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STRENGTHENING THE TECHNICAL AND MANAGERIAL CAPACITIES OF THE CARPENTRY COOPERATIVES IN MUKALLA AND SEIYUN

SM/YEM/92/035*

THE REPUBLIC OF YEMEN

Technical report: Training Manual on Surface Planing and Thicknessing**

Prepared for the Government of the Republic of Yemen
by the United Nations Industrial Development Organization
acting as executing agency for the United Nations Development Programme

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* Previously SM/PDY/87/005.
** This document has not been edited.

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INTRODUCTION

This training manual is one of a series prepared by a UNIDO expert while serving as Chief Technical Adviser on a UNDP financed and UNIDO executed project in the Republic of Yemen, to strengthen the Technical and Managerial Capacities of the Carpentry Cooperatives in Mukalla and Seiyun (project No. SM/PDY/87/005, now SM/YEM/92/035).

The entire scope of the training envisaged to be given, with the intended audience for each topic is given in Annex I.

The syllabus, namely the topics, the duration of lectures (theory) and practical work and the level of competence attained after completion of the course on this topic is given in Annex II.

SURFACE PLANING AND THICKNESSING

After cross-cutting and ripping has been completed, the workpieces have their gross dimensions (lengths, widths and thicknesses). Thicknesses are usually the standard thicknesses of sawnwood. The gross dimensions are the net ones plus additions for processing. These additions are in fact layers to be removed during planing and thicknessing in order to obtain plane sides and rectangular cross-sections of the workpieces.

The next operations after sawing to the gross sizes are planing and thicknessing. Various machines are used to perform these operations, such as: surface planer-jointer, thicknesser and multi-face planer-profiler. Different planing machines can be used, depending on the number of faces to be processed simultaneously such as: one, two, three or four-side planers.

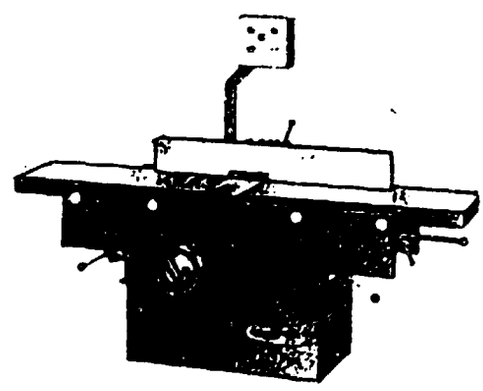
Very often, these operations are combined with tenoning, rebating, grooving, profiling etc. and these are usually done on the multi-side planer-profiler.

The most important requirements for planing and thicknessing are: smooth surfaces, straight sides and edges, rectangular cross-cuts and accurate thicknesses and widths. This depends on: the machines' accuracy, a correct selection and maintenance of cutting tools and on the operators' skills.

The purpose of this manual is to train the carpenters who will perform planing and thicknessing operations in the correct, accurate and safe machining of furniture and joinery parts.

1. Surface planers/jointers

Surface planers are used to remove any unevenness left after the preceding operations and to obtain the required shapes and dimensions to the cross sections of the workpieces.



The principle of planing is shown in Fig. 1 hereunder.

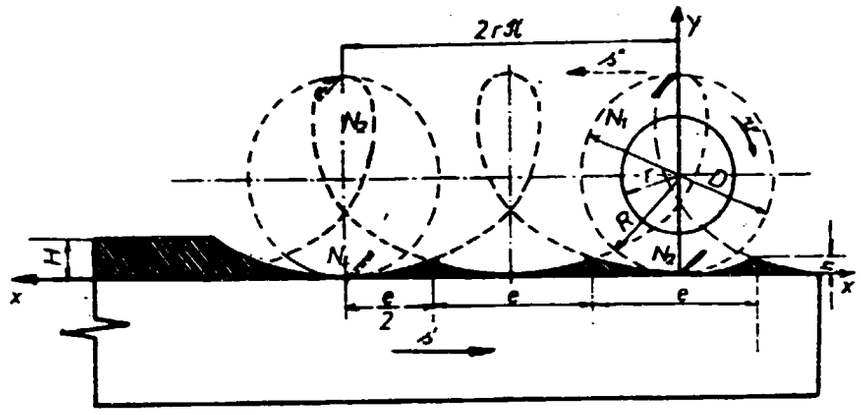


Fig. 1: Principle of planing.

The cutter-block with two knives (N_1 and N_2) rotates the knives sweeping the length of the circumference with radius R. A workpiece moves in the x-x plane and the cutter-block removes a wood layer of thickness H. The planed surface is not perfectly even, but is wavy, and the quality of planing is expressed by the length and depth of the waves of the extended cycloid. The cutting direction on all planers is always opposite to the direction of feed of the workpiece. The length of the cutting edge of the knife is always longer than the width of the workpiece (i.e. open cutting).

The cutting speed of the planer is usually of the range of 20 to 40 m/sec and can he computed by using the formula:

$$v = \frac{D \cdot \pi \cdot n_c}{1000} \ (m/sec.)$$

where: D = Diameter of the cutterblock (mm)
π = 3.14
n_c = Number of cutterblock revolutions per second.

In cases of fully driven machines n_c is obtained using the following formula:

$$n_c = \frac{n_m \cdot D_m}{60\ D_c}$$

where: n_m is the RPM of the electric motor driving the machine,
D_m is the diameter of the V-belt pulley on the motor,
D_c is the diameter of the V-belt pulley on the cutter block axle.

Example:

Diameter of a cutterblock D = 150 mm
Electric motor has n_e = 2850 RPM
Diameter of V-belt pulley on motor D_e = 250 mm
Diameter of pulley on the cutterblock D_c = 200 mm

$$n_c = \frac{2850 \cdot 250}{200 \cdot 60} = 59.38 \text{ revolutions per second}$$

$$v = \frac{150 \cdot \pi \cdot 59.38}{1000} = 26.67 \ (m/sec)$$

With the same feeding speed the quality of planing will be improved if the cutting speed is higher, or for the same quality of planing a higher cutting speed will allow higher feeding speed, i.e. a higher productivity of the machine.

Surface planers are usually one or two-sided planers. They are used to remove unevenness to obtain a plane, even and smooth base on the workpiece. This is necessary for further processing. The planers are used for planing two adjacent sides of a workpiece, at required angle, which is most often 90 degrees.

The cutter-block is placed between the front (infeed) and the rear (outfeed) worktable, as shown in Fig. 2.

Key:
1. Workpiece
2. Cutterblock
3. Infeed work table
4. Outfeed work table

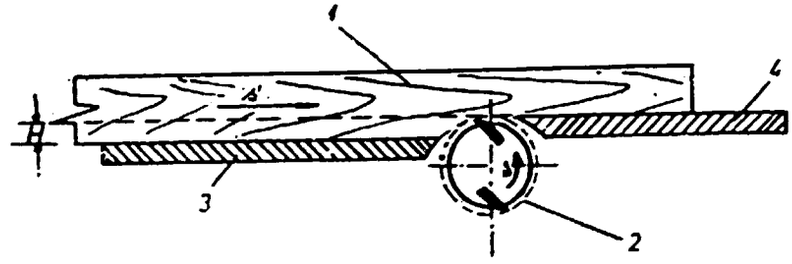


Fig. 2: Position of cutterblock and work tables on a surface planer.

The work tables are in horizontal planes. The outfeed work table is in the plane which is tangential to the circumference of the cutting edges. The infeed worktable is in a lower parallel plane. The distance between these two planes is equal to the depth of cut (H).

The planers are usually fed manually, but mechanized feeding devices can also be used. Such a planer is shown in Fig. 3.

Key:
1. Main body
2. Infeed work table
3. Outfeed work table
4. Cutterblock
5. Wheel for lifting the infeed table
6. Wheel for adjusting the outfeed table
7. Guiding fence
8. Set screws for setting fence plane
9. Ditto
10. Electric motor

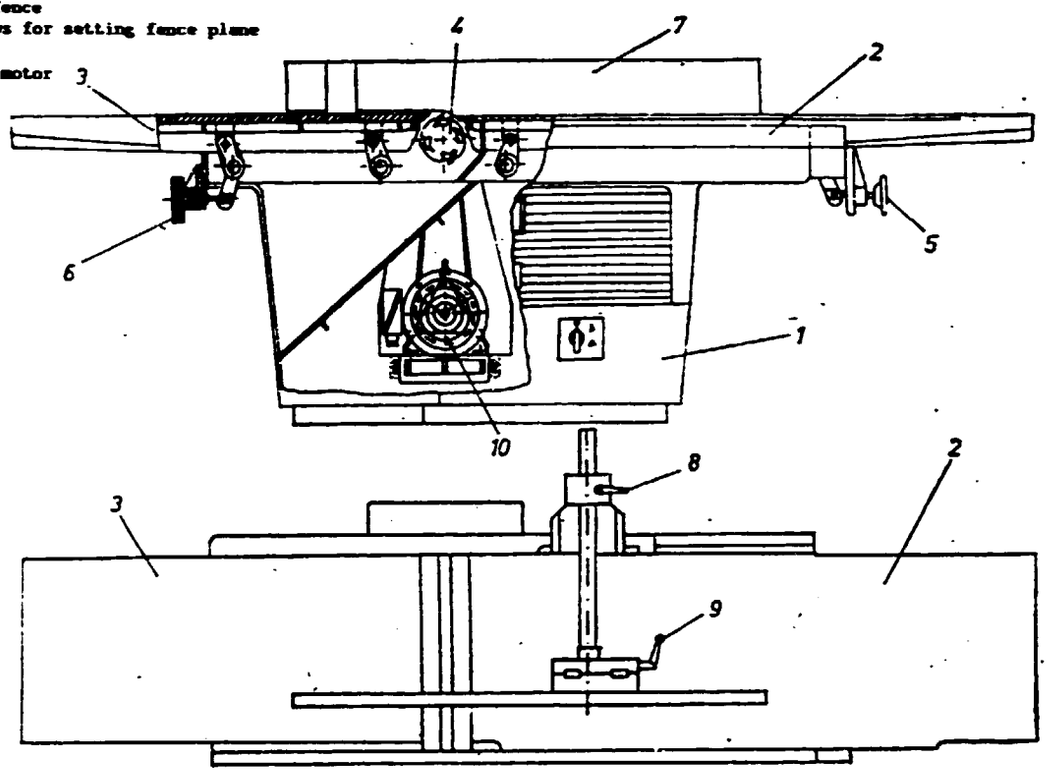


Fig. 3: General View of a planer.

The machine's body is made of cast iron. It supports other parts and serves to fix the machine to the foundation. Special openings are made to connect the dust extraction outlet and pipes. The work tables are of cast iron with their upper surfaces planed smooth. Their heights can be adjusted by means of inclined slides or by eccentrics (see figs. 4 and 5). The infeed work table can be moved up and down by up to 20 mm, but for regular planing, the depth is seldom more than 2 to 3 mm.

Key:
1. Worktable
2. Slope sliders
3. Leading screw

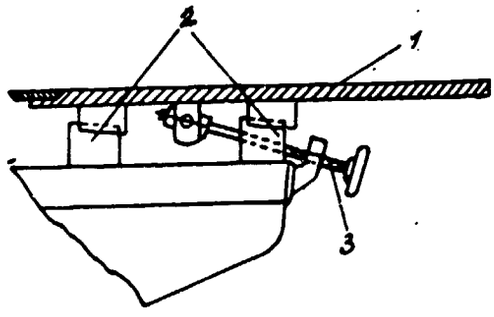


Fig. 4: Adjustment of the worktable with an inclined side.

Key:
1. Work table
2. Eccentrics
3. Controlling lever

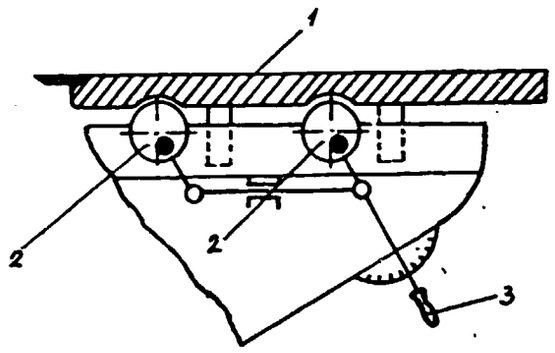


Fig. 5: Adjustment of the work table with an eccentric.

The cutter-block is the most important part of a planer. Modern planers have precisely cylindrical cutter-blocks. Cutter blocks with square cross sections were used in the old machines. These are dangerous and should be replaced by cylindrical ones. Fig. 6 hereunder shows the construction of a planing cutter block and one method of setting the knives.

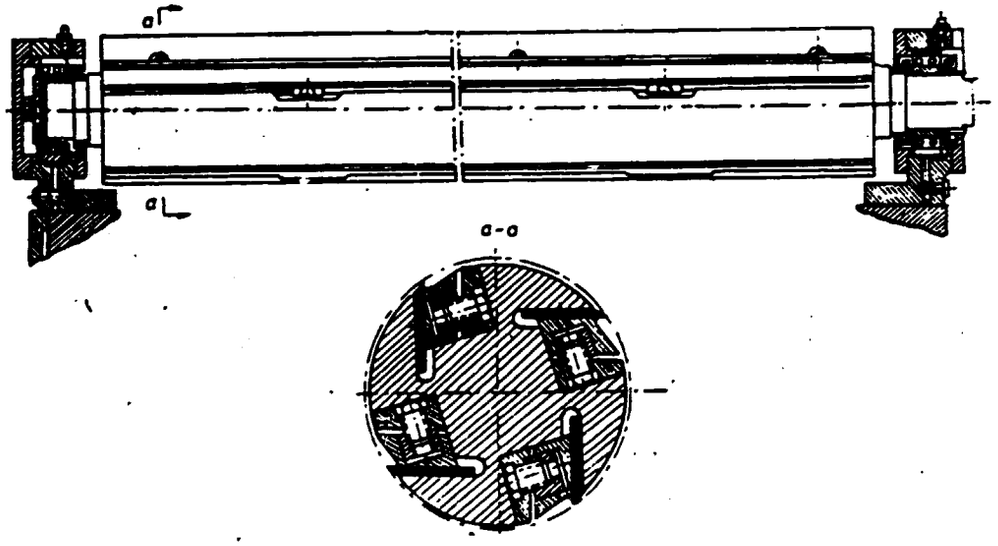


Fig. 6: Planing cutterblock with knives fixed with screws.

Some other methods of fixing knives are shown in Fig. 7.

Fig. 7: Various methods of setting planing knives.

The best way for fixing knives in a cutter-head is by hydraulic tightening because an equal pressure can be assured. This type of cutter-head has no openings which in the other types usually cause intensive air turbulence and high noise levels.

Besides cutter-blocks with straight knives, there are also cutter-blocks with spiral knives. These cutter-blocks are quieter but their maintenance and knife setting are more complex. Surface planers work in a very simple way. Mostly they have only one electric motor whose rotation is conveyed to the cutter-block by means of V-belts.

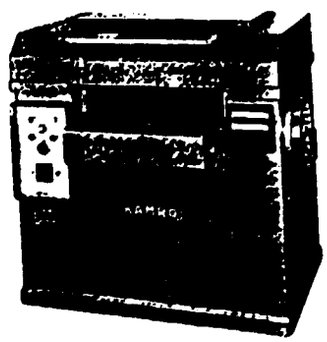
Attempts to mechanize feedirg of the planers have been made, but from the technical point of view manual feeding is considered to be satisfactory.

The most important technical data for surface planers are:

- width of planing	usually 400 to 600 mm
- number of knives in the cutterblock	2 or 4
- Speed of cutter-block	up to 6000 RPM
- Electric motor power	about 5 kW.

2. Thicknessers

Thicknessers are used for planing to the required thickness. Prior to thicknessing, the workpiece must have planed base surfaces.



The cutting direction on the thicknesser is opposite to that in which the workpiece is fed, and the vertical component of the cutting force pulls

the workpiece up. In order to neutralize this vertical force, pressers are used to press the workpiece to the work table. The feeding of thicknessers is mostly done by means of feeding rollers. The principal components of a thicknesser are shown in Fig. 8 hereunder.

Key:
1. Workpiece
2. Work table
3. Smooth (dead) rollers
4. Upper infeed grooved roller
5. Upper outfeed smooth roller
6. Roller pressure spring
7. Cutter block with 4 knives.
8. Front pressure bar
9. Rear pressure bar
10 Presser spring
11. Kick-back stop.

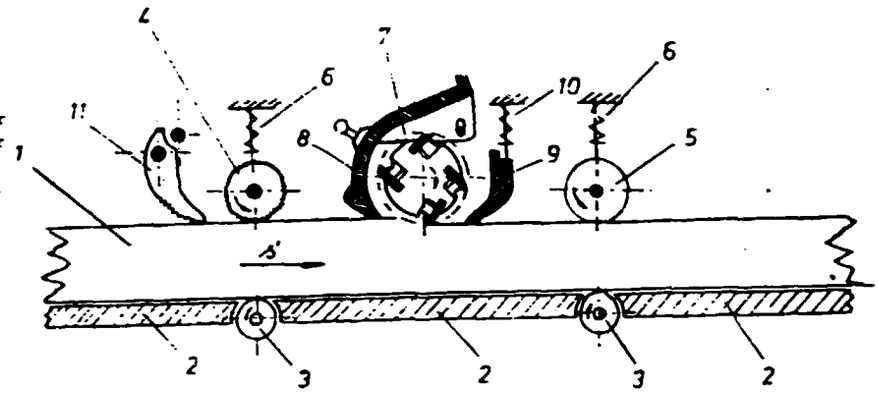


Fig. 8: Principal components of a thicknesser.

The feeding rollers are on the upper side, while the dead rollers are built in the work table. The rear (outfeed) roller is smooth because it is in contact with already planed surfaces. The front upper feeding roller is grooved to assure a better grip and safe feeding. This roller can be grooved because it is in contact with rough surfaces.

The general view of a thicknesser is shown in Fig. 9. The main body of a thicknesser is made of cast iron in the form of an open box. It supports all other parts and fixes the machine to its foundation. The work table is placed in the opening of the body. On the lateral sides of the body are housings for cutter-block bearings. The driving motor and its gear box are located in the body's hollow space. The work table is made of cast iron with the upper surface planed smooth. It has strengthening ribs on its underside.

Slots exist in the transversal direction of the work table for placing lower dead rollers (see fig. 10). The rollers are higher than the work table by 0.1 to 0.2 mm. This height depends on the dimensions and characteristics of the wood being planed. Softer woods require a bigger and hard woods a smaller difference. These rollers reduce friction between the workpieces and the work table and facilitate feeding. The adjustment of the lower dead rollers is done by means of a lever or screws. The adjustment by lever is more convenient.

Key:

1. Main body
2. Work table
3. Adjusting wheel for the work table
4. Sliding guide for the work table
5. Metric scale showing thickness of a work piece
6. Cutter block with knives
7. Front pressure bar
8. Rear pressure bar
9. Infeed grooved roller
10. Outfeed smooth roller
11. Lower smooth roller
12. Wheel for adjusting the height of lower roller
13. Kick-back stop
14. Lever for changing the feeding speed
15. Main switch lever
16. Motor switch
17. Machine's hood
18. Dust extraction outlet

(There are four sliding guides, two on each side.
Only one is shown for simplicity.)

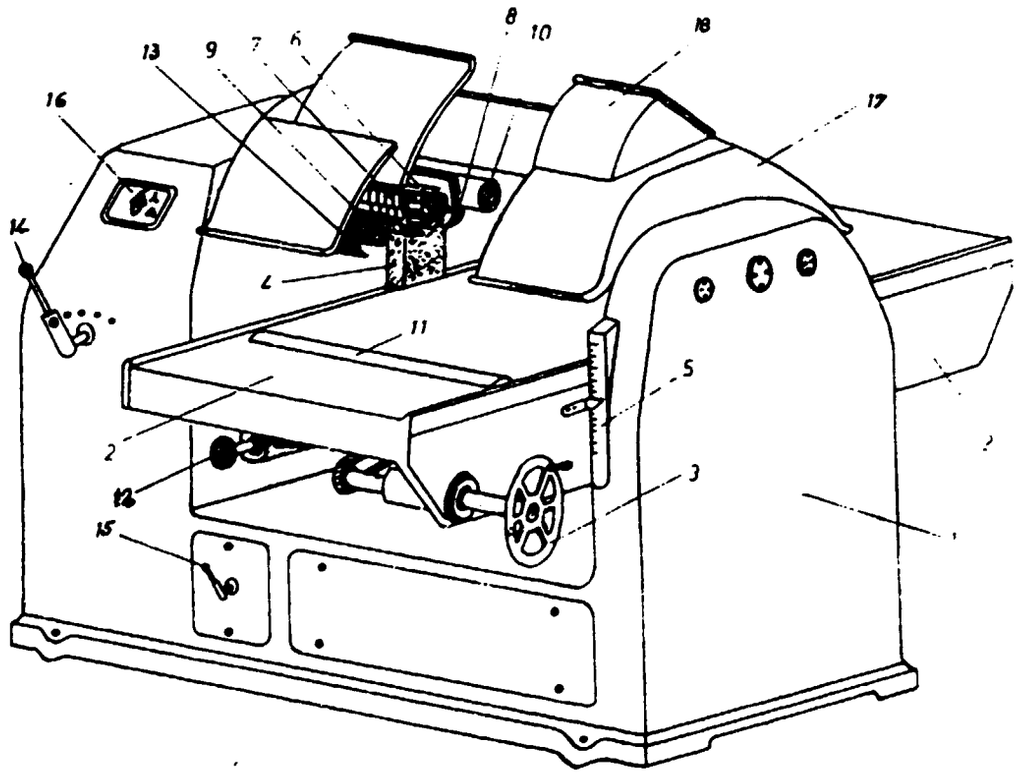


Fig. 9: General view of a thicknesser.

Key:
1. Work table
2. Lower smooth rollers
3. Screws for adjusting worktable height

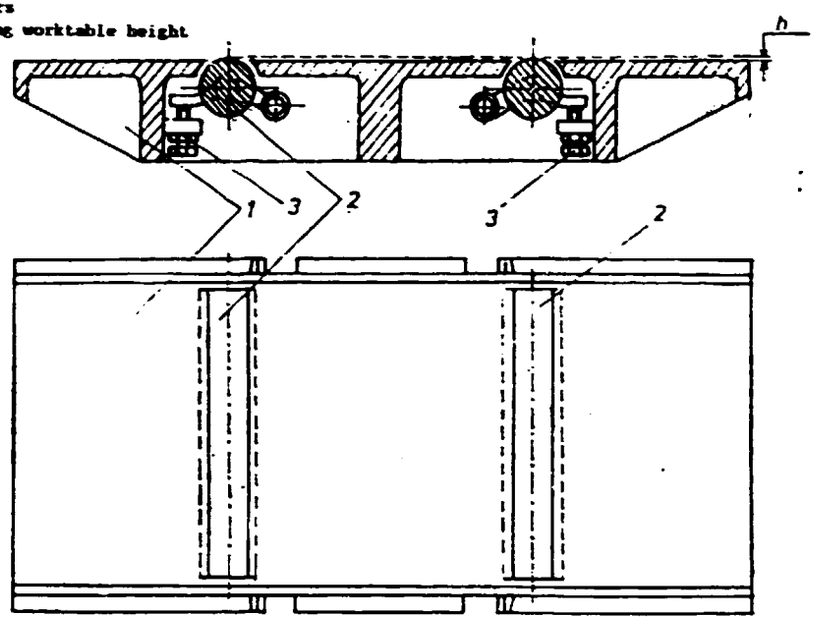


Fig. 10: Work table of a thicknesser.

The adjustment of the thickness of a workpiece is done by lifting or lowering the worktable. Some machines are constructed with a manual and others with a mechanical adjustment of the work table. The mechanism for a manual adjustment of the work table is shown in Fig. 11 hereunder.

Key:
1. Work table
2. Leading screws
3. Wheel
4. Sliding guides
5. Lower rollers

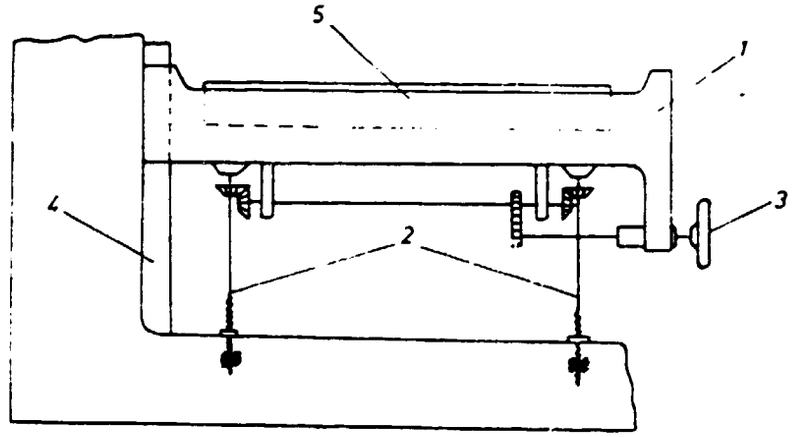


Fig. 11: Manual adjustment of the work table.

Cutter-blocks of thicknessers could have either circular or square cross sections. The latter ones belong to the older type of thicknessers. The diameters of these cutter blocks range from 100 to 140 mm, but some very heavy machines could have cutter blocks of 200 mm in diameter.

The pressure bars have two functions: to press the workpiece to the surface of the work table and to prevent splitting of wood along the fibres because of the cutting force. The front pressing bar is constructed in a way to direct shavings to the machines' dust outlet. They could be either a single piece or have a sectional construction. Modern thicknessers usually have sectional pressure bars. These enable the simultaneous thicknessing of more workpieces with some variations of thickness. Namely, thicknesses of workpieces that have been surface planed but not yet thicknessed could vary by up to 5 mm. A view of the single piece front pressure bar is shown in fig. 12.

Key:
1. Cutter-block cover
2. Pressure bar
3. Pins
4. Handle for lifting pressure bar
5. Screw for adjusting the pressure bar
6. Weight or spring

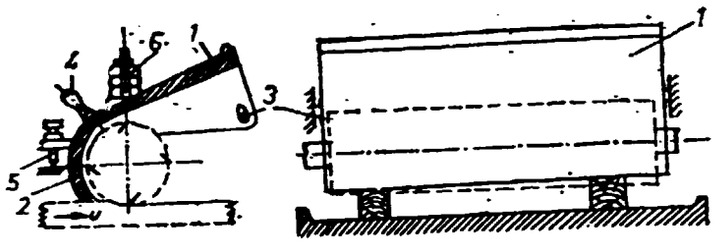


Fig. 12: Front pressure bar as a single piece construction.

A sectional pressure bar permits a better utilization of the machine's capacity and is therefore nowadays regularly incorporated in modern thicknessers. Every single presser is independently loaded with a spring and can adapt to variations in thickness of the workpieces. However. the differences must not be greater than 5 mm.

A view of a sectional pressure bar is shown in Fig. 15. The rear pressure bar is always constructed as a single piece, because the thickness of all processed workpieces are identical.

This pressure bar prevents shavings from falling on the planed surfaces before the upper outfeed roller, because otherwise, these would be pressed into the wood, leaving imprints.

Feeding is done by the upper rollers: infeed rollers are grooved whereas outfeed rollers are smooth. Infeed rollers can also either be made of one piece or be sectional. Modern thicknessers usually have sectional grooved rollers. They can be constructed in different ways, but have the same possibility to adapt to the various thicknesses of workpieces. A view of a sectional infeed roller is shown in Fig. 13.

Key:
1. SEction of the pressure bar
2. Body of the pressure bar
3. Springs
4. Screws to adjust spring tension

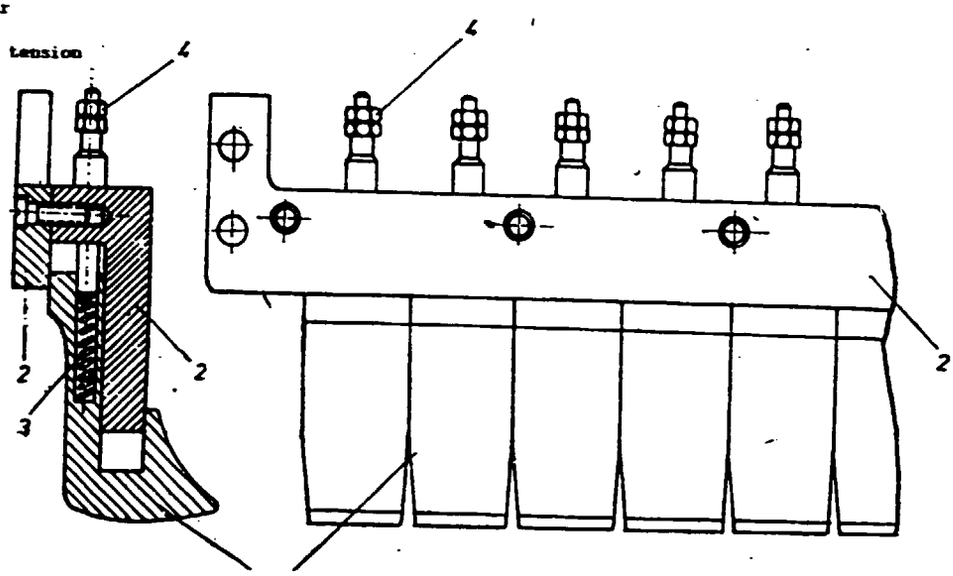


Fig. 13: Sectional pressure bar.

Key:
1. Chain pulley
2. Shaft
3. Sections (rings)
4. Rubber segments

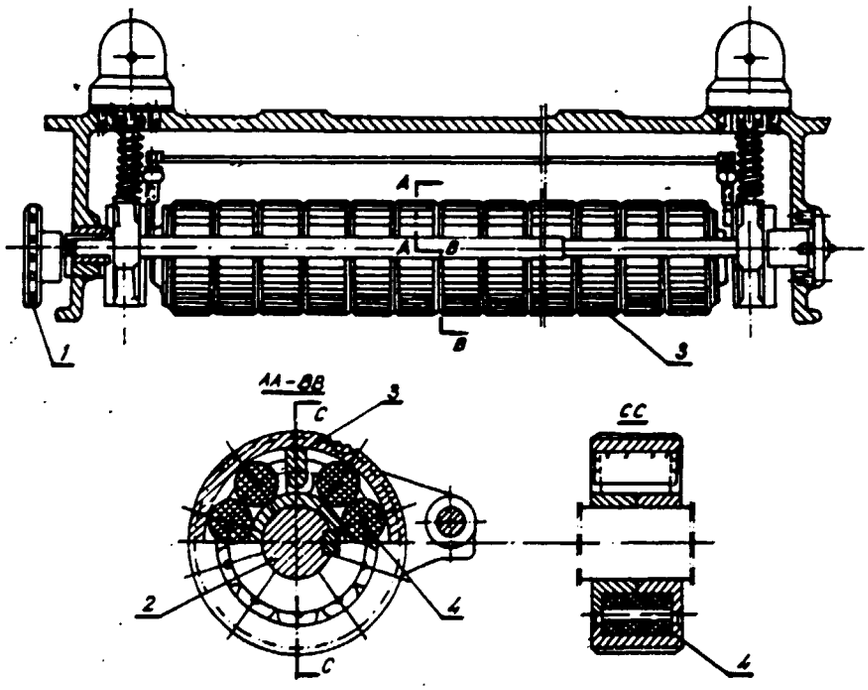


Fig. 14: Grooved infeed sectional roller.

The upper outfeed roller is always made of a single piece for the same reason as the rear pressure bar.

Geometric relations of rollers and pressure bars to the cutterblock are shown in Fig. 15 hereunder.

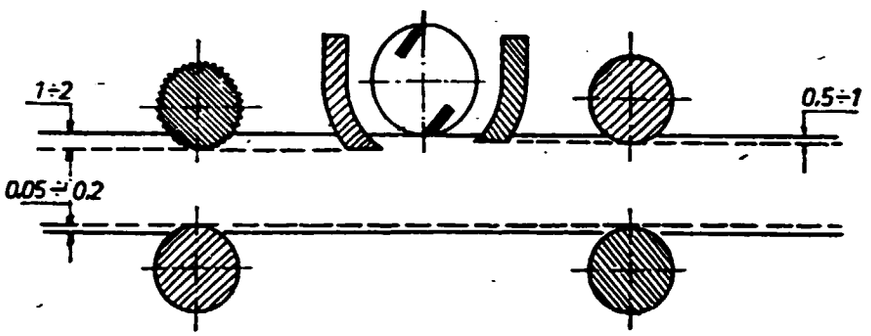


Fig. 15: Relative politions and adjustments of rollers and pressure bars.

The most important technical data for medium size thicknessers are:

Width of work table:	around 600 mm
Maximum thickness of workpieces	around 200 mm
Number of knives in cutter block	mostly 4
Feeding speeds	10 to 20 m/min.
Number of feeding speeds	1 to 4 or stepless
Electric motor power	around 10 kW

The transmission of power to feeding and cutter elements in a thicknesser is shown in Fig. 16.

Combined planing machines exist that are used for both surface planing and thicknessing with the same cutter block. Often other woodworking tools are added on the same shaft, such as: circular saws, drills etc. These machines are called universal woodworking machines and are used mostly in small handicraft workshops.

Key:
1. Pulley
2. Electric motor
3. Cutterblock pulley
4. Pulley
5. Gear box pulley
6. Chain
7. & 8. Chain pulley for upper rollers
9. Chain tension weight
10. Tension wheel
11. Clutch lever
12. Lever for changing feeding speed.

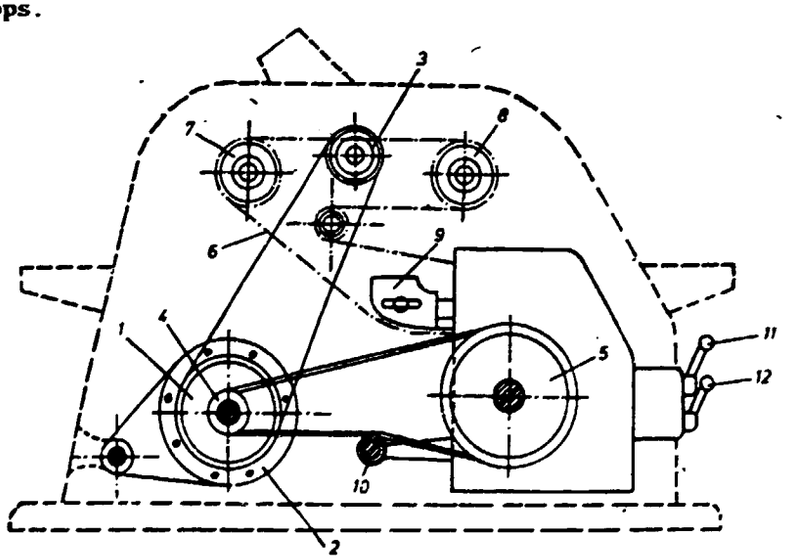


Fig. 16: Transmission of power to feeding rollers and cutterhead in a thicknesser.

3. Multi-side planers profilers

These machines can be classified as: two-side, three-side and four-side planers and profilers.

Two-side planers are used to plane two parallel surfaces simultaneously with one passing of the workpiece through the machine. They are used for processing bigger assembly blocks in specialized workshops. Two-side planers are used to get flat surfaces and required thicknesses of the parts processed. Therefore, they unite functions of both surface planers and thicknessers. To meet these requirements two-side planers have two cutter blocks placed in order first to perform surface planing and after that, thicknessing operations.

The principal components of a two-side planer are shown in Fig. 17.

Key:
1. Work table
2. Front work table of the surface planer
3. Surface planer's shaft with a cutterblock
4. Pressure rollers
5. Infeed grooved rollers
6. Lower infeed rollers
7. Thicknesser's shaft with a cutterblock
8. Front pressure bar
9. Rear pressure bar
10. Outfeed smooth roller

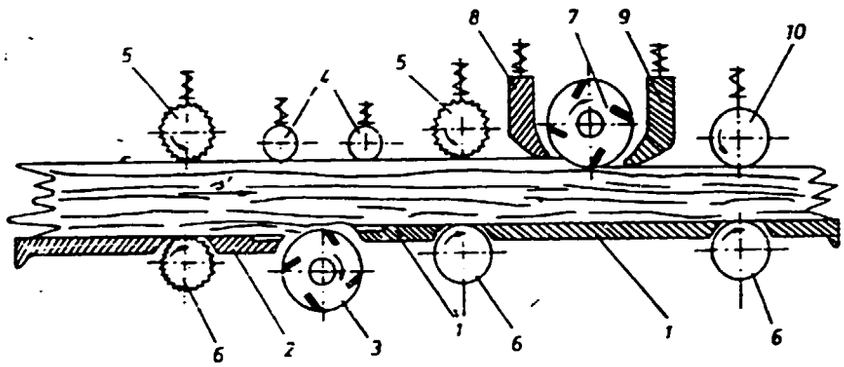


Fig. 17: Principal components of a two-side planer.

By lifting and lowering the worktable, the machine can be adjusted to produce the required thickness.

Three-side planers are used to plane three sides of wooden parts in one passing through the machine. There are three types of such planers and three-side planer-profilers. The wide three-side planers are used mostly by the sawnwood producers to make flooring and panelling products. These machines have one horizontal cutterblock to plane one side and two vertical spindles to make a tenon and a groove on the lateral sides. The narrow three side planers are used for processing small narrow parts which already have been planed on a surface planer. They are used for the production of packing boxes and other similar products.

Three-side planers/profilers are used for production of joinery products, to make profiled parts for windows and doors.

Three-side planers are rarely used nowadays because they have been replaced with the more versatile four-side planers.

Four side planers are used for planing simultaneous and profiling three or four sides of wooden components. A particular characteristic of these machines is that they can make profiled parts of very complex cross sections.

Short parts can be processed with any need for preliminary planing, but for the long workpieces it is recommended first to plane one face on a surface planer.

The feeding of these machines is exclusively mechanical, by means of feeding rollers. The total number of cutter blocks and spindles can vary from 4 to 8 and most often it is 5 or 6.

In workshops manufacturing joinery and furniture, narrow four-side planers are predominantly used. They have minimum four, but usually five cutter blocks with knives. In the case of five cutter blocks, the first is used for planing the base side and the other two pairs are used for planing two horizontal and two vertical sides. The cutter blocks are arranged to work like a planer thicknesser system, as shown in fig. 18.

Key:
1. Infeed work table
2. Outfeed work table
3. Upper feeding rollers
4. Lower feeding rollers
5. Front part of the right guiding fence
6. Planing cutter-block
7. Pressure rollers
8. Right vertical cutter-block
9. Rear part of the right guiding fence
10. Left vertical cutter-block
11. Front pressure bar
12. Pressure roller
13. Thicknessing cutter-block
14. Front Pressure bar
15. Rear pressure bar
16. Rear cutter-block
17. Pressure plate

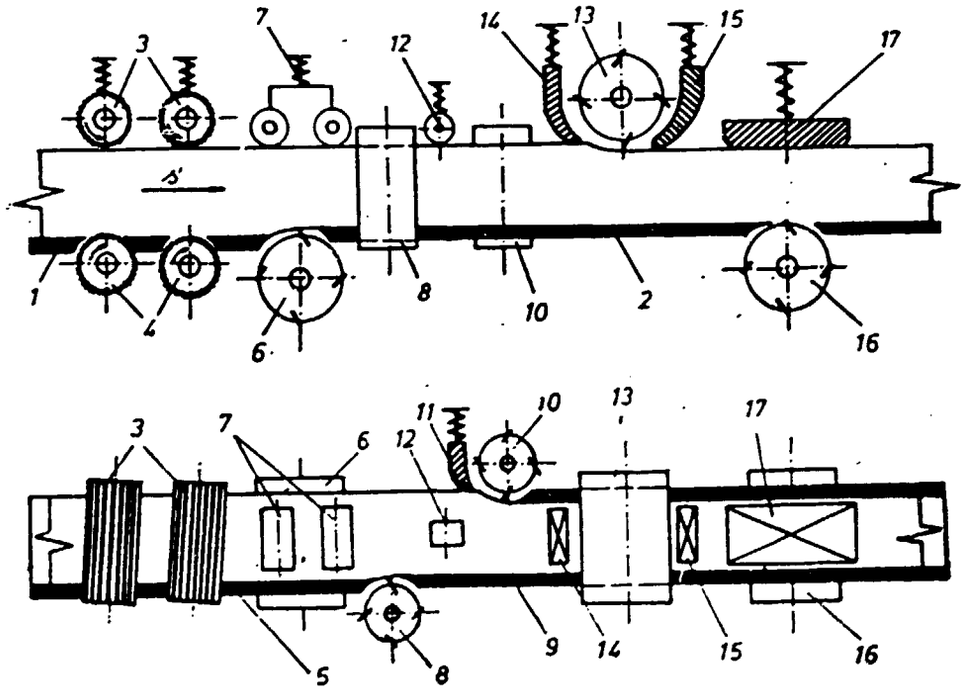


Fig. 18: Principal elements of a four-side planer.

The feeding mechanism always consists of single-piece rollers, because the parts are processed one after another. Upper infeed rollers are inclined or have inclined grooves in order to press the workpieces against the guiding fence.

For a better leading of the workpieces, modern four-side planers have the first lower cutter-block with grooving cutters to make a groove on the lower side of the workpieces. In such a case, the work table has a tenon-like profile to lead the workpiece until it has been planed on three sides. At the end the last lower cutter block will plane the fourth side and remove the groove. The last, fifth cutterblock can be set from the upper or lower side or at a certain angle to cut the required profiles. A general view of a four side planer is shown in Fig. 19.

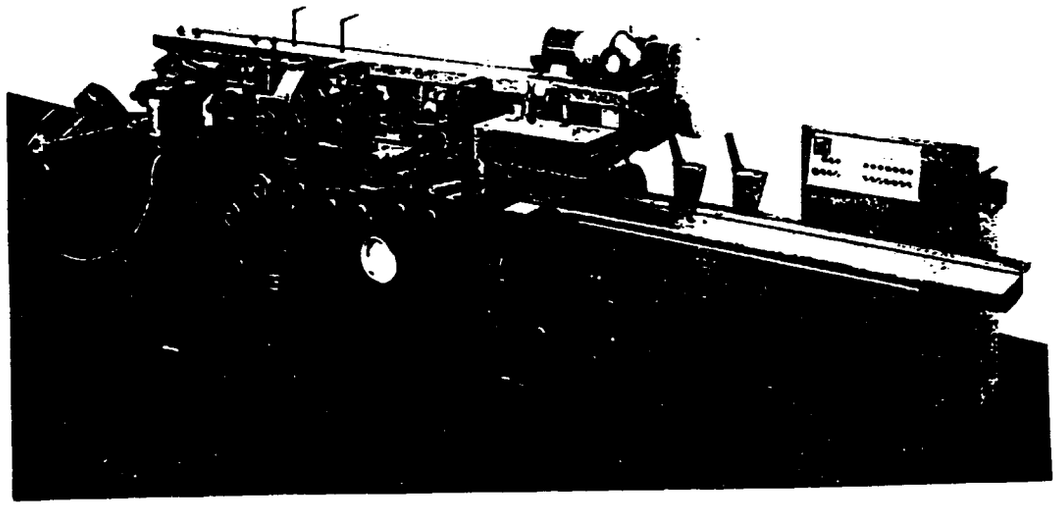


Fig. 19: A general view of a four-side planer.

The horizontal cutter blocks are placed on a cantilevered shaft. A typical cutterblock is shown in Fig. 20.

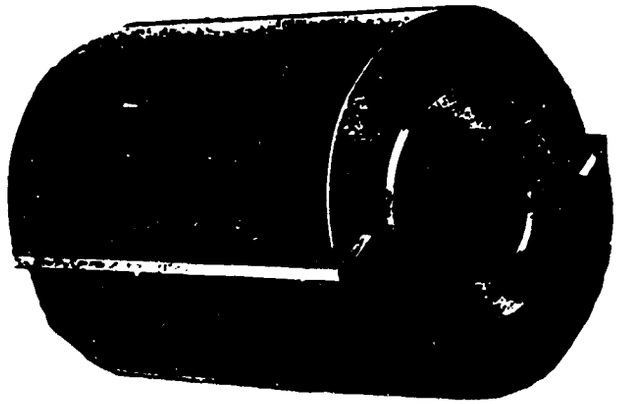


Fig. 20: A cutter-block for planers with two knives.

Because of the relatively high rotational speed, knives must be set safely. There are several systems to do so: knives with a nose, knives with a slit, knives with a toothed resting surface etc.

The most important parameters for cutterblocks are: overall diameter (D), diameter of a shaft (d), and length (L). The most common sizes of cutterblocks for narrow four side planers are:

Diameter (D)	100 or 125 mm
Diameter of a shaft (d)	30 or 40 mm
Length (L)	40 to 200 mm

The technical aspects of setting up four-side planers focuses on getting the geometric relations between the feeding mechanism, the planing knives and the pressure rollers to the cutting planes. It is necessary to define the basic setting plane, as shown in Fig. 21.

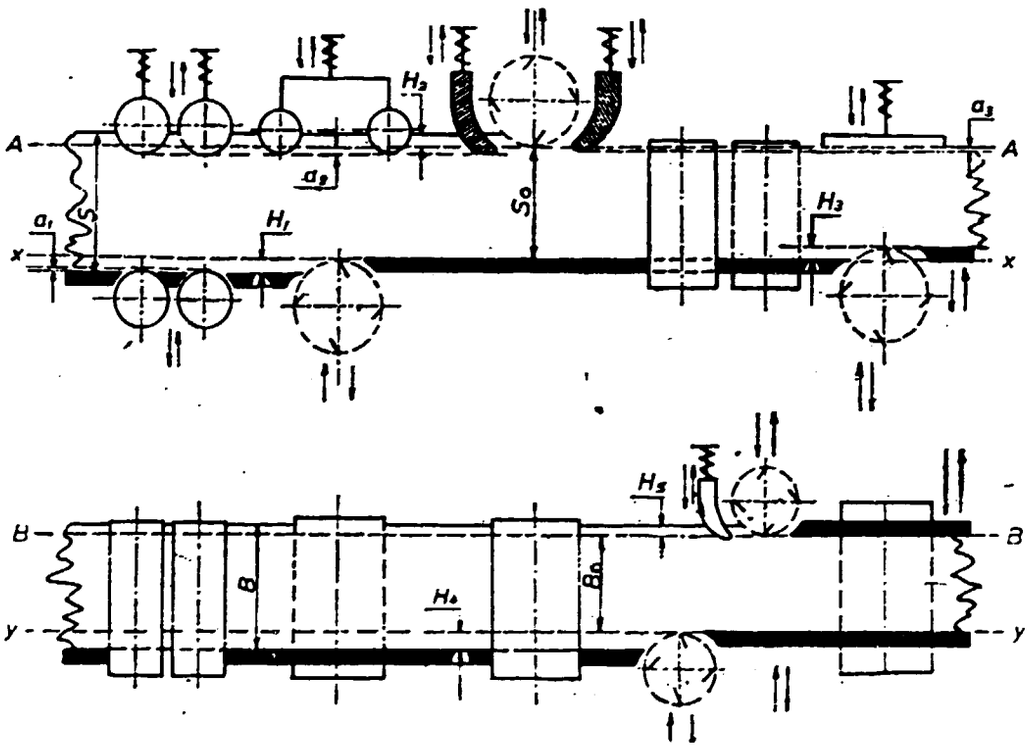


Fig. 21: Technical aspects of setting up a four-side planer.

The horizontal setting base x - x is the plane of the fixed rear, (outfeed) work table, and the vertical setting base is predetermined by the line y - y. The planing cutterblock and right vertical cutterblocks should be set in a position so that their bases are tangential to the cutting circles.

The infeed table and the right guiding fence are lower than the x - x or y - y axes respectively or H_1 and H_4 by 2 to 3 mm. The outfeed work table is in a plane which is above the x - x axis for the size of H_5, i.e. the cutting height of the rear cutterblock.

The lower rollers are higher than the work table for a_1 by 0.3 to 0.5 mm. The upper horizontal plane A-A and left vertical plane B-B are parallel to the bases x-x or y-y respectively, and at a distance of S_o or B_o from them respectively. The planes A-A and B-B should be tangential to the cutting circles of the upper or left vertical cutterblocks. All elements in front of the thicknessing cutter block are lower than the plane A-A by a_2 (= 1 mm). All pressers behind the thicknessing cutterblock are lower than the plane A-A by a_3 (= 0.5 mm). All pressers on the left side should be set evenly with the plane B-B.

The most important technical data for narrow four-side planers/profilers are:

Width of workpieces processed	up to 300 mm
Thicknesses of the workpieces	up to 100 mm
Cutting speed	30 to 50 m/sec.
Feeding speed	10 to 30 m/min.
Driving power	
- for cutterblocks total	about 15 kW
- for feeding	about 3 kW

4. Cutting tools for planers

Wood planing tools consist of cutterblocks with knives. The correct geometry of the cutting elements is obtained using grinding wheels and positioning the knives correctly in the cutterhead. The position of the knives in the cutterhead is predetermined by the construction of the cutterheads (see fig. 22).

Key:
1. knife
2. trapezoidal wedge

Clearance angle $\alpha \pm 10°$
Hook angle $\beta = \pm 40°$
Chip angle $\gamma = \pm 40°$
$\delta = \alpha + \beta$

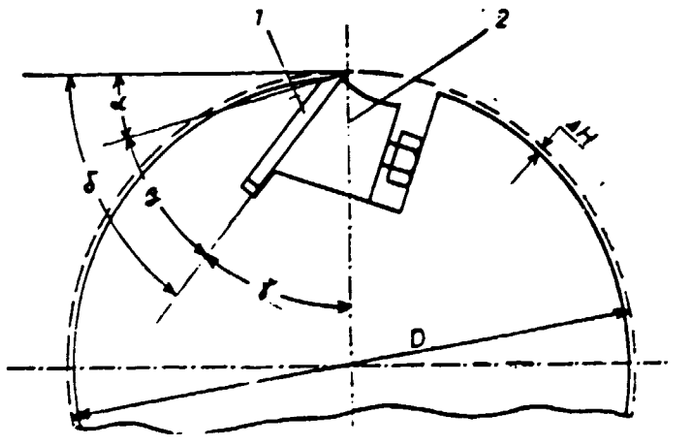


Fig. 22: Position of a knife in a cutter-block.

The position of the knife is predetermined by the angle δ, which is usually 50 degrees. It is the sum of the clearance angle α and the hook angle β. If the clearance angle α is 10 degrees, then the hook angle β is 40

degrees. The knife is set so that the cutting edge sticks out of the cutterhead by 0.8 to 1 mm.

For planing cutterblocks, straight knives are used, but profiled cutters could be also used. The thicknesses of the knives is 2.5 to 5mm, their widths is about one third of the cutterblock diameter and their lengths correspond to the working length of the cutterblocks.

The knives can be made of solid high speed steel alloys or with inserted hard metal cutting edges. Some possible knife constructions are shown in Fig. 23.

Key:
1. Thin solid knife.
2. Thin knife with inserted cutting edge.
3. Thick knife with slits.
4. Thick knife with slots.

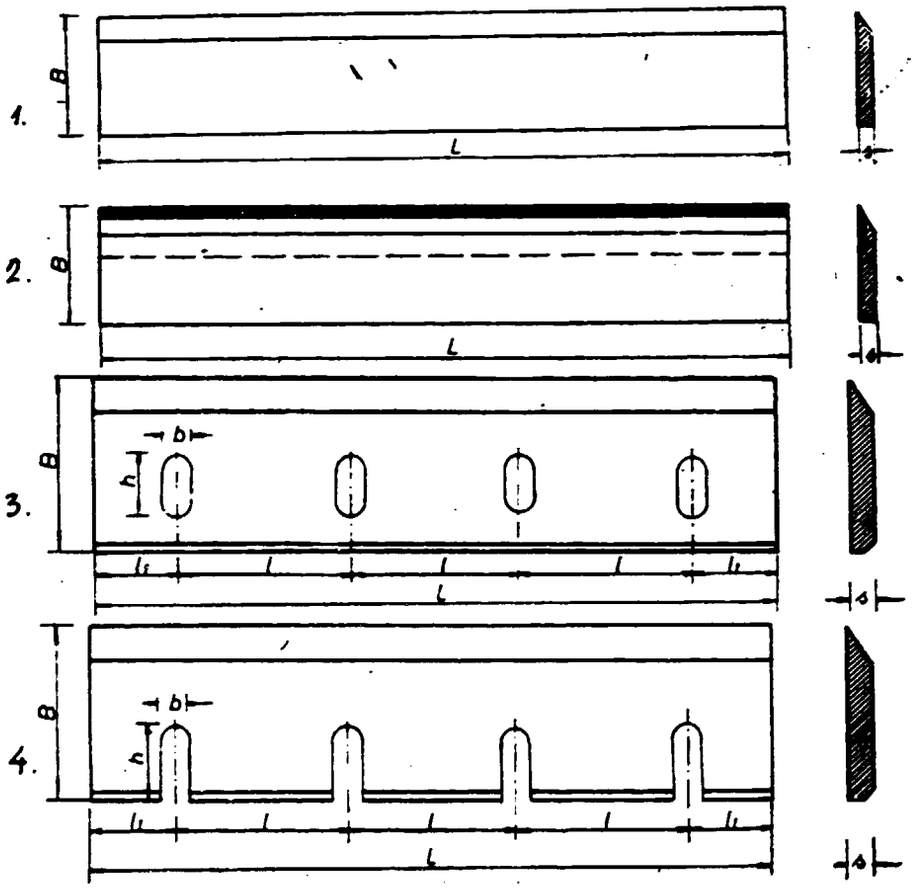


Fig. 23: Straight planing knives.

Profiled knives are used for three side and four-side planers. The cutting edges of these knives are bevelled or curved lines. Some profiles are shown in Fig. 24.

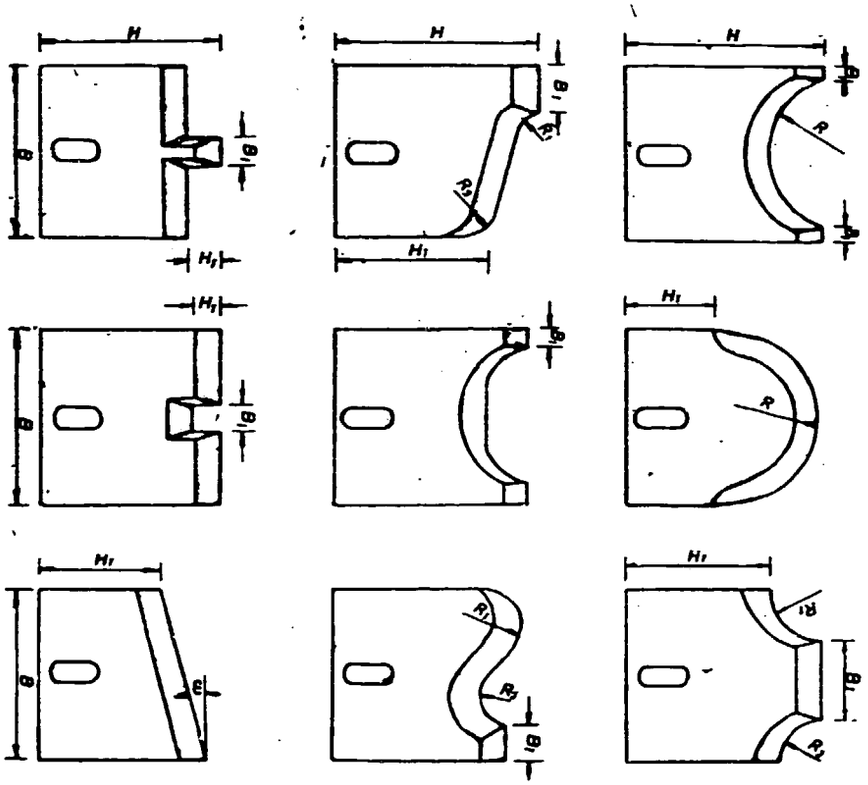


Fig. 24: Some examples of profiled knives.

Profiles made on a four sided planer are shown in fig. 25.

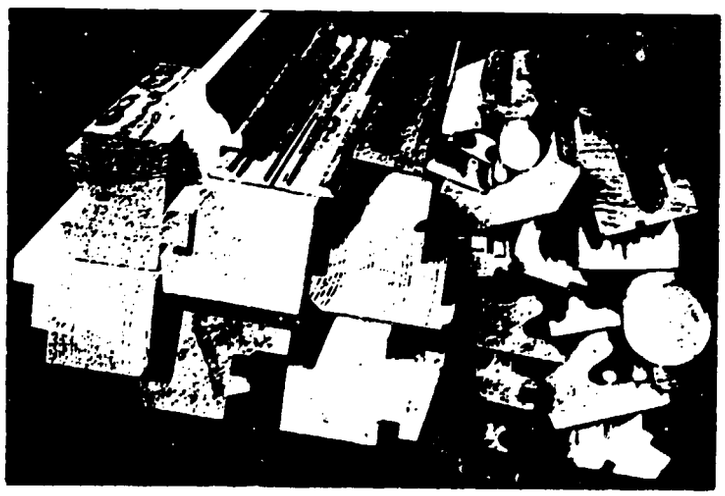


Fig. 25: Profiles made on a four-side planer.

The preparation of planing tools includes: grinding, balancing and setting knives and profiled cutters. Grinding of knives is regularly done on special knife grinding machines with cupped grinding wheels. All knives of one cutter block must have equal weights and the centre of gravity must be in the middle of the knife's length. Before setting, the knives should be balanced on a special knife balancing scale (see fig. 26).

Key:
1. Knife
2. Balance weight
3. Rest

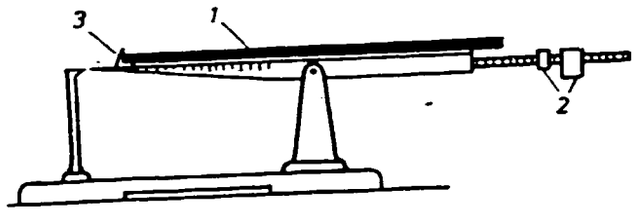


Fig. 26: Knife balancing scale.

The knife (1) is placed against the rest and the scale is brought in an equilibrium position with the balance weight. The knife is then turned to the inverse position, and if the centre of gravity is in the middle, the scale will stay in the equilibrium position. All other knives to be set in the same cutter block are checked in the same way, without moving the balancing weight. If they are not in balance, some material should be removed from the back side of the heavier knife. It is very important to control the balancing for a new set of knives, and this should be done from time to time for the knives in use. Tightening screws should be balanced as well every time new screws are used.

Tightening the knives in the cutterhead is usually done by means of trapezoidal wedges with screws, as shows in fig. 27.

Key:
1. Cutterhead
2. Knife
3. Wedge
4. Tightening screw

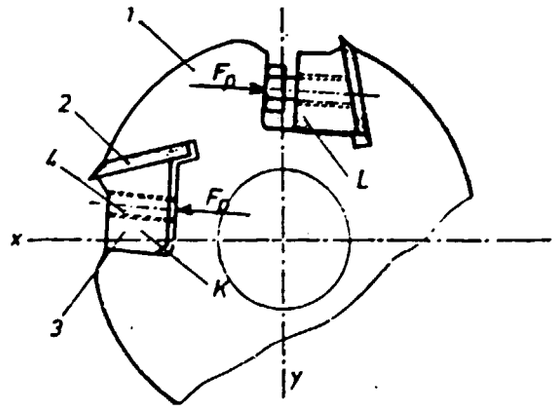


Fig. 27: Tightening knives in the cutterhead.

As is shown in Fig. 27, there are two kinds of wedges, marked L and K. The difference is only in the position of the screws.

A better way of fixing knives in the cutterhead is hydraulic tightening, which is more and more used on modern machines (see Fig. 28.)

Key: (a)
1. High pressure hose
2. Hose connection
3. Pumping handle
4. Manometer
5. Unloading screw
6. Hydraulic pump

Key (b):
Relsease of knives from the cutterblock:
1. Unloading screw
2. Outlet for the hydraulic fluid.

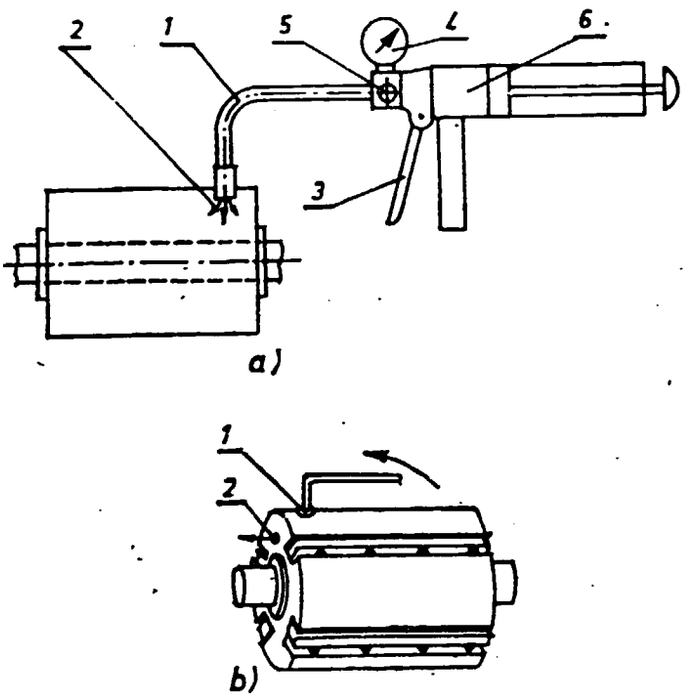


Fig. 28: Hydraulic tightening of knives.

Before tightening knives must be set in such a way that all cutting edges become generating lines of the same rotating cylinder. This means that all knives must stick out of the cutterhead by an equal cutting height (H).

A special knife setting comparator should be used for a proper setting of knives as shown in Fig. 29. The setting of knives visually or by using primitive accessories like a wooden lath etc. should be stopped immediately

Key:
1. Knife
2. Cutterhead
3. Screw for adjustment of knives
4. Base of the instrument
5. Indicator of the comparator

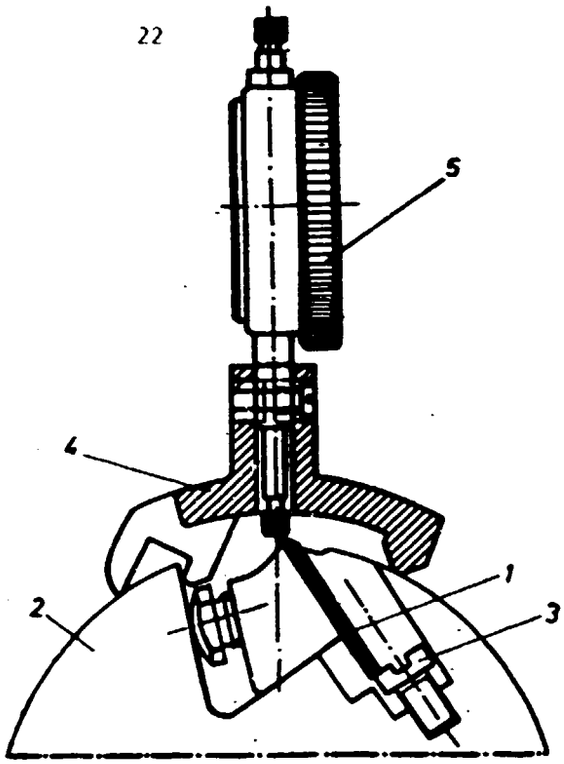


Fig. 29: Knife-setting comparator.

Once the knives have been properly set then the tightening of the screws should be done going from the middle of the knife towards both ends.

5. Jigs used for planing and thicknessing operations.

Jigs are rarely used for planing and thicknessing operations. However, by using some jigs the range of various operations can be increased. Some simple jigs that can be used in the Cooperatives in order to improve some operations presently performed with hand tools or by using some other machines will be shown here.

Among the jigs used for surface planing, two could be applicable in the Cooperatives immediately. The first is a jig for tapered parts such as legs for chairs and tables (or any other tapered part).

The construction scheme of this jig is shown in Fig. 30 and a photo of the jig in operation in Fig. 31.

Key:
a workpiece
b wedge
c cutter

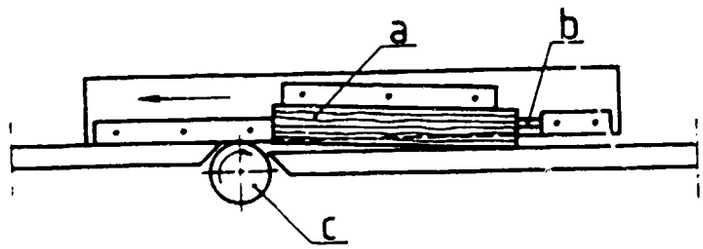


Fig. 30: Principle of the surface planer tapering jig.

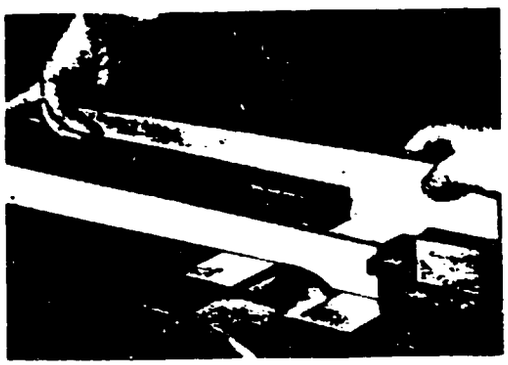


Fig. 31: Tapering on a surface planer by using a jig.

The second jig is foreseen for smoothing circular edges after bandsawing. Figures 32 and 33 show a view of the jig and its use in operation.

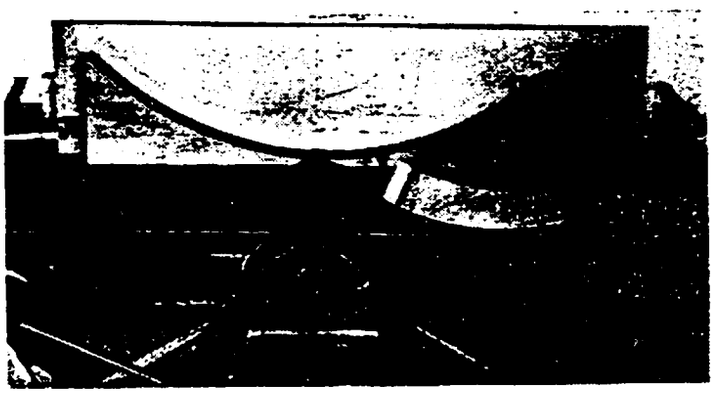


Fig. 32: A workpiece and the jig for machining circular edges.

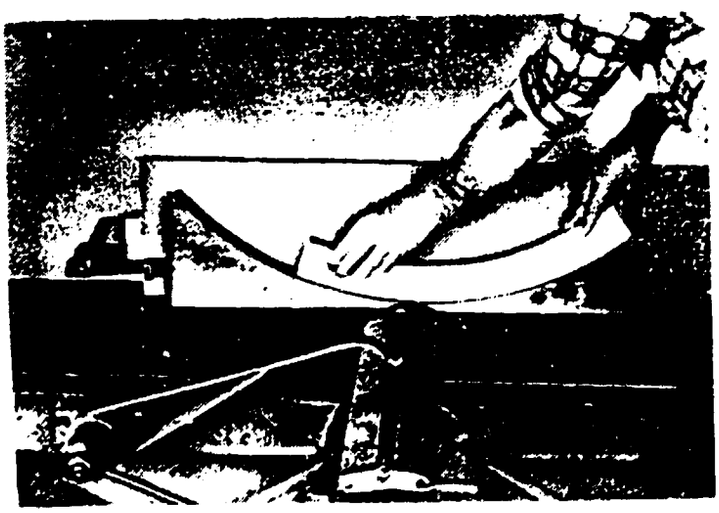


Fig. 33: A jig for machining circular edges (in operation).

Both worktables of the planer should be levelled and set in the same plane. Separate jigs must be made for each different radius of curvature. The centre of curvature of both guiding surfaces falls on the vertical line going through the centre of the cutter block.

The part of the jig's guiding surface behind the cutter should be tangential to the cutting circle. The front part of the jig should have a guiding surface radius bigger to take into account the depth of cut.

Some other jigs are also used for thicknessing operations. A jig for tapering is a simple wedge-shaped wooden base with a stopper (see figs. 34 and 35).

Key:
1. Workpiece
2. Wedge
3. Stopper
4. Cutter-block

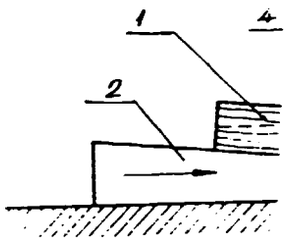


Fig. 34: Principle of a tapering jig for thicknessing.

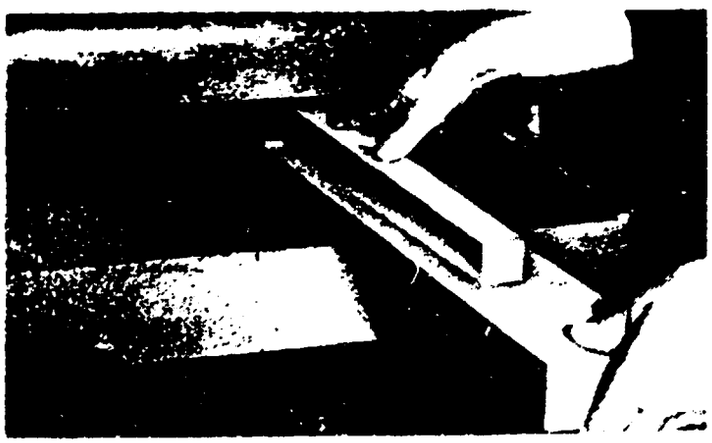


Fig. 35: Feeding a workpiece with a tapering jig in a thicknesser.

The workpiece can be tapered on its entire length or only partly, depending on the height adjustment of the work table.

A jig for tapering both sides of the workpiece is shown in fig. 36.

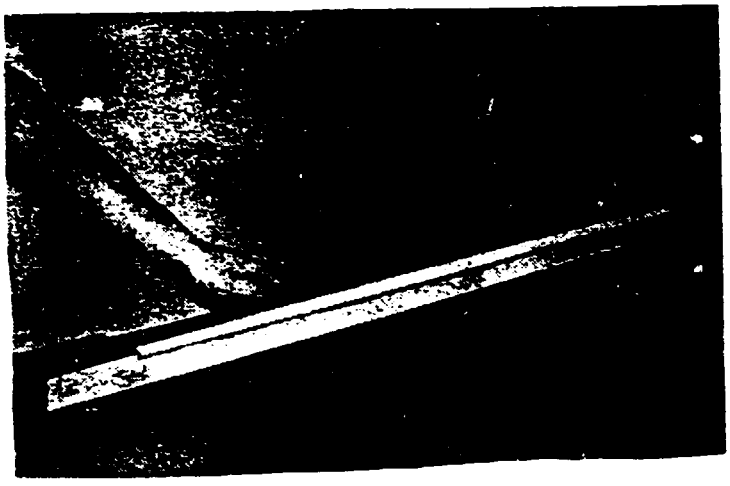


Fig. 36: Jig for tapering both sides of a workpiece.

A jig for making trapezoidal profiles is shown in fig. 37.

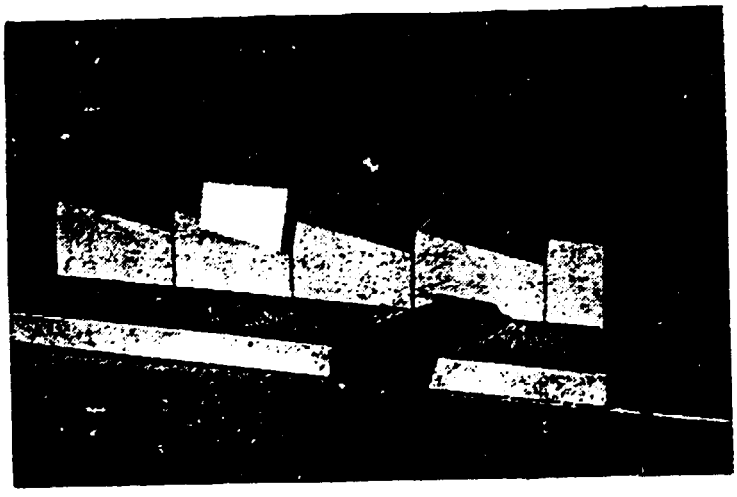


Fig. 37: Jig for making trapezoidal profiles.

The jig consists of a base board and guiding profiles fixed on its top surface. It is fixed on the thicknesser's work table with ordinary carpenters' clamps. Rectangular profiles fed into the thicknesser come out trapezoidal shaped. As shown in the picture, the jig can be constructed for machining several workpieces simultaneously.

6. Planing/jointing operations

In order to perform planing operations correctly, the operator should follow the instructions given hereunder:

- The cutting tool should be checked to ensure that it has been properly sharpened. A new set of cutting knives should be balanced prior to use.

- The knives should be set using appropriate knife setting controlling instruments; knives should be tightened starting from their middle, moving outwards alternatively (left and right).

- The rear worktable should be set so that it is in the plane which is tangential to the cutting circle and then fixed.

- The front work table should be set lower than the rear work table by 0.5 mm (maximum 1 mm) depending on the roughness and straightness of the workpieces and on the required quality of planing.

- The guiding fence should be set to the desired position. That position should be changed during planing so as to use equally the complete length of the knives.

- The safety guard to cover part of the cutter block should be set, leaving open only the portion which will be used for planing.

- The machine should be switched on, its sound should be listened to and the smooth working of the machine should be observed.

- Several workpieces should be planed taking care that the surfaces already planed should be pressed on the rear work table. Both hands should be used. The workpieces should be inspected prior to planing so as to decide which direction of planing is better to avoid splitting.

- A pair of planed workpieces should be taken, and the planed surfaces put against each other to check their straightness.

- In case of incorrect straightness, the front table should be raised to decrease the cutting height.

- Once the straightness is correct, planing can be continued.

- The wider face of a workpiece should be planed first, and then the adjacent narrow face. When planing the narrow face, the wide face should be pressed against the fence so that the planed surfaces are at a right angle (90°). If another angle is required, the fence should be adjusted to that angle (if possible), or a wooden jig attached to the fence should be used.

- The smoothness of planing should be controlled and if it is not satisfactory, the fence should be moved to another portion of the knife or the knives replaced with sharp ones.

- When work is finished, the machine should be switched off, cleaned and the whole cutterblock should be covered with the safety guard.

7. Thicknessing operations

The thicknessing operations should be performed by applying the following instructions:

- The infeed grooved roller should be adjusted to be 1-2 mm below the plane which is tangential to the cutting circle. The lower position (close to 2 mm) is for soft woods and the higher one (about 1 mm) for hard woods: The front pressure bar should be set at the same height.

- The outfeed's smooth roller should be adjusted to be about 0.5 to 1 mm below the same plane depending on the hardness of the wood. The rear pressure bar should be set at the same height.

- The lower dead rollers built in the work table, should be adjusted to be 0.1 to 0.2 mm above the work table (0.1 mm for hard wood and 0.2 mm for soft woods).

- The required thickness of the workpiece should be adjusted by lifting or lowering the work table and by controlling the pointer on the millimetric scale on the side.

- The machine should then be switched on, the sound listened to and it should be observed to check whether it works normally.

- The feeding speed, which is usually 10 to 20 m/min, depending on the sizes of workpieces, the hardness of the wood and the required quality of planing, should be adjusted. For planing bigger widths, harder wood and better quality planing, lower feed speeds are necessary.

- One workpiece should be planed and its thickness checked. Care must be taken that the workpiece is oriented and fed into the machine so as to avoid splitting.

- If necessary, the machine thickness must be adjusted until it is satisfactory.

- The work can then be continued. From time to time (approximately after each 50 pieces), the thickness and smoothness of planing, should be checked.

- If the machine has a sectional infeed roller and pressure bar, more than two pieces can be planed at the same time. If the machine is of the old type, with a single piece roller and pressure bar, two workpieces can be fed at the same time, provided they are fed at the outer limits of the cutter block.

When the operation is finished, the machine should be switched off and cleaned. The operators should note that the minimum length of a workpiece is limited by the distance between the infeed and outfeed rollers. The shorter parts should be thicknessed as multiple lengths and resawn into shorter elements after thicknessing.

8. Planing with four-side planers

Four-side planers are complex machines and require skilful and careful set-up and very attentive work from the operators. The most important for correct planing is setting the work tables, cutters and feeding rollers. The basic principle is the same as for surface planers and thicknessers. Namely, setting the tables and cutters that serve as bases for the workpieces is almost the same as setting the surface planers, and setting the pressure bars, rollers and cutters that serve for planing the workpieces to the required thicknesses is the same as setting thicknessers.

The front work table is set 2 to 3 mm below the horizontal plane which is tangential to the cutting circle of the lower planing cutter block. In the same way, the right fence is set, 2 to 3 mm to the right hand side of the vertical plane tangential to the cutting circle. The lower rollers are set to stick out 0.3 to 0.5 mm above the work table. The infeed rollers and pressure bars are set about 1 mm below the plane which is tangential to the thicknessing circle. The pressers behind the cutter are set about 0.5 mm below the cutting plane.

After all settings are finished, the connections of the dust extraction pipes must be checked and all motors can then be switched on, one at a time, the last being the one of the feeding rollers. The sound of the machines should be listened to and a general visual observation of the machine must be made.

The feeding speed must be adjusted to be in accordance with the size of the workpieces, species of wood and the required quality of the planing. Planing should be started with a lower feeding speed and it can be increased after checking the results of the planing. The width, thickness, evenness and the cross section's profile should be checked using a vernier calliper and templates for profiles. Work can only continue when satisfactory results have been achieved.

After the planing operation is completed all motors must be switched off and the machine cleaned.

If the next job calls for machining with the same tools, only thicknessing cutters, feeding rollers and pressers should be adjusted to the dimensions of the new workpiece.

9. Safety measures

This group of machines has both hand fed surface planers and mechanically fed thicknessers and multi-side planers. Therefore, the safety measures for each are different.

Safety measures on surface planers focus on the protection of the operator's hands, while on thicknessers and multi-side planers the prevention

of damage to the machine is stressed. The operator's skill and knowledge of the machine are the best safety measures.

According to statistics, surface planers are rather dangerous machines. The most important safety measure on this machine is to cover the part of the cutter block which is not in use at the moment, with a hinged or rotating cover and a guide bar (see figures 38 and 39).

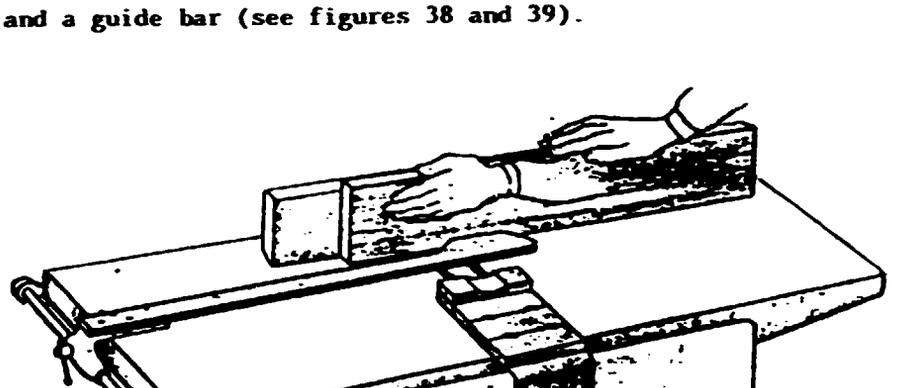


Fig. 38: Hinged cover and guide bar on a surface planer.

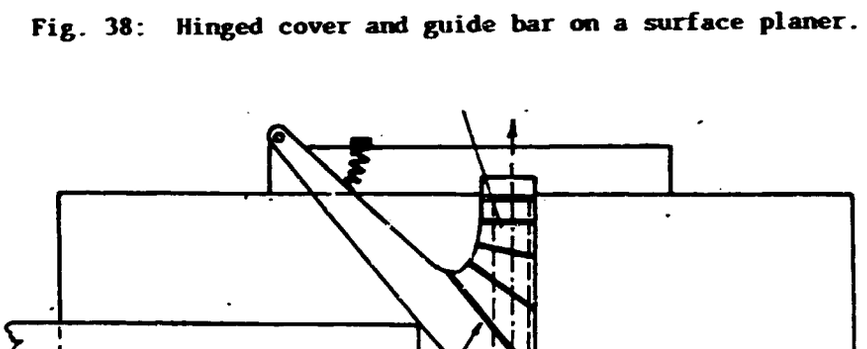


Fig. 39: Rotating cover on a surface planer.

Other safety measures on the surface are as follows:

- Use of round cutter blocks with knife projections not more than 1.1 mm.

- Clearance between table lips and knife edge circumference not greater than 5 mm.

- Placement of both hands firmly on the workpiece with fingers and thumbs close together and well clear of the edges (see fig. 40).

- Use of a feeder block for short workpieces (see fig. 41).

- Use of the correct jigs for tapering operations.

The most important safety measure on thicknessers is to have properly maintained and used kick-back stops. These stops must be at rest at least 3 mm below the cutter knife circle (see fig. 42).

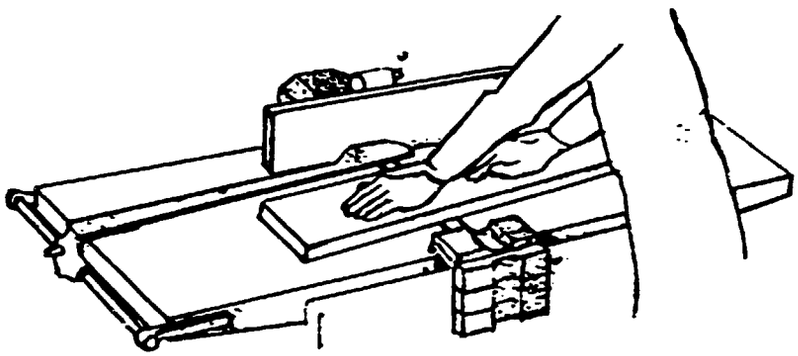


Fig. 40: Both hands on the workpiece with fingers close together and well clear of the edges.

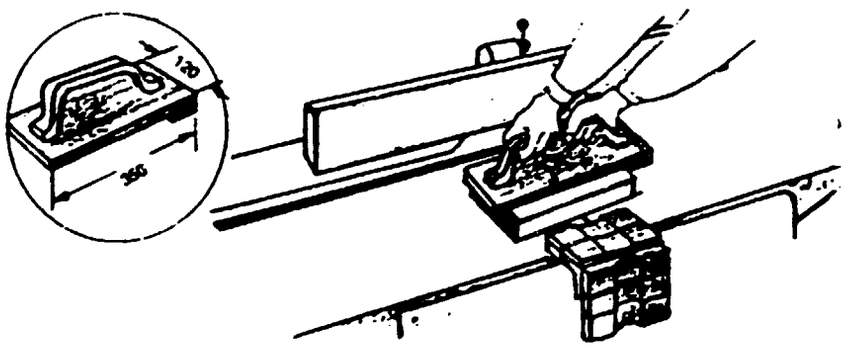


Fig. 41: A feeder block used for planing short workpieces.

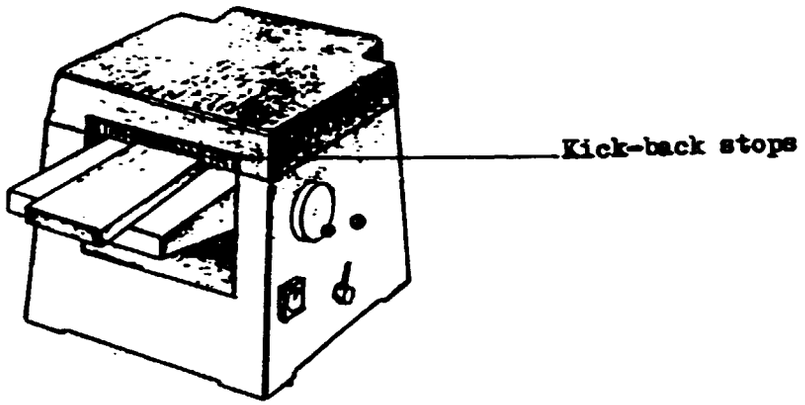


Fig. 42: Kick-back stops on a thicknesser

Before feeding the workpiece, the cutter-block should attain its full operation speed. Chips or splinters should not be removed from the work table while the machine is still running. Thicknessing of very short workpieces should be avoided. Such workpieces should be planed as longer pieces and cross cut to their final length later. When thicknessing wedge shaped or tapered pieces it must be ensured that the jigs used are safe and appropriate for the workpiece concerned, and a low rate of removal should be started with.

When setting knives wood gauge blocks or adjustable gauges should be used (see Figs. 43 and 44).

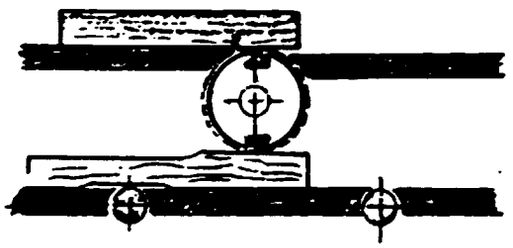


Fig. 43: Checking knife setting with a wood gauge block.

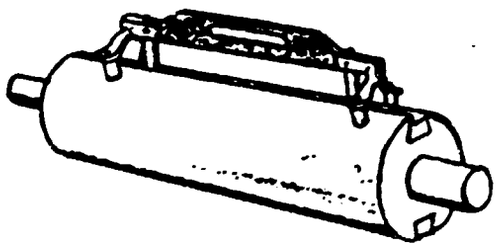


Fig. 44: Checking knive setting with adjustable gauges.

Most of the safety measures on four-side planers are incorporated in the construction of these machines. Proper setting of tools, feeding rollers and pressers and choosing an adequate feeding speed will ensure safe operation.

10. Organization of the working area

Surface planers are operated by one man, while thicknessers and four side planers require two men: an operator and an assistant. Therefore, the piles of workpieces before and after surfacing should be positioned on pallets next to each other on the left side of the machine (see Fig. 45).

Key:
1. Surface Planer
2. Workpieces to be planed
3. Planed workpieces
4. Operator

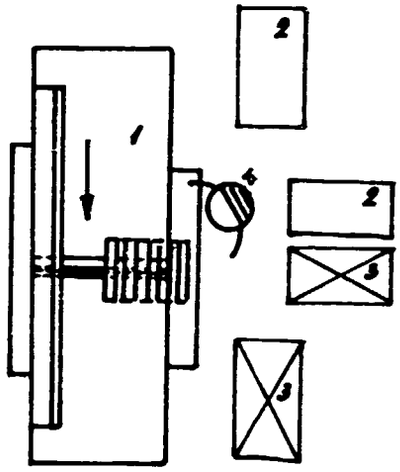


Fig. 45: Organization of work area for a surface planer.

The positioning of workpieces before and after processing (on pallets is similar for both thicknessers and four-side planers (see fig. 46).

Key:
1. Thicknesser
2. Workpieces to be thicknessed
3. Workpieces thicknessed on one side.
4. Workpieces that have been thicknessed on both sides
5. Operator
6. Assistant

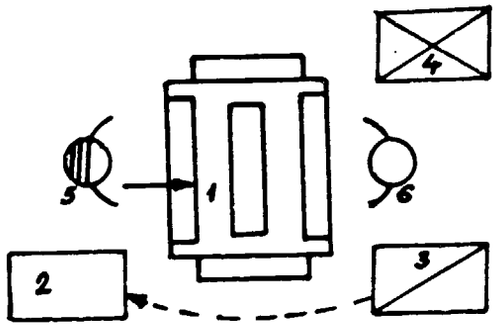


Fig. 46: Organization of work area for a thicknesser.

The pallets with workpieces should be within reach of the hands of the operators and assistants. Walking in order to take or to pile workpieces should be avoided.

Pallets should be used as bases for the workpiece stacks.

ANNEX I

TRAINING PROGRAMME FOR FURNITURE AND JOINERY PRODUCTION

This training programme is designed to achieve the objectives and outputs of the project entitled "Strengthening the Technical and Managerial Capacities of the Carpentry Cooperatives in Mukalla and Seiyun" (project No. SM/PDY/87/005).

After visiting all the production units of these Cooperatives, (the three units of the Coastal Strip Carpentry Cooperative and the four units of the Carpentry Cooperative, Seiyun), and after studying the present state of their production, it has been concluded that a thorough training of operators and managerial staff is a prerequisite for all improvement. Due to this conclusion, the training programme prepared and proposed hereunder is more comprehensive, and the training activities are more numerous than originally planned in the project document. It has been designed to meet the specific requirements of the cooperatives which are on the point of transmitting from handicraft to industrial production. The topics for the training courses selected are:

COURSE NUMBER	TITLE OF COURSE	DESIGNED FOR:
1.	Production systems and types of production in the wood processing industry.	Management staff of the Cooperatives and their production units.
2.	Furniture products, classification, standards, design and construction	Production Department staff
3.	Joinery products, classification, standards, design and construction	Production Department staff
4.	Product development in the secondary wood processing industry	Staff of the production and sales departments.
5.	Organization and planning of production.	Production planning staff.
6.	Work allocation and control of production	Production planning staff, supervisors and foremen.
7.	Planning, cost accounting, pricing, cost control and optimization of a product line.	Accountants, salesmen and staff of the production department.
8.	Inventory control and purchasing techniques.	Purchasing unit's staff and staff of the production department concerned with material planning.
9.	Basic elements of marketing	Management, sales and production department staff.
10.	Modern industrial production management	Managerial staff.
11.	Information and documentation systems in the secondary wood processing industry.	Managerial staff, top and middle management of the cooperatives.
12.	Plant layout	Staff of the production department and production supervisors.

COURSE NUMBER	TITLE OF COURSE	DESIGNED FOR:
13.	Wood, affiliated products and other materials used in the production of furniture and joinery	The technical department's staff, supervisors, foremen and operators.
14.	Wood seasoning and preparation	The technical department's staff and people working in the timber yard.
15.	Cross-cutting and trimming of sawnwood	Operators of cross-cutting and ripping machines, and foremen in the wood cutting area.
16.	Panel sizing.	Operators of panel sizing machines and their foremen.
17.	Veneering and laminating surfaces and edges of wood based panels.	Operators laminating surfaces and edges of panel furniture components.
18.	Surface planing and thicknessing of components	Operators of surface planers/jointers and thicknessers and their foremen.
19.	Tenoning, mortising and drilling	Operators of tenoning, mortising and drilling machines and their foremen.
20.	Moulding and routing	Operators of moulding and routing machines and their foremen.
21.	Sanding and surface finishing.	Operators of sanding and surface finishing machines and their foremen.
22.	Preassembling, assembling and packaging.	Assemblers, packagers and their foremen.
23.	Managing of quality and quality control	Managerial staff at all levels, foremen and quality controllers.
24.	Jigs, templates and fixtures in the secondary wood processing industry.	Production department's staff.
25.	Tool sharpening, maintenance and managing.	Tool sharpeners and persons in charge of ordering tools.
26.	Internal transport, receiving and storage of materials and shipping of products.	Persons working in storage and internal transport services.
27.	Maintenance of equipment	Maintenance personnel.
28.	Safety measures in the secondary wood processing industries.	Foremen and supervisors in workshops.
29.	Motivation of employees	Managerial staff at all levels.
30.	Innovation and development techniques and methods.	Managerial and production department staff.

PURPOSE AND METHOD OF TRAINING

Training of employees is an integral part of production in modern industrial enterprises. Technical and technological developments offer new technical means and new production methods which make human work easier, safer and more productive. To be able to utilize such advancement, people working in industry have to learn and to train in order to achieve new knowledge and skills necessary for handling modern equipment and processes.

In developing countries, such training has decisive importance for the better utilization of new production techniques and for mastering new technological processes. To avoid unnecessary mistakes and gain indispensable skills, training courses are the most suitable way, because, in a short time, people can learn the best way of performing their duties in production.

The output of these training courses should be knowledge acquired by workers who will increase their abilities for effective production. To achieve this, the training method will rest on three stops as follows:

1. The lecturer will explain a new method.
2. The lecturer will demonstrate the new method.
3. The trainee will perform the new method under the lecturer's supervision.

Short manuals written in a simple language, understandable to the workers, will be prepared by lecturers for each course, translated into Arabic and distributed to the trainees. All graphs, tables and formulas will be adjusted to the level understandable to the people to be trained.

Theoretical teaching will be conducted in a classroom and its duration will be adapted to the minimum of theory which has to be known for a certain job. This part of the training will be performed by the CTA, other experts in the project and by United Nations Volunteers assigned to the project.

The practical part of the training will be organized at the work areas of the respective production operations. This part of the training will be carried out jointly by the experts and the UN Volunteers. The working area must be organized in a proper way, including the prepared production documents, tools, jigs, gauges, protective devices, pallets, materials and everything that is necessary for safe, productive and good quality work. The lectures should explain and show how to check a machine, tools, jigs, and in the case of wrong adjustment, how to correct them and how to prepare correctly all that is needed for the production operation.

The lecturer will show the correct way of performing the operation and supervise the performance of the trainees until he concludes that their work is fully acceptable and that the quality of the products is satisfactory. The counterparts with higher skills and experience will also be engaged to train less qualified labourers and to supervise their practical work.

Most of the training courses conducted for the Coastal Strip Carpentry Cooperative will be repeated for the Carpentry Cooperative in Seiyun, while in some cases the trainees from Seiyun will be invited to come to Mukalla. Persons from the production units outside of Mukalla and Seiyun will be travelling to these two places. Some of the practical training could and should be carried out in the satellite units by he UN volunteers.

SELECTION OF TRAINEES

Trainees will be selected by the counterpart, according to their jobs and to the topics of the training programme. Besides workers who will directly perform particular production operations, all other people concerned with certain aspects of the production, such as: foremen, supervisors, management staff, maintenance personnel, etc. can be included in the training. The list of trainees is an integral part of the training programme and it

determines the number of copies of the training manuals to be prepared and distributed for each course.

TIMING OF TRAINING COURSES

The training courses will be prepared and conducted mostly during the experts' missions, and those to be conducted by the volunteers will be scheduled in between those missions. The priority should be given to the courses which are a prerequisite for the better understanding of other topics.

The timetable of all courses is a part of this programme, though the exact schedule can be changed depending on the timing of the future missions by the experts.

Some of the courses are intentionally foreseen for the last mission, hoping that by that time the workshops will be the missing equipment, which is indispensable for a proper training of the operators.

SYLLABI OF COURSES

This programme contains syllabi of all courses planned to be conducted during the project execution. The courses are broken down into topics, and, for each topic, the training duration, both theoretical and practical, and the level of competence to be reached are given.

The selection of topics and the required level of competence is aimed to reach a minimum knowledge needed for successful manufacturing of furniture and joinery products in a medium-scale factory.

Each course has its number and topics are subdivided into a decimal classification following the numbers of the courses.

Once all the training courses are completed the training material can be compiled into a printed handbook to be used throughout the country.

ANNEX II

SYLLABUS OF THE COURSE ON SURFACE PLANING AND THICKNESSING OF COMPONENTS (Course No. 18 in Annex I)

This course is foreseen for operators of the surface planers/jointers and thicknessers and their foremen.

STAGE	TOPICS	TRAINING TIME (hours)		LEVEL OF COMPETENCE TO BE REACHED
		THEORY	PRACTICE	
18-1	Introduction	0.25	--	Understanding the purpose of the course.
18-2	Surface planers/joiners.	0.50	1	Being able to operate surface planers/jointers.
18-3	Thicknessers.	0.50	1	Being able to operate thicknessers.
18-4	Multi-spindle planers/profilers.	0.5	--	Acquiring general knowledge about planers/profilers.
18-5	Wood planing and thicknessing.	0.5	--	Being able to select and set correctly wood planing and thicknessing equipment.
18-6	Jigs used for planing and thicknessing operations.	0.50	1	Knowing about various jigs used for planing and thicknessing.
18-7	The planing/jointing operation.	--	1	Being able to perform correctly planing/jointing operations.
18-8	The thicknessing operation	--	1	Being able to perform correctly thicknessing operations.
18-9	Safety measures.	0.25	0.25	Being able to apply safety measures in these operations.
18 10	Organization of the working area.	0.25	0.25	Being able to organize the working area for safe and comfortable work.
	TOTAL	3.25	5.50	