the trainees and their operation is to be demonstrated. It is recommended that the instructor begins each exercise with a demonstration in connection with instructions related to the given instructional example. The trainees are to be motivated to perform the exercise in good quality. Expected difficulties have to be pointed out.

The exercises can be done either as a compact whole according to the recommendations mentioned in Section 3 or in two exercise stages.

By means of the “Instruction Examples for the Practical Vocational Training − Fundamentals of Fitting” four exercises can be performed by using different techniques of fitting.

The “Instruction Examples for the Practical Vocational Training − Fundamentals of Fitting” contain a list of the material (starting material, tools, measuring and testing means and auxiliaries), the sequence of operations for doing the exercises and a comprehensible workshop drawing. This provides the trainees with the information necessary to perform the exercises purposefully.

If the course of the exercises shows that the quality of the practising workpiece is insufficient, more extensive exercises will have to be done. In this case, any waste products should be used. After the trainees have sufficiently proved their skills with these products, the envisaged Instruction Example can be manufactured.

It is necessary that the instructor previously produced the practising workpiece by himself so that he knows all the problems of the manufacturing process.

Thus it is possible to name clear main points for evaluating the performances – problematic points of the practising workpiece can be pointed out. During the task–related instructions the sequences of operation and workshop drawings should lie on the tables so that the trainees can take down notes into their handbooks.

The individual Instruction Examples are shortly described in the following to give a survey of the practising workpiece to which the previously imparted knowledge should be applied:

Instruction Examples

Instruction Example 31.1. Mitre Angle Gauge

A testing means is made of a 2–mm–thick steel sheet by filing an angle sector of 135°. The fit test is performed with the light gap test method by means of an available angle gauge or a protractor.

(Figure 1)

Instruction Example 31.2. Square Bolt for a Three–jaw Chuck Wrench

A square with a wrench opening of 12 mm is filed to a round stock with a diameter of 16 mm. The accuracy of the fit is tested with a square bush of corresponding size of a three–jaw chuck. The drag mark method is used as test method.

(Figure 2)

Instruction Example 31.3. Lock for Three–jaw Chuck Wrench

The pre–fabricated square bolt is now being equipped with a head and a lock. The fitting work is performed by reaming with ISA–standardized hand reamers. The required pin joints are to have clearance and interference fits. Limit gauges are used to test the fit.

(Figure 3)

Instruction Example 31.4. Pulley and Shaft to be Fitted together

An available pulley is joined with a pre–fabricated shaft. The bore of the shaft has to be adjusted according to the desired fit size – the subsequent mechanical treatment is performed by reaming. The feather key is to be inserted into the shaft keyway, if necessary it has to be pre–worked by filing true to size.

(Figure 4)

All trainees can do the exercises simultaneously, provided that the material prerequisites are guaranteed (availability of a sufficient number of devices).

In this case, the trainees can individually carry out the exercises–each trainee should be given as much time as he needs.

If there are not enough working tools available, the trainees will have to be split up in groups. It is favourable to divide them into groups according to the use of the various tools, measuring and testing means.

If the suggested Instruction Examples are not used for the exercise, it will also be possible to select other practising workpieces. The instructor should take care that all techniques previously discussed can also be practised with these pieces.

Major points as to practical work

It is advisable for the instructor to select certain aspects which he will give his particular attention when supervising and evaluating the trainees' exercises. Here are a few suggestions:

– Do the trainees carefully prepare the workplaces?
– Do they select the proper tools (size, form) for the fitting works?
– Do the trainees recognize the fit sizes from the engineering drawing?
– Do the trainees adhere to the correct sequence of the fitting works?
– Do the trainees correctly apply the test methods?
– Do the trainees meet the quality requirements?
– Are the trainees able to correctly assess the quality of their work?
– Do the trainees observe the labour safety rules?

The main points of evaluation have to be made known to the trainees prior to the beginning of the exercise!

3.3. Examples for Recapitulation and Control

This section contains tasks for consolidating and testing the acquired knowledge and skills; the answers to each task are also given:

1. What is the purpose of fitting?
(To assemble component parts, according to their function, to sub–assemblies.)

2. Which types of fits are mainly distinguished?
(Interference and clearance fits, cylindrical and flat fits.)

3. Which methods can be applied in fitting works?
(Individual or single–piece production and series production.)

4. Which manufacturing condition is good for an efficient economic assembling?
(The elements belonging together according to their function have to be exchangeable.)

5. Which tools are used for manual fitting works?
(Files, scrapers, hand reamers.)

6. Why has the internationally valid ISA System of Fits been adopted?
(To render possible the international exchange of ready–to–assemble component parts and sub–assemblies.)

7. Which specifications have to be recognizable in an engineering drawing?
(The permissible dimensional variations have to be given inform of numbers or symbols.)

8. How is the specification of an ISA fit size marked?
(Nominal size specification, tolerance zone and quality number.)

9. Which practical importance does the application of the ISA System of Fits have for testing?
(Standardized gauges make possible a time–saving testing of the quality of the fit without determining the actual size.)

10. Which recommendation has to be paid attention to during the testing?
(Testing means and workpiece must have the same reference temperature.)

11. What does “shift–fitting” mean?
(A symmetrical element has to fit into the matching piece also in case of a rotation of 90° or 180°.)

4. Teaching Aids

For a better understanding by the trainees it is recommended to make available demonstration objects.

These can be component parts and smaller sub–assemblies of machines, but also self–made models of flat tracks, dovetail guides and cylindrical guides. It is also favourable to use prepared practising workpieces in the instructions (on the basis of the “Instruction Examples...”) to demonstrate good and bad fitting work.

If the trainees are to be familiarized more profoundly with the ISA System of Fits, it is recommended to prepare blackboard drawings or transparencies for overhead projection with extracts from ISA tables and representations of fits.

Likewise, such teaching aids can also be derived from national standards.

Pinned Joints

1. Objectives and Subject Matters of the Practical Vocational Training in the Techniques of Making Pinned Joints

The trainees who have completed the course are supposed to have a good command of the techniques of making pinned joints. To achieve this, the following is required:

Objectives of training

– The trainees will have a ready knowledge of the purpose and the types of pinned joints and the stresses in pinned joints.

– The trainees will master the various techniques of making joints by use of fitting cylindrical or taper pins.

– The trainees are in a position to select the right type of pin for a particular joint.

– They select the right type of tool and aids and use them in the proper way. They keep strictly to all safety regulations.

To meet these objectives, the instructor or teacher should emphasize the following points of content:

Subject matters of training

– Knowledge

• Purpose and types of pins and pinned joints
• Stresses in pinned joints
• Types of tools and auxiliary accessories, fields of their application
• The technological steps of fitting cylindrical and taper pins, grooved pins and dowel pins
• Undoing pinned joints
• Labour safety regulations

– Abilities

• Preparing the component parts for assembly
• Assembling the component parts and inserting the pins
• Checking the component parts prior to and after assembly
• Undoing pinned joints

2. Organizational Preparations

All instructions, demonstrations and exercises should be prepared thoroughly and meticulously.

2.1. Planning the Practical Vocational Training in the Techniques of Making Pinned Joints

Draw up a time schedule and set an approximate number of hours in which you expect to complete the instruction on the various techniques of making pinned joints. Plan an appropriate number of hours for the theory instruction on each subject, the practical demonstration, the instruction in the preparation of a particular job, especially the exercises, the proper execution of the exercises, for repetitions and checks.

When planning your time schedule, remember the level of know−how of your trainees, the conditions of training, the jobs which your trainees will take on in future and the degree of difficulty of the respective training stage.

The emphasis at each stage of training is always on the impartment of high craftsmanship and teaching of mechanical skills with the help of practice−related exercises which should be given the biggest chunk of time in your schedule.

2.2. Preparing Labour Safety Instructions

A short labour safety instruction should precede every practical exercise, where the main points of the safe handling of all tools, auxiliaries, etc. are explained to avoid injuries. The directions which are binding on the safe handling of drills, countersinks and reamers should be repeated as they apply to the techniques of pinning. The following focal points should be repeated several times:

– Make sure that all tools are clean, sharp and undamaged.

– Use hammers, drifts, punches, etc. which are in good condition.

– Make sure that the workpiece is clamped securely and safely. Never apply excessive force. This may damage the workpieces.

– Put all measuring and testing means aside at their proper places. Use pads, supports, etc. where provided, to protect them against impact, shock and corrosion.

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

– It is regarded as good workmanship to keep one's workplace tidy and always to put down individual components together with their matching parts.

Have a notebook or file at hand where you keep minutes of these instructions. All trainees shall certify with their signature that they were instructed accordingly.

2.3. Preparing the Teaching Aids

– Each trainee should have a copy of the “Trainees' Handbook of Lessons−Pinned Joints”.

– Prepare surveys and tables which you can write at the blackboard prior to theory struction periods.

– Make available a sufficient number of pins, pinned joints, as well as samples or functional assemblies with pinned joints for demonstration.

2.4. Preparing the Working Materials

– Each trainee should have a copy of the “Instruction Examples... −Pinned Joints” for theoretical reading.

– Make sure that a sufficient number of tools, measuring and testing means and auxiliary accessories are available as specified in the “Instruction Examples.... −Pinned Joints”.

– Check that there is a sufficient supply of tools, measuring and testing means and auxiliary accessories for the practical exercises at hand.

– The following is recommended as a basic stock:

- Marking gauges, steel scribers, centre punches
- Locksmith's hammers, light metal hammers, drifts, punches
- Vernier callipers, plug limit gauges, try squares

- Drills, cylindrical and taper reamers, countersinks, triangular scrapers
- Cutting fluid, machine grease, tap wrenches
- Vices with protected jaws, specific clamping devices

– A bench–type or column–type drilling machine and the required work–holding devices are needed for preliminary operations (drilling, boring, countersinking).

– Check the safe and reliable operation of these machines before your trainees use them.

3. Recommendations for the Practical Vocational Training in the Techniques of Making Pinned Joints

The following paragraphs make suggestions for the theory instructions, demonstrations of the techniques of making pinned joints as well as for checking and assessing the trainees' knewly acquired know–how.

3.1. Introductory Instruction

The trainees should be instructed on the basics of the subject. For this, use a room where they can sit down and take notes. The trainees should be asked to enter the answers to the questions in the “Trainees' Handbook”. The trainees are supposed to have a good command of the techniques of boring, drilling and reaming before they are instructed on the techniques of making pinned joints. The essentials of these techniques should be repealed occasionally.

The contents of the “Trainees' Handbook” follow the system of the introductory demonstration and instructions. The focal points in that “Handbook” can be discussed in the order given there.

Purpose and types of pins and pinned joints

To start with, explain to your trainees the advantages of joining parts with pins. Use visual aids to demonstrate the mechanical details and functions of the different kinds of pinned joints. This way, jour trainees will understand the difference of pinned joints used. Discuss with them the various kinds of joints and their applications. Explain the designations of all pins to enable them to identify the nominal diameter of a pin in order to select the right size of drill for making a hole. Where no pins or pinned joints are available, use the Figures in the “Trainees' Handbook” to make your trainees familiar with them.

Stresses in pinned joints

Make frequent use of the blackboard to explain the stresses in pinned joints. Your trainees must understand that a positive connection in a properly pinned joint can only be achieved if the preworked bore holes are of the right size and match the diameter of the pin. Use a drawing on the blackboard to discuss, in addition to friction, the shearing stress in pinned joints, which can be so strong that the pins shear off.

Tools and auxiliary accessories

Introduce the tools and auxiliary accessories, and their applications. Your trainees will have some knowledge from their instructions on the manual techniques of material working. Discuss these points again with your trainees. Ask them questions to find out what they remember. Repeat the details of the following tools:

– Drills, countersinks, reamers
– Locksmith's hammers, light metal hammers
– Non–ferrous metal punches, drifts
– Clamping devices, supports, pads.

Technological process of making pinned joints

Pinned joints, generally, are made by using two different technological methods. It is recommended to explain and illustrate the differences in these methods. Joints which use cylindrical pins or taper pins typically involve the operation of reaming. Ask your trainees as many questions as you think are needed to make sure that they remember the details of this technique. Refer to the “Trainees' Handbook”, where the technique is described and the formulae are given for calculating bore hole and countersink dimensions. Use practical exercises to illustrate your explanations. Ask several trainees to demonstrate the calculations at the blackboard. Be very particular about pointing out the details of fitting taper pins. Emphasize the importance of using taper pins of the right length.

Joints which use grooved pins or dowel pins need not be reamed. The technological operations for these joints can be explained with reference to the points using cylindrical or taper pins.

Undoing pinned joints

There are essential differences in undoing pinned joints, depending on whether the hole is a through hole or a blind hole. Discuss these differences with your trainees. The loosening and dismantling of pinned joints is a most requisite procedure. However, the fact must be stressed and explained several times that seized pins and pins in blind holes must be removed with a drill. This is in most striking contrast to what the trainees were told about the specifics of pinned joints. It is a major point to make them understand that some way out of a given situation must always be found, even if it involves destroying the pin. It is more important not to damage the component parts of the joints. The trainees should be told that this is a rule, and follow it.

Safety at work

The main points of safe boring, drilling, countersinking and reaming should be discussed once more. These main points can be taken from the “Trainees' Handbook of Lessons”.

3.2. Exercises

Instruct your trainees to observe all safety regulations. This should be done before the practical exercises are begun. Then show every trainee his place of work and check that the machines and other pieces of equipment in the workshop are in good condition.

Begin each exercise by explaining the theoretical background and follow it with the practical performance of the exercise. Tell your trainees to go about their work with a sense of good craftsmanship.

Also tell them where to expect difficulties. The practical exercises can be done in the sequence in which they are given in the “Instruction Examples....”. Using the “Instruction Examples .... – Pinned Joints” your trainees can do four exercises in different techniques. The “Instruction Examples....” contain a list of materials for each exercise, tools, measuring and testing means, auxiliary accessories, the details of the technological operations and a workshop drawing.

The trainees will find there the information they need to execute the exercises properly and thoroughly. The instructor is advised to make the trainees aware of weak spots, where there may be difficulties and enable them to correctly assess the results of their work.

The instructor will do good to previously do the exercises himself. To make the instructor more aware of the points which his trainees are to achieve in their practical training, we will describe now the instruction examples for practical vocational training.

Instruction Examples

Instruction Examples 32.1.: Making a Pinned Joint for Fastening

Two square bars are to be joined successively by using a grooved cylindrical pin, a taper pin and a cylindrical pin. Check each pin for tight fit. Undo the joint. Then fasten a suitable piece of sheet metal to the square bar by means of a grooved drive stud (round head) and a grooved drive stud (countersunk).

(Figure 1)

Instruction Example 32.2.: Making a Support Plate

Grooved pins are inserted according to half length reserve taper grooved dowel pins into specific locations on a 10 mm steel plate. Another piece of plate is to be located on the first, which serves as a support. The shape and the size of the second plate can be varied by the instructor.

(Figure 2)

Instruction Example 32.3.: Making a Swivel Joint

A simple swivel joint is to be made from flat steel pieces and pins. One and is made pivotable by a cylindrical pin with a loose force fit. A fixed joint is produced at the other end using a grooved cylindrical pin. The joint is to be secured against torsion by a grooved taper pin.

(Figure 3)

Instruction Example 32.4.: Making a Container with Lid

A container is to be made from 8 mm plate metal. The plates are held together by grooved taper pins. The lid is removably connected to the body by close−tolerance grooved pins.

(Figure 4)

All trainees can do the exercises together if sufficient numbers of component parts are available. This will give every trainee a chance of doing all exercises himself. Allow the trainees as much time as they need to complete the exercises. If not enough component parts, tools, etc. are available, the trainees can work in groups. Each group should practise the use of a particular type of pin. Other exercises can be done instead of those suggested above. In that case the instructor should make sure that the techniques taught in this course can be practised extensively.

Major points as to practical training

It is advisable for the instructor to select certain aspects which he will give his particular attention when supervising and evaluating the trainees' exercises. Here are a few suggestions:

– Do the trainees prepare their workplaces with sufficient care and circumspection?
– Do they select the appropriate types and sizes of tools for the exercise they want to do?
– Will they do the job in the correct sequence of operations?
– Do they grease the pins before inserting them?
– Are the trainees able to meet the quality requirements?

In particular:

• Do the pins fit the holes exactly and tightly?
• Are the heads of the pins flush with the surface of the work−piece (except pins for holding)?
• Do the pins serve the intended purpose in a joint?

– Are the trainees able to assess their own work correctly?
– Have all labour safety regulations been observed?

3.3. Recapitulation and Checks

A list of questions has been compiled for this paragraph. They are intended to check the trainees' know−how. A question is followed by the correct answer in brackets. The letter "Q" indicates that the question has already been asked in the "Trainees' Handbook....".

1. What are pinned joints?
"Q" *(Pinned joints are disconnectable joints, whereby two or more individual parts are held together by pins. Several different types of such connections are known.)*

2. Name the main types of pins.
"Q" *(Cylindrical pins, taper pins, grooved pins, dowel pins)*

3. How are pinned joints specified?
"Q" *(Pinned joints are specified as to the function of the pin in the joint.)*

4. What types of pinned joints are produced?
"Q" *(Pinned joints for fastening, driving, holding, swivelling, fitting, securing and shearing.)*

5. What is typical of a pinned joint for fastening?
“Q” *(Pinned joints for fastening hold together two or more component parts without frictional connection.)*

6. What is typical of pinned joints for holding?
(One component part is held at another component part by a pin.)

7. What is typical of a pinned joint for swivelling?
(The component parts of the joint are movably or swivably connected with one another.)

8. What is typical of a pinned joint for fitting?
“Q” *(The component parts of this joint are fixed in a definite position relative to one another.)*

9. What is typical of a pinned joint for securing?
(The component parts of this joint are protected against becoming loose accidentally under dynamic loads.)

10. What is typical of a pinned joint for shearing?
(Pinned joints of this type secure their component parts, which are connected directly with each other, from overloads. The pin will break when the load becomes too heavy.)

11. Identify stresses which the pin in a joint is exposed to.
“Q” *(Frictional forces between the walls of the bore hole and the surface of the pin, external forces that act on a component part of the joint, shearing stresses by the parts of the joint.)*

12. Name important tools and accessories for making pinned joints.
“Q” *(Locksmith's hammers, light metal hammers, non−ferrous metal punches and drifts, drills, countersinks, reamers, clamping devices and supports.)*

13. What is the sequence of operations when making a joint by using a cylindrical pin?
(Setting up and clamping the component parts, drilling, countersinking, reaming, checking, cleaning the hole, pinning.)

14. What holes will you drill for a cylinder pin having a diameter of 26 mm?
“Q” *(Rough−drill a 24 mm diameter hole and countersink it to 25.8 mm diameter.)*

15. How will you produce bore hole for taper pins?
“Q” *(Use a drill of the nominal diameter of the taper pin. Large holes are made stepwise.)*

16. What is the taper per unit length of taper pins and what does it mean?
(A taper per unit length of 1:50 means that the diameter is reduced by 1 mm for every 50 mm of length)

17. What type of countersink will you use to deburr a bore hole?
“Q” *(Use a 90−degree included angle countersink.)*

18. What should be taken into consideration when reaming a taper pin joint?
“Q” *(When reaming a hole for a taper pin joint, test the fit of the pin before you drive it in.)*

19. What condition must be satisfied with respect to the length of a taper pin?
“Q” *(The length of the taper pin must be 2 mm shorter than the thickness of all parts of the proposed joint.)*

20. How will you shorten the length of a taper pin?
“Q” *(Saw off the thicker end of the pin with the hacksaw and file a new head.)*

21. How do you insert a pin?
(Drive the pin in with an aluminium hammer or a locksmith's hammer and a non−ferrous metal punch. Proceed from the end at which you applied the reamer.)

22. How should a pin fit its hole?
“Q” *(The upper edge of the pin must be flush with the edge of the bore. More specifically, both*

ends of a cylindrical pin must be flush with the edge of the bore. Taper pins, on the other hand, have their thicker end flush, the thin end is 2 mm inside the hole.)

23. What are the differences in the technological operations when producing a joint by using a grooved pin or a cylindrical or a taper pin?
“Q” *(The bore hole for the grooved pin is made in accordance with the nominal diameter of the pin. Bores for cylindrical pins must be reamed, those for grooved pins need not be reamed.)*

24. How can you remove a pin from a through hole?
“Q” *(Apply several blows on a drift of a nominal diameter somewhat thinner than that of the pin. Apply the drift to that end of the pin which is opposite to the driving−in end.)*

25. How can you remove a drive stud?
(Apply a flat chisel sideways between the head of the grooved pin and the surface of the component part and slightly lift the drive stud by a few blows with a hammer. Remove it with a pair of longs.)

26. How can you remove seized pins?
(They have to be removed with a drill.)

4. Teaching Aids

Use visual aids to reinforce the trainees' understanding of your instructions. Such aids can be pins, pinned joints or components or assemblies of machines with pinned joints. Instructors are advised to use sample joints made by the trainees during their practical exercises and demonstrate good and bad joints.

Threaded Joints

1. Objectives and Contents of the Practical Training in the Techniques of Making Threaded Joints

Trainees who have completed the course are supposed to have a good command of the techniques of making threaded joints. To achieve this, the following is required:

Objectives of training

− The trainees will have a ready knowledge of the purpose and the types of threaded joints and the stresses in these joints.

− The trainees will master the various techniques of making direct and indirect screwed joints for fastening purposes.

− The trainees are in a position to select those joints which serve an intended purpose.

− They can choose the right type of tools, auxiliaries and aids and use them properly, strictly keeping to all regulations on health and labour safety as well as fire protection.

To meet these requirements the instructor or teacher should emphasize the following points of content:

Content of training

Know−how

– Purpose and types of bolts, screws, nuts, locking devices, washers and threaded joints

– Stresses in threaded joints

– Types of tools and their uses

– The technological steps of making direct and indirect bolted and screwed joints for fastening purposes

– Undoing threaded joints

– Safety regulations

Abilities

– Preparing the component parts for assembly
– Assembling the component parts and inserting bolts, screws, nuts and locking devices
– Checking the component parts before and after assembly
– Undoing a threaded joint.

2. Organizational Preparations

Instructions, demonstrations and exercises should be prepared thoroughly and meticulously. This includes:

2.1. Planning the Practical Training in the Techniques of Making Joints

Set an approximately appropriate number of hours in which you want to complete the instruction in the individual techniques of making threaded joints. Plan an appropriate number of hours for the theoretical introduction into each technique, the practical demonstrations, the task–related instructions in preparation of the exercises, the proper execution of the exercises for recapitulations and controls.

When planning your time schedule, remember the level of knowledge attained by your trainees, the conditions of training, the future jobs which your trainees will take on, the degree of difficulty of this training.

The emphasis at each stage of training is always on the teaching of manual skills. They must be given the biggest chunk of time in your schedule.

2.2. Preparing Labour Safety Instructions

A short labour safety instruction should precede any practical exercise, where the major points of the safe handling of all working tools are explained to avoid injuries. The details of the safe handling of drills, countersinks and thread cutting dies will be explained.

These main points should be repeated several times:

– Make sure that the tools are of the right type and size and in proper working order.

– Make sure that the workpiece is clamped tightly and safely. Do not use excessive force in clamping a workpiece as it will cause damage.

– Use assembly tools of the right size for tightening or loosening bolted and screwed joints. Tools of the wrong size tend to damage the workpiece and may slip off causing injuries.

– Make sure that large parts cannot drop to the ground when the bolts and nuts or screws are removed.

– Always keep your workplace in order, store all tools properly and place individual parts always together with their matching parts.

A notebook or file should be at hand to keep minutes of these instructions. All trainees are required to certify with their signature that they were instructed accordingly.

2.3. Teaching Aids and Materials

– Every trainee should be given a copy of the “Trainees' Handbook of Lessons – Threaded Joints”.

– Surveys and tables should be prepared as blackboard drawings prior to the instructions.

– Different kinds of tools, bolts and screws, a number of threaded joints, as well as functional models of assemblies using threaded joints should be used in the demonstrations.

2.4. Working Tools

– Each trainee should have a copy of the “Instruction Examples for Practical Vocational Training – Threaded Joints” as a theoretical basis of the exercises.

– Make a sufficient number of component parts and joints always available for practical exercises, as described in the “Instruction Examples...”.

– Make sure that a sufficient number of tools, measuring and testing means as well as auxiliaries are available as specified in the “Instruction Examples... – Threaded Joints”.

The following basic stock of tools, measuring and testing means as well as auxiliary accessories is recommended:

– Marking gaugers, steel scribers, centre punches
– Locksmith's hammers, flat chisels
– Vernier callipers, try squares
– Drills, countersinks, thread taps, die stocks, dies
– Screw drivers, wrenches and spanners of different types and sizes
– Cutting fluid, machine grease, tap wrenches
– Vice with protected jaws, suitable types of clamping devices.

– A bench–type drilling machine or column–type drilling machine and the required work–holding devices should be available for necessary preparatory work, such as drilling, boring and countersinking.

– Check the safe and reliable operations of these machines before your trainees use them.

3. Recommendations for the Practical Training in the Techniques of Making Threaded Joints

The following paragraphs make suggestions for the theory instructions, the demonstration of the techniques of bolting and screwing as well as for checking and assessing the trainees' newly acquired know–how.

3.1. Introductory Instruction

The trainees should be instructed on the fundamentals of the subject. For this, use a room where they can sit down and take notes, or answer the questions in the “Trainees' Handbook...”. The trainees are supposed to have a good command of the techniques of boring, drilling, countersinking and thread cutting before they are instructed in the techniques of making threaded joints. The essential details of these techniques should be explained occasionally.

The contents of the “Trainees' Handbook ...” follow the system of the introductory demonstration and instruction. The main points in that “Handbook” can be discussed in the order given there.

Purpose, Types of Bolts, Screws, Nuts, Locking Devices, Washers and Joints

To start with, explain to your trainees the advantages of joining component parts by bolting or screwing. Use demonstration models to explain the mechanical details and functions of the different kinds of threaded joints. From this, your trainees will understand the uses of the different joints discussed. Discuss with them the various kinds of joints and their uses. Explain the designations of all bolts and screws to enable your trainees identify the right type of bolt or screw from a piece list. They should be able to identify the nominal diameter and the length of engagement in order to select the right kind of drill and know the depth of the hole to be drilled. Where no original bolts, nuts, screws or joints are available, use the figures in the “Trainess' Handbook...” to make your trainees familiar with them.

Stresses in Threaded Joints

Make frequent use of the blackboard drawings to explain the stresses in threaded joints. Your trainees should understand that in order to make a properly bolted or screwed joint, they must choose two component parts, one having an external thread, the other with an internal thread, and screw them together by turning in opposite directions.

Illustrate the details of positive and non−positive joints and what they have in common. Explain to them the details of all stresses that may occur in a threaded joint and make them understand how to take them into account when assembling the component parts. Discuss and compare the various ways stresses can act in a joint, i.e. prestressing, service stress, tensile and compressive stresses as well as shearing stress. Say why there is a self−retaining effect in threads for joints that are made for fastening purposes.

Tools

Introduce the tools and explain their uses. Your trainees will have some knowledge of that from the instruction in techniques of manual material working. Discuss these points again with your trainees. Ask them questions to find out what they remember.

Explain the following tools to your trainees:

- Drills, countersinks, thread taps, die stocks, dies
- Screw drive for screws with cross slots and intersecting slots.
- Open ended wrenches, ring spanners, box spanners
- Hexagon pin−type wrenches, adjustable wrenches
- Torque spanners, electrically actuated wrenches

Use the figures in the “Trainees' Handbook...” to illustrate your points. When you describe the tools, always tell your trainees how to use them properly and safely: Tell them what may happen when they use the wrong type or size of tool, such as a screw driver, spanner or wrench. Show them damaged bolts, screws and nuts to reinforce their understanding. Do not forget to mention the bodily injuries that can be caused by slipping tools.

The Technological Steps of Making Threaded Joints

The differences in bolted and screwed joints lie mainly in the preparations for making them. It is recommended to illustrate these differences by examples.

Direct and indirect threaded joints should be dealt with separately.

A screwed pipe joint is a good example to illustrate a direct screwed joint. A detailed explanation of a screwed pipe joint is given in the section on the cutting of external thread in the “Trainees' Handbook...”. The example of a pipe joint there will be understood clearly by your trainees. It is that of a simple screwed joint using a piece of pipe and joining it to another piece by a short thread. Another typical example of a pipe joint is joining pipes by a bell piece and a long thread. This technique is mainly used in permanent pipe installation systems whose position cannot be changed. The technique is practised in the example no. 33.4., but it is good to explain it now to give the trainees a full picture of all techniques.

Most parts that are made for fastening purpose are indirectly bolted or screwed. The details of indirect joints are explained in the “Trainees' Handbook...”. The two examples are those of a joint comprising a bolt, component parts and a nut, and of a bolt, component parts and another component part with a receiving thread. It is recommended to repeat the details of these joints when discussing the technique of thread cutting.

(A good time is when the calculation of the drill diameter and the bore depth from the available kind of screws is the topic.)

Give examples in figures. Use blackboard drawings on the basis of the respective diagram in the “Trainees' Handbook...” and enter dimensions for the calculation. Require your trainees to describe by exactly calculated values the techniques of drilling, boring, countersinking and thread cutting. Then give them the most important details of the assembly operations.

Tell them that these are “rules”. A summary of these rules is given in the “Trainees' Handbook...”. The trainees should give the answers to the questions in their “Handbooks”.

Undoing Threaded Joints

The undoing of threaded joints should be explained with particular reference to safety aspects. Emphasize the need of using tools of the right type and size, the safe handling of all dismantled components and their identification for re−assembly. The loosening and dismantling of bolted or screwed joints is certainly a most requisite procedure. However, the fact should be stressed and repeatedly explained that bolts and screws and nuts which cannot be loosened despite the use of rust solvents, must be removed with a drill (bored out). This is in most striking contract to what the trainees were told about the specifics of bolted and screwed joints. It is a main point to make them understand that some way out of a given situation must always be found, even if by destruction.

It is most important that the component parts in the joint remain undamaged. The trainees should be told that this is the rule, and follow it.

Safety at Work

The main points of safe boring, drilling, counterboring and thread cutting should be discussed again.. These main points can be taken from the “Trainees' Handbook...”.

3.2. Exercises

Instruct your trainees to observe the labour safety regulations, before they start doing practical exercises. Then show every trainee his place of work and check that the machines and equipment in the workshop are in working order.

Begin each exercise by explaining the theoretical background and follow it with the practical execution of the exercise. Tell your trainees to go about their work with a sense of good craftsmanship. Also tell them where to expect difficulties. The practical exercises can be done in the order in which they are given in the “Instruction Examples...”.

Using the “Instruction Examples for Practical Vocational Training − Threaded Joints” the trainees can do four exercises in different techniques.

The “Instruction Examples...” contain lists of component parts (material), tools, measuring and testing means, auxiliary accessories and a workshop drawing. The trainees will find there the information they need to exercise the examples properly and thoroughly. The instructor is advised to make the trainees aware of the weak spots, where they may be facing difficulties, and enable them to assess the results of their own exercises correctly.

The instructor will do good to do the exercises himself, using the same tools his trainees will have to use, before he asks them to do the exercises themselves.

To make the instructor more aware of the major points which his trainees are to achieve in practise, we will now describe the exercises of the “Instruction Examples...”.

Instruction Example 33.1. Making a threaded joint

Different kinds of bolts and screws are screwed into two flat pieces of metal, the choice being open. The flat component part which is on top has through holes, the holes in the bottom component part are tapped. The purpose of the exercise is to practise the use of different types of tools for heads of different shapes. Further practice in the techniques of cutting internal thread is intended.

(Figure 1)

Instruction Examples 33.2. Making a threaded joint with locking devices

Different kinds of bolts and screw with locking devices are screwed into two flat pieces of metal, the choice of the metal being open. The purpose of the exercise is to practise the proper use of different kinds of locking devices. Further practice in the techniques of cutting internal thread and making threaded joints is intended.

(Figure 2)

Instruction Example 33.3. Making a container with lid

A container is made of 8 mm plate sections, the joints are made with countersunk screws. The lid is fitted on stud bolts and knurled nuts and can be screwed on the container.

(Figure 3)

Instruction Example 33.4. Making a pipe joint

Two pieces of a 1–inch pipe are to be joined by a pipe bell on a long thread. The purpose of the exercise is to practise the use of the die stock for cutting pipe thread and making the joint of the two pieces of pipe by a pipe bell without turning the pipes.

(Figure 4)

All trainees can do the exercises together if sufficient pieces of metal, bolts, tools, etc. are available.

This will give every trainee a chance of doing all exercises himself. Allow them as much time as they need to complete the exercises.

Where not enough component parts, bolts, tools, etc. are available, the trainees can work in groups. Each group should do one exercise at a time.

Other exercises can be done without prejudice to those suggested above. In that case the instructor should make sure that the techniques previously taught in this course can be practised extensivily.

Major Points for Practical Training

We recommend that the instructor selects certain aspects which he will give his particular attention. Here are a few suggestions:

- Do the trainees prepare their places of work with sufficient care and circumspection?
- Do they select the right type and size of tools for a particular assembly job?
- Will they do a job in the correct sequence of operation?
- Do they grease the bolts before they screw them in the metal component?
- Are the trainees able to meet the quality requirements?

In particular:

  - Are all screws properly tightened?
  - Have the locking devices been properly used?
  - Will the threaded joint perform the intended task?
  - Have the holes been tapped properly?
  - Are the trainees able to asses their own work correctly?
  - Have all labour safety regulations been observed?

3.3. Recapitulation and Controls

A list of questions has been compiled for this paragraph, which are to check the trainees' newly acquired knowledge. Most of these questions have been asked in the "Trainees' Handbook of Lessons...".

1. What is a bolted or screwed joint?
(Bolted or screwed joints are detachable joints where two or more individual component parts are joined by bolts, screws and nuts, directly with each other.)

2. What conditions must be satisfied by a threaded joint which is exposed to dynamic stress?
(Suitable locking devices are used where detachable joints have to be secured against accidental loosening due to the action of dynamic stress.)

3. Give uses of countersunk bolts and screws.
(They are used in industrial plant and machinery, where safety requires that no screw head projects from the surface of a component part.)

4. What is the difference in the length of engagement of a cheese head bolt or screw and a countersunk bolt or screw?
(As to cheese head bolts or screws the threaded shanks are inserted into a component part. As to countersunk bolts and screws the heads are flush with the surface of the part into which they are screwed.)

5. Where does the shape of a sheet metal screw differ from that of a wood screw?
(On sheet metal screws, there is thread on the entire cylindrical portion of the screw, with a tip, whereas on wood screws the thread is only as long as the tapered portion of the shank.)

6. What conditions must be satisfied by the materials of which nuts, bolts and screws are made?
(Bolts, screws and nuts must be made of the same material and have the same kind of coating.)

7. Identify uses of knurled nuts and wing nuts.
(Knurled nuts nad wing nuts are used for producing detachable joints of component parts by hand.)

8. Identify elements of locking devices which must be used once only.
(Cotter pins, spring rings and out–bent locking devices are used once only.)

9. Suggest an effective way of locking when the shank of a bolt projects the nut.
(The locking effect can be enhanced on bolts which have their shanks projecting beyond the nut by screwing a counternut onto the projecting portion of the shank. Both nuts must be screwed tight.)

10. Give uses for washers.
(Washers are used on bearing faces when the latter are not properly machined, where bolts, screws and nuts are to be tightened on oblong holes and where slopes of the bearing face must be compensated.)

11. Name different types of threaded joints.
(There are direct joints, indirect joints, fastening joints and adjustable joints.)

12. Identify a critical specification of a thread for fastening purpose.
(It must have a high self–retaining effect.)

13. Name different kinds of stress in threaded joints for fastening purpose.
(There are prestressing and service stress, which act as tensile or compressive forces, and shearing stress.)

14. What may happen when the blade of a screw driver is too narrow?
(The clearance between the blade and the slot is too big, the blade may slip and damage the screw head. Injuries can be caused.)

15. What may happen when an extension is used on an open ended wrench for tightening a bolted or screwed joint?
(The joint will be overly prestressed, the threaded bolt will fail either when being tightened or later, under the action of the service stress.)

16. Name applications of the torque spamnner.
(The torque spanner is used on high−strength bolted and screwed joints which require a specific torque or where there are several bolted or screwed joints on one component part and their prestressing is the same.)

17. Give details of making a tapped hole for a screw.
(For blind holes, consider the length of thread engagement and the run−out depth of the thread tap. The tap hole must be made deeper by that dimension.)

18. Where several component parts are to be joined by a screw, which part must have a receiving thread?
(The receiving thread must be in the part which is the last as seen from the head of the screw.)

19. How is a trainee to proceed in tightening a joint which comprises a bolt and a nut?
(Grip the bolt head tightly and tighten the nut.)

20. Where should the locking element be placed in a joint consisting of a bolt and a nut?
(At the side where the nut is applied.)

21. How will you proceed in tightening several screws or bolts in the lid of a container?
(Start from the middle and proceed outwards, crosswise.)

22. Give important details of dismantling component parts.
(Use a suitable support so that the parts cannot drop to the ground. Mark the parts for re−assembly. Loosen the joints before you dismantle the parts fully.)

23. What general requirements must be met by assembly tools?
(The tools must be of the right type and size for the job in hand, and they must be in proper working order.)

4. Teaching Aids

Use visual aids to reinforce the trainees' understanding of your instruction. Visual aids, or other illustrative material, can be bolts, screws, nuts, locking devices, threaded joints or component parts or assemblies of machines with threaded joints. Instructors are advised to use the sample joints made by the trainees during their practical exercises and illustrate good and bad joints.

Feather Key Joints

1. Aims and Contents of Vocational Training in the Field of Techniques for Manufacturing Feather Key Joints

After having completed the vocational training, the trainees shall master the techniques for manufacturing feather key joints.

For this purpose, the following aims must be reached:

Aims

– The trainees have thorough knowledge of the purpose and kinds of and stress on feather key joints.

– They master the various techniques used for manufacturing fitting key and sliding key joints.

– They are able to choose the suitable fastening devices according to the function of the respective feather key joint.

– The trainees are able to choose the right tools and auxiliary means and to use them according to the regulations on health and labour safety and fire protection.

In order to achieve these aims, the following contents must be imparted by the instructor:

Contents

Knowledge

– Purpose of feather key joints, kinds of feather key and profile shafts as well as kinds of feather key joints

– Stress on feather key joints

– Kinds and fields of application of tools, devices and auxiliary means

– Technological processes for manufacturing feather key joints and profile shaft joints

– Detachment of feather key joints

– Labour safety

Abilities

– Preparation of the parts for assembly
– Assembling the parts and putting the feather keys in
– Checking the parts before, during and after assembly
– Detachment of feather key joints

2. Organizational Preparations

In order to ensure that the instructions, exercises and demonstrations go off smoothly, the instructions must be carefully prepared.

This includes the following measures.

2.1. Planning of the Training in Techniques for Manufacturing Feather Key Joints

Starting from the total number of teaching hours, the individual sections of this lesson should be planned separately.

Time planning is recommended for the following sections:

– Introduction into the techniques in the form of an instruction.
– Required demonstrations.
– Task–related instruction in preparation of the exercises.
– Carrying out of the exercises.

– Recapitulation and tests.

With the planing of the time, following factors should also be considered:

– The level of education of the trainees;
– The conditions of training;
– The future field of working of the trainees;
– The difficulties the respective section may offer.

The focal point of each section of training is the acquisition of skills by practical exercises, which, therefore, must be given the major portion of time.

2.2. Preparation of the Instruction on Labour Safety

Before the beginning of the exercises, a brief instruction is held on the appropriate use of the working means and on accident–free working.

The same hints are applicable which have to be observed with filling, scraping, drilling, reaming, milling and shaping. Special attention has to be paid to the following points:

– Use only clean, undamaged and sharp tools.

– Clamp the tools firmly and safely – but so that they are not damaged.

– Measuring and testing tools must be kept carefully and protected against damage due to shock and corrosion.

– The workshop place has to be kept in order, individually manufactured elements of a component are kept only together with their counterpart.

The trainees confirm the instruction on the above points by their signatures in a book especially started for this purpose.

2.3. Preparation of the Teaching Aids

– The “Trainees' Handbook of Lessons – Feather Key Joints” is distributed according to the number of trainees.

– Surveys and especially meaningful illustrations from the “Trainees' Handbook of Lessons” may be prepared as blockboard drawings before the lessons.

– Various feather keys, different feather key joints as well as models or serviceable components may be used as illustrative material, as far as they are available.

2.4. Preparation of the Working Means

– As a theoretical basis of the exercises that have to be done, the “Instruction Examples for Practical Vocational Training – Feather Key Joints” are distributed among the trainees.

– The materials which are required for the exercises must be prepared and placed at the disposal in sufficient quantity according to the enumeration in the “Instruction Examples for Practical Vocational Training”.

– The workshop has to be inspected as to the complete supply of tools, devices, measuring and testing tools and auxiliary equipment corresponding to the planned exercises.

– Recommended basic equipment:

• Steel scriber, centre punch
• Locksmith's hammer, light metal hammer, non–ferrous metal drift pins
• Finishing files, triangular scrapers
• Vernier caliper, dial gauge and stand, external limit gauges, plug limit

gauges
• Drills, countersinking cutters, thread taps, reamers, tap wrenches
• Screw drivers, adjustable pliers, pliers for shaft snap rings in various sizes
• Cutting oil, machine grease, soluble oil emulsion
• Vice with protective jaws, special clamping mens
• Hand screw press, pullers.

– For the necessary preparatory work – drilling and countersinking – a bench–type or upright drilling machine with the corresponding clamping means is required.

– The serviceability of this machine is to be tested before the beginning of the exercises and taking into consideration the regulations on health and safety at work.

3. Recommendations for Vocational Training in the Techniques for Manufacturing Feather Key Joints

The following sections contain suggestions for the structuring of the instructions, the demonstrations of the techniques as well as of the exercises and tests.

3.1. The Introductory Instruction

If possible, the introductory instruction should be held with the trainees in a classroom. During the instruction pay attention that the trainees write down supplements or answers of questions in the "Trainees' Handbook of Lessons".

An essential presupposition for manufacturing the various kinds of feather key joints is also the knowledge and mastering of the techniques of manual working and machining of material. This knowledge should be reactivated when the opportunity arises. The instruction can be held according to the focal points indicated in the "Trainees' Handbook of Lessons".

Purpose of feather key joints, kinds of feather keys and profile shafts as well as kinds of feather key joints

In the form of a lecture the trainees are explained what is understood by feather key joints, what tasks the feather key joints have to fulfill and what are the advantages and disadvantages of feather key joints.

It is recommendable to explain different kinds of feather key joints on the basis of the available illustrative material; in this context, also the differentes in the use of the various feather keys can be demonstrated.

The various feather keys should be shown and their special fields of use be explained.

After this, it should be pointed to the manufacture of the joints by profile shafts. It should be emphasized that these joints follow the principle of feather key joints, although no additional connecting elements are used.

The trainees should understand that this kind of joints is especially used for highly stressed machine parts.

Stress on the feather key joints

This is best explained with the help of a blackboard drawing according to Figure 9 from the "Trainees' Handbook of Lessons". The trainees should understand that the positively connected joint is only stressed when the rotating movement starts and that the power transmission is only enabled by the exact fit of feather key and keyway. By the blackboard drawing the trainees are explained the acting forces and the shearing stresses to be derived thereform.

Tools, devices and auxiliary means

Starting from the knowledge in the fields of manual working and machining of material, these working means are presented in connection with their fields of use.

This focal point should be developed in the form of a talk with the trainees, the instructor testing the level of knowledge of the trainees by systematic questions.

The following working means must be mentioned:

- Shank cutters and side milling cutters
- Internal broaches and keyway cutting tools
- Files and scrapers
- Presses and screwing fixtures
- Hammers and non−ferrous metal drift pins
- Pliers and screw drivers
- Pullers (extractors)

Technological processes for manufacturing feather key joints and profile shaft joints

Since the steps of work with the manufacture of the various kinds oft feather key joints differ only slightly, it is recommendable to describe in detail the manufacture of one commenly used fitting key joint. In the “Trainees' Handbook of Lessons”, this sequence of operations is described in great detail by 8 partial steps. This should be follow by a supplementary explanation of the sliding key and profile shaft joints. For the considation of already imparted knowledge it is important that the trainees realize the relation of cause and effect. This can be achieved by constantly drawing their attention to the consequences which an omitted or wrong step of work may have for the serviceability of the feather key joint. In doing so, the instructor may point to the development of qualities such as accuracy, conscientiousness and perseverance in working.

Detachment of feather key joints

The detachment of feather key joints must be explained to the trainees by two essential steps. One thing is to explain how shaft and hub can be separated.

Starting from their knowledge, the trainees should answer the question how very tight interference fits between shaft and hub can be detached. The methods suggested by the trainees my be discussed, then the correct suggestions are confirmed and/or supplemented by the instructor. In conclusion, the individual steps for removing the keys out of the keyways of the shafts are explained.

Hints on health and safety at work

While repeating the instructions on health and safety at work from the fields of manual working and machining of material, special points are emphasized which are especially applicable in the present field. These focal points are to be found in the “Trainees' Handbook of Lessons”.

3.2. Exercises

On principle, the necessary instructions on labour safety must be given before beginning the exercises. Then, the workshop places are allocated to the trainees and the technical equipment of the workshop is checked as to its serviceability. It is recommendable to begin every exercise by a demonstration by the instructor in connection with explanations related to the respective instruction example. In doing so, the trainees are motivated to carry out the exercise in a good quality. In this context, the focal points for assessment are mentioned and it is pointed to problems to be expected with the respective workpieces for exercise.

The instructor must have manufactured the workpiece which is the subject of the exercise himself before!

The exercises can be done in succession in the order of the instruction examples offered.

According to the “Instruction Examples for Practical Vocational Training − Feather Key Joints” − 4 exercises in different techniques can be carried out. The material “Instruction Examples for Practical Vocational Training” gives a list of the required initial material, working tools, measuring and testing tools and auxiliary means as well as the sequence of operations for doing the exercises and a clear working drawing. Thus, the trainees are provided with all required information for implementing the exercises systematically. The initial materials must be prefabricated by machines before beginning the exercises. It is necessary that the shafts and hubs are available true to size in accordance with the dimensions indicated in the working drawing, otherwise the individual operations belonging to the exercise cannot be observed correctly. If no feather keys from standardized assortments are available, these must be manufactured too. The corresponding dimensions are to be found in the working drawing.

In order to give a survey by what exercises the imparted knowledge shall be put into practice, the individual instruction examples are briefly described below.

Instruction examples

Instruction example 34.1. Fitting key joints I

A hub is to be connected with a shaft by a round−end flat key as a fitting key. The axial displacement of the hub is prevented by two shaft snap rings.

(Figure 1)

Instruction example 34.2. Fitting key joint II

A hub is to be connected with a stepped shaft by a Woodruff key as a fitting key. The axial displacement of the hub is prevented by one shaft snap ring.

(Figure 2)

Instruction example 34.3. Sliding key joint I

A hub is to be slidably mounted on a shaft using a straight−ended flat key, which is to be fixed in an ending key way of the shaft by locking screws.

(Figure 3)

Instruction example 34.4. Sliding key joint II

A hub is to be slidably mounted on a shaft using a round−ended flat key, which to be fixed in a closed keyway of the shaft.

(Figure 4)

After having fulfilled these tasks, the trainees detach the joints. All trainees can carry out the exercises at a time, if materials and tools can be provided in sufficient quantity. In this case, the trainees can do the exercises individually − each trainee shall take the time he needs.

If not enough working means are at the disposal, tasks and trainees are divided into groups. It is recommendable to proceed according to the field of use of the various feather keys. If the instruction examples offered are not used for any exercise, other pieces for the purpose of exercise may be chosen. In doing so, pay attention that all the techniques that had been discussed previously can be practised by these pieces for exercise.

Criteria in practical exercise

It is recommendable to fix criteria for assessing the exercises. These can be the following:

− Do the trainees prepare their workshop places carefully?
− Are the appropriate tools − size and form − chosen for the assembly?
− Do the trainees observe the correct order of the individual steps of work?
− Do the trainees slightly grease the parts before assembling them?
− Do the trainees fulfill the quality standards of work?

• Do the feather keys exactly fit in the keyways?
• Are shaft and hub exactly assembled corresponding to the given fits?

− Are the joints detached in the correct way?
− Are the trainees able to judge their own work correctly?
− Do the trainees observe the regulations on health and safety?

3.3. Examples for Recapitulation and Tests

For consolidating and testing the acquired knowledge and skills, this section contains questions which are also included in the “Trainees' Handbook of Lessons”.

1. What are feather key joints?
(Detachable joints where parts that shall do rotating movements are positively connected.)

2. What are the special advantages of feather key joints?
(Guarantee of true running of the parts, stability of the joints even with higher rotary powers.)

3. What is the disadvantage of feather key joints?
(They do not stand often changing shock−like stress.)

4. What kinds of feather keys are distinguished?
(Flat keys and Woodruff keys)

5. What kinds of feather key joints are distinguished?
(Fitting key joints, sliding key joints, profile shaft joints.)

6. What kind of stress is a feather key in a joint exposed to during the transmission of power?
(− Surface pressing between the side faces and the machine parts;
− Shearing stress due to opposite forces applied.)

7. What technique is used for making the keyways in the shafts?
(Milling)

8. What techniques are used for making the keyways in the hubs?
(Broaching or shaping.)

9. What techniques are used for reworking of feather keys?
(Filing, scraping)

10. What are the criteria for checking the individual parts, if a fitting key joints shall be made?
(Surface quality of shaft and bore hole in the hub; length, width, depth and alignment of the keyway of the shaft and of the hub, fit size of shaft and hub.)

11. How tight must be the fit of feather key in the keyway of the shaft?
(The lateral surfaces of the key must perfectly fit to the keyway of the shaft; there can be a slight interference fit.)

12. How can a hub be placed on the shaft, if there is an interference fit between the two parts?
(The hub is shoved on the shaft in hot condition.)

13. What are criteria for checking after a fitting key joint has been made?
(Clearance between feather key back surface and keyway of the hub, firm fit of hub and shaft, firm fit of the fitting key, fit of the hub in the right place on the shaft, exact true running of the hub on the shaft.)

14. How can the axial displacement of the hubs on the shaft be prevented?
(Shaft snap rings or retainer rings are mounted on the left and on the right sides of the hubs.)

15. What enables the firm fit of the sliding key in the keyway of the shaft?
(The sliding key is fixed by locking screws in the keyway of the shaft.)

16. What kind of fit is required between shaft and hub with a sliding key joint?
(Easily sliding clearance fit.)

17. How is a fitting key joint detached, if there is an interference fit between shaft and hub?
(The parts are drawn apart by an appropriate pulling device; if the fit is too tight, the hub must be heated for a short time, then, the fitting key is lifted out with the help of adjustable pliers.)

4. Explanations to the Teaching Aids

In order to facilitate the understanding on the part of the trainees, it is recommendable to use illustrative objects. These may be individual parts of components or machines, which include feather key joints. Also, work–pieces from exercises held before – according to the “Instruction Examples 1 to 4” – may be included in the instruction to show well made or inferior feather key joints.

Manual Working of Material/Metal – Course: Manual working of metal. Methodical course–guide for instructors – Part 2

Table of Contents

Manual Working of Material/Metal – Course: Manual working of metal. Methodical course–guide for instructors – Part 2

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Introduction

The present guide shall help the instructor to accomplish the practical Locational training by giving practical recommendations as to the

- – preparation,
- – accomplishment and
- – review of the practical vocational lessons.

At the beginning of the methodological guide the instructor is informed of the aims and contents of the course. The guide also states the previous knowledge required for acquiring the working techniques of machining of material. The emphasis is on the recommendations of didactic and methodology of the practical vocational lessons. The recommendations suggest the instructor how to plan and prepare the lessons. Possible forms and methods of accomplishing the instructions and exercises are also explained.

The last section deals with the peculiarities of the individual training units. It also contains a summary of the necessary teaching aids and working tools to facilitate organizing the course.

A methodically arranged complex of questions and answers shall help the instructor to test the know ledge of the trainees.

1. Aims and contents of the course

On completion of this training course the trainees should have the necessary knowledge, abilities and skills to work with

- – engine lathes,
- – horizontal or vertical milling machines,
- – horizontal shaping machines and
- – boring/drilling machines.

This implies that the trainees

- – are able to decide on the purpose and application of the relevant machine and technique,

- – are capable of setting up, operating, servicing and maintaining the machines and know the construction of the machines,

– have knowledge of how to determine the cutting values, such as speeds, feeds and stroke length.

– are able to select the proper tools and accessories for setting up the machines and know the construction of the different types of tools and accessories,

– have knowledge of how to meet the safety requirements in machining of material.

The course comprises the following training units (TU):

1st TU: Chipping
2nd TU: Riveting
3rd TU: Grinding of Simple Tools
4th TU: Shearing
5th TU: Bending
6th TU: Straightening
7th TU: Annealing, Hardening, Tempering

To successfully acquire the skills of these working techniques, the trainees must have previous knowledge of and master the basic skills in the working techniques of manual working of material. In addition, they should have basic knowledge of engineering drawing to be able to “read” the working drawings.

2. Organizational preparation of training

In order to ensure that the instructions, demonstrations and exercises go off smoothly, the training must be well prepared. The following is to be made available:

Classroom and workshop

Though the instructions could be given in the workshop, it is better to do it in a room where the trainees have adequate facilities to sit and write.

If a daylight projector shall be used, a bright projection area and electric supply are required.

The demonstrations of the working techniques, followed by exercises, are to be done in the workshop directly on the relevant machine. One machine with the necessary cutting and operating tools, measuring and testing tools and accessories should be available for each trainee. The necessary working tools, related to the “Instruction Examples for Practical Vocational Training”, are summarized in the “Methodical Guide for Instructor”.

Teaching aids

Sufficient copies of the “Trainees' Handbook of Lessons” equalling the number of trainees are to be made available. The “Trainees' Handbook of Lessons” is mainly used in the introductory instruction for introduction and recapitulation. It explains the technical knowledge of one training unit, which is absolutely necessary for mastering the relevant technique, in a clearly arranged and easily conceivable way. Many illustrations add up to better understanding. Tasks and questions are included to recapitulate, strengthen and test the knowledge acquired. But they may also be used by the trainees for acquiring the knowledge by themselves. A summary of all questions is contained in a complex of questions and answers in the present methodical guide in the sub–section of the relevant training unit. Tasks and questions included in the “Trainees' Handbook of Lessons” are marked with “A”.

Sufficient copies of the “Instruction Examples for Practical Vocational Training”, depending on the number of trainees, are to be made available. They explain the technology for practising the examples, supplemented by working drawings. By means of the “Instruction Examples ...” workpieces can be produced and working algorithms practised to develop essential practical skills. Based on the “Instruction Examples ...”, the availability of the materials and necessary working tools can be checked and arranged by the trainees themselves.

The “Instruction Examples ...” of each training unit are arranged with increasing level of difficulty and should be followed in the sequence given. The textbooks

– “Basic Vocational Knowledge – Working of Metal”
– “Formulas and Tables – Metal”
– “Machine Elements and Assemblies and their Installation”

can be used by the instructor for the instructions to consolidate knowledge and refresh basic knowledge.

The textbook “Formulas and Tables – metal” is particularly recommended for exercises of technical calculations.

All tools and accessories required for the working technique are to be made available as visual and/or demonstration aids. Various workpieces related to the conditions of the relevant factory are also to be made available for demonstration.

If transparencies shall be used, the daylight projector is to be checked for serviceability and the transparencies are to be checked for completeness. It is recommended to use the series of transparencies “Machining of Material” consisting of 37 transparencies (see “Methodical Guide for Instructor”).

Blackboard drawings are to be prepared prior to the instructions.

If further teaching aids are available, the instructor can complete the “Methodical Guide for Instructor”. This will give him a comprehensive survey and facilitate the preparations for the instructions.

Working tools and materials

The trainees' working places are to be checked for neatness, serviceability and completeness of the working tools and materials.

The completeness of the required technological documents (drawings, instruction examples for the relevant working technique) is to be ensured. Tests and/or recapitulations are to be prepared. The materials required for the exercises are specified in the relevant “Instruction Examples for Practical Vocational Training” – including the required dimensions. In a few cases the raw materials are to be made available in a certain stage of prefabrication that is to be prepared on advance.

3. Accomplishment of the training

3.1. General recommendations for the procedure of the course

The training course proceeds in the succession of the individual training units. The training units “Setting up and operation” should always be started with, since they will impart the basic knowledge required for the other training units. The training should then proceed with the training units according to the serial number of the training units. The knowledge and skills in the relevant working technique should be taught by an alternation of instructions and exercises. The instructions shall teach the knowledge required for accomplishing the working technique. In the exercises to follow the trainees shall put into practice the theoretical knowledge acquired. Practising of the work routines should take most of the time available for training and go on until a specified level of perfection has been reached. The practical exercises are to be considered the heart of the training. At the end of the exercises each trainee should be informed of the level of skills developed. Therefore, the following procedure of teaching a working technique is recommended to the instructor:

– introductory instruction,
– exercises with accompanying instructions,
– final instruction.

3.2. Introductory instruction

This lesson shall teach the theoretical knowledge required for the relevant working technique. It is to be given by the instructor at the beginning of each training unit. After that instruction the trainees should be able to carry out the exercises properly and with as good results as possible.

Related to the individual training units, the whole group of trainees is to be informed of

– the purpose and meaning of the relevant working technique,

– the construction, maintenance, types of machines, cutting tools, clamping tools, measuring and testing tools,

– the technological flow of work on the respective machine in the relevant working technique.

The instruction should also include labour safety instructions. This is absolutely necessary before each exercise is started in order to avoid accidents. The labour safety instructions should be as vivid as possible explaining accidents and incidents that actually happened in the factory. The trainees should be informed of general rules of labour safety and be referred to further specific hints to be given during the practical work. The trainees must be convinced that accidents cannot be avoided unless the labour safety instructions are strictly followed. A control book is to be prepared to give proof of labour safety instructions given outlining in brief the hints and explanations given to the trainees. Each trainee has to sign in the control book the labour safety instructions for ready reference in the event of any neglect.

General rules of labour safety:

– Wear close−fitting clothes! Loose clothes may be caught and pulled about by rotating machine parts.

– Never work at machines without protective headgear!

– Protect your feet by solid footwear!

– Never remove any protective devices from the machine!

– Do not reach into rotating machine parts! Switch off the machine first!

– Use tools in proper condition only!

– Clamp workpieces and tools safely and firmly!

– Use safety goggles (particularly with short−chip material) to avoid injuries of the eyes!

– Do not remove metal chips by hand! Use a chip hook, chip brush or hand broom!

– Keep naked hands off workpieces with burrs! Use protective gloves or a piece of cloth!

– Cover with sand and remove any oil slicks resulting from oiling of the machine!

– Never do any measuring or testing unless the machine is at rest!

– Do not set the speed or operate any switches unless the machine is at rest!

– Do not open any gear or motor covers until after switching off the main switch!

The introductory instruction may have the form of a lecture or dialogue or combination of these two forms.

The <u>lecture by the instructor</u> shall introduce the trainees into the new working technique and inform them of the aim of the instruction. Moreover, this is a way of teaching unknown knowledge, such as of the construction and operation of the relevant machine, of the construction and type of working tools to be used.

For more vividness of the lecture it is necessary to show and explain, e.g. to demonstrate, all working tools to the trainees. The construction and operation of the machine should be demonstrated in the workshop directly on the respective machine, the engine lathe, for example. The following steps are recommended for the demonstration of a working process:

– Demonstration at normal pace of work.

The instructor mentions the individual steps of work. The trainees get an idea of the entire process.

– Demonstration at decelerated pace

The process is disassembled into single components with the emphasis being on explanations.

– Repetition of difficult steps.

– Demonstration of the entire process at normal pace of work.

– One or two trainees repeat the demonstration of the working process.

– Evaluation of the demonstration.

It is important that all trainees can match the demonstration.

The lecture by trainees should be used as a means of recapitulating and consolidating knowledge already taught. For this purpose the trainees should be requested to deliver a continuous lecture, e.g. about the construction of vertical and horizontal milling machines.

The teaching dialogue shall serve to jointly elaborate (instructor with trainees) new knowledge, e.g. of technological processes. The dialogue is based on existing knowledge which is to be applied to new situations. For example, the dialogue may be preceded by reading some sections in the “Trainees' Handbook of Lessons”.

The elaboration of new knowledge in the dialogue can be considerably supported by the use of various visual aids, such as original cutting, clamping, measuring and testing tools, of the illustrations in the “Trainees' Handbook of Lessons”, of transparencies and models. It is recommended to use the series of transparencies “Manual Working of material” which can be applied for every training unit (see “Methodical Guide for Instructor”). The dialogue may also be used as a means of recapitulating known knowledge. All trainees can be involved in the recapitulation by the form of questions and answers of the dialogue. So the instructor can easily judge the level of knowledge of the trainees. The questions contained in the “Trainees' Handbook of Lessons” should be included in the teaching dialogue. Immediately upon elaboration of one or more key points, the trainees may requested to answer orally or in writing. In this way, the instructor can find out whether or not the trainees have understood everything. On the other hand, the questions in the individual sections of the “Trainees' Handbook of Lessons” are a means of control if the trainees had been requested to elaborate some technical key points on their own.

3.3. Exercises with accompanying instructions

Immediately before any exercises the trainees should be given specific hints for the workpiece to be practised.

According to the individual instruction examples, the trainees should be provided with information

– on the aim of the exercise,
– on the raw material of the workpiece,
– on the cutting, clamping, measuring and testing tools and accessories immediately required,
– on the steps of work (difficult steps should be demonstrated again),
– on certain dimensions and critical points of the workpiece,

– on criteria for judging the performance at the workpiece and on intermediate controls.
– on the time of the exercise to be kept.

A finished workpiece should be shown to the trainees to make clear the aim and key points of the exercise. It is useful when the instructor has previously made the workpiece himself so as to know the problems connected with its manufacture.

So he can clearly state the performance rating criteria and point out critical points of the workpiece. During such instructions each trainee should have the sequences of operations and the working drawings of the "Instruction Examples for Practical Vocational Training". The trainees may then add necessary hints under headline "Comments" of the "Instruction Examples...".

The aim of the exercises is to learn and to develop the skills of important operations in machining of metal workpieces up to an intended level of perfection. Therefore, the exercises must be repeated several times and be carried out purposefully. If the instructor is of the opinion that the first example of any training unit would make too high demands on the trainees' skills, preparatory exercises must be planned in terms of time and availability of material. Such preparatory exercises could comprise:

– Practising of the manipulation for setting up and operating the machines without workpieces.
– Practising of the possibilities of clamping of any blanks desired.

It is also possible to start immediately with the exercises based on the "Instruction Examples for Practical Vocational Training". If the "Instruction Examples for Practical Vocational Training" offered are not used for the exercises, it is also possible to select other workpieces. In this case, attention should be paid to the fact that the workpieces selected lend themselves to practising of all working techniques already discussed. Before the trainees start practising, the instructor should make sure that the labour safety instructions and the instructions on how to behave in the workshop have been given. If not, they should be given now. For the exercises on lathes, the existing engine lathes should be assigned to the trainees according to their body height. The height of the machine can be compensated by footboards (gratings).

Upon assignment of the working places to the trainees including checking for completeness and serviceability of all cutting, measuring, testing tools and accessories, the trainees should receive their material. Each trainee should produce his workpiece himself, from cutting the blank until completion of the part. This is the only way of fair rating of the trainee's performance. The performance rating criteria are to be made known to the trainees before they start with the exercises. Each trainee should start practising based on the sequences of operations and working drawings.

All trainees should carry out the exercises on the same workpiece in the same sequence!

In this way the instructor keeps control of things. In the event of any difficulties the instructor must find out whether they face individual trainees only or the whole group. Individual trainees may be guided individually. If the whole group is facing the difficulties, the exercises should be interrupted for additional hints to be given to all trainees. The instructor should always walk from one trainee to another one to get exactly informed of the state of machining. He should praise good results and criticize bad results.

The instructor must always keep control of things.

The trainees must not practise unsupervisedly.

If the instructor finds out that the working techniques are carried out wrongly, he must make corrections immediately.

Since the trainees are working with machines, special attention is required. The trainees must not operate the machines unless they have first been instructed in the operation or the controls and in the hazards of injuries. One trainee only should work at the machine at a time.

In the event of waiting times because of occupied machines it is useful to keep the trainees busy with intermediate jobs, such as

– sharpening of worn–out cutting tools,
– repair of damaged working tools,
– refilling of coolant and lubricant.

With increasing level of intricacy of the exercises intermediate controls are recommended. This is an opportunity for the instructor to rate the performance already prior to the completion of the exercise. Workpieces of bad workmanship can be eliminated already in this stage if reworking is required or a good final result cannot be expected any more. This is all the more important if single parts are to be matched and one part cannot be made fit because of pour quality of machining.

It is a waste of time if trainees continue machining of parts which are of no use.

In this case it is more useful if the trainee stops the exercise and starts again with new raw material.

Intermediate controls, which are announced to the trainees in advance, stimulate the trainees and make them feel confident to go on with the exercises.

The instructor should note down the results and observations of the intermediate controls to take them into account for the final control.

Upon completion of each exercise the workpiece must be rated.

It is important that the rating is based on the rating criteria stated before the beginning of the exercise.

In preparation of the control and evaluation of the results the instructor must ensure that

– each trainee is informed of the rating criteria,
– a sheet of paper is prepared to fill in the results of rating.

Experience showed that the trainees are stimulated by seeing and comparing their performances on a rating sheet visible for anybody.

This rating sheet may have the form of a clearly arranged table:

Table 1: Example of a rating chart

Training unit 1

	1s1 instruction example				2nd instruction example				3rd instruction example			
Rating criteria	**accuracy to size**	**surface finish**		**time of exercise**	**accuracy to size**	**surface finish**		**time of exercise**	**accuracy to size**	**surface finish**		**time of exercise**
1st name												
2nd name												
3rd name												

The rating sheet should be open to inspection by all trainees. During the controls, whether intermediate or final, the trainees should have the opportunity of self–assessment of their performance. In this way, the trainees learn to exercise self–control. Observations and results of the intermediate controls noted down during the exercises are to be taken into account for the rating. Irrespective of the form of rating (mark, point or percentage system), general rules of rating the quality of the workpieces and the way of working are to be observed. The following rules of rating are recommended:

Very good performance

The workpiece is faultless. All specified sizes have been complied with. The workpiece surfaces are clean. Full use of the workpiece is ensured. The workpiece has been produced within reasonable time and with no additional help by the instructor. The trainee has a good command of the working techniques and properly uses the tools and accessories.

Good performance

The workpiece shows minor faults in terms of compliance with specified sizes and cleanness of the workpiece surfaces. The use of the workpiece is ensured. No reworking is required. The trainee basically works on his own. With certain reservations the trainee has a good command of the working techniques.

Fairly good performance

The workpiece shows several faults which can be removed by reworking, such as deviations from specified sizes, unclean surfaces. The use of the workpiece is ensured.

The trainee works with little help. He has no good command of the working techniques.

Satisfactory performance

The workpiece shows major faults in terms of accuracy to size and quality. It can just be used. Reworking is necessary.

The trainee needs the help of the instructor because he has a poor command of the working technique and doss not always find faults himself.

Unsatisfactory performance

Specified sizes have not been complied with. The workpiece is of no use. The trainee is not able to work on his own. He has no command of the working techniques.

3.4. Final instruction

At the end of each exercise and immediately on completion of each training unit the results must be evaluated. Such evaluation should have the form of discussions with the whole group of trainees to find out:

To which degree did each trainee achieve the aims envisaged? It is recommended to guide the trainees, based on the rating criteria made known before the exercise, to assess their results themselves. The instructor should

- complete the trainees' assessment,
- rate the results,
- generalize the experience gathered by the trainees,
- point out typical faults made by the trainees in their work and the causes,
- show to the trainees ways of removing and avoiding faults in preparation of the next exercise.

The results of the evaluation should be recorded in a table (see table 1). At the end of a training unit it is useful to have a prepared test. In this may the instructor will get a comprehensive survey of the trainees' knowledge actually acquired and of their practical experience. The complex of questions and answers of each training unit facilitates the preparation and evaluation of such tests.

Chipping

1. Objectives and contents of practical vocational training in the working technique of “Chipping”

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

Objectives

– Knowledge of purpose and application of chipping.

– Proper command of the various working techniques of chipping and capability of separating or, resp., cutting workpieces.

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

– Capability of making decisions on quality independently.

The following contents have to be imparted to the trainees:

Contents

– Purpose of chipping
– Tools, accessories and means of protection for chipping
– Action and working techniques of chipping

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. The following steps have to be taken:

2.1. Preparations for instructions on labour safety

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

The following points should be emphasized:

– Use proper hammers and chisels only!

– Chisel heads must be free from burrs!

– Protect your hands from accidents by providing the chisel with an impact guard (cover)!

– Wear safety goggles to protect your eyes from injuries!

– Enclose your workplace in the direction of impacts by means of protective gratings or protective screens.

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 during the instructions a vice should be installed at the place of instruction.

– The “Trainees' Handbook of Lessons – Chipping” is to be handed out to the trainees in sufficient numbers.

– When using the transparencies series of “Chipping”, check whether they are complete (transparencies nos. 10.1 – 10.5.) and whether the overhead projector is in working order. (Check the operating conditions at the place of instruction and make sure of the proper mains supply!)

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

– All the tools and accessories for chipping 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 – Chipping” must be handed out to the trainees to provide them with the theoretical foundations for the exercises to be carried out.

– The initial materials required for the exercises must be prepared and laid out in sufficient numbers on the basis of materials mentioned in the “Instruction Examples ...”.

– Each trainee is to be provided with a workbench at which a vice, the required steel supports and good lighting are available.

– The instructor has to check whether the workbenches of the trainees are fully equipped with tools and accessories necessary for the planned exercises.

Recommended basic equipment:

– steel rule, protractor, depth gauge, vernier caliper
– steel scriber, prick–punch, double–point punch
– hammer, hand hacksaw
– flat chisel, cape chisel, half–round grooving chisel, mortise chisel
– bastard and smooth files – 300 mm (flat)
– C–clamps

Bench– or column–type drilling machines and the required clamping tools (machine vice, holding clamps, C–clamps) must be provided for the necessary preliminary work (drilling) in some of the exercises.

Based on the regulations on labour safety, the instructor has to check that the drilling machines are in good working order prior to the exercises.

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. The biggest time share must be allocated to the exercises.

3. Recommendations for practical vocational training in the working technique of “Chipping”

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

Variant no. 1

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

1.1. Introductory instruction for the whole subject, with demonstrations based on the “Trainees' Handbook of Lessons”.

1.2. Exercises in chiselling based on the “Instruction Examples 10.1. – 10.5.” with subsequent evaluation.

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 cutting–off chipping based on the “Instruction examples nos. 10.1. – 10.3.” with subsequent evaluation.

2.3. Additional instruction in the working technique of chipping chiselling.

2.4. Exercises in cutting–off and chipping chiselling based on the “Instruction examples 10.4. and 10.5.” with subsequent evaluation.

2.5. Final test on theory knowledge based on the “Example for recapitulation and tests”

Practical skills should be checked immediately after handing over the finished workpieces. 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”.

The instruction can be given based on the main points contained in the “Trainees' Handbook of Lessons”.

Purpose of chipping:

The trainees have to learn that cutting–off and chipping by chiselling are energy and time–consuming activities. The instructor has to give examples of such cases where it will not be possible to employ machining techniques and where, therefore, chipping is required.

Based on the transparencies nos. 10.1. and 10.2. the instructor can describe the positions and actions of chisels.

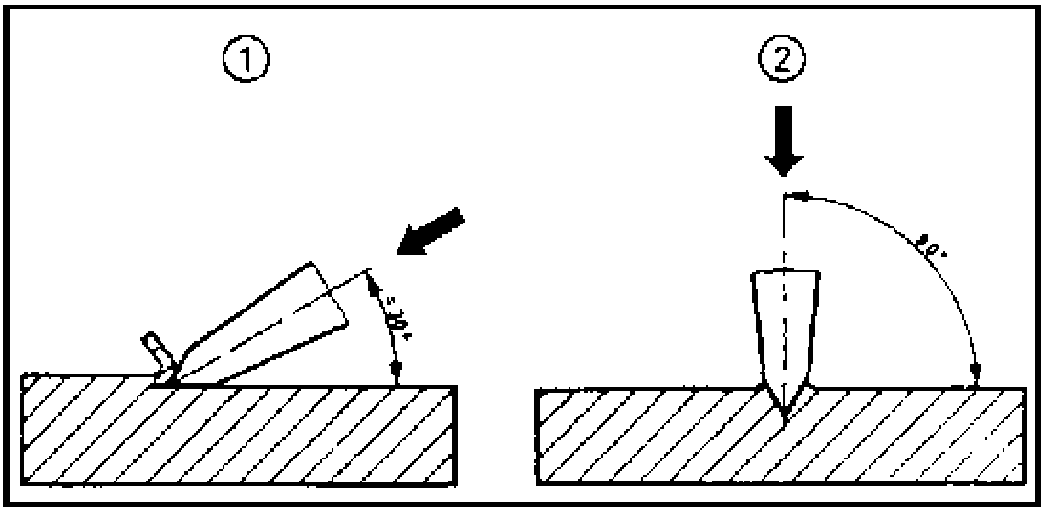


Figure 10.1

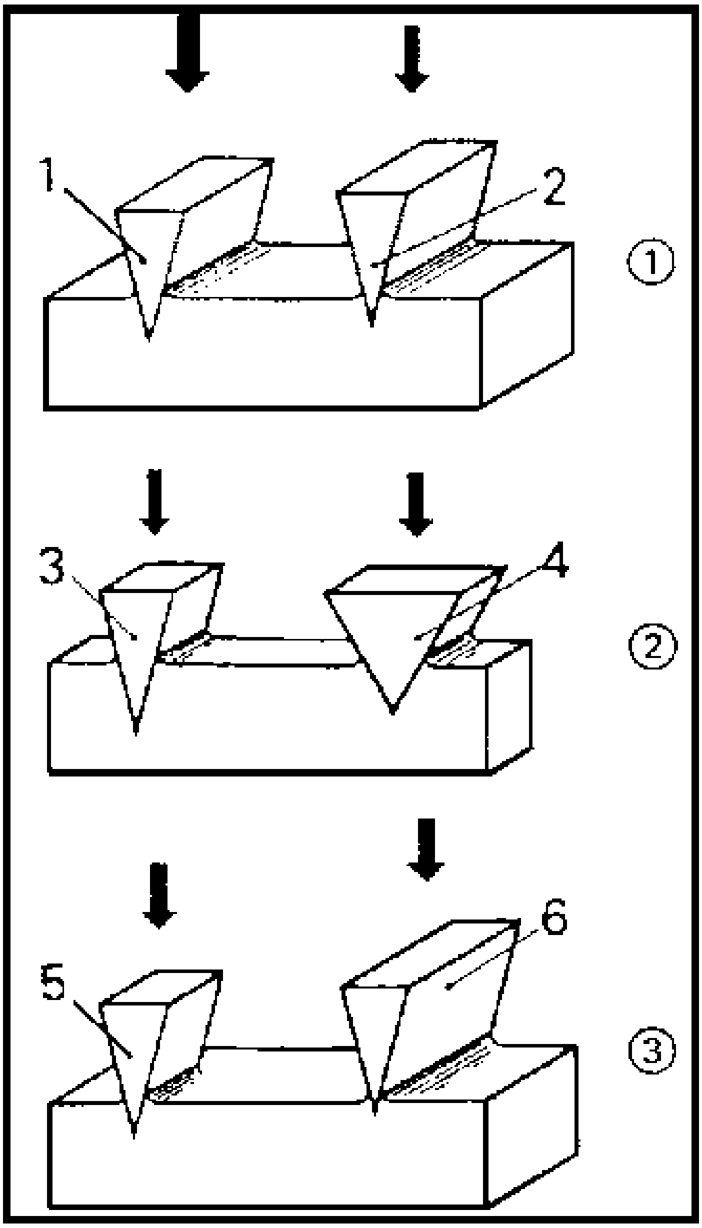


Figure 10.2

<u>Tools, accessories and protective means for chipping:</u>

The following original tools should be shown and the instructor has to explain when to use them:

– flat chisel (chipping chisel)
– round chisel
– cape chisel
– shear chisel
– grooving chisel
– mortise chisel
– punching tool

If it is not possible to show all the chisels as original tools, transparency no. 10.3. can be used as a teaching aid. The respective illustrations are also contained in the “Trainees' Handbook of Lessons”.

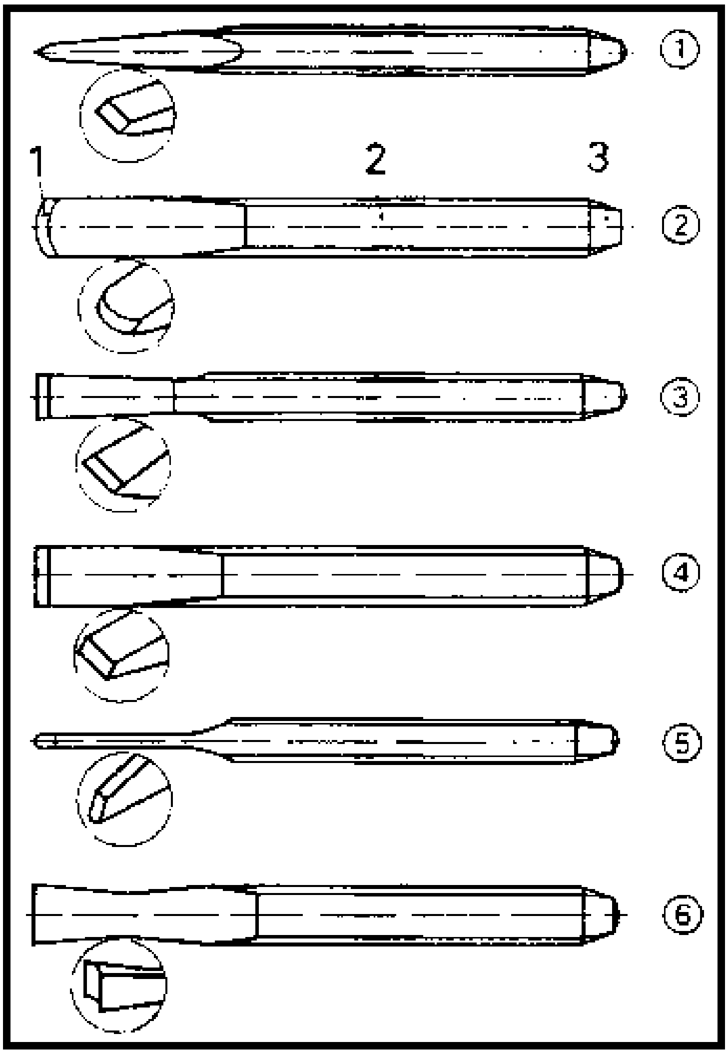


Figure 10.3

When explaining the kinds of chisels the instructor has to mention how chisels are ground.

This includes a description of the relation between the wedge angle of the tool edge and the material properties:

material property	**wedge angle**
soft (aluminium)	30° – 50°
medium–hard (steel)	60°
hard (tool steel)	60° – 70°

Other tools and accessories to be mentioned are:

– locksmith's hammer
– supports (steel plates and blocks, anvil)
– vice.

The instructor has to stress that surface plates must never be used as a support, because the chisel edge would destroy the surfaces of the plates. The following means of protection should be mentioned:

– protective gratings and screens
– safety goggles and impact protection

Action and working techniques of chipping:

This subject can be clearly explained by using transparencies nos. 10.1. and 10.2. as teaching aids. The instructor has to deal in detail with handling the chisel when chipping and cutting−off. This instruction can be supported by the hints contained in the “Trainees' Handbook of Lessons” and the respective illustrations, as well as by using transparencies nos. 10.4. and 10.5. as teaching aids.

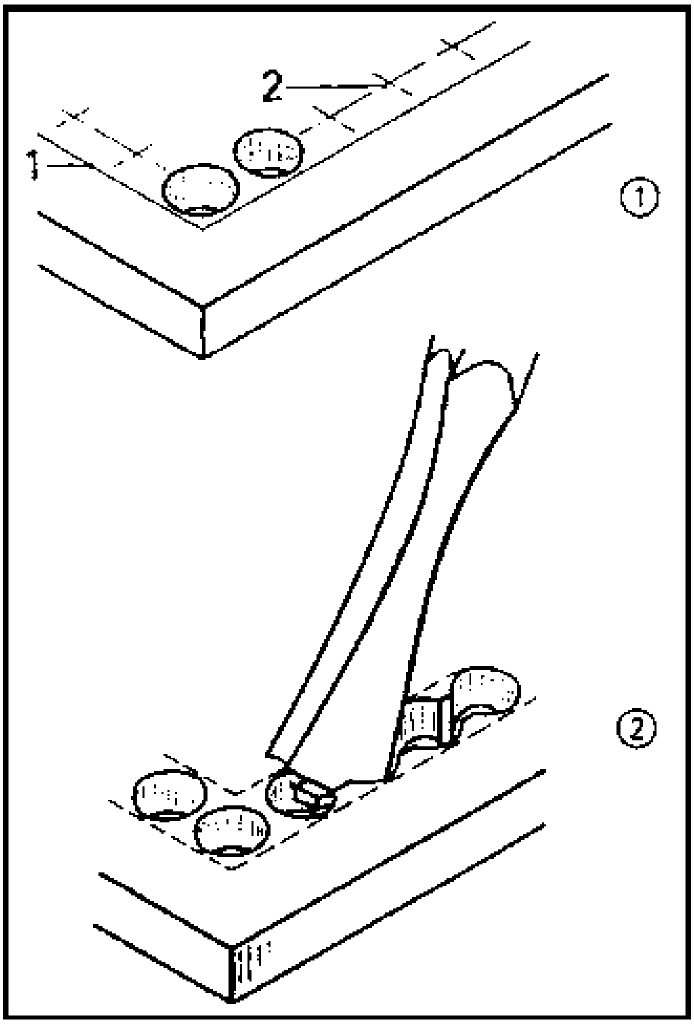


Figure 10.4

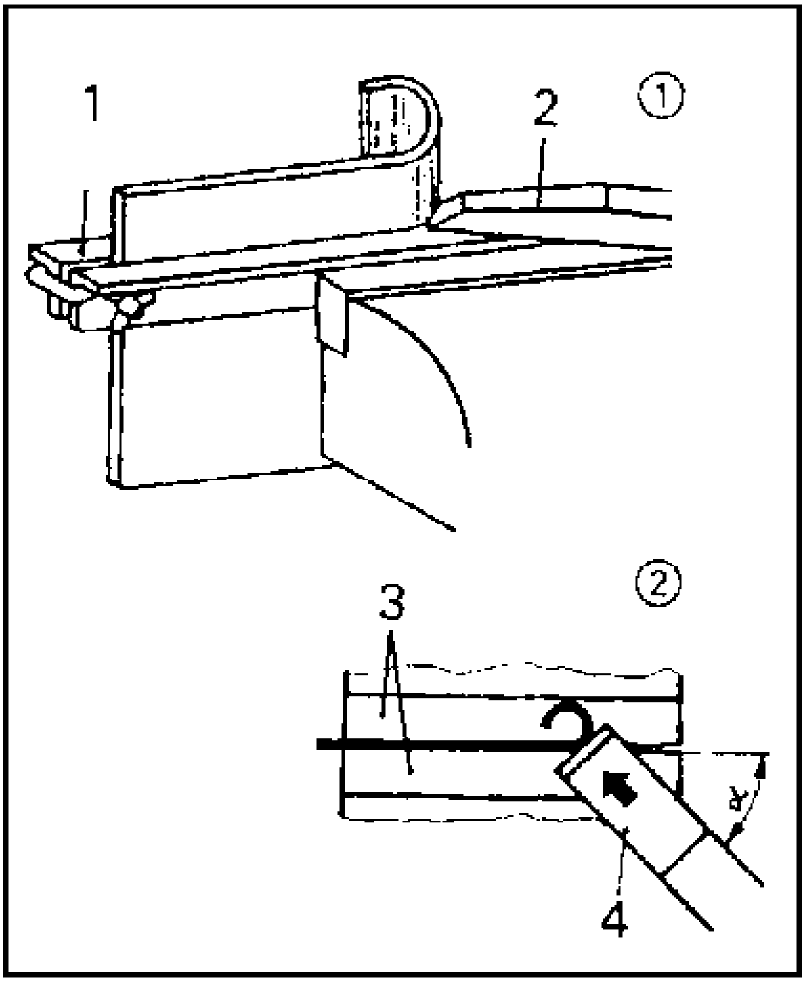
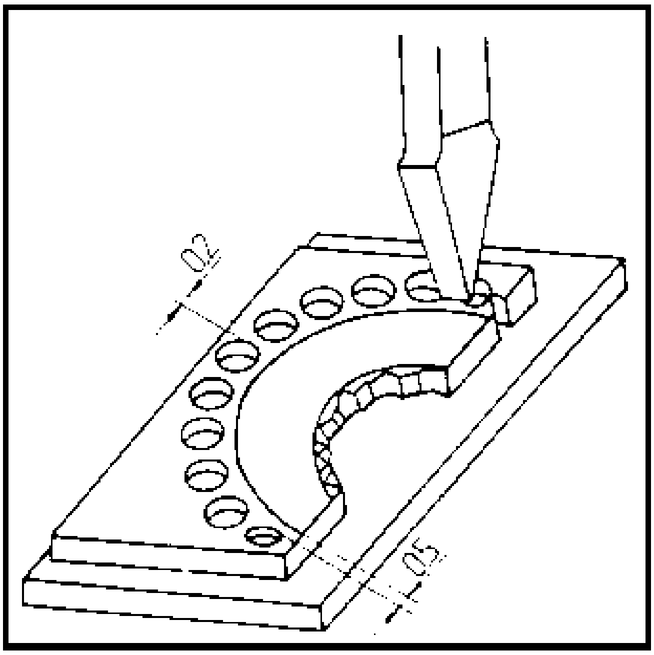


Figure 10.5

If possible, the instructor has to give a demonstration of chipping and cutting−off chiselling on small−size steel parts. When speaking about cutting−off chiselling of curved contours the instructor has to refer to the preparation of this work by scribing a bore line. He has also to refer to the necessary formulae, and a calculation should be done using the available widths of a double−point punch.

D = y − 0.2 mm
x = D/2 + 0.5 mm

D = diameter of drill
y = width of double−point punch
x = distance of bore line from scribed line



Drilling and chiselling out of curved contours

3.2. Exercises

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

Subsequently, the trainees can begin with their first exercises based on the “Instruction examples for practical vocational t raining”.

However, it is necessary to prepare every individual exercise by a brief “job−related instruction” in the course of which the trainees are shown a finished workpiece in order to demonstrate the objectives and purpose of the exercise.

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

Thus, the main points of evaluating the achievements can be clearly defined, and the instructor can inform about difficult areas in the exercise. During these instructions the sequences of operations and the working drawings should be placed on the desks so that the trainees can put down additional notes therein. All the trainees can perform these exercises simultaneously, provided that the necessary tools etc. are available. In this case the trainees can carry out all the individual exercises by themselves. Each trainee should be given as much time as required.

If there are not enough tools available, the instructor has to form groups of trainees. It is recommended to divide these groups on the basis of applying the various kinds of chisels:

group no. 1 – working with flat chisels only
group no. 2 – working with flat, cape and grooving chisels.

If there are still trainees who cannot take part in these exercises, they should perform additional exercises to consolidate working techniques acquired earlier.

3.3. Examples for recapitulation and tests

This section comprises questions which are to consolidate and test the previously 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 chipping?
(Cutting−off or chipping of material.)

2. When do we employ the chipping technique?
“A” (If it is not possible to employ mechanical techniques or if these are too costly.)

3. What is the material chisels are made of?
“A” (Unalloyed tool steel with hardened cutting edge.)

4. What are the criteria for selecting chisels?
“A” (The criteria are: kind of work and hardness of material of the workpiece.)

5. What kinds of chisels do we know?
(flat, round, cape, shear, grooving, mortise and punching chisels (tools).)

6. What is the purpose of using flat chisels?
“A” (Flat chisels are the most common tools for cutting−off and chipping chiselling)

7. What is the purpose of using cape chisels?
“A” (They are used for cutting out horizontal grooves and for cutting−off the webs in bore lines.)

8. What is the recommended wedge angle of cutting edges for working on medium−hard steel?
“A” (60°)

9. Which additional tools and accessories do we need for chipping?
“A” (Hand hammer, supports, vice.)

10. What is the basic principle for selecting the hammer?
“A” (The hammer must have double the weight of the chisel.)

11. Which property must supports have?
“A” (They must not be hardened so that they can absorb the impact of blows.)

12. Why must surface plates never be used as supports?
“A” (The penetrating chisel edge would leave notches and uneven spots on the plates so that they could no longer be used for their proper purpose.)

13. What do you have to take into account when chiselling a workpiece in a vice?
(You must hammer against the fixed jaw of the vice and use a firm counter−support.)

14. Which protective means are used to prevent accidents?
(Protective gratings or screens, goggles and impact protection.)

15. What is the task of protective screens and safety goggles?
“A” (To protect people from being hit by flying chips and fragments of workpieces.)

16. What is the action of chiselling?
(The impact of the hammer on the chisel head is transferred to the cutting edge, which can perform its chipping work now.)

17. What is the position of the chisel in a chipping operation?
“A” (The chisel inclination towards the surface of the workpiece is about 30°.)

18. How are metal sheets chiselled which are clamped in a vice?
(The chisel must be in an inclined position – with an angle of inclination of 45°.)

19. What is the position of the chisel in a cutting−off operation?
“A” (Perpendicular to the surface of the workpiece.)

20. How can we chisel off curved contours from thicker workpiece?
“A” (Scribing and punching of a bore line with a double−point punch; drilling; chiselling off the webs with mortise chisel.)

4. Application of the working technique of “Chipping”

Based on the variants mentioned in section 3, the exercises can be designed as a single subject−oriented instruction or in several stages.

Based on the “Instruction examples for practical vocational training − Chipping” the trainees can carry out 5 exercises with an increasing degree of difficulty.

These “Instruction examples ...” also comprise a list of materials (initial material, hand tools, measuring and testing tools, accessories) as well as a sequence of operations associated with the exercise. Also contained is an illustrative working drawing. Thus, the trainees avail of all the necessary information in order to begin their exercise−related work.

If the course of the exercise reveals that the quality of the workplaces does not meet the requirements, the trainees must carry out comprehensive preliminary exercises.

In this case they should use any waste parts. After having practised the skill sufficiently, the envisaged workpiece can be manufactured.

The following hint for organising the work should be taken into account :

The trainee has to carry out 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 achievements.

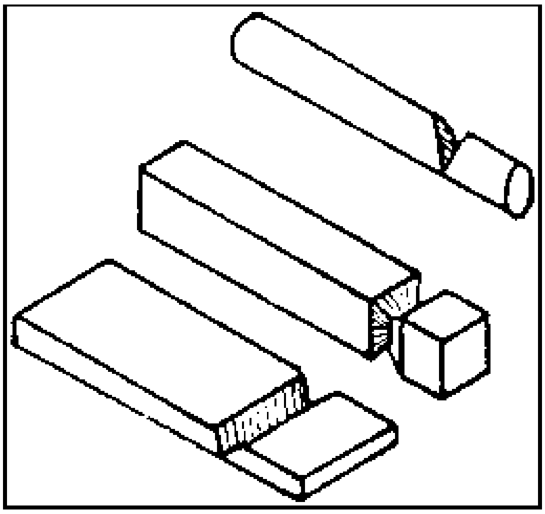
If the proposed instruction examples cannot be used for the exercises, it will be possible to select other workpieces. In this case the instructor has to make sure that the trainees can practise all the working techniques mentioned earlier.

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 knowledge previously acquired can be practised.

Instruction example 10.1.

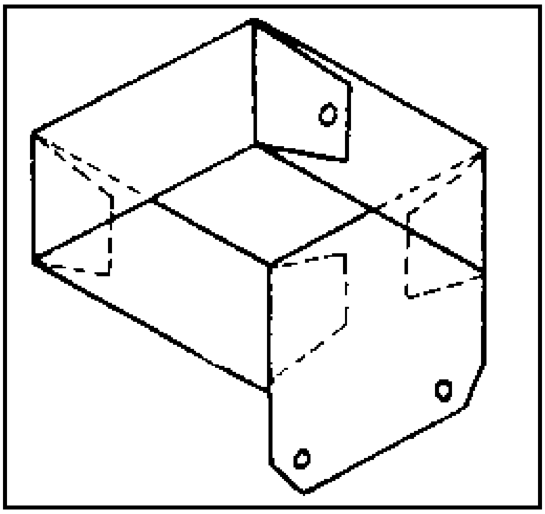
Training workpieces for cutting−off chiselling



The technique of cutting−off chiselling will be practised at various cross−sections of steel.

Instruction example 10.2.

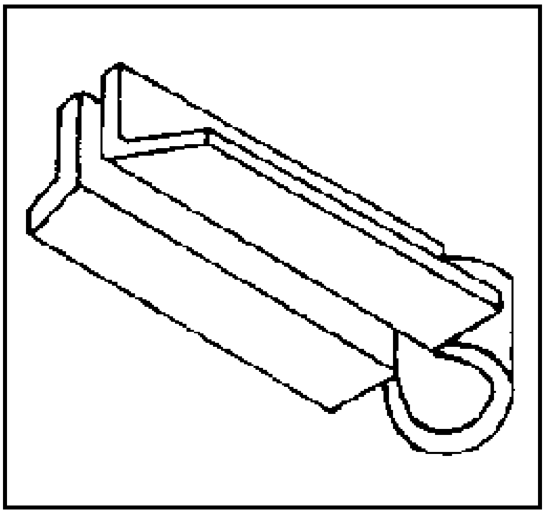
Case for safety goggles



Cutting−off and shearing chiselling practises are employed to form a metal sheet in such a way that it can be bent to form a case. This case for safety goggles must be properly dimensioned. It can be fixed close to the drilling or grinding machines.

Instruction example 10.3.

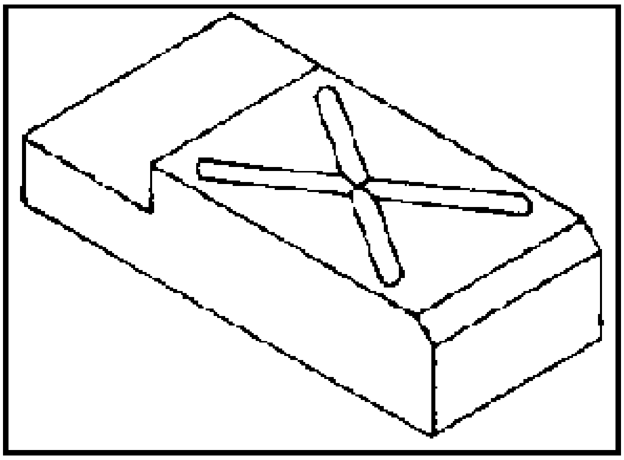
Dog vice for sheet metal



The trainee has to produce a bore line on angle steel and to chisel off sections and cut−outs. This workpiece can be used for clamping metal sheets in a workshop vice.

Instruction example 10.4.

Drilling support

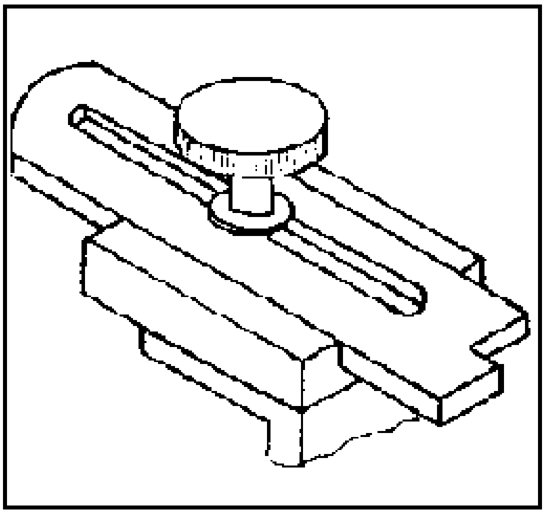


The trainees practise the chipping chiselling of surfaces and grooves on cast iron. They employ cape and grooving chisels.

After its completion this workpiece can be used as an accessory for drilling machines.

Instruction example 10.5.

Marking gauge



Several flat steel components serve to practise cutting–off and chipping chiselling by producing break–throughs and by working on surfaces. After its completion this device can be used as an accessory for marking–out operations.

4.2. Criteria for practical training

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

Cutting–off chiselling

– Is the chisel position precisely perpendicular?

– Does the trainee drill the corner points in thin metal sheets and continue by chiselling on a hardened support?

– Does the trainee notch thicker sections from all sides in order to break them?

– Does the trainee prepare long dividing lines by producing a guide notch?

– Does the trainee prepare curved contours, which are to be chiselled off, by providing a bore line?

Chipping Chiselling

– Is the chisel position properly inclined?

– Does the trainee chisel off thin layers at narrow surfaces with the chisel in an angular position?

– Does the trainee chisel off thicker layers in several stages?

5. Captions and legends of the “Chipping” transparencies series

Transparency no. 10.1. Position of chisel in chipping and cutting–off operations

(1) chipping chiselling

(2) cutting–off chiselling

Transparency no. 10.2. Principle of wedge penetration (chisel edge) into the material

(1) equal wedge angles – unequal action of force

1 action of higher force

2 action of lower force (smaller depth of penetration)

(2) different wedge angles – equal action of force

3 smaller wedge angle

4 bigger wedge angle (smaller depth of penetration)

(3) different edge lengths – equal action of force and equal wedge angle

5 smaller length of edge

6 bigger length of edge (smaller depth of penetration)

Transparency no. 10.3. Kinds of chisels

(1) flat chisel (chipping chisel)

(2) round chisel

(3) cape chisel

(4) shear chisel

(5) grooving chisel

(6) mortise chisel

Transparency no. 10.4. Chiselling–off of thin metal sheets

(1) Scribing and drilling

1 scribed line

2 bore line

(2) Chiselling out of “webs” with a mortise chisel

Transparency no. 10.5. Shearing–off of metal sheets

(1) shearing–off of longer metal sheets by shearing chisel and dog vice for sheet metal (angle steel with clamp)

1 dog vice for sheet metal

2 shearing chisel

(2) shearing process in a vice

3 vice jaws

4 chisel

angle of inclination of about 45°

Riveting

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”” must 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.

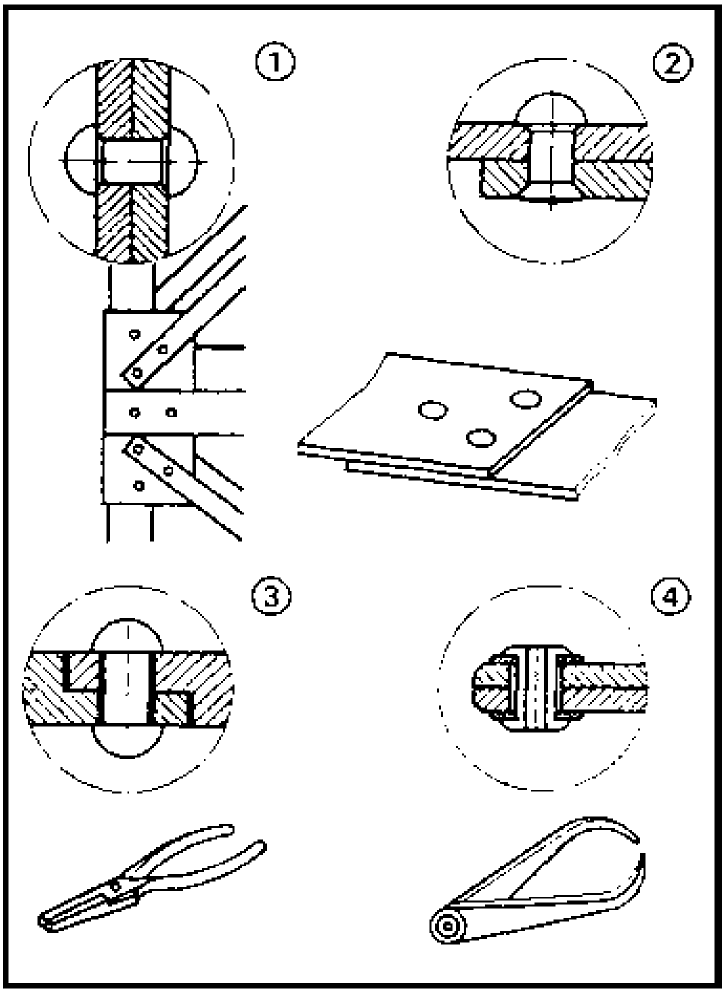


Figure 11.1

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.

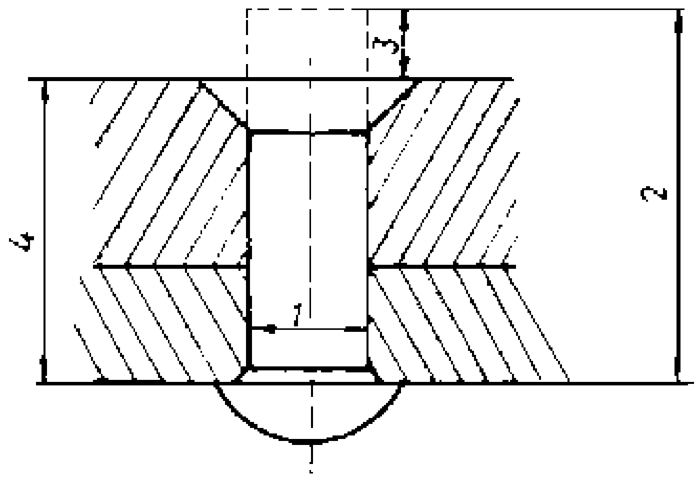
The following items have to be added when speaking about the hot–riveting process:

– forge fire
– riveting block
– riveting tongs.

<u>Calculations for choosing rivets</u>

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:

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

$$L = s + A$$

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
<u>A = 1.5 x D</u>
rivet shank diameters exceeding 20 mm
<u>A = 1.6 x D</u>

− in boiler construction:
up to rivet shank diameters of 20 mm
<u>A = 1.7 x D</u>
rivet shank diameters exceeding 20 mm
<u>A = 1.8 x D</u>
Allowances for countersunk closing heads:
<u>A = 0.5 x D</u>

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").

<u>Technological process of riveting</u>

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

− clamping/drilling
− deburring/countersinking
− insertion/drawing−in
− upsetting
− preforming/heading
− 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 afterwards. 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.

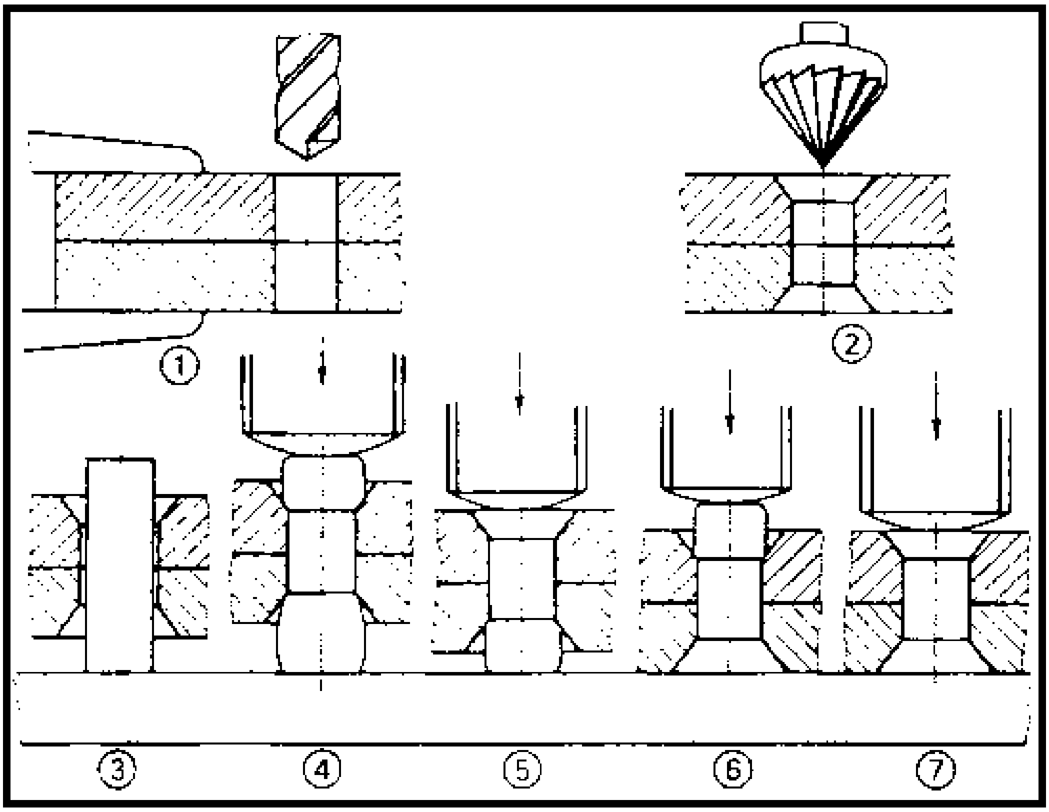


Figure 11.2

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.

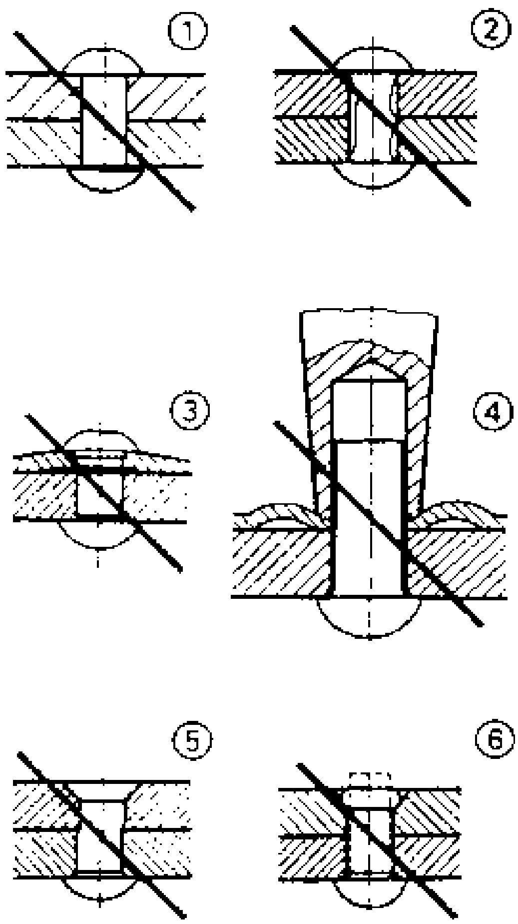


Figure 11.3

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 unclamped 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!

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. <u>Examples for recapitulation and tests</u>

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 must 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.

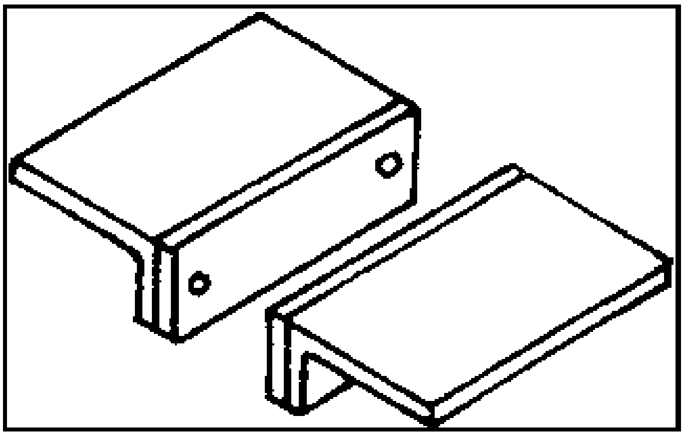
If the proposed “Instruction examples ...” are not included in the exercises, it will be also possible to select other workpieces. In this case the instructor has to make sure of it that all the working techniques mentioned before will be practised with this workpiece.

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

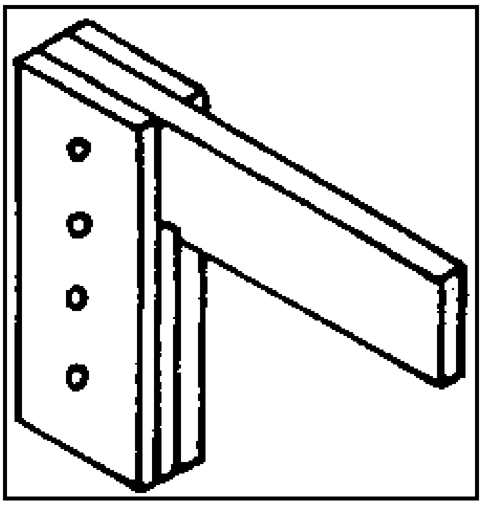


An aluminium sheet and a steel sheet will be rigidly joined by double−sided countersunk−head riveting. The trainees use rivet bolts of 4 mm aluminium wire.

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.

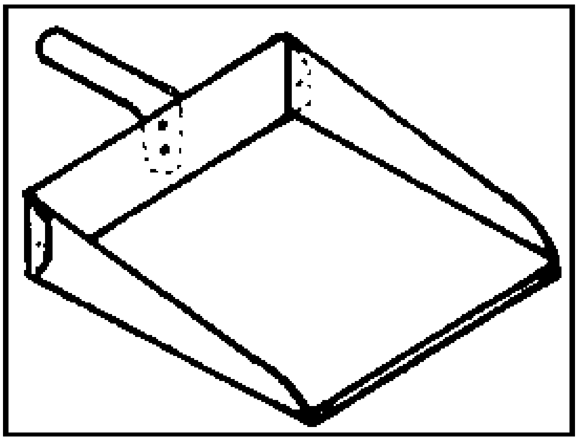
Try square



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.

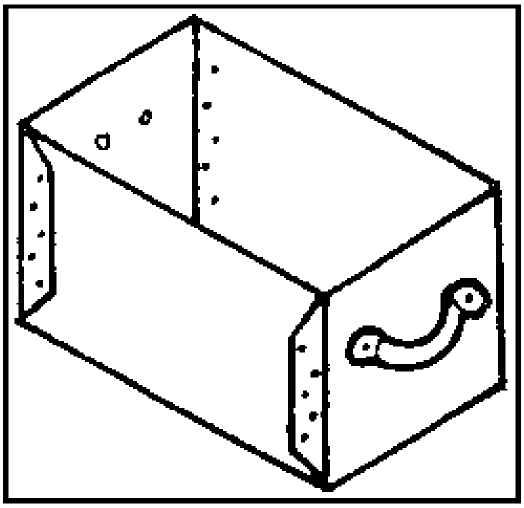
Waste shovel



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.

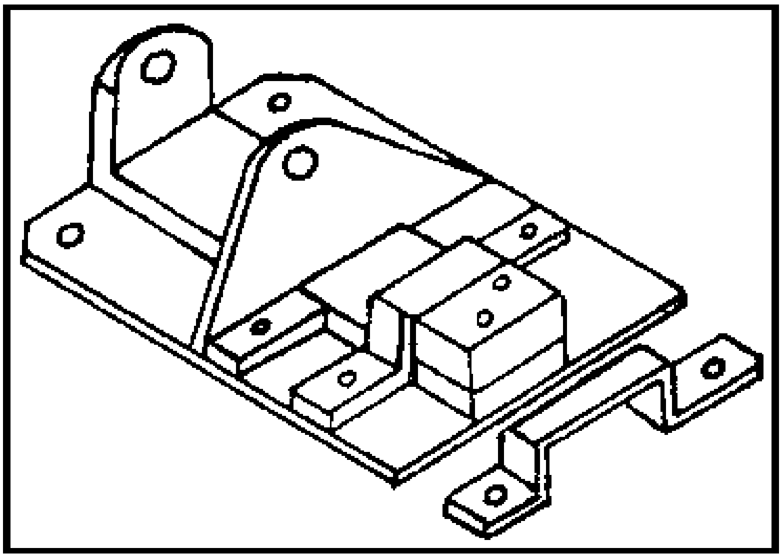
Waste bin



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 workplaces 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.

Grinding of Simple Tools

1. Objectives and contents of practical vocational training in the working technique of “Grinding of Simple Tools”

By concluding their training, the trainees shall have a good command of the working technique of “Grinding of Simple Tools”. Therefore, the following objectives have to be achieved:

Objectives

– Knowledge of purpose and application of the off–hand sharpening technique.

– Proper command of the working techniques and capability of off–hand sharpening of the most common tools.

– Capability of making decisions on the quality of their work independently.

The following contents have to be imparted to the trainees:

Contents:

– Purpose of sharpening
– Machines and tools for sharpening
– Action of grinding and whetting
– Applications of off–hand sharpening
– Hints for mounting and dressing of grinding wheels

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 measures:

2.1. Preparations for instructions on labour safety

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

The following main subjects have to be imparted to the trainees:

– Only one trainee must work at a grinding machine at a time.

– A safety distance of at least 1 m around the grinding machine is to be observed.

– A trainee at the grinding machine must never be distracted, pushed or teased.

– The conditions of safety at the grinding machine have to be permanently checked:

• maximum distance of grinding support 1 – 2 mm.
• distance of spark killer 5 mm (maximum)

– Grinding machines without attached eyeshields must be operated with the safety goggles on.

– Never grind the tools without the guidance of the left hand.

– Grinding wheels must be stressed frontally only – no lateral stress is allowed.

– You must never wear gloves or use pieces of cloth when holding the tools during sharpening.

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

2.2. Provision of teaching aids

The "Trainees' Handbook of Lessons – Grinding of Simple Tools" has to be handed out to the trainees in sufficient numbers. When using the transparencies series of "Grinding of Simple Tools" check whether they are complete (transparencies nos. 12.1. – 12.3.) and whether the overhead projector is functional. (Check whether the operating conditions are appropriate on the spot 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 grinding wheels and tools to be sharpened 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 – Grinding of Simple tools" must be handed out to the trainees to provide them with the theoretical foundations for the exercises to be carried out.

Based on the materials listed in the "Instruction examples ..." the initial materials necessary for the exercises have to be prepared and laid out in sufficient numbers.

For simple repair work or the production of tools the workbenches of the trainees have to be provided with firmly installed vices. The instructor has to check whether the workbenches are fully equipped with tools and accessories – based on the planned exercises – if other repair work or the production of new tools is planned in addition to sharpening.

Recommended basic equipment:

- vernier caliper, protractor, grinding gauge
- steel scriber
- hand hacksaw, locksmith's hammer
- whetstone.

Based on the number of trainees a sufficient number of grinding machines (bench–type and pedestal grinding machines) is to be provided.

For the purpose of off–hand sharpening of tools made of tool steel, flat wheels made of corundum must be available.

Tools with carbide cutting edges require flat wheels made of silicon carbide.

2.4. Time schedule

Time planning is recommended for the following training stages

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

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

3. Recommendations for practical vocational training in the working technique of "Grinding of Simple Tools"

The following paragraphs comprise proposals on conducting trainee instruction, demonstration of the working techniques and on the form of exercises and tests.

The following course of events is recommended:

– Introductory instruction accompanied by demonstrations based on the “Trainees' Handbook of Lessons”.

– Exercises in sharpening based on the “Instruction examples 12.1. – 12.5.” and subsequent evaluation.

– Final test of theory knowledge based on the “Examples for recapitulation and tests”.

Practical skills should be checked immediately after handing over the completed workpiece. Theory knowledge can be checked constantly. However, it is recommended to have a final test written 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 supplements and answers to questions in the “Trainees' Handbook of Lessons”.

The subjects of instruction can follow the main points contained in the “Trainees' Handbook of Lessons”.

Purpose of sharpening

The instructor shows dull tools (chisels, drills) and workpieces which were treated with these tools in order to explain the purpose of sharpening the tools to the trainees. The instructor has to point out that the use of dull or damaged tools can result in great losses. The trainees have to understand that the technique of off–hand sharpening is high–quality manual work. They will learn that nearly all the common tools in a locksmith's shop are maintained this way.

Machines and tools for sharpening

Based on the hints contained in the operating manuals and folders the instructor makes the trainees familiar with the bench–type and pedestal grinding machines in the workshop. The basic design of a bench–type grinding machine can be also seen on transparency no. 12.1.

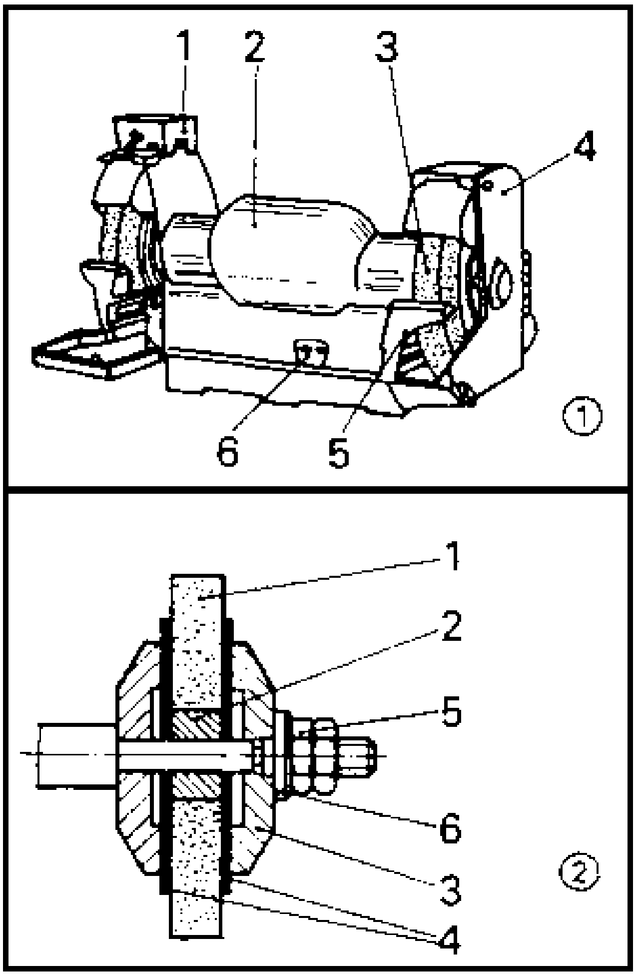


Figure 12.1

The grinding wheels used as tools for sharpening are the subject of the subsequent instruction in the different forms and structural composition of such wheels. The following forms should be illustrated:

- flat grinding wheels
- dish wheels
- cup wheels.

If these grinding wheels are not available as originals, transparency no. 12.3. or the figures contained in the "Trainees' Handbook of Lessons" can be employed as teaching aids. It is also recommended to demonstrate coarse, medium and fine−grained grinding wheels and their respective fields of application. The trainees should be shown the silicon carbide and corundum wheels used for off−hand sharpening. They must learn to select the proper wheels by eyesight.

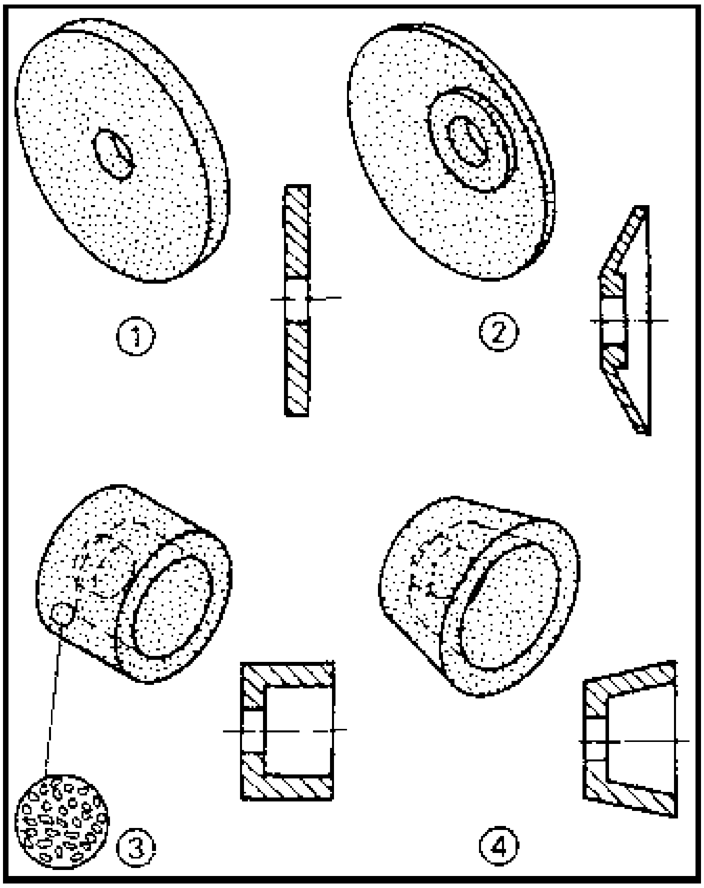


Figure 12.3

Action of grinding and whetting

The action of grinding can be seen during the grinding process.

Transparency no. 12.2. can support the necessary explanations. As some burrs will occur at the cutting edge during the grinding process, the trainees are given a detailed description of the whetting process. It is recommended to demonstrate the position of the cutting edge on the whetstone and the kinds of movement involved in whetting. The instructor should never forget to underline the importance of this process and to stress that tool life greatly depends on an exact whetting process. (The tool life of a properly whetted chisel can be four times as long as that of a chisel which has not been whetted).

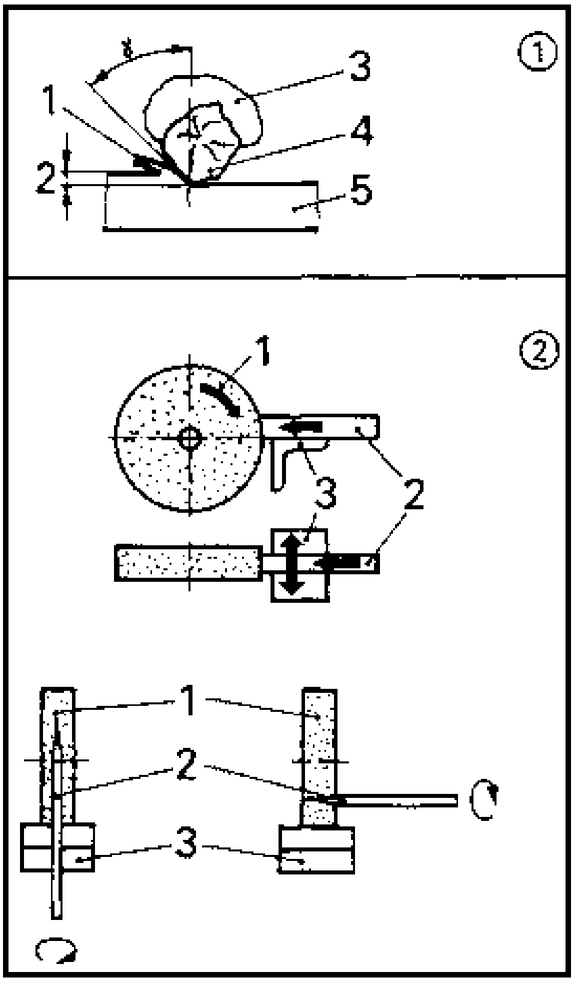


Figure 12.2

Applications of off–hand sharpening

Based on the detailed descriptions contained in the “Trainees' Handbook of Lessons”, the instructor can describe the sharpening technique for the following tools:

- centre punch and scriber
- flat chisel
- drill with standard drill point

This description can be supported by using the sequences of operations given in the “Instruction examples for practical vocational training”. As the different positions of the hand are the main point in these processes, the trainees must be demonstrated how to hold the tools. The instructor can do so by simply showing a grinding wheel and the hand positions associated with grinding. This must be supplemented by repeated demonstrations at a grinding machine later.

Hints for mounting and dressing of grinding wheels

The instruction in mounting the grinding wheels should follow the order contained in the “Trainees' Handbook of Lessons”. When describing the individual activities the instructor has to mention all the associated safety regulations. These activities must be carried out in a workshop under the supervision of the instructor only. Supervision is also necessary for dressing of grinding wheels with a hand dresser.

3.2. Exercises

If it has not been possible to include the demonstrations in the instructions by now, this should be done right now prior to the beginning of the exercises.

These demonstrations must be so designed that not more than two trainees watch them at a time. These trainees have to repeat this action immediately afterwards under the supervision of the instructor. It will be necessary for the instructor to repeat these demonstrations frequently, for the proper sharpening technique can be only acquired by detailed observation and immediate duplication.

Subsequently, the trainees can begin with their first exercises based on the "Instruction examples for practical vocational training".

However, it will be necessary to prepare every individual exercise by a "job−related instruction". This comprises the demonstration of a finished workpiece in order to underline the purpose and objectives of this exercise.

The instructor must have completed such a workpiece himself in order to understand all the problems involved in the production of the workpiece.

Thus, the instructor can clearly indicate the main points of evaluation and assessment of the achievements as well as crucial manufacturing areas. 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 notes therein.

The trainees can carry out all the exercises simultaneously in the given order, provided that the number of tools etc. will allow this. If this is not the case, the trainees have to be grouped into teams − based on the tasks and the number of tools, machines etc. available.

If there are only a few grinding machines available, the exercises in sharpening should be done in parallel with exercises in other working techniques. Preferably, the techniques of "drilling, countersinking and counterboring" as well as "manual reaming" and "manual thread cutting" should be practised. During these exercises waiting times might occur at the drilling machines, and these times could be usefully bridged by exercises in sharpening.

The supervision of the instructor has to concentrate on some crucial points:

Since it is difficult to learn the proper positioning of the hands, as can be seen from repeatedly occurring handling errors, the instructor has to keep a close eye on the trainees. The instructor can reduce the trainees' anxieties caused by the rotating grinding wheels through calm and steady demonstrations and permanent supervision.

The trainees are requested to have their tools checked frequently. The instructor can recognise errors in the position of hands from the characteristic grinding pattern. If a trainee does not learn the proper handling techniques − even after prolonged exercises − the instructor has to guide the trainee's hands for a while. The exercise is characterised by & constant alternation of demonstration and duplication.

Exercises at the grinding machine should not exceed 2 hours, because the attention of the trainees will slacken off very fast. In addition, you have to keep in mind that bench−type and pedestal grinding machines are not designed for continuous operation − danger of overheating. This is the reason why the sharpening process should be interrupted by other working techniques. Thus, the "Instruction examples..." concentrate on the production of simple tools and the subsequent sharpening operation.

3.3. Examples for recapitulation and tests

This section comprise questions which are to consolidate and test the previously 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 sharpening?
(Cutting edges of tools have to be prepared for cutting in manufacturing processes by grinding and whetting or dull edges are re−ground for further use.)

2. What is the advantage of off−hand sharpening?
"A" (You can do it at any grinding machine immediately without any time−consuming preparations.)

3. Which tools can be treated by off−hand sharpening?
(Steel scribers, scribers of beam trammels and scribing blocks; centre punches, chisels and drills of all kinds,

screwdrivers and scrapers.)

4. Which is the main wheel form used in off−hand sharpening?
“A” (Flat wheel.)

5. When do we use cup wheels for sharpening?
“A” (In case we have to create flat surfaces without any hollow grinding.)

6. What are the components of a grinding wheel?
(Abrasive and bonding agent.)

7. What kinds of wheels are used for off−hand sharpening?
(Corundum wheel and silicon carbide wheel.)

8. What kind of wheel is used for sharpening tools made of tool steel?
“A” (Soft to medium−hard corundum wheel with medium grain size.)

9. What is the action of grinding?
“A” (Irregularly shaped abrasive grains will shave fine segmental chips from the workpiece.)

10. What do we understand by 'self−sharpening' of the grinding wheel?
“A” (Dull abrasive grains will get loose by the pressure of the workpiece and they will give way to the sharp abrasive grains which lie behind them.)

11. What is the purpose of whetting?
“A” (The occurring sharpening burr has to be removed from the tool cutting edge in order to increase the tool life.)

12. How do we whet a cutting edge?
(Both sides of the edge are to be angularly rubbed on the whetstone until the burrs are removed.)

13. What is typical of the technique of sharpening punches and scribers?
“A” (Sharpening of the tapered end in a horizontal position, sharpening of the points in a vertical position.)

14. What is typical of the technique of sharpening chisels?
“A” (Vertical sharpening of the cutting edge in a slightly upward position and with simultaneous to−and for−movements.)

15. What is the working movement for sharpening drills?
“A” (The main cutting edge of the drill is brought into a horizontal position and then the drill is pressed upwards and to the right simultaneously.)

16. Which angles are to be maintained when grinding drills with standard drill point?

- angle of point 118°
- complementary angle of the drill edge angle 55°
- clearance angle 4−6°

17. What grinding faults can we detect by eyesight?

- unequally long main cutting edges
- main cutting edges with unequal angles
- hollow−ground main cutting edges

18. What do we understand by 'drill−pointing'?
“A” (This is the lateral resharpening of the drill edge in a vertical position.)

19. Why is it necessary to dress grinding wheels?
(To guarantee true running and surface finish of the grinding wheel.)

4. Application of the working technique of “Grinding of Simple Tools”

The exercises can follow the order given in the “Instruction examples for practical vocational training – Grinding of Simple Tools” for 5 (or, resp. 8) examples.

These “Instruction examples...” contain a list of materials (initial materials, hand tools, measuring and testing tools, accessories) as well as the sequence of operations for working or manufacturing the workpiece.

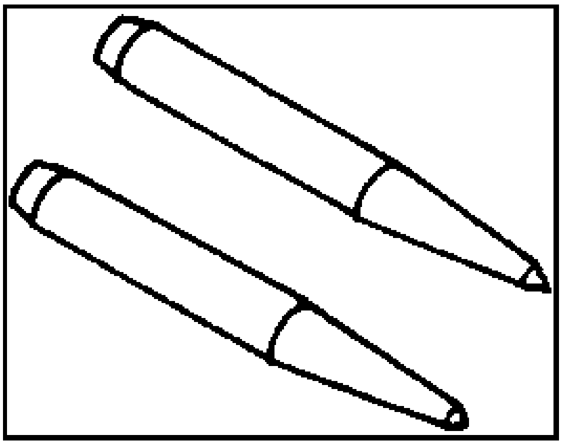
Thus, the trainees avail of all the necessary information to begin their exercise−related work.

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 practised.

Instruction example 12.1.

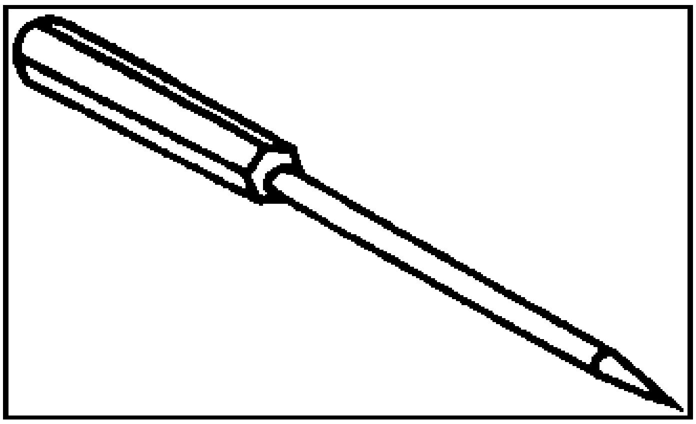
Centre punch and scribing punch



This exercise serve to practise the simple sharpening technique of worn punches as well as the production of these two kinds of punches.

Instruction example 12.2.

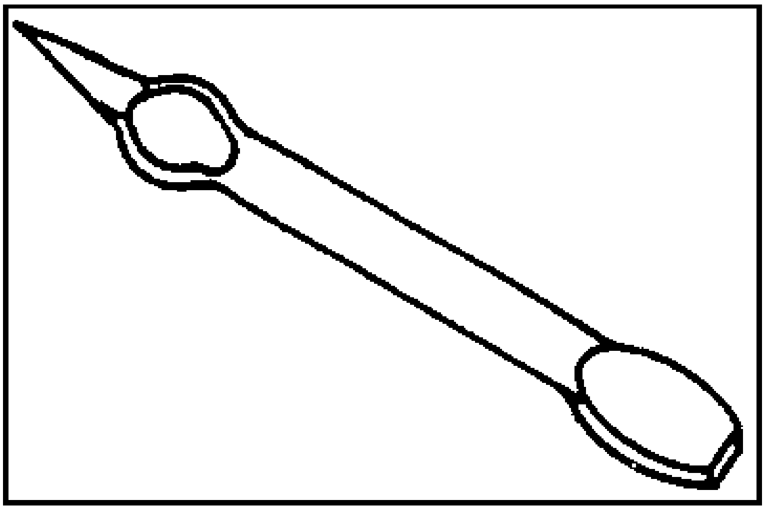
Steel scriber



Similar to the practice involved in sharpening the punches, the trainees practise how to sharpen or to manufacture steel scribers professionally.

Instruction example 12.3.

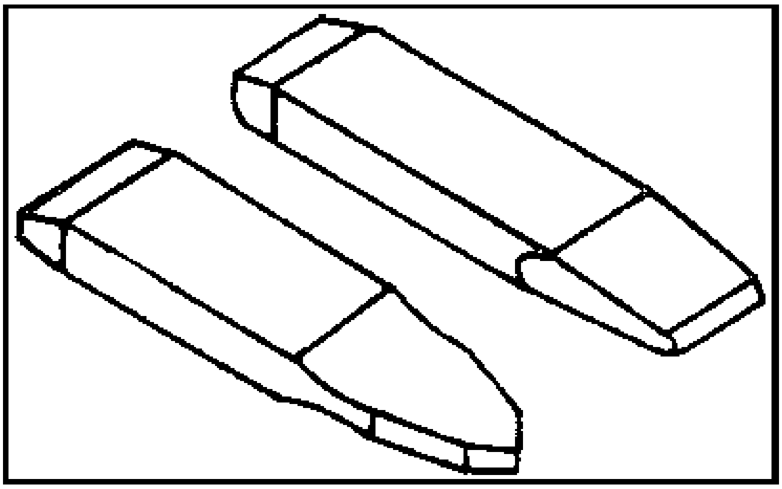
Screw driver



The trainees practise the proper grinding of screw drivers. The instructor underlines the importance of a slightly hollow−ground blade.

Instruction example 12.4.

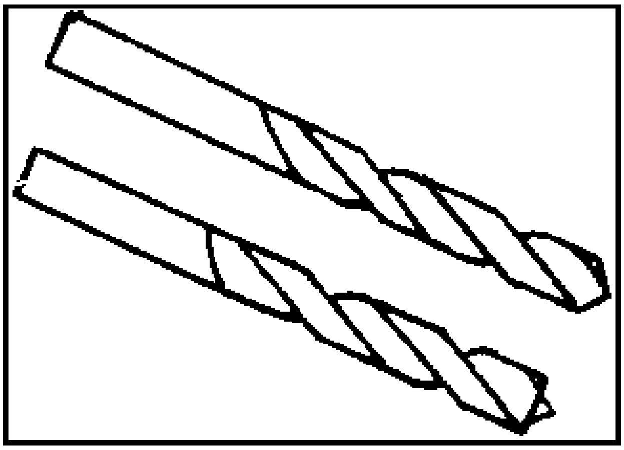
Flat chisel and cape chisel



Based on the special requirements of parallelism and angularity of the cutting edges, the working technique of sharpening chisels is the main subject of this exercise.

Instruction 12.5.

Drills with standard drill point as well as flat drill point and centre point



This exercise serves to practise grinding of the two main types of drill points of drills for steel. The instructor gives special hints for avoiding typical grinding errors.

4.2. Criteria for practical training

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

– Does the trainee employ the appropriate grinding wheel?

– Did he check the distances at the grinding machine?

– Punch and scriber:

  • Does the trainee grind the tapered end with a horizontal position of the hand?

  • Does the trainee grind the tapered end with a vertical position of the hand?

  • Does the trainee cool the tool regularly?

  • Does the trainee stick to the given dimensions?

– Flat chisel, cape chisel and scraper

  • Does the trainee grind the cutting edge through regular to− and for−movements?

  • Does he cool the tool sufficiently?

  • Does he comply with requirements for angularity and parallelism of the cutting edges with the outer edges?

– Drills

  • Does the trainee apply the main cutting edge of the drill in a horizontal position and with a setting angle from the left of about 58 degrees?

  • Does the trainee prese the drill upwards and to the right simultaneously?

  • Did the trainee avoid typical grinding faults?

5. Caption and legends of the "Grinding of Simple Tools" transparencies series

Transparency no. 12.1. Construction of a grinding machine

(1) grinding machine

1 dripping vessel

2 drive motor

3 grinding wheels

4 protective hoods

5 support table

6 switch

(2) clamping mechanism of the grinding wheel

1 wheel

2 lead bushing

3 bored flange

4 cardboard disks

5 hexagonal nuts

6 washers

Transparency no. 12.2. Principles of the grinding process

(1) action of grinding

1 chip

2 cutting thickness

3 bonding agent

4 abrasive grain

5 workplace rake angle

(2) Kinds of movement associated with grinding

1 grinding wheel

2 workpiece

3 support

Transparency no. 12.3. Kinds of grinding wheels

(1) flat wheel

(2) dish wheel

(3) cup wheel, straight

(4) cup wheel, tapered

Shearing

1. Objectives and Subject Matters of Vocational Training in Shearing Techniques

After having terminated the training, the trainees are to surely master the most common techniques of "shearing". For that purpose, the following objectives will have to be attained:

Objectives

– The trainees will have acquired profund knowledge about types and working means for shearing.

– They will know how to master the different techniques used in shearing sheet metals and sections with various tools and machines.

– They will have been enabled to select the appropriate tool as to sheet thickness and way of cut.

– The trainees will know how to apply tools and machinery, while considering the health protection, labour safety and fire precaution measures.

– They will know how to assess the quality of their work.

To achieve the aimes required, the instructor has to impart the following subject matters:

Subject Matters

Knowledge

– Purpose of shearing
– Types and fields of application of tools and machinery
– General construction of shears
– Operating characteristics and techniques of shearing
– Process routines of shearing
– Instructions on labor safety

Abilities

– Knowing how to operate mechanical shears and special machines to shear sheet metals and sections.

2. Organizational Preparations

To ensure a trouble−free course of instructions, exercises and teaching, it is necessary to organize a well−prepared training. For that purpose, the following measures are indispensable.

2.1. Planning the Training in Shearing Techniques

Proceeding from the entire hour volume, the times for the individual training sections of this didactic unit should be planned in a differentiated manner.

It is recommended to make a time schedule for the following training sections:

– for introduction in the techniques in the form of instruction
– for demonstrations required
– for instructions related to task in preparing the exercises
– for executing the exercises
– for recapitulations and controls

In planning the time schedule, the following factors are to be taken into consideration additionally:

– Trainees' present state of education
– Conditions of training
– Trainees' future employment
– Degree of difficulty of the training section

Key point of any training section is always the acquisition of skilled abilities and facilities to be acquired by exercises. The largest period of time should be allocated to them.

2.2. Preparing the Instructions on Labour Safety

Before the exercises start, a brief instruction should be given, comprising the proper handling of working means and recommandations as to avoiding accidents during work. The following key points have to be stressed particularly:

– Use gloves when transporting large sheet plates − risk of getting injured.

– Only use sharp shears being in working order − blade clearance must be correctly set.

– Do not work with your hands between the shear blades − risk of getting injured.

– Hand−lever shears and plate shears to be operated by one person only. As for larger sheet metals and long sections, a second person may help shove the material trough from the side.

– Correctly adjust the toe dog when working with lever shears and shearing machines.

– Do not stay within the swivel range of hand lever during the shearing operation.

– After finishing shearing on the hand−level shear, secure hand lever against dropping.

– Shear steel sections with section knives only.

– Only operate shearing machines after being instructed comprehensively. Observe the manufacturer's operating instructions exactly.

– At once, throw waste material into the waste container after shearing operation.

After being instructed, the trainees have to confirm above recommendations with their signature in the control book.

2.3. Providing the Teaching Aids

– The “Trainees' Handbook of Lessons – Shearing” will be distributed among the trainees according to their number.

– Essential illustrations from the “Trainees' Handbook of Lessons” should be used as visual aids (e.g. as pictures on flip charts, blockboards etc.).

– Workpieces that are sawed, chiseled or sheared should be provided as visual aids.

– Special tools the trainees do not know yet should be used as visual aids as well, as far as they can be transported.

– If transparencies on shearing are available, they should be included in the instruction in any case.

2.4. Providing the Working Means

– The “Instruction Examples for Practical Vocational Training – Shearing” as a theoretical basis for the exercises to be carried out are to be distributed among the trainees as to their number.

– The unmachined materials required for the exercises are to be prepared and made available in a sufficient quantity, using the given material stated in the “Instruction Examples for Practical Vocational Training”.

– Check the workshop's complete outfit with tools, machines, measuring and testing means as well as auxiliaries according to the planned exercises.

– Recommended basic outfit:

- Steel scriber, beam trammels, smooth files and bastard cut files
- Engineer's hammer, aluminium hammer
- Steel rule, caliper gauge
- Tinners' snip, tinners' through snip
- Curve shear, plate shear, hand–lever shear
- Vise, surface plate

– Check serviceability of machines to be employed for shearing operation, considering labour safety regulations before the exercises begin.

3. Recommendations Regarding Execution of Vocational Training in Shearing Techniques

The following sections contain proposals on how to arrange the trainees' instruction, the demonstration of the techniques as well as exercises and controls.

3.1. Introductory Instruction

The introductory instruction should be performed with the trainees in a class−room, if possible. During the instructions, attention has to be paid to the trainees' noting down necessary supplements or replies to questions in the “Trainees' Handbook of Lessons”. With regard to the key points contained in the “Trainees' Handbook of Lessons” the instruction can be given as to the following subject matters.

Purpose of Shearing

At the beginning of instruction it is necessary to explain to the trainees the purpose of shearing compared to other cutting procedures − such as sawing and chiseling. In this connection, the advantages of shearing have to be clearly presented. A brief demonstration may support this fact.

3 trainees are to cut a sheet metal of 2 mm thickness (length and width of about 50 mm) into two halves.

These trainees receive the following tools and auxiliaries:

1st trainee − hand−type hack saw, vise
2nd trainee − flat chisel, engineer's hammer, surface plate
3rd trainee − hand−lever shear

The other trainees have the following observation tasks:

− Time expenditure starting from setting the tool up to the cut sheet metal
− Comparing force consumption
− Assessing accuracy to size on scribed line
− Assessing expenditure for re−work due to the appearance of cutting line.

If this demonstration cannot be conducted in the class−room, it should be effected − in any way − in the workshop before the exercise starts. In this case, the prepared demonstration workpieces should be shown during the instruction.

Tools and Machines

The following common shears are to be introduced in groups. Shears available in the workshop should be used as visual aid in this connection:

− Tinners' snip, tinners' through snip, hole cutting shear
− Curve shear, plate shear, hand−lever shear
− Cutting tools
− Roller shear, electric hand−lever shear
− Hammer shear machine.

The explanations concerning these tools and machines must contain the characteristic features of these working means, the special possibilities of employment and their functional principles. Subsequently, the trainees should be in the position to select the most favourable shear when a certain work−piece to be sheared is mentioned after knowing the thickness of material as well as form and length of cut. The trainees should ask a few questions about this key point − for instance:

“With which shear is it most favourable to cut a circular disk out of a 3 mm thick sheet−metal plate?” Following this question−answer talk the trainees should solve in writing the respective task contained in the “Trainees' Handbook of Lessons”.

General Construction of Shears

With the help of a blackboard drawing as to “Figure 12” of the “Trainees' Handbook of Lessons” the angles and the blade clearance on shears can be descriptively explained now. It is necessary that the trainees know about the general construction of shears in order to be able to assess the serviceability of shears entrusted to them in the workshop and, if required, to perform minor adjustments or repairs of these working means.

Mode of Operation of Shears

The 3 stages of the shearing process should be briefly explained, while using figures 17 to 20 of the "Trainees' Handbook of Lessons" for drawing a panel sketch.

With the help of the joint face appearance, the trainees should be explicated the necessity of minor re−work (de−burring).

It should be stressed that sheared material edges would be very sharp and may thereforce cause injuries.

Shearing Techniques

The techniques − cutting−in, cutting−off, cutting−out and punching − are to be described in a general account in order to elucidate the differences of possible ways of cut.

Selected Technological Sequences of Shearing

Since the shearing process has a very simple work sequence, it is only necessary in this connection to demonstrate the handling of the shear in combination with the material to be cut. It should be particularly referred to the exact scribing, the correct alignment of the workpiece between the shear blades and to the observance of the right way of cut.

The fallowing exemplary sequence will be described in the "Trainees' Handbook of Lessons":

1. Cutting in sheet metal with the tinners' snip
2. Cutting off sheet metal with the hand−lever shear
3. Cutting off angular section with the hand−lever shear

With the help of these examples it is very clearly explained which particularities have to be noted when sheets and sections are scribed and cut.

Hints on Labour Safety

During the shearing operation, incised wounds may occur very quickly, which can only be avoided by exactly observing the hints on labour safety and the regulations on how to operate tools and machines. The essential hints on labour safety are contained in the "Trainees' Handbook of Lessons" − they should be given very urgently.

3.2. Practical Exercises

Basically, the necessary hints on labour safety have to be given prior to the exercises. Subsequently, the trainees receive their workplaces and the equipment available in the workshop will be checked as to its serviceability.

It is recommended to start any exercise with a demonstration by the instructor in connection with an instruction related to the didactic example. Here, the trainees should be motivated to perform the exercises in good quality. Difficulties to be expected should be indicated. At the same time, rating key points are to be made known.

It is necessary that the instructor performs the exercise himself before. Only in this way does he know the difficulties arising during the operation.

The course of exercises may be effected in the sequence of the instruction examples proposed. With the help of the "Instruction Examples for Practical Vocational Training" 5 exercises can be carfied out by using various tools. For that purpose, a list of materials (unmachined material, tools, measuring and testing instruments as well as auxiliaries), the work routine to carry out exercises and a descriptive work drawing are contained in the documentation "Instruction Examples...". Thus, the trainees attain all the information required to implement the exercises purposefully.

To give a survey which practical pieces the knowledge previously imparted is to be applied to, the individual instruction examples will be briefly described hereinafter.

Instruction Examples

Instruction example 13.1. Smother and putty knife

The sheet−metal parts for a smoother and a putty knife are to be cut out with the thinners' snip and the tinners' through snip.

Instruction example 13.2. Roof tiler trowel

Sheet parts for two different roof tiler trowels are to be cut out with the curve shear.

Instruction example 13.3. Smoothing trowel

The sheet part for a smoothing trowel is to be cut out with the mechanical plate shear.

Instruction example 13.4. Brick trowel

The sheet part for a brick trowel is to be cut out with the hand−lever shear.

Instruction example 13.5. Hinge−joint

Respectively an angle, a round and a flat are cut to length with the section blades of the hand−lever shear.

All the trainees may carry out the exercises at the same time, if the material prerequisites have been ensured (availability of sufficient working means).

In this case, the trainees can do each exercise individually and each trainee should have so much time as he would need. If there are not enough working means available, the trainees must be grouped, considering to be favourable to group them as to the use of the different tools.

Should the proposed instruction examples not be used for exercising, it is also possible to choose other practical pieces. Here, it should be noted that all the techniques previously talked about could also be exercised on these practical pieces.

Key Points of Practical Work

To execute the practical work it is recommendable to stipulate key points of observation and rating. They may be distinguished by the following criteria:

- Do the trainees prepare their workplaces carefully?
- Are the mentioned tools placed ready and checked as to their serviceability?
- Are the workpieces scribed exactly?
- Do the trainees achieve the quality features required? Particularly:
    - Is the line of cut exactly on the scribed line?
    - Can transverse cracks and shoulders be seen at the line of cut?
    - Is the workpiece presented for control in a straightened and de−burred state?
    - Are the workpieces accurate to size?
- Do the trainees apply the appropriate test method?
- Are the trainees able to correctly assess the quality of their work themselves?
- Are the trainees observing the labour safety regulations?

3.3. Examples for Recapitulation and Control

Tasks have been compiled in this section to strengthen and revise knowledge and abilities acquired so far. Tasks also contained in the "Trainees' Handbook of Lessons" have been marked with the letter "A".

1. What is the purpose of shearing?
"A" *(Sheet metals and sections are cut in a non−chip, straight−lined or curve−shaped way.)*

2. Which are the advantages of shearing compared to sawing?
"A" *(No metal is removed from the material by cutting, the scribed line can be exactly followed, joint faces require little re−work, shearing process is fast, way of cut may be straight−lined or curve−shaped.)*

3. How are shearing techniques differentiated?
"A" *(cutting in, cutting off, cutting out, punching)*

4. Which cuts can be made with the tinners' snip?
"A" *(Short straight−lined and short curve−shaped cuts on thin sheet metals.)*

5. For which cuts is the tinners' through snip employed?
"A" *(Straight longer cuts on thin sheets.)*

6. For which cuts is the curve shear employed?
"A" *(Circular and curve−shaped cuts on thin and medium−thick sheets.)*

7. For which cuts is the plate shear used?
"A" *(Long cuts on thin sheets.)*

8. For which cuts is the hand−lever shear used?
"A" *(Short straight−lined and curve−shaped cuts on medium−thick sheets and sections.)*

9. Why have the shear knives a great wedge angle?
"A" *(So that they are sufficiently stable and the blade edges do not break out so quickly.)*

10. Why is it necessary to keep a blade clearance?
"A" *(So that the blade edges do not rub on each other and get dull.)*

11. What will happen when too great a blade clearance has been adjusted?
"A" *(The sheet will be bent off during the shearing operation.)*

12. What is the task of the dog on the lever−type shear and shearing machine?
"A" *(Keeping the sheet metal in horizontal position to avoid pitching down.)*

13. Why is an aperture angle of 15° important during the shearing process?
"A" *(To prevent the workpiece from being pushed out of the shear.)*

14. In which stages is the shearing process performed?
"A" *(Notching, cutting and tearing)*

15. What is the difference between the cutting−out and punching techniques?
"A" *(Cutting−out − material being cut out is the workpiece; Punching − material being punched is scrap.)*

16. What is to be expected in the sheet when the shear knives are completely closed?
"A" *(Transverse cracks developed the end of cut.)*

17. Why is the scrap side of a sheet to be situated on the right−hand side?
"A" *(On shearing, the upper shear knife presses the right−hand sheet part downwards, cuts bends or twists it.)*

18. Why must steel sections be cut in section knives?
"A" *(Section knives are adapted to the steel section and make a clean shearing possible. They are more stable than plane shear blades.)*

19. What will happen when steel sections are cut on plane shear blades?
“A” *(Cutting edges break out.)*

20. Why must the hand lever be arrested on the hand−lever shear after the shearing operation?
“A” *(Because is may fall down – risk of getting injured.)*

21. Why must the rendered waste material be thown in the waste container immediately?
“A” *(Because the cutting residues have been bent and are very sharp−edged – risk of getting injured.)*

Bending

1. Aims and Contents of Practical Vocational Training in the Techniques of Bending

After having terminated their training, the trainees shall be able to surely master the most common techniques of bending procedures. For that purpose, the following aims have to be achieved:

Aims

– The trainees will have profound knowledge of kinds and fields of application of the working means to be used for bending.

– They will master the different techniques to be used for bending sheet metals, pipes and sections with various tools, appliances and machines.

– They will be enabled to select the appropriate working means according to the kind of material, material thickness and shape of bending.

– The trainees will be capable of adequately employing the tools, appliances and machines while adhering to the health, labour safety and fire protection regulations.

– The will know how to assess the quality of their work themselves.

To reach the objectives so demanded, the following subject matters have to be imparted by the instructor:

Contents

– Knowledge:

• Purpose of bending
• Kinds and fields of application of tools, appliances and machines
• Phenomena occurring in the material
• Fundamentals of calculation
• Bending techniques
• Hints on labour safety

– Skills:

• Folding, turning over, flanging, seaming, crimping, rounding of, and rolling of sheet metals
• Rounding of sections and pipes
• Rolling of sections

2. Organizational Preparations

To ensure a trouble−free course of instructions, exercises, and vocational practice, it is necessary to prepare the training well, with the following measures to be taken:

2.1. Planning the Training in Bending Techniques

Proceeding from the total hour volume, the times for the individual training sections of this vocational unit should be planned in a differentiated manner.

It is recommended to draw up a time schedule for the subsequent training sections:

− for introducing the techniques in the form of instruction
− for necessary demonstrations
− for instructions to prepare the practical exercises
− for executing the practical exercises
− for recapitulation and controls.

While the hours are being scheduled, the following additional factors are to be taken into consideration:

− the trainees' educational level
− the training conditions
− the trainees' future employment
− the degree of difficulty of the training section.

The focus of each training section is always the acquaintance of practical skills and abilities by exercises, which will take the most comprehensive period of time.

2.2. Preparing the Instructions on Labour Safety

Before the practical exercises begin, the trainees are briefly instructed on the adequate handling of working means and given recommendations for an accident−free work. In general, those regulations are valid which are to be observed for manual techniques in hammering and straightening.

Especially, the following key points should be observed:

− Use only proper hammers − the hammer shaft must be tightly wedged with the hammer head.

− Select the correct striking plate with regard to the form of bending − a hard and inflexible surface is required.

− Workpieces to be campled have to be tightly fixed in the clamping fixture so that they are not torn away by the striking impact.

− Always strike against the fixed vise jaw so that the vise screw will not be damaged.

− Mind your hands and head when working on presses.

− Work with welding torches must not be performed until the instructor has given the necessary instructions.

− Always observe fire protection − place ready water for fire fighting, do not work close to inflammable materials.

− Only bend sheet metals and sections over 8 to 10 mm thickness and pipes of more than 1/2 “ in a heated state.

− Use only dry sand as filler for hot bending of pipes to avoid steam formation.

Knowing about these hints is to be confirmed by the trainees' signing in the control book.

2.3. Providing the Teaching Aids

– The “Trainees' Handbook of Lessons – Bending” is to be distributed among the trainees according to their number.

– Illustrations contained in the “Trainees' Handbook of Lessons” and having a high indicative value should be used as visual aids (e.g. on flip charts, blackboards etc.)

– Workpieces showing well and badly performed bendings may be provided as visual objects.

– Particular tools and appliances not yet known to the trainees should also be used as visual illustrations, the same applies to brochures and photos of bending machines.

– If transparencies on bending are available, they should, in any case, be included in the instruction.

2.4. Providing the Working Means

– The “Instruction Examples for Practical Vocational Training – Bending” as theoretical basis for the practical exercises to be performed should be distributed according to the number of trainees.

– The basic material required for the exercises should be prepared and provided with the help of the specification of materials given in the “Instruction Examples .....” in sufficient quantity.

– The workshop should be checked whether or not it is completely equipped with tools, appliances, machines, measuring and testing means as well as auxiliary means as to the exercises planned.

– Recommended basic outfit:

- Steel rule, steel square, vernier caliper
- Steel scriber, centre punch
- Smooth files, hand hack saw, hand−lever shear
- Machinists' hammer, light metal hammer, special hammers for sheet metal working
- Straightening plate, surface plate, vise
- Various intermediate plates and bending mandrels
- Drills and counterbores
- Hand screw press, bending devices, folding bench, rolling device
- Welding torch, dry sand

– Machines to be employed for bending have to be checked as to their serviceability with regard to labour safety before starting the exercises.

– For necessary drilling and counterboring operations, a table−type or column−type drilling machine with appurtenant clamping fixtures is required.

– Check serviceability of this machine prior to the practical exercises with regard to labour safety.

3. Recommendations for Implementing Vocational Training in Bending Techniques

The following sections contain proposals on how to arrange the trainees' instruction, the demonstration of techniques as well as exercises and controls.

3.1. Introductory Instruction

The introductory instruction should be given, if possible, with the trainees in a classroom. Attention is to be paid during the instruction to the trainees' noting down necessary additions or replies to questions in the "Trainees' Handbook of Lessons". An essential prerequisite for learning the bending techniques is the trainees' mastering the techniques in testing and hammering. This knowledge should be repeated, if necessary.

For your instruction you can use the "Trainees' Handbook of Lessons" with the following focal points:

Purpose of bending

Initially, it would be favourable to explain to the trainees the purpose of bending with the help of visual objects and illustrations. In this connection, it must be made clear that bending is, due to its versatility, used in many fields of manufacture and performed by various techniques. Predominantly, the techniques in folding, turning over, flanging, seaming, rounding and rolling should be discussed.

Selected tools, appliances and machines

Out of the variety of applicable working means it is recommendable to introduce or repeat the following:

- Hammer
- Welding torches
- Angle bending appliances, strip rolling devices, pipe benders
- Screw presses
- Folding bench, rounding device, crimping and flanging machine
- Vise, blacksmith's anvil

These working means may also be dealt with in a question–answer talk with the trainees, as far as the trainees have previous knowledge. Already here, particular characteristic features in their application can be stressed. If tools cannot be shown, the trainees should have a look at the illustrations in the "Trainees' Handbook of Lessons".

Processes in the material

During this instruction section, the tensile and compressive stresses and their effects occurring during the bending process are to be discussed. The terms "stretching and upsetting" as well as "neutral axis" have to be explained.

In this connection, it is recommended to show the stretching and upsetting zone on a spot of rupture of a square section strongerly bent. It is also favourable to make a blackboard drawing as to Fig. 14 of the "Trainees' Handbook of Lessons" to show the neutral axis.

Subsequently, the influences of such material properties like "plasticity", "elasticity", "strength" and "strain hardening" are to be explained.

The trainees should keep in mind the knowledge so acquired in the form of rules and key sentences.

To deepen the knowledge, the trainees have now to answer the questions asked in the "Handbook of Lessons" following the respective section.

In supplement of the influence data depicted just now, the influences of the bending radius, particularly the minimum bending radius, and the influences of beat reaction for the quality of bending can be discussed.

It is recommendable to put side by side a hot bent and a cold bent square section of 16x16. The trainees are to state the differences in quality of bending and derive from it the findings for their own work.

Fundamentals of calculation

Comprehensively dealing with this focus is essential. The trainees are to be explained the necessity of the exact blank of the basic material. As for calculating the blank size, the straight length in dependence of the neutral axis position must be ascertained first.

The formulae required for it are distinctly introduced in the “Trainees' Handbook of Lessons”.

With an example of application it is demonstrated that the blank length can be calculated out of a sum of different partial lengths. Here, the trainees should develop more examples for calculation to be solved by them without assistance, if possible.

Bending techniques

The techniques depending on material thickness and form of bending edge, as mentioned in the beginning, are described in the “Trainees' Handbook of Lessons”, in principal.

Versions for each technique are shown, describing the manual making of bends with hammers or with mechanical devices as well as machines. It is not recommendable to describe the techniques all together during the lessons, what is more, it is favourable first to only explain the bending procedures which can be practised in the workshop with the help of existing working means.

That means that following the description of folding sheets practical exercises should be done, applying immediately in practice the knowledge just imparted.

Subsequently, the following techniques will be dealt with in the same way.

It would be better, in case of slow learners or those having only a small previous knowledge, to impart the know−how in small, closely restricted sections and then support it with respective practical exercises.

Hints on Labour safety

Give the essential hints at the respective place, when bending procedures to be performed are described. These recommendations are contained in the text and as a compilation in the “Trainees' Handbook of Lessons”.

3.2. Practical Exercises

Basically, the necessary hints on labour safety have to be given prior to the practical exercises. Then, the trainees receive their working places and the technical equipment of the workshop is checked as to its serviceability. It is recommended to start any exercise with a demonstration in connection with the teacher's instruction related to the instruction example. Here, the trainees are to be motivated to perform the exercises in good quality. Difficulties to be expected have to be pointed out and evaluation key assessment should be mentioned at the same time.

It is necessary for the instructor to have previously performed the exercise himself. Only in such a way does he know the difficulties that may arise during its execution.

The course of exercise may be in change of instructions on the special techniques and the appurtenant exercises. With the helf of “Instruction Examples for Practical Vocational Training − Bending”, 6 practical exercises can be done by applying different techniques.

For that purpose, the “Instruction Examples.....” contain a material list (base material, tools, appliances, measuring and testing instruments as well as auxiliary means), the sequence of operations to carry out the practical exercises and an illustrative working drawing. The trainees receive all the required information in it to be able to perform the exercises purposefully.

To give a survey, to which practical pieces the knowledge previously imparted is to be applied, the following individual instruction examples are briefly described.

Instruction examples:

Instruction example 14.1.: Mounting angle

Sheet metals of 1 mm and 2 mm thick steel are to be folded in the vise. For that purpose, a sheet with a simple bending edge is to be bent manually.

A second sheet shall receive two bending edges by means of machinist's hammer and intermediate plate.

Instruction example 14.2.: Half−round bracket

A sheet steel strip is to be folded and rounded off in the vise with the help of a bending mandrel so that a serviceable half−round bracket is the result. Before bending, the straight length is to be calculated.

Instruction example 14.3.: Hasp

During this exercise, a sheet steel is to be rolled on a rolling device as well as round sections to be folded and bent to a round object by means of bending mandrels, so that a serviceable hasp will be the result after assembly.

Instruction example 14.4.: Double pipe knee

A steel pipe is to be rounded off twice with a bending device as well as with a machinist's hammer in the vise. In this case, sand filler and local heating are to be applied to. The heating length has to be calculated before.

Instruction example 14.5.: Beaker jacket

A thin sheet steel is to be folded with the folding press, turned over and rounded off. Subsequently, a jacket seam joint is fabricated.

Instruction example 14.6.: Beaker

The previously fabricated beaker jacket is further worked on. After flanging, a bottom piece is connected with the beaker jacket by a bottom seam joint.

All trainees can do the exercises at the same time so far as material and equipment are available in sufficient quantity and number.

In this case, the trainees are able to perform any single exercise individually – each trainee should have as much time as needed.

If there are not enough working means, the trainees must be split into groups. Here it is favourable to divide them into groups according to the application of different tools and appliances.

As versions for the exercises to be done, the bendings can be made with various working means as well.

In such a way, foldings should not only be made on the vise, but also on the folding press and folding bench. Even so should roundings not only be exercised manually, but also on the rounding−off device, if available.

Should the proposed instruction examples not be used for exercises, it would be possible to select other practising pieces. In this case, attention is to be paid to the fact that all the techniques previously discussed can be practised on these pieces as well.

Focal points for practical execution

It is recommended for the to fix certain criteria for the assessment of the exercises. These could be the following:

– Do the trainees prepare their working places carefully?
– Is the straight length of workpiece exactly calculated?
– Is the basic material exactly cut to size?
– Are the appropriate working means selected and properly operated?
– Are the workpieces tightly clamped?
– Do the workpieces receive the required form and accuracy to size?
– Are workpieces damaged by improper work?
– Are the trainees able to assess the quality of their work themselves correctly?

– Do the trainees adhere to the labour safety regulations?

3.3. Questions for Recapitulation

To strengthen and check the knowledge and abilities so acquired, the following tasks have been made out in this section and are also contained in the “Trainees' Handbook of Lessons”:

1) What is the purpose of bending?
(To remodel workpieces that must have angular or rounded shapes for a specified purpose of application.)

2) Which techniques are used for bending of sheet metals?
(Folding, turning over, flanging, seaming, crimping, rounding, rolling.)

3) What does the term “neutral axis” mean?
(Transition zone in the bent workpiece where no tensile and compressive stresses occur.)

4) Which material properties must parts to be bent not have?
(They must not be brittle or spring–tempered.)

5) What does the term “spring–back” (elastic recovery) mean?
(Elastic materials spring back after an action of force by a certain measure.)

6) What will happen when a sheet metal is being bent around a bending edge that is in accordance with the streak flow of rolling direction?
(Cracks may occur on the bending's outer edge.)

7) What does the term “strain hardening” mean?
(When tensile and compressive stresses change for several times, the internal stresses grow and result in hardening at the bending point.)

8) Which influence has the bending radius on developing cracks in the workpiece?
(The larger the bending radius, the smaller the risk of cracks.)

9) Which influence has workpiece thickness on bending radius?
(The thicker the workpiece, the larger the bending radius must be.)

10) Which influence has the material heating on the bending procedure in case of thick workpieces?
(With growing heat, the internal resistance within the material decreases, the bending procedure becomes easier and is without risk of crack formation.)

11) What does the term “stretched length” mean?
(Length of workpiece before being bent; is calculated from the neutral axis length.)

12) How does the position of the neutral axis change when workpieces are bent around a radius that is smaller than five times the workpiece thickness?
(It shifts to the internal side of the bending.)

13) How is the stretched length of a workpiece calculated, if several different bendings have to be effected?
(Each bending is calculated individually as a partial length, then the partial lengths are summerized.)

14) To which side have you to hammer when a sheet metal is to be folded on the vise?
(Towards the side of fixed jaw.)

15) Which side of the workpiece has to be scribed with the steel scriber?
(On the bending's internal side.)

16) From which sheet thickness onwards should workpieces be hot–bent?
(From 8 mm sheet thickness onwards.)

17) What is the significance of hardwood or metal intermediate plates for bending on the vise?
(They serve to compensate distances when workpieces with several bending edges are to be folded. They

also absorb the impact when you strike with a machinist's hammer.)

18) How are sheets with long bending edges clamped in the vise?
(With sheet clamp or angular sections, both being additionally fixed with a ferrule.)

19) What is to be done before sections are folded?
(Prior to bending, the upsetting zone is to be separated.)

20) How are sheet metals to be turned over?
(They are folded by 90° and turned over with presses or hammers to a bending angle of up to 180°.)

21) How is a sheet metal cylinder flanged manually?
(Slightly flange with the hammer pane (striking face of a hammer) on the bordering tool and finish flanging with the hammer face on a plane striking plate.)

22) By which working steps is seaming marked?
(Turning over with shims, hooking−in, pressing together.)

23) What does "crimping" mean?
(Producing curl−like recesses in sheets to stiffen the metal.)

24) How can sheet metals be rounded off in a vise?
(Clamp the sheet with the bending form and turn it over step by step with the hammer.)

25) With which appliances can sections be rounded off?
(With bending devices, bending dies, section bending machines, swage block.)

26) What is to be noted when pipes of over 1/2" in diameter are rounded off?
(Pipe must be filled with sand prior to being bent.)

28) What is to be noted when welded pipes are rounded off?
(Welding seam must be lateral to bending radius in neutral axis.)

29) Which length has to be exactly calculated prior to hot−bending?
(The bend length to be heated.)

30) How is the bend length scribed?
(From the dimension length, the dimension leg is scribed to one side on the unbent pipe and the bending leg to the other side.)

31) How may sheet rims be rolled?
(With hammers on round sections, with devices or presses.)

32) How may springs be wound?
(Mechanically with lathes or manually with winding mandrels and wood clamp in the vise.)

Straightening

1. Aims and Contents of Practical Vocational Training in the Techniques of Straightening

After having completed their vocational training, the trainees shall master the most commonly used techniques of straightening. For this purpose, the following has to be achieved:

Aims

- The trainees have thorough knowledge of the kinds and fields of application of the working means for straightening.

– They master the different techniques that can be used for the straightening of materials in cold and hot condition.

– They are able to decide for the appropriate technique according to the kind of deformation.

– The trainees are able to choose tools, devices and auxiliary equipment according to the respective purpose and to use them skilfully and observing the regulations on health and labour safety as well as fire protection.

– They are able to assess the quality of their work themselves.

In order to achieve these aims, the instructor has to impart the following contents:

Contents

Knowledge

– Purpose of straightening
– Kinds and fields of application of tools, devices and auxiliary equipment
– Processes in the material
– Techniques of straightening
– Hints on health and labour safety

Skills

– Straightening of bendings and bucklings
– Straightening of distortions
– Straightening of dents and corrugations in metal sheets
– Straightening of cold and heated materials

2. Organizational Preparations

To ensure a trouble–free course of instructions, exercises and vocational practice, it is necessary to prepare the training well, with the following measures to be taken:

2.1. Planning the Training in Straightening Techniques

Starting from the total hour volume, the hours spent on the individual training sections of this vocational unit should be planned in a differentiated manner. For the following training sections it is recommendable to prepare a schedule:

– for the introduction to the techniques in the form of an instruction,
– for required demonstration,
– for the task–related instruction in preparation of the exercises,
– for the implementation of the exercises,
– for recapitulation and controls.

In planning the time, the following additional factors are to be taken into consideration:

– the level of education of the trainees,
– the training conditions,
– the future field of working of the trainees,
– the degree of difficulty of the training sections.

The acquisition of skills and abilities is the focal point of each training section; therefore, the exercises must be given the major portion of time.

2.2. Preparing the Instructions on Labour Safety

Before beginning with the exercises, a brief instruction has to be given on the appropriate use of tools and equipment and on accident−free working. In general, the same regulations are valid as for hammering and bending.

The following points must be especially emphasized:

− Use only clean and intact tools and equipment.

− When using hammers, make sure that the head of the hammer is firmly connected with the shaft by the cotter punch.

− Choose the appropriate support − it must have an inflexible surface.

− The workpieces must be firmly clamped so that they are not torn away by the hammer blows.

− When working at presses make sure that your hands and head are protected.

− The use of welding torches is only allowed after previous instructions given by the instructor.

− Pay attention to fire protection: place water ready for fire fighting; do not work near inflammable materials.

Knowledge of these instructions has to be confirmed by the trainees by signature in the control book.

2.3. Providing the Teaching Aids

− The “Trainees' Handbook of Lessons − Straightening” is to be distributed among the trainees according to their number.

− Especially indicative illustrations from the “Trainees' Handbook of Lessons” should be arranged for as blackboard drawings.

− Workpieces which have been deformed by transport or machining may be used as visual aids.

− Special tools not yet know to the trainees, e.g. moving irons, may be used as visual aids, too.

− If in the field of straightening transparencies for overhead projection are available, they should be included in the lessons.

2.4. Providing the Working Means

− As a theoretical basis of the exercises to be carried out the “Instruction Examples for Practical Vocational Training − Straightening” should be distributed among the trainees.

− The basic material required for the exercises should be prepared and provided in sufficient quantity according to the details given in the “Instruction Examples...”.

− The workshop has to be checked as to its complete equipment with tools, devices, measuring and testing instruments as well as auxiliary means according to the exercises planned.

− Recommended basic equipment:

• Locksmith's hammers, straightening hammers, light metal hammers, mallets, rubber hammers
• Moving irons and tap wrenches
• Tongs and clamps
• Welding torches with accessories
• Hand screw presses
• Vice, straightening plate

– Straightening machines that shall be used for mechanical straightening must be checked as to their serviceability with regard to safety before starting the exercises.

3. Recommendations for Implementing Practical Vocational Training in Straightening Techniques

The following sections contain suggestions for teaching, demonstrating the techniques and carrying out and tests.

3.1. Introductory Instruction

The introductory instruction should be given, if possible, in a classroom. Make sure that the trainees note down supplements and answers to questions in the “Trainees' Handbook of Lessons”.

An important precondition for learning the techniques of straightening is the mastery of the techniques of testing and hammering.

This knowledge must be recapitulated, if required.

For your instruction you can use the “Trainees' Handbook of Lessons” with the following focal points:

Purpose of straightening

It is recommendable to start the lessons by explaining the trainees the purpose of straightening with the help of visual aids. In doing so, it must be made clear that due to transport or machining of the materials deformations may occur, which – for the moment – prevent a further quality processing of the respective workpiece. The trainees shall understand that the various kinds of deformations can be eliminated by different techniques of hammering, bending and local heating up.

Tools, devices and auxiliary equipment

The possibility to straighten thin metal sheets, pipes and sections by hand has to be mentioned and, in addition, the most commonly used working means have to be introduced and/or repeated, such as:

– Locksmith's hammers, straightening hammers, light metal hammers, mallets and rubber hammers

– Welding torches, blacksmith's fire, annealing furnace

– Screw presses, straightening machines

– Vice, anvil, straightening plates

These working means may also be dealt with in a question – answer talk with the trainees, provided that the trainees have previous knowledge. Already here, special distinctive features in the use of the working means may be pointed out.

If no tools can be shown, the trainees should look at the corresponding illustrations in the “Trainees' Handbook of Lessons”. After this, it is recommendable to have the trainees answer the questions in the “Trainees' Handbook of Lessons” in writing in order to apply the knowledge acquired in this field.

Processes in the material

It is very important to deal with this point thoroughly to explain the trainees basic processes which take place within the material when it is exposed to external forces.

Make sure that the terms of “axial elongation”, “compression and elastic recovery” are correctly and clearly explained.

It is recommendable to draw the simple illustrations from the “Trainees' Handbook of Lessons” on the blackboard in order to show the sequences of motions by the individual steps.

As a practical proof, a simple demonstration can be given: A square section – if possible from a very soft material – is given a lattice–shaped marking on the side as is to be seen in Figure 11 of the “Trainees' Handbook of Lessons”. Then, the square section is bent. The charged pattern of the lines, which had been parallel before, impressively demonstrates the effects of tensile and compressive stresses.

This must be followed by an explanation of the possibilities of neutralizing these stresses by systematic counterstresses as well as local heating up. Especially it must be emphasized that the internal resistance of a material is reduced by heating it up and that – as a result of this – the workpiece is easier to form. The utilization of this quality should be immediately described on the basis of examples showing the deformation of thick sections and pipes with thick walls.

Techniques of straightening

The various techniques should always be described in connection with the thickness and kind of deformation of metal sheets, pipes and the shape of sections.

In the “Trainees' Handbook of Lessons”, these techniques are described according to the kind of deformation. It is not recommendable to explain all techniques together. Rather should the explanation of the straightening of bendings and buckings be immediately followed by a practical exercise, for which the 1st instruction example can be used. This way, the theoretical knowledge is consolidated by practical exercise without delay. Especially for weak trainees or for those who have only a small previous knowledge, it is better to impart the knowledge in small steps followed by corresponding practical exercises. The following sections – straightening of twistings, dents and corrugations in metal sheets – can be treated in the same manner.

The “Instruction Examples for Practical Vocational Training” offer exercises for each of these focal points. The mentioned instruction mainly describe the straightening by hand.

If straightening machines are available, this instruction is to be supplemented with the help of the operating instructions of the respective machine. The instruction directly at the machine would be the most effective one.

Hints on Labour Safety

Taking into consideration the hints on labour safety of the hammering and bending techniques especially applicable points have to be emphasized and supplemented. These focal points are included in the “Trainees' Handbook of Lessons”.

3.2. Practical Exercises

On principle, the necessary hints on labour safety must be given prior to the practical exercises. Then, the working places are assigned to the trainees and the technical equipment of the workshop is tested as to its serviceability.

It is recommended to start every exercise with a demonstration by the instructor in connection with an instruction related to the respective instruction example. In doing so, the trainees should be motivated to implement the exercise in a good quality. It must be pointed to difficulties that may perhaps occur. The criteria of assessment must also be mentioned.

It is necessary that the instructor himself has done the exercise before.

Only then he will know the difficulties of the exercise.

Instructions on the special techniques and corresponding practical exercises may alternate.

On the basis of the “Instruction Examples for Practical Vocational Training – Straightening” 5 exercises can be carried out using different techniques. For this, the “Instruction Examples” include a list of the required materials (basic material, tools devices, measuring and testing instruments as well as auxiliary equipment), the sequence of operations for carrying out the exercises and an illustrative working drawing.

Thus the trainees get all necessary information for systematically implementing the exercises.

The basic material must be deformed according to the defects indicated in the working drawing, so that the exercises can be done according to the respective sequence of operations. If there are workpieces available showing similar deformations they may be used as well.

The following instruction examples give a survey of those practising pieces which should be manufactured for putting the previously imparted knowledge into practice.

Instruction examples

Instruction example 15.1. Straightening of bendings and Ducklings

This instruction example includes three individual exercises:

A 2 mm thick buckled steel sheet has to be straightened with the help of the flat punch of the hand screw press;

An 8 mm thick buckled flat material has to be straightened by means of the locksmith's hammer in the vice;

A 15 mm thick bent square section has to be heated up with the welding torch and then straightened by means of the locksmith's hammer.

Instruction example 15.2. Twistings

This instruction example includes 2 individual exercises:

A 5 mm thick distored flat material has to be straightened with the help of a moving iron in the vice;

A 10 mm thick distorted square section has to be straightened by means of a moving iron in the vice.

Instruction example 15.3. Bent angle section

This instruction example includes 2 individual exercises:

A unilaterally bent angle section of a width of leg of 20 mm has to be straightened by the hammer peen;

A double–sidedly bent angle section of a leg width of 45 mm has to be heated up locally by means of a welding torch and straightened.

Instruction example 15.4. Bent pipe

A bent steel pipe of a diameter of 1 inch has to be filled with fine–grained sand, to be firmly closed and then straightened in the vice.

Instruction example 15.5. Dented and corrugated metal sheets

Steel sheets of 3 mm in thickness each and with various defects – such as small dents, one big dent, completely corrugated surface – have to be straightened by means of the straightening hammer. The same metal sheets may also be straightened by means of the roller straightening machine.

All trainees can do the exercises at the same time, provided that materials and equipment are available in sufficient quantity and number.

In this case, the trainees can do their exercises individually, i.e. each trainee should get as much time as he needs. If there are not enough working means, groups must be formed. The trainees should be divided into groups according to the use of the different tools and devices.

If you do not like to use the instruction examples offered for the purpose of exercise, you may choose other practising pieces. If this is the case, make sure that all techniques that had previously been explained are practised with these pieces.

Focal points for practical execution

It is recommendable to fix certain criteria for the assessment of the exercises. These could be the following:

– Do the trainees prepare their working places properly?
– Do they select the right tools – as to size and form?
– Are the workpieces clamped firmly enough?
– Do the trainees meet the quality requirements?

Especially:

• Do the workpieces get their correct form?
• Can the workpieces be used for further treatment after straightening?

– Do the trainees use the correct testing method?
– Are the trainees able to assess their own work properly?
– Do the trainees observe the regulations on labour safety?

3.3. Questions for Recapitulation

In this section, tasks are compiled to improve and check the acquired knowledge. These tasks are also included in the “Trainees' Handbook of Lessons”:

1. What is the purpose of straightening?
(Materials which had been twisted, bent or deformed during transport or machining are given back their original form.)

2. What are the techniques which are manily used for straightening?
(Hammering, bending, local heating up)

3. What hammers can be used for straightening steel sheets?
(Locksmith's hammers, straightening hammers)

4. What hammers can be used for straightening aluminium sheets?
(Light metal hammers, mallets, rubber hammers)

5. For what sort of straightening work are moving irons used?
(For the elimination of twistings in flat sections.)

6. For what sort of straightening work can the hand screw press be used?
(For straightening bent sections and dented metal sheets.)

7. What tensions occur at the bending radii of deformed materials?
(At the external radii it comes to tensile stresses – axial elongations; at the internal radii it comes to compressive stresses – linear compressions.)

8. What happens, if a too little force affects the material?
(The material springs back elastically into its initial position – the extension was elastic.)

9. How are tensile and compressive stresses eliminated at bent workpieces?
(The effects of the systematic application of force or local heating followed by cooling put the workpiece back to its normal form.)

10. What is the advantage of straightening thick sections and pipes with thick walls in red−hot condition?
(The resistance of the material is reduced with increasing heating up this requiring less force for straightening.)

11. How can slightly bent thin sections be straightened?
(Manually in the vice or by means of the press.)

12. How can little bucklings at sections and strips of metal sheets be straightened?
(By clamping the buckled spot in the vice and fastening the jaws or by hammering on a rigid and plane support.)

13. What must be borne in mind when straightening bent pipers?
(Before being straightened, the pipe must be filled with fine−grained sand and firmly closed on either side.)

14. How are large dents eliminated in metal sheets?
(By hammer blows starting from the rim of the bulge and drawing outwards or by local heating up with the welding torch.)

15. Why are better not too many hammer blows applied when straightening with hammers?
(Because by hammer blows the material becomes harder and more brittle, which may lead to the formation of fissures or to fracture.)

Annealing, Hardening, Tempering

1. Objectives and Contents of the Vocational Training in the Working Techniques "Annealing, Hardening, Tempering"

The trainees shall have full command of the most common working techniques of the heat treatment of simple tools, testing devices and machine parts made of unalloyed steel, after having concluded the training.

− The trainees have knowledge of the purpose, the types and spheres of application of the various heat treatment processes.

− They have command of the structure and the operation of the devices and auxiliary means and are able to use them appropriately by observing labour safety and fire protection regulations.

− They have knowledge of the preconditions for heat treatment with regard to material engineering and material shaping.

− They master the various technological routines of the heat treatment processes of annealing, hardening and tempering of tools, testing devices and small machine parts.

− They are able to carry out quality controls independently.

2. Organizational Preparations

In order to ensure an undisturbed run of the instructions, exercises and instruction works it is necessary to prepare the training very well. The following measures have, among others, to be taken:

2.1. Preparation of Labour Safety Instructions

Prior to the beginning of the exercises, a short−term instruction with regard to the suitable dealing with working means specifying hints on works not involving accidents have to be given. The following features have to be imparted:

- – Wear working garments, aprons and handgloves!
- – Protect your eyes by means of protective glasses!
- – Do not remove safety devices installed at devices!
- – Do not touch cyanide salts and nitrites for melting baths with bare hands!
- – Cover melting baths after use.
- – Only use predried, cleaned workpieces for heat treatment.
- – Take care for fire protection.
- – Remove oil slicks on the floor immediately.
- – Place hot workpieces only at places marked for that.
- – Plut in order the tools, devices and auxiliary means after having finished work and keep them clean.
- – Do careful hygiene after having finished work.

The knowledge of those hints is to be confirmed by the trainees' signatures in the control book.

2.2. Preparation of Means of Instruction

– The “Trainees' Handbook of Lessons – Annealing, Hardening, Tempering” is to be distributed among the trainees according to their number.

– Charts may be made prior to the instructions as blackboard figures.

– Coloured tables, figures, originals and models of devices and auxiliary means as well as break samples of heat–treated workpieces may be produced as illustrative material and prepared for the instructions (see section 4).

2.3. Preparation of Working Means

– The “Instruction Examples for the Practical Vocational Training – Annealing, Hardening, Tempering” is to be distributed among the trainees according to their number and intended as theoretical basis for the exercises to be carried out.

– Starting materials required for the exercises are to be prepared in an appropriate number by means of the material data given in the “Instruction Examples...”.

– The workshop is to be checked for a complete equipment with tools, devices and auxiliary means according to the exercises intended.

– Recommended basic outfit:

- smith's hearth with coal shovel, swatter and fire rake, stock of charcoal;
- muffle furnace with temperature gauge;
- inserts with sand and charcoal powder filling;
- melting bath for salt filling;
- hot bath for oil filling;
- quenching tanks for water and oil;
- hooks, spears, tongs, worn–out files, hammers;
- handling devices for small and medium–sized workpieces: sieves and baskets;
- cleaning agents: scouring cloths, sawdust, brooms;
- additives: clay, paper
- quenching media: water – fire–resistant, heatproof lubricating oil;
- melting agents: cyanide salts and nitrites.

The functionability of the devices is to be checked with regard to labour safety and fire protection regulations prior to the beginning of the exercises.

2.4. Planning of Training Phases

Starting from the total hours the periods for the individual training phases of this training unit are to be planned independently from each other.

For the following training phases it is advisable to take a phasing:

– for the introduction into the working techniques in the form of instructions;
– for necessary demonstrations;
– for task–related instructions for the preparation of exercises;
– for the execution of the exercises;
– for recapitulations and control works.

The following factors are to be considered when planning the periods:

– the state of training of the trainees;
– the conditions of training;
– the future employment of the trainees;
– the degree of difficulty of the training phases.

Focal point of each training phase is always the acquisition of mechanical abilities and skills by means of exercises, that feature must be given most of the time.

3. Recommendations for the Execution of the Vocational Training in the Working Techniques "Annealing, Hardening, Tempering"

The following sections include recommendations on how to organize the instructions for the trainees, the demonstrations of the working techniques as well as the exercises and control works.

3.1. The Introductory Instruction

If possible, the introductory instruction is to be carried out in a class room with the trainees. During the instruction it has to be taken into consideration that the trainees shall write necessary supplements or answers to questions in the "Trainees' Handbook of Lessons – Annealing, Hardening, Tempering". The instruction can be carried out with regard to the contents given in the "Trainees' Handbook of Lessons":

Purpose of heat treatment of steel

In the beginning, the trainees are to be made familiar with the term of "heat treatment" as a sequence of various processes of heating and cooling down. They shall realize that tools, measuring and testing devices as well as various machine parts must have special properties which are only reached by a heat treatment which, however, is to be carried out appropriately.

In this connection, a *demonstration* may be carried out:

A few chisel blows are to be made onto a steel plate of about 4 mm thickness by means of an unhardened flat chisel. Subsequently, this process is to be repeated by means of a hardened flat chisel.

All the trainees shall examine the steel plate and the two flat chisels and draw the necessary conclusions. Subsequently, a broken chisel may be used as an example of an unsuitable heat treatment.

The consideration of the heat treatment of alloy steels is necessary. The term of "alloy steel" is to be explained or recapitulated, the special properties of those steels have to be mentioned.

It must be said that a correct heat treatment can only be carried out if the conditions given by the steel manufacturer are strictly adhered to, therefore, he shall supply tables specifying the appropriate temperature data. If possible, such a table should be shown.

All sections to be dealt with in the following are therefore only to be referred to unalloyed steels!

Types of heat treatment processes

The trainees may be made familiar with the most common heat treatment processes by means of the chart given in the “Trainees' Handbook of Lessons”.

Those processes may be explained more in detail by means of the subsequent sections in the “Trainees' Handbook of Lessons”.

In addition, the special processes of “surface hardening” and “hardening and tempering” should be mentioned, but it is to be indicated that also other variants and processes are used in industry apart from the processes mentioned.

Devices and auxiliary means for heating, transportation and cooling down of workpieces

The devices and auxiliary means suitable for the production of individual parts or small series are to be mentioned and explained by means of appropriate figures, originals and models:

- smith's hearth with coal shovel, swatter and fire rake, stock of charcoal;
- gas burner to temper and flame hardening;
- Furnaces with and without temperature gauges, equipped with one or more compartments;
- melting baths for metal or salt melts as well as hot oil baths;
- sheet−metal inserts for casehardening with sand and carbon−containing powder filling;
- hooks, spears, tongs;
- handling devices such as self−tightening claws and hangers on lifting devices;
- sieves and baskets;
- quenching tanks for water and oil filling.

The effect of the different quenching media is to be explained by means of the chart in the “Trainees' Handbook of Lessons”.

A short exercise of conversions is to be made for temperature data if the unit of “degree centigrade” is not used. The conversion into “Kelvin” and “Fahrenheit” is possible according to the following table:

<u>Centigrade</u>		<u>Kelvin</u>		<u>Fahrenheit</u>
0 °C	=	273 K	=	32 F
100 °C	=	373 K	=	212 F

Since the Fahrenheit units do not run in the same rate as “Centigrade” and “Kelvin”, conversion must be effected by means of a self−made numerical line onto which these units are entered.

Principles and types of annealing, hardening and tempering

In the sections included in the “Trainees' Handbook of Lessons” the essential facts related to the mentioned heat treatment processes have been stated.

The individual principles of the procedures as well as the specific features of application are to be discussed step by step. The questions following the sections should immediately be answered in writing by the trainees and entered in the appropriate free places of the “Trainees' Handbook of Lessons”.

Those answers must be checked during the discussion by a comparison! Wrong answers must not be overlooked!

Annealing:

After definition of the term, the possibility is to be made evident to the trainees on how temperatures may be assessed at workpieces without temperature gauges. As to plain carbon steels, the standard colour values may be imparted by means of the table in the “Trainees' Handbook of Lessons”.

Those standard values are only to be applied if no exact temperature gauge is existing at the device to heat the workpiece!

Subsequently, the following processes are to be discussed individually:

– stress−free annealing
– soft annealing
– normalizing.

The importance of a correctly effected annealing process is to be demonstrated to the trainees. They must realize that workpieces become useless or require refinishing when the annealing is not effected correctly and expertly. It must be explained that the adherence to the holding time is vital to reach the desired change in structure.

Therefore, calculations are to be made by means of the rule:

Holding time = 20 minutes plus half of workpiece thickness

The section “Control of the annealing result” should be made clear by suitable illustrative materials of various break samples.

The trainees are to be made qualified to exactly assess the appearance of the break. Subsequently, the trainees shall answer the complex of questions in the “Trainees' Handbook of Lessons”.

Hint:

Now, the introductory instruction may already be finished and simple exercises for “annealing” could be carried out. But it is advisable to continue the instruction with regard to “hardening” and “tempering” in order to carry out a complete sequence of exercises by means of the “Instruction Examples for the Practical Vocational Training”.

Hardening:

It is recommended to continue the instruction with regard to “hardening” according to the following sequence:

– definition;
– preconditions for hardening by means of heat treatment as to material engineering;
– principle of hardening by means of heat treatment;
– types of hardening by means of heat treatment;
– hardness−related shaping of the workpieces;
– hardening defects;
– specific working hints for practical execution of work;
– hardness measurement.

After an exact definition it is necessary to mention the material−related preconditions for hardening by means of heat treatment – the trainees must learn that not all unalloyed steels are hardenable, and that is why they must know the carbon content of the workpiece to be hardened!

Subsequently, the three essential hardening processes are to be explained:

– quenching
– interrupted hardening
– hot quenching.

As to the latter process, calculations are to be carried out regarding the holding time in the hot bath. The rule is:

Holding time = Diameter or thickness in mm . seconds/10 mm

The section “hardness−related shaping of workpieces” may be demonstrated by means of illustrative materials showing positive and negative features of shaping. The appropriate figures in the “Trainees' Handbook of Lessons” shall be used for problem discussions.

In the same connection, the discussion on “hardening defects” may be effected, it should not be done without illustrative materials.

As to the work in the workshop, specific practical hints are of special importance. Thus, it is advisable to check the procedures resulting from theory only for their practical use and to explain them more in detail.

In this connection, the packing of workpieces should especially be dealt with which protects the work−pieces from scaling or carbon loss. Furthermore, possibilities to cover the workpieces having great cross−section differences are to be mentioned.

Point out: It is also important to ensure a preheating of all parts when hardening several parts in order to save time and quicker reach the hardening temperature.

The complex “Hardening” is to be finished with the section of “Hardness measurement”.

If there are hardness measuring devices available, now deal with their application; at the same time the formation of the hardness number according to Rockwell (HRC 50) is to be explained. Supplementary, demonstrate the simple hardness test by the file test.

Tempering:

Since this process directly follows the hardening process, it must be discussed subsequently. In this connection, the relation between tempering temperature and certain examples of application is of special importance; a chart in the “Trainees' Handbook of Lessons” shows this fact concerning plain carbon steels.

The connection between tempering temperature and hardness may also be illustrated by means of the following table with regard to a tempering test:

Tempering temperature	Rockwell hardness
200°C	63.5
240°C	62
260°C	60.5
280°C	58
300°C	56.5
320°C	54.8
340°C	54

A steel was gradually tempered according to the table, and the hardness was controlled each time as to the Rockwell process. It was determined that the Rockwell hardness decreases with increasing temperature, but steel's toughness increases.

The tempering test indicated that the tempering temperatures must be held in very narrow limits. Subsequently, explain the processes of tempering from outside and the tempering from inside.

Hint:

Now, the instruction may be finished and the appropriate exercises will be carried out. The following items as to “surface hardening” and “hardening and tempering” may be imparted in a supplementary instruction given at a later date.

Application of surface hardening and hardening and tempering

The possibilities to harden only the surfaces of workpieces as is possible by means of “flame hardening” and “casehardening” should be mentioned as specific processes of heat treatment. When explaining those processes, the material–related preconditions (carbon content) must be especially pointed out.

Casehardening is to be demonstrated by means of the term of “carburization”, an existing insert with appropriate charge material should be shown as original.

At the end of the instruction, impart “hardening and tempering” as possibility to increase strength and toughness simultaneously in general.

3.2. The Exercises

On principle, the necessary instructions as to labour safety must be given prior to the beginning of the exercises. Then, show the workshop and the existing equipment to the trainees and demonstrate its operation. It is advisable to begin each exercise by a demonstration given by the instructor in connection with an instruction related to the instruction example. Therefore, motivate the trainees to carry out the exercise with good quality. Refer to difficulties which may occur.

The exercise may be effected either thematically completed or in several phases according to the hints given in section 3.

6 exercises can be accomplished for various processes of heat treatment by means of the “Instruction Examples for the Practical Vocational Training”.

The material “Instruction Examples ...” includes a list of materials (starting material, tools and devices and auxiliary means) and the sequence of operations to execute the exercises as well as a clearly represented workshop diagram.

Hence, the trainees get all the necessary information for being able to systematically execute the exercises.

If it becomes apparent during the exercises that the quality of the exercise pieces is not sufficient, more extensive exercises must be carried out; in that case, any waste parts should be used. When the skills have been practised enough, the intended instruction example may be produced.

The instructor must already have produced the exercise piece by himself and he must know the problems occuring in its production!

The focal points of rating to estimate the performance may thus be mentioned definitely – problematic points at the exercise piece can be referred to. During the task–related instruction, the “sequence of operations” and the workshop diagrams of the instruction examples should lie on the tables so that the trainees can write comments in their notebooks.

In order to give a general view at which exercise pieces the knowledge previously imparted should be applied, the individual instruction examples have been described in the following in short:

Instruction examples:

Instruction examples 16.1.: assembly tools

A small spiral spring (wire diameter appr. 1.0 mm) is to be made bendable by soft annealing in a smith's hearth. Bend hooks at the ends by means of tongs and, subsequently, harden and temper the spiral spring again.

Instruction examples 16.2.: marking and riveting tools

Prefabricated scriber, centrepunch, rivet header and rivet drawer are to be treated from outside by quenching and subsequent tempering. Use the muffle furnace.

Instruction example 16.3.: flat chisel and cape chisel

Prefabricated flat chisels and cape chisels are to be treated by quenching and subsequent tempering from inside. The muffle furnace is used.

Instruction example 16.4.: assembly tools

Prefabricated hexagon socket wrenches, box wrenches and screw drivers are to be treated by interrupted hardening and subsequent tempering from outside. Any furnace and separated quenching media are used.

Instruction example 16.5.: locksmith's hammer

Prefabricated locksmith's hammers are to be treated by hot–quenching and subsequent tempering from outside. Any furnace and a salt melting bath are used.

Instruction example 16.6.: testing means

Prefabricated steel straightedges, back squares and centre squares are to be treated by casehardening and subsequent tempering. A controllable furnace with appropriate insert is used.

All trainees can execute the exercises at the same time, if the material preconditions have been guaranteed (enough working means).

In that case, the trainees can execute each individual exercise independently – each trainee should get so much time he needs.

If there are not enough working means available, the trainees must be divided into groups. In this connection, it is advisable to divide these groups according to the use of the various devices:

1st group	– work on smith's hearth
2nd group	– work on muffle furnace
3rd group	– work on any furnace and on melting bath.

If the instruction examples offered will not be used for exercises, it is possible to select other exercise pieces. In this case, it should be taken into consideration that all the working techniques discussed previously may also be practised on those exercise pieces.

Focal points for practical execution

For the execution of the works it is recommended to determine focal points for examination and estimation. Those focal points may be characterized by the following features:

- Do the trainees carefully prepare their working places?
- Are the prefabricated exercise pieces clean and dry?
- Are the devices for heating operated appropriately?
- Are the correct temperature ranges identified?
- Are the technological sequences adhered to?
- Do the trainees adhere to the regulations on labour safety?

3.3. Examples for Recapitulation and Control

For strengthening and checking the knowledge acquired, tasks have been assembled in this section, the tasks are given together with the appropriate answers. Tasks also included in the “Trainees' Handbook of Lessons” have been marked with the letter “A”.

1. What is heat treatment?
“A” *(a systematic sequence of heating and cooling)*

2. What is the purpose of heat treatment processes?
“A” *(change of properties of unalloyed and alloy steels)*

3. According to which criteria are the heat treatment processes selected?
(according to the purpose of application and the kind of material of the object to be treated)

4. Which are the most common processes of heat treatment?
(annealing, hardening, tempering)

5. Which requirements have to be made on devices for heating the workpieces?
“A” *(temperature must be reached quickly, kept constant and must be adjustable without difficulty; steady* heating *of workpieces has to be ensured)*

6. Which devices are used for heating?
(smith's hearth, gas burner, furnaces, melting baths)

7. What is the advantage do of melting baths compared to the smith's hearth?
(temperature is exactly adjustable, no danger of overheating, no scaling of workpiece surfaces)

8. Which requirements have to be made on quenching tanks?
“A” *(quenching media must always be kept cool)*

9. Which main effects can have quenching media?
(coarse and mild effect)

10. Which effect has the use of a coarse quenching medium onto the workpiece?
“A” *(great strength and hardness, especially at the case, little elasticity)*

11. Which requirements have to be made on the workpieces being prepared for the annealing process?
“A” *(they must be clean, rust−free and free of scale)*

12. What principle is the basis for annealing?
“A” *(heating of the workpiece and holding of annealing temperature over a certain period, subsequently, slow cooling down)*

13. What is the purpose of stress−free annealing?
“A” *(elimination of stresses existing in the prefabricated workpiece)*

14. What is the purpose of soft annealing?
“A” *(makes farther working processes for hardened or carbon steels possible)*

15. What is the purpose of normalizing?
“A” *(equalization of irregularities in the steel structure, achieving a fine−grained structure)*

16. Which rule has to be heeded for holding massive workpieces at annealing temperature?
(20 minutes plus half of material thickness)

17. Which holding time has to be considered when a shaft of 84 mm diameter must be annealed?
“A” *(62 minutes)*

18. Acc. to which criteria are annealing defects evaluated?
“A” *(according to the appearance of the broken workpiece)*

19. Which annealing faults may be deducted from a coarse−grained structure?
“A” *(steel was heated too long or at a too high temperature)*

20. What is the purpose of hardening by means of heat treatment?
“A” *(to make steels hard and wear−resistant for certain purposes)*

21. Which minimum carbon content must have a steel for being hardened?
“A” *(0.35% of carbon)*

22. Which effect has a higher carbon content on the mechanical properties?
“A” *(great hardness and strength, little toughness and elasticity)*

23. Which working steps are required for hardening?
“A” *(heating to hardening temperature, holding and sudden cooling down of the workpiece)*

24. What hardening temperature has to be chosen for an unalloyed steel of 0.8% carbon content?
(780 °C)

25. What is the characteristic feature of interrupted hardening?
“A” *(quenching is effected for a short time, in most cases first in a powerful and then in a mild quenching medium)*

26. A workpiece having irregular shapes shall be hardened by hot−quenching. Its average thickness is 100 mm. Which time has to be met in the melting bath during the cooling−down process?
(600 seconds or 10 minutes, respectively)

27. What has to be considered when dipping the workpieces into melting baths?
(correct dipping according to shape, only dip dry workpieces)

28. Why it is advisable to harden workpieces in a carbon−containing packing?
“A” *(workpiece cannot be scaled and absorbs carbon, thus avoiding carbon loss at high heat effect)*

29. What is a simple way to test hardness?
“A” *(by a file test; if the file is slipping, the workpiece is harder than the file)*

30. What is the purpose of tempering?
“A” *(to give the workpiece a useful hardness after hardening)*

31. What effect has the tempering temperature on useful hardness?
“A” *(the higher the tempering temperature, the smaller the hardness)*

32. Why can temper colours facilitate temperature determination?
“A” *(a thin oxide layer inking according to temperature is produced when heating a blank steel)*

33. Which properties can reach workpieces after surface hardening?
“A” *(the workpieces withstand great impact and bending stresses by hard surfaces and a tough core)*

34. Which steels can be treated by flame hardening?
“A” *(unalloyed steels of 0.35% to 0.6% carbon content)*

35. Which steels can be treated by casehardening?
“A” *(tough steels of a carbon content below 0.25%)*

36. Which properties shall be reached by hardening and tempering?
“A” *(at relatively high strength values, a great toughness shall be guaranteed continuously)*

4. Explanations to the Means of Instruction

Apart from models and originals of devices and auxiliary means, break samples of heat−treated workpieces are recommended as additional illustrative material. The following samples should be manufactured:

- steel of little carbon content
- steel of high carbon content
- steel having been heated too long or at a too high temperature
- steel having been heated extremely high so that it is already burned
- hardened and broken flat chisel.

Furthermore, examples for good and bad manufacture should be produced by means of the figures included in the “Trainees' Handbook of Lessons”. Those examples will show envisaged affects after hardening (cracks).

Existing defects should be made visible by a paint coat on a workpiece having cracks.

For demonstrating the annealing colours, a table of colours including the appropriate colours is recommended which can be made as blackboards charts.

Series of Transparencies – Basic Skills in Metal Working

Table of Contents

Series of Transparencies – Basic Skills in Metal Working

10.1

INSTITUT FÜR BERUFLICHE ENTWICKLUNG

METAL

PROFacto

This series of transparencies was elaborated by a team of authors under the auspices of the Zentralstelle für Bildungswesen des Schwermaschinen– und Anlagenbaues:

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1. Notes on the series "Basic skills in metal working"

When training people for occupations in the metal–working industry, the acquisition of work experience, abilities and skills in manual and simple mechanical metal–working is of fundamental importance.

The work techniques

– scribing
– measuring and testing
– sawing
– shearing
– drilling and countersinking
– threading
– filing
– bending and straightening

are taught in complex assignments.

The series “Basic skills in metal−working” is suitable both for imparting knowledge and for developing the ability of trainees within the framework of polytechnical training and for consolidation and revision purposes further vocational training.

When designing the transparencies, great importance was attached to the use of coloured and perspective representations of the technical and technological relations and facts.

Despite the necessary simplification, scientifically based information is given.

For reasons of economy, the transparencies have been designed in A 4 format and are kept in a folder together with technical and methodical notes.

The transparency cases are ideal for keeping personal notes and additional self−made covering sheets which are used with the transparencies.

For proper placing of the transparencies on the overhead projectors in upright size or broadside format, a simple frame has been enclosed with the series. The three−point arrangement of the frame (narrow side to the left) allows proper fixing of the covering sheets in the supporting system.

The covering sheets can easily be adjusted to size and allow the teachers to provide additional information or to vary their presentation of information. The original transparencies are not damaged by this. To help make the plastic covering sheets true to size, markings have been provided on the edge of the sheets (short vertical or horizontal strokes).

In the technical notes, no information about health protection, industrial safety or fire prevention has been given. For information of this type, see the relevant regulations and specialized literature.

2. List of projection films on “Basic skills in metal−working”

m no.	Film title
1	Tidiness at the workplace
2	Sawing by hand
3	Selection of saw blades
4	Power hacksaw
5	Sawing work
6	Shearing
7	Clearance of cutting edges in shearing
8	Shearing and punching
9	Holding and guidance of the scriber
10	Scribing

11 Punching

12 Twist drills

13 Drillings

14 Bench−type drilling machine

15 Countersinking

16 Internal threading

17 External threading

18 Calculation of length subject to bending

19 Bending in vice I

20 Bending in vice II

21 Straightening of workpieces

22 Measuring with a vernier caliper

23 Testing of components

24 Testing with form gauges

25 Design and use of files

26 Types of file

27 Filing I

28 Filing II

3. Notes on the transparencies

Film no. 1

Tidiness at the workplace

An essential task of polytechnical training is educating the trainee to achieve order and discipline. The first transparencie of this series allows the teacher to inform the trainees from the first lesson on how to arrange their workplace most suitably thus contributing to tidiness at the workplace.

The arrangement and selection of tools and testing instruments depends to a large extent on the work to be done.

For this reason, the arrangement of the tools and testing instruments on the work table should be considered only as an example. The arrangement of tools in drawers depends on the number and type of the tools.

It is essential that the attention of the trainees be drawn to the importance of properly placing and preparing tools and testing instruments for high−quality work.

Film no. 2

Sawing by hand

The transparency shows the initial sawing of a flat steel with a hand hacksaw and, in a magnified section two saw teeth cutting into the steel.

In this way basic knowledge from the manual training, such as the design of the hand hacksaw, can be revised and consolidated. Using this transparency, the following crucial points can be dealt with:

– Clamping of a workpiece (maximum dimension is in the direction of cutting, rigid clamping)

– Clamping of the saw blade (the teeth point in the direction of cutting – red arrow –)

– Initial sawing under a small lead angle

– Geometry of the cutting edge.

It is advisable to mark the individual angles at the saw tooth with different colours and to explain these using a self–made covering sheet.

Film no. 3

<u>Selection of saw blades</u>

The selection of saw blades is mainly governed by the tasks to be fulfilled.

The transparency is intended to help the trainee to recognize the saw blades by their pitch (spacing between crests) and to select them according to the material to be worked and in accordance with its properties.

In three magnified sections, a coarse, a medium and a fine pitch can be distinguished. The teacher should take this opportunity of explaining how the selection of saw blades should be made according to the material to be worked:

Section 1: fine saw pitch for

– thin–walled workpieces such as pipes, sections, etc.

– hard materials such as alloyed steels and cold formed materials such as wires, sheets and plates, etc.

Section 2: coarse saw pitch for

– soft materials where a large number of cuts can be expected, such as aluminium

– plastic materials such as thermoplastic material, etc.

Section 3: medium saw pitch for general workshop use.

Film no. 4

<u>Power hacksaw</u>

In this transparency, the power hacksaw is shown as a diagrammatic sketch. In a magnified section the operating principle of the sawing process is illustrated. The following can be acquired by the trainee:

– Design and operating principle of a power hacksaw (crank drive)
– Clamping of the workpiece
– Drawing mode of operation
– Load of the saw frame and
– Altering the cutting pressure by shifting the weight on the saw frame.

Film no. 5

<u>Sawing work</u>

Two examples of special sawing work are given. In example 1 the trainees are informed about the sawing of deep cuts with the saw blade turned by 90°, Example 2 shows the sawing of pipes in prismatic clamping jaws.

The hand hacksaw is not shown. It should be pointed out that when sawing pipes the pipe must be turned several times in order to avoid tooth breakage and uneven cutting. In both examples, the function of the clamping jaws which are used must be dealt with.

Film no. 6

Shearing

Sheets and plates as well as flat and sectional bars can be cut by shearing, while scribing can be adhered to precisely. This requires knowledge of the shearing process. The relevant transparency shows the operating principle of shearing in a simplified way.

The two shear blades with the conical cutting edges and the holding down clamp with the workpiece can be seen.

The acting forces are marked by red arrows. A distinction must be made between the absorption of force by the holding down clamp and the continuously acting cutting forces of the shear blades.

The workpiece is shown in the phase of bending and initial separation (slide planes form in the material).

In a magnified section of the area of cut, the trainees can see: plate is pushed forward and is difficult to guide.

Note that the plate thickness in Figure 1 is magnified. In general, hand plate shears are only used for cutting thin sheets (e.g. steel sheet up to about 1 mm thick, aluminium sheet up to about 2 mm thick).

Figure 2 shows the punch (dark blue), the die plate (green) and the sheet strip (workpiece/lighter blue). In the die plate only the path of the punched material is indicated. The outline of the opening in the die plate has been omitted. The opening in the die plate (lower die) can be illustrated in a self−made covering sheet.

The following form of representation is recommended (cf. transparency no. 7)

s = blade clearance
? = clearance angle

Film no. 9

Holding and guidance of the scriber

Transferring the shape and size of the workpiece according to workshop drawings to the starting material requires great care. The scribed lines must be clearly visible and must also remain visible during working. For this reason, scribing is often carried out with a scriber. Using transparency no. 9, holding and guidance of the scriber can be explained to the trainees. The accuracy of the size of the workpiece is determined mainly by the quality of scribing.

Instruction in careful, scrupulous work and care of the scribing tools is the essence of this transparency.

Film no. 10

Scribing

Before scribing bores, one or two reference edges are required. The reference edges of the workpiece (underlined in red) can be derived from the simplified technical drawing (dimensioning from 2 reference edges).

The fitting of the try square to the prepared reference edges is shown. The teacher should demonstrate how the dimensions must be plotted from the right−hand reference edge using the steel measuring tape.

Scribing is done using the scribing point. This scratches the surface of the workpiece. A considerable notch effect is caused by the sharp base of the scribed line, causing concentrations of stress which have several times the value of normal stresses. Therefore this danger must be indicated during lessons. With soft materials or materials where the surface must not be damaged (because of the corrosion hazard), scribing points of brass or lead pencils should be used.

The transparency does not show whether or not the surface of the workpiece has been prepared for scribing. Whitening with whiting, coppering with copper sulphate or varnishing with scribing varnishes make the scribed lines easier to distinguish. Using a concrete example from the works production, it should be shown that the shape to be scribed and the quantity play an essential part in the selection of the scribing process.

Film no. 11

Punching

Punching is the technique immediately subsequent to scribing. The punch provides a scribed line with controlling punch marks in order to control the scribed lines, which become less visible as work proceeds. Half of the control punch marks must be left on the work edge. Furthermore, centres of bores are fixed by punching. In practice, a distinction is made between marking–out punches (point angle 30 – 40°) and centre punches (point angle 60°) (see transparency).

Punching requires a lot of skill.

The punch must be inclined so that the position of the centre can be observed.

When the centre corresponds with the scribed centre, the punch must be held vertically; the side of the hand must rest on the workpiece. The punch must then be driven into the workpiece by a short vertical blow with a locksmith's hammer up to a weight of 250 g.

Film no. 12

Twist drills

The punched bore (see transparency no. 11) is drilled by means of a drilling tool and a drilling machine.

As a rule, standardized twist drills are used in practice. Twist drills above 10 mm in diameter are generally made with a taper shank (machine taper) and below 10 mm diameter with a cylindrical shank.

The transparency can be used both for showing the parts of the drill, the tool geometry and the parts of the drill point, and for revision, exercise purpose and checking progress. The following can be seen on the two drills (top to bottom):

Left drill: diameter > 10 mm

> tang, taper shank of tool, mark recess (neck), body with principal cutting edge, flute and secondary cutting edges (margins)

Right drill: diameter < 10 mm

> cylindrical shank, body with principal and secondary cutting edges and flute.

Figure 1 shows the angles at the cutting edge of the drill. The angle of lip clearance ?, lip angle ? and cutting rake ? must be explained. The relation of the cutting rake to the flute helix angle in connection with the material to be worked must be mentioned.

In Figure 2 the designations at the drill point, such as the principal cutting edge, helical flute, chisel edge angle of point, flank, web thickness (secondary cutting edge, margin not drawn) and the flank of the secondary cutting edge can be discussed.

In Figure 3 the point angle, which is formed by the two principal cutting edges, is marked. This largely depends on the material to be worked. For aluminium it is 130 – 140°, and for steel approx. 118°.

The point angle affects the service life of the drill's cutting edges. The two principal cutting edges must be of equal length in order to avoid drilling faults.

Explain to the trainees that labour productivity is increased by continuously improved drill points using commercial spiral drills. (e.g. centring grind drill).

Film no. 13

Drillings

Using this transparency, the purpose, use and special features of drilling can be dealt with and effective operating processes such as drilling with drill jigs can be explained.

Figure 1 shows that it is advisable to pre-drill large holes.

The pre-drilled hole serves as a guide and also relieves pressure from the chisel edge of the larger drill. Moreover, it helps prevent the drill from going off-centre.

The illustrated hole is a through hole.

Figure 2 shows a through hole.

Figure 3 shows a blind hole. The trainees should be instructed that, when determining the depth of the hole, one should not start at the drill hole point but at the cylindrical part of the hole.

Figures 4 and 5 show that a base is required for making a through hole so that the drill table is not damaged.

Film no. 14

Bench-type drilling machine

The transparency shows the design and operating principle of a commercial bench-type drilling machine in section. The trainees should by familiarized with the design and operating principle of the machine step by step. The coloured representation of the most important assemblies is of great assistance and allows trainees to draw conclusions regarding the modular unit principle of machine tools.

It is advisable to trace the direction of force lines from the driving motor via the belt drive to the drill spindle and the tool.

The trainees should make use of their prior knowledge. The most important assemblies shown are:

- electric motor as drive
- cone pulley drive
(other types are equipped with gear drives)
- drilling spindle with feeding mechanism and chuck
- drill table for holding workpieces
- column to support the assemblies.

Film no. 15

Countersinking

With this transparency the trainees are given a survey of the most important countersinks and can classify countersinking into the systematics of manufacturing processes. Countersinking is a technique in which pre-drilled or cored holes are bored and their faces worked.

This is illustrated by four examples.

Figure 1 Counterbore and counterboring tool with pilot

The counterbore is used for countersinking cylindrical recesses (bolt head reception). The fixed or exchangeable pilot pin guides the counterboring tool with pilot.

Figure 2 Tapered countersink (countersinking cutter)

Tapered countersinks are used for taper countersinking and for deburring. The angles of taper correspond to the standardized countersunk angles of bolts and rivets and are of 60° or 120°. The spacing of the cutting edges is non−uniform in order to avoid the cutting edges from digging in.

Figure 3 Counterbore with spiral flutes

Counterbores with spiral flutes are used for boring cored holes. It is clear from the picture that counter−bores with spiral flutes are provided with several principal cutting edges, in most cases 3, more seldom; this allows smooth running.

Figure 4 Centre drill

The centre drill is a combination of a single−edged drill and a centre reamer or form countersink and is used for centring workpieces as a preparation for turning. The cutting edge angles of the countersinks have been indicated and should be supplemented by the standardized numerical values.

The trainees should be made aware that in countersinking too there is a rotating primary motion and a straight−line feeding motion.

Film no. 16

Internal threading

This transparency shows the preparation of a bore with internal thread in four steps.

Step 1 Preparation of a core hole

The core hole is prepared with the spiral drill using a table drilling machine. The diameters of the core hole bores are standardized. If the core hole is excessively large, the thread is not sufficiently cut (Refer to the use of chart books or standards, the selection of the correct diameter of spiral drill and checking by means of a vernier caliper).

Step 2 Spot−facing of the bore

The core hole bore should be spot−faced up to the nominal thread diameter by a 60° conical countersink.

Step 3 Entering tapping of the internal thread

The entering tap must be applied at right angles to the workpiece surface on all sides and turned into the core hole bore with low feeding power.

The marked start of cut should be observed when determining the depth of the core hole in a blind hole bore.

Step 4 Plug tapping of the internal threading

The plug tap is initially turned in by one hand. Once insertion into the entering tappings of the thread is secured, the tap wrench can be put on and the thread can be plug tapped.

In magnified sections the quantity of chips is shown which is obtained in internal threading.

The trainees should be instructed that the chips are to be loosened and broken by alternately turning forward and backward. The trainees must recognize by means of practical examples how important standardization is for the national economy.

Film no. 17

External threading

A simple cutting die is shown on the transparency. This cuts an external thread on a bolt.

The design of the cutting die should be explained:

- Cutting die holder (shown in green) with outlined threaded pins (holding screw, 2 thrust bolts and 2 spreading screws).

- Cutting die with 4 cutting edges: spot-faced at 60° on both sides. The start of the cut has a length of 1.25 to 1.5 times the pitch. Cutting dies are made of tool steel (shown in bluish-grey).

As compared with internal threading, external threading has the following special features:

- Before using the cutting tool, the bolt head must be chamfered and, if necessary, filed so that it is crowned (top left).

- The thread is cut by the cutting die in one operation without interruption (cooling, lubrication, chip breaking and chip removal are necessary)

- After starting the cut, no more pressure should be exerted.

Film no. 18

Calculation of length subject to bending

Bending is the plastic change in the shape of a solid body and is used in a number of ways in the metal-working industry. When forming a material, its volume remains constant. During bending, the material layers are stretched and upset. Since only the so-called neutral fibre retains its original length, it is used for calculating the length subject to bending.

A bent workpiece is shown on the transparency in a very simplified way. The neutral fibre has been drawn in black. As a rule, it passes through the centre of gravity of the material cross-section (with symmetrical cross-sections it passes through the centre).

In order to illustrate stretching and upsetting to the trainees, a covering sheet can be placed within the range of length, 1_3 to illustrate this in a grid structure.

In the case of a very small bending radius ($r<5$ s) the bending radius is shifted towards the pressure side.

The formula for calculating the length subject to bending shown on the transparency only applies if the bending radius is r 5.

Using this transparency, a simple length subject to bending can be calculated.

This transparency is suitable for checking progress, etc.

For this purpose, the formula should be covered over.

Note that an example with a bending radius < 5 s has had to be chosen because of the design of the transparency.

Film no. 19

<u>Bending in vice I</u>

Sheets, strip and flat steels of small dimensions are angled or bent in a vice.

The transparency shows the angling of workpieces in the vice with two examples:

Figure 1 Sheets of low strength and parts with a free bending leg are bent with a wooden hammer. The blows should be applied near the bending edge. Shims with formed edges (not shown) give the desired form to the bending point. Shims of wood or other soft material prevent damage to the workpiece surface. Plastic yielding results in internal stresses which favour the formation of cracks.

Figure 2 When bending short free legs a block of hard wood or another softer material should be used together with a locksmith's hammer.

Direct blows with a locksmith's hammer would result in buckling of the workpiece edges and workhardening of the material.

Film no. 20

<u>Bending in vice II</u>

This transparency shows the rounding off of a workpiece in the vice in two figures.

Figure 1 Preliminary bending of a flat steel or sheet

The figure shows the phase of preliminary bending over a mandrel (round steel or pipe). Ensure that the workpiece is firmly clamped.

Figure 2 Finish bending

The finish bending of the pre−bent workpiece also proceeds in a vice.

Observe its resilience.

When bending soft materials use shims to prevent surface damage caused by the vice−jaws (shown in brown).

Film no. 21

<u>Straightening of workpieces</u>

Workpieces must be straightened in the case of

- distortion of the components after heat treatment in the production process
- distortion caused by transport or storage.

Its purpose is to restore the original shape, and it is essentially based on a displacement of material. Straightening requires great technical skill and theoretical knowledge about the structural constitution and stress distribution. Using Figures 1−3 essential basic knowledge can be gained using three examples.

Figure 1 Deformations in the centre of the sheet are eliminated by stretching by applying light, uniform circular, hammer blows, striking more densely towards the edge. For small sheet thicknesses and sensitive materials a wooden or rubber hammer should be used.

Figure 2 Edge stresses are eliminated in a simular way.

Figure 3 The buckled angle steel is aligned by stretching of the upset side.

Note: This method (one−sided stretching) can also be used to round off an angle steel.

Finally, bending and straightening should be compared with other production methods from the point of view of material economy.

Film no. 22

Measuring with a vernier caliper

The design and handling of the vernier caliper can be demonstrated efficiently with functionable models and the vernier caliper itself. This transparency is suitable for revision purposes and for learning the three basic possibilities of measuring with vernier calipers.

1 Measuring of external dimensions between the fixed and the movable leg

2 Measuring of internal dimensions by cross jaws − the measuring blades for internal measurement are aligned with the measuring faces for external measurement.

3 The depths of blind holes and grooves are measured by the depth micrometer (not shown in green).

In the magnified section, a part of the sliding member with the vernier and the beam millimeter divisions can be seen. The last scale division has not been drawn accurately; it must coincide with the scale division for 34 mm on the beam.

Film no. 23

Testing of components

The verbal statements in German must be translated for the trainees:

Testing	Measuring
Dimensional testing:	Gauging:
Non−dimensional testing:	Comparing with specimens:

The transparency shows the testing of components using selected examples.

In the lessons, the teacher should supplement the symbolic representation using actual examples from practice.

In the Section "Measuring" reference should be made to comparing the physical quantity to be measured such as length, temperature, work, etc. (measuring quantity) of the workpiece, components or machine with a known quantity of the same type such as unit lengths, scale divisions, etc.

The purpose of measuring is the numerical determination of a measuring value (measuring value = numerical value × unit of measurement).

The Section "Gauging" should illustrate that a component must be checked for observance of the actual dimension within a tolerance range (limit gauges) or that the form of a component approaches a specified form (form gauges).

Non−dimensional testing deals mainly with the comparison of specimens, such as comparing the sound of grinding wheels after slight bouncing (clear sound indicates proper condition), etc.

Film no. 24

Testing with form gauges

This transparency shows how to check the planeness of one or several faces and the angularity of a component.

Figure 1

Checking the angularity of a component with a thin steel try square.

The thin steel try square is shown here checking an angle of 90° on a component.

If there is angularity no gap is present when the thin steel try square is set on the surfaces to be checked (red).

(Mention the bevelled edge steel square).

Figure 2

Checking the planeness of the two bearing surfaces (red) of the component.

The hairline gauge has wedge−shaped ground measuring faces. The measuring edge is slightly rounded off. It is a high−quality testing tool and must be handled and used with care.

Typical testing patterns are found in testing. The handling of the hairline gauge when checking planeness must be explained (light gap method).

Film no. 25

Design and use of files

The transparency shows a double−cut flat file on a workpiece which is clamped in a vice.

The basic design of a file and its usage can be explained by means of this transparency:

− The shank of the file with the two cuts and the tang with the handle can be seen; conclusions can be drawn about the cross−section

− The magnified section shows the contour of the file teeth and the chip space during one stroke of the file. Owing to the angular ratios given the file can be assumed to be one used for steel working. Using a self−made covering sheet the geometry of the cutting edge can be shown, if required. But it is in any case clear that scraping is required−,(negative rake angle).

The contact of the file on the workpiece shown and the distinguishable grooves in the workpiece should prompt discussion on the correct filing direction with reference to the workpiece edge and the quality required (see transparency no. 27) Explain to the trainees that manual filing for repairs and assembly work is at present often more economical than the use of the corresponding machines.

Film no. 26

Types of files

The correct selection of files is important for high−quality filing.

Three characteristic types of file are shown:

1 Single−cut files	for soft metallic materials milled teeth
2 Double−cut files	for hard metallic materials cut teeth
3 Rasps (rasp cut)	for soft materials such as wood, etc.

The file teeth are clearly recognizable in magnified sections.

Film no. 27

Filing I

The teacher can explain the mode of operation when filing using four figures:

Figure 1 Rough filing is done if more than 0.5 mm material is to be removed

Figure 2 Cross stroke filing is required when a high degree of planeness is required.

Figure 3 Smoothing is done with longitudinal strokes

Figure 4 Filing of 2 work faces in one plane

Film no. 28

Filing II

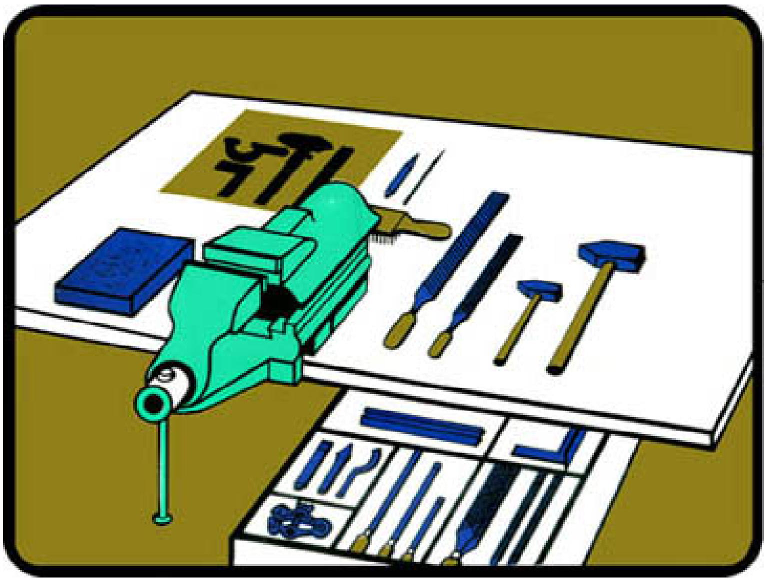
Rough filing is compared with smoothing.

Figure 1 As a rule, only the motion of the arm should be used for filing.

When rough filing, the right hand has a guiding and feeding function while the left hand exerts pressure.

Figure 2 When smoothing and when using moderate sizes of file the left hand must assume the guiding function while the right hand is responsible for feeding.

List of films



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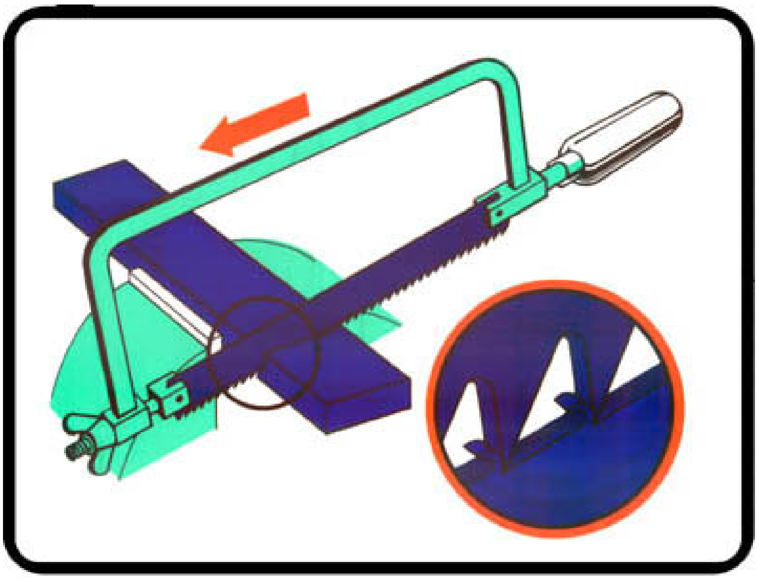

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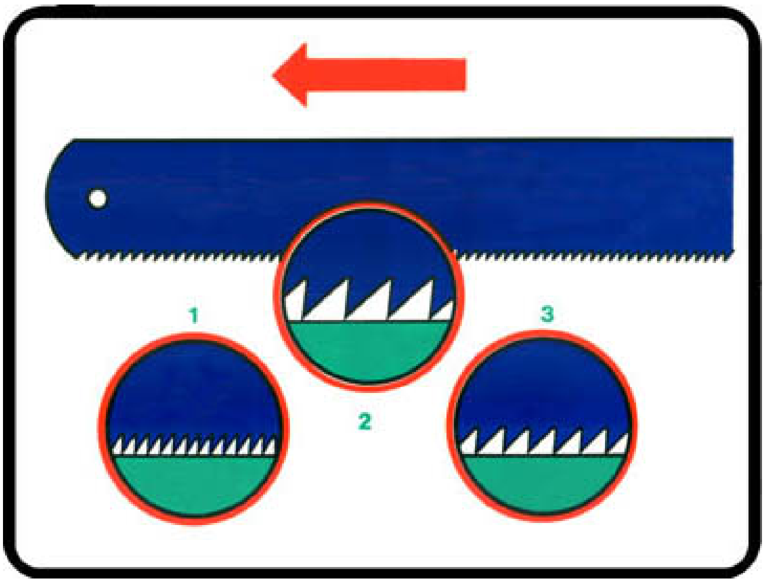

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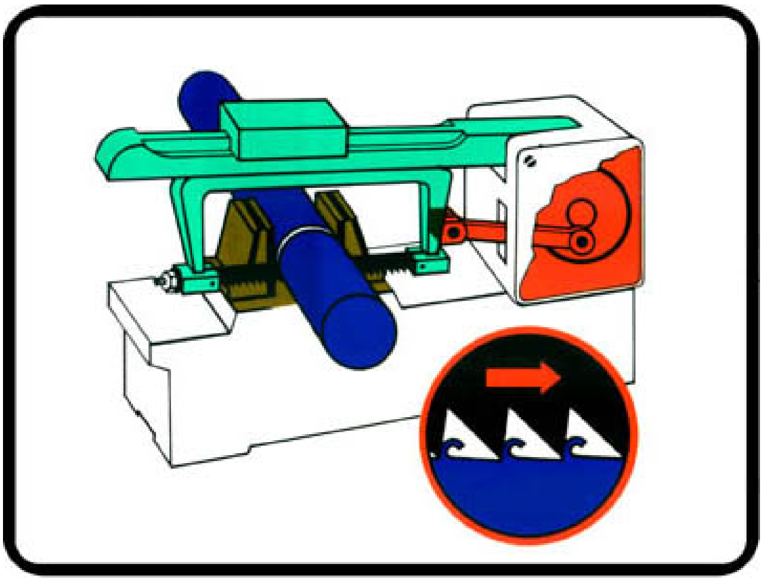

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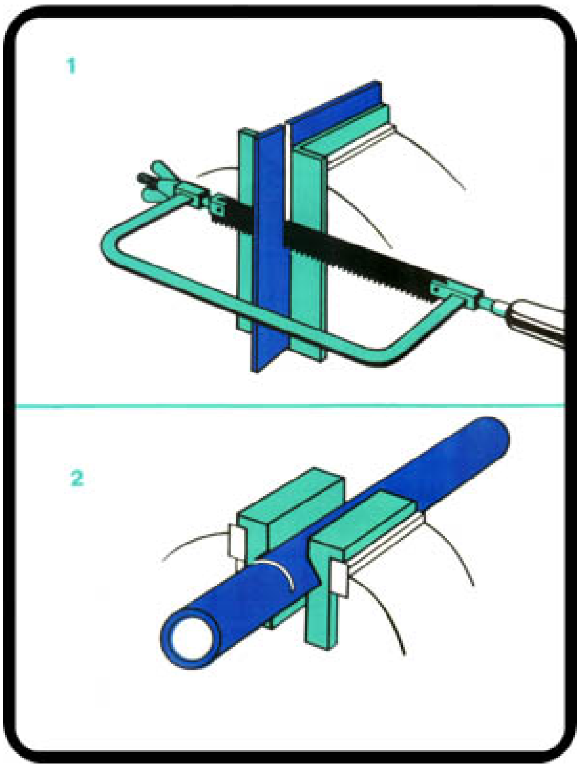

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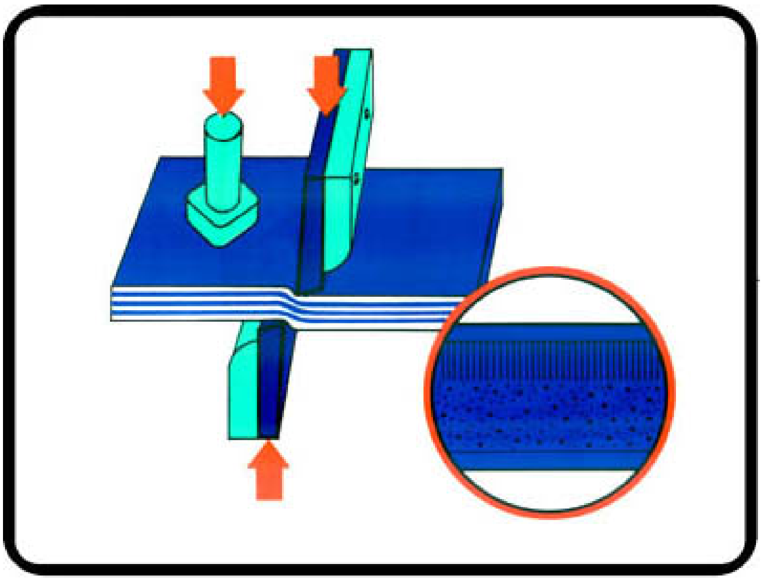

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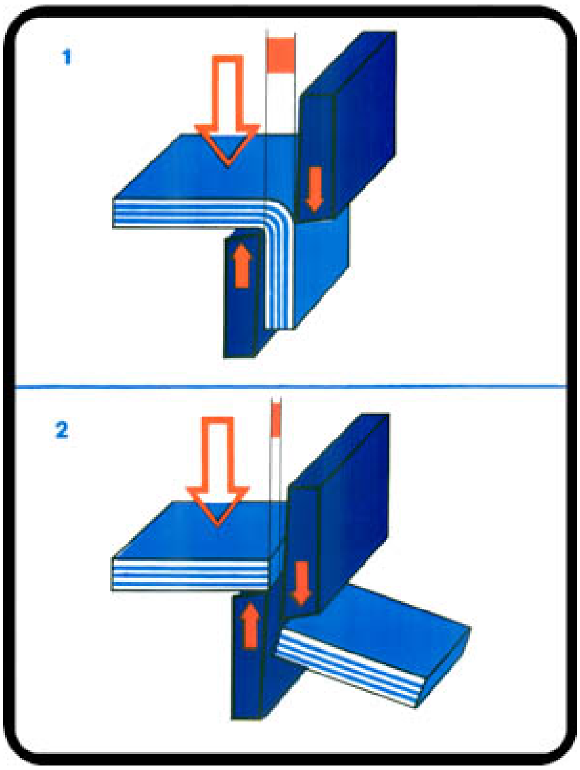

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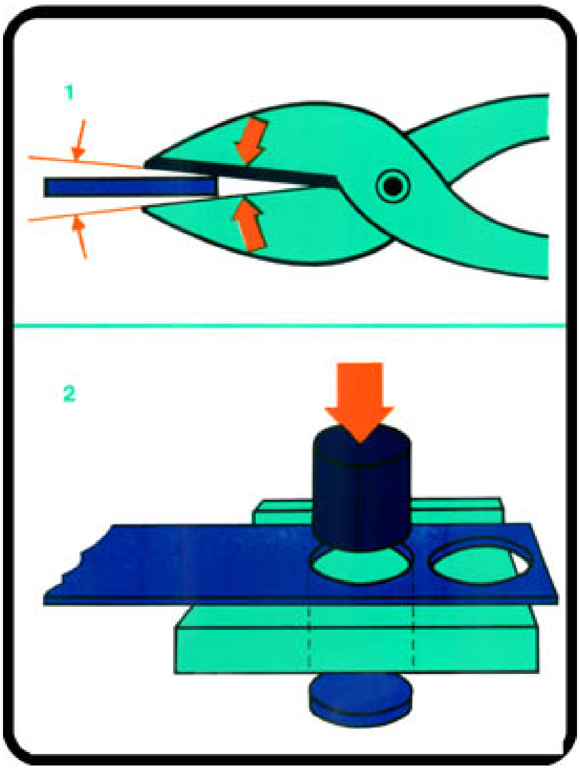

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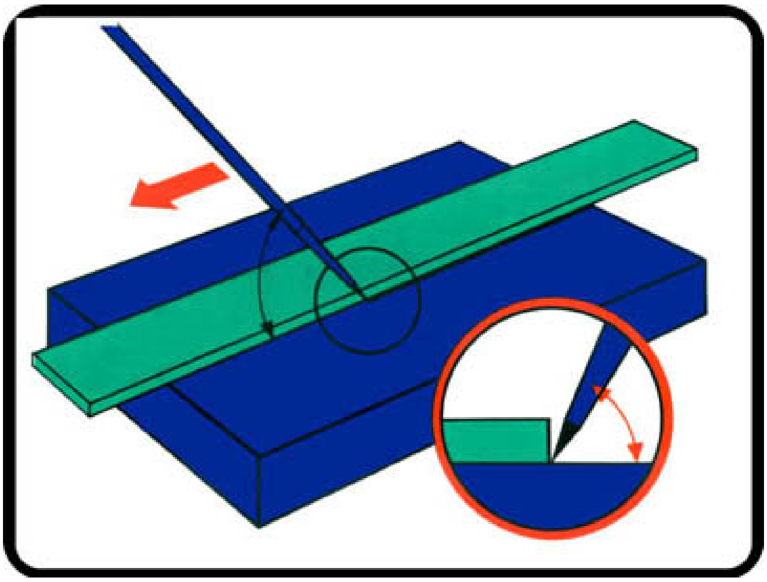

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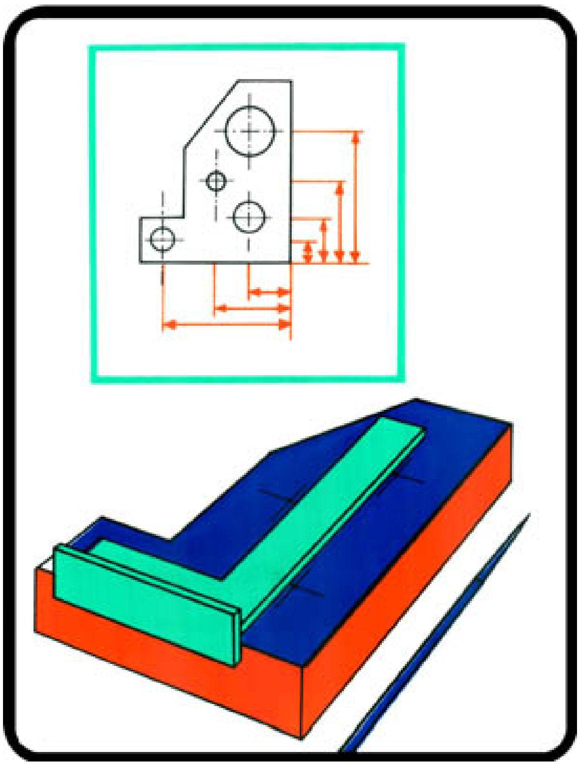

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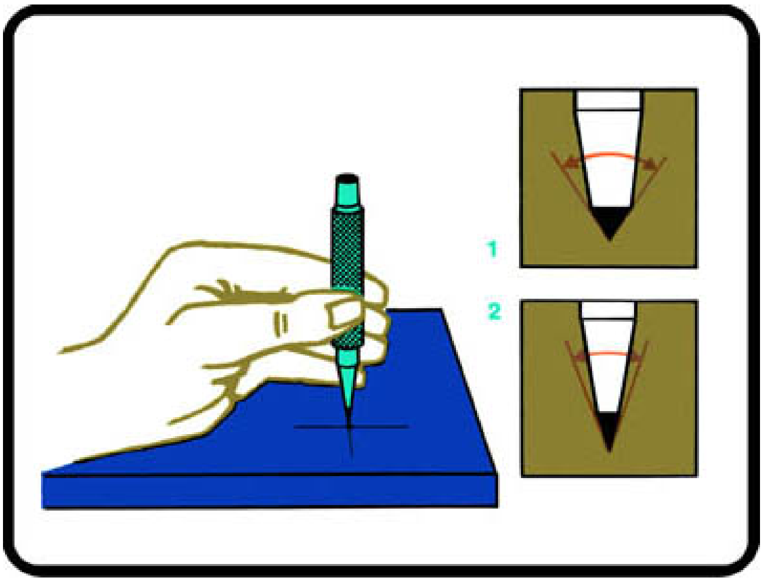

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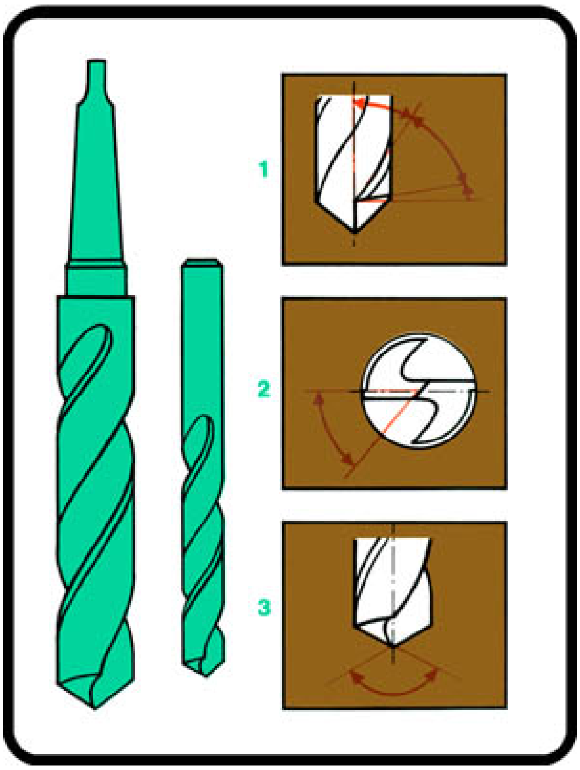

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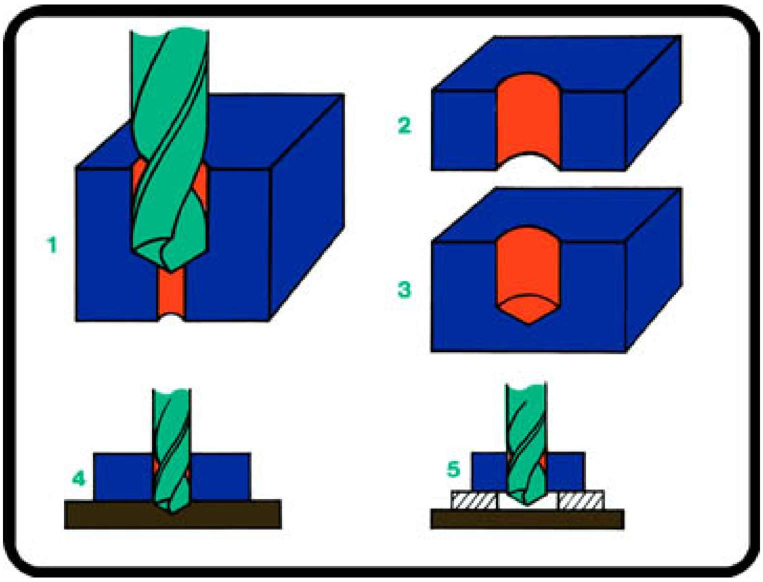

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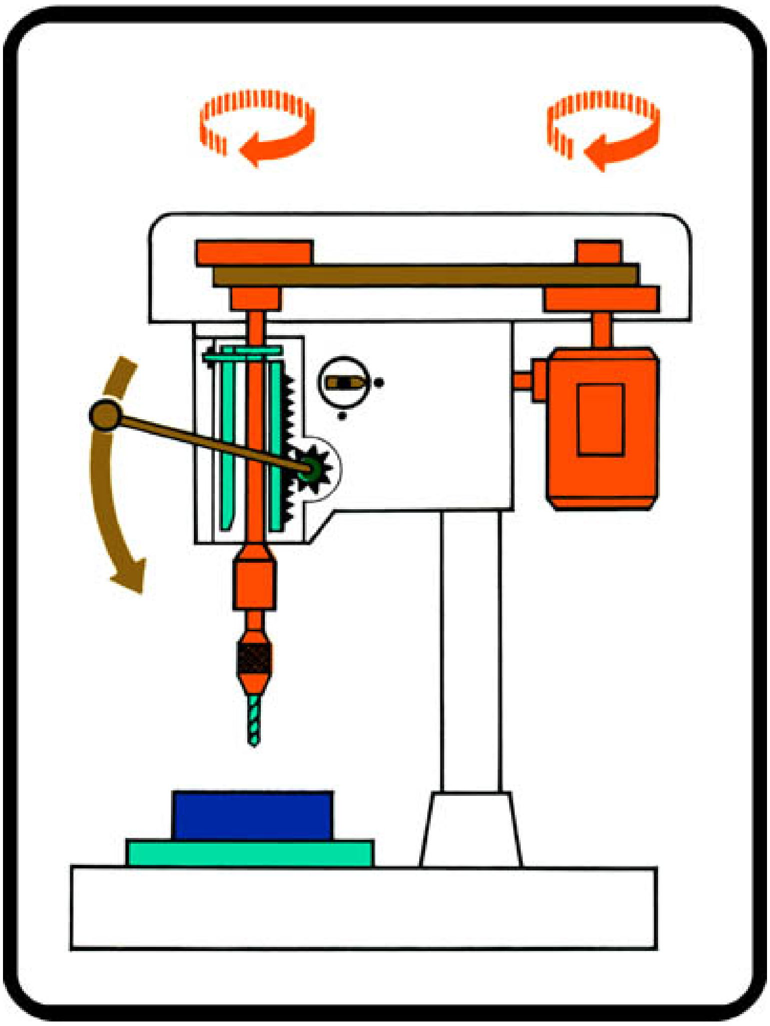

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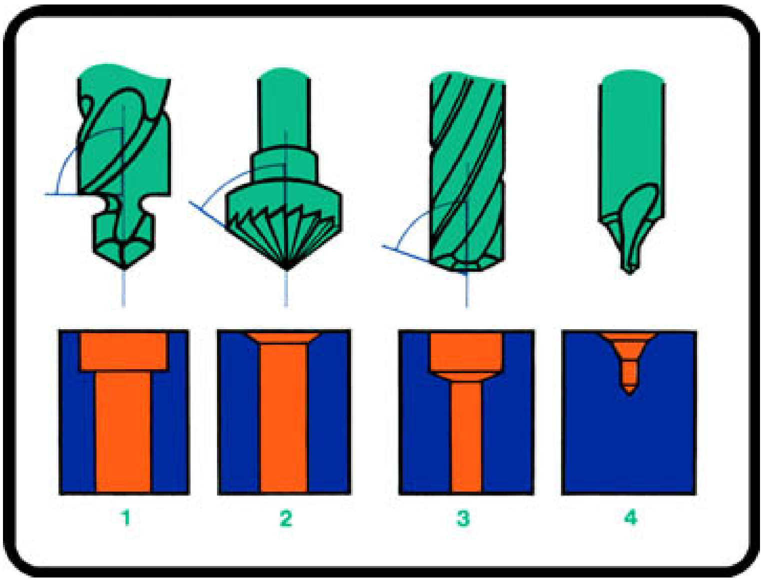

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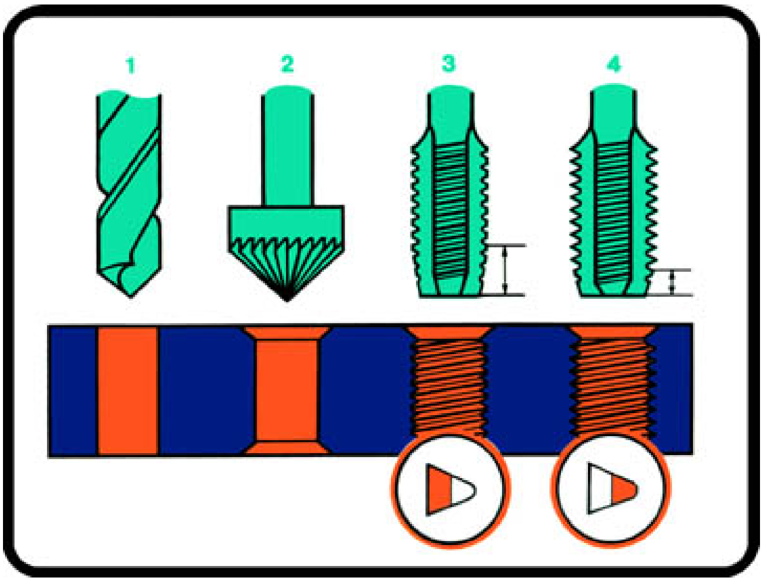

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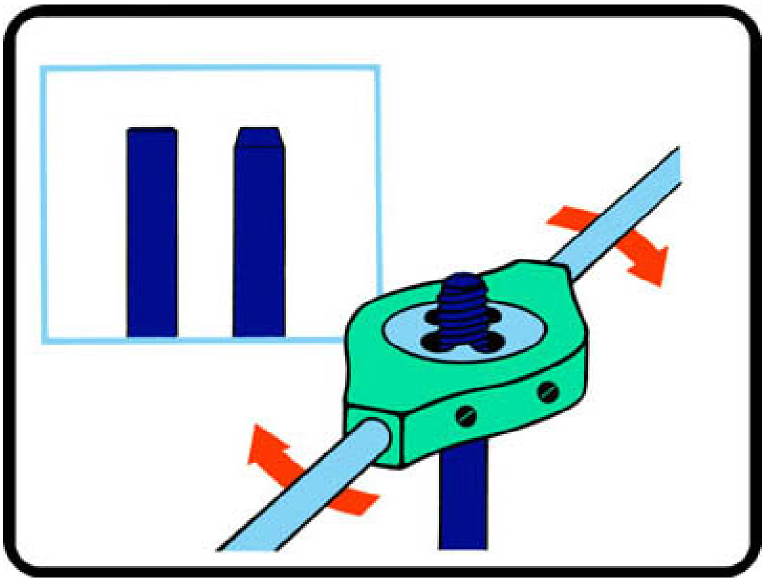
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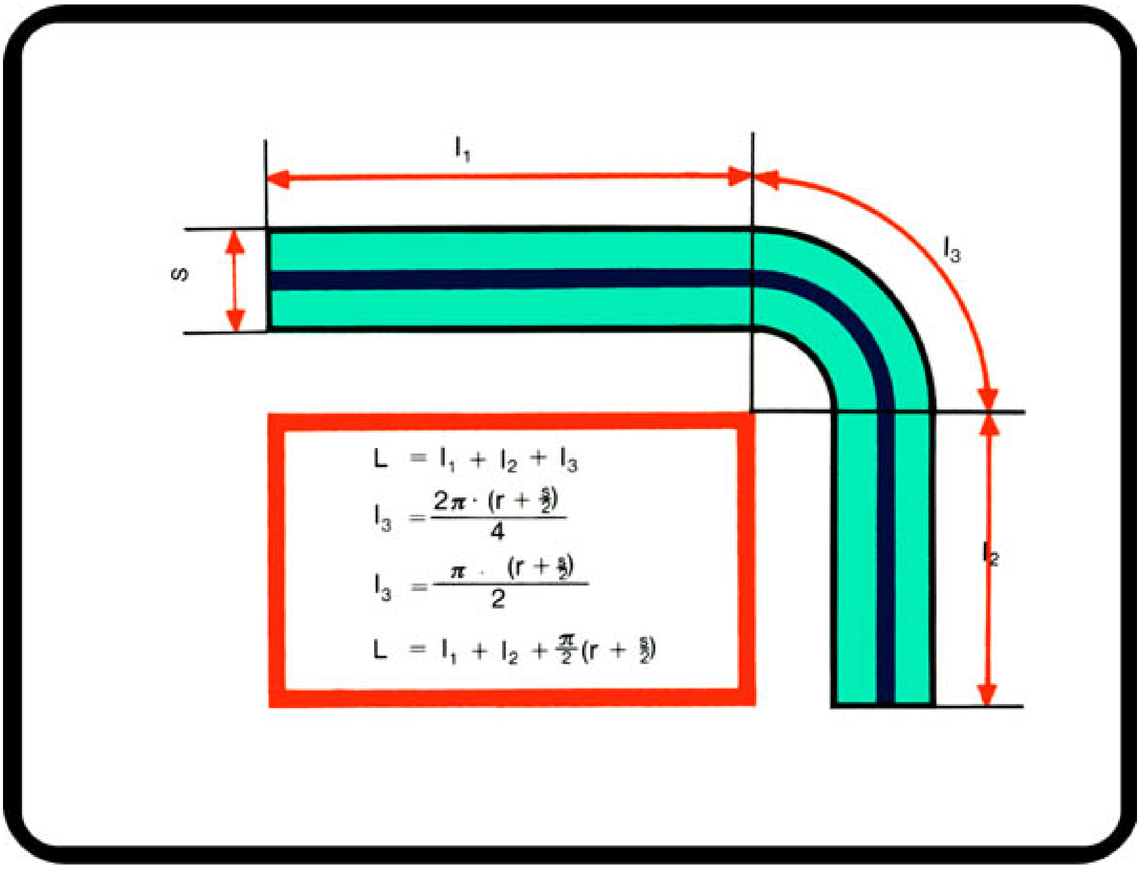

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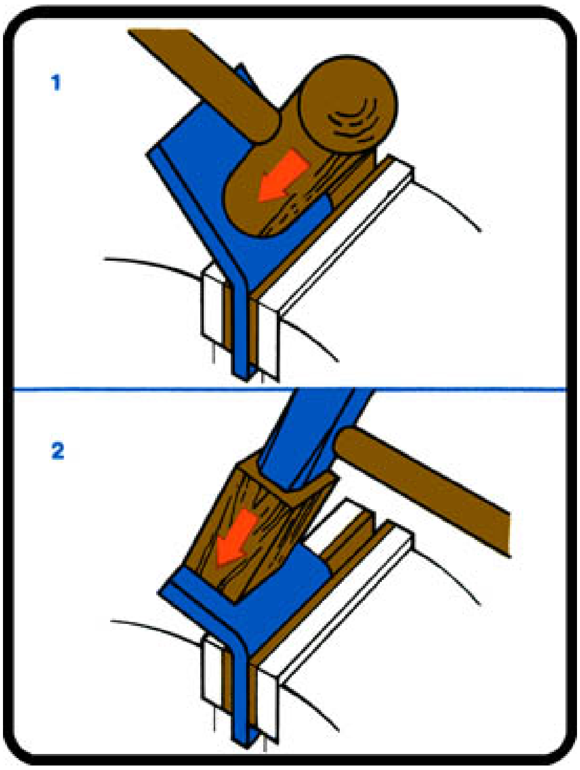

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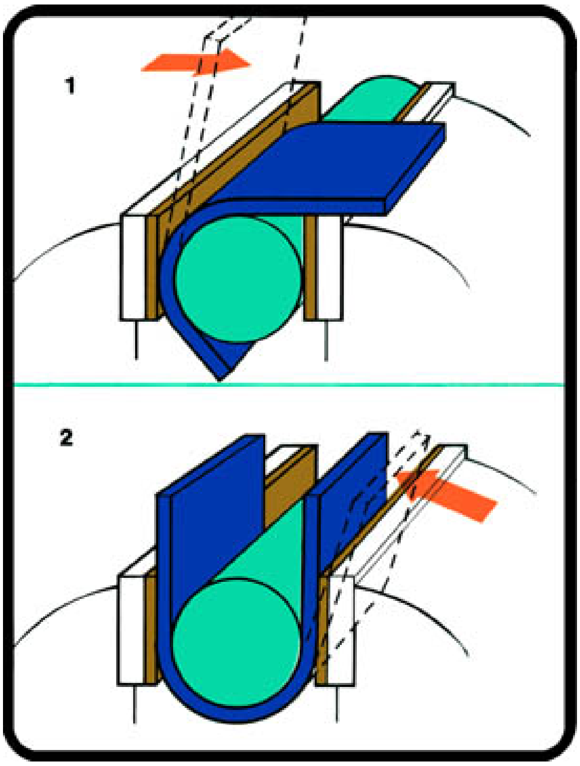

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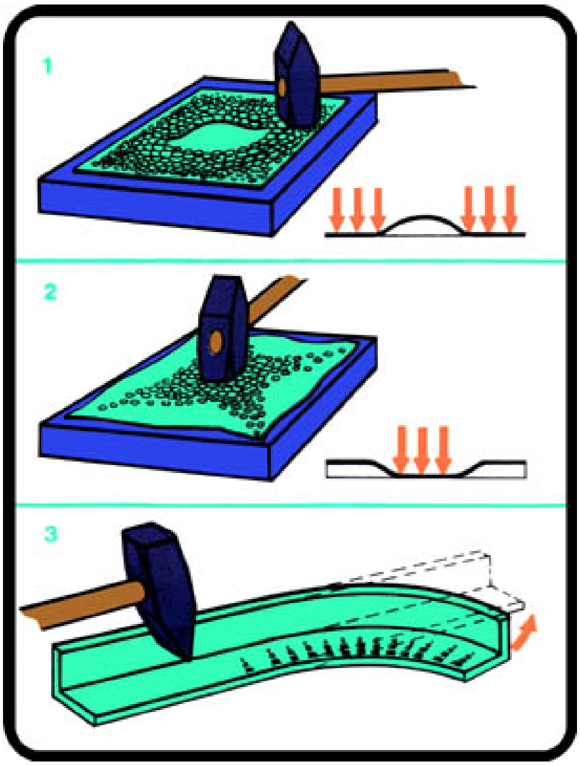

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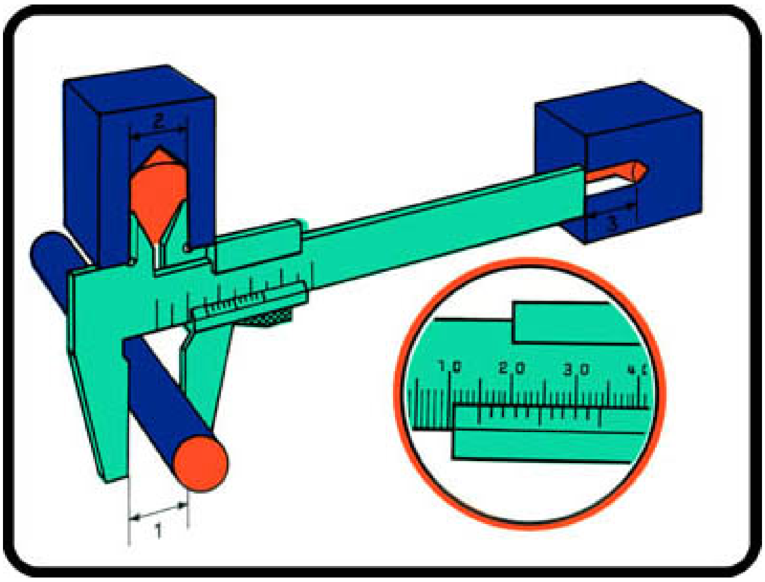

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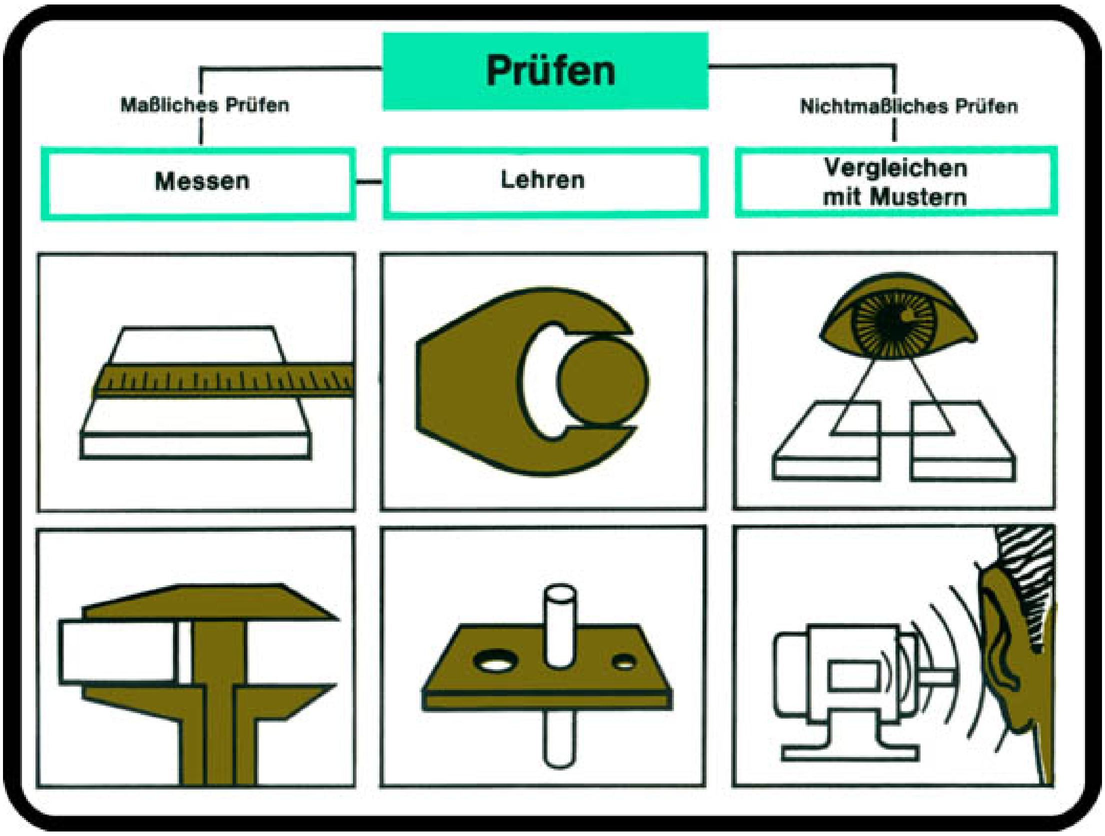

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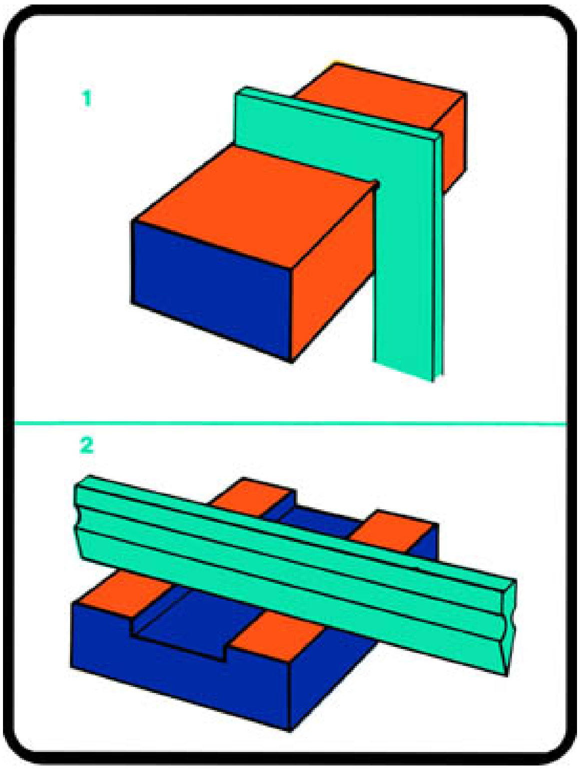

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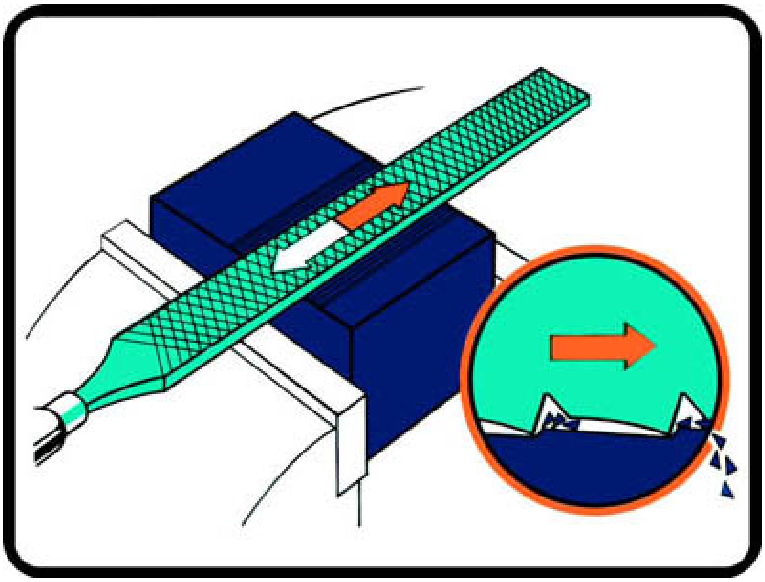

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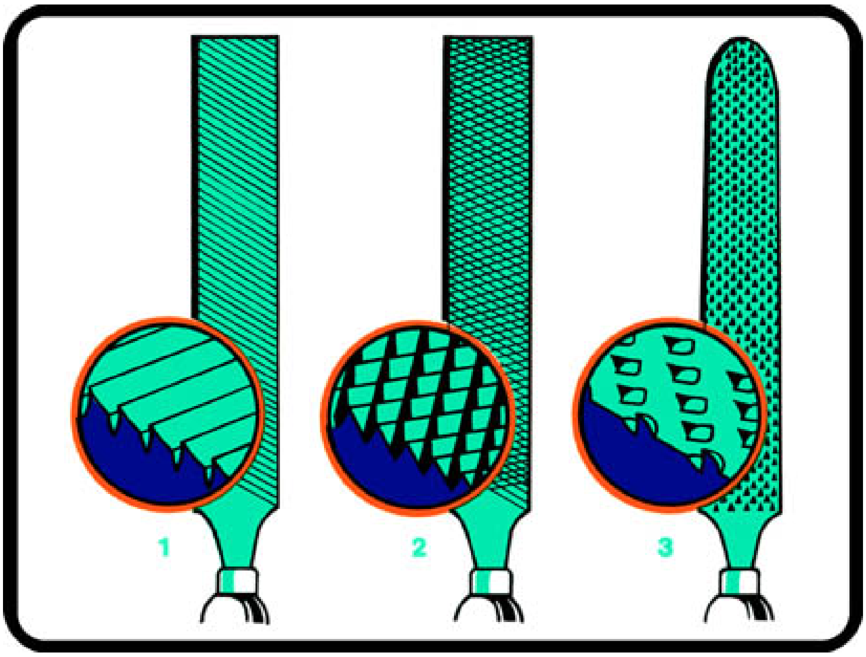

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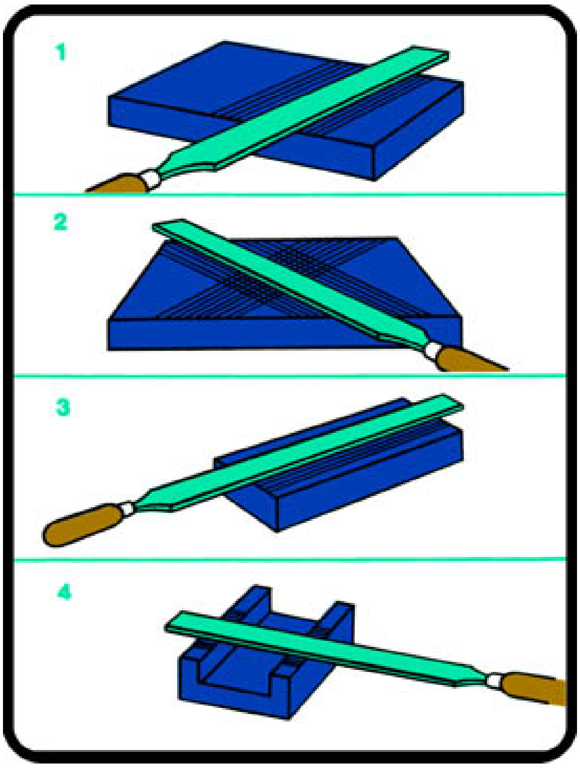

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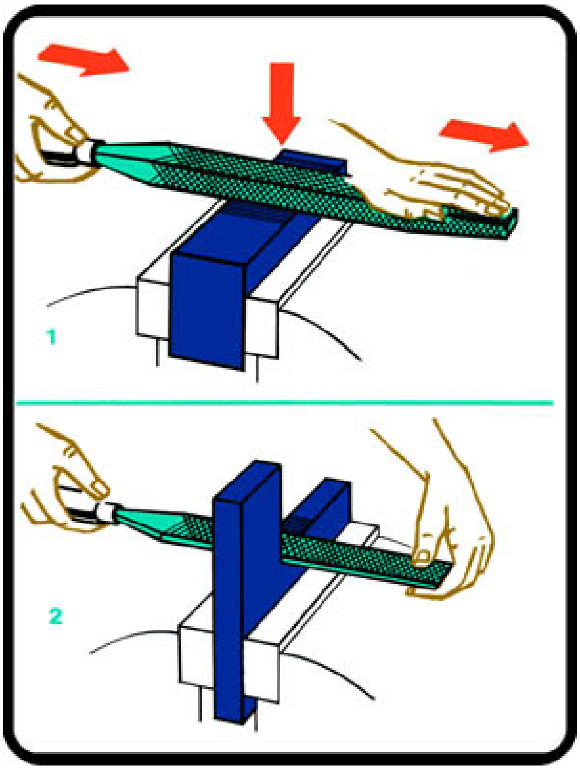

Film no. 28

Illustrated Knowledge Metal Engineering/Basic – Bildreihen für die Grundstufe Metall

Table of Contents

Illustrated Knowledge Metal Engineering/Basic – Bildreihen für die Grundstufe Metall

Helmut Pfisterer

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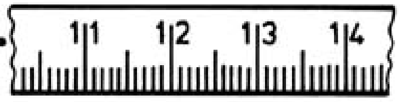

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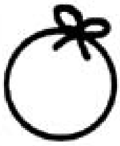

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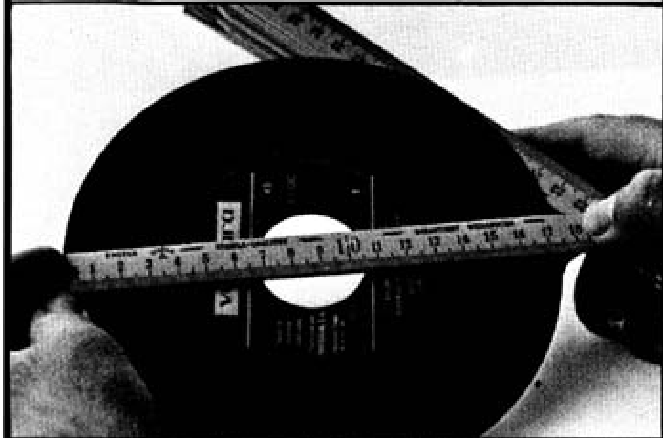

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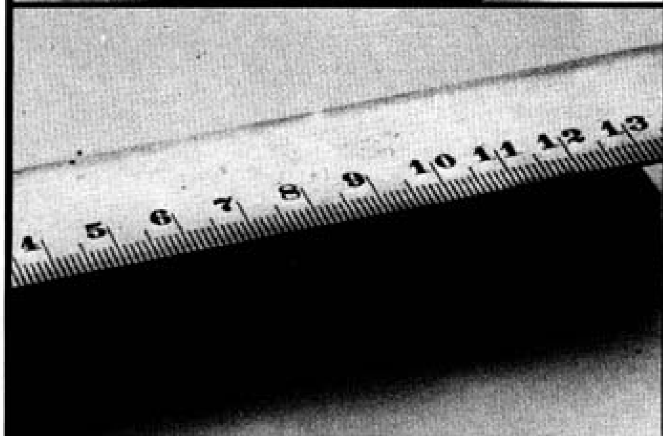

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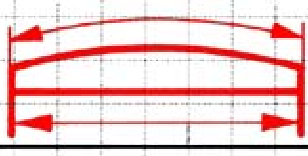

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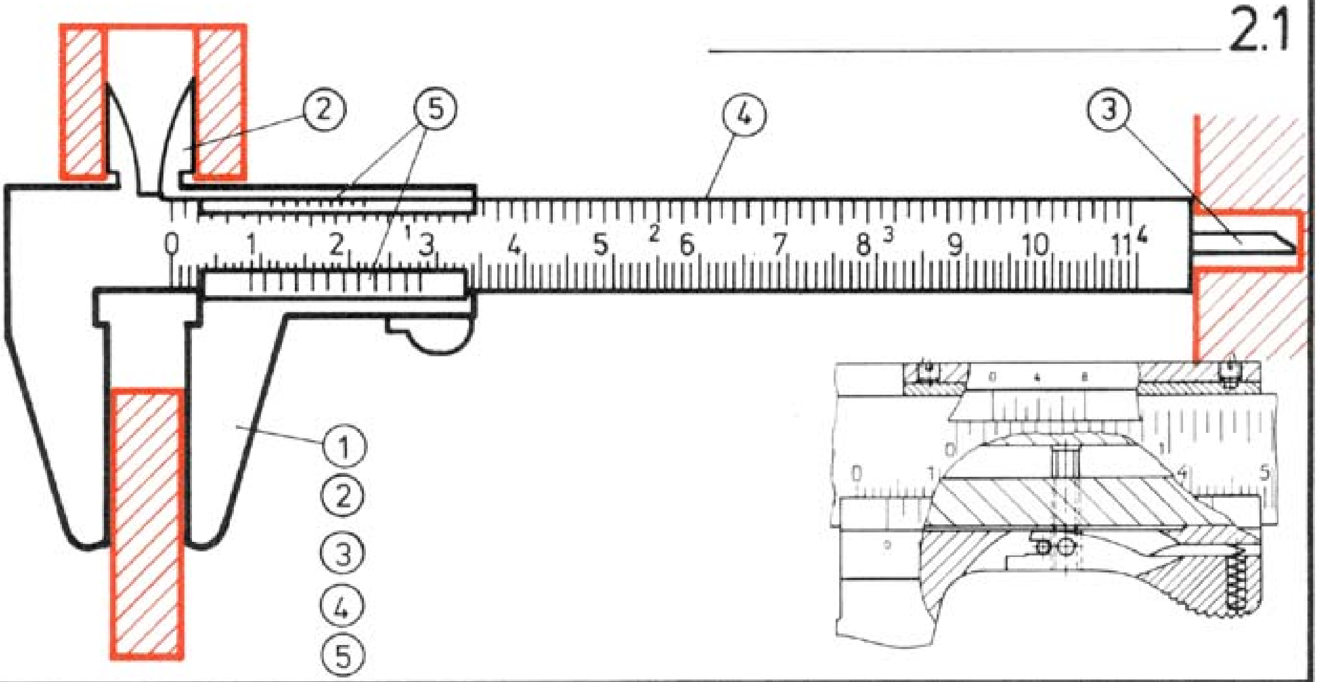

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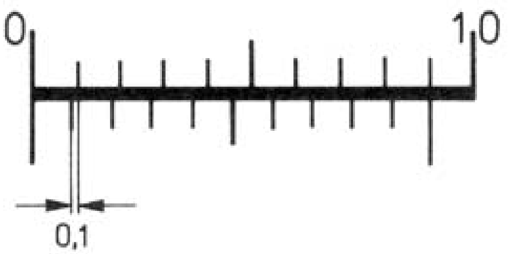

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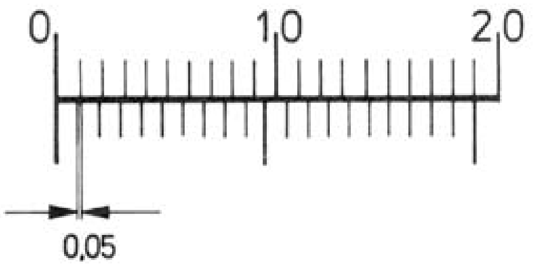

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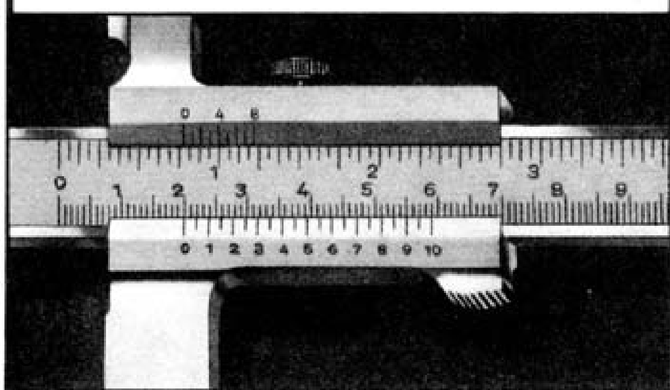

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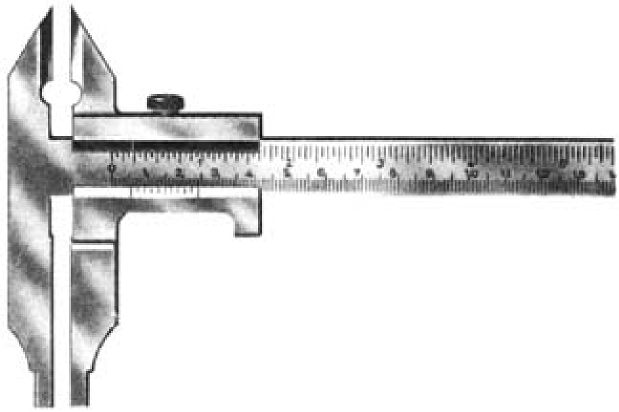

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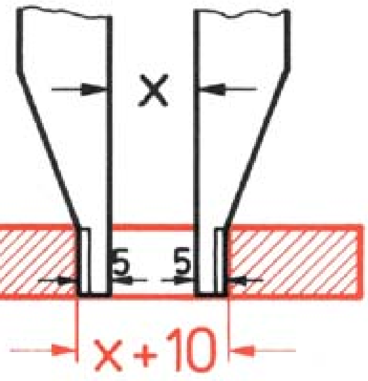

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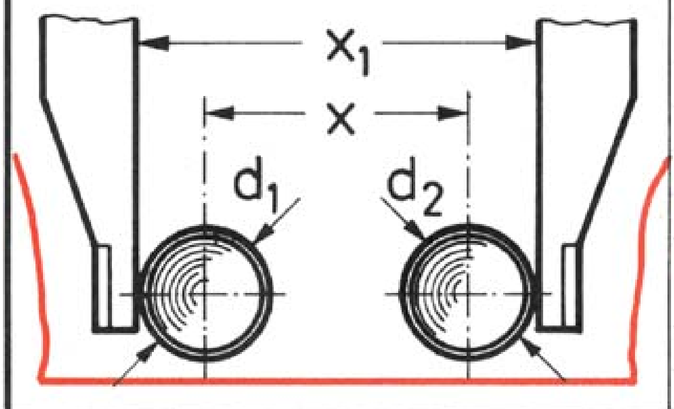

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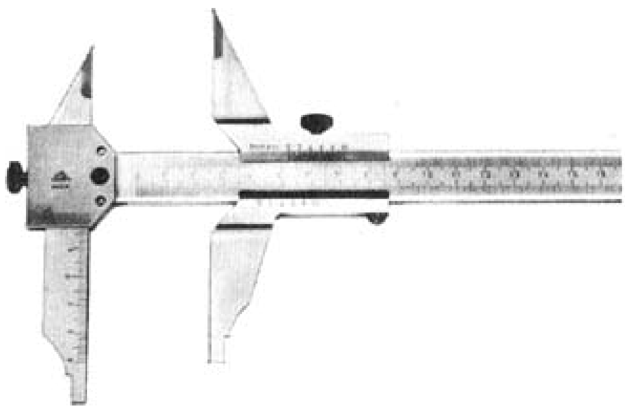

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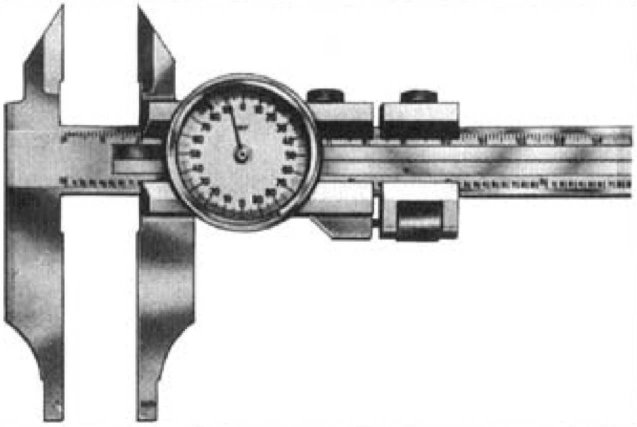

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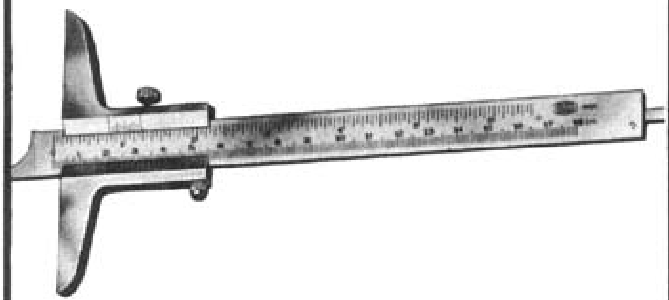

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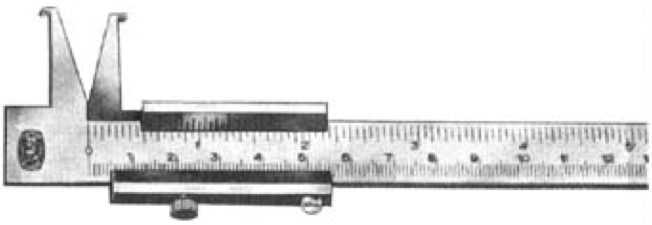

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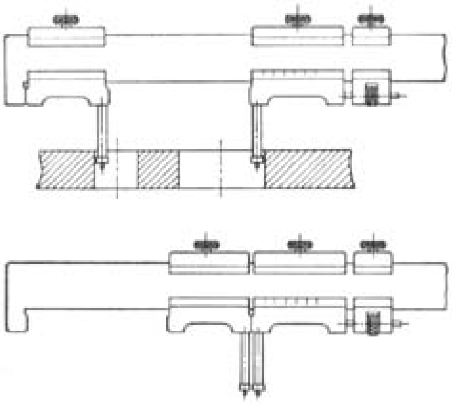

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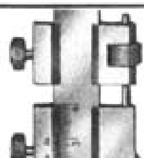

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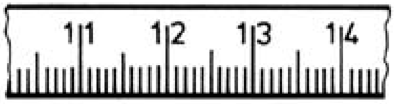

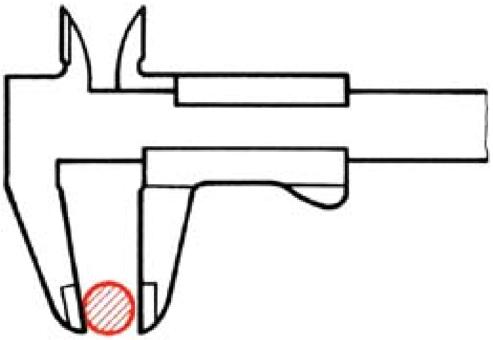

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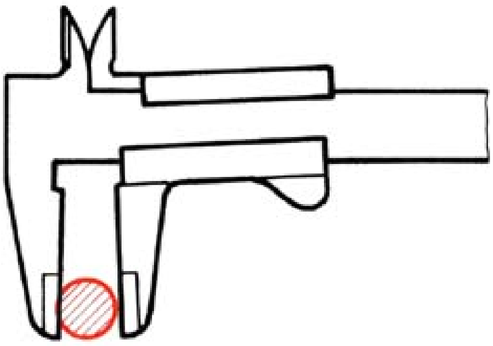

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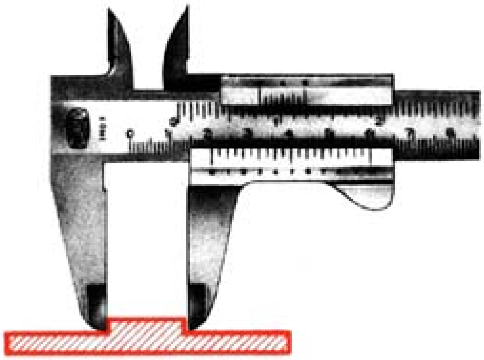

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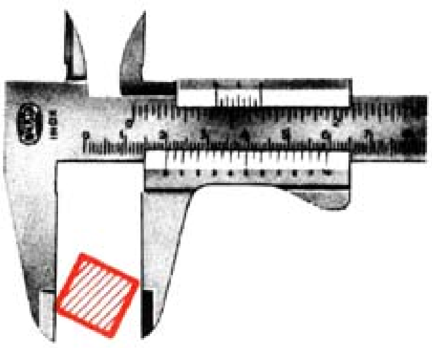

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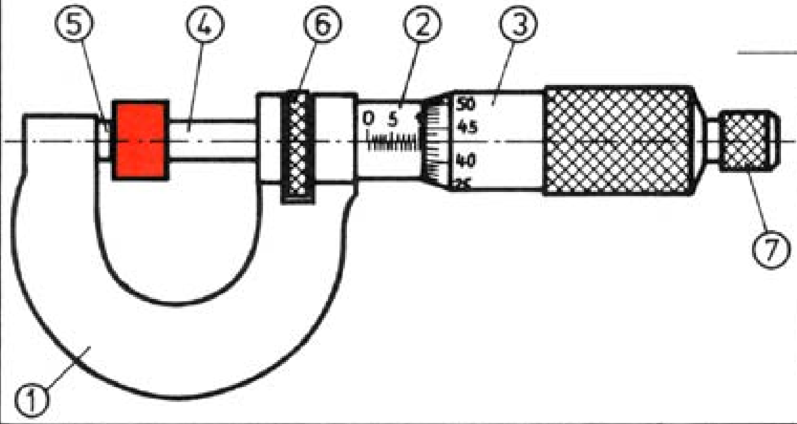
4.5



5.1

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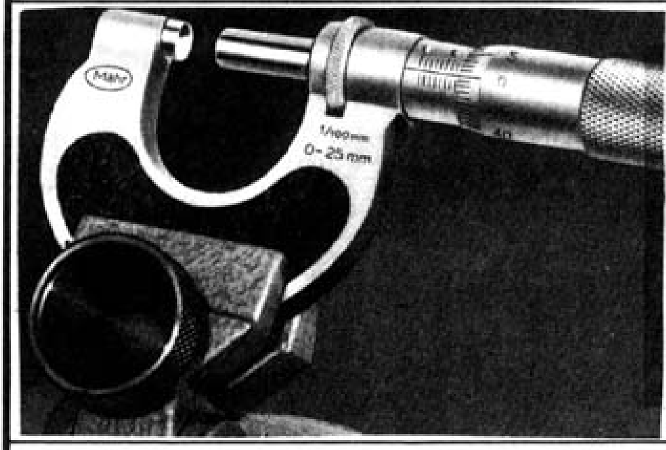
⑦



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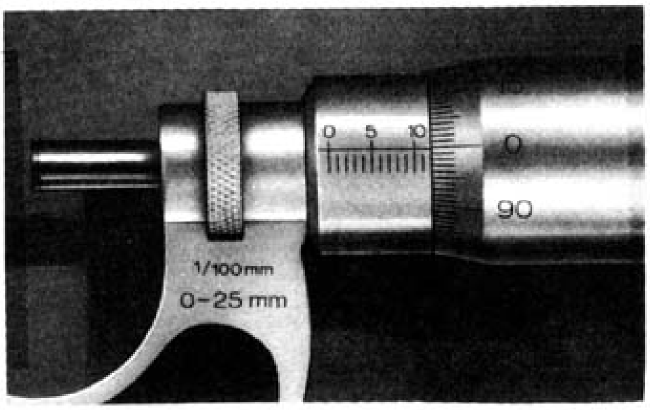

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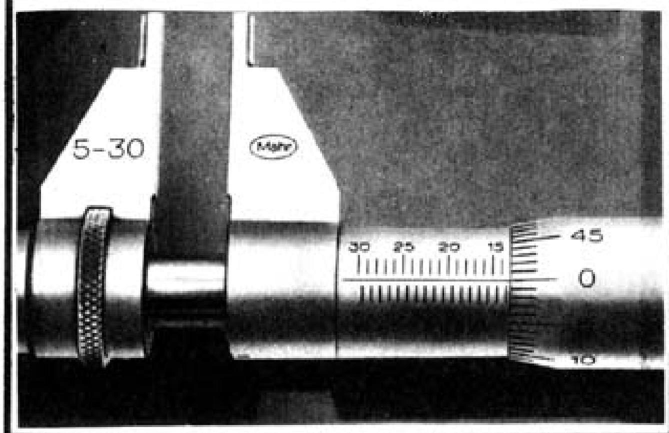
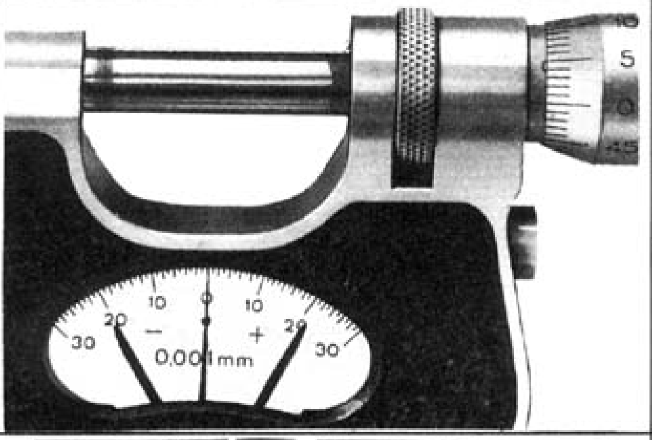


5.4

7

5.5

5a



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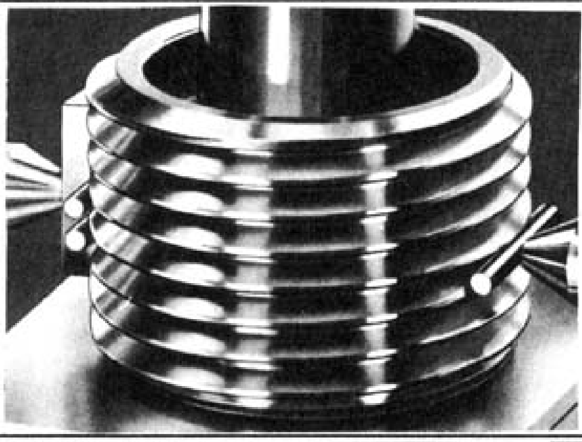

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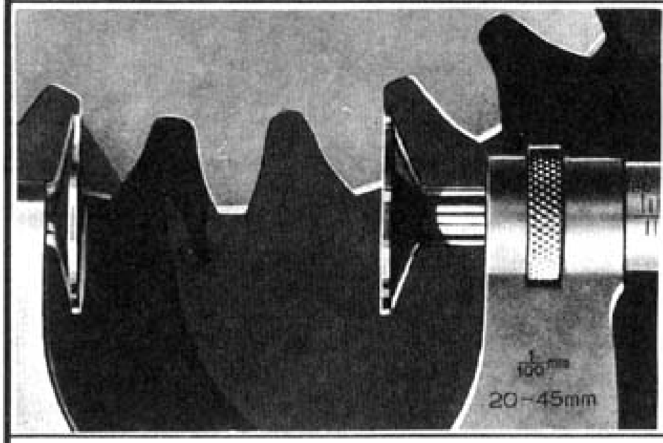

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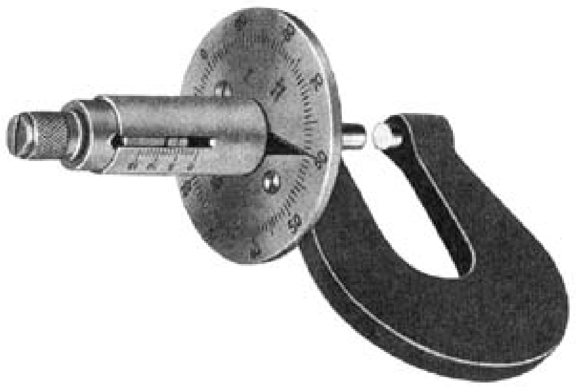

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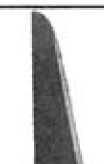

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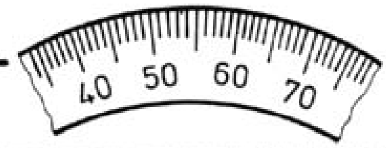

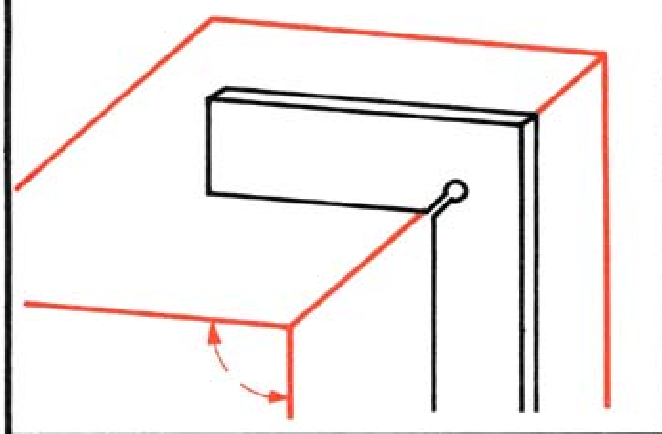

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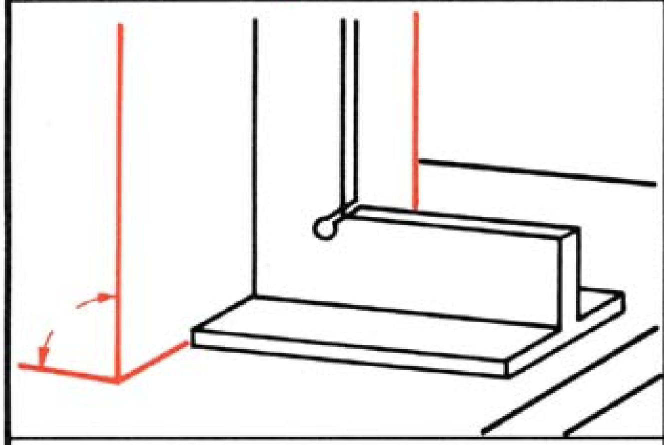

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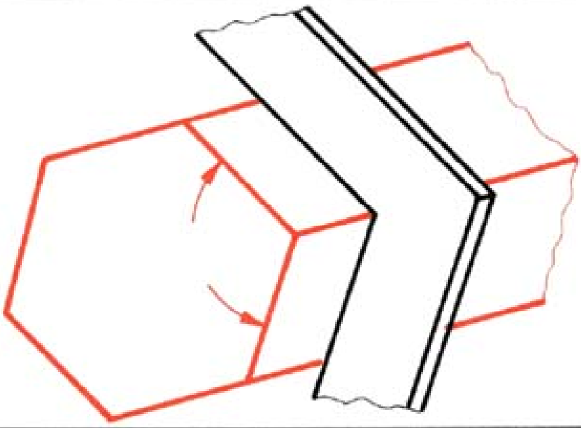

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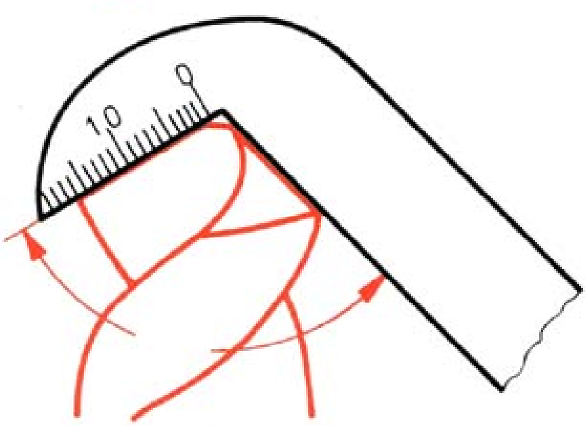

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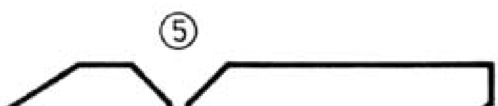

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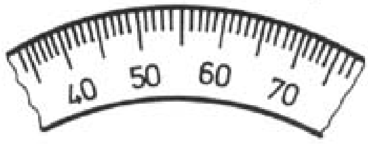

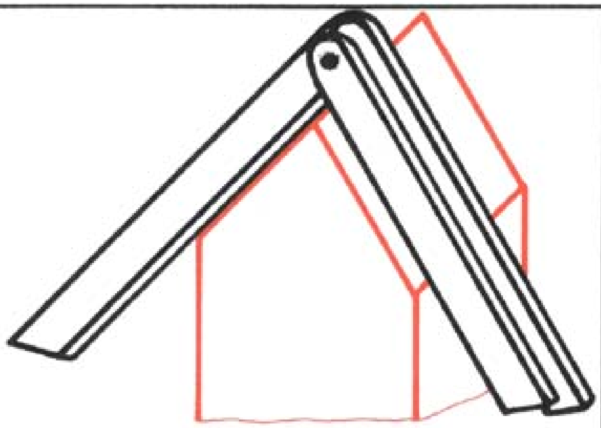

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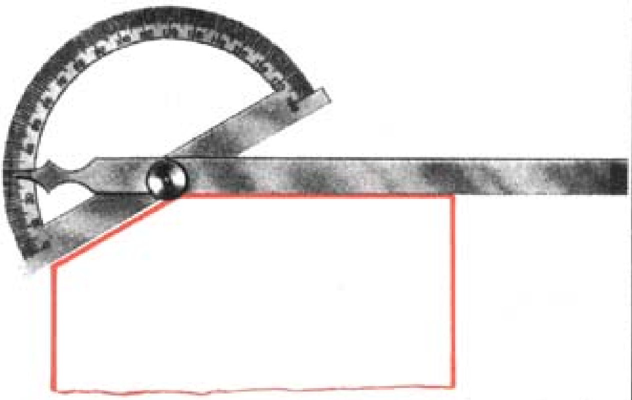

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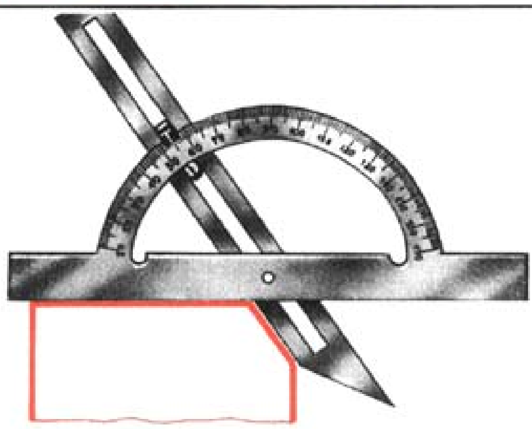

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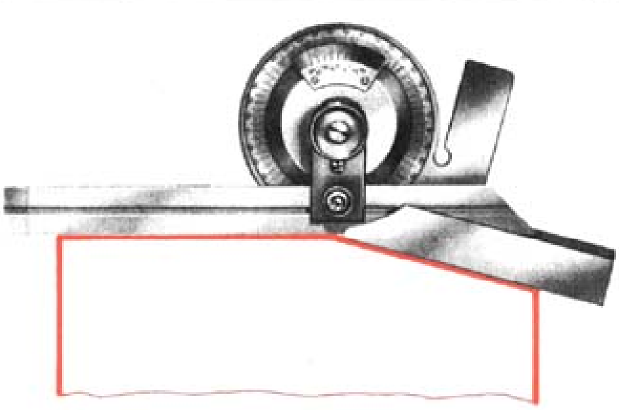

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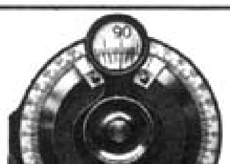
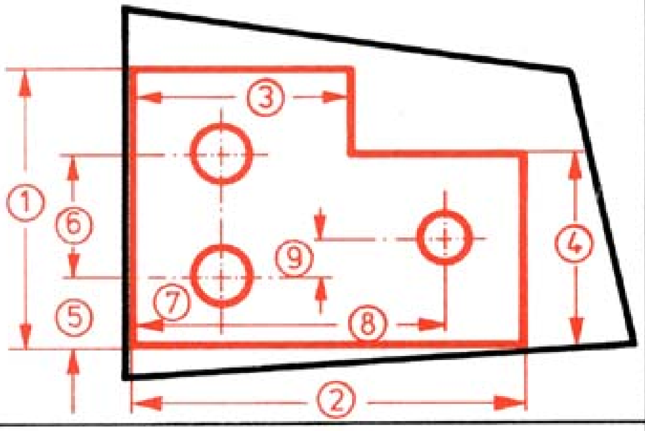


7.5

2. Marking/Punch marking – Markierung/Schlagstempelmarkierung

1



1.1

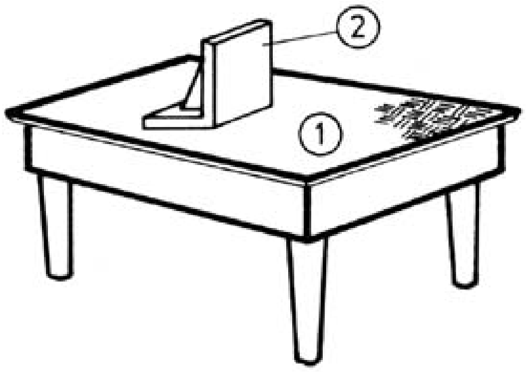
1

2 3

4

5 6 9

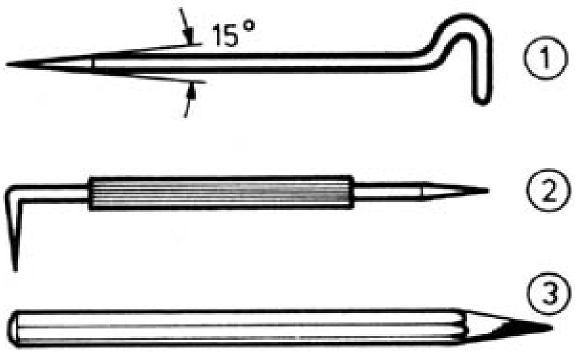
7 8



1.2

1

2



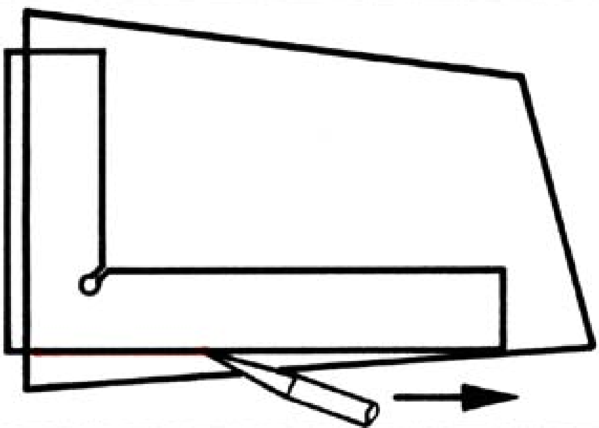
1.3

1

2

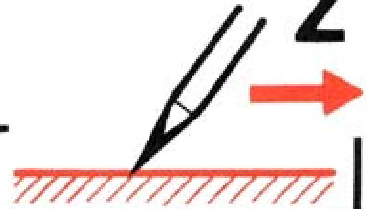
3

!



1.4

1.5



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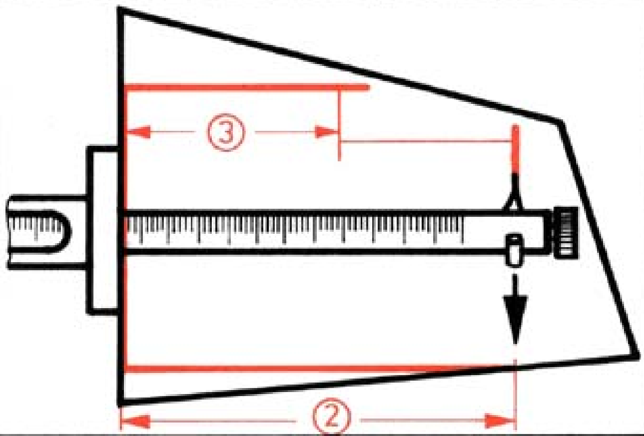

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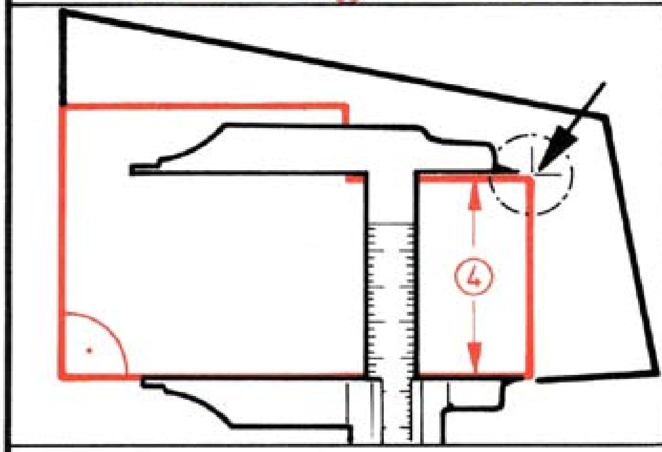

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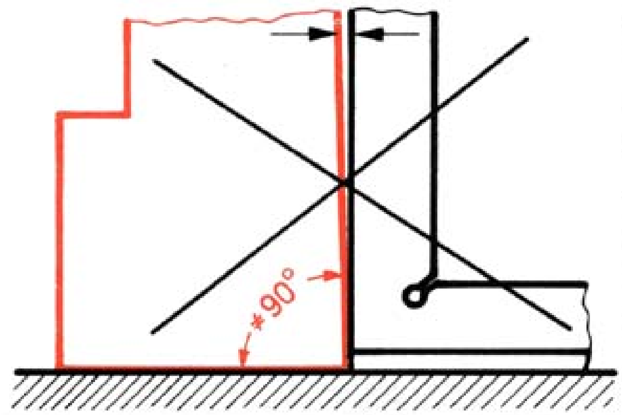
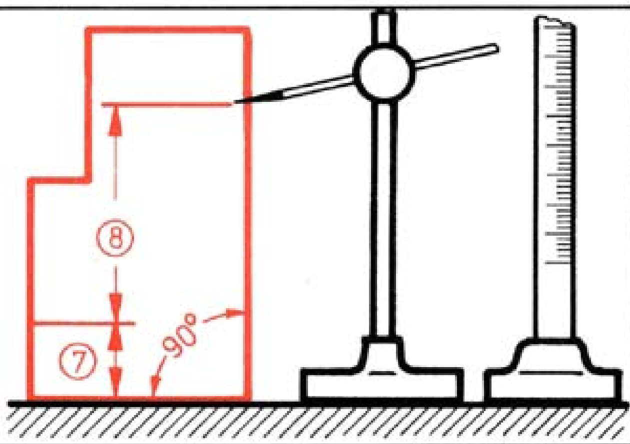


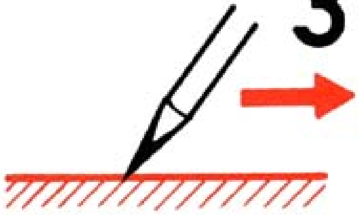
2.3



2.4

13

2.5



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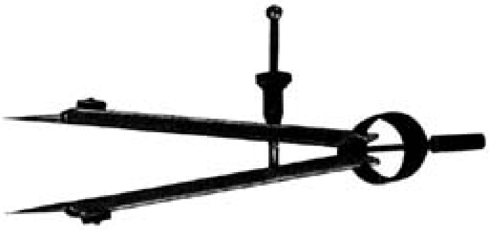

3.1

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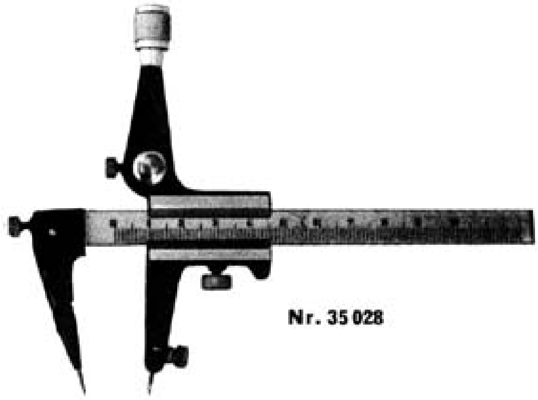

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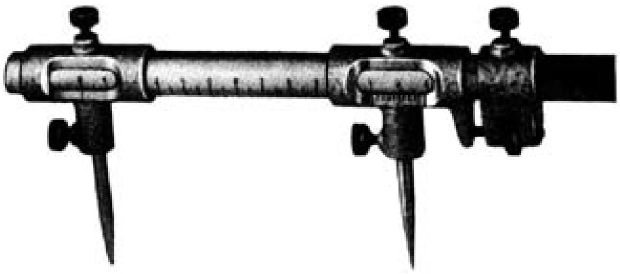

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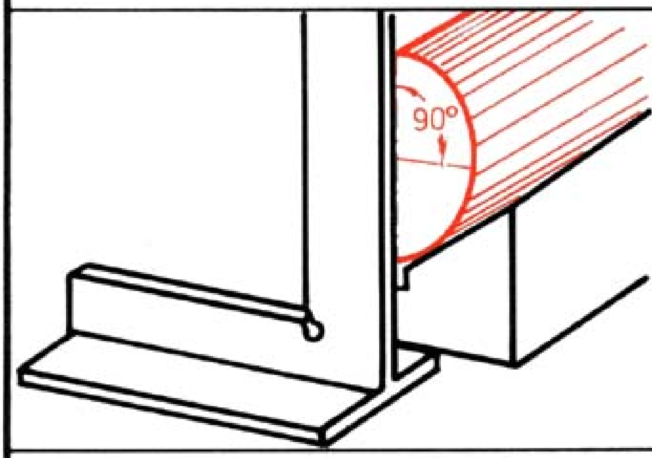
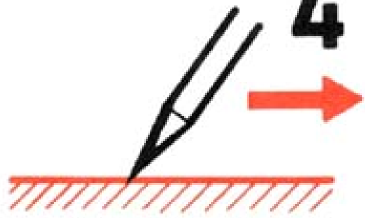
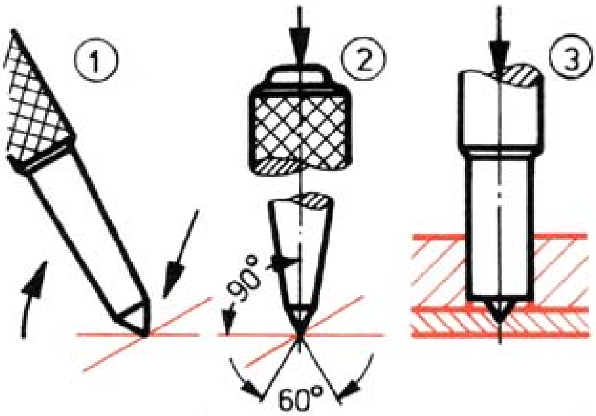


3.4

3.5

4



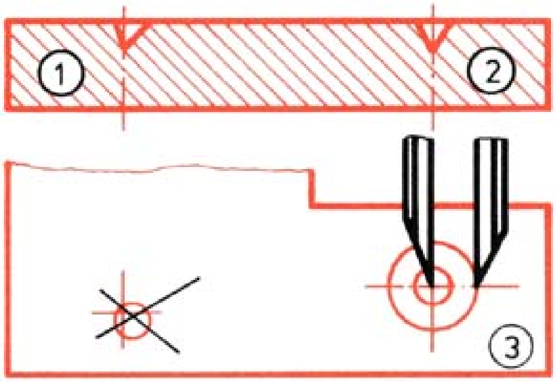


4.1

1

2

3



4.2

1

2

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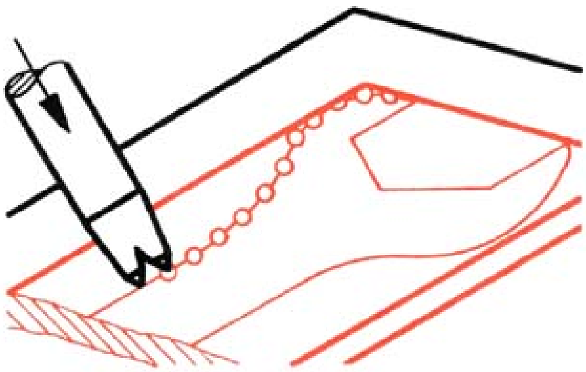

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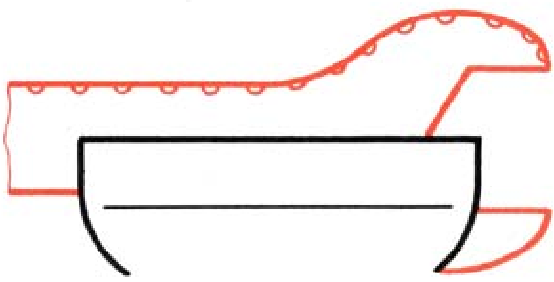

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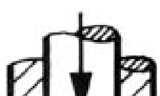
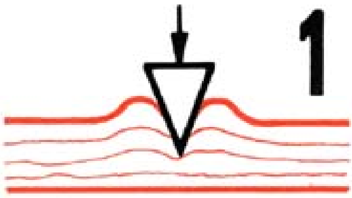
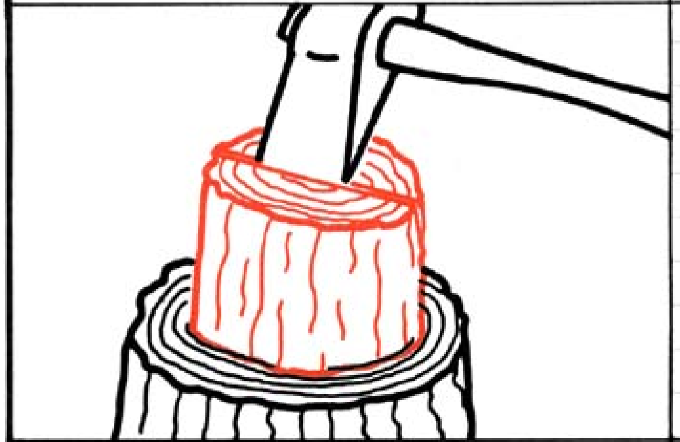


4.5

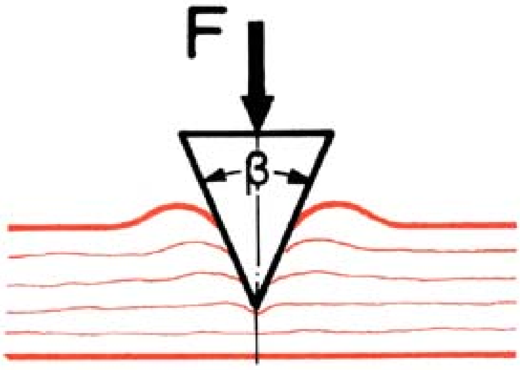
3. Chipping – Meißeln



1



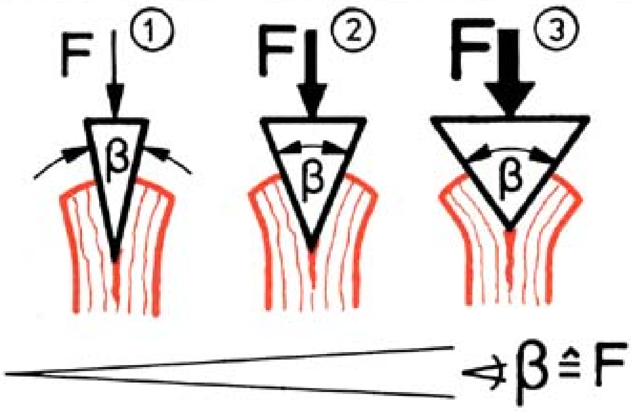
1.1



1.2

F =

∢ β =



1.3

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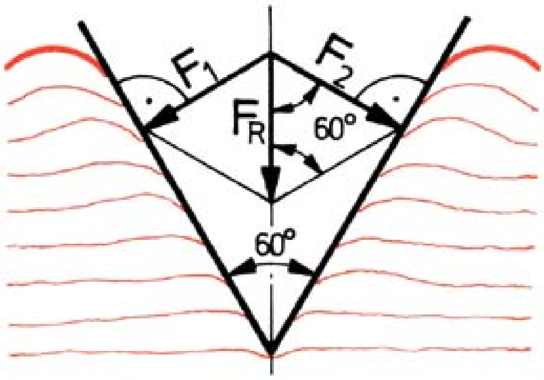
③

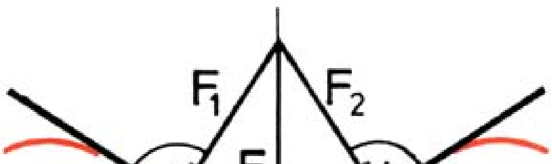


1.4

$F_1 = F_2$

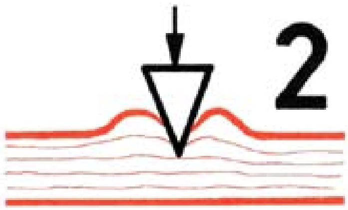
$\sphericalangle 60°: F_R = F_1 = F_2$

17



1.5

$F_1 = F_2 < F_R$



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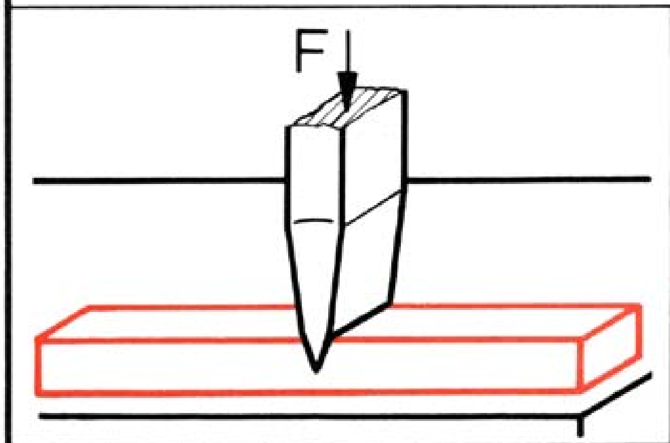
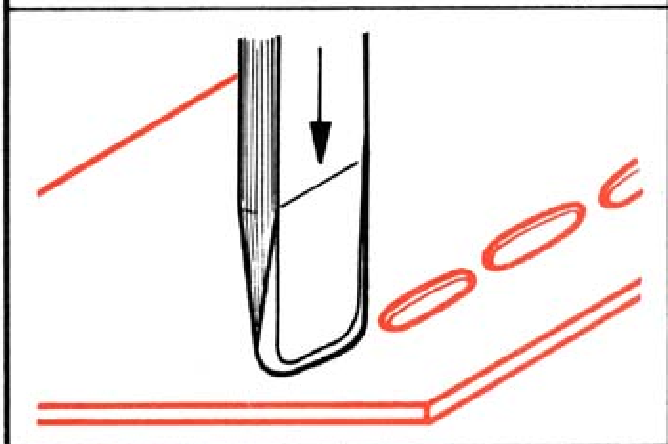
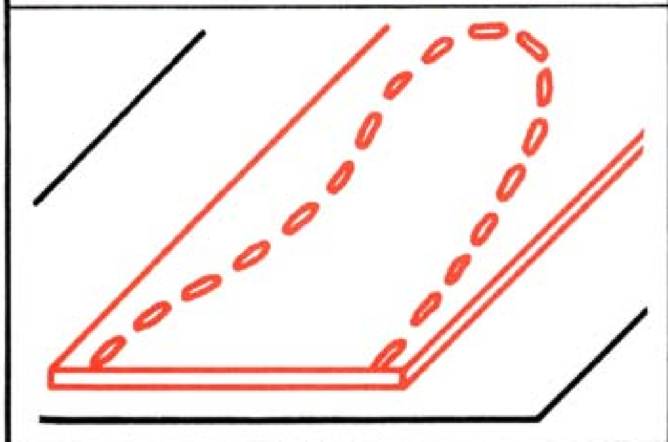


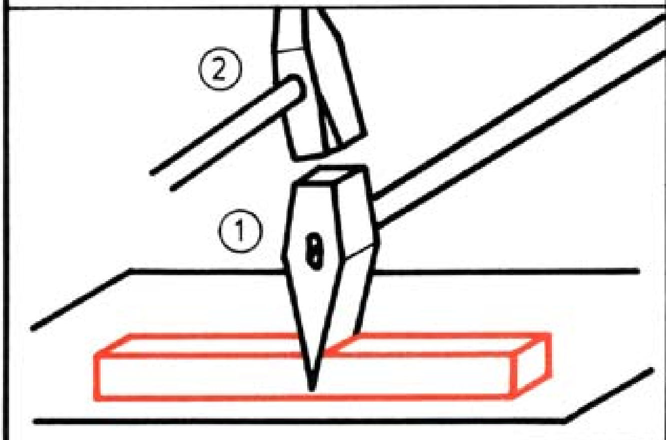
2.1



2.2



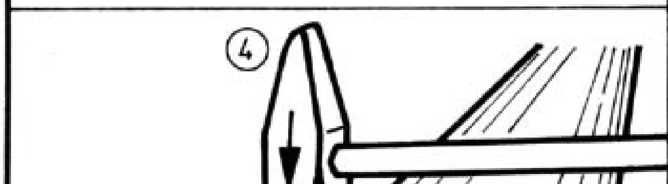
2.3



2.4

1

2

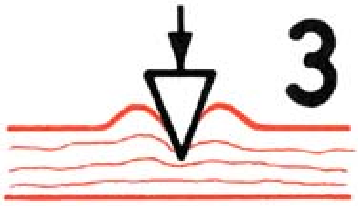


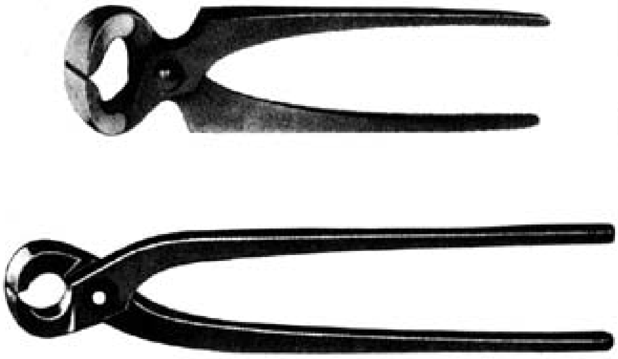
2.5

1

2

3





3.1

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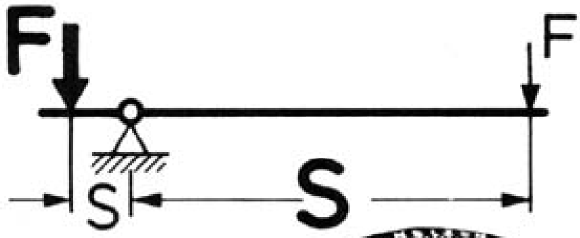
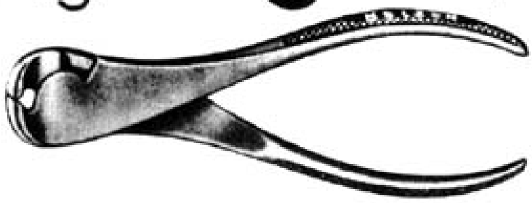
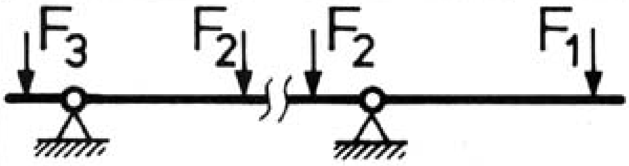
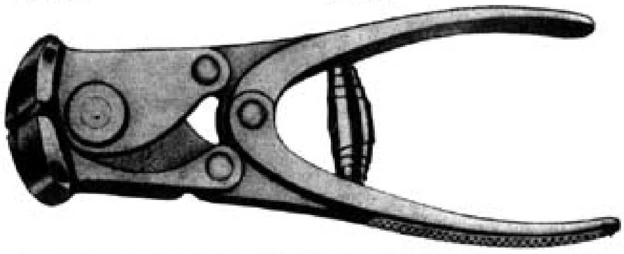




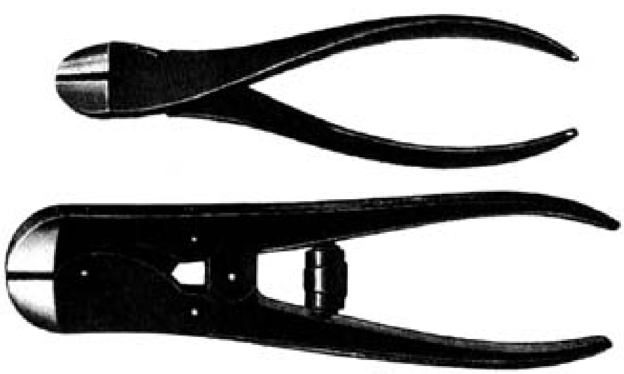
3.2

$$\mathbf{F} \cdot s = F \cdot \mathbf{S}$$





3.3



3.4

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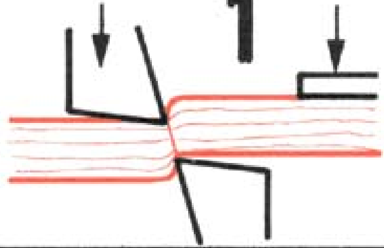
②

19

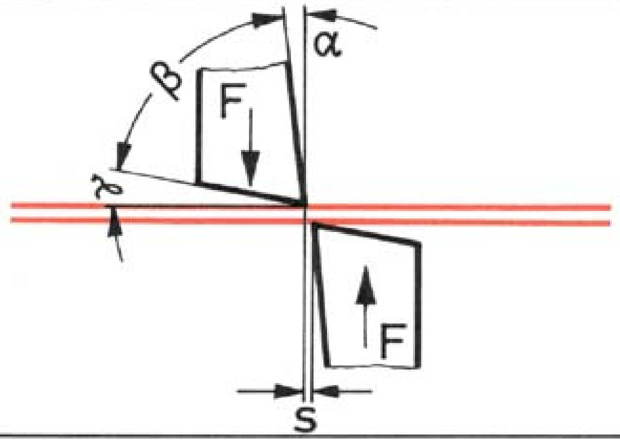
3.5

①

4. Shearing – Scheren



1

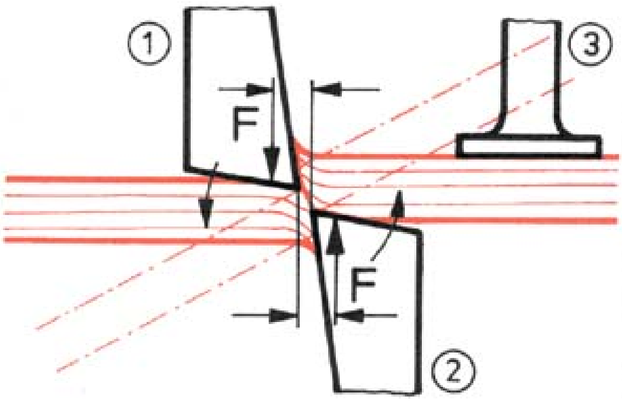


1.1

∢ α = 2......4° =

∢ β = 75.....82° =

∢ γ = 5......13° =



1.2

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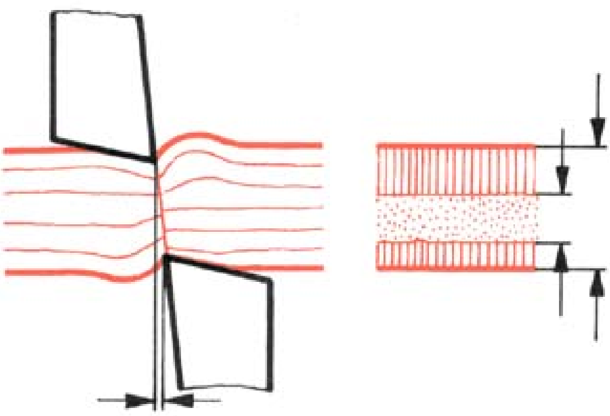

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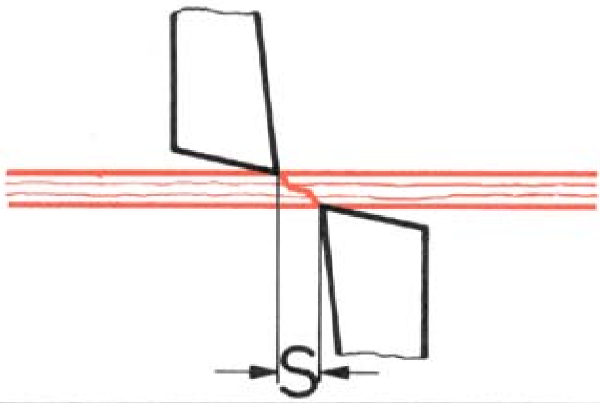

1.4

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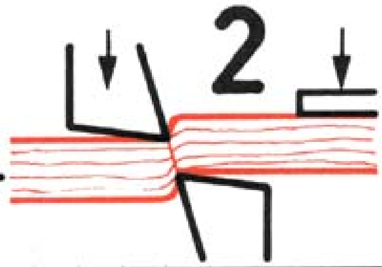
1.5



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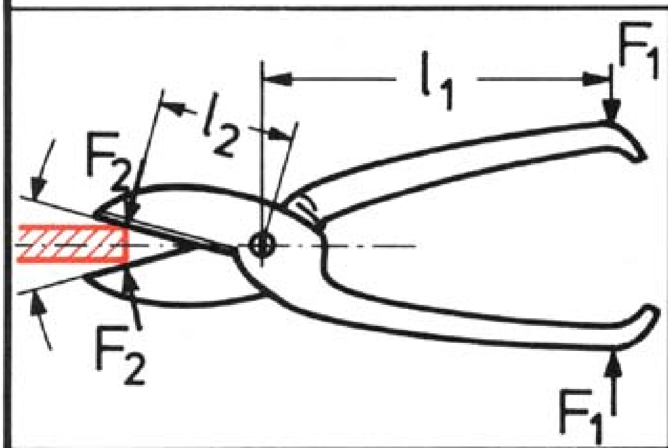

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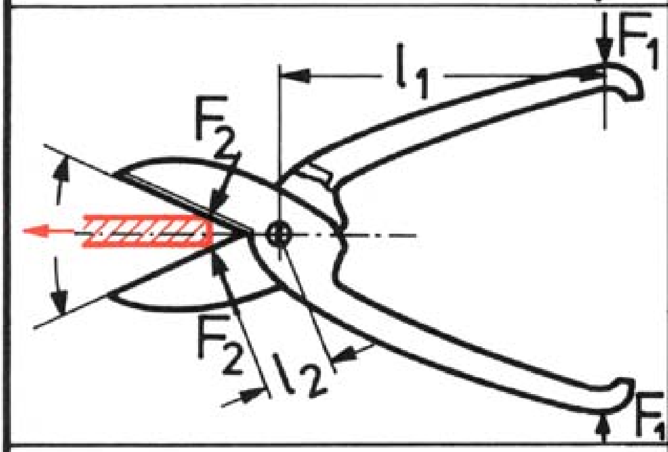

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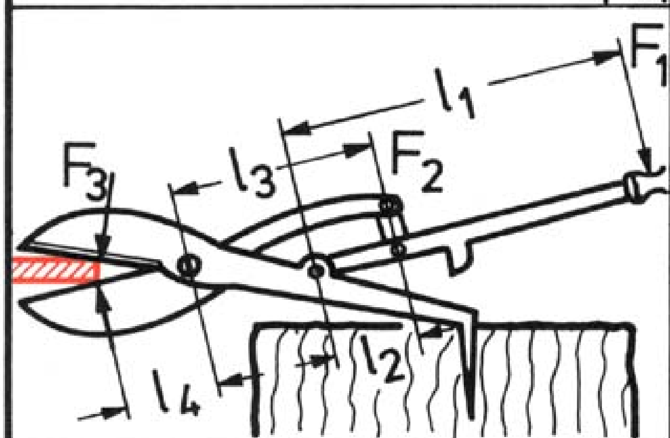

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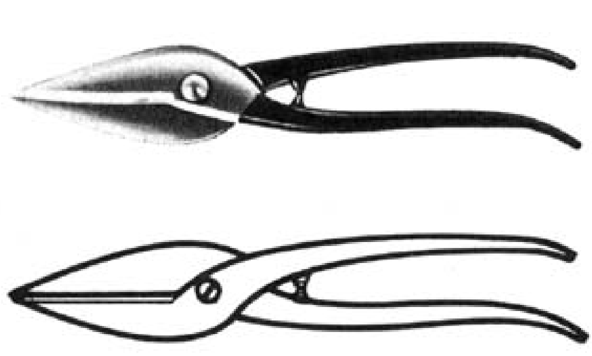

2.4

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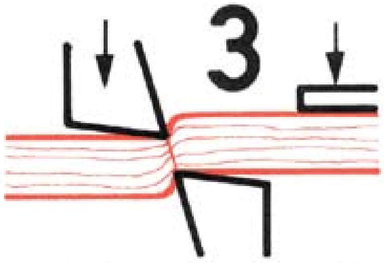

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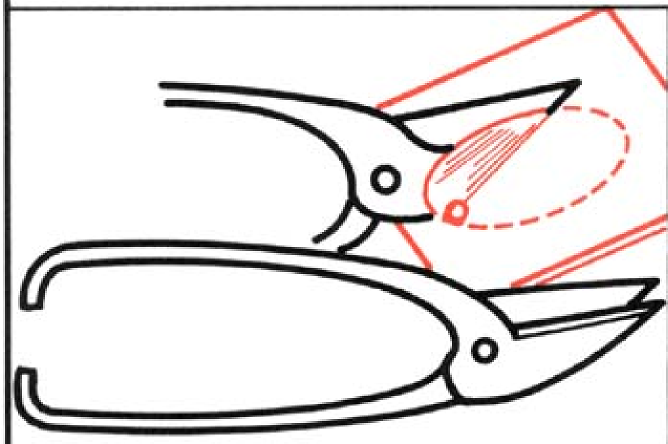

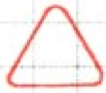

3.2

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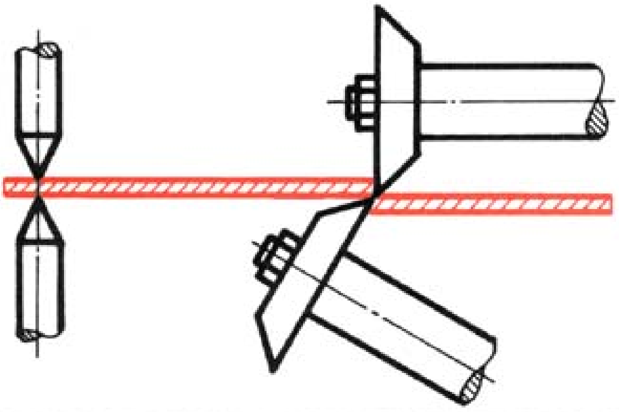
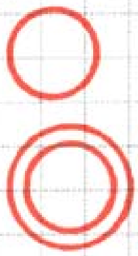
3.3





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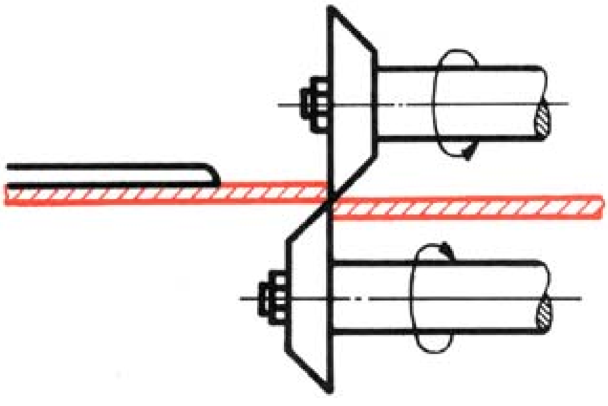

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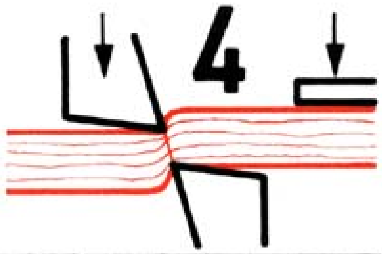

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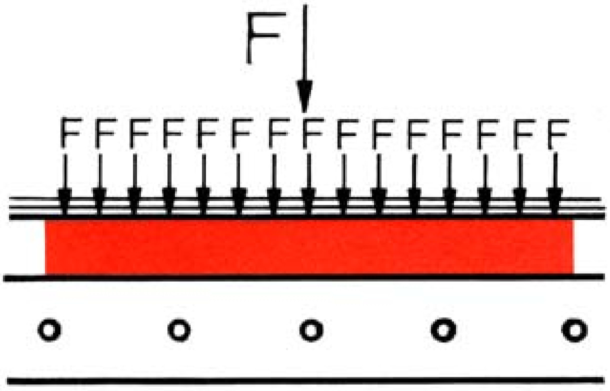

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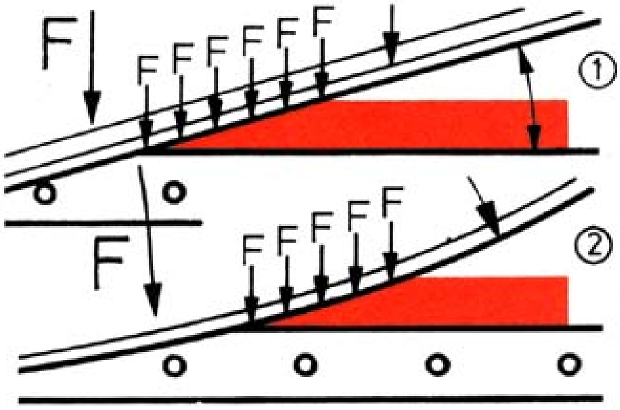

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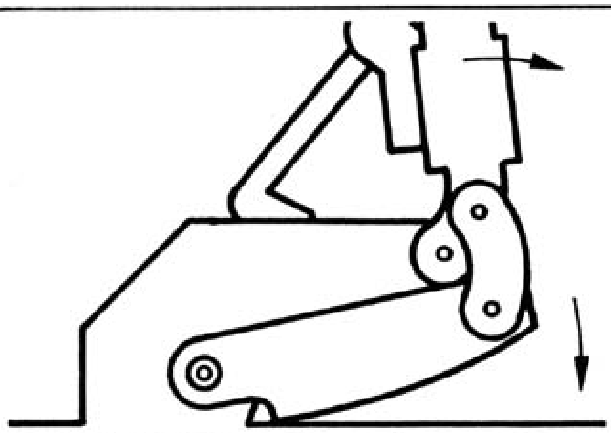

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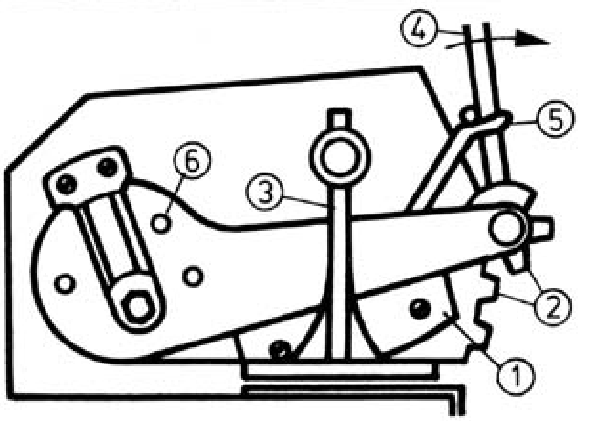

4.4

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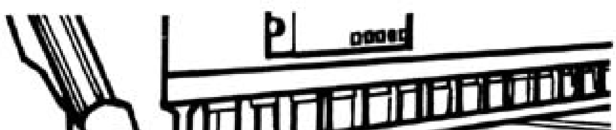
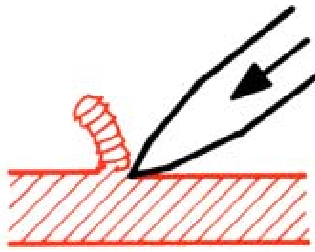


4.5

5. Angled tools/Keyed angles – Winkel am Werkzeug/Keilwinkel



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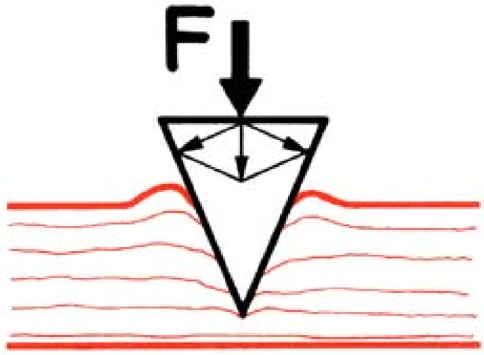
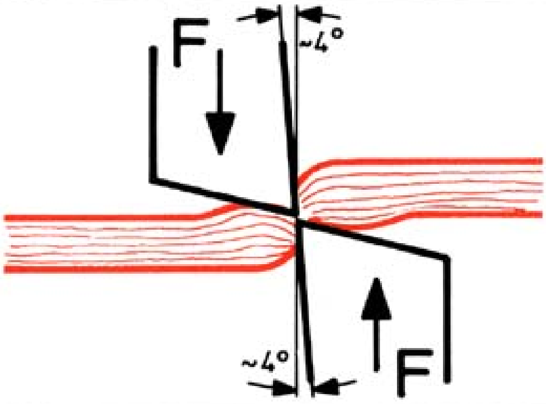


1.1



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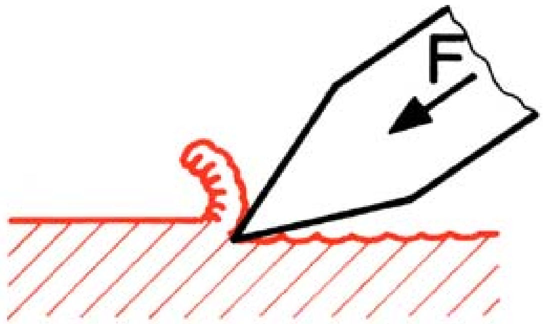

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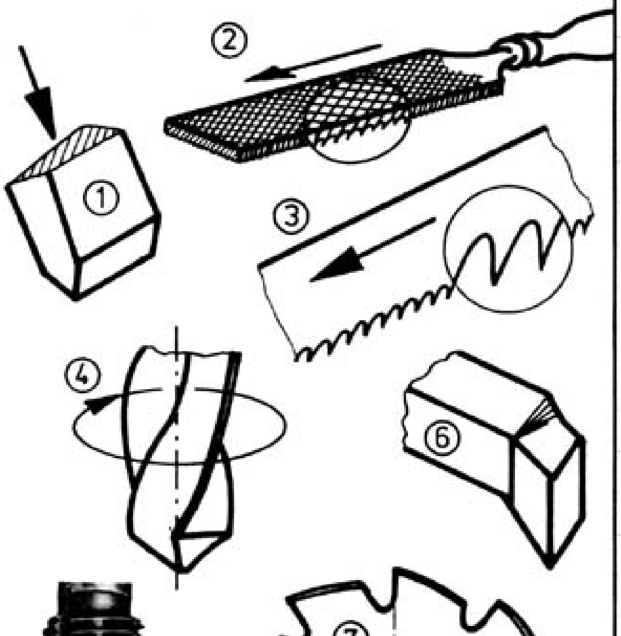

1.4

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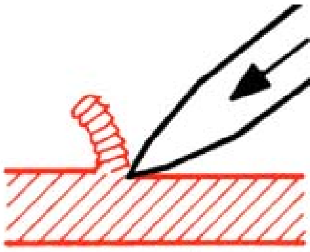

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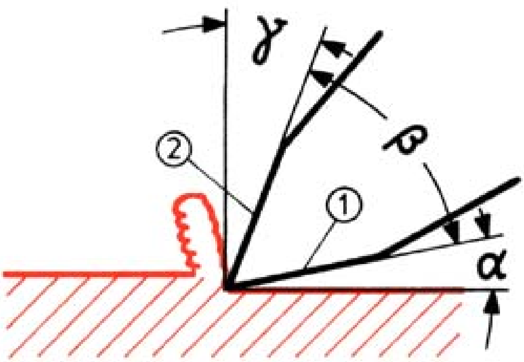

2.1

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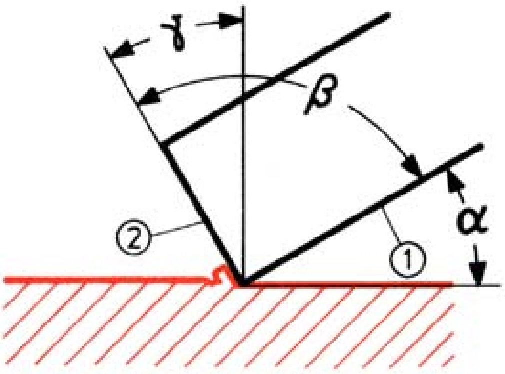
$\sphericalangle \alpha =$

$\sphericalangle \beta =$

$\sphericalangle \gamma =$



2.2

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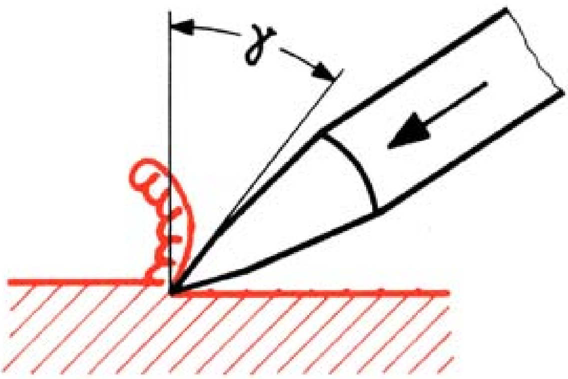
②

$\sphericalangle \alpha =$

$\sphericalangle \beta =$

$\sphericalangle \gamma =$



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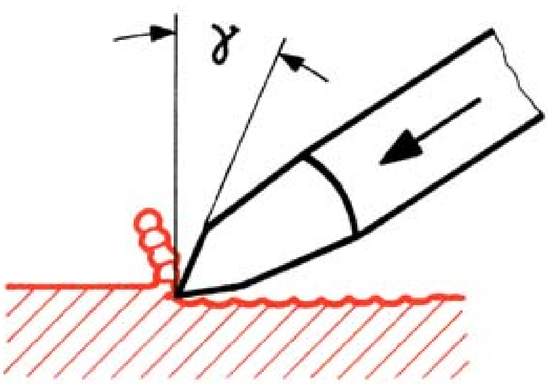

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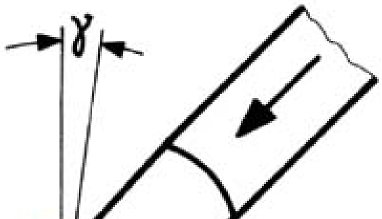

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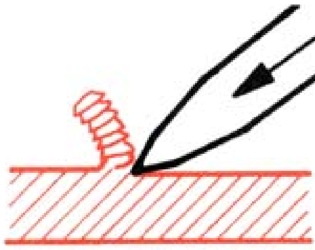

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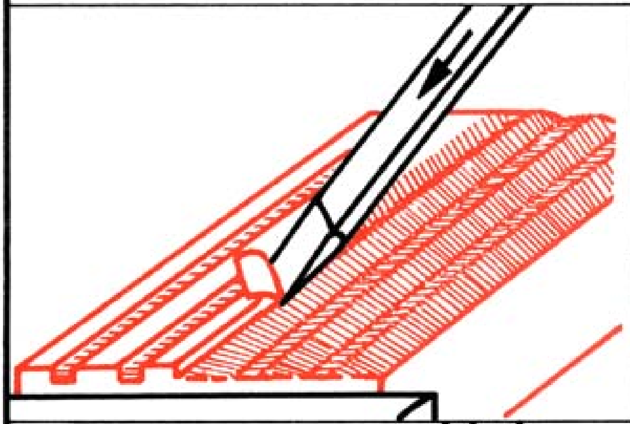
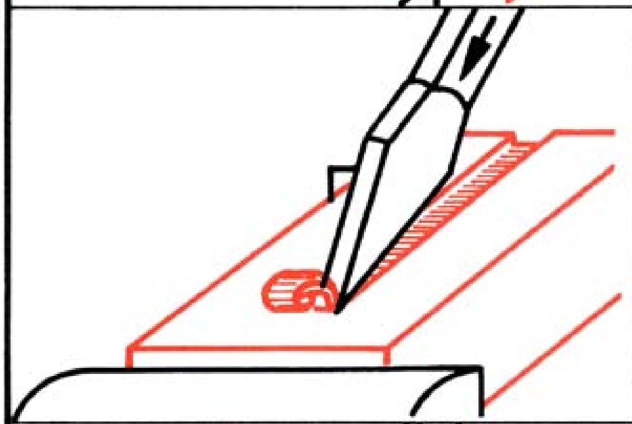


3.1



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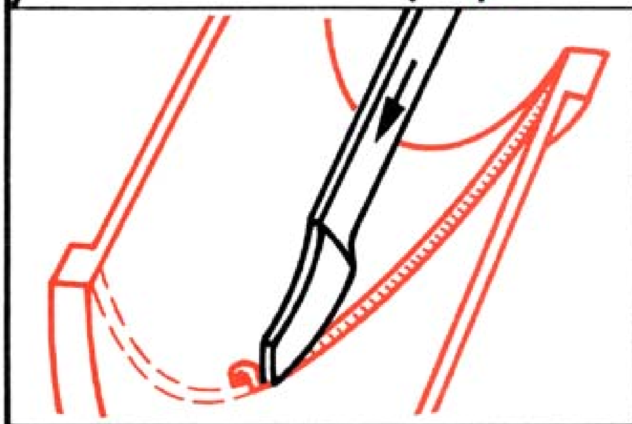
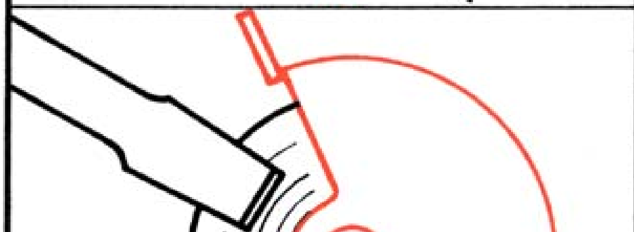


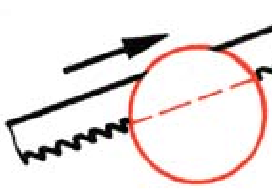
3.3

3.4



3.5

6. Sawing manual – Sägen



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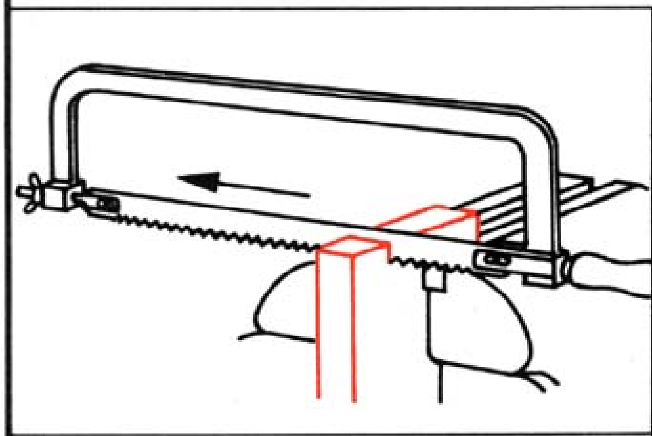

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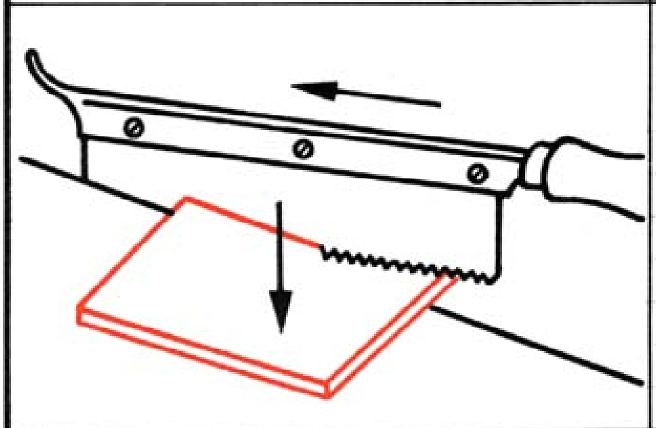

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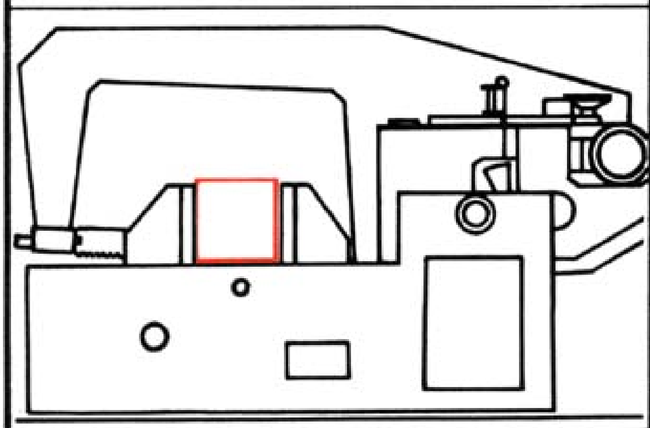
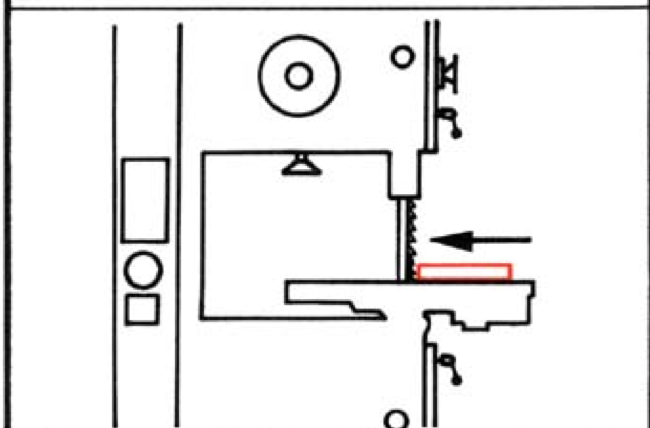
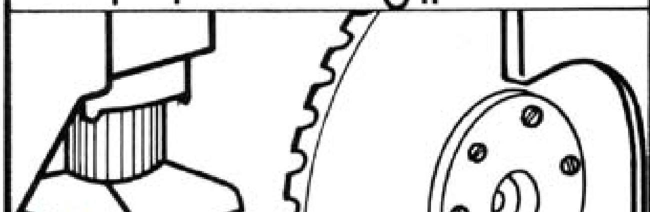


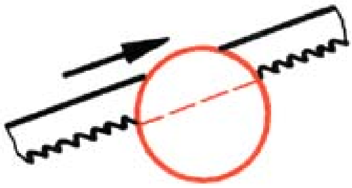
1.3



1.4



1.5



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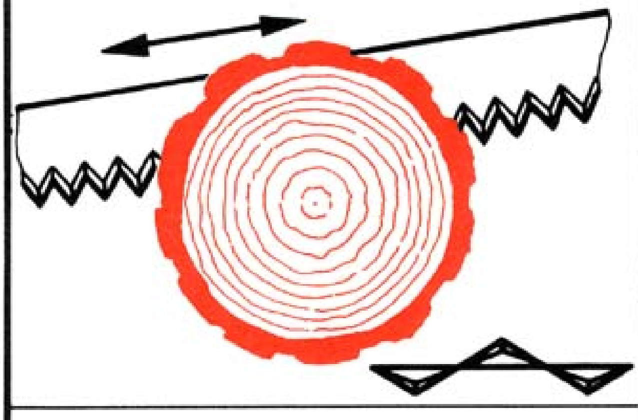

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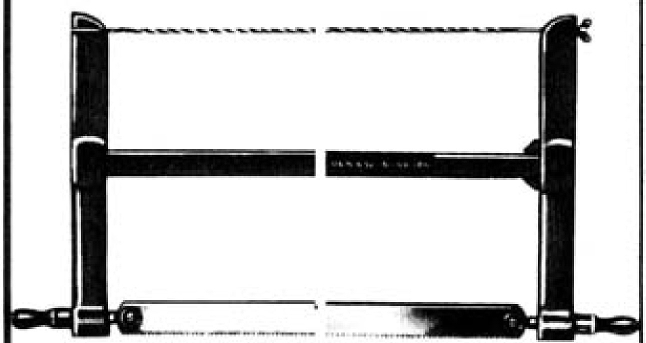

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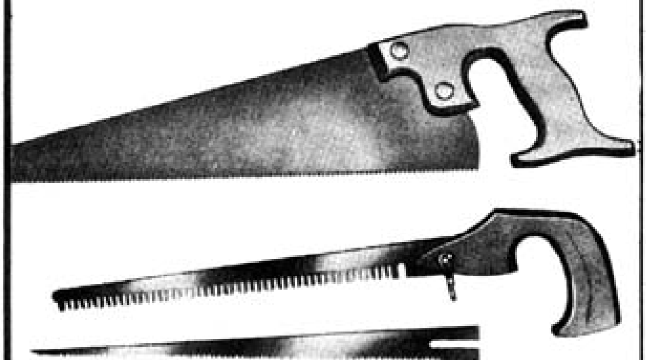

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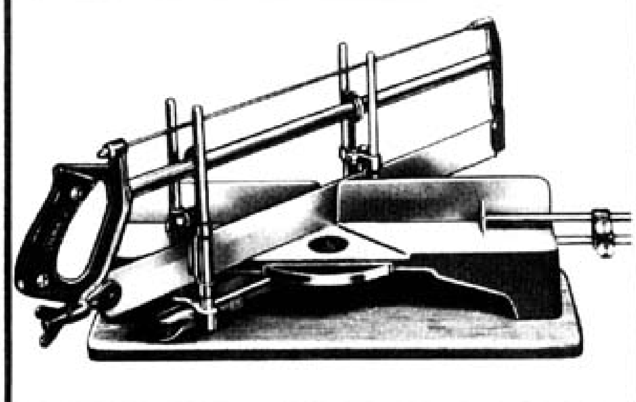
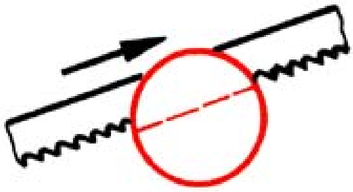


2.4

2.5



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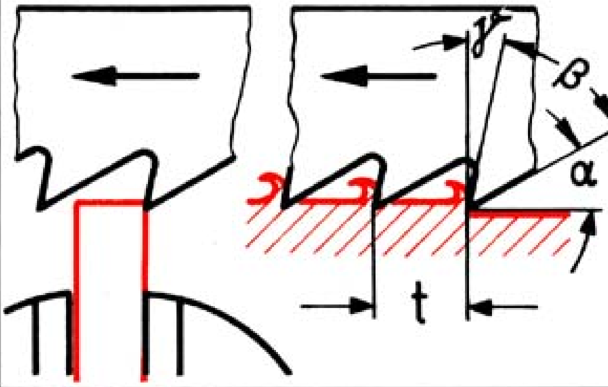
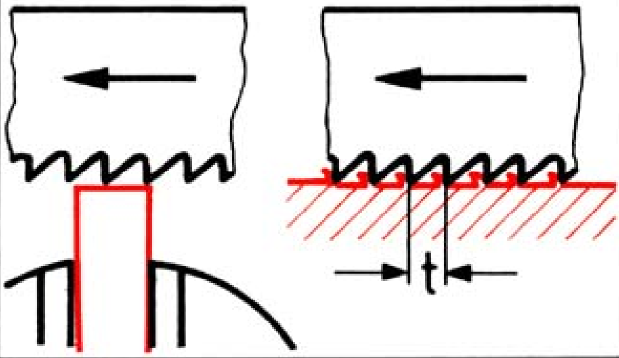


3.1

∢ $\alpha = 30°$

∢ $\beta = 50°$

∢ $\gamma = 10°$

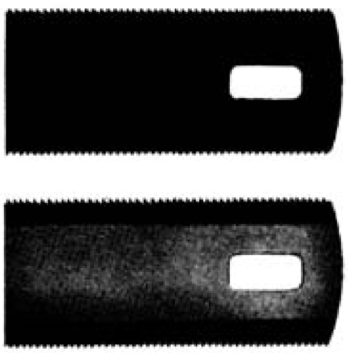


3.2

∢ $\alpha = 40°$

∢ $\beta = 50°$

∢ $\gamma = 0°$



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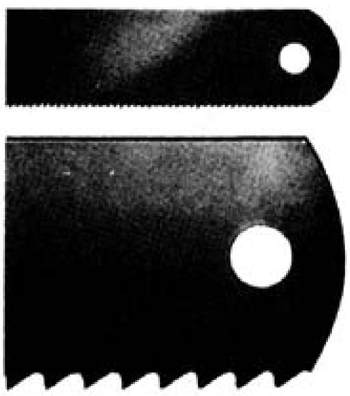

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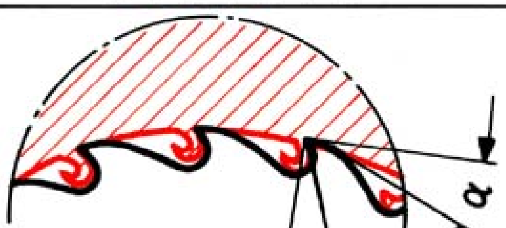

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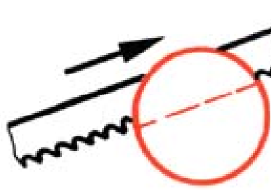

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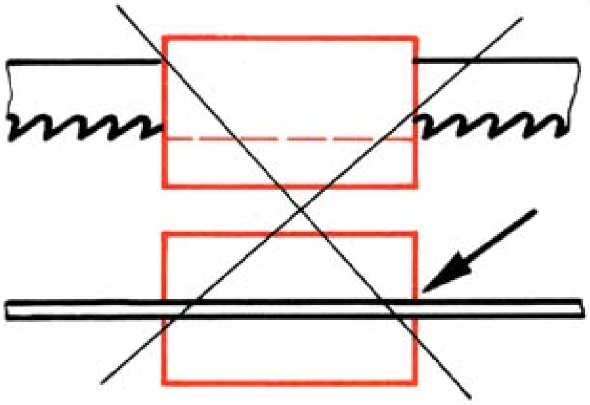
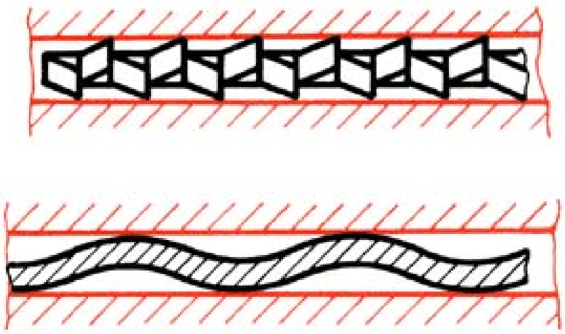


4.1



4.2

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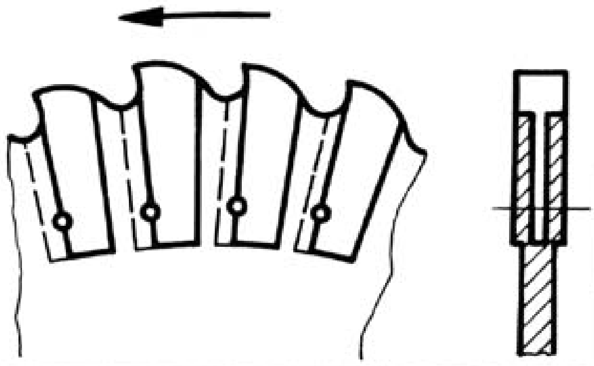

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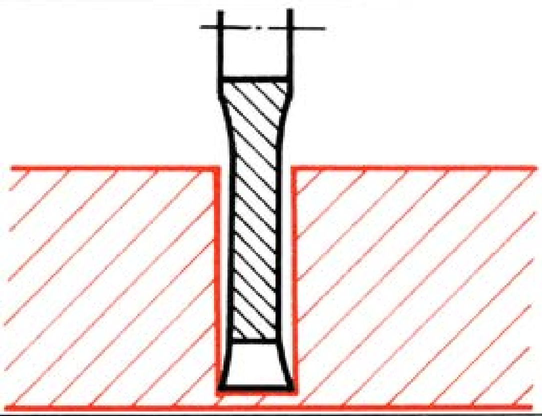

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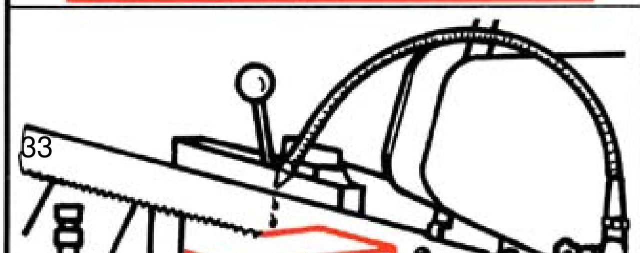
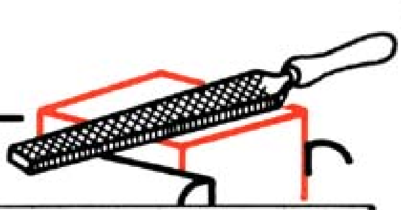


4.5

7. Filing – Feilen



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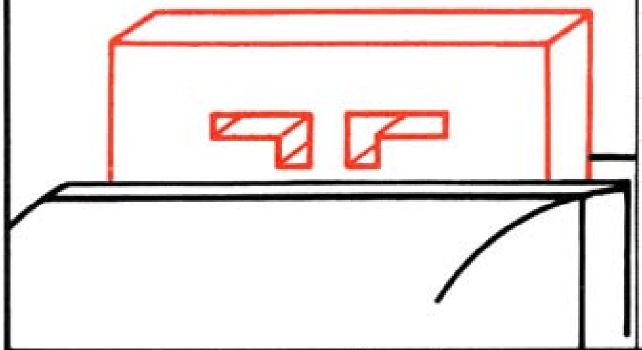

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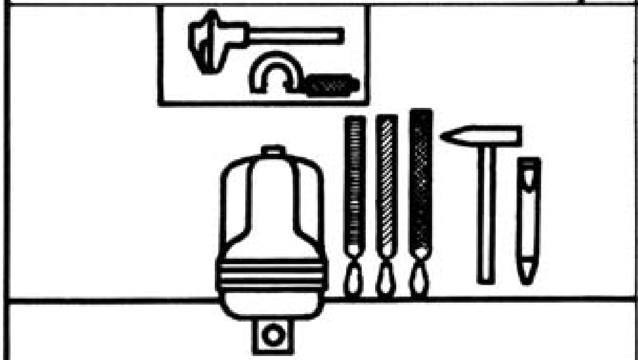
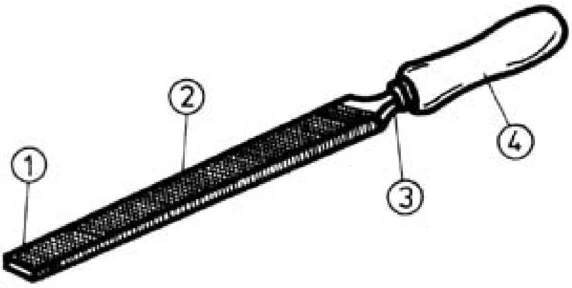


1.2



1.3

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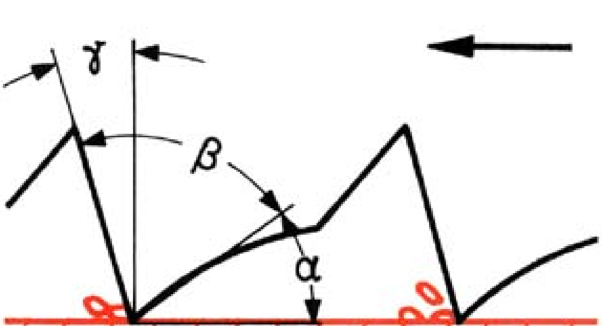
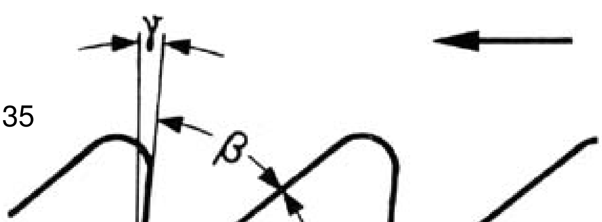


1.4

∢ α

∢ β

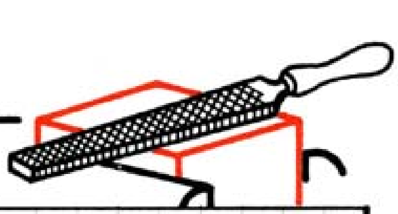
∢ γ



1.5

∢ α

∢ β



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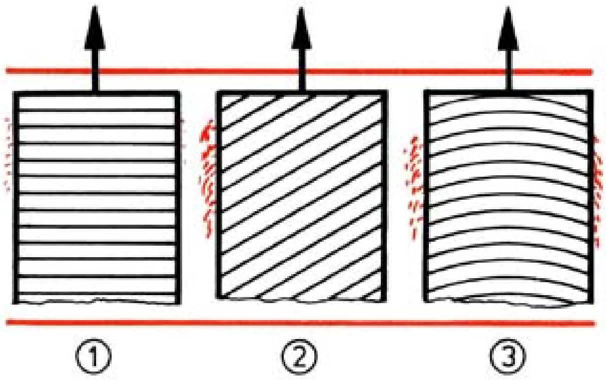

2.1

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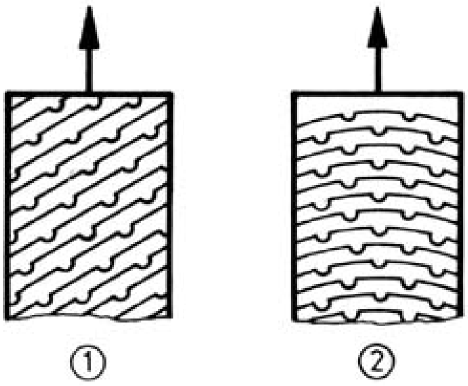

2.2

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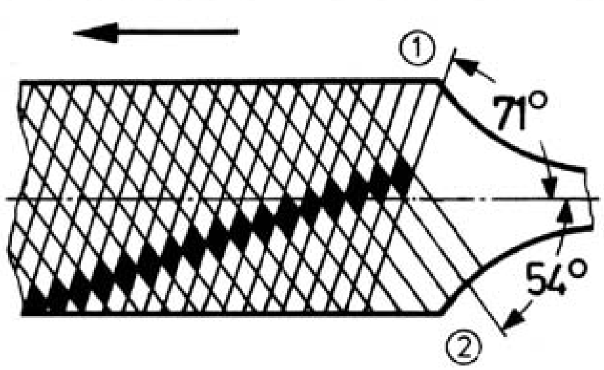
②



2.3

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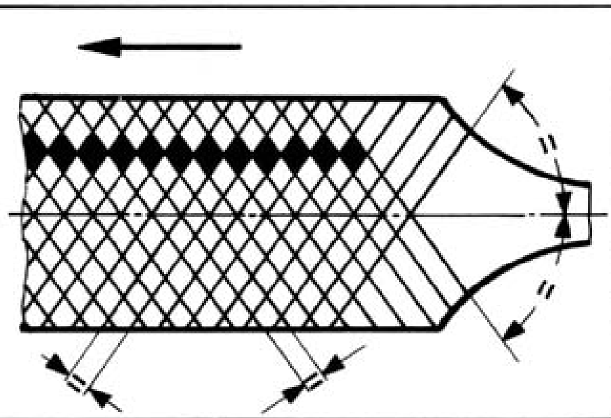
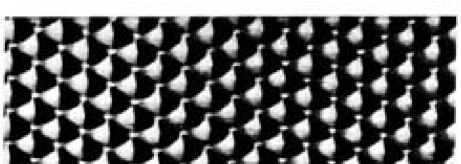
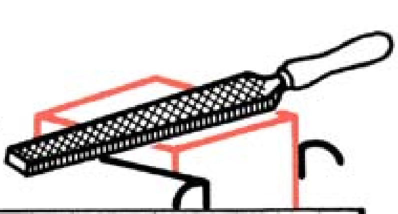
②



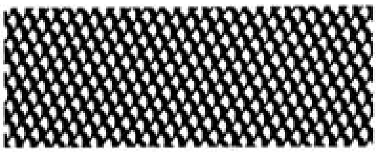
2.4



2.5



3.1



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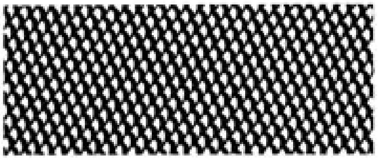

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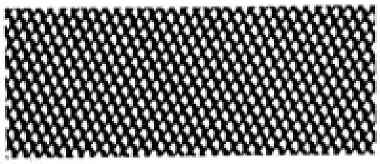

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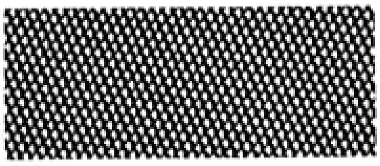

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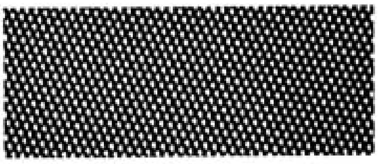

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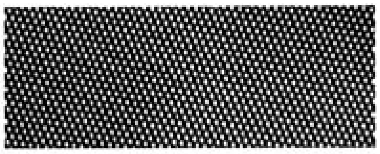

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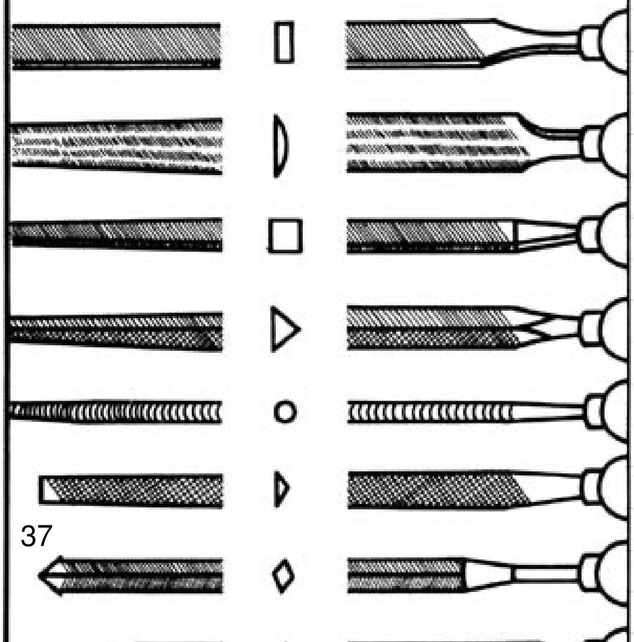

3.41

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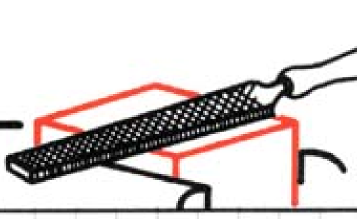
4



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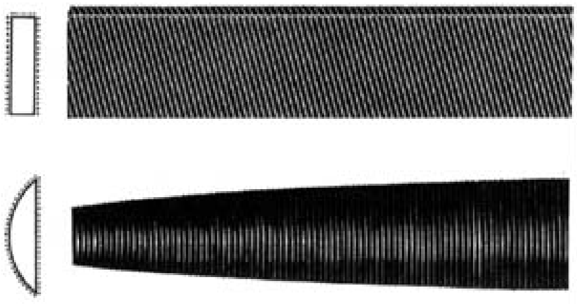

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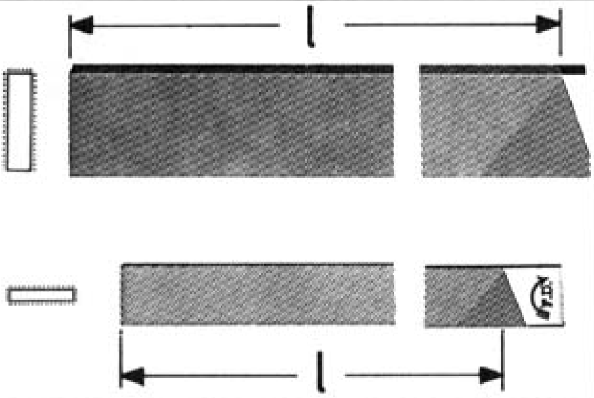

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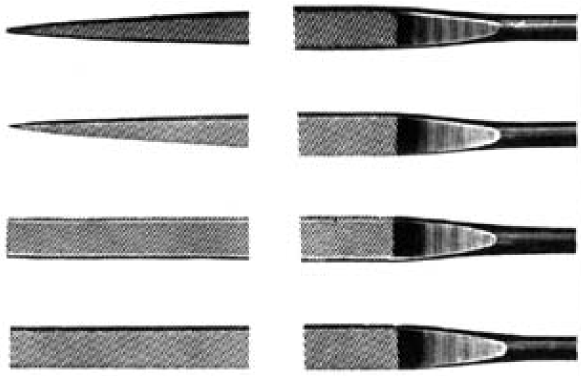

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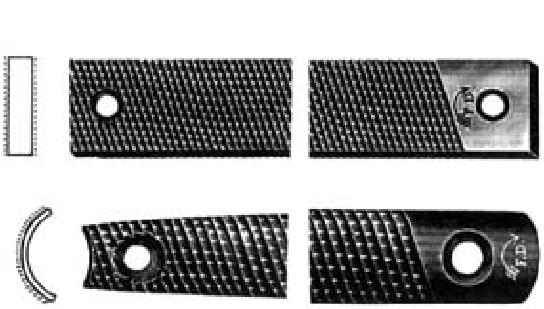

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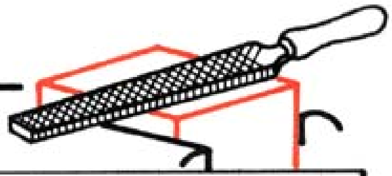

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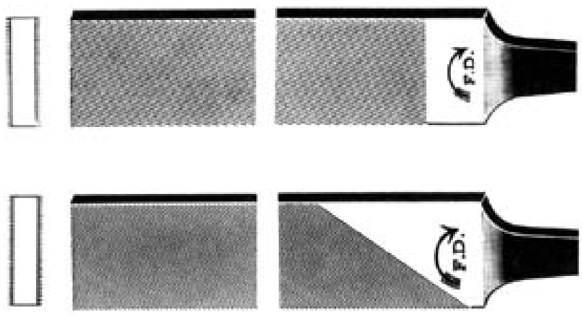

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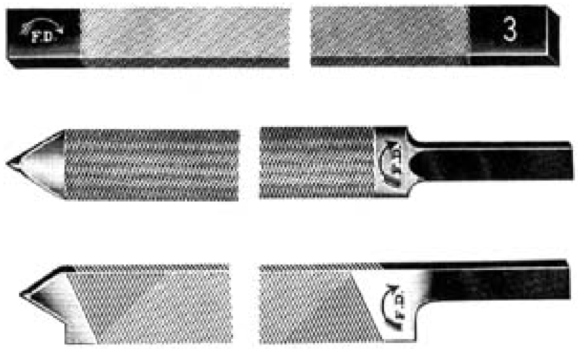

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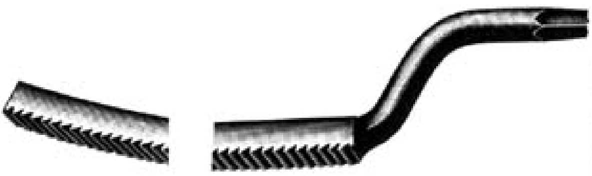

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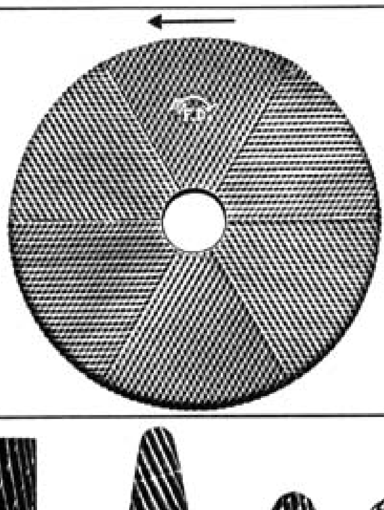
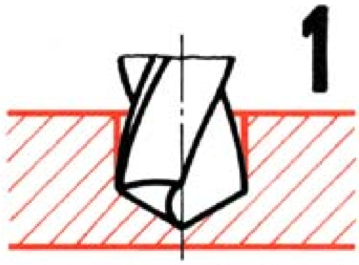
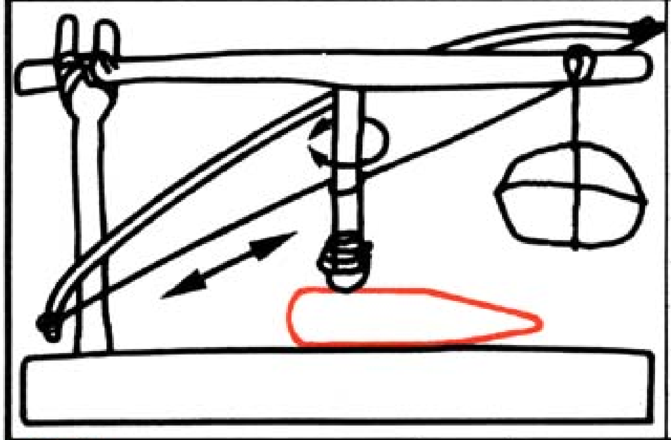


5.5

8. Drilling, Counterboring, Countersinking – Bohren, Reiben

1





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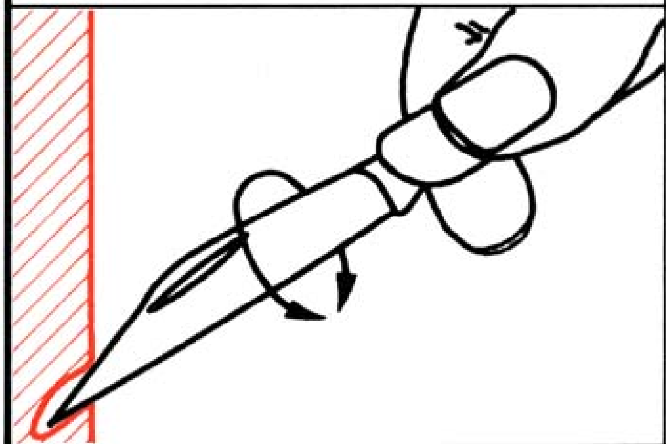

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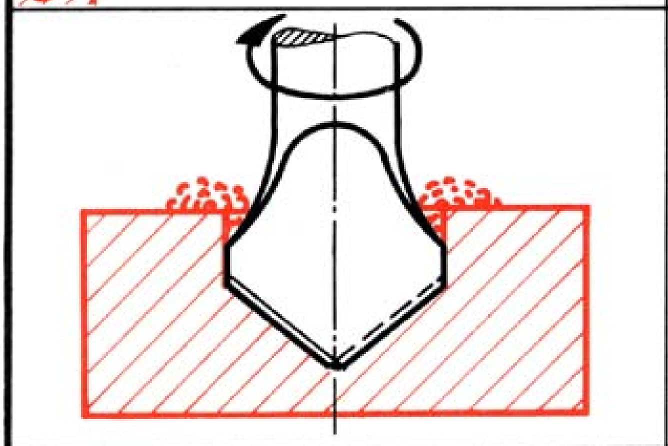

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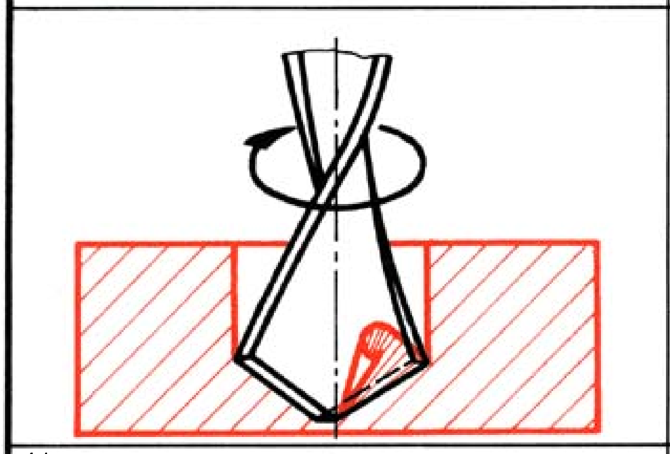
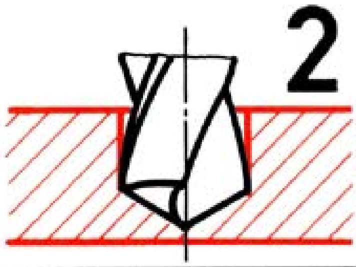


1.4

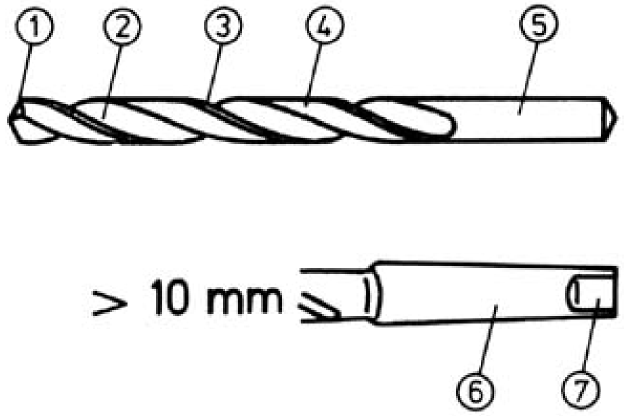
41

1.5

2



2.1



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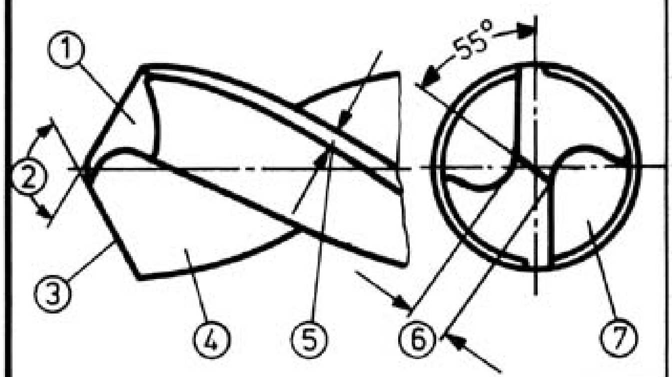
2.2



①
② ∢ б
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④
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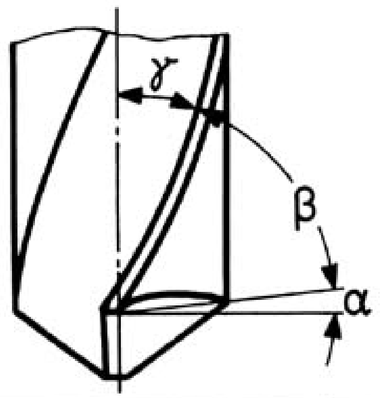
⑥
⑦

2.3

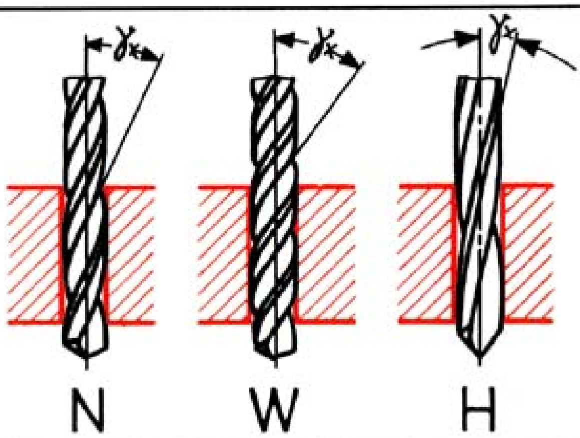


∢ α =

∢ β =

∢ γ =

2.4

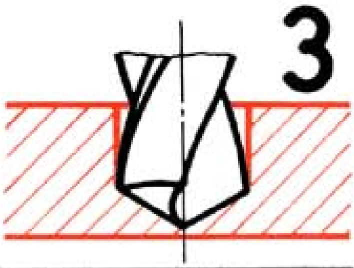


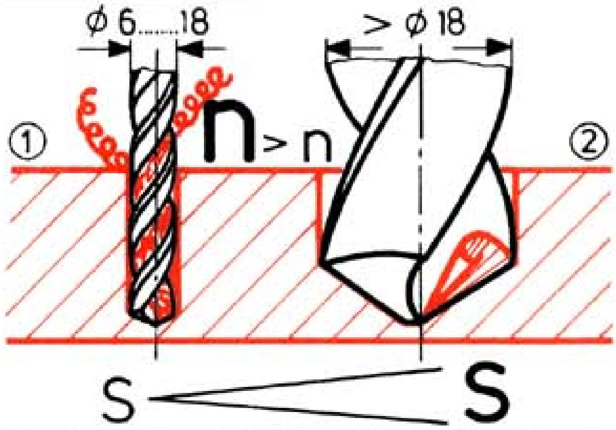
N - ∢ γ
W - ∢ γ
H - ∢ γ

2.5

∢ б

3





3.1

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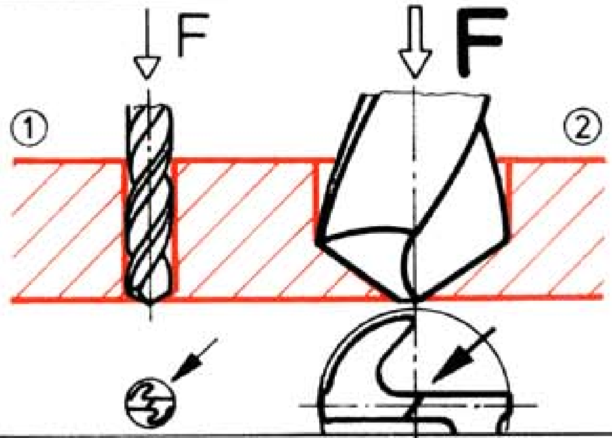

3.2

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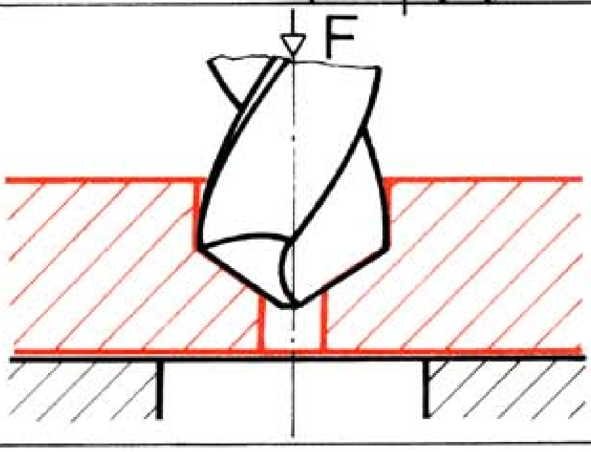

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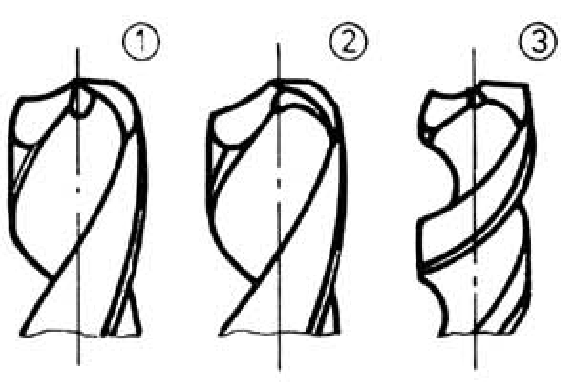

3.4

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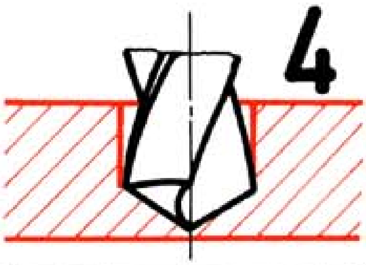

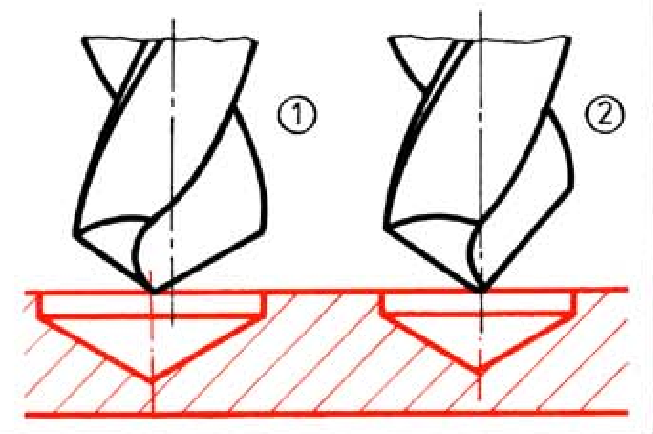

4.1

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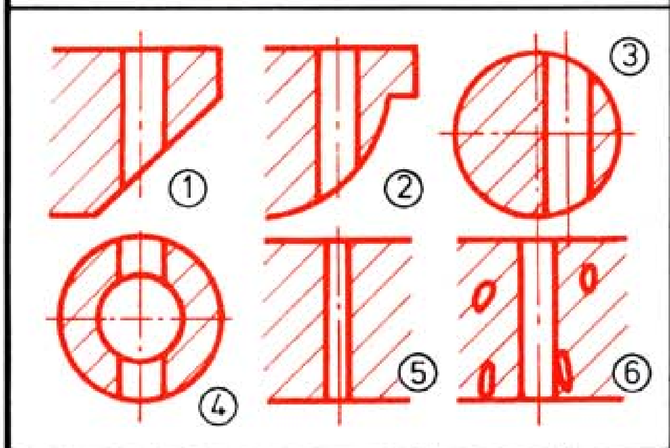

4.2

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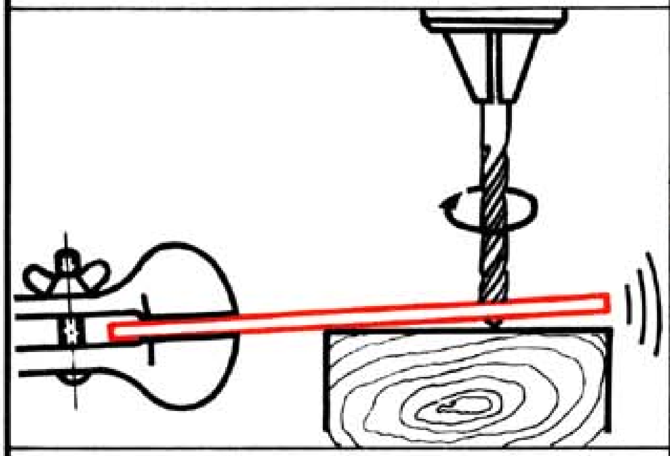
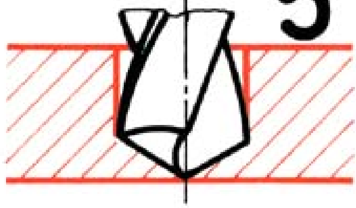


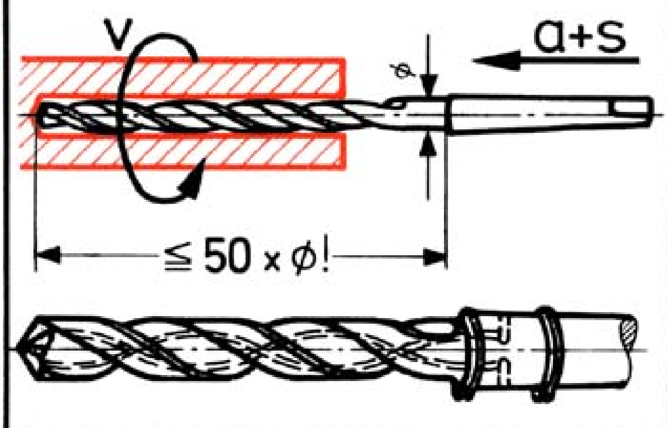
4.3

4.4

4.5

5





5.1

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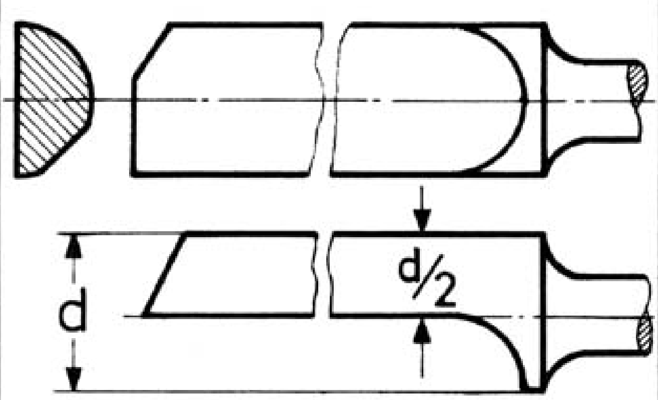

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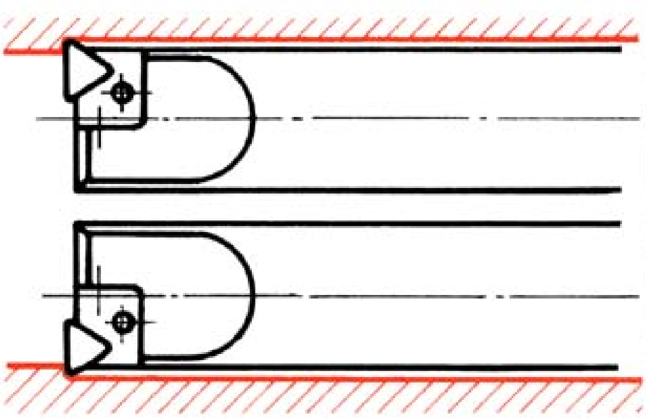

5.3

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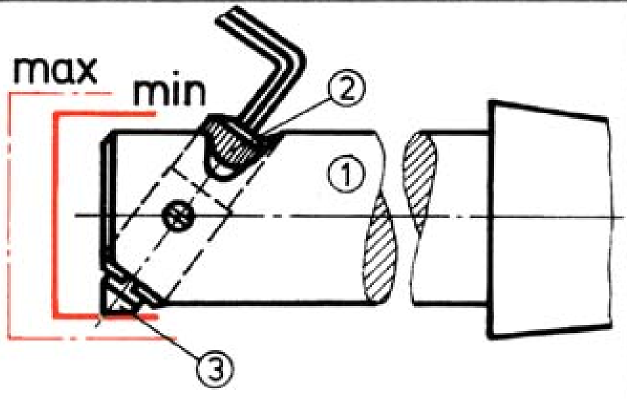

5.4

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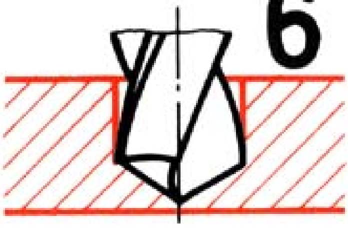
5.5



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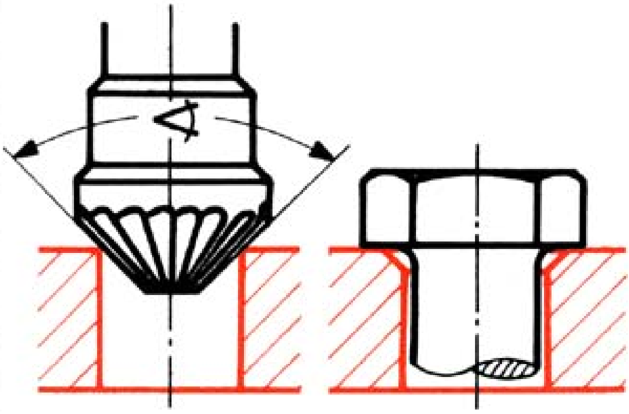
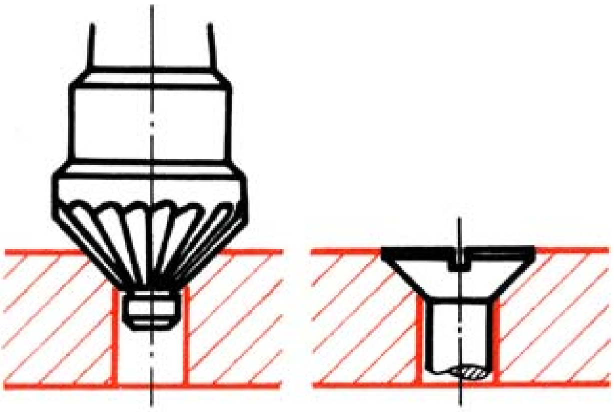


6.1

$\sphericalangle$ = 60°, 75°, 90°, 120°



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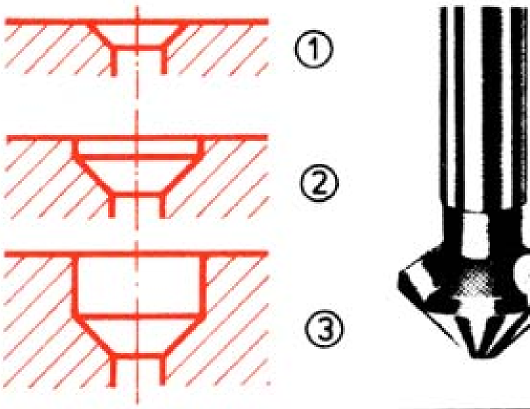

6.3

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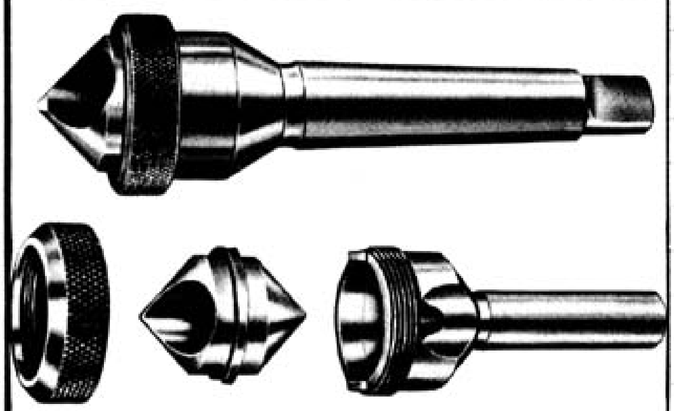
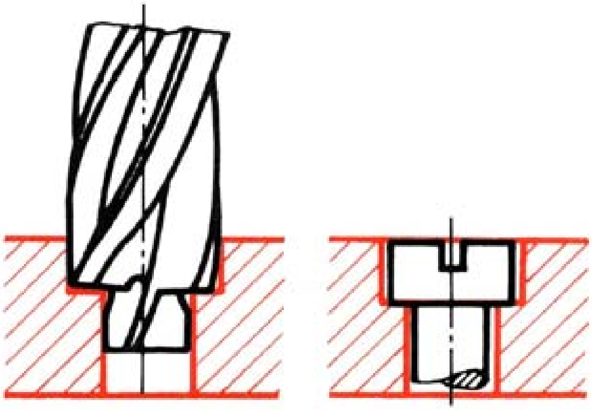


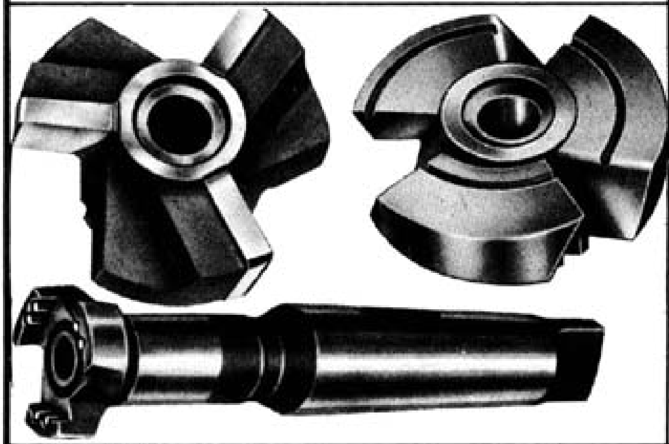
6.4

6.5

7



7.1



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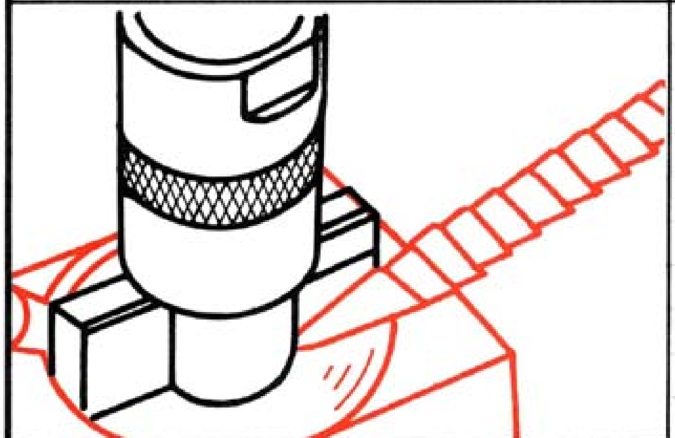

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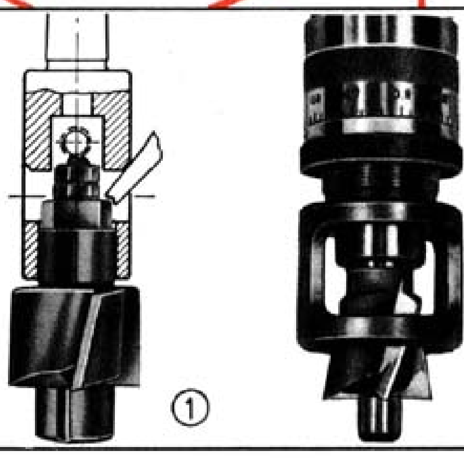

① ②

7.4

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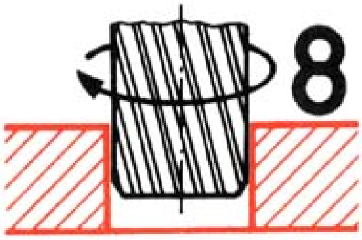
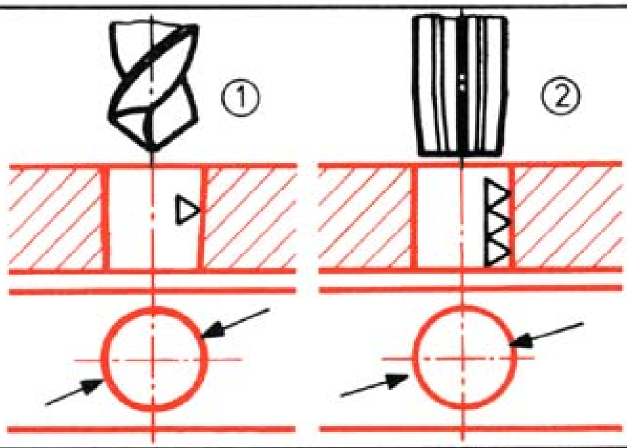
47

7.5



8

8.1



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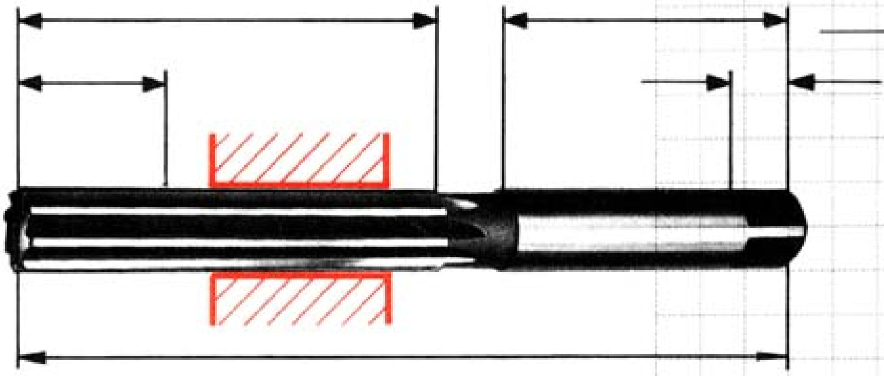
8.2



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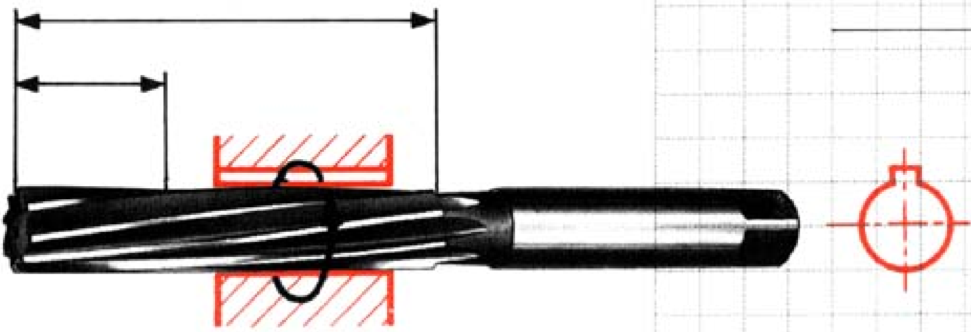

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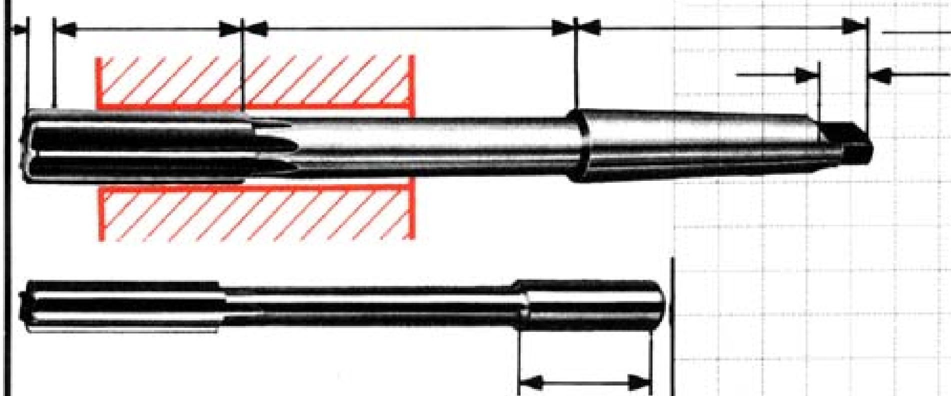

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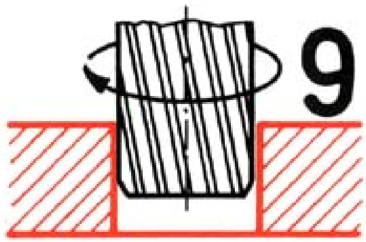

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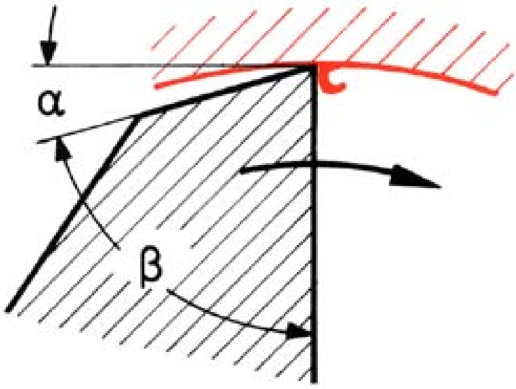
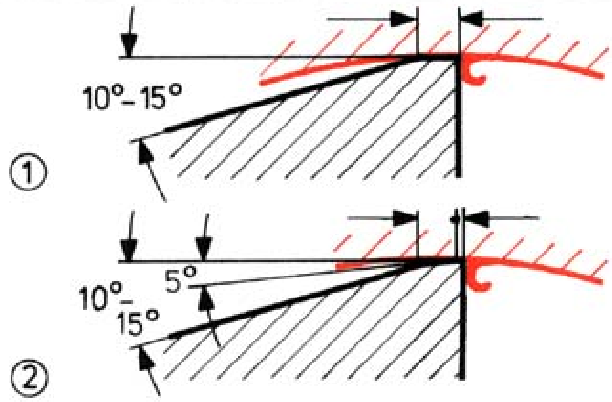


9.1

∢ α =

∢ β =

∢ γ =



9.2

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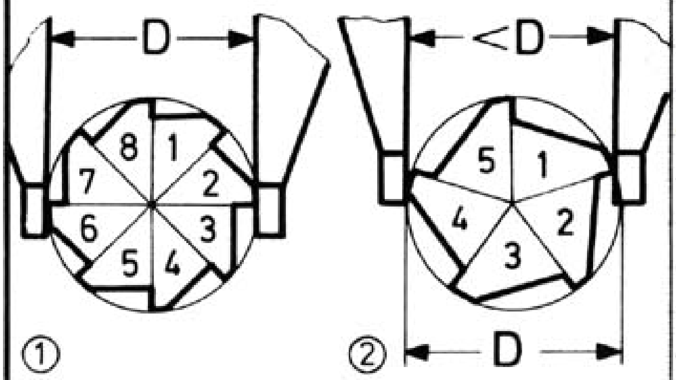

9.3

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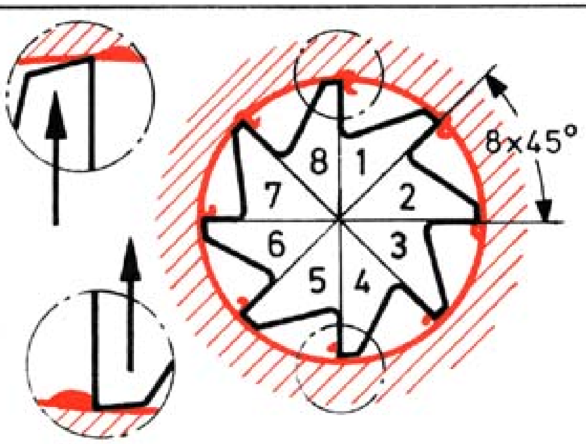
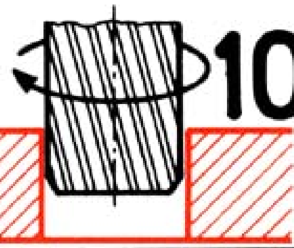
②



9.4

9.5



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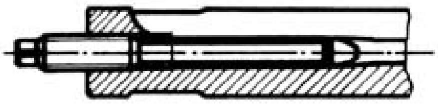
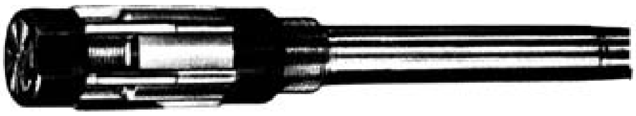
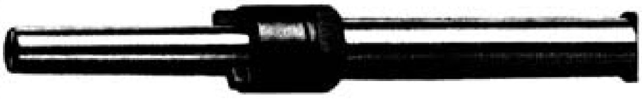


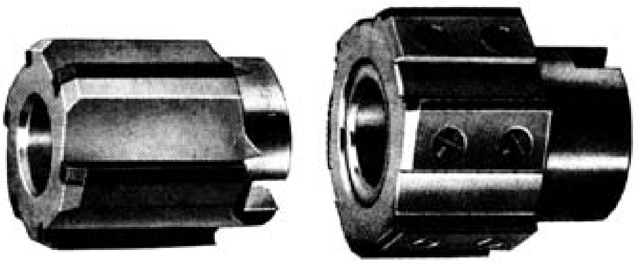
10.1



10.2



10.31



① ②

10.32

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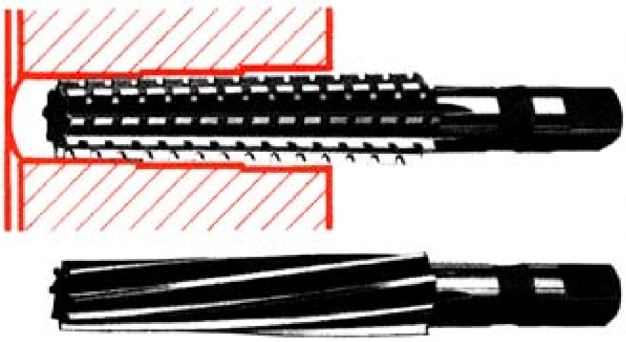
②



10.4

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10.5

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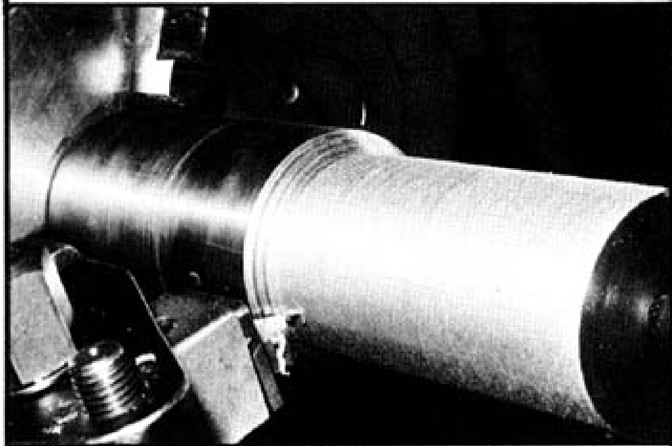
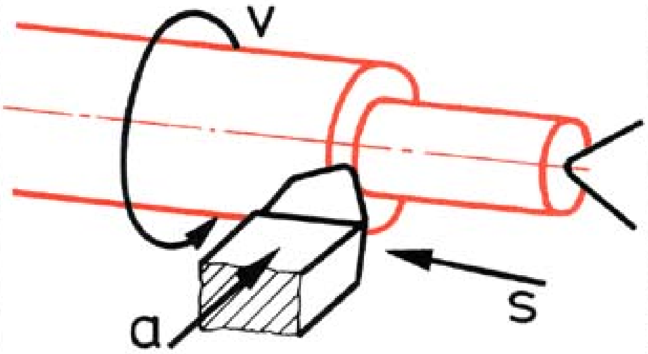
9. Turning – Drehen

1

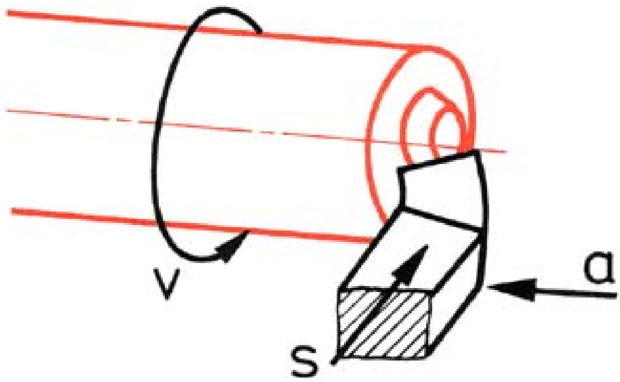


1.1



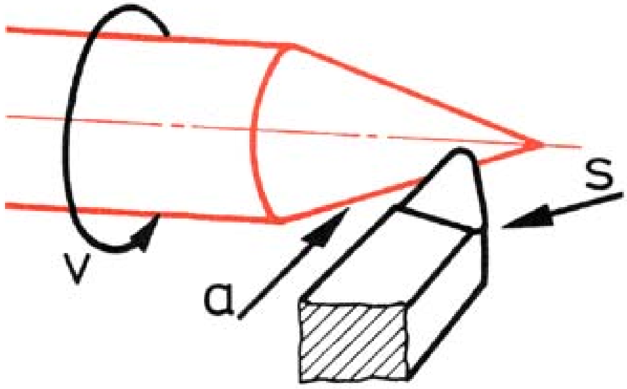
1.2

v –
a –
s –



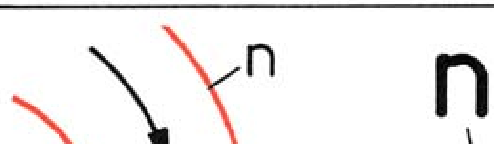
1.3

v –
a –
s –

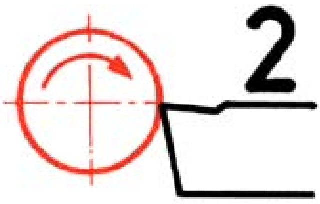


1.4

v –
a –
s –



1.5



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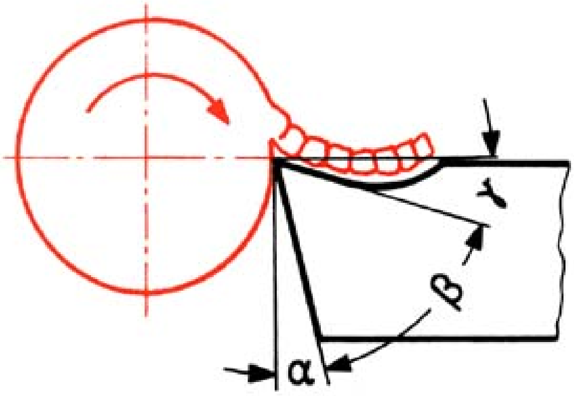
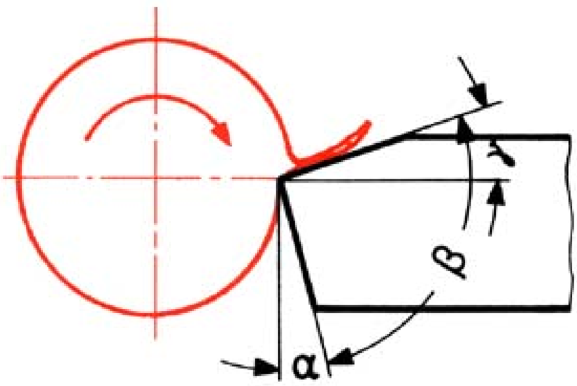


2.1

∢ α =
∢ β =
∢ γ =



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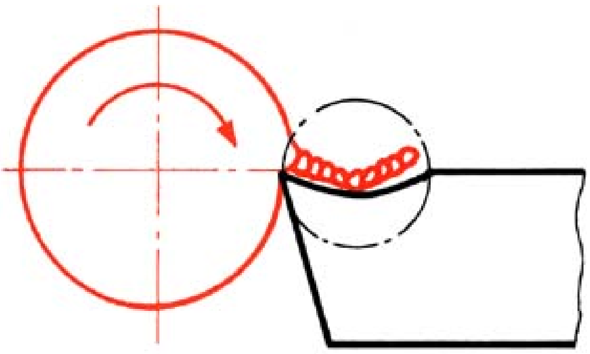

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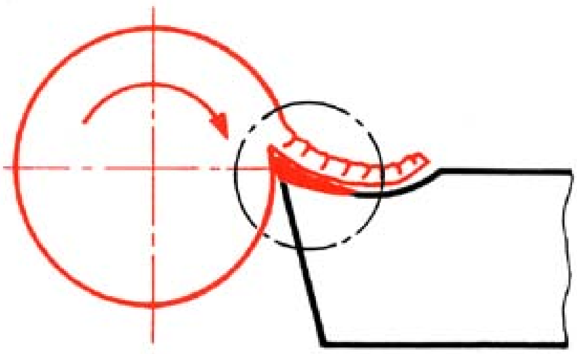

2.4

53

2.5

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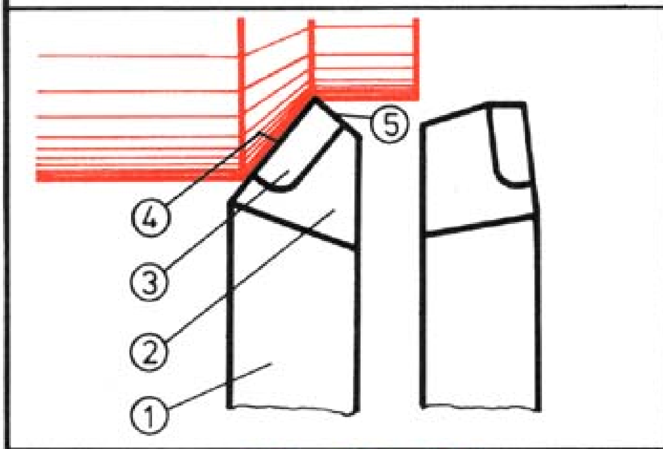
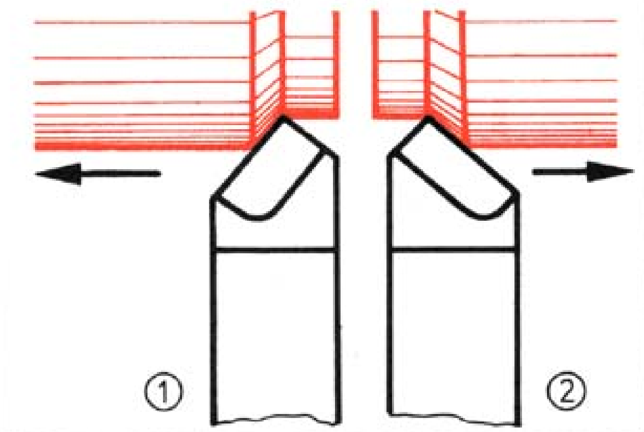
3



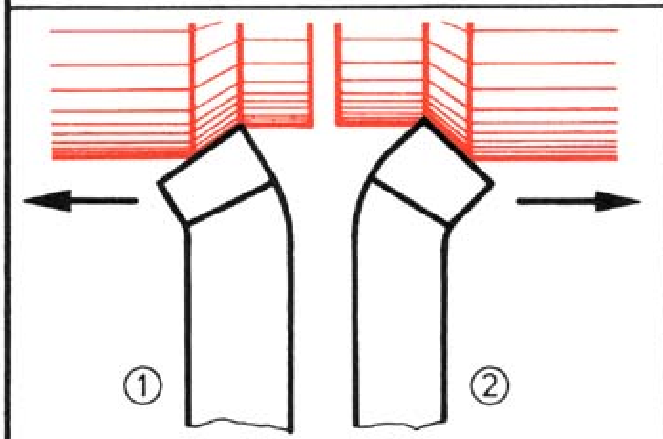
3.1

1
2
3
4
5



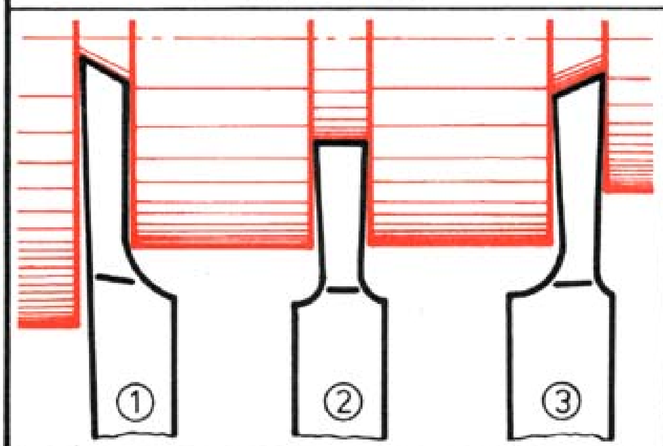
3.2

1
2



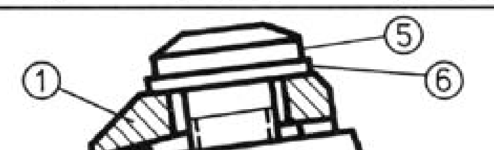
3.3

1
2



3.4

1
2
3

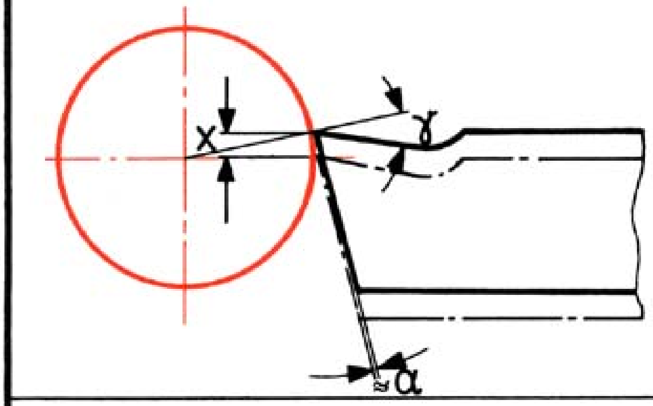


3.5

1

4

4.1

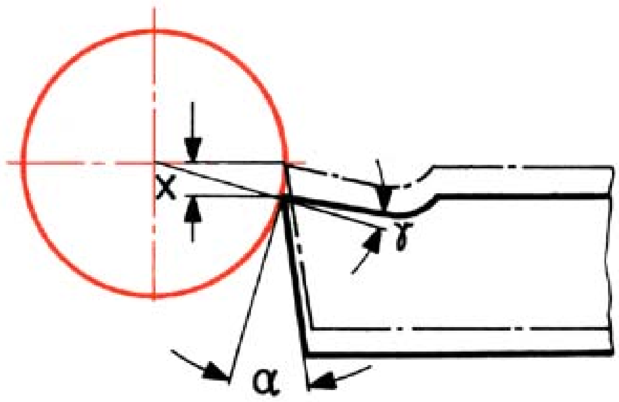


$\sphericalangle \alpha =$

$\sphericalangle \beta =$

$\sphericalangle \gamma =$

4.2

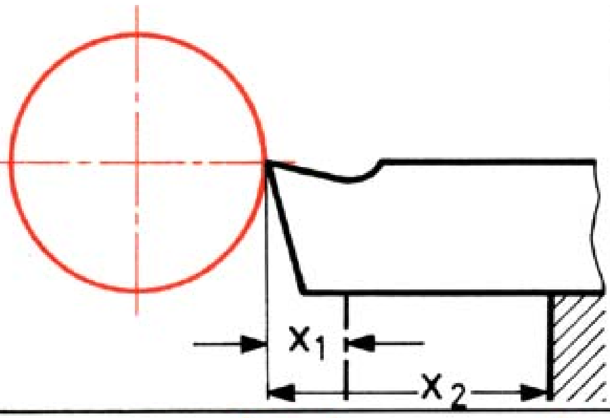


$\sphericalangle \alpha =$

$\sphericalangle \beta =$

$\sphericalangle \gamma =$

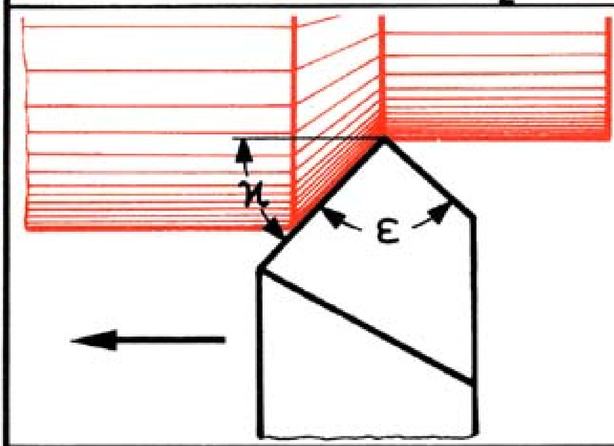
4.3



$x_1 =$

$x_2 =$

4.4

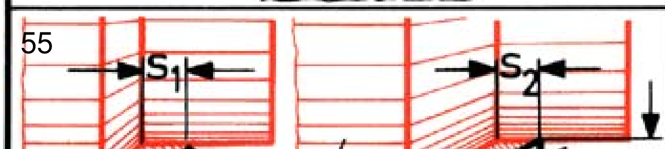


$\varepsilon =$

$\varkappa =$

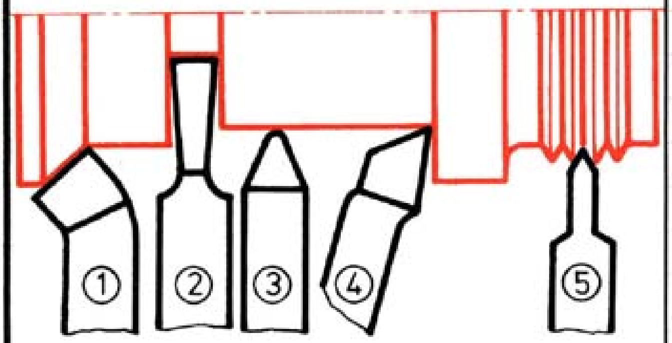
55

4.5



5

5.1



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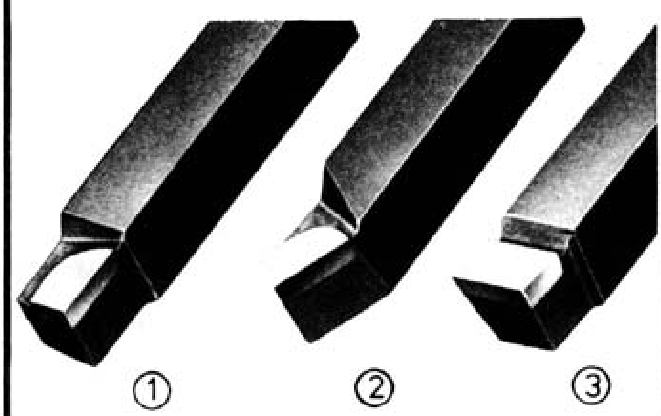
5.2



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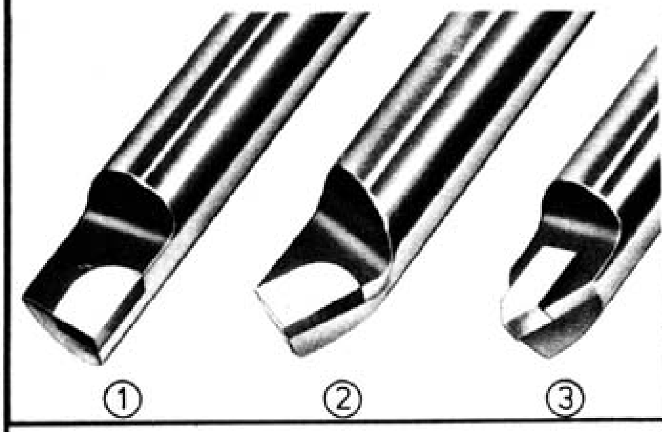
5.3



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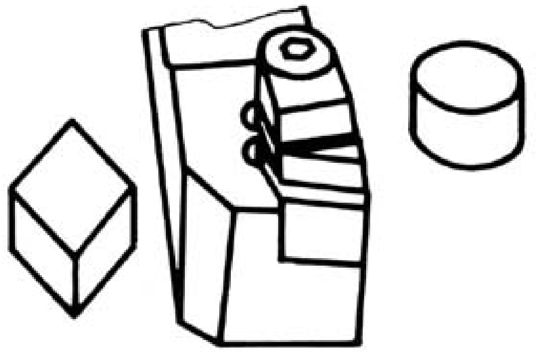
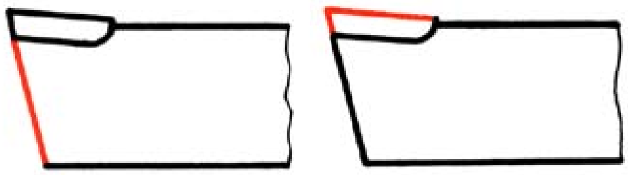
5.4



5.5

5a

5.1



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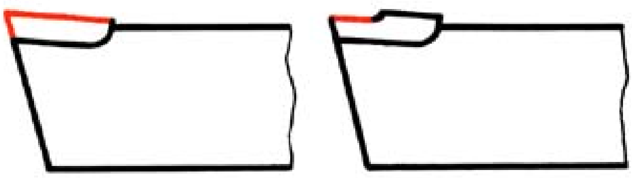
5.2



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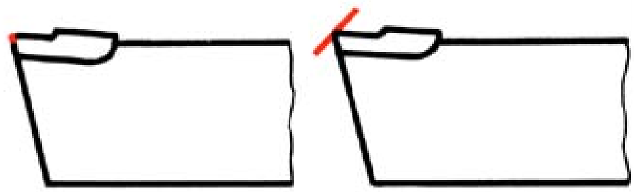
5.3



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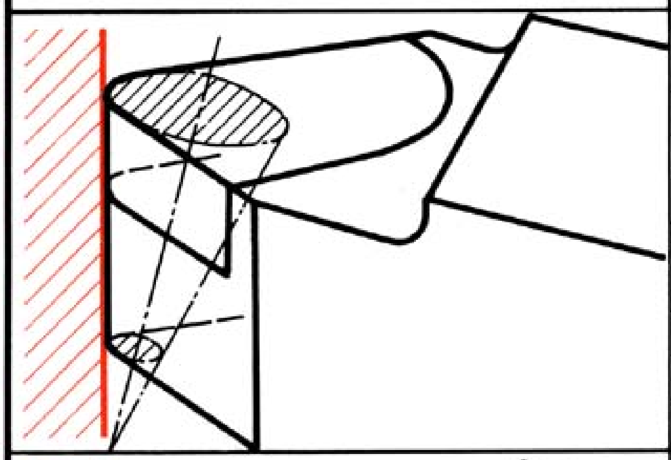
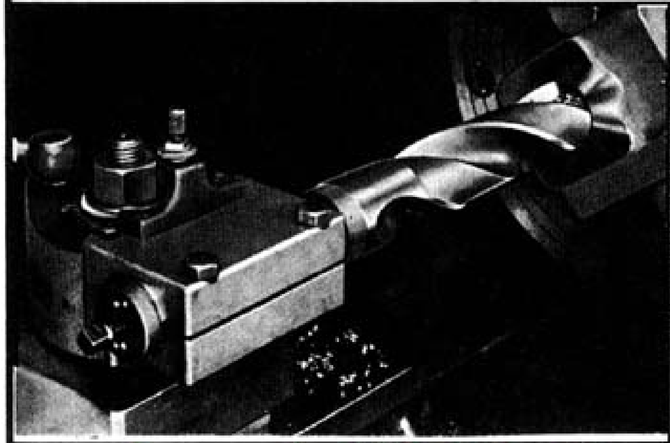
5.4



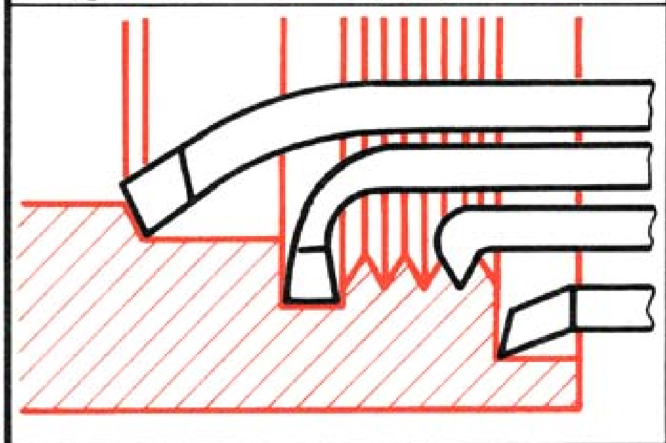
57

5.5

6



6.1



6.2

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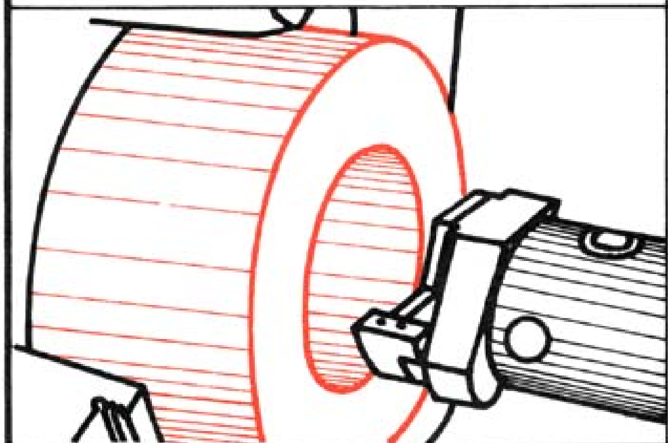

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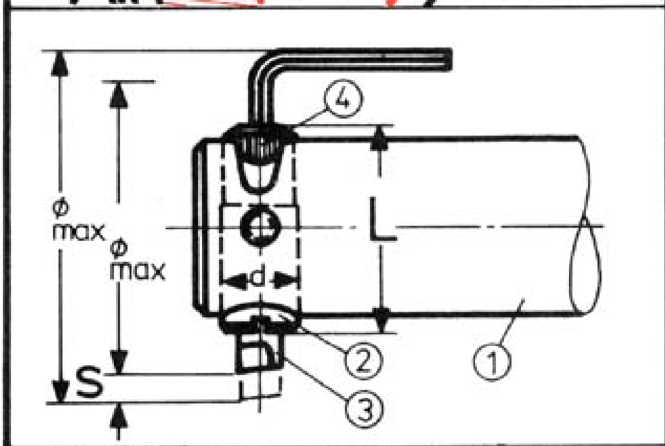

6.4

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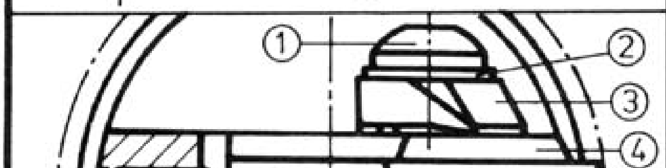
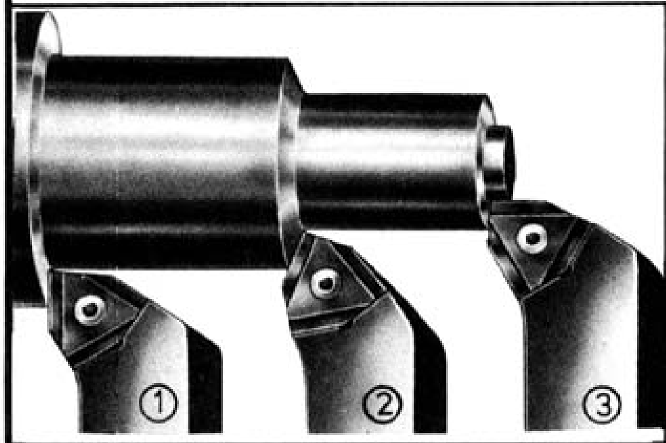


6.5

①

7



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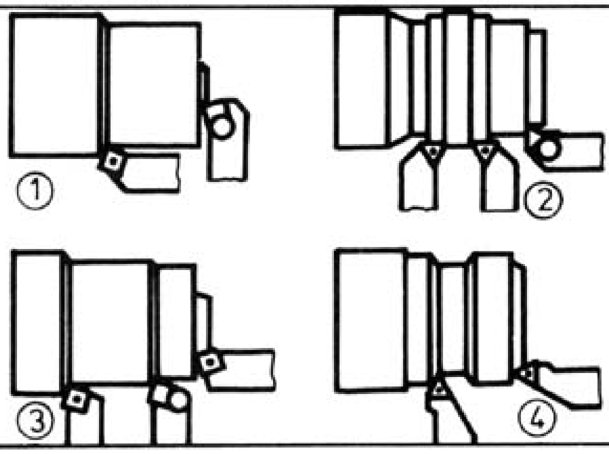

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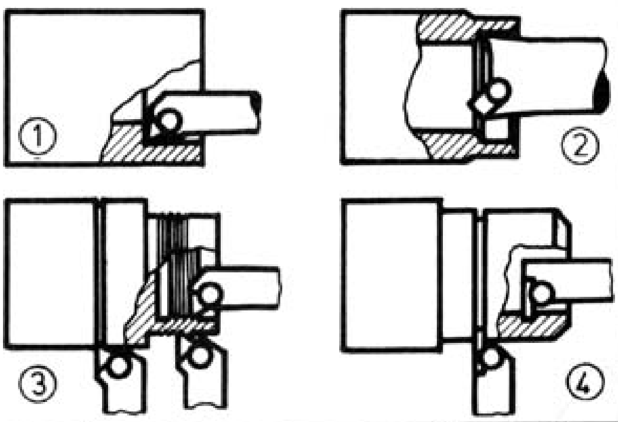

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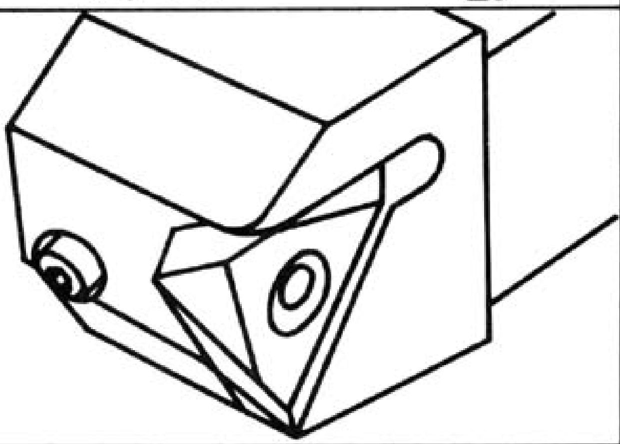

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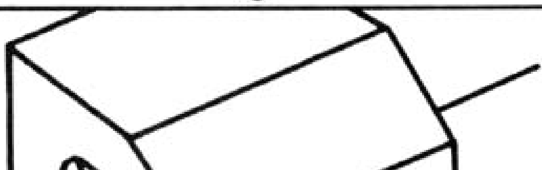

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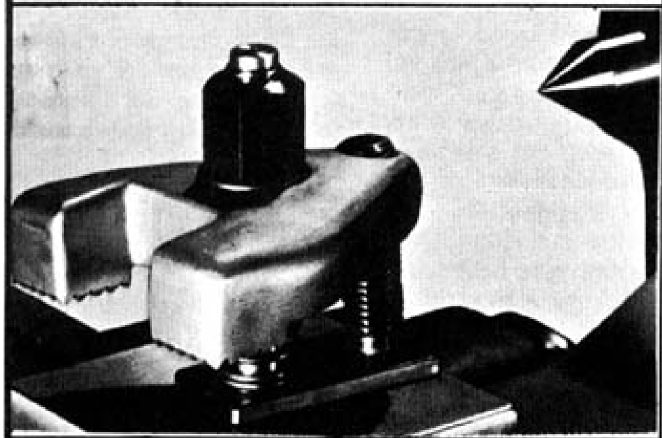

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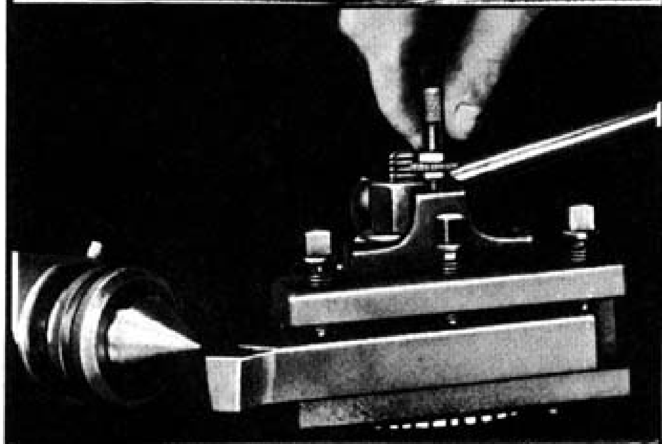

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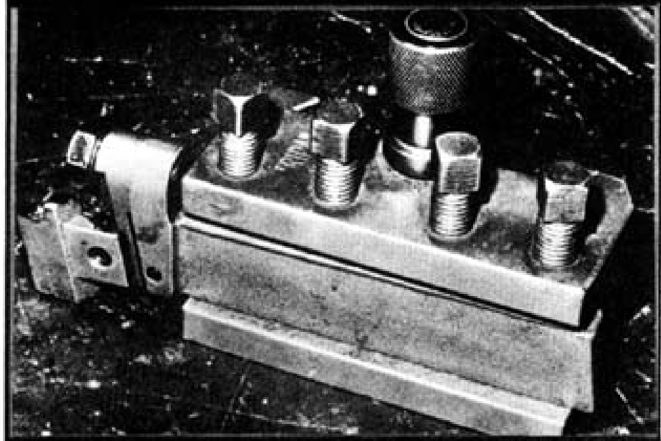

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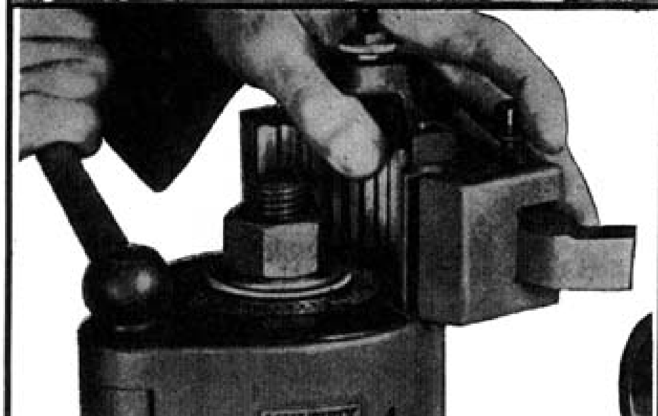
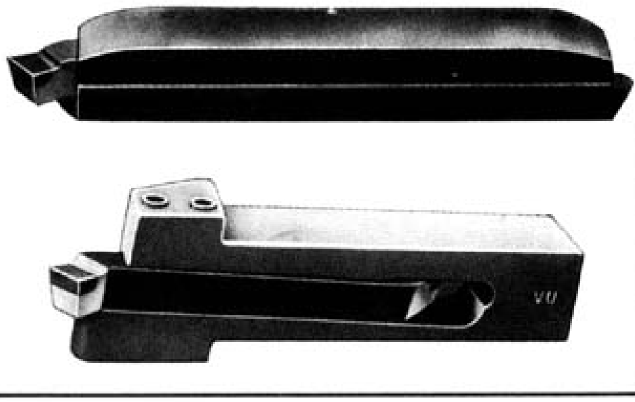


8.4

8.5

9

9.1



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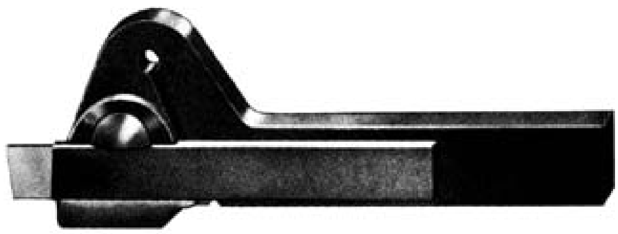

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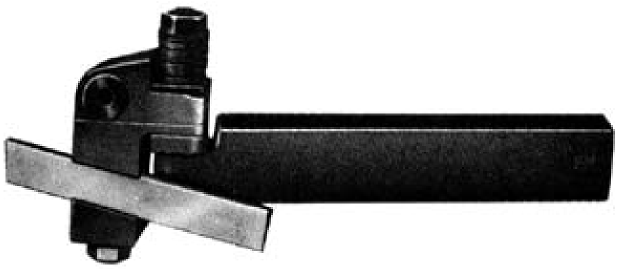

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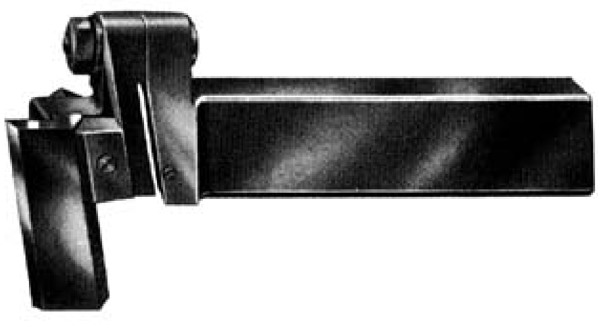
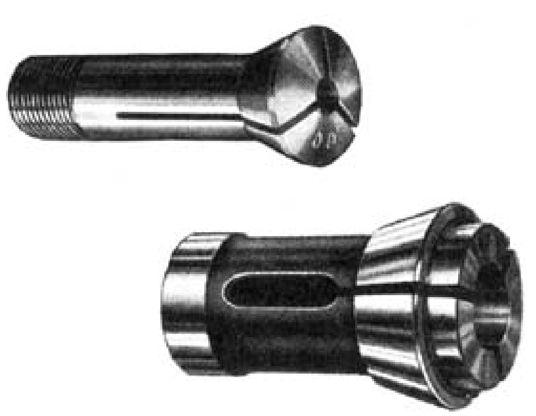


9.5

10

10.1



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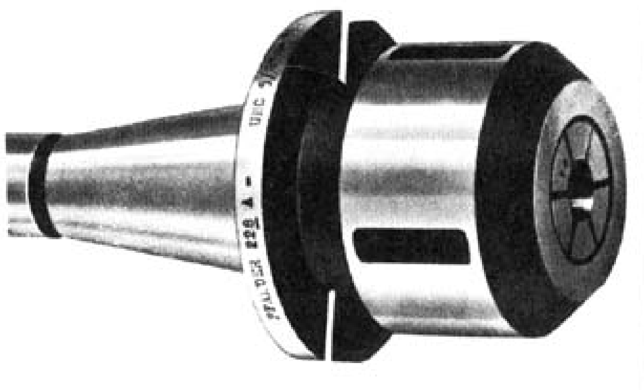

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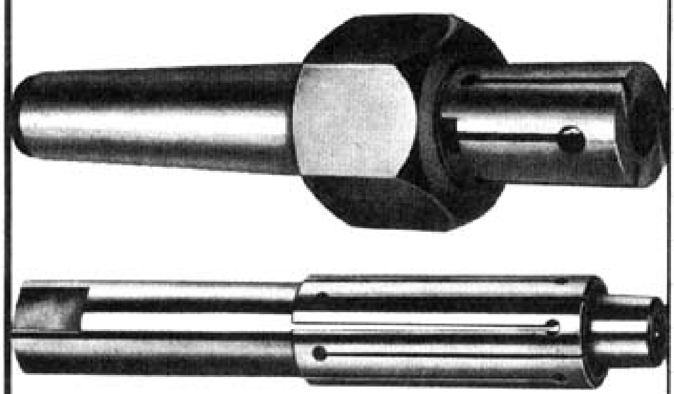

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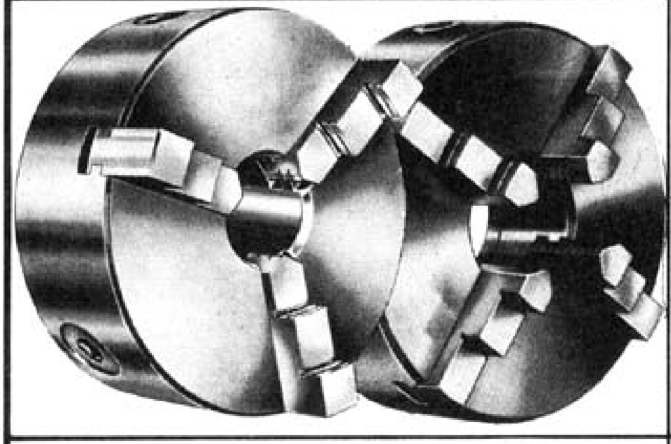
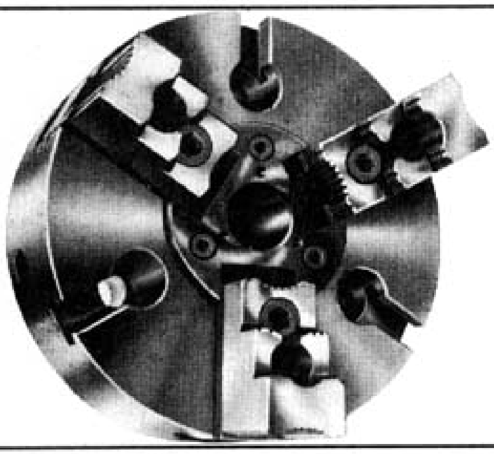


10.5

1

2

10a



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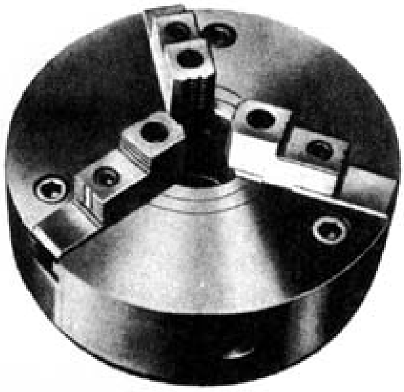

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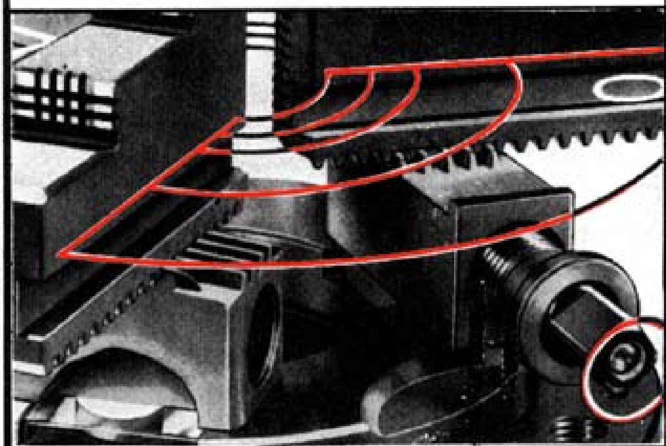

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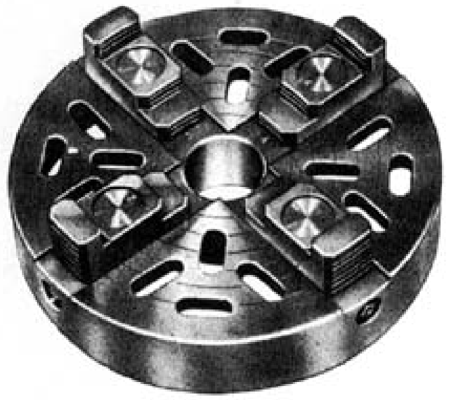
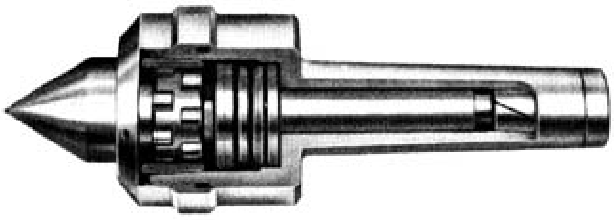


10.4

10.5

11

11.1



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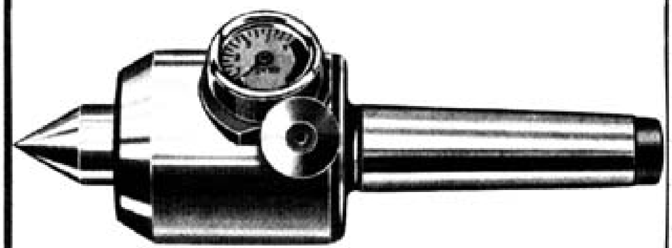

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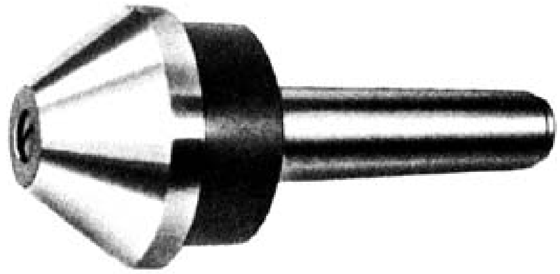

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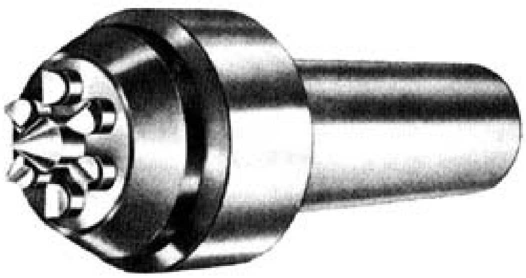
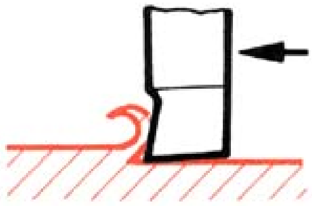


11.5

10. Shaping – Hobeln



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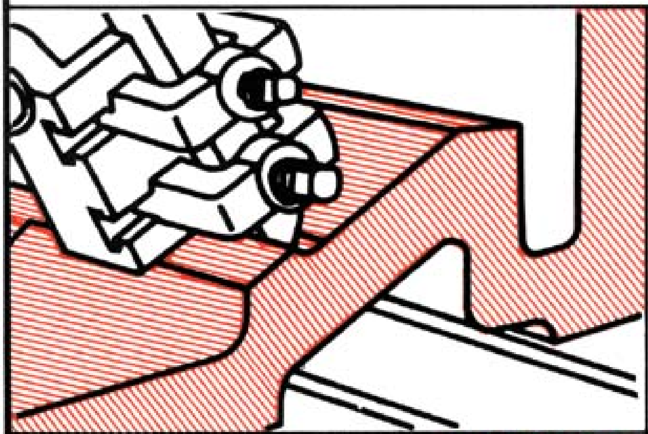
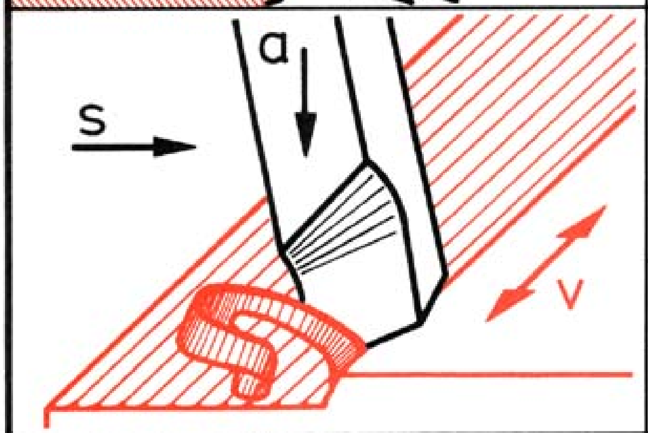
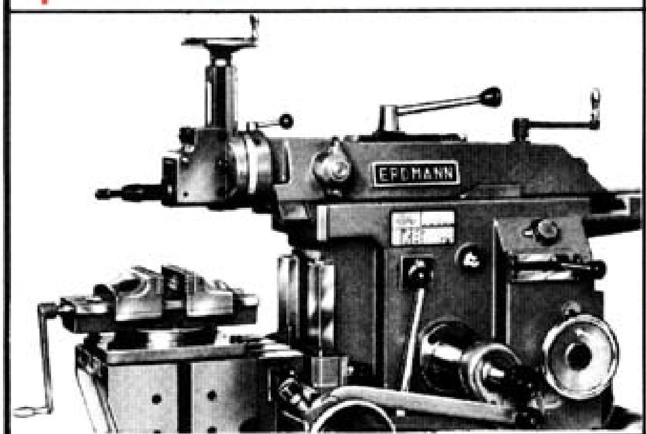


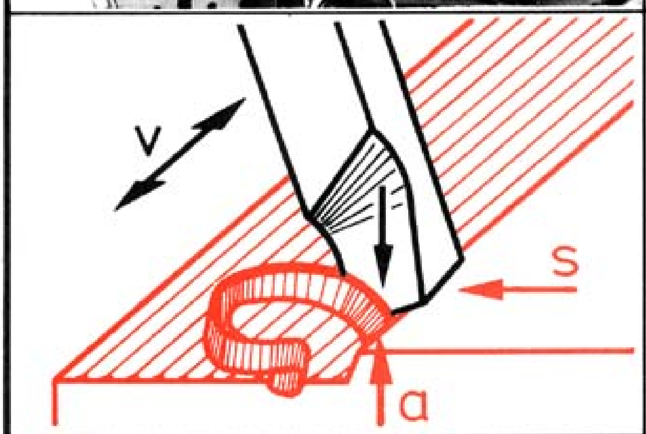
1.1



1.2



1.3



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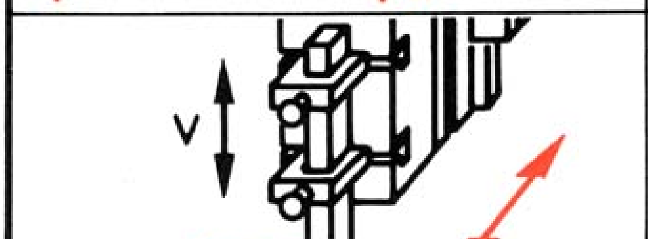
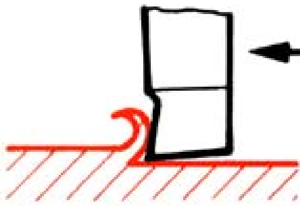
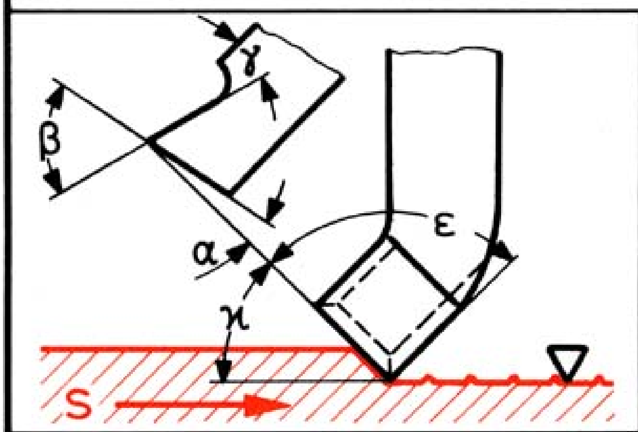


1.5

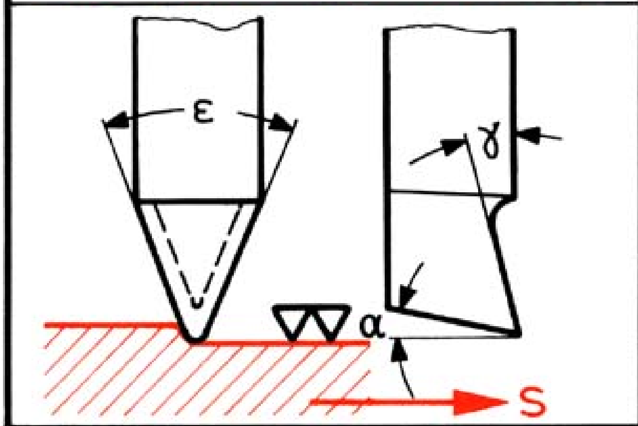


2

2.1



2.2



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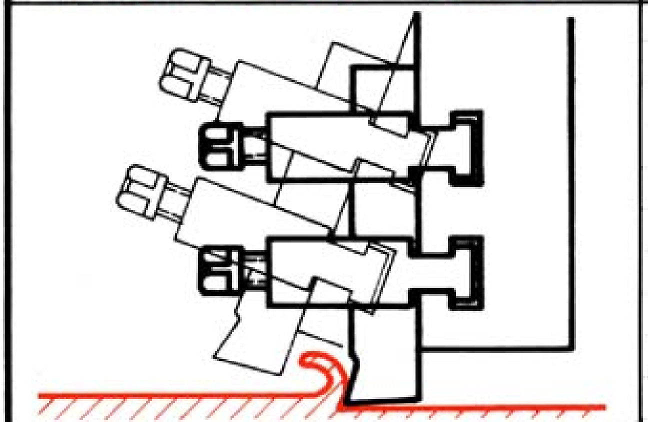

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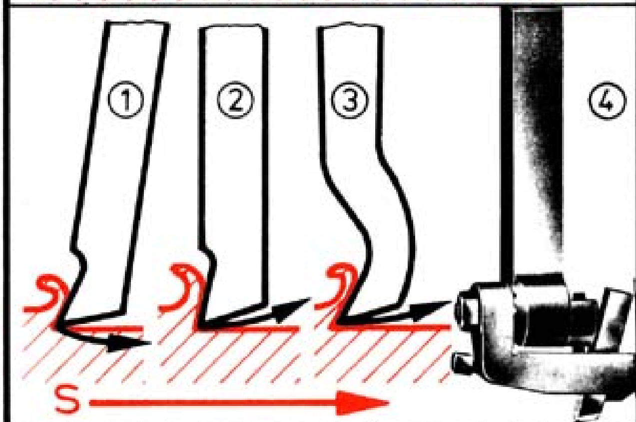

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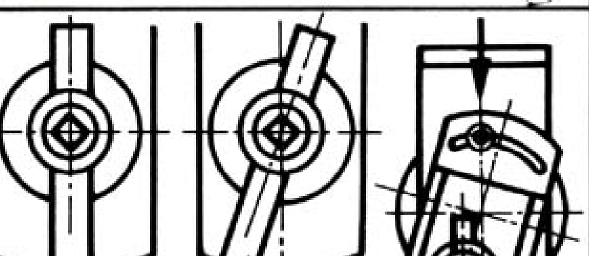
2.5



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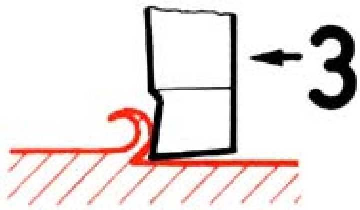
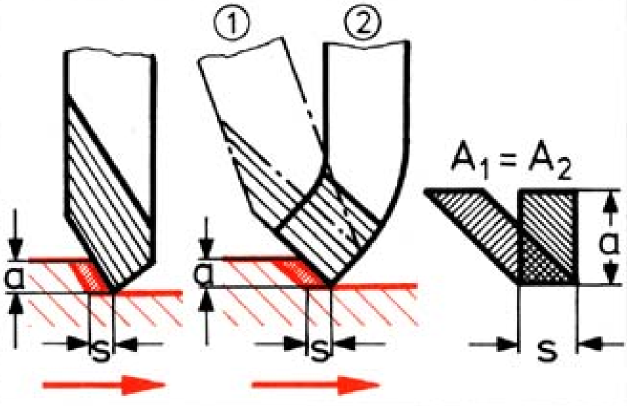


3.1



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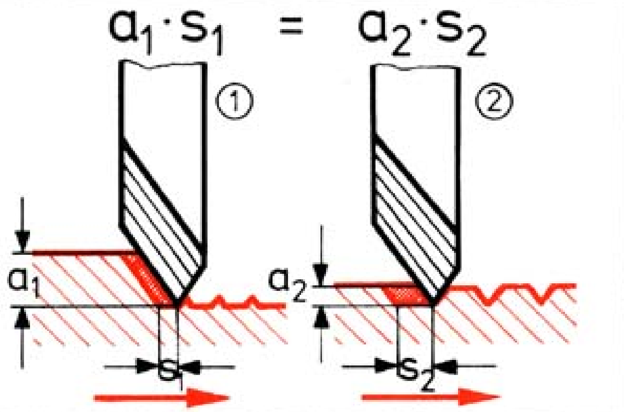
3.2



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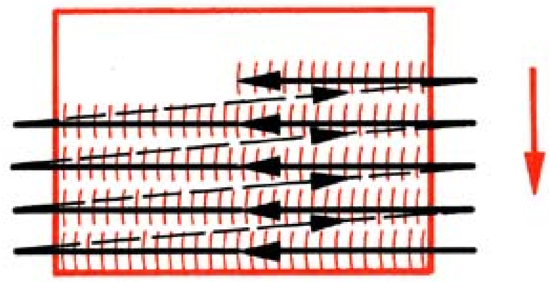
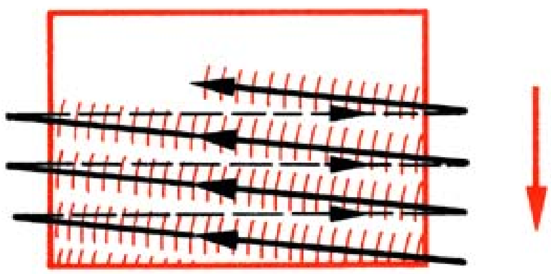
3.3



3.4



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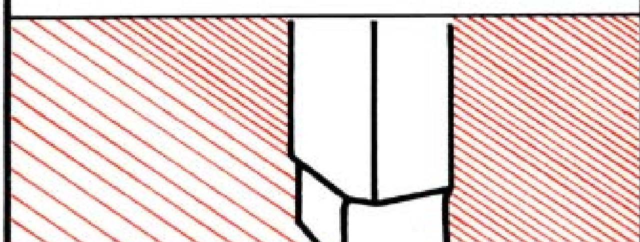
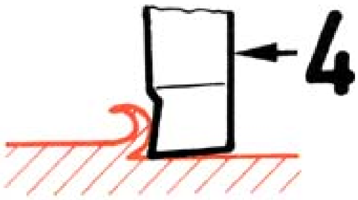
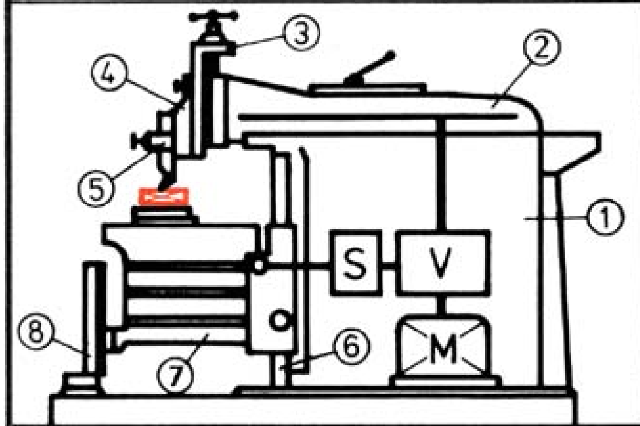






4.1

① ⑦

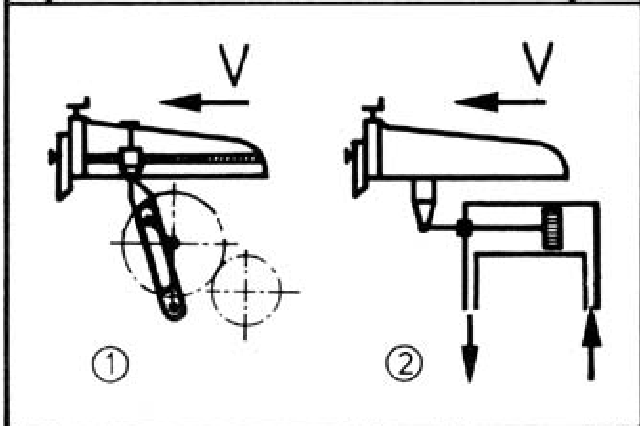
② ⑧

③ M

④ V

⑤ S

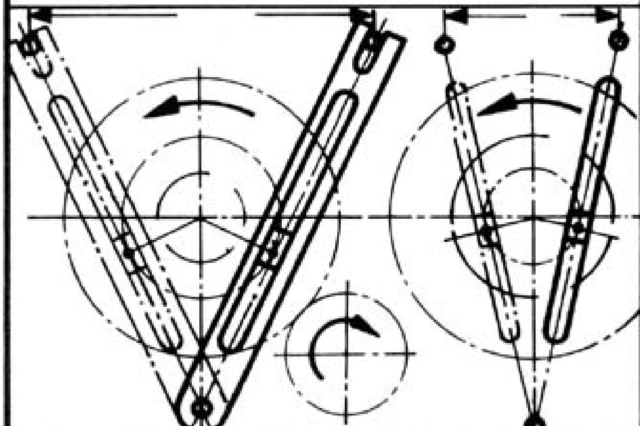
⑥



4.2

①

②



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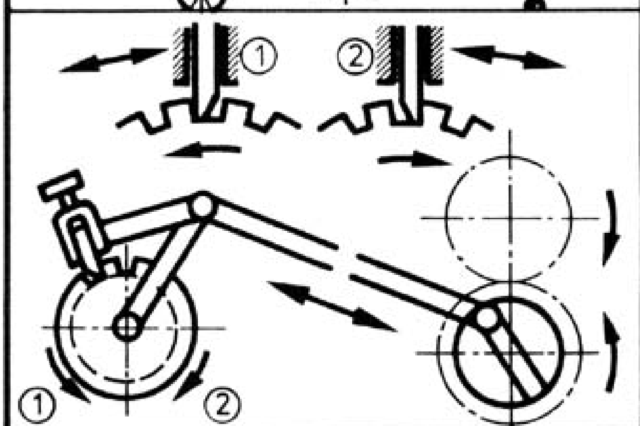

4.4

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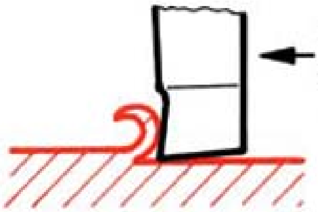
4.5



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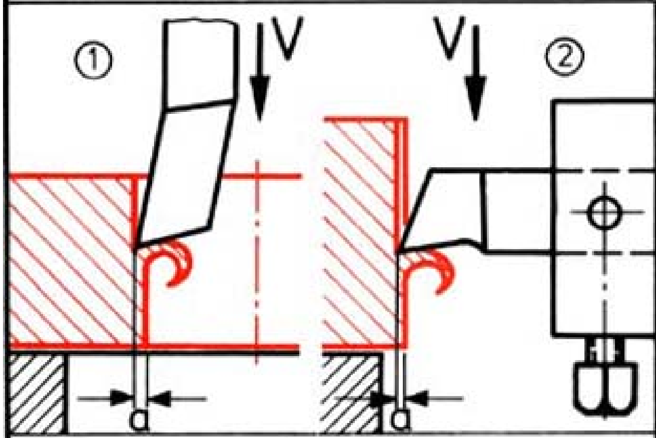

5.1

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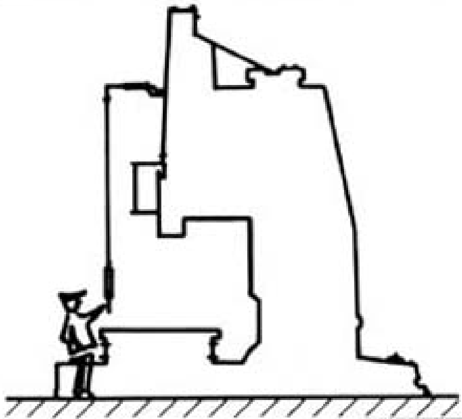

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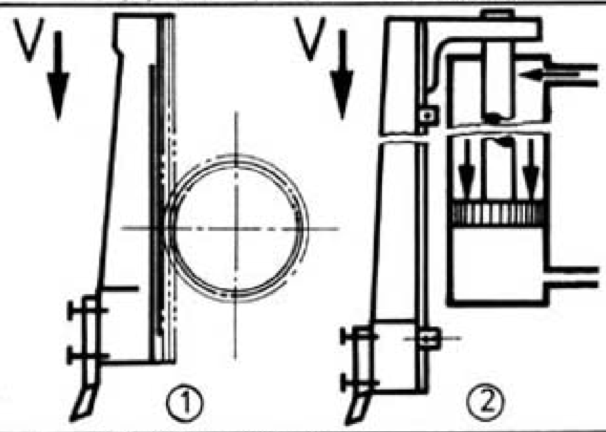
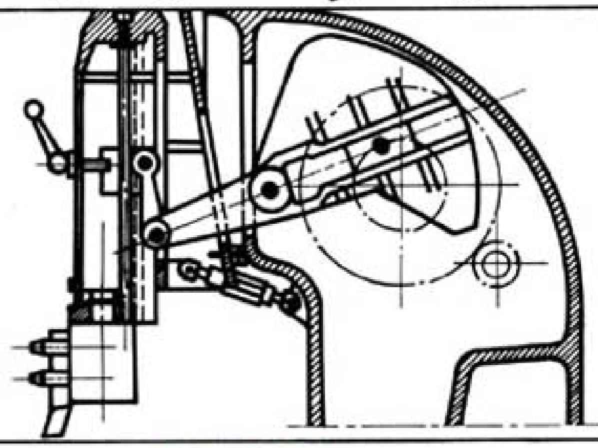


5.3

①

②



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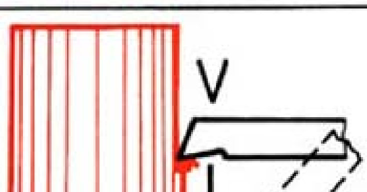
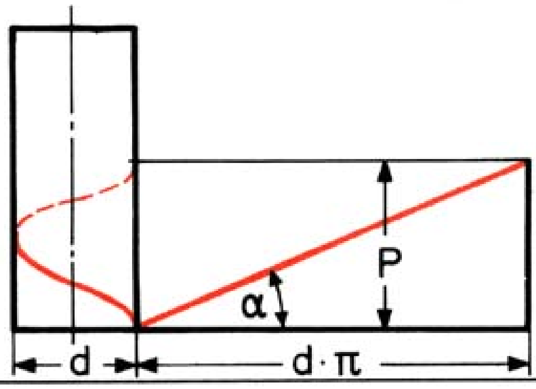


5.5

11. Thread cutting – Gewinde schneiden

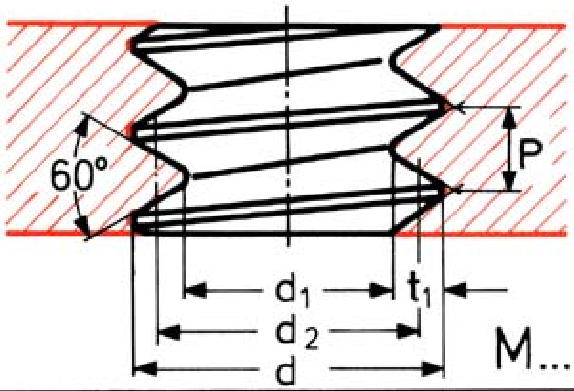
1

1.1



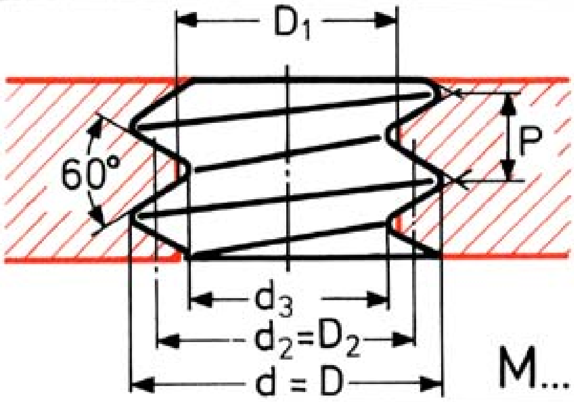
d =
d · π =
P =
∢ α =

DIN(M) 1.2



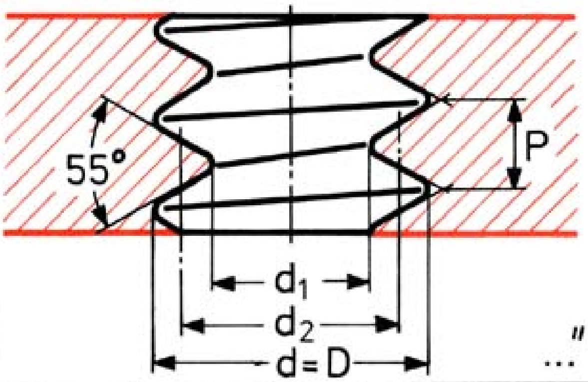
d=
P=
$t_1 = 0{,}6495 \cdot P \approx 0{,}1 \cdot d =$
$d_2 = d - 0{,}6495 \cdot P =$
$d_1 = d - 1{,}299 \cdot P \approx 0{,}8 \cdot d =$
∢ 60° =

ISO(M) 1.3



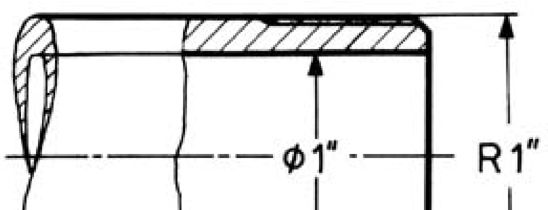
d = D =
P =
$d_3 =$
$D_1 =$
$d_2 = D_2 =$
∢ 60° =

Whitworth (″) 1.4



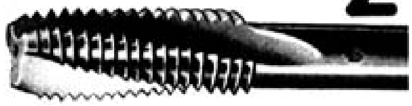
d = D =
P =
$d_1 =$
$d_2 =$
∢ 55° =
z =

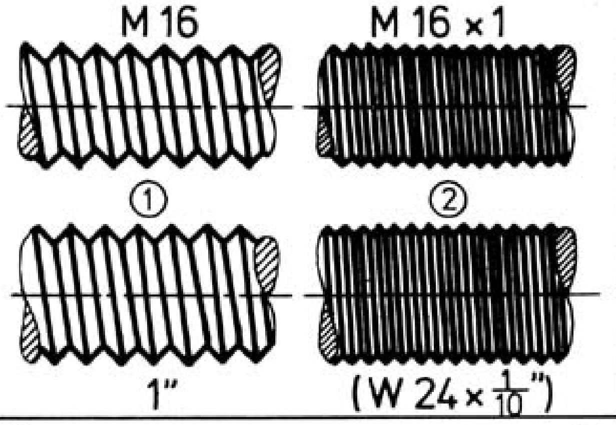
1.5



1″ =
R1″ =
1/2″ =
R1/2″=

2





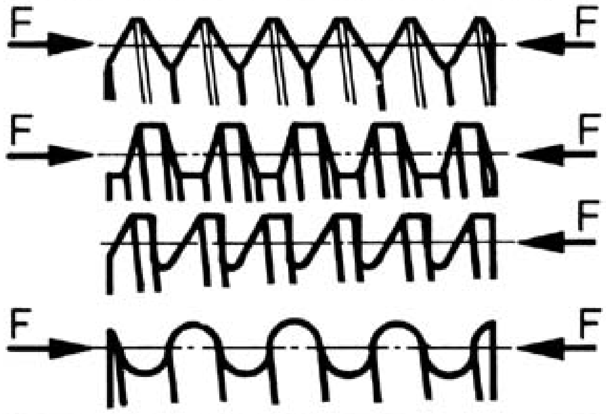
2.1

① M 16 =
1″ =

② M 16 × 1 =
W 24 × $\frac{1}{10}$″ =

M 2 × 0,25 =

M50 × 1,5 =



2.2

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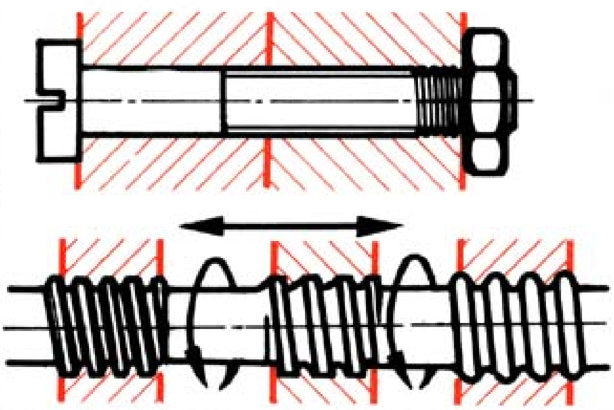

2.3

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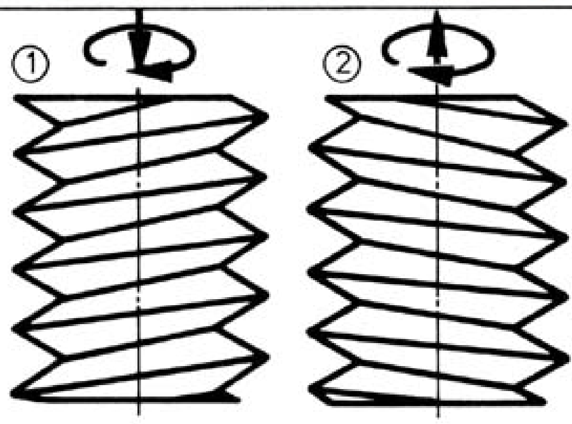
②



2.4

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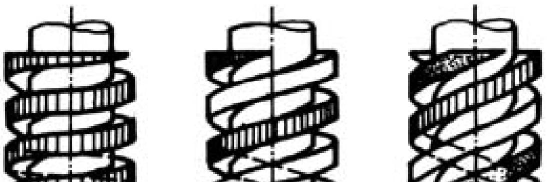
②



2.5

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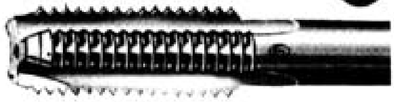
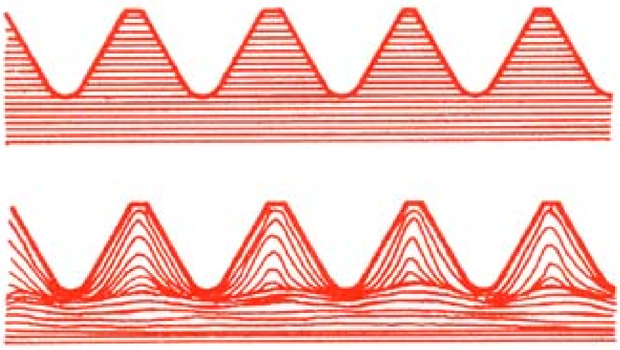
3





3.1

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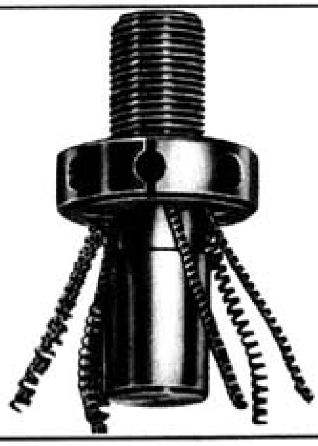
②



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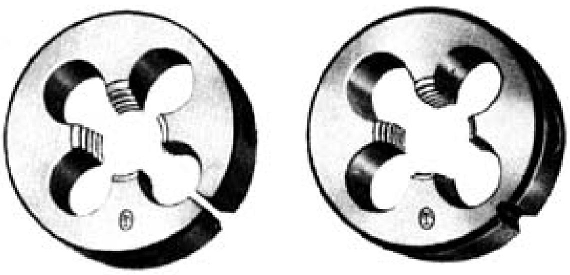

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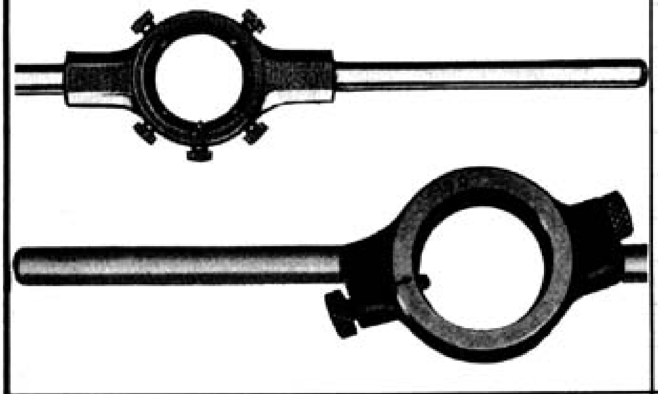
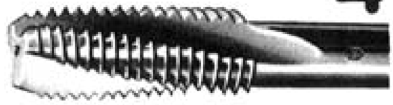
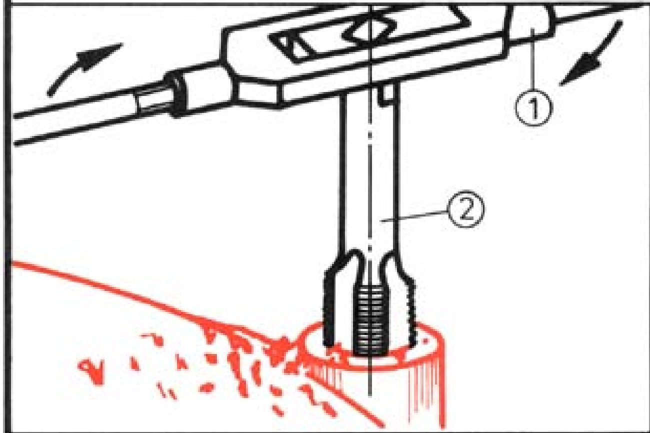


3.4

3.5

4





4.1

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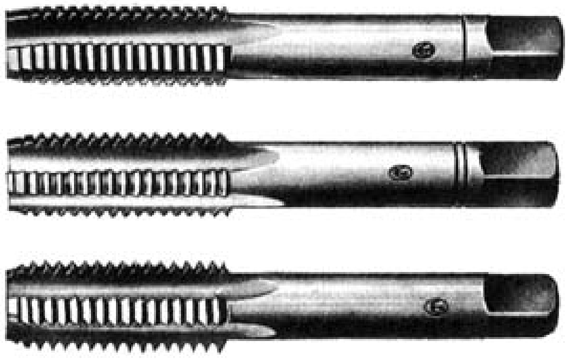

4.2

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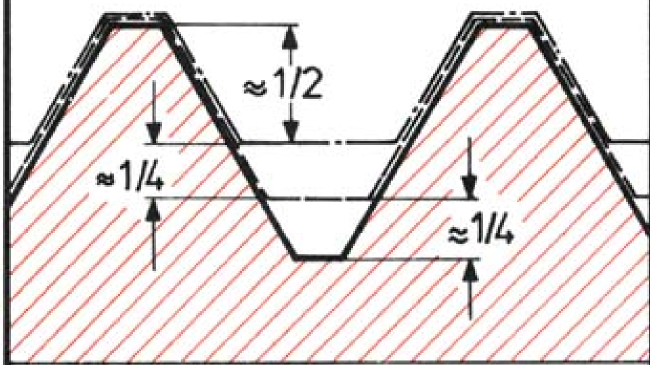

4.3

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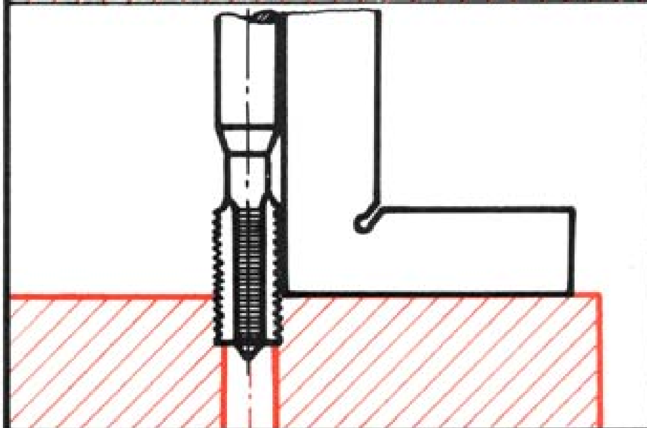

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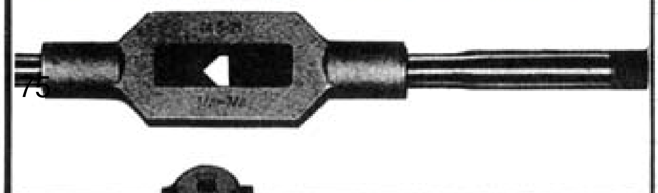

4.5

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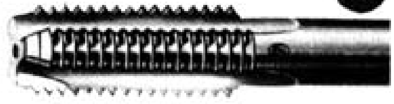
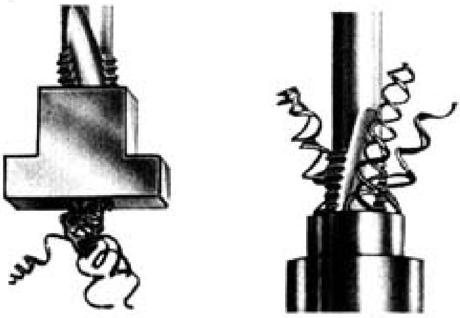
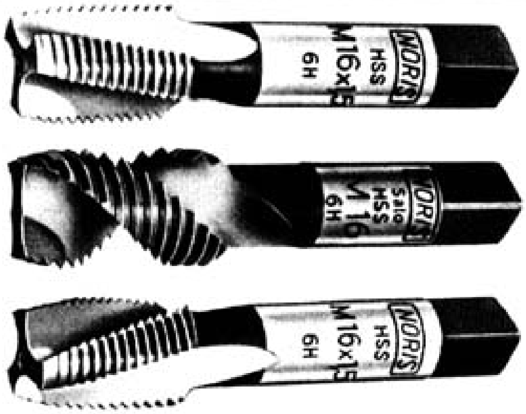
5



5.1



5.2



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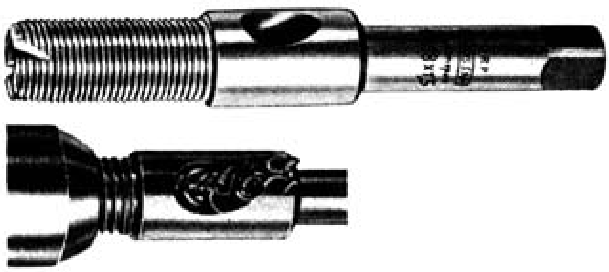

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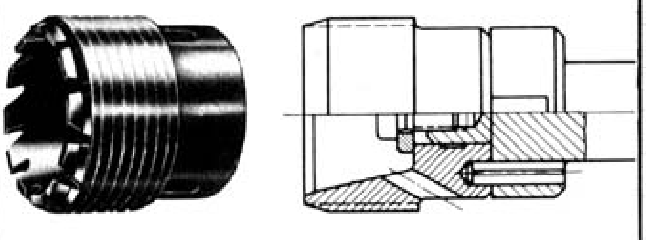

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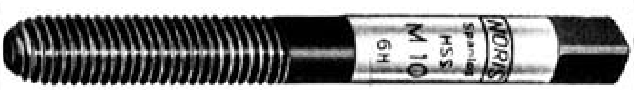

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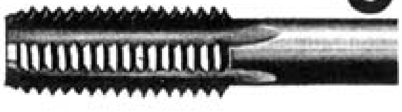
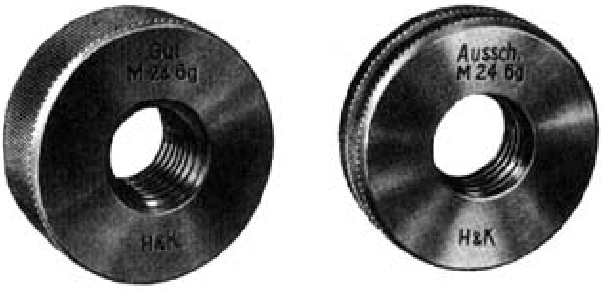


6.1



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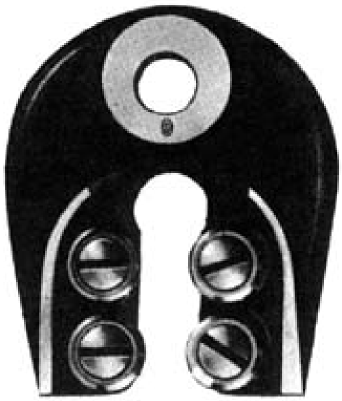
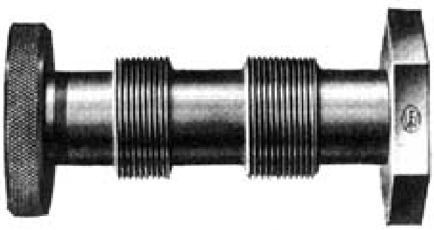


6.3



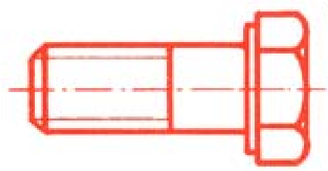
6.4

6.5

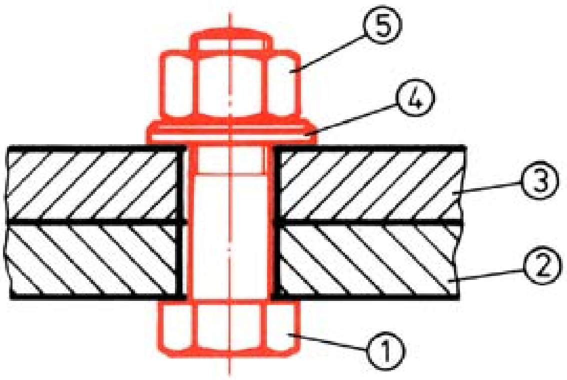
77

12. Threaded joints – Schraubenverbindungen

1



1.1



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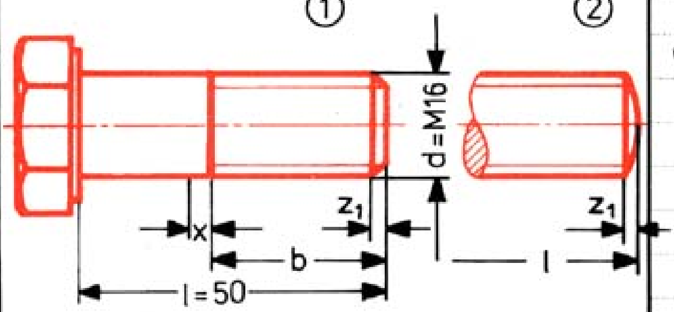
1.2

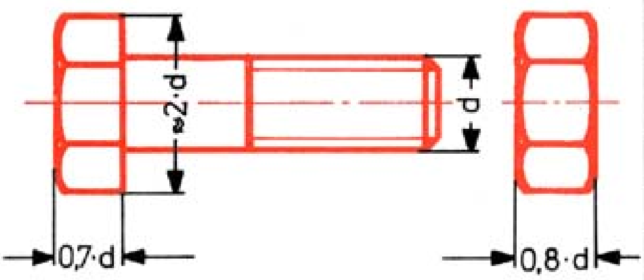


M 16 × 50 DIN 931 – 6.8

①
②
M 16 —
50 —
DIN 931-
6. .8

~~4A~~	~~4D~~	~~4S~~	~~5D~~	~~5S~~	~~6D~~	~~6S~~	~~6G~~	~~8G~~	~~10K~~	~~12K~~	–
3.6	4.6	4.8	5.6	5.8	6.6	6.8	6.9	8.8	10.9	12.9	14.9
					⧄			⊠	□	⊟	⊞

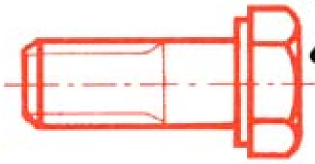
1.4



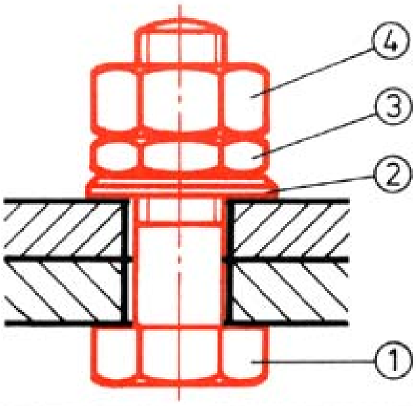
1.5

①

2



2.1



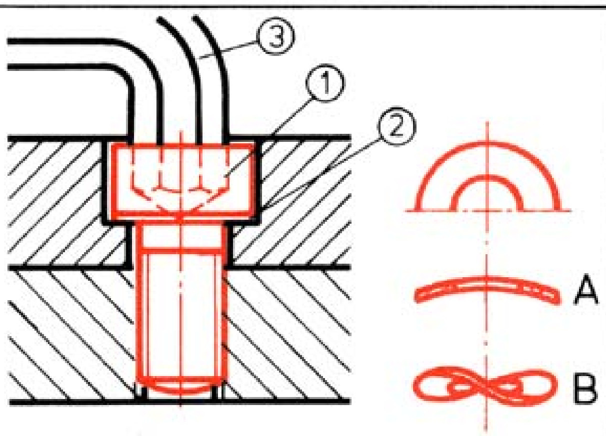
1

2

3

4

2.2

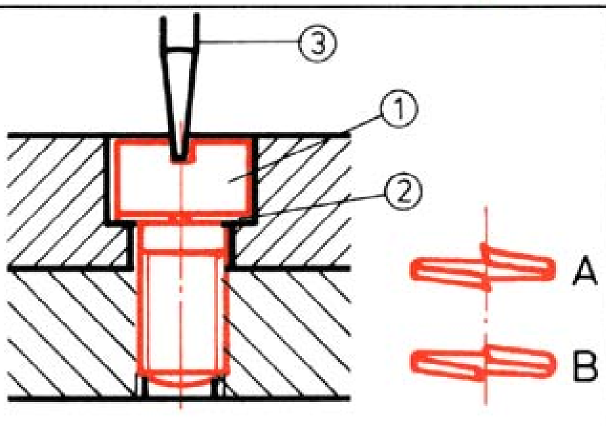


1

2

3

2.3

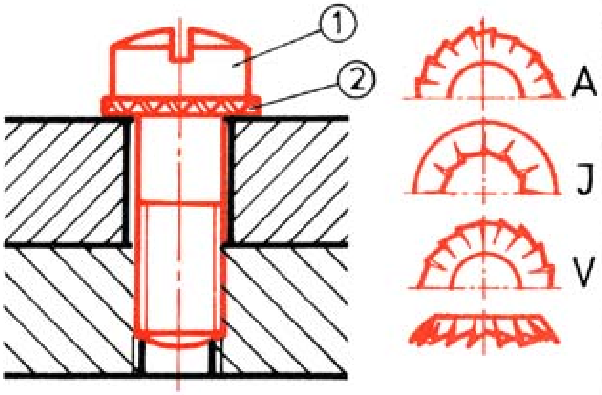


1

2

3

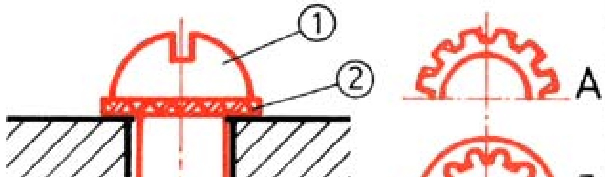
2.4



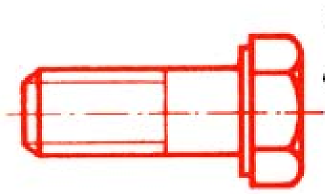
1

2

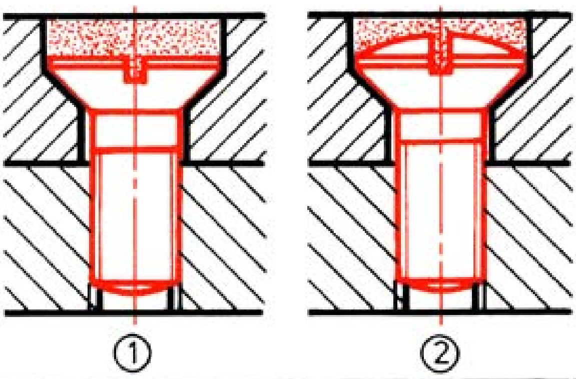
2.5



1



3



3.1

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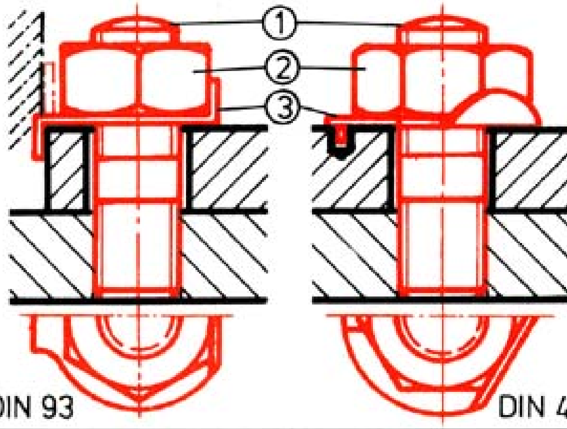

3.2

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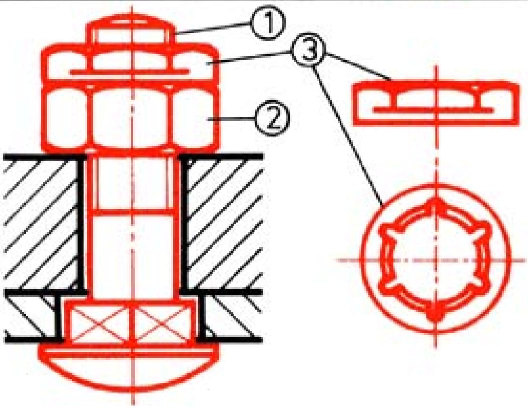

3.3

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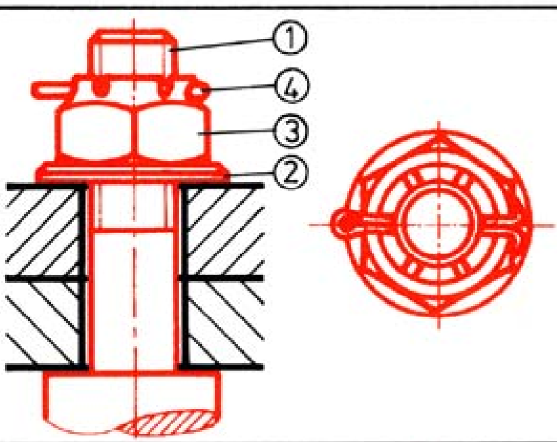

3.4

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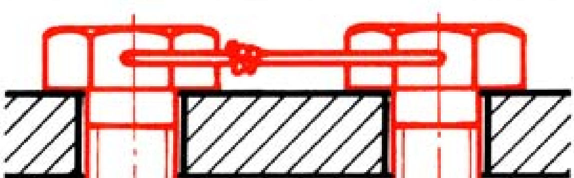

3.5

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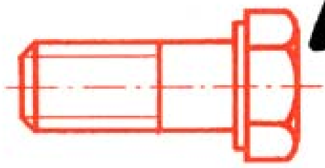

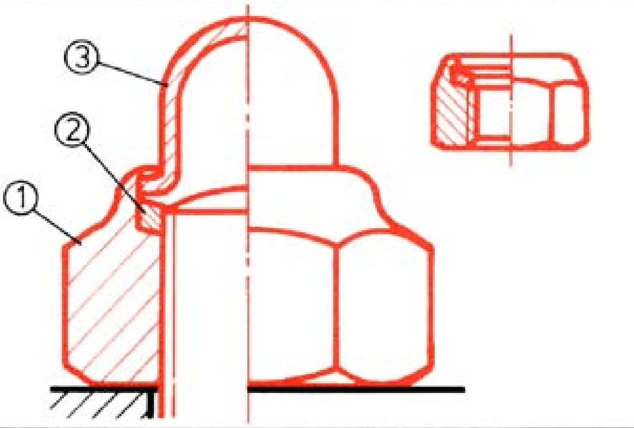

4.1

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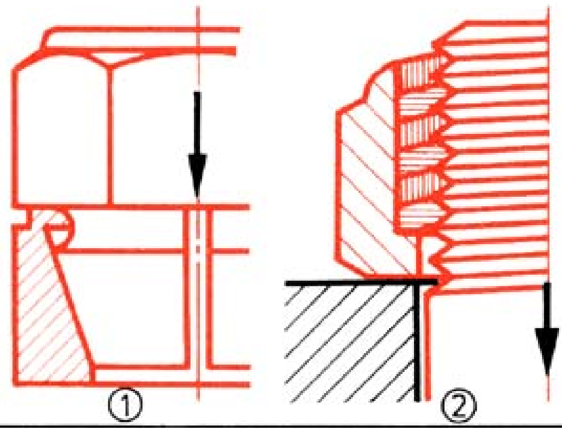

4.2

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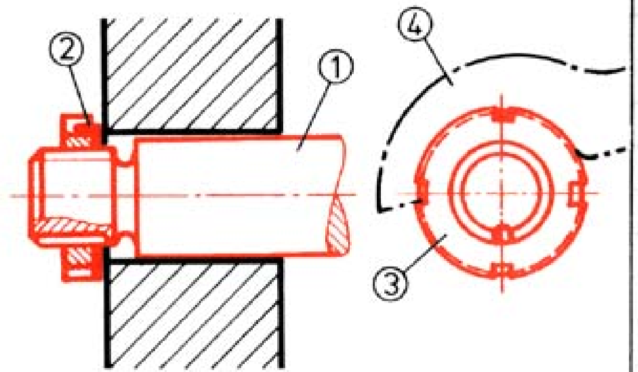
②



4.3

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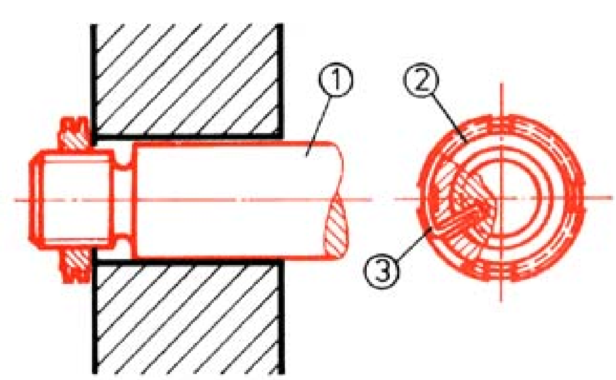

4.4

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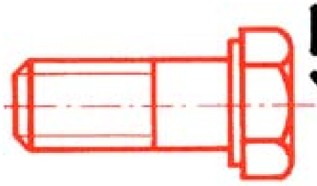

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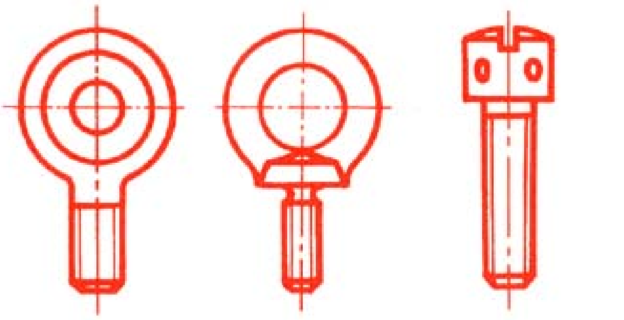

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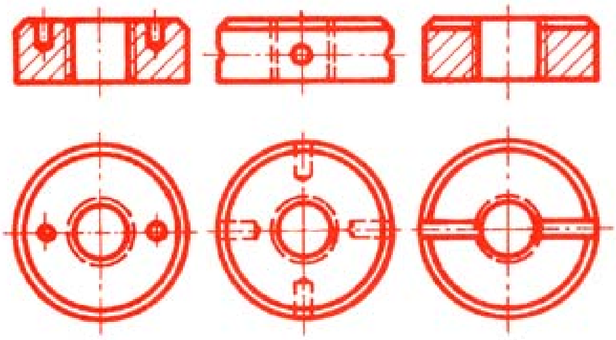

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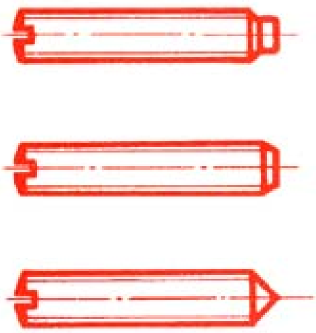

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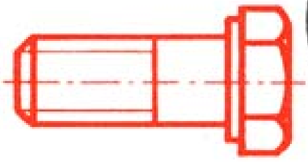

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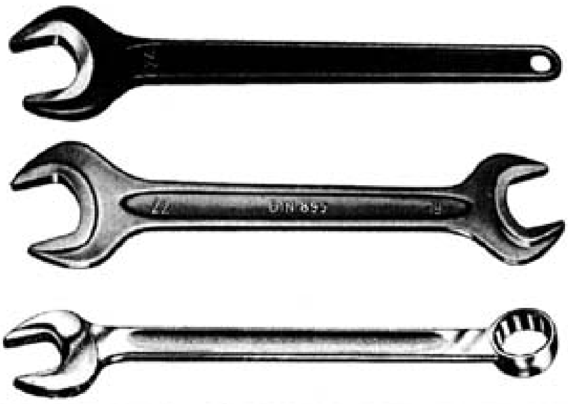

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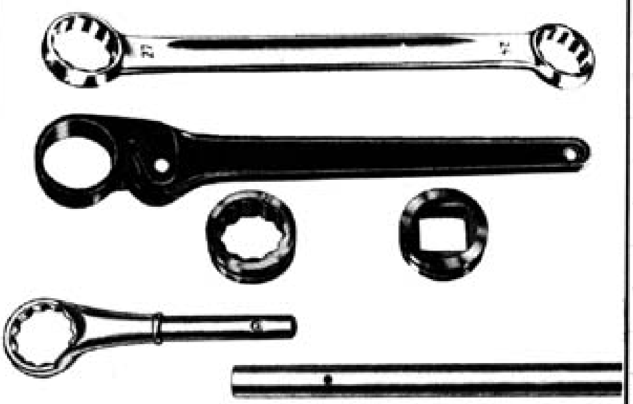

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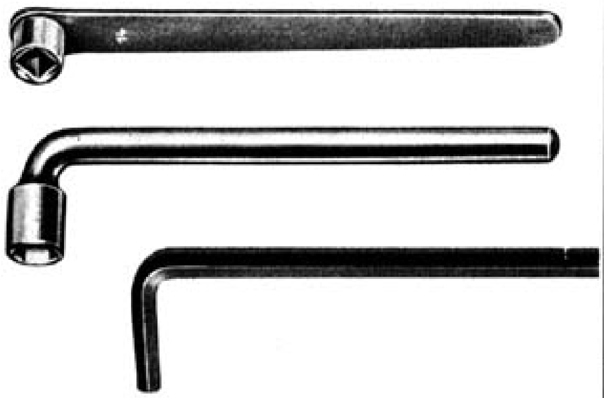

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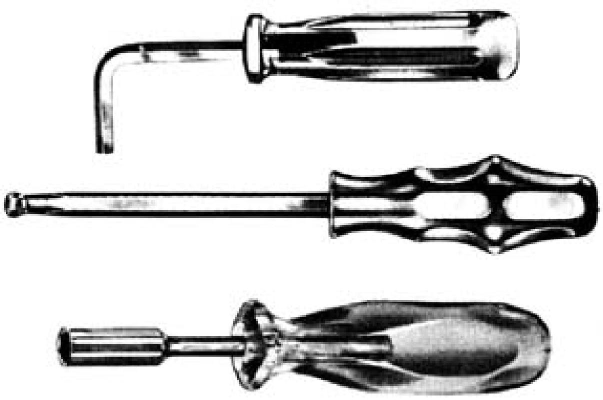

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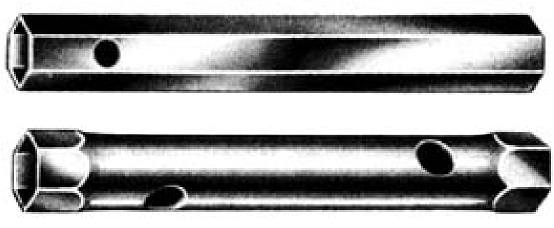

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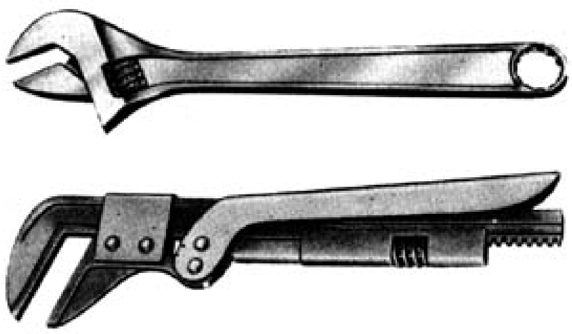

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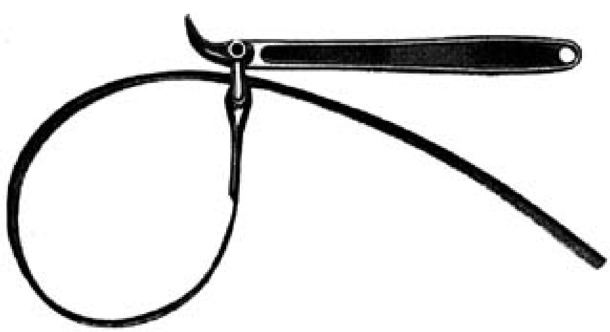
7.3



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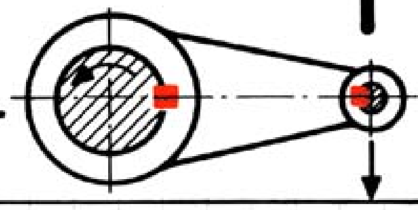
13. Keyed joints – Keilverbindungen

1



1.1

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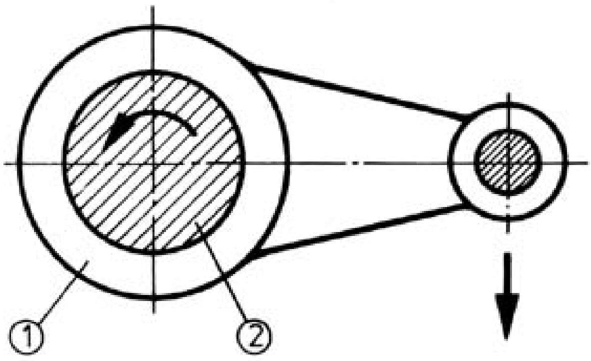

1.2

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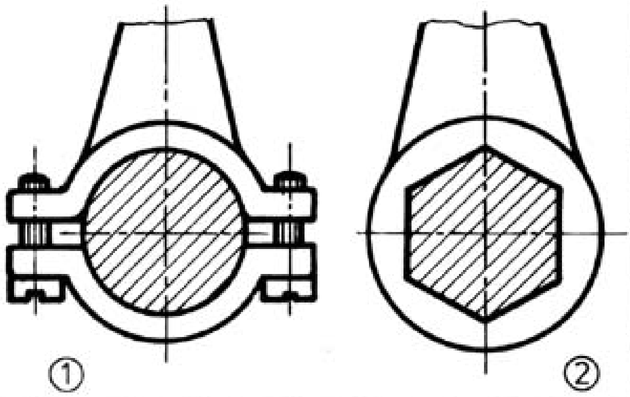

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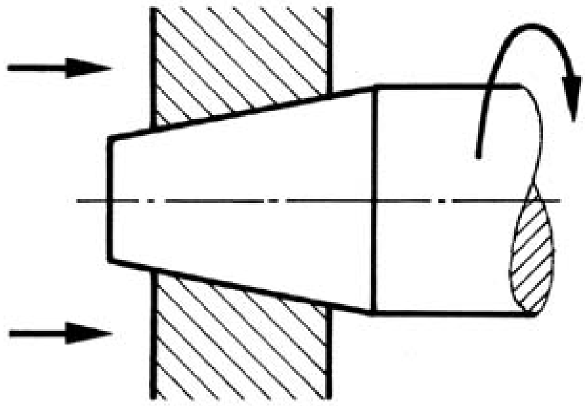

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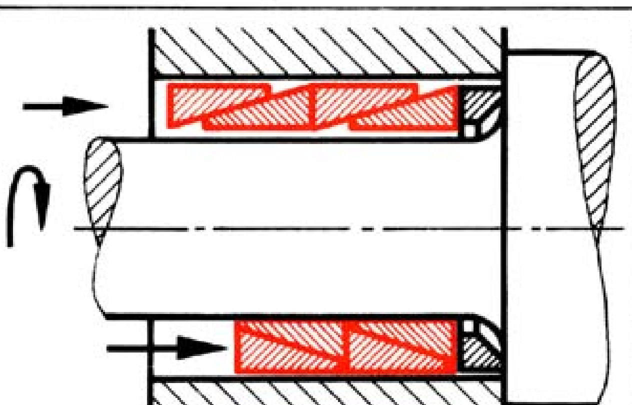

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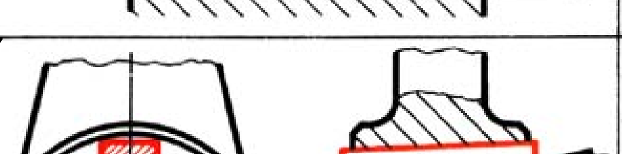

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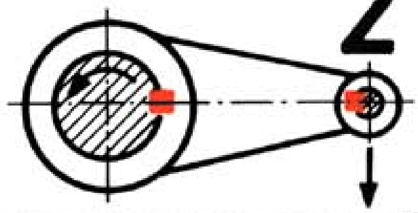

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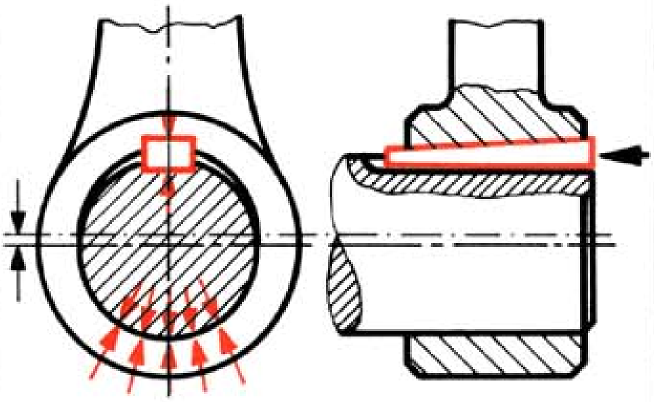

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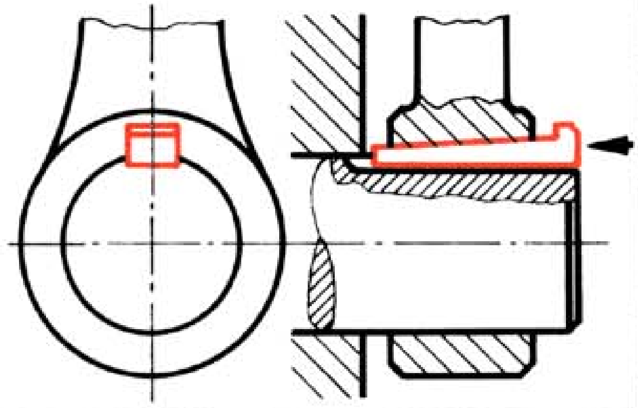

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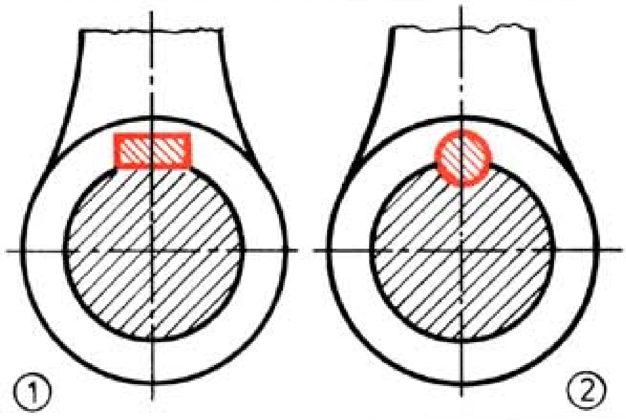

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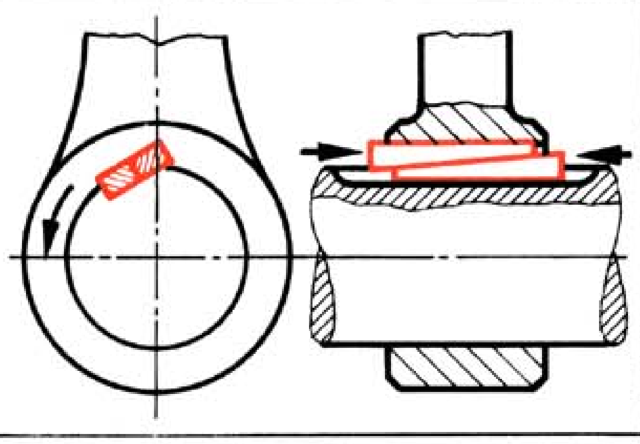
2.4



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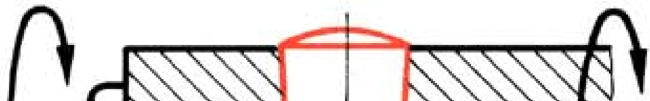

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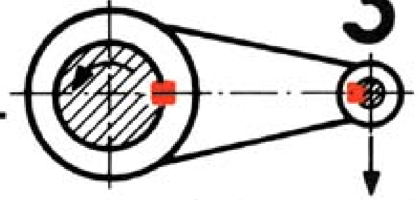

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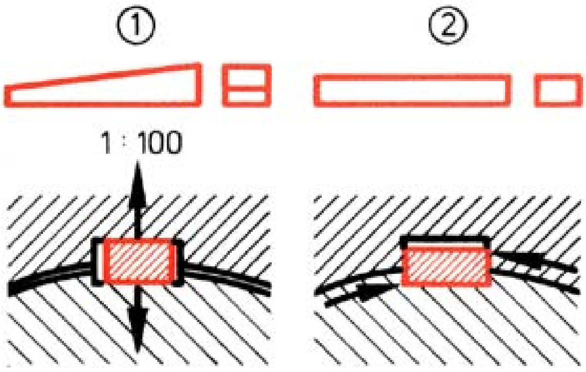

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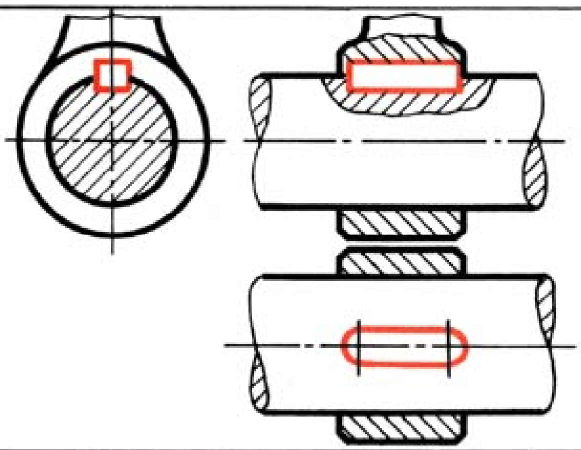

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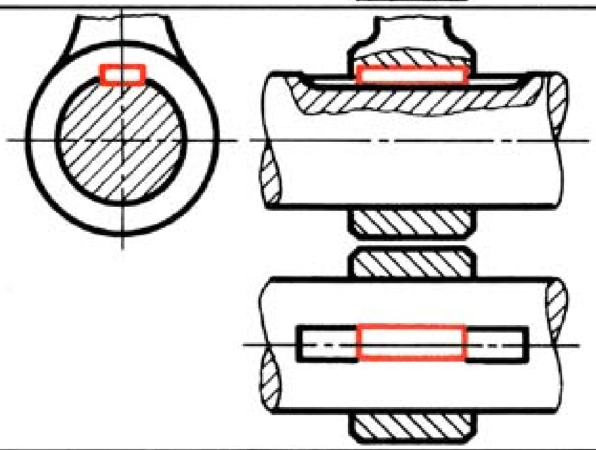

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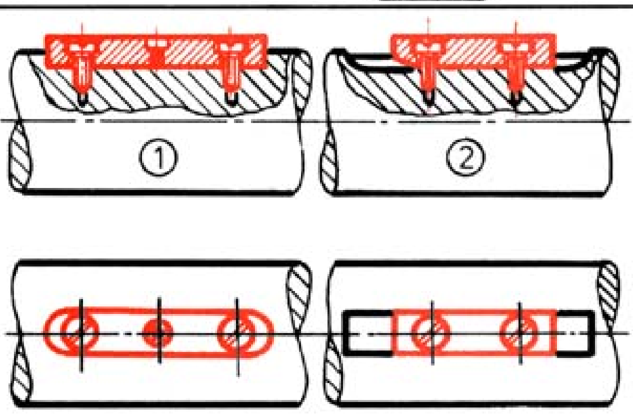

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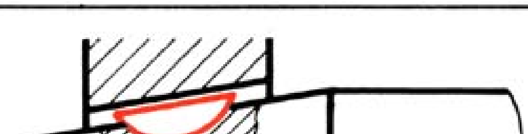

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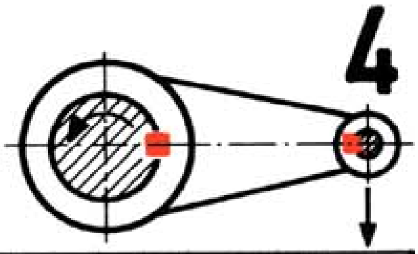

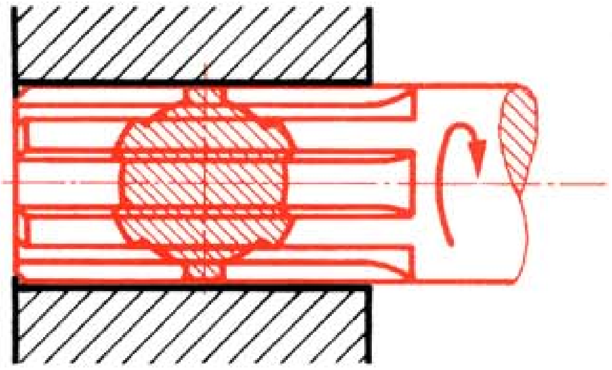

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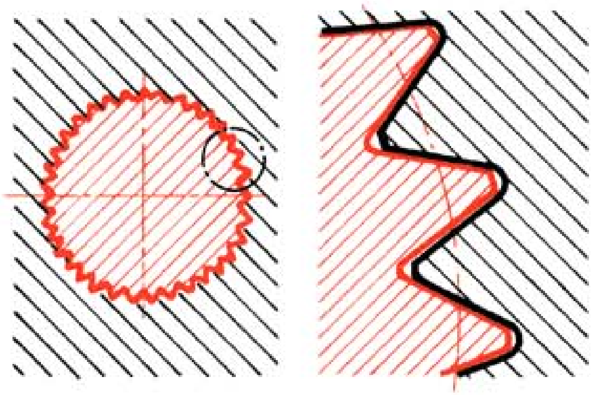

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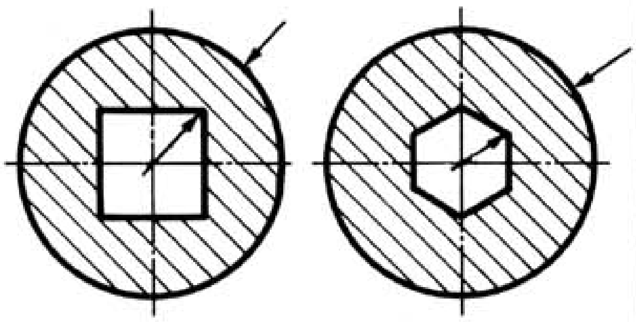

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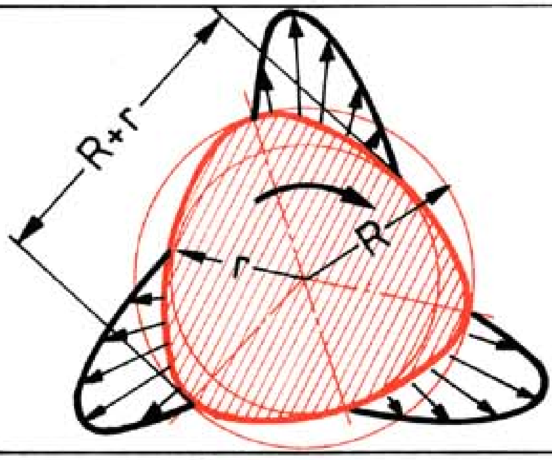

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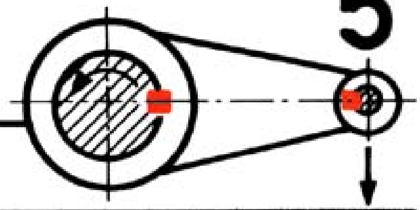

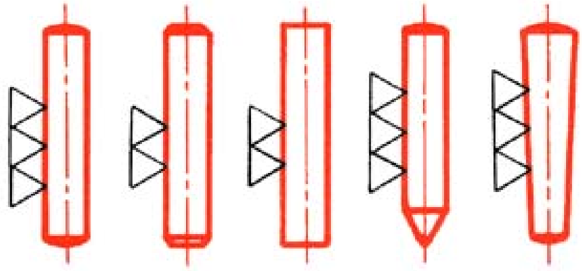

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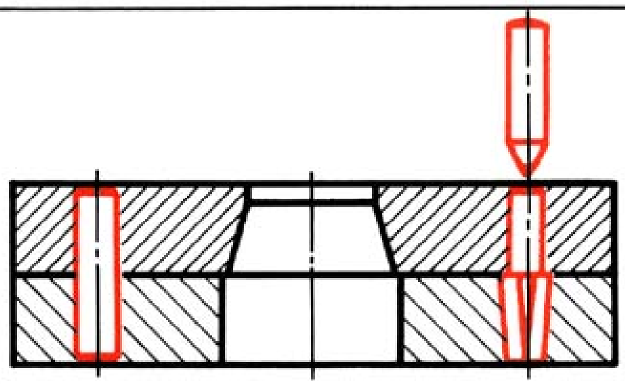

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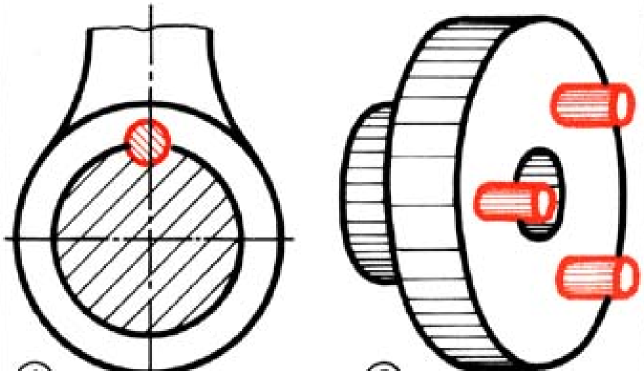

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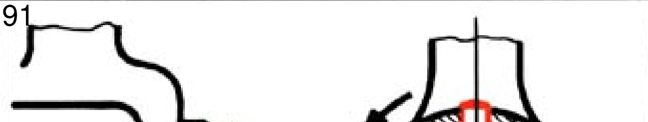

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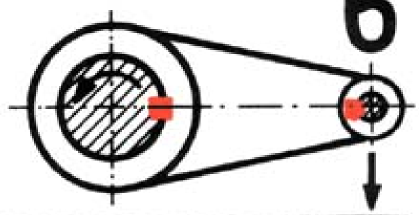

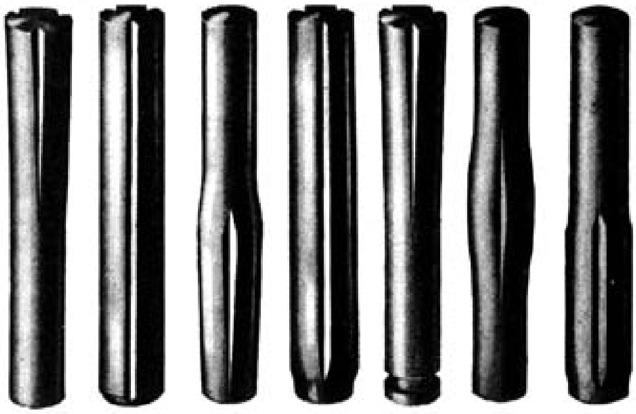

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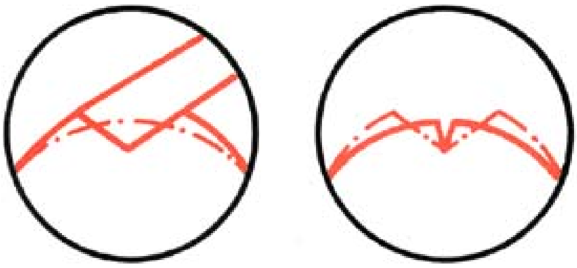

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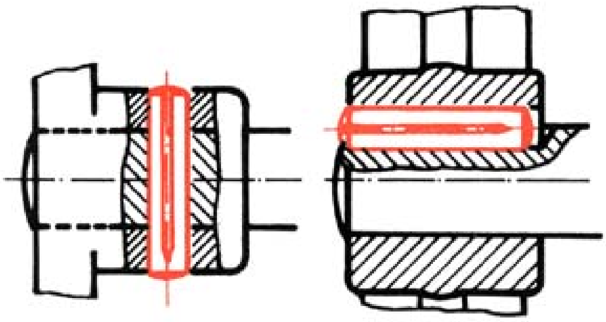

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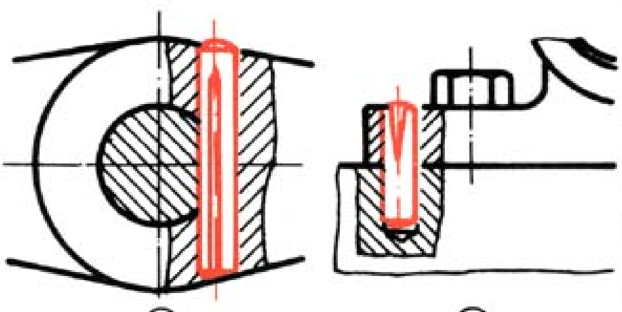

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14. Soldering joints – Lötverbindungen

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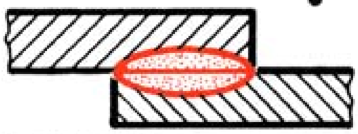

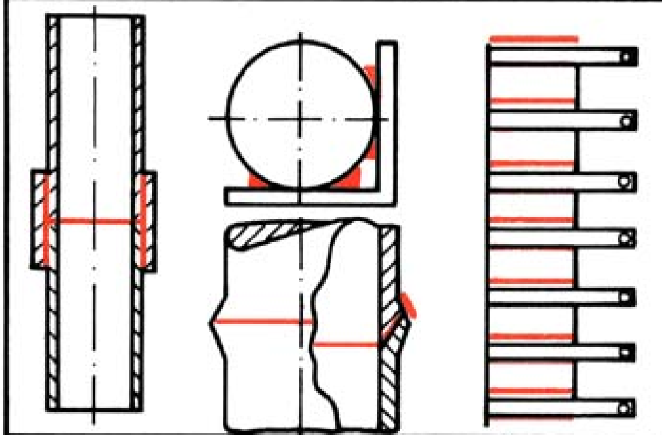

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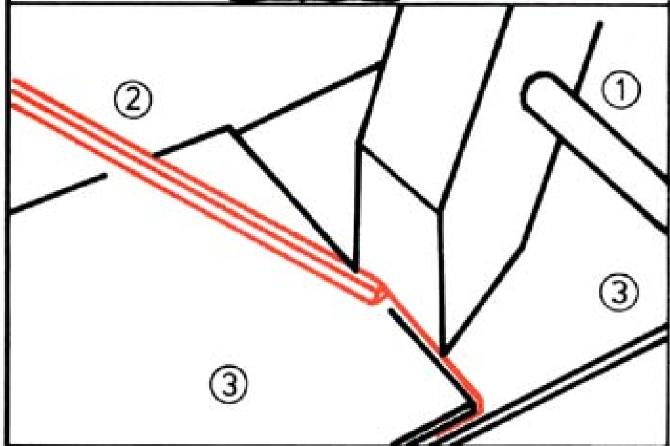

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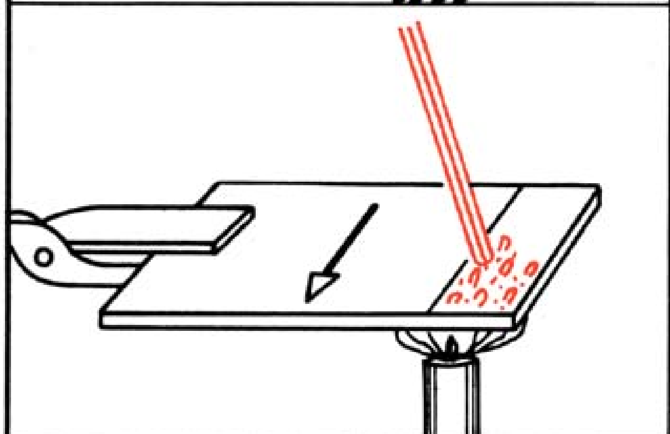

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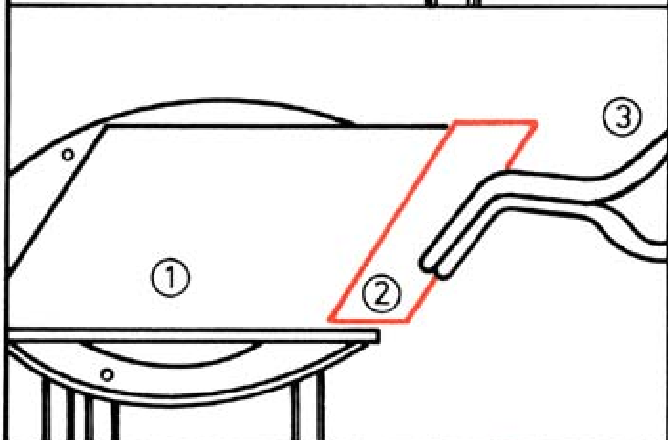

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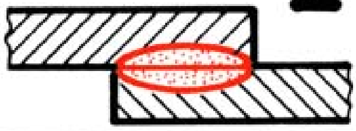

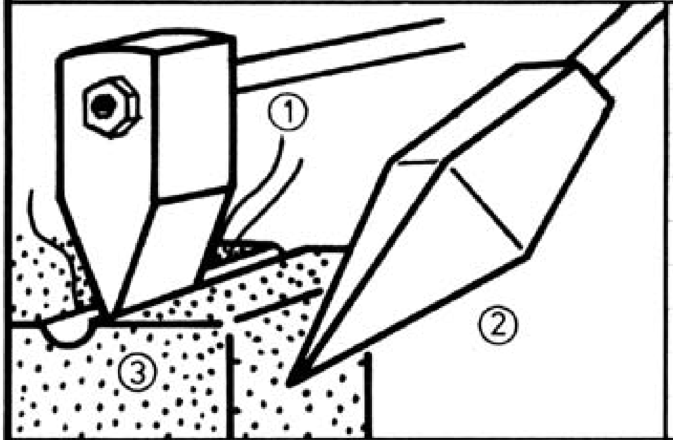

2.1

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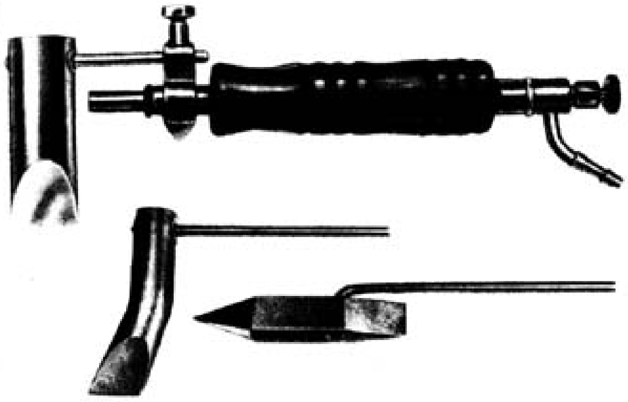

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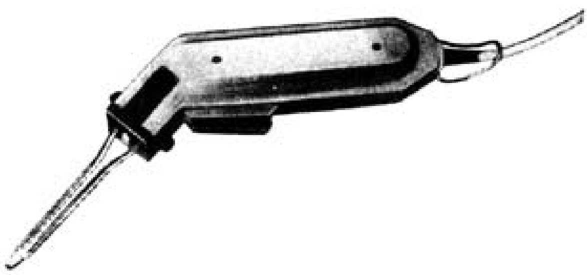
2.3



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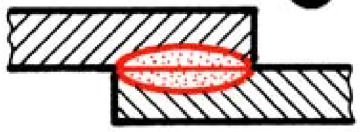
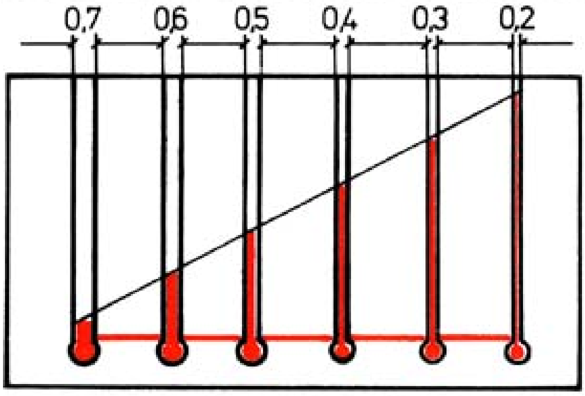
3





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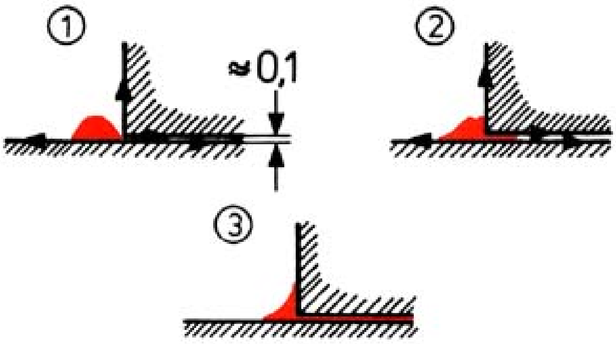

3.2

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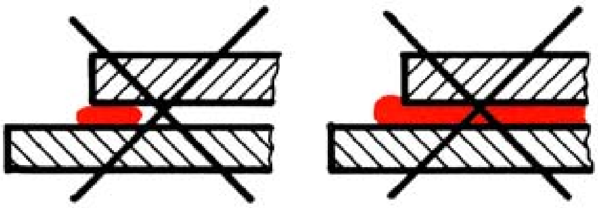

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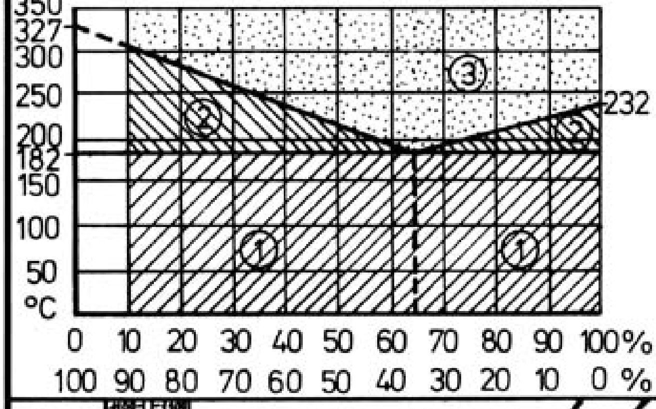

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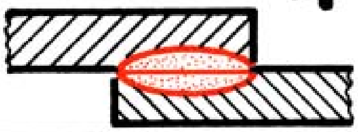
1080 °C ——

945°...1020°C–

4



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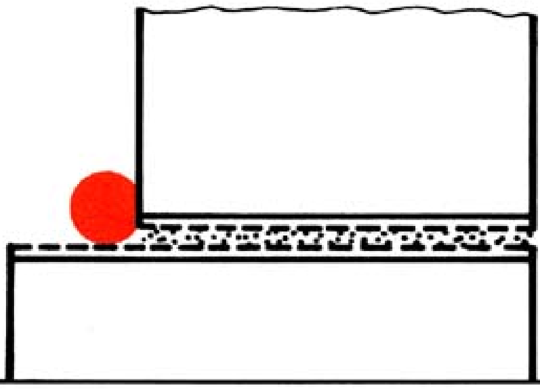

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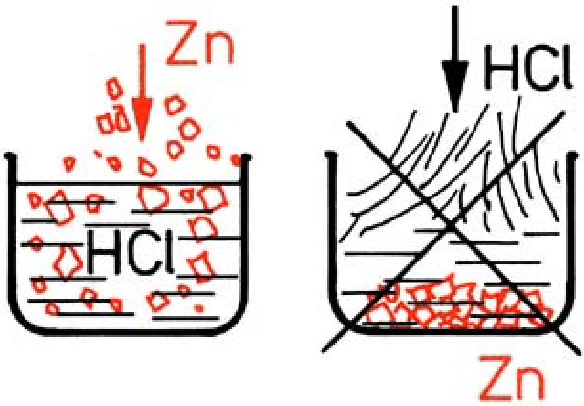

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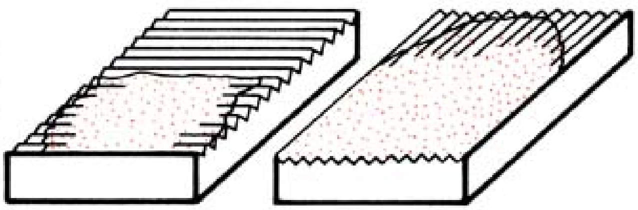

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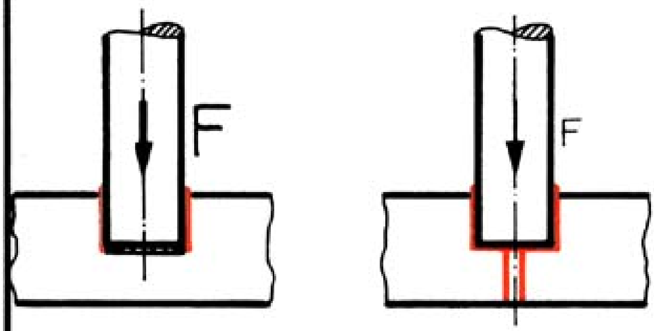

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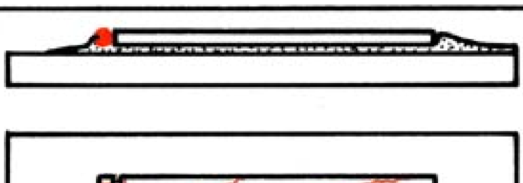
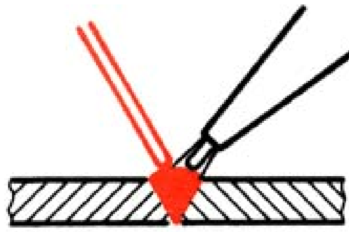
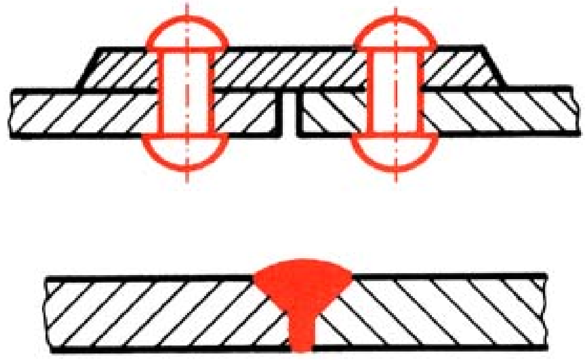


15. Welded joints – Schweißverbindungen

1





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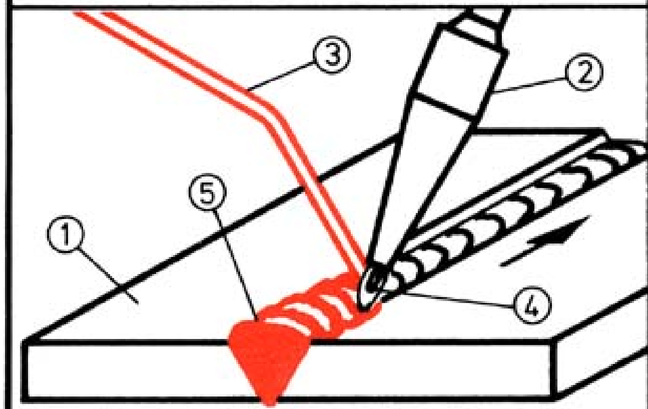

1.2

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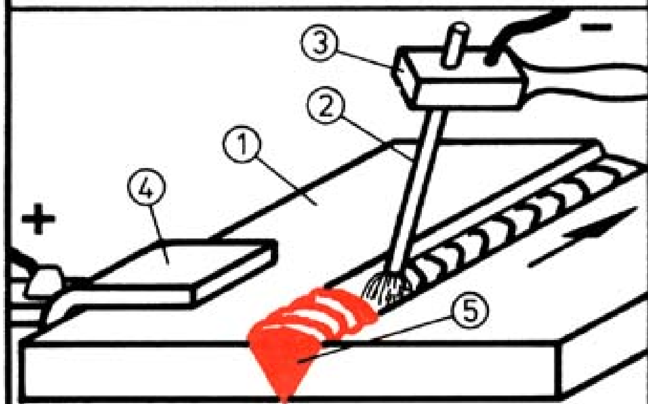
4
5



1.3

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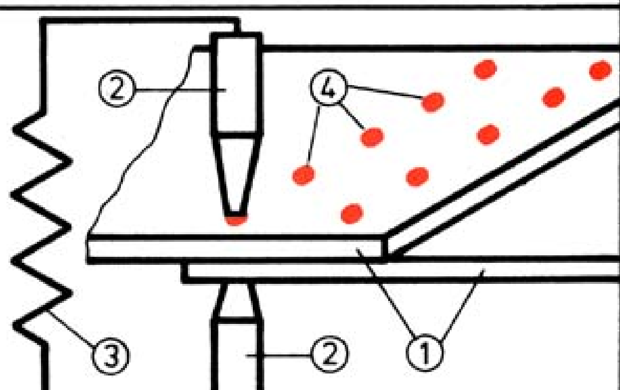

1.4

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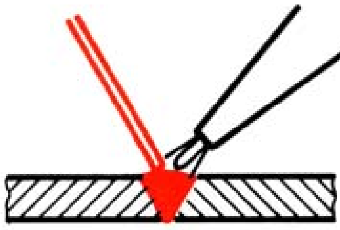
1.5



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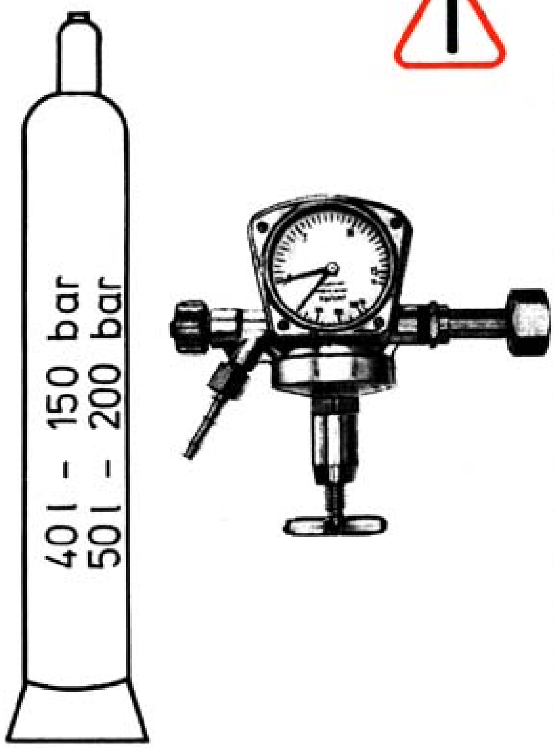
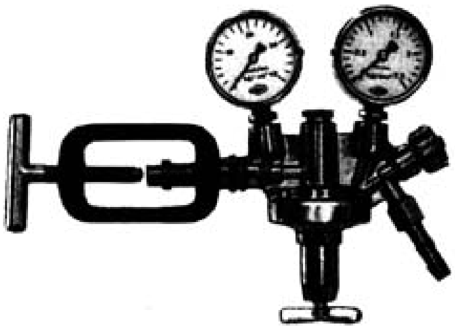


2.1

O_2–

2.2

H_2–



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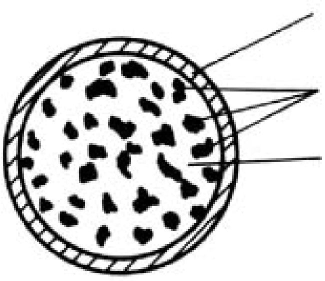
C_2H_2–



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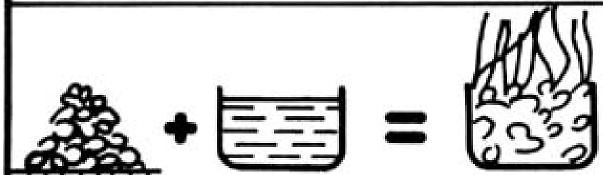
C_2H_2–



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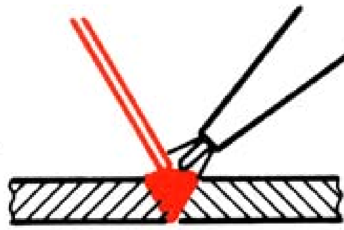

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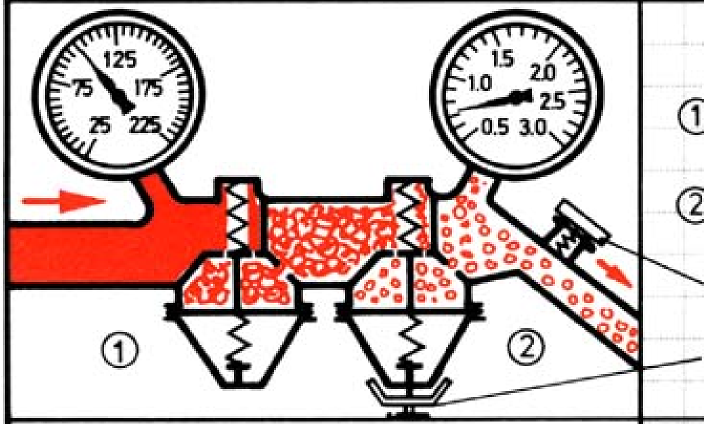

3.1

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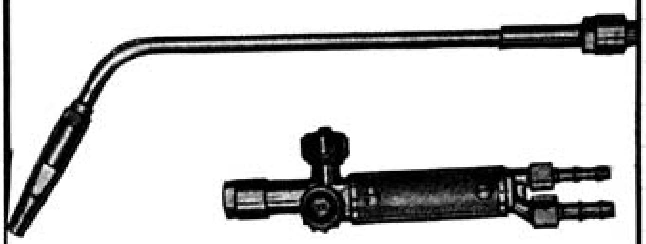

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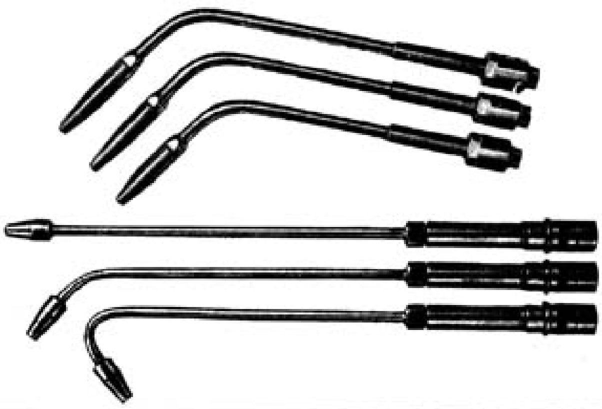

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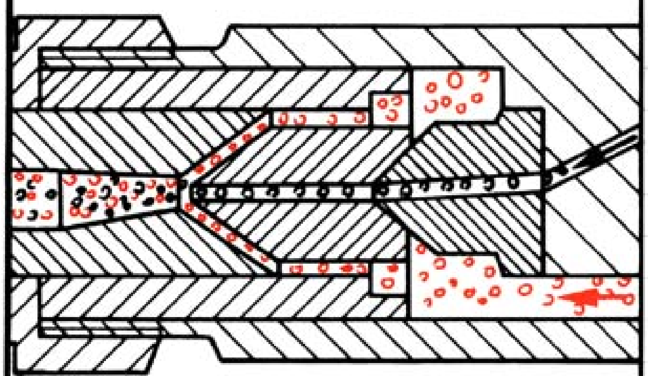

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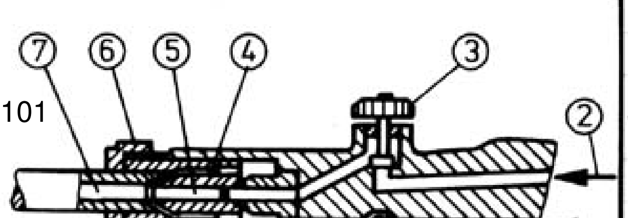

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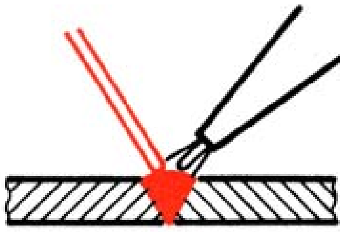

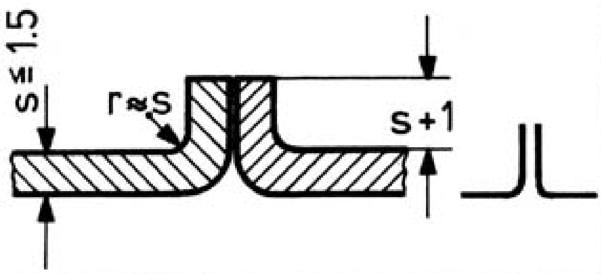

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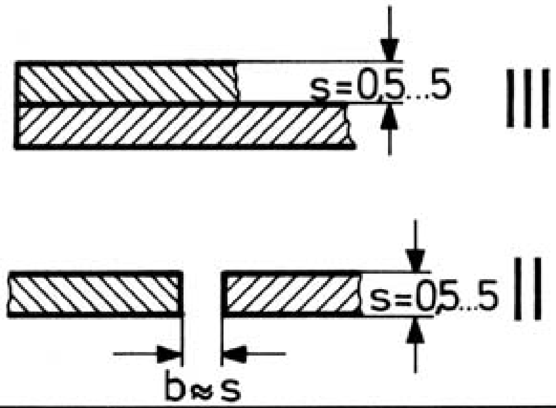

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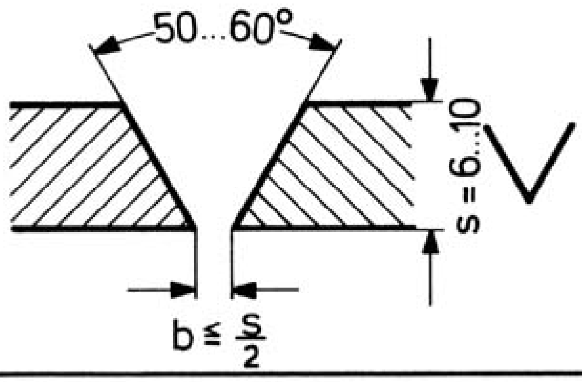

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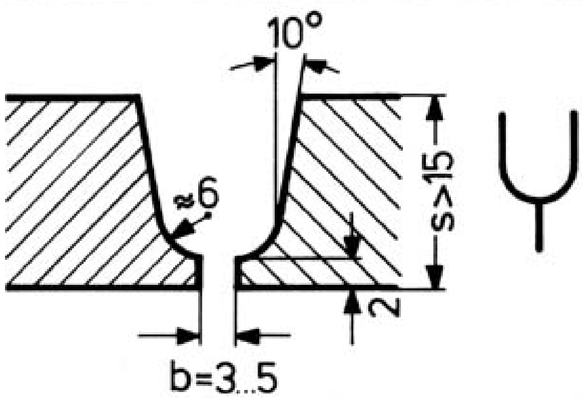

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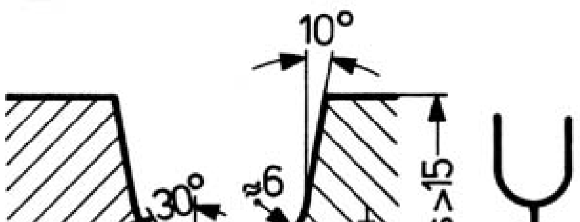

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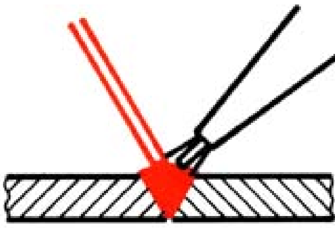
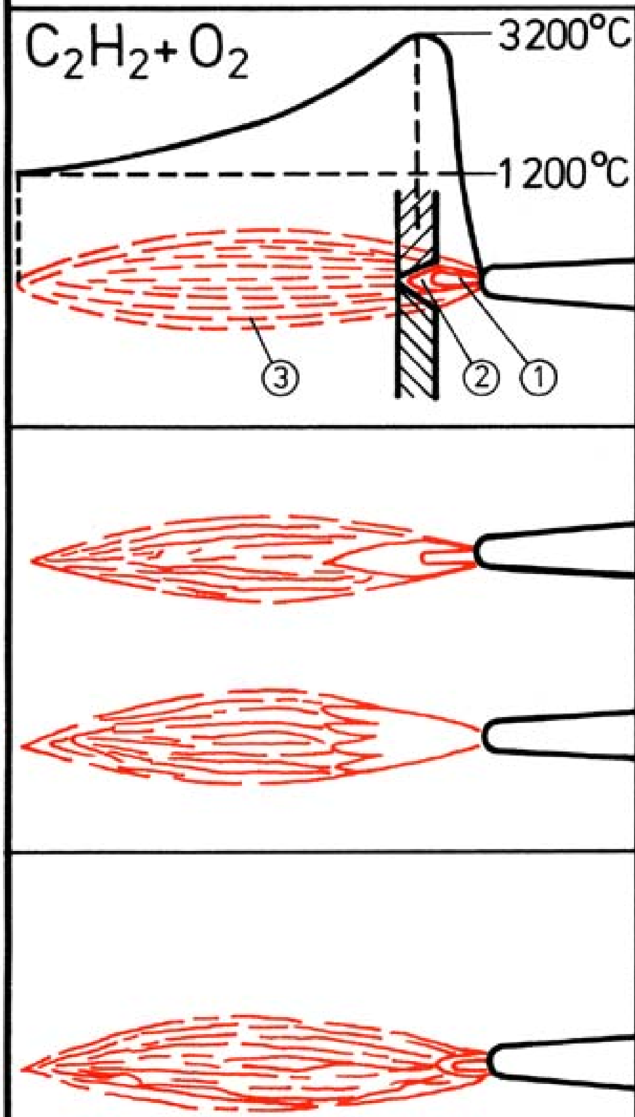


5

$C_2H_2 + O_2$



5.1

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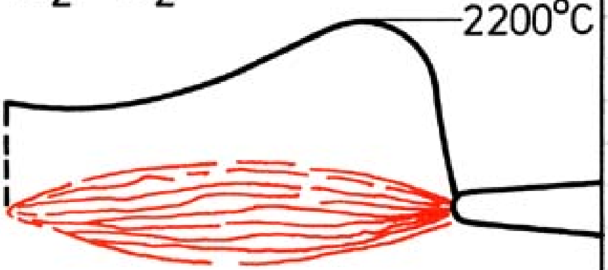
5.2

5.3

$H_2 + O_2$

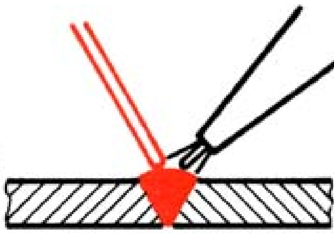


5.4

$C_3H_8 + O_2$ ≦ 2700°C

103

5.5



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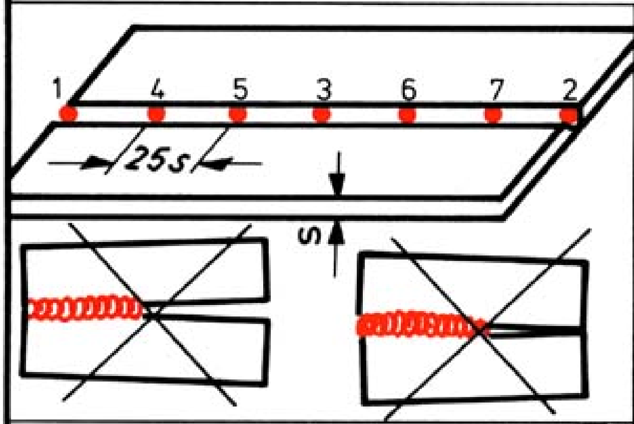

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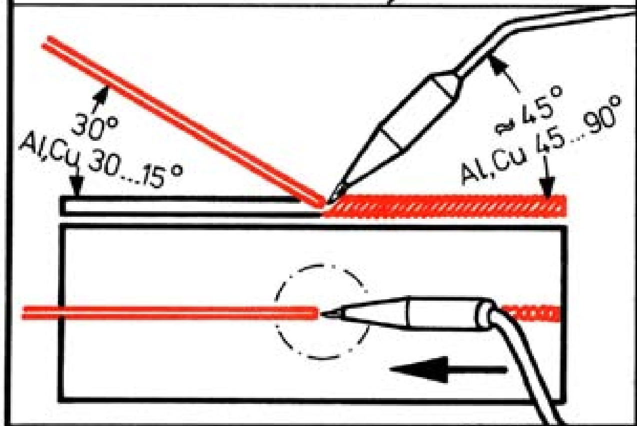

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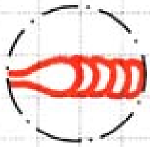

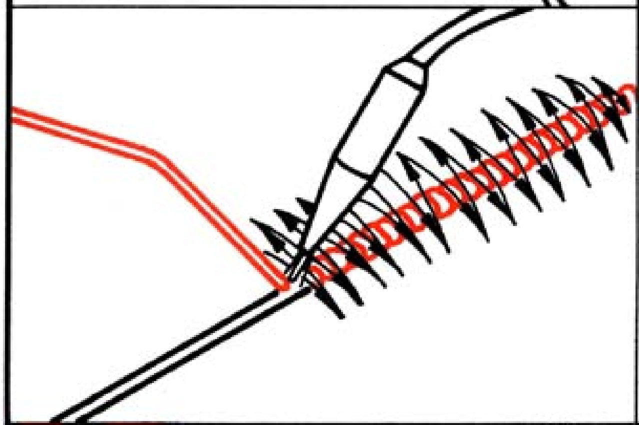

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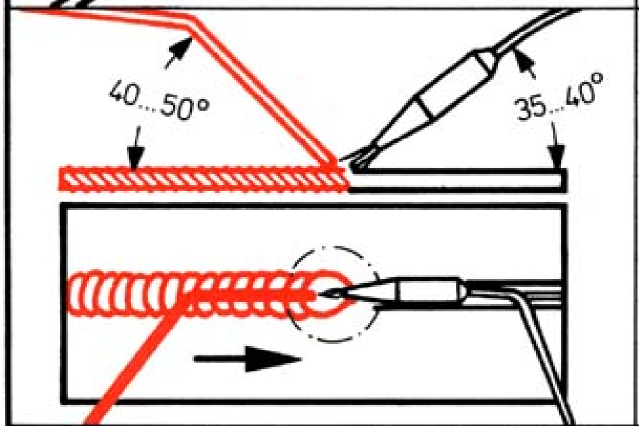

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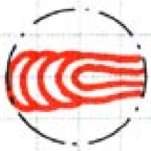

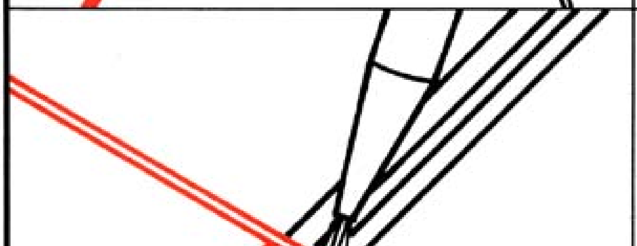

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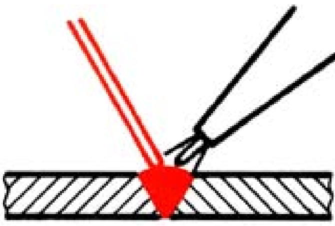

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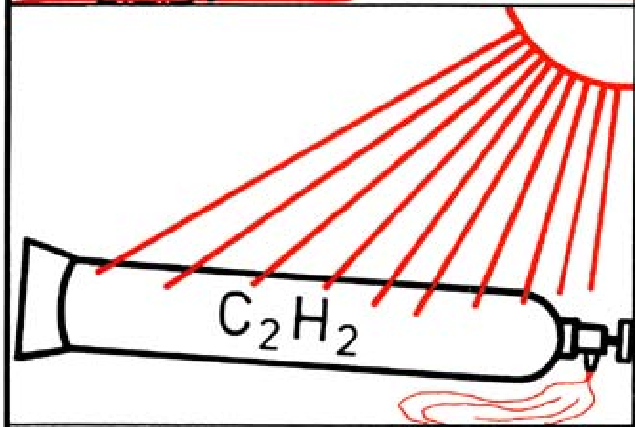
7.1



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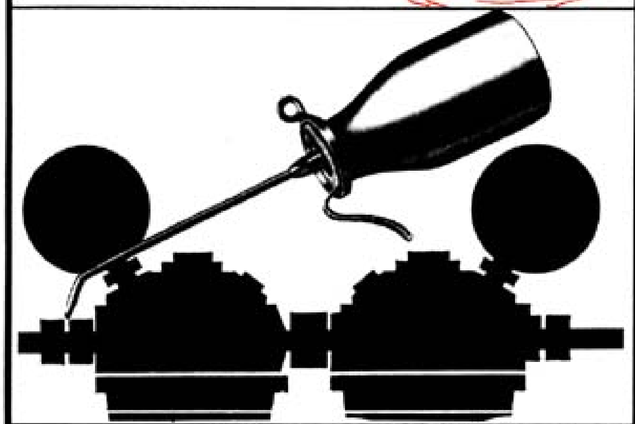
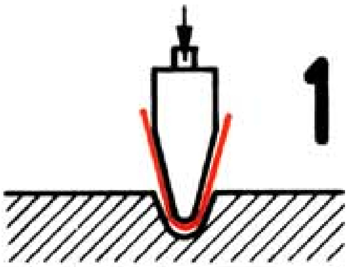


7.3

7.4

7.5

16. Folding/Bending – Umformen/Biegen



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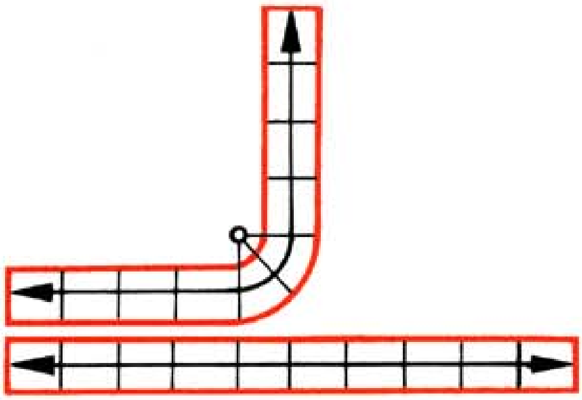

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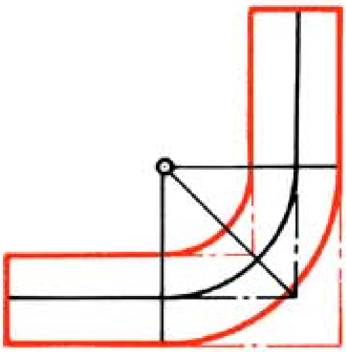

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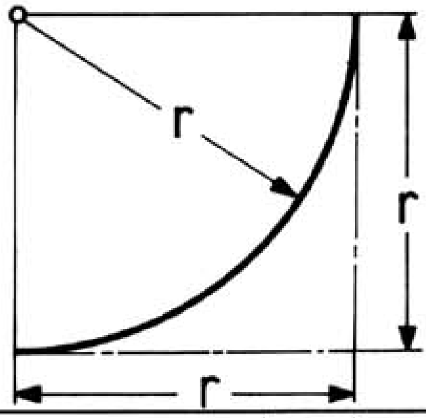

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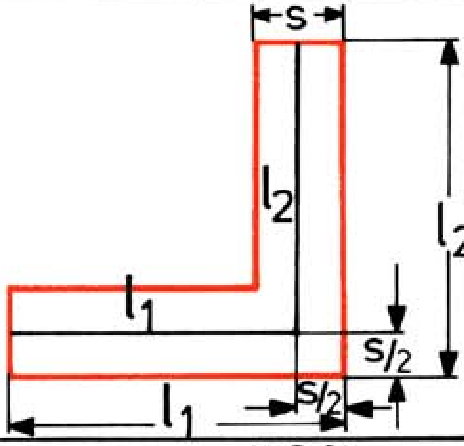
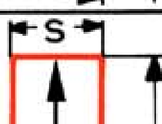


107

1.5



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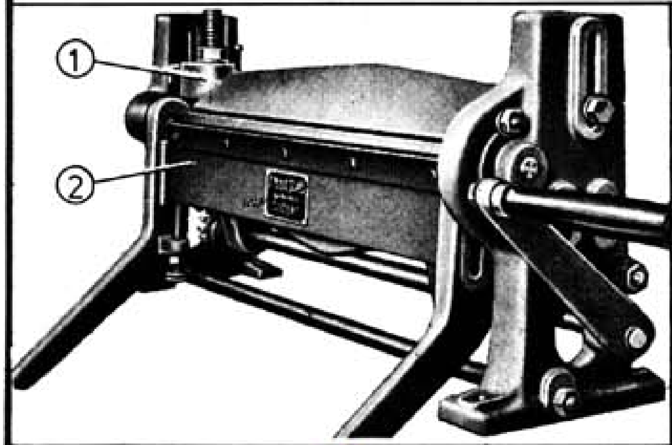

1.2

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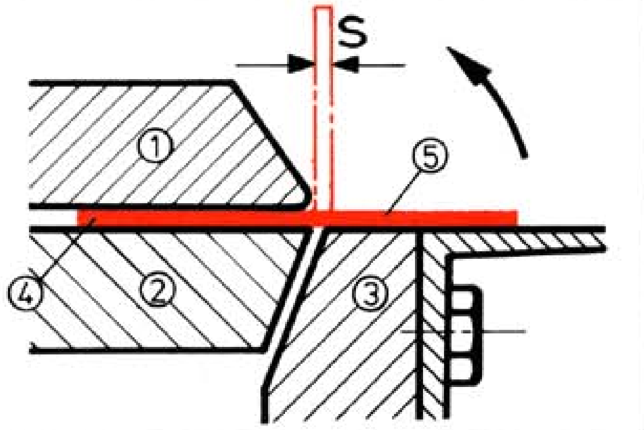

2.2

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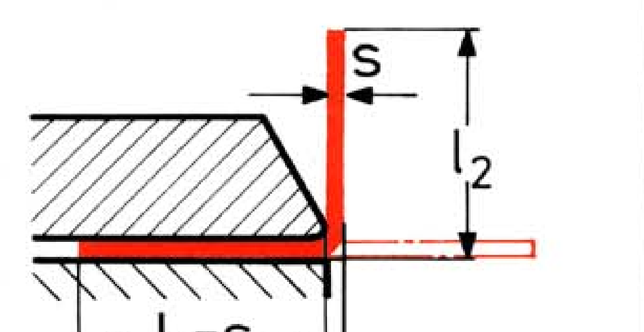

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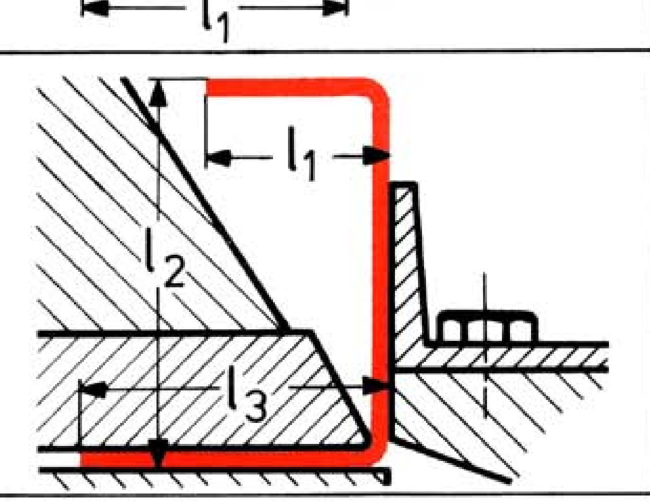

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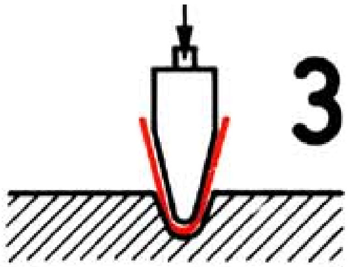

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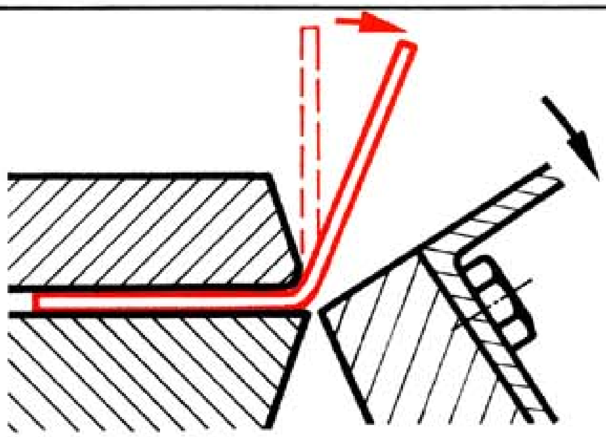

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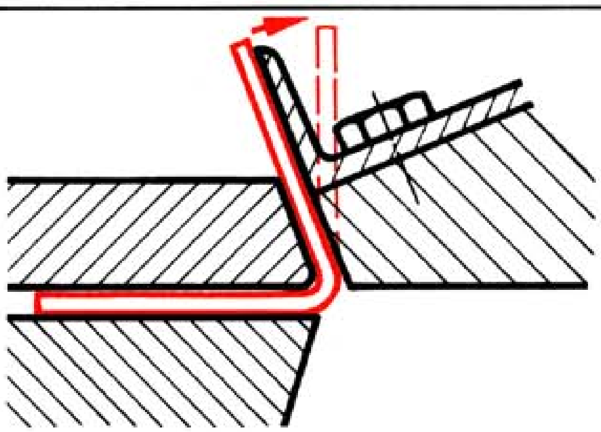

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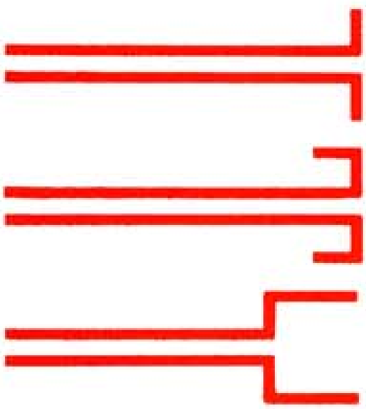

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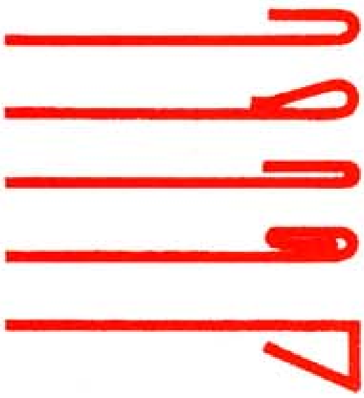

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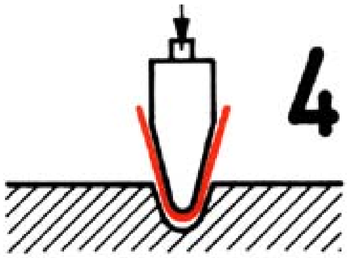
3.5



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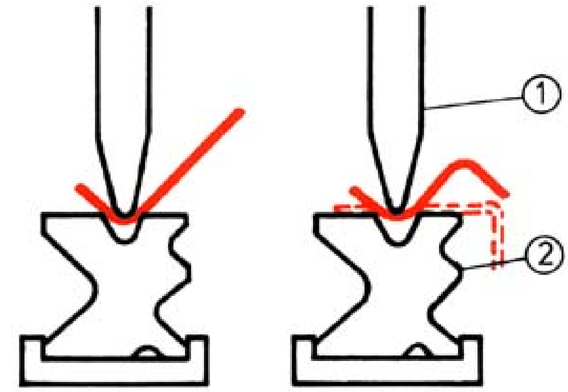

4.1

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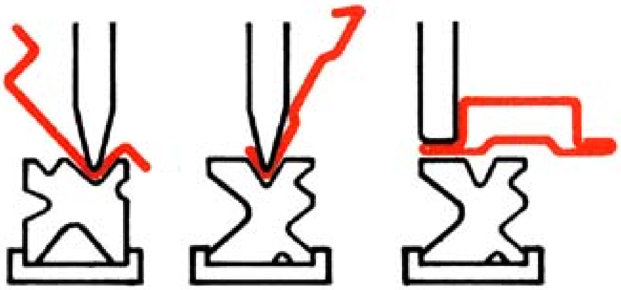

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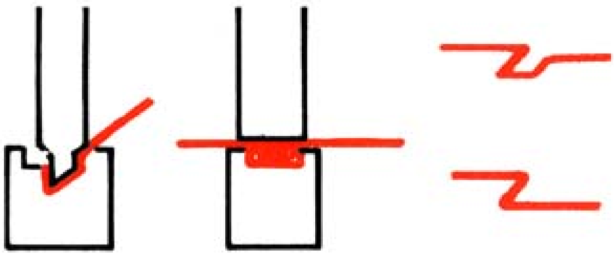

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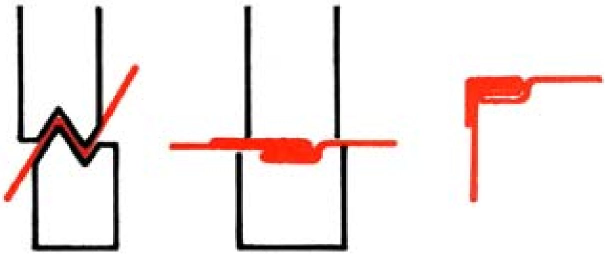

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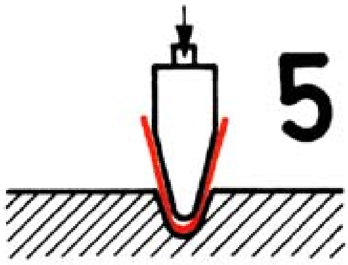

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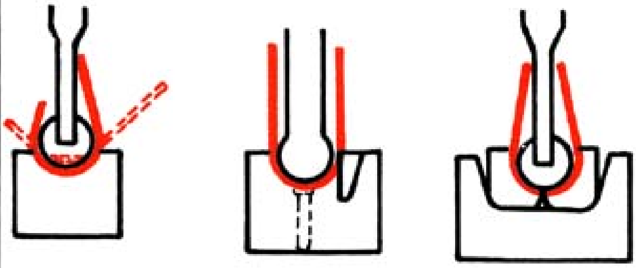

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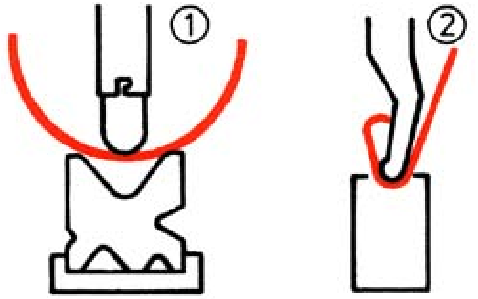

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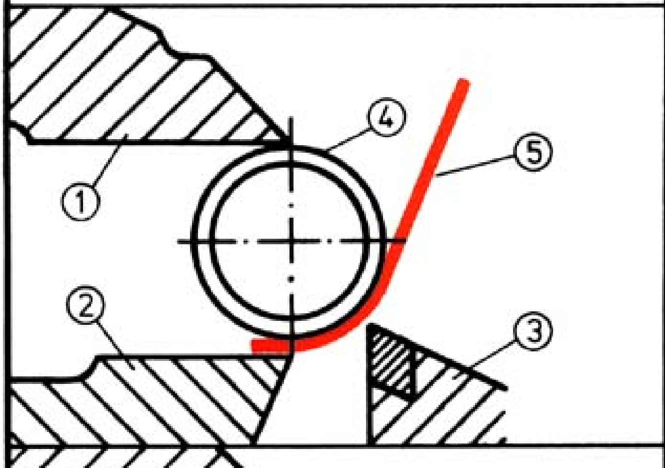

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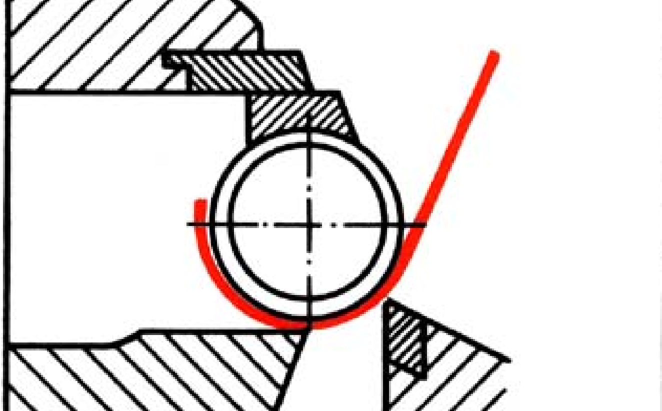

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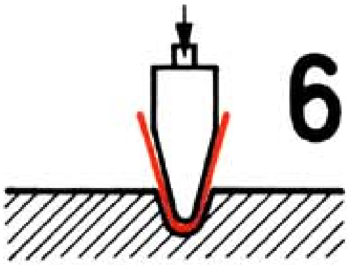

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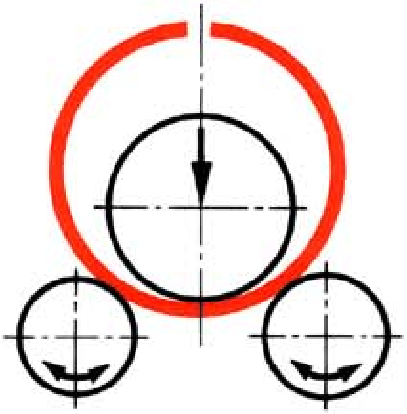

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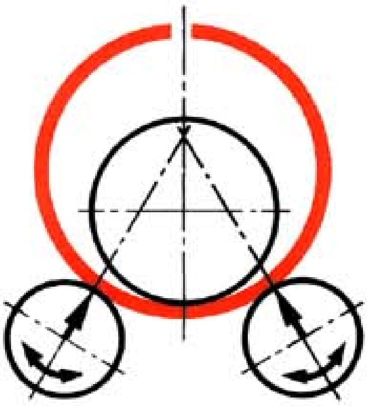

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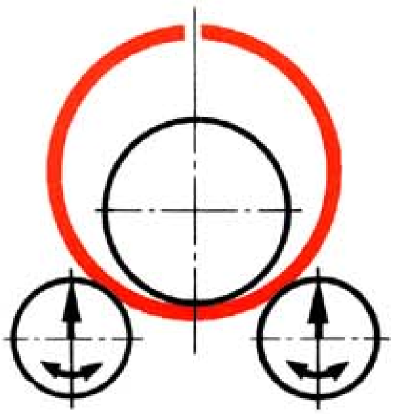

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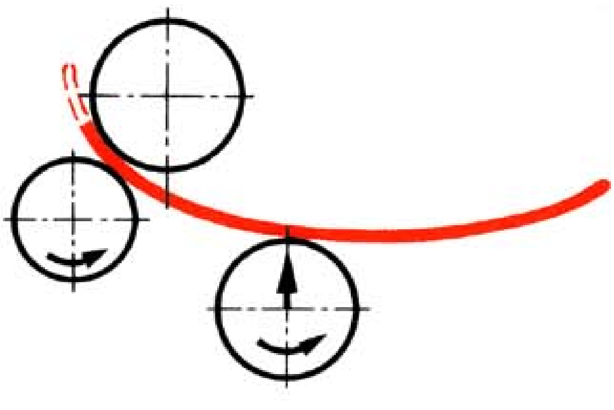

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