

*fao/sida sawmill manuals*

# **frame saw manual**

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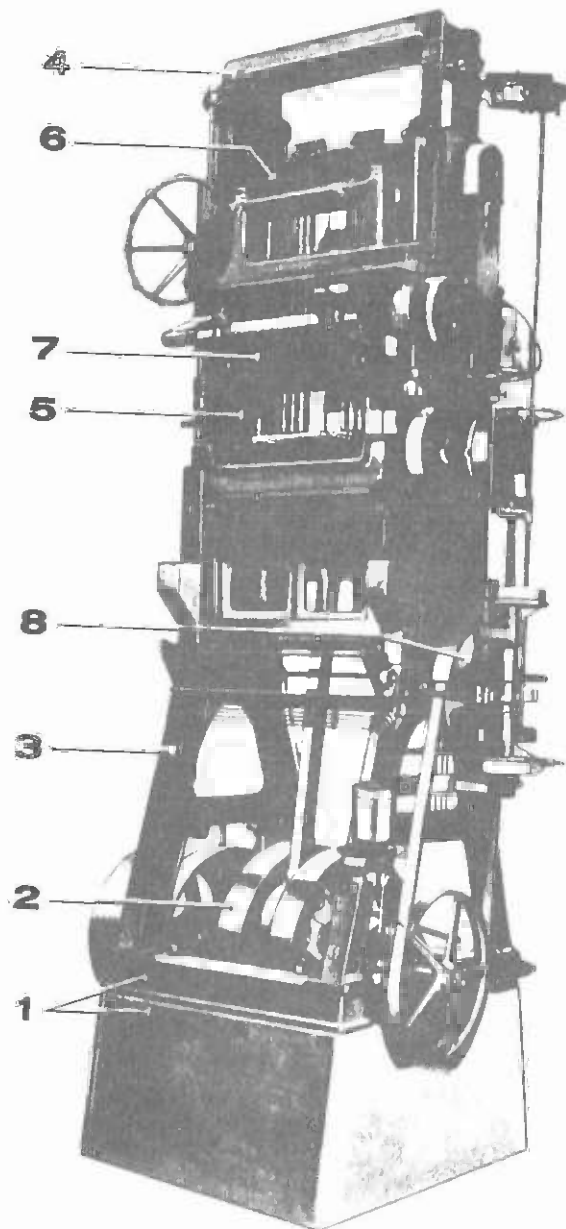
## INTRODUCTION

This manual deals with the construction and operating principles of the frame saw. Many different kinds and makes of frame saws are in use. A very common type of Swedish origin, originally made in 1946, has been chosen as the example in this manual. Today's modern frame saw has the same basic function, although capacity, infeed and sawing accuracy is increased. Where frame saws of other makes differ considerably, this is pointed out.

FAO gratefully acknowledges its indebtedness to the Government of Sweden whose financial aid made possible the publication of this manual and to the Employers Federation of Swedish Industries, who provided the original material.

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# PART I - CONSTRUCTION AND OPERATING PRINCIPLES

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## 1. Foundation with Base Plate

The saw frame must be built on a strong foundation of reinforced concrete of about 60-80 m<sup>3</sup>. Sometimes, however, up to 90-100 m<sup>3</sup> is necessary to get a strong enough base for the saw frame when ground conditions are bad.

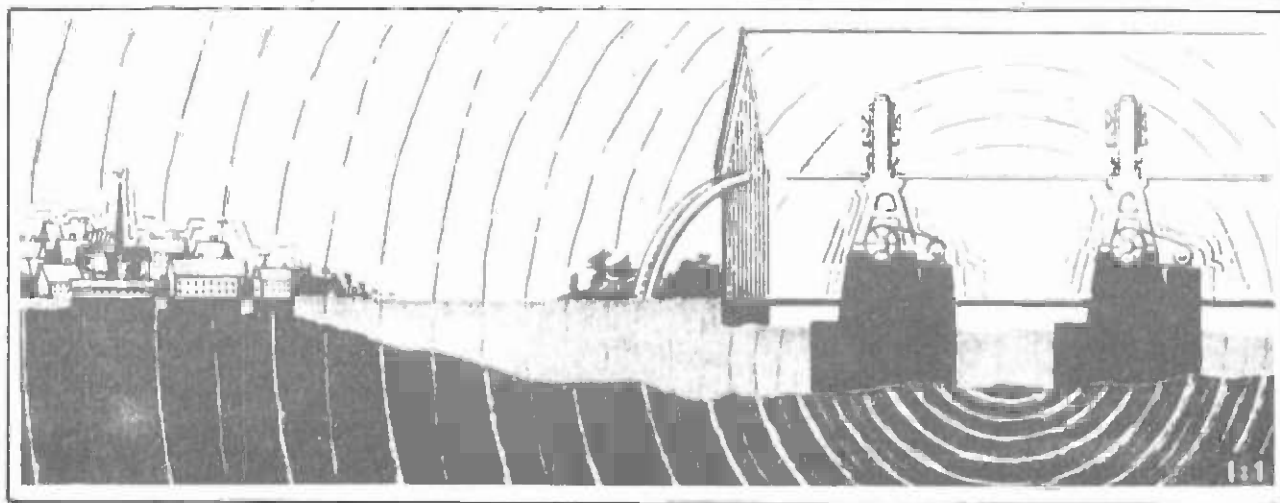
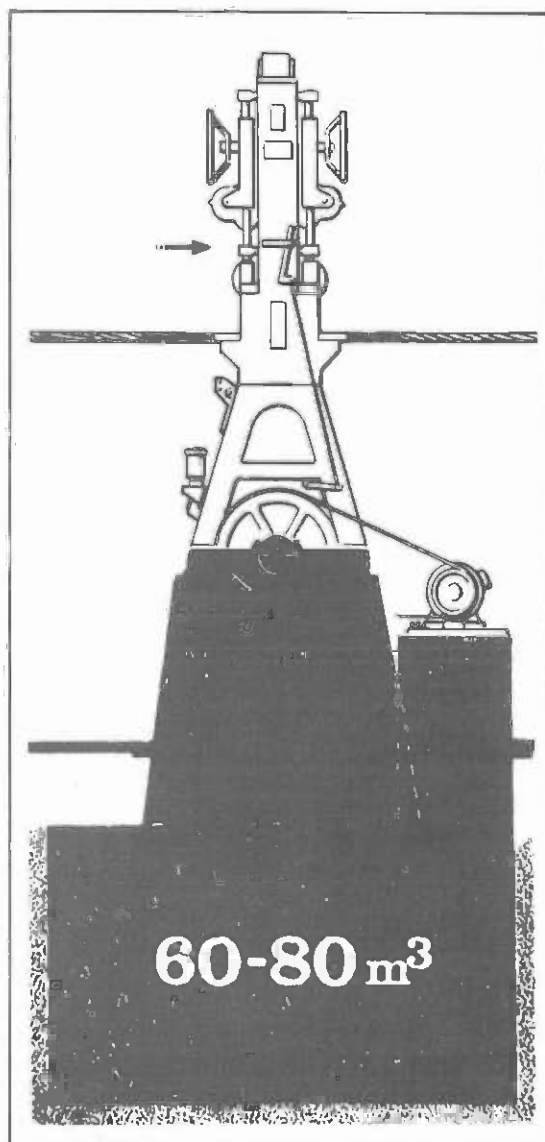
The foundation should be somewhat longer in the longitudinal direction of the saw mill than in the transverse direction, since the principal direction of motion of the moving parts of the frame coincides with the direction of sawing. Accurate drawings should be supplied by the manufacturer.

The function of the foundation is:

to support the frame saw's weight and to absorb all the powerful forces that are created and that cause strong vibrations when the saw frame is working.

The foundation must therefore be erected on solid ground. If there is no such ground available, pile driving must be done.

At the same time, the foundations must not be directly on solid rock, which can carry vibrations to adjoining areas some distance away.



A foundation on rock needs an intervening layer of a suppressing material, for example, clay or sand. Sand especially is good at absorbing vibrations.

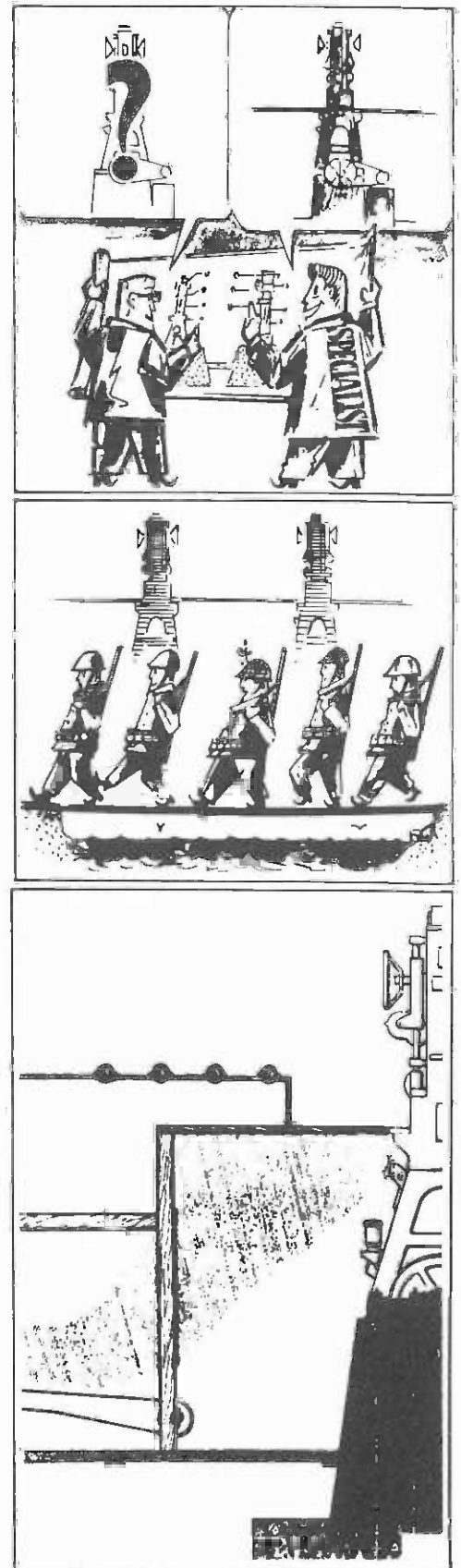
It must be repeated that, when the preliminary studies for anchoring the frame saw foundation are done, a good solid ground base must be found. If there is any doubt, always consult a specialist, because the consequences of error could be serious.

It is also unwise to run all the saw frames within the mill at the same speed (number of revolutions). It is best to make the frames work out of sequence in order to counterbalance each other's motions, the same as a group of soldiers breaking step when crossing a slender bridge. The ideal situation is to have the moving parts of one frame at the upper dead centre when the moving parts of the other frame are at the bottom dead centre. In practice, however, this is not possible to achieve and instead one tries to vary the speed of each frame.

Usually the cant frame works four to five revolutions faster per minute than the log frame, which avoids harmonic peaks of vibration. In addition, it also avoids the sympathetic vibrations in the surrounding ground which creates disturbing shaking to buildings in the vicinity.

To obtain the necessary working height on the ground floor of the sawing building, the foundation should be built up to a suitable height above the floor to make enough space for necessary conveying machinery, etc.

In the past the cant frame has often been mounted too low. The trend now is to raise it to a better working height on the upper floor.



When installing modern roll conveyers the aim is to obtain a working height of 700 mm.

On top of the foundation a BASE PLATE is fixed:

- by embedding it in the concrete bed, and
- by 8 anchor bolts (45 mm) embedded in the concrete bed. These anchor bolts must penetrate the whole foundation to get adequate anchorage.

The base plate consists of a deep U section frame.

The U-shape is partly chosen because this design has very high "bending resistance", especially where the bearing housings are positioned. (For technical explanations of this see PART II - FORCES AND MOVEMENTS.

This U-shape makes a strong plate, but other types of beams can also be used.

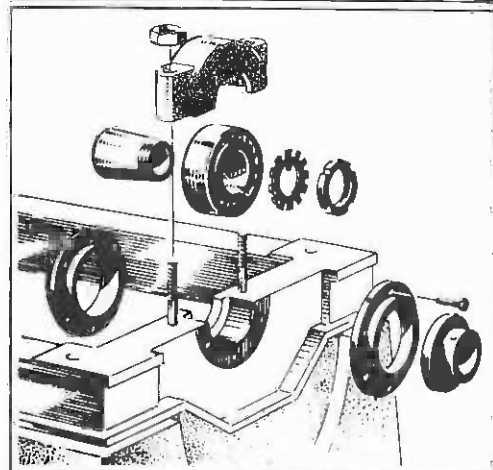
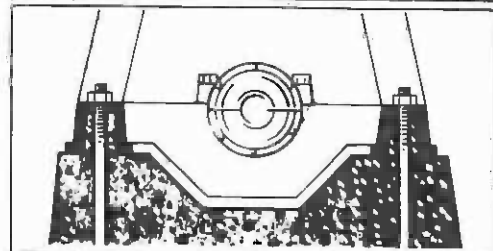
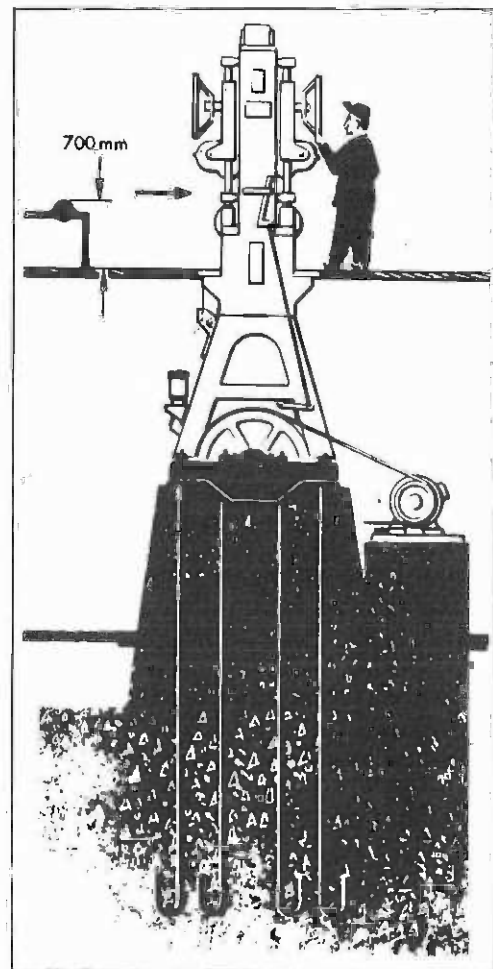
Another advantage of the U-shape is that it can be filled with concrete, so that the anchorage of the plate to the foundation is strongly reinforced.

In the base plate there are bearing housings for the roller bearings of the crankshaft.

The lower half of the housing is placed in the base plate itself.

The upper half (called the bearing cap) is fastened with bolts in the base plate.

There is one disadvantage with this system. If the outer ring of the crankshaft roll bearing, which is normally fixed in the bearing housing, starts to rotate in the base plate, the whole base plate must be substituted or reconstructed in situ.



Therefore the most modern types of frame saws are fitted with detachable bearing housings made of cast steel for the crankshaft roll bearing. Some older frame saws have "white metal" ring lubricated bearings. (See appendix.)

The function of the base plate is:

to hold the construction of the frame together;  
to support the whole weight of the frame saw (about 10 tons);  
to absorb and transmit to the foundation the powerful "inertia forces" that arise during sawing.

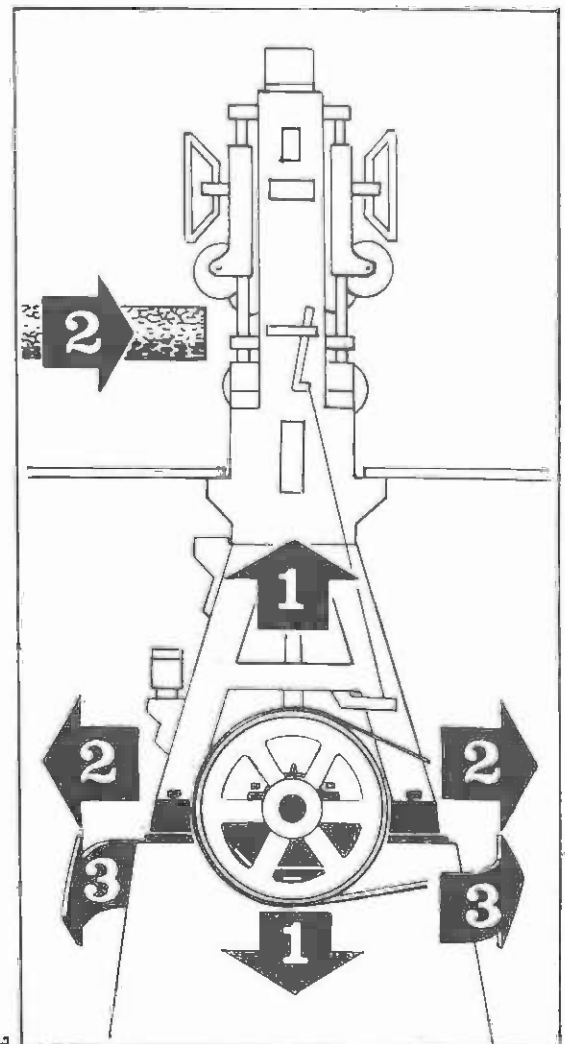
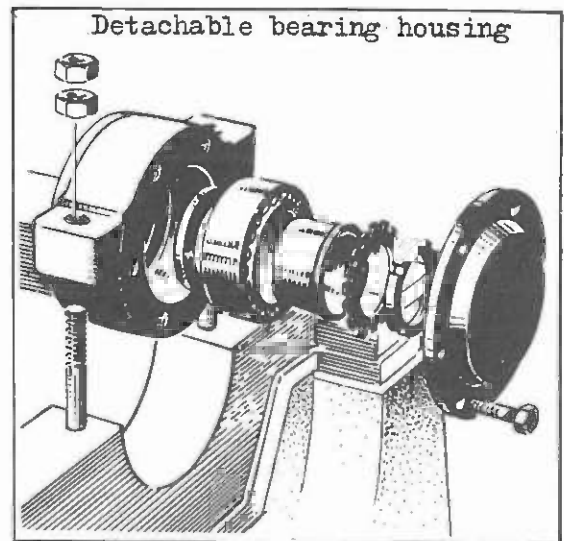
The predominant forces that influence the base plate are:

1. VERTICAL FORCES that arise due to:
  - the up and down movement of the upper end of the connecting rod.
  - the up and down movement of the sash.
2. HORIZONTAL FORCES that arise mostly due to:
  - the flywheel counterweights which, in certain positions, have a horizontal component of movement.
  - the lower end of the connecting rod which, in certain positions, has a horizontal component of movement.
  - the pressure of the log against the saw blades.
3. SIDE FORCES from:
  - the belt tension.
  - the power from the motor.

These forces can vary considerably, depending on the size of the motor and how the power is transmitted, i.e.

- through direct drive, or
- through transmission drive.

More detail on these stresses is explained in Part 2 - FORCES AND MOVEMENTS.





## 2. Crank Section

The crank section consists of:

- a crank shaft of:
  - 2 centre shafts
  - 2 flywheels with counterweights
  - 1 crank pin
- a connecting rod.

### A. Crankshaft with flywheel

The crankshaft is mounted in the base plate by means of two spherical SKF roller bearings (see appendix). (Some frame saws have white metal ring lubricated bearings instead.)

It is a detachable type, which means that it is built up of several parts.

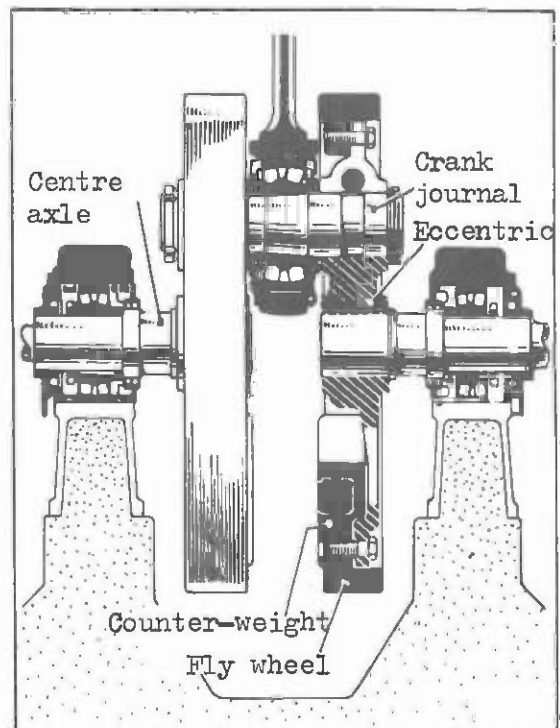
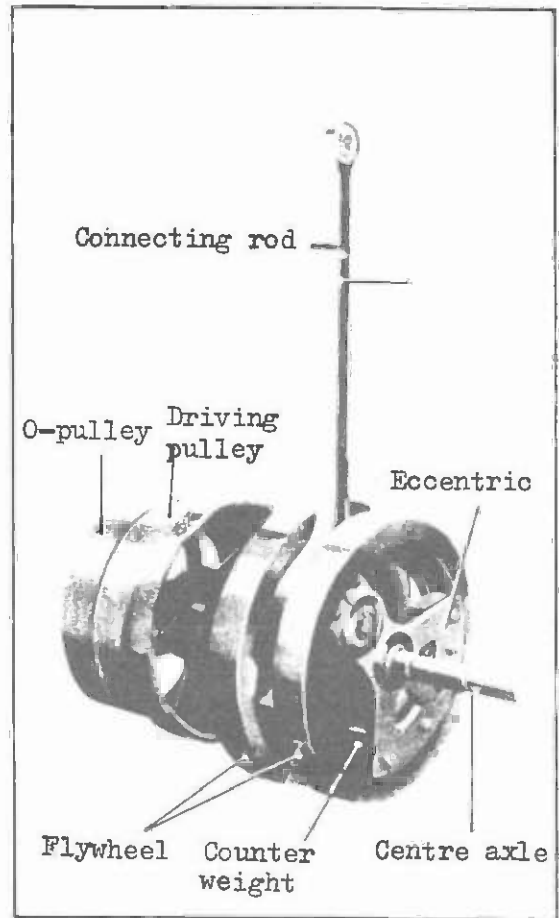
The crankshaft is divided into two similar halves. Each half consists of:

- one centre shaft pressed into an eccentric;
- onto this eccentric has been bolted a flywheel with a counterweight.

The crankshaft halves are joined together by means of a crank pin. The connecting rod is attached to this pin by the lower connecting rod bearing.

The crank pin is fitted with mechanical joints in both the crankshaft halves, which make it easy to disassemble. (In some frame saws the eccentric and the flywheel are cast in one piece).

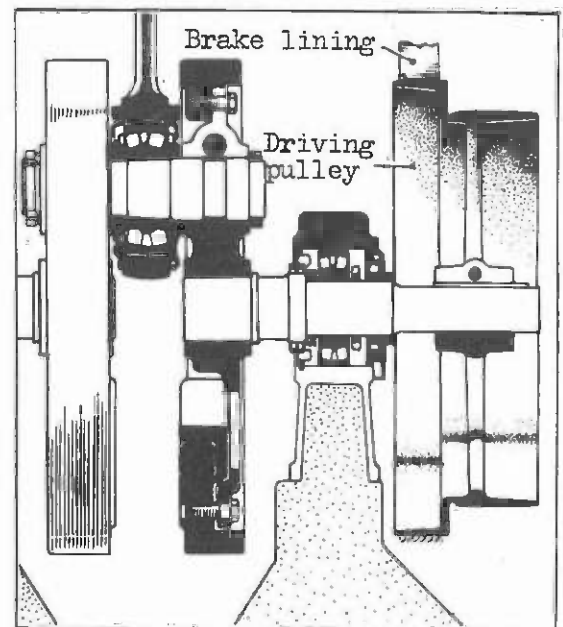
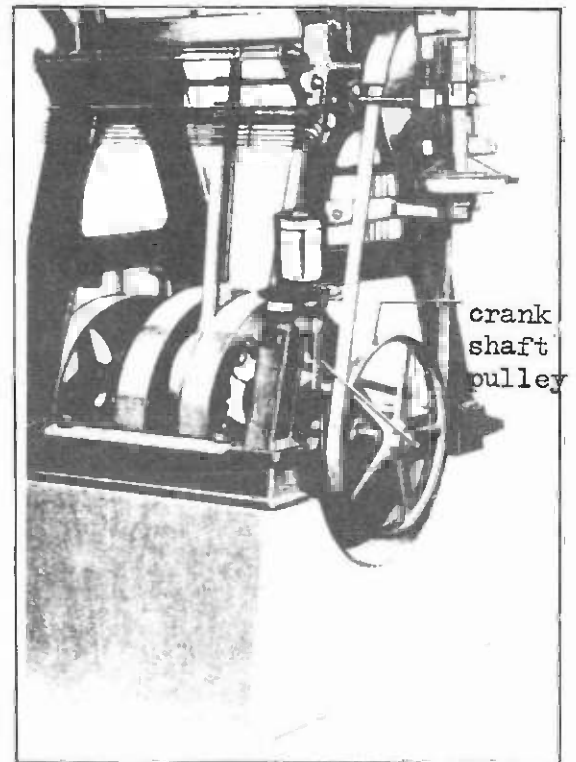
When the two halves have been joined together by the crank pin, the flywheels are positioned on either side of the connecting rod, placed as close as possible to the connecting rod bearing. This is done to reduce the strain in the shaft. The shorter the crank pin, the more rigid it is and the better it resists strains. (In other models the flywheels are located outside the base plate and the counterweights are positioned on either side of the crank pin.)



On the ends of the crankshaft outside the bearings in the base plate are fixed:

- a crankshaft pulley on the feeding side which, in turn, drives the friction disc or pulley for the log feeding mechanism. A variable drive mechanism (see page 33) can be mounted. When this is done, there is no need for a driving pulley, since log feeding is powered by a separate electric motor.
- a keyed-on driving pulley on the driving side to transmit the driving power from the motor to the crankshaft. The driving pulley has a two-piece hub, which makes it easy to disassemble.

The above applies when each frame saw is direct - driven from its own separate motor.



If there is a system with one motor driving more than one saw through a transmission gear, it is necessary to have, in addition, a free running pulley - an O-pulley - running on strong double-row roller bearings adjacent to the driven pulley, on an extension of the crankshaft. The transmission belt from the motor pulley is connected to either the driven pulley or to the adjacent free running O-pulley. When the power is to be disconnected, the belt is moved by means of a belt guide from the driving pulley over to the O-pulley. When power is to be connected, the belt is moved back from the O-pulley to the driving pulley.

The belt guide consists of a clamp through which the belt passes. A lever at the operator's position on the infeed side of the saws, close to the log feeding control, moves the belt sideways.

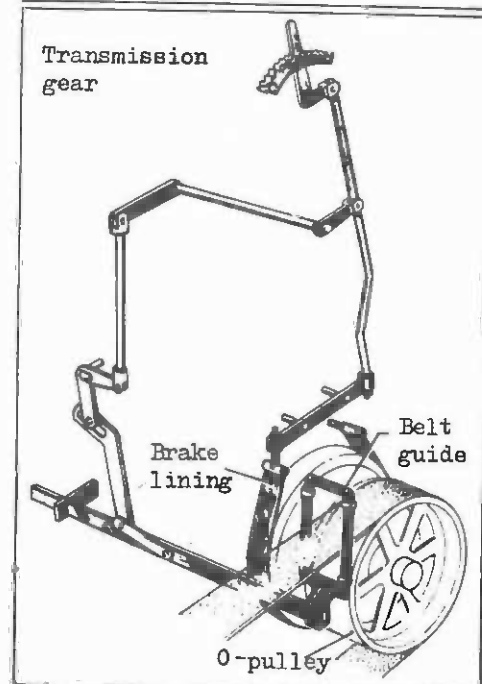
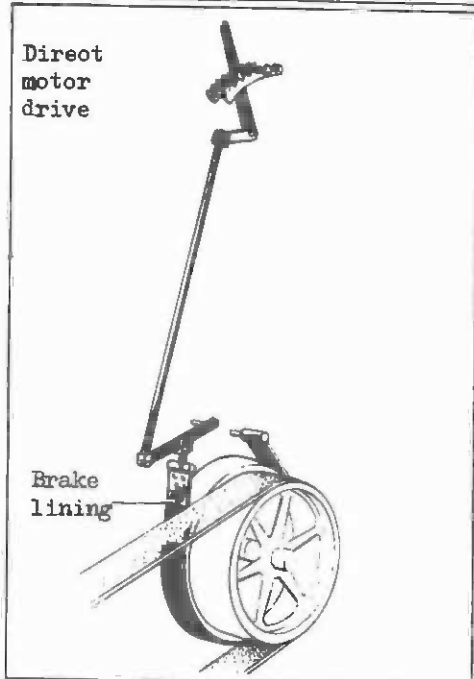
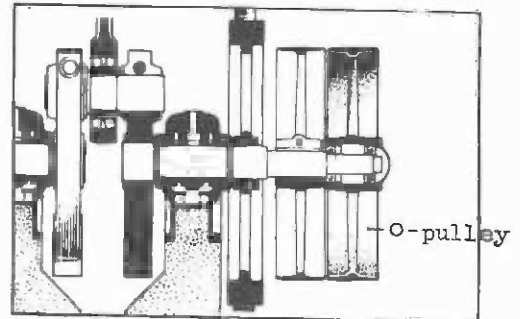
Braking the crankshaft rotation can be done in two different ways, depending on whether the saw is powered by direct motor drive or transmission gear:

- Direct driven saws.

The brake system consists of an ordinary brake lining surrounding a brake drum on the driving pulley. The lining is tightened around the brake drum by means of a lever placed at the operator's position on the upper stand close to the infeed controls.

- Transmission gear driven saws.

The belt guidebar is connected with a brake lining that surrounds the brake drum of the fixed driving pulley. The brake is actuated when the belt guide lever is moved to its bottom position, which moves the belt over to the O-pulley.



The forces on the crankshaft and the connecting rod are very complex. See PART 2 - FORCES AND MOVEMENTS). It is therefore not possible to fully balance a frame saw.

To enable the moving parts to work as smoothly and quietly as possible the crankshaft is fitted with flywheels and fixed counterweights, which together counterbalance some of the rotating parts of the frame.

The parts that move up and down, however, cause high free vertical forces. By using extra counterweights it is possible to reduce or eliminate these vertical forces. But, in doing so, free horizontal forces will develop.

The difficulty is to find the degree of balancing that is best for each individual machine.

Even if total balancing is not achievable, at least by partial balancing, free forces are reduced and distributed more evenly both in the vertical and horizontal directions.

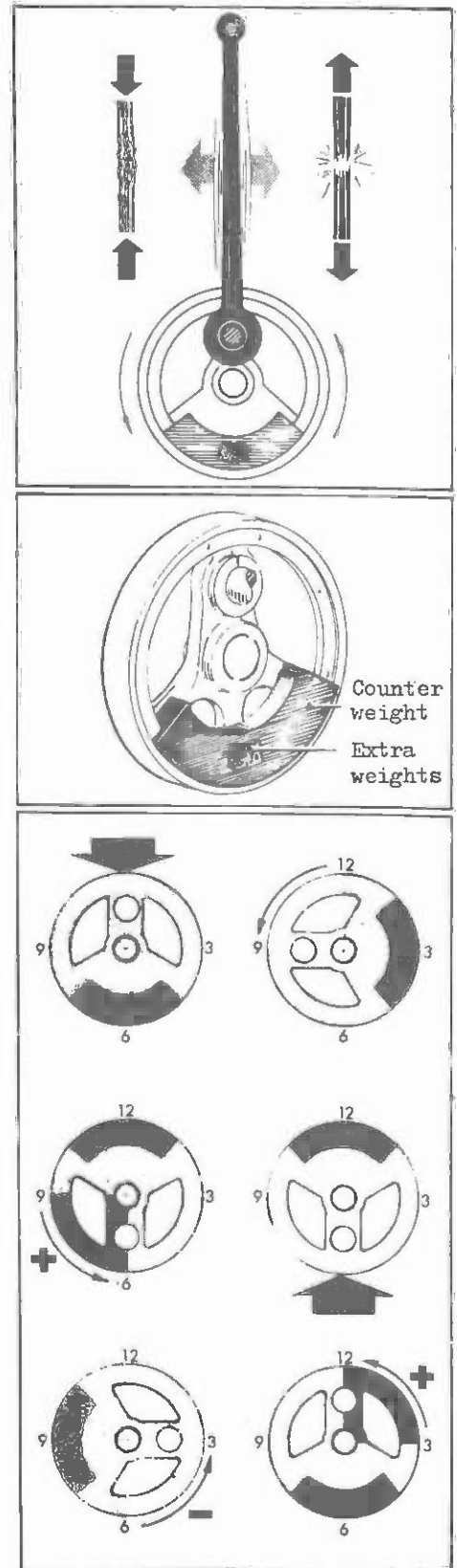
To achieve the best balance, the fixed counterweights are provided with cavities, where iron or lead weights can be inserted to fine-tune the balance.

Above all, it is essential to counter-balance:

- the high force (+) on the lower connecting rod bearing in the "9 to 6 o'clock" section and the "3 to 12 o'clock" section and, in addition,
- the negative force (-) on the lower connecting rod bearing in the "12 to 9 o'clock" section and the "6 to 3 o'clock" section.

In addition, the counterweights help to overcome:

forces at TDC and BDC, the "12 and 6 o'clock" positions.



The function of the flywheels and the counterweights is therefore:

to balance the inertia caused by the up and down movement of the sash and the connecting rod.

Part 2 -- FORCES AND MOVEMENTS explains balancing in detail.

#### B. The connecting rod

The connecting rod is made from one piece of I-section steel 2 m. long.

The function of the connecting rod is:

to transmit the rotating movement of the crankshaft to the sash and to transform this rotating movement into a reciprocating movement.

This means that the connecting rod must turn 700 times/minute when the number of revolutions is 350 revolutions/minute.

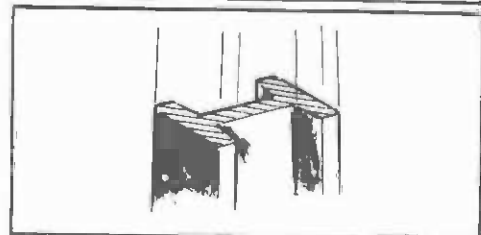
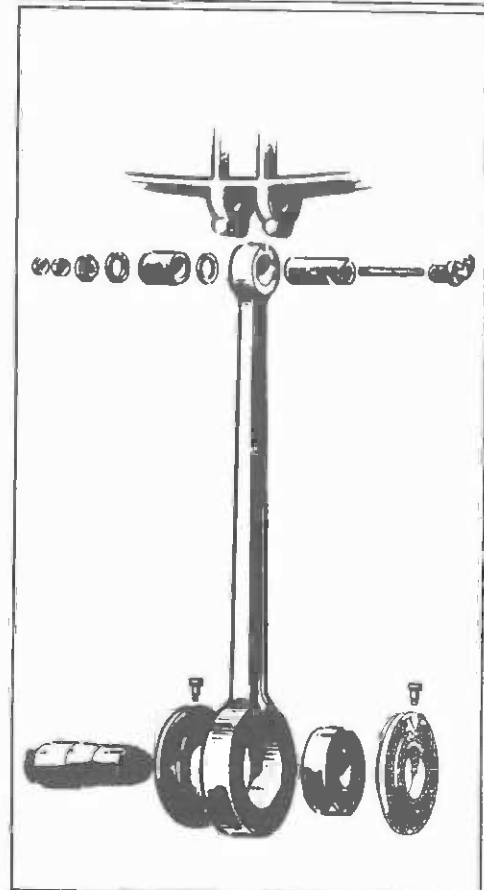
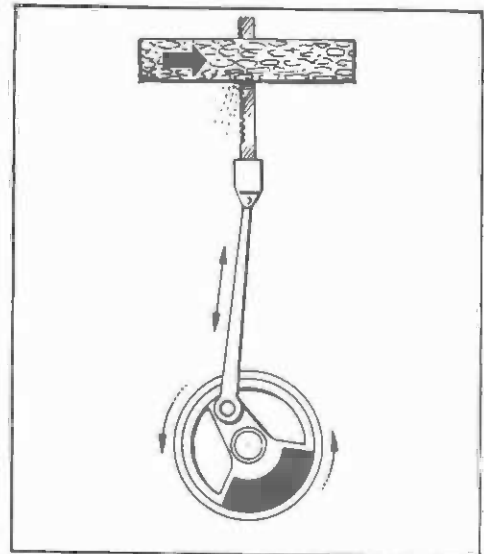
The forces that act on the connecting rod depend on:

- the weight of the sash (250-400 kg with inserted blades).
- the weight of the connecting rod itself, 250 kg.
- the number of revolutions per minute.

In total, the connecting rod must absorb inertia forces of about 20 tons.

To enable the connecting rod to withstand these strains it is necessary:

- to make it of special steel.
  - to design it for strength.
- This is the reason why the I-section is chosen.



The connecting rod is subject to both compression and tension. (See Part 2 - FORCES AND MOVEMENTS.) These are not constant but alternate during each turn of the crankshaft. These stress variations could cause the material of the connecting rod to weaken and failure might occur from fatigue.

For anything that is exposed to repetition of stress, there is a "fatigue limit", which is the maximum repetition of stress that the body in question can be exposed to without fracturing from fatigue.

The fatigue limit of the connecting rod depends on:

- the type and structure of its material;
- the surface condition of the material.

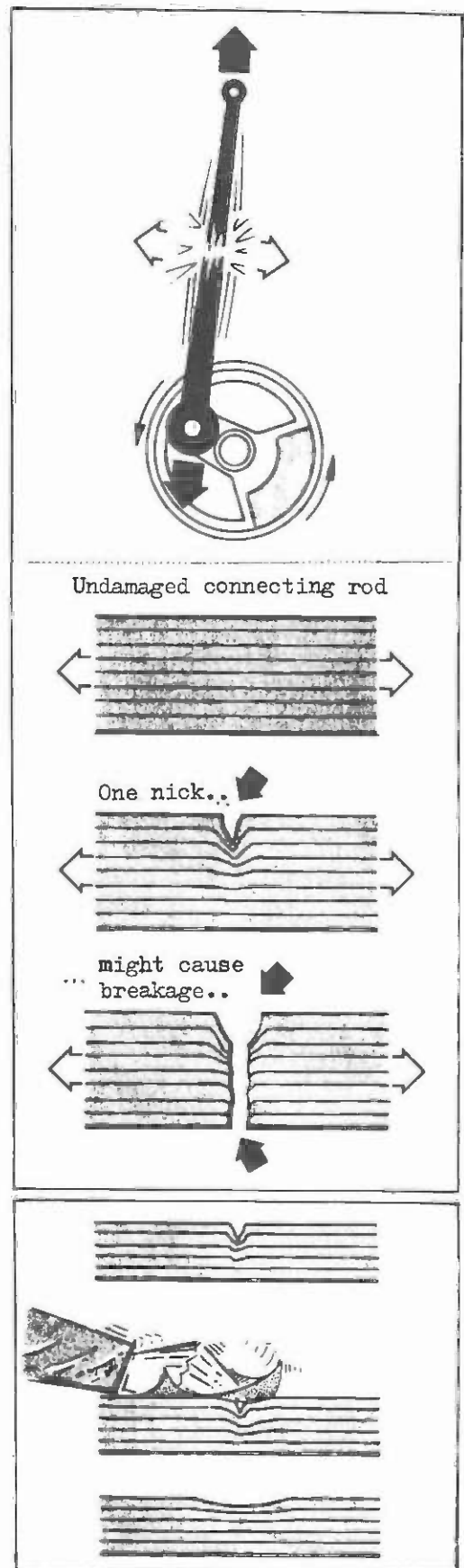
This means that the more even and smooth the connecting rod is, the more repetition of stress it will stand before it fractures from fatigue.

Therefore, the connecting rod must be protected from any nicks. Under no conditions must it be hit against any solid object or be tapped with a hard or sharp tool.

Every nick creates a concentration of stress which gets bigger the deeper the nick is.

A relatively small nick on a connecting rod might, because of the strong concentration of stress around it, eventually result in an apparently inexplicable breakage.

Every nick on the connecting rod must be ground down with an emery or polishing cloth.



Another thing to note is that corrosion, e.g. formation of rust, reduces the fatigue limit considerably and increases the risk of fatigue breakdown.

Saw mills situated near corroding air or water should paint connecting rods with anti-corrosive paint.

The connecting rod has two bearings, one lower and one upper.

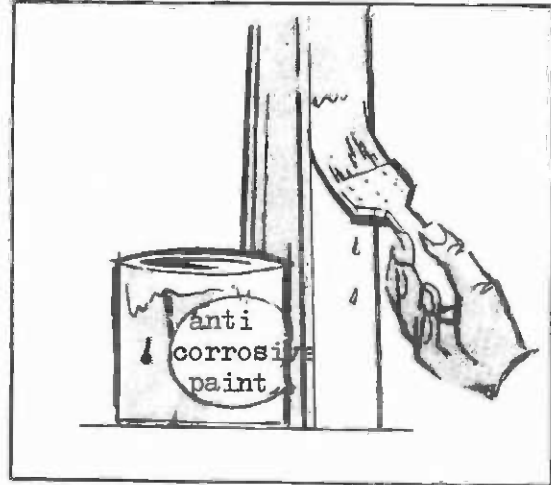
The lower connecting rod bearing is mounted on the crankshaft journal. A spherical SKF-roller bearing (see appendix) has been chosen for the lower end to eliminate:

- any alignment defects in the vertical direction of the frame.
- any side forces working on the connecting rod, for instance, due to sash imbalance.

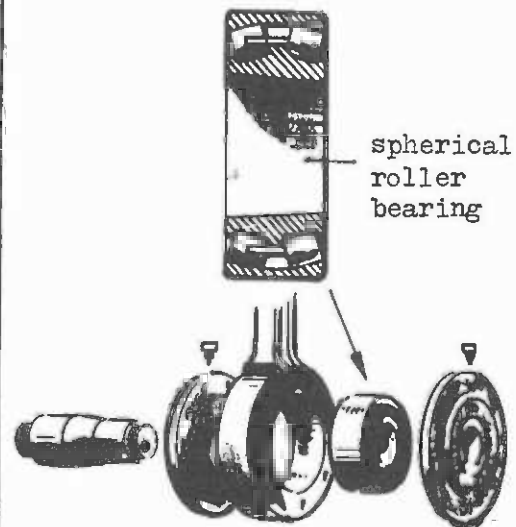
Such an imbalance might occur if the mass of the frame is not symmetrically distributed around its centre; for example, if the blades are not perfectly centred.

The upper connecting rod bearing consists of a needle bearing (see appendix). There is a hole in the piston pin which serves as a tank for lubricating oil.

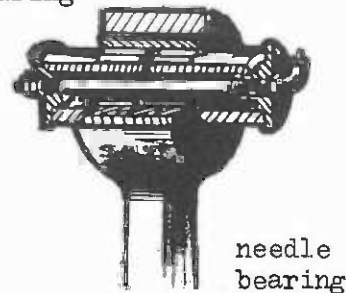
A needle bearing is chosen to ensure that all the parts above the crankshaft are as small and light as possible. A needle bearing is smaller and lighter than other bearings.



lower connecting rod bearing



upper connecting rod bearing



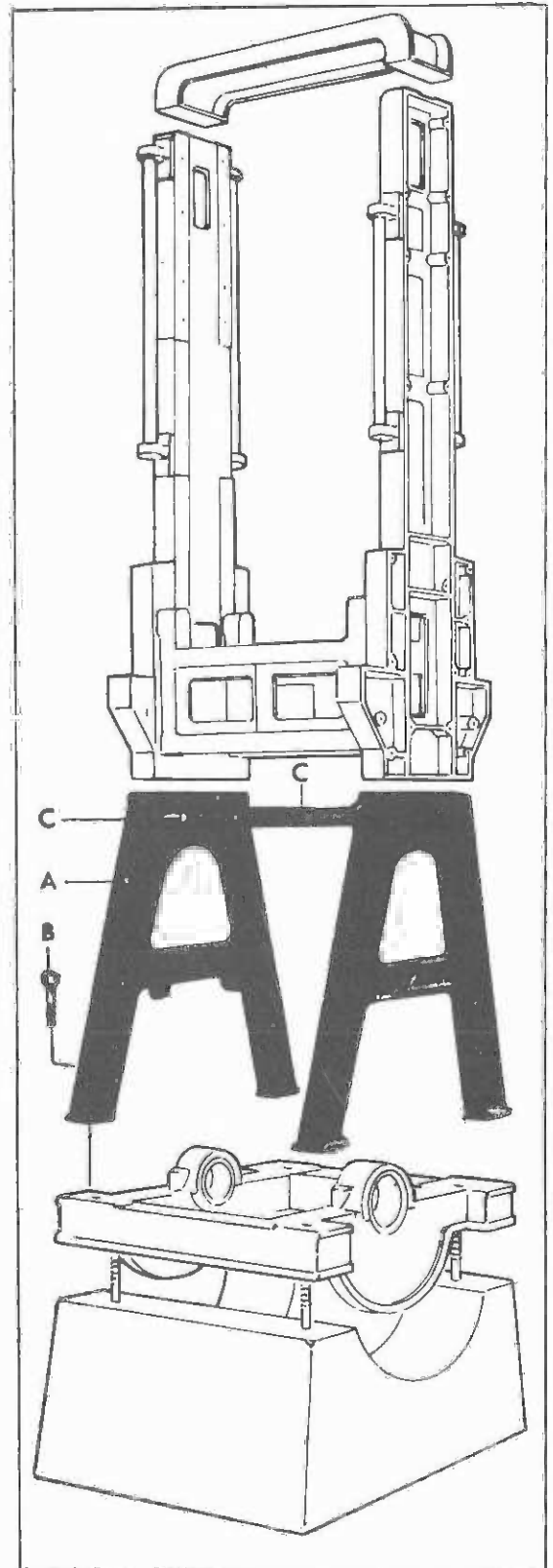
### 3. Bottom Frame

The bottom frame is placed at the lower floor level of the sawmill building. It consists of:

- A. two lower side frames which are both fastened to the base plate by
- B. four bolts at the bottom, and joined together by
- C. two stay bolts at the top.

The function of the bottom frame is:

to extend the sash height to enable connecting rod to be larger;  
to support the two upper side frames;  
to support the brake and belt guide systems;  
to serve as a support body for parts of the feeding mechanism and lubricator.





#### 4. Upper Frame

The upper frame is attached to the lower frame by bolts. It consists of:

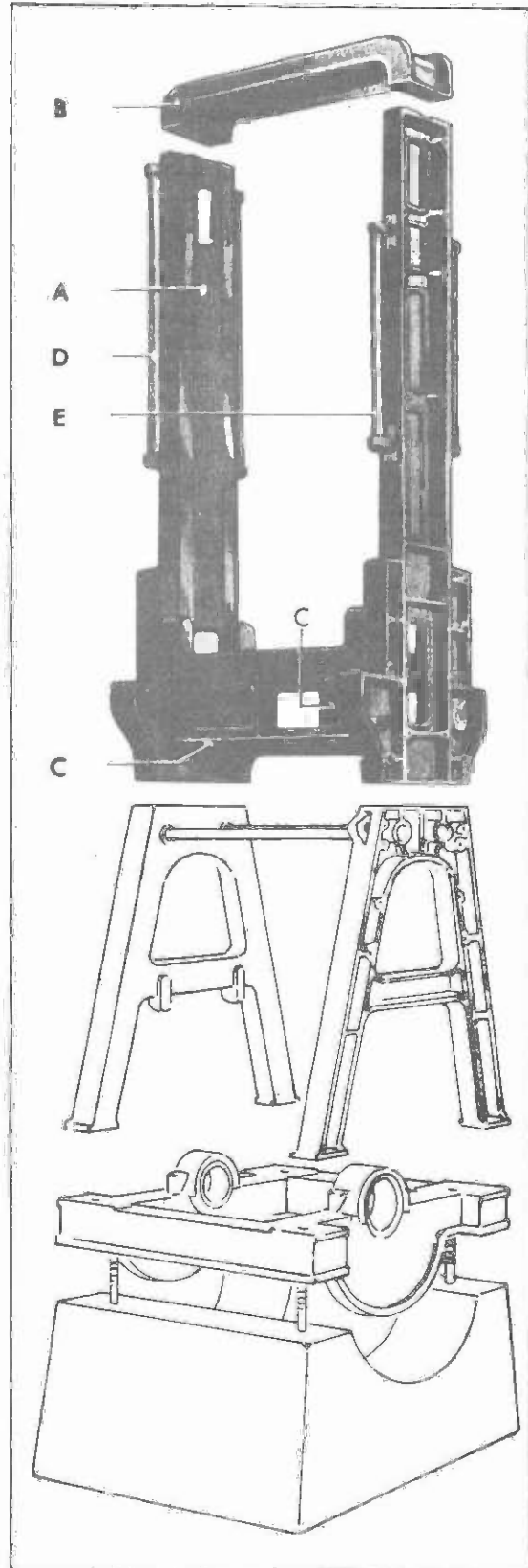
- A. two upper side frames,
- B. one top piece, and
- C. two connecting plates at the bottom, one on each side.

The function of the upper frame is;

to support the system of guides;  
to support the roll frame and the feeding mechanism;  
to transmit to the foundation, through the bottom frame, the vertical forces created when the sash presses against the guides.

To be able to support the roll frames attached to both the infeed and outfeed sides of the upper frame there are:

- D. at the driving side a vertical cylindrical shaft, the attachment shaft, or the swinging shaft.
- E. at the feeding side, a similar shaft called locking shaft.



## 5. Guide System

To the side frames four guides, two upper and two lower, are attached with bolts. A saw frame guide is described as:

- a guide rail having
- a polished surface that is
- made of cast iron. This material has low friction for the wear plates to run on.

The function of the guides is:

to locate the sash in relation to the centre line of the frame, and to guide the sash when it is moving vertically (up and down).

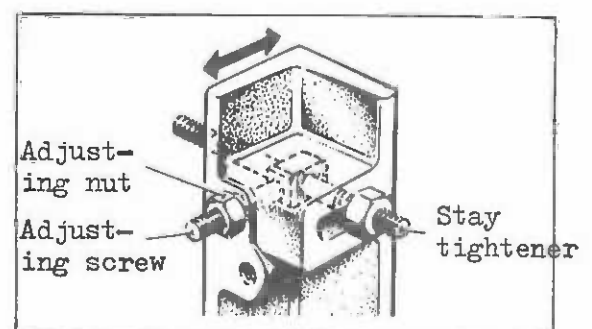
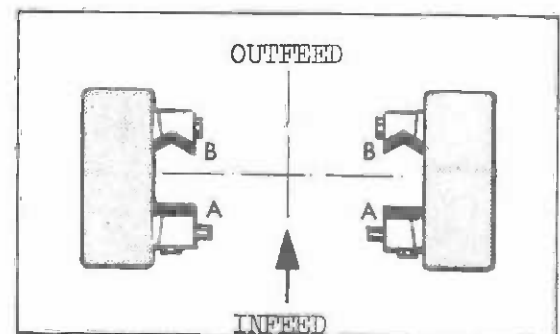
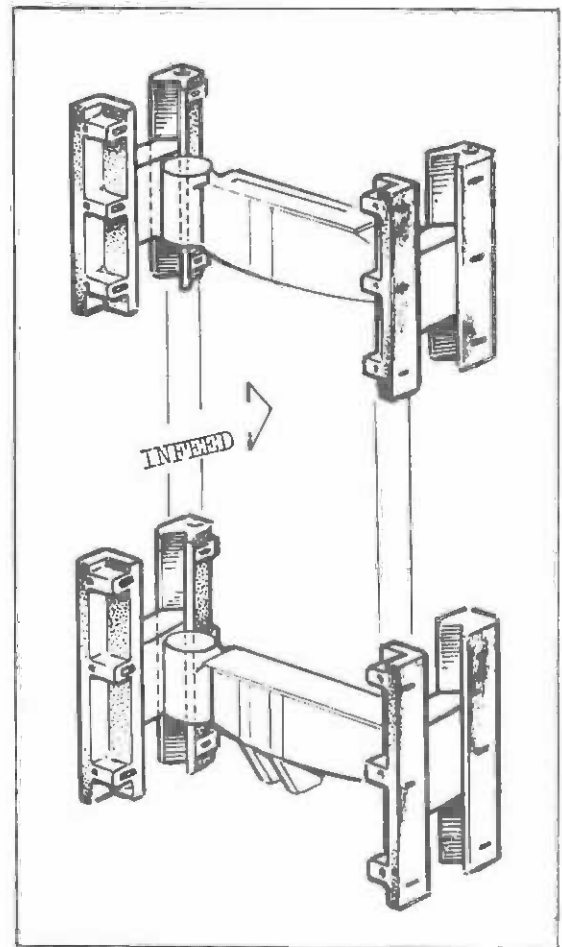
There are two different kinds of guides:

- Flat guides, which have completely straight and plane slide faces. They are positioned on the infeed side.
- V-Guides, which have slide faces shaped like a V. They are positioned on the outfeed side.

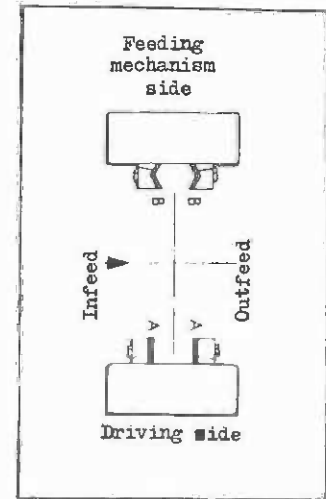
Thus the sash is guided on both the infeed and outfeed side during its movement upward and downward. The front guides (as seen from the infeed side) are always adjustable. The reason for this is that the tolerance between guide and friction plate, (the "play"), must be adjustable to correct wear on guides and wear plates.

If the guide is too tight (the "play" made too small) overheating, and a risk of damage to guides and friction plates could result.

If the guide is not tight enough (the "play" too big) the sash will be loose and this could be transmitted to the sawlines, resulting in poor sawing. There is also a risk that the guide, the friction plate and guide bolts will break, with the risk of further damage.

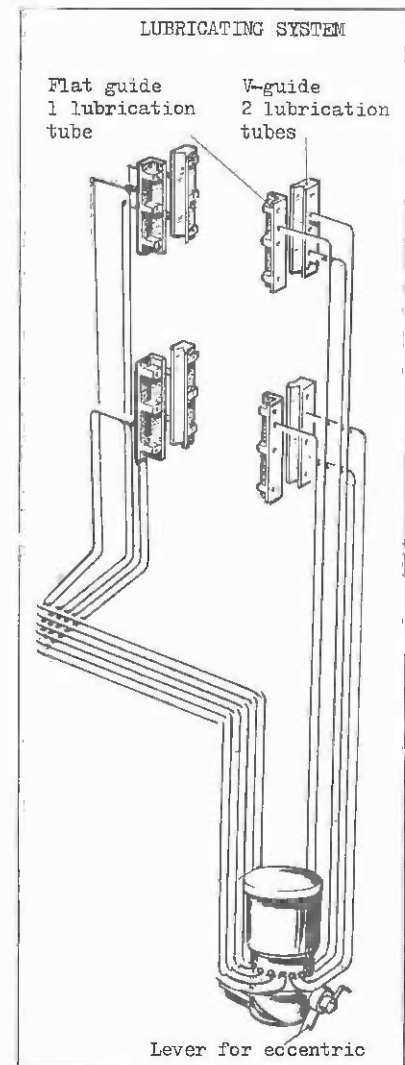


Some frame saws have the guides mounted, as shown in the figure alongside.



The guides are lubricated from a 12-tube grease pump, a high pressure lubricator. The lubrication is proportional to the speed of the saw frame, stopping when the saw frame stops. The lubricant flows with a pressure of up to 100 atmospheres (10 mPa). The lubricator is mounted on one of the side frames. It is driven by an eccentric directly from the crankshaft.

- To each V-guide two lubrication tubes are connected, and
- to each flat guide one lubrication tube is connected.



The load on the lower guides is heaviest as they are mounted closest to the upper end of the connecting rod. Therefore, they take the horizontal forces created by the upper end of the connecting rod at certain positions of movement.

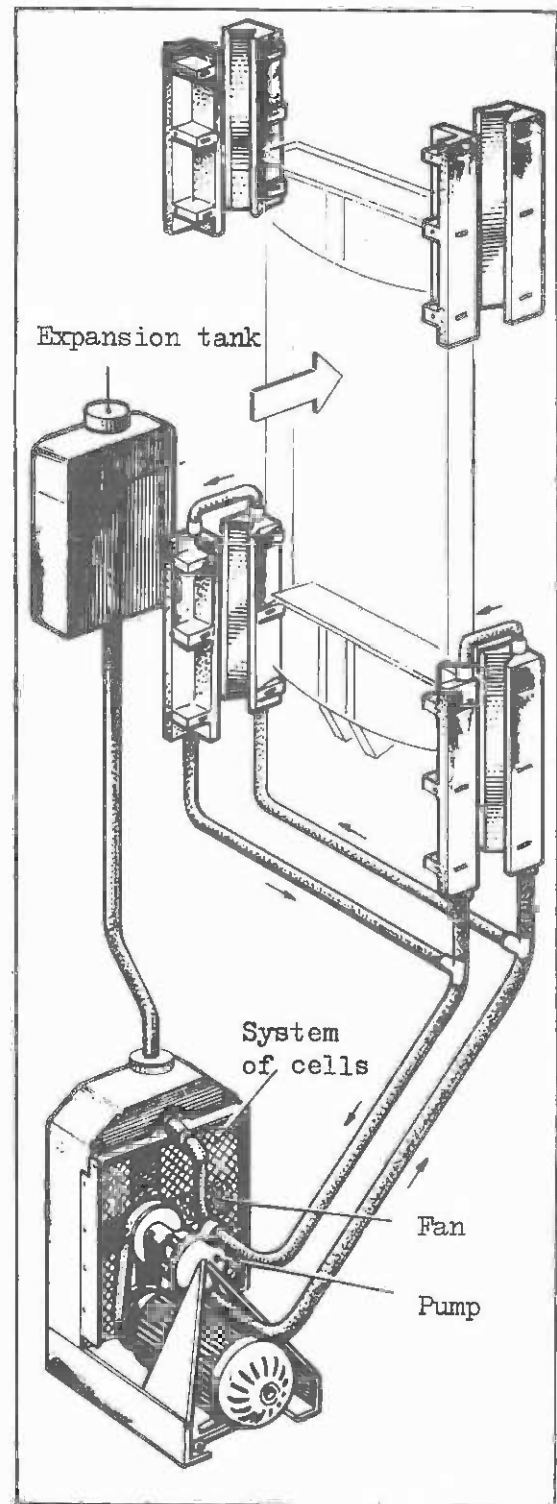
Because of this high pressure these guides are provided with water cooling, making it easier to carry away the heat caused by the high pressure.

This makes it possible to adjust the guides of the sash with minimum tolerance, which markedly improves the efficiency of sawing.

The water cooling device is a closed system where the water is continuously pumped. It consists of:

- a system of radiator cells,
- an electric fan, and
- a pump.

This self-contained equipment can be placed beside the frame, or on the bottom floor, or in any other suitable place. Water is led through tubes to the guides which are hollow, so that the water can pass through them.



6. Sash

The sash consists of four parts:

- A. one upper cross beam
- B. one lower cross beam
- C. two columns, one on each side.

The lower cross beam has a bracket on its under side in the form of two wings. Attached to these is the upper crank pin which connects the sash with the connecting rod.

The distance between the upper and the lower cross beam is adjusted, so that the upper blocks in the lowest position of the frame and the lower blocks in the highest position of the frame do not touch the log.

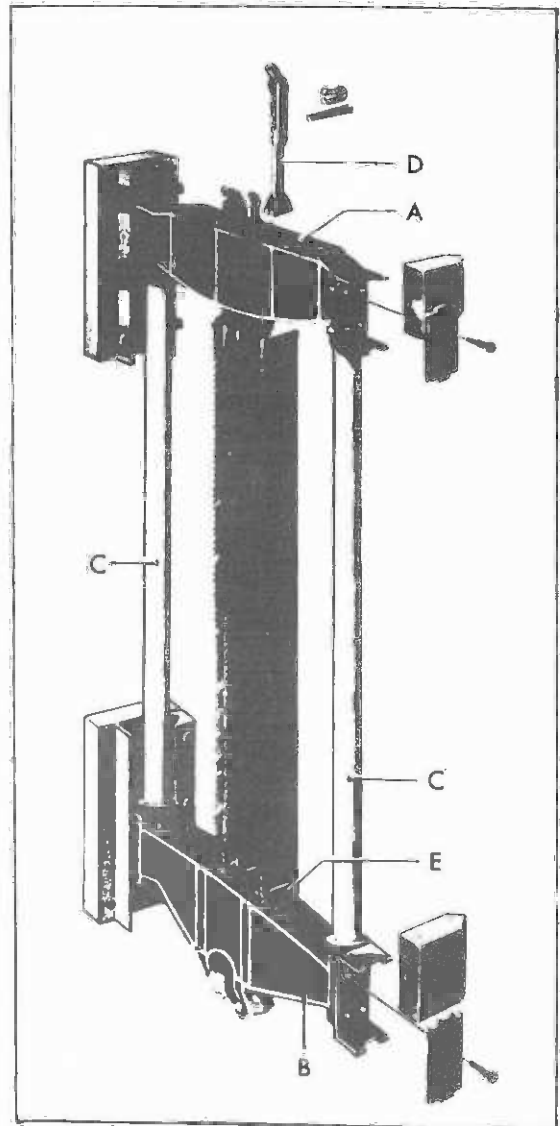
The columns are made of steel tubing to keep weight down. In relation to its weight tubing has high resistance to compression and tension stress.

The two columns and the two beams make up the sash into which the saw blades are inserted.

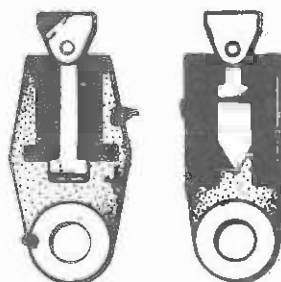
To hold the sawblades each cross beam is provided with a slot, i.e. a clearance into which are inserted:

- D. top hangers at the top, and
- E. bottom hangers at the bottom.

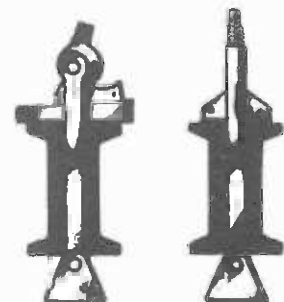
The saw blades are fitted into these hangers when the saw blades are set.



Bottom hangers



Top hangers



The sash is constructed:

- to withstand the stresses created when the blades are fitted. Each blade is fitted with a tension of 7-9 tons. If seven blades are fitted, the total tension will be 50-65 tons.
- to enable, in particular, the lower cross beam to absorb forces from the moving connecting rod. These forces are of a magnitude of 15-20 tons and they alternately put the beam under bending stress upwards and downwards.

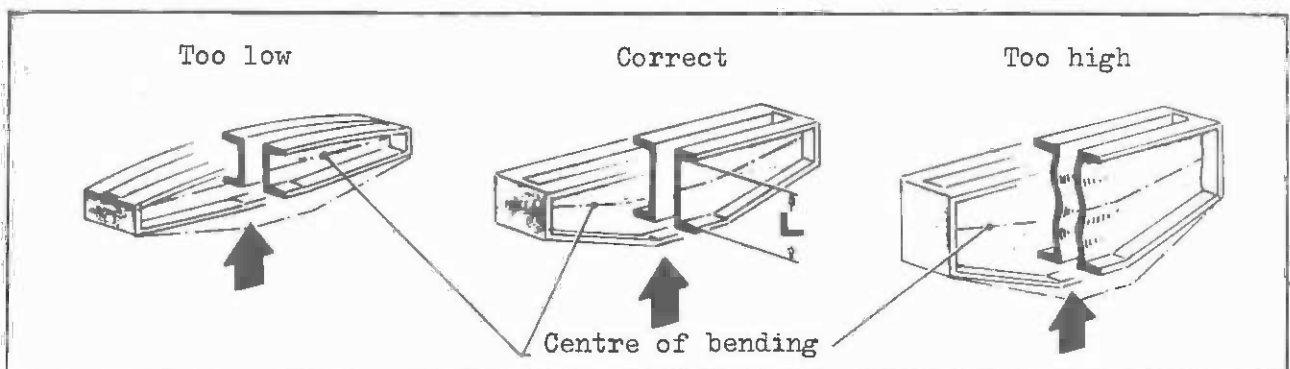
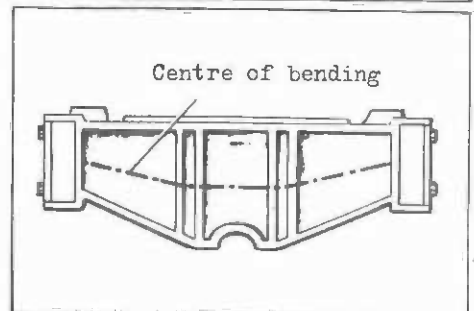
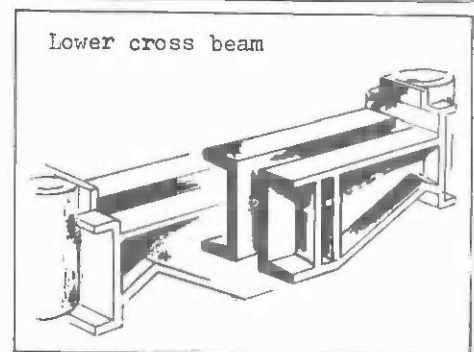
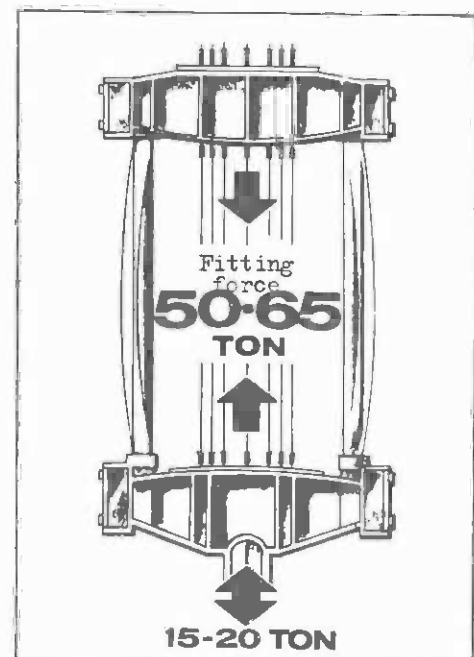
At the top dead centre, where the whole sash must slow down, stop and change direction, the connecting rod will bend the beam down.

At bottom dead centre, where the sash once again must slow down, stop and change direction, the force from the connecting rod will bend the beam up.

The cross beam, seen in a cross section, is in principle like two U-beams back to back.

The U-beam is chosen because it gives advantage both in manufacturing and in strain distribution, such as:

- the U-form is easy to manufacture in the foundry.
- in resisting stress, the U-form has an advantage because this shape gives a high bending resistance (i.e. resistance against bending stress).



In the centre of the cross beam there are two strongly dimensioned angular stiffeners or ribs, the function of which is to steady the beam against the forces mentioned above.

The tension stress acting on the sash through the set of blades depends on, and varies with, the number of blades and how tight each blade has been fitted.

The stress that the connecting rod transmits to the sash, mainly the lower cross beam, primarily depends upon:

- the weight of the sash, and
- the number of revolutions per minute.

The sash must be dimensioned according to the diameter timber to be sawn. The bigger the timber, the bigger the sash and the higher the weight.

The width of the sash can vary between 18" and 34", which is the inside dimension and also the diameter limit of any log that can pass through the frame.

The weight of the sash varies between

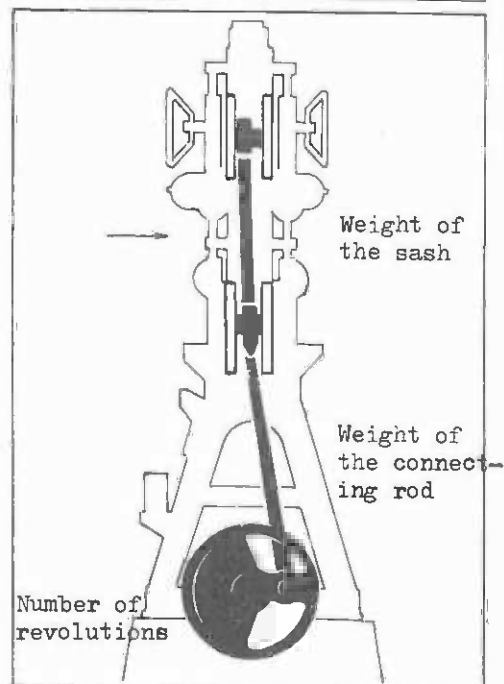
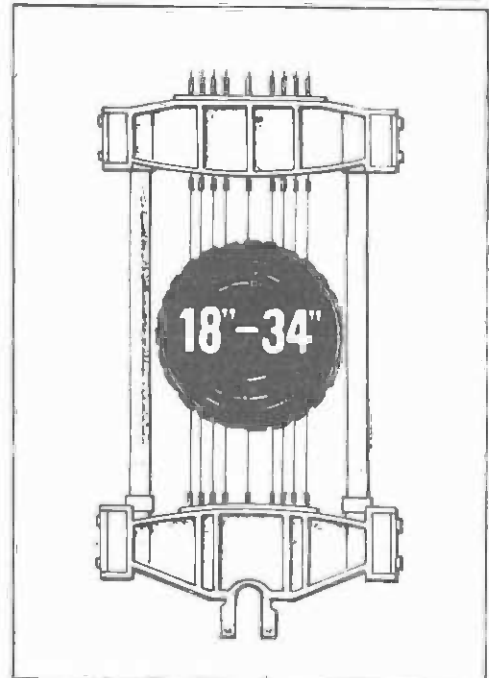
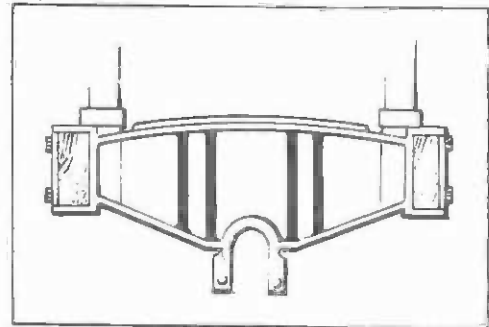
- about 250 kg for a 15" frame with inserted blades, and
- about 400 kg for a 34" frame with inserted blades.

The stress transmitted by the connecting rod to the lower cross beam of the sash will increase:

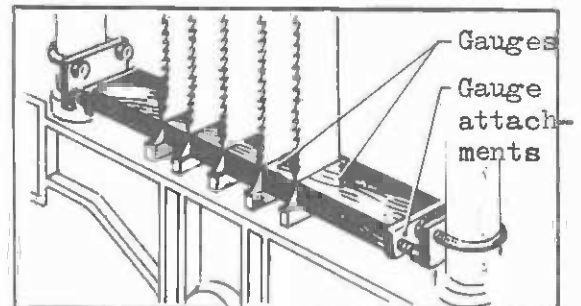
- with increased weight of the sash;
- with increased speed (rev./min.)

There is a limit to the stress placed on any piece of machinery and, in this case, the manufacturers place restrictions on the weight and speed as under:

for a 18" frame	... 380-390 rev./min.
for a 24" frame	... 360-365 rev./min.
for a 30" frame	... around 320 rev./min.



To the columns of the sash four gauge attachments are fastened, one in each corner. Between these and the outer blades on either side, blocks or gauges (measuring bodies located between adjacent blades to determine the thickness of the sawn timber) are located. This makes it possible to align the whole set of blades with screws fixed in the gauge attachments.

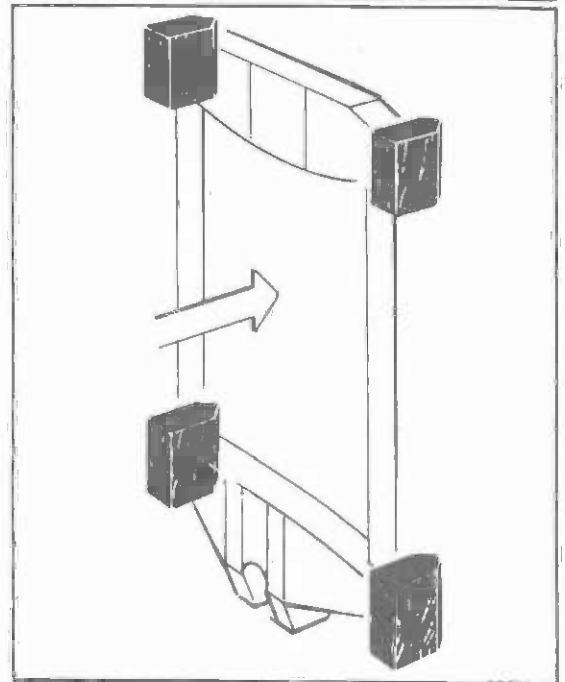


In the four corners of the sash, the ends of the cross beams are provided with brackets for the sliding blocks.

The function of the sliding blocks is to guide the sash into the guides of the upper frame.

The surface of the blocks is made up of interchangeable friction plates made of a low friction, low wear material such as aluminium blocks with a special bakelite finish, "pockenholz" or other low friction material. The aluminium blocks are preferred for weight and maintenance reasons.

The aim is to get friction as low as possible between the friction plates and the guides, in order to prevent overheating, because overheating can cause the guides to buckle.



The sliding blocks on both sides of the sash are made in the same way:

- on the infeed side as flat blocks, and
- on the outfeed side, as pointed blocks to steer the sash in the guides.

So the sash is guided both on the feeding mechanism side and the driving side of the frame.

The system with flat blocks and flat guides makes adjustment of the sash easier and the number of surfaces requiring careful clearance adjustment is reduced.

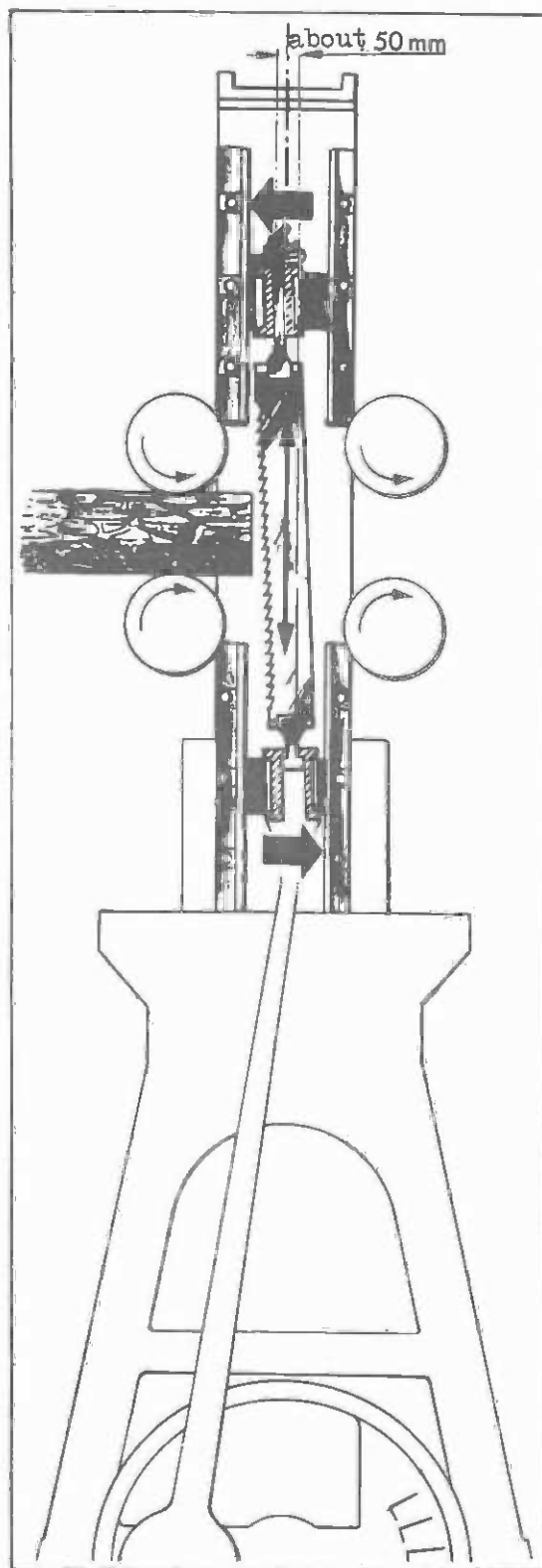


Blades must be fitted into the sash with an overhang setting, to make the blade at the upward stroke move away from the cutting line in the log, which is continuously fed.

Overhang setting means that the tooth line is set away from the vertical and has a slope away from the log at the bottom.

This overhang must be obtained without fitting the blades so that the tension line falls diagonally through the blades.

To get a correct overhang, the two cross beams are not vertically one above the other. In relation to a vertical plumb line through the centre of the saws the upper sliding blocks are displaced towards the front (log infeed) and the lower sliding blocks towards the rear (log outfeed). The overhang is about 50 mm from vertical.



## 7. Roll Frame and Feed rolls

The function of the roll frame is:

to support the upper and lower feed rolls;  
to create a roll pressure between the feed rolls

It consists of:

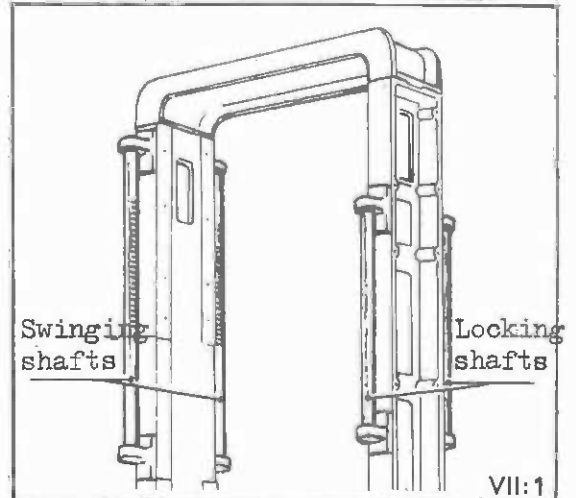
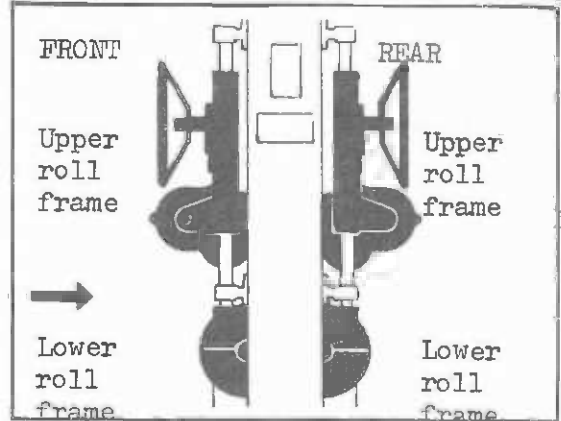
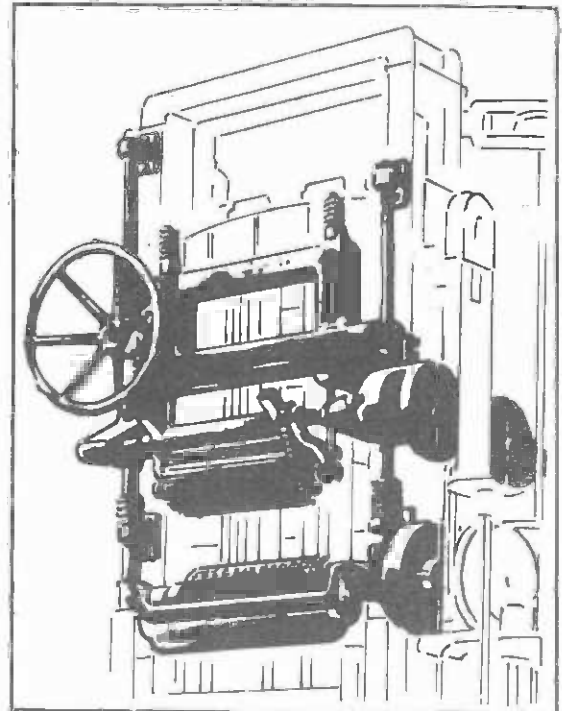
- the upper roll frames, one in front and one at the back. (Seen from the infeed side).
- the lower roll frames, one in front and one at the back. (Seen from the infeed side).

### The upper roll frame

The frame is supported on both the infeed and outfeed sides by shafts attached to the upper frame:

- on the driving side of the frame, by vertical holding swinging shafts;
- on the feeding mechanism side of the frame by locking shafts.

Each upper roll frame is fixed on and can swing out on the swinging shaft to give access to the sash (e.g. when changing blades). Each roll frame carries an upper feeding roll.



VII:1

The roll frame is cast and provided with:

- a vertical hole A for the holding shaft on the driving side.
- a vertical notch B for the lock and the locking shaft on the feeding mechanism side.
- two vertical holes B' for the clamps.
- a horizontal hole C for one sprocket shaft on the driving side.
- two horizontal holes D and D' for the supporting shaft to the upper roll clamps.

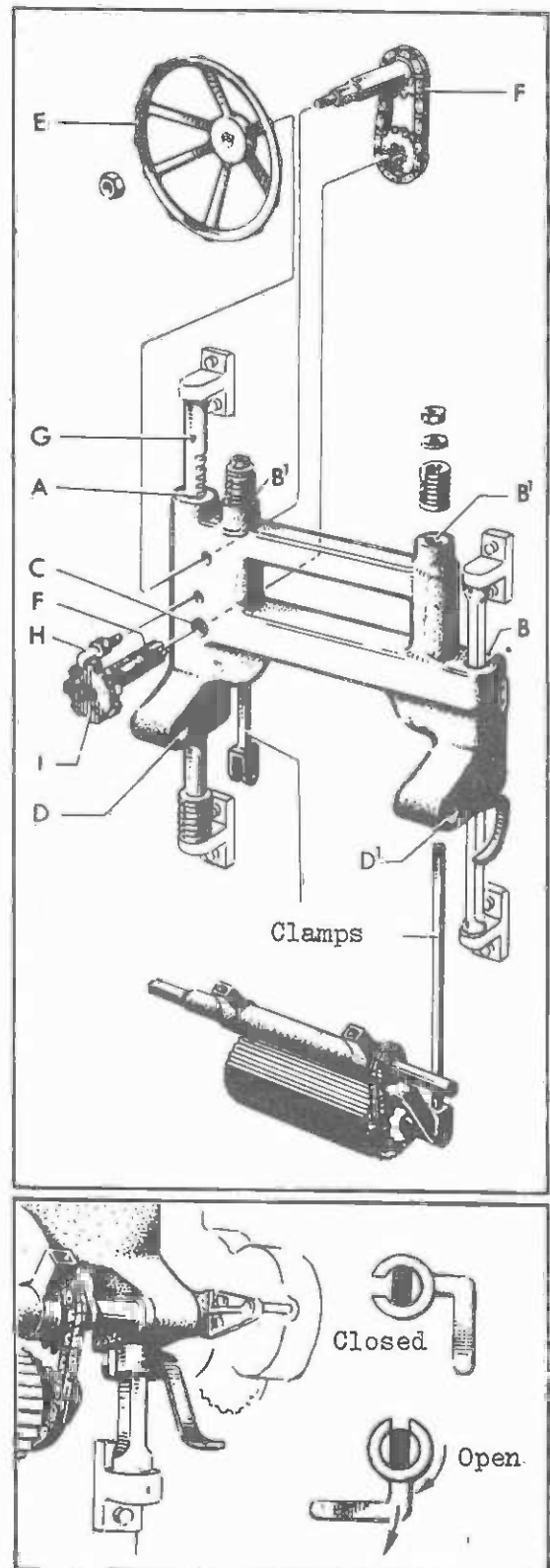
Each roll frame can be raised and lowered along the vertical swinging shaft to make it possible to adjust it to different diameter logs. This is done manually by means of the hand-wheel.

The hand-wheel acts on a toothed transmission gear F of which the teeth are meshing with the corresponding rack of teeth of the swinging shaft G.

The toothed transmission gear is provided with a locking device in the form of a catch H which meshes a ratchet wheel I.

This is placed on the shaft between the hand-wheel and the gear.

With this device the gear and the roll frame can be locked in the correct position for any given log diameter. When raising and lowering the frame the catch must be in the raised position.



### The lower roll frame

The lower roll frames are constructed on the same principle as the upper ones. Since they must give firm support to the log during sawing, they are fixed vertically.

Like the upper roll frames they swing outwards. Nowadays they are made of cast steel for strength.

Each roll frame supports a lower feed roll. Both the upper and lower roll frame can be locked inwards, (i.e. the operating position) by a simple catch on the feeding mechanism side of the stand which is then turned so that it totally encloses the locking shaft. This also eliminates any play in the roll frame. The lock is inaccessible when the saw is working.

### The feed rolls

The feed rolls are called:

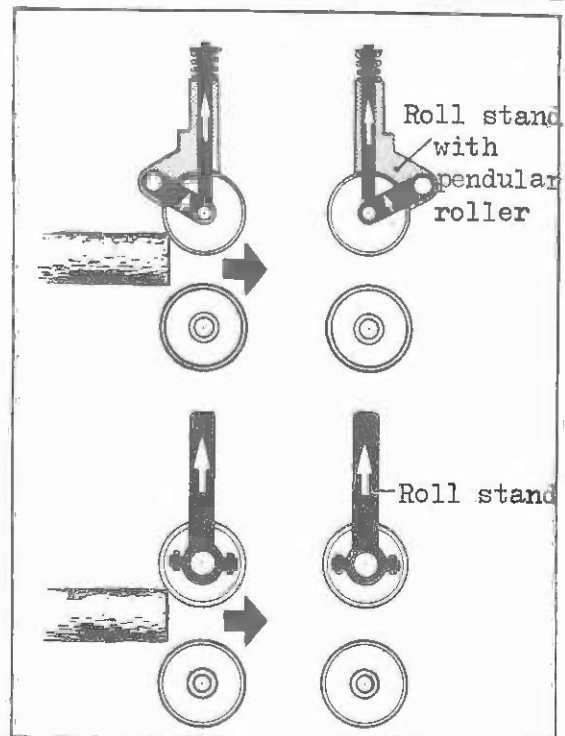
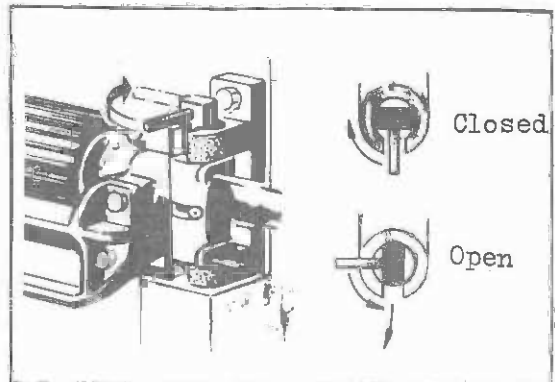
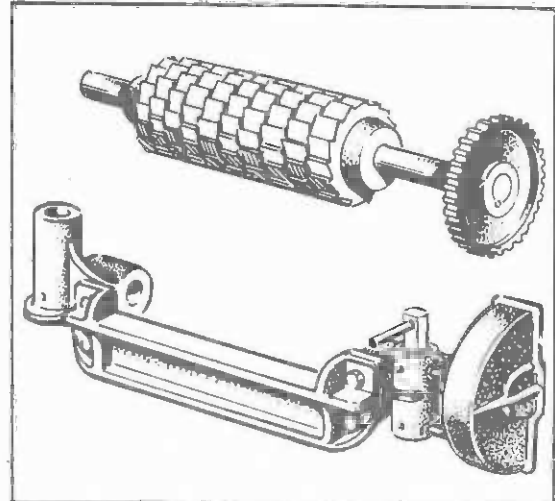
- upper feed rolls
- lower feed rolls.

The function of the feed roll is to feed the log through the frame saw in the smoothest possible way.

The upper rolls consist of one front and one rear roll which:

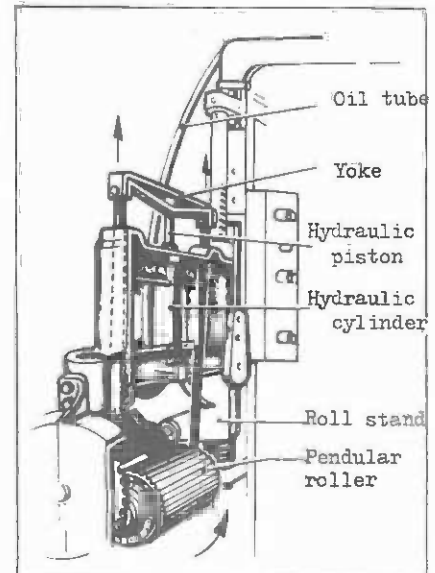
- rotate on shafts mounted in rising and falling clamps (roll clamps) on the upper roll frame. Such a roll is also called a pendular roller.

(In some models the roll shaft is mounted directly on the rising and falling roll frame - a fixed roll. The roll frames are adjusted vertically with a hand-wheel and then they are automatically self-adjusting from the bottom position.)

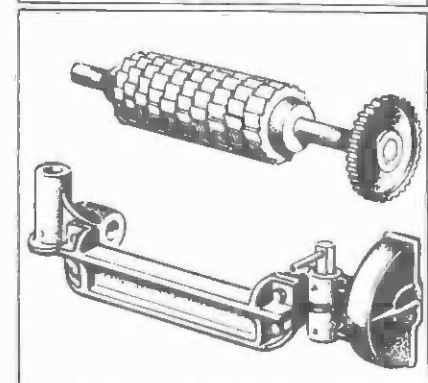
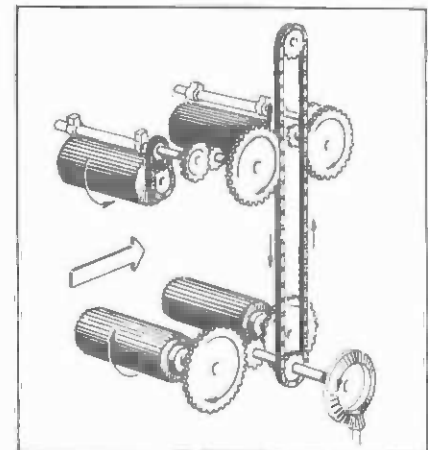


- are self-adjusting vertically (because of the rising and falling clamps) to small variations in the diameter of the log. If, however, sawing is done butt end first, the rolls have to be lifted by a special device because they cannot open themselves up from the small end of one log to the butt end of the next one.

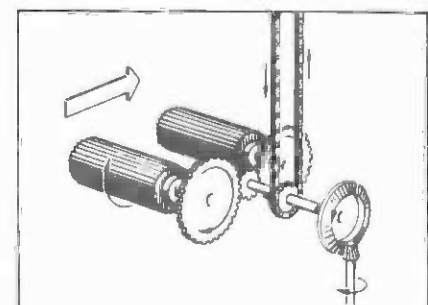
This lifting is one by means of a hydraulic cylinder which the sawyer can control from the log carriage. The cylinder has a piston mounted between the pendular roll clamp and the roll frame. The pressure comes from a hydraulic pump on the upper side of the side frame.



(In some frame saws the lifting is done by pneumatic valves operated by the sawyer from the log carriage. The lifting device consists of a pneumatic cylinder with a piston which is mounted on the roll frame. The air pressure comes from a separate motor driven compressor.)



The lower feed rolls, one front and one rear:



- consist of roller sections that are mounted on a cylinder of cast steel. These centre cylinders are mounted vertically, fixed in interchangeable metal bushes in the lower roll frame. Because the bushes are interchangeable there is no risk of the rolls pulling sideways because of wear in the bearing boxes.
- are driven from the feed mechanism by means of a cog wheel transmission. On the side of the feeding mechanism the shaft journal of the roll is provided with chain wheels that mesh with a cog wheel of the feeding mechanism when the swinging roll frame is engaged.

### Pattern of feed rolls

The function of the feed rolls has earlier been described as:

to feed the log through the frame by rotating, and also to restrain the log while being fed to prevent it turning or moving sideways.

This task must be done under very different conditions dependent upon:

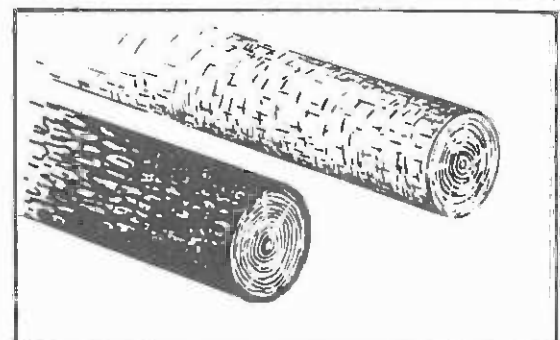
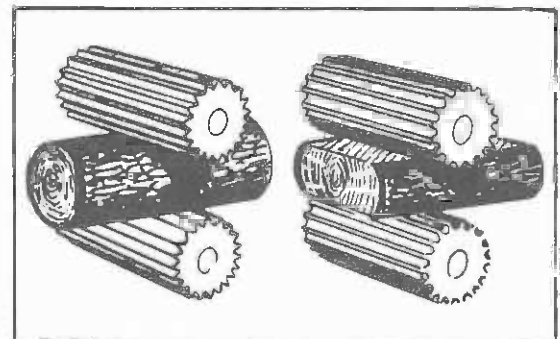
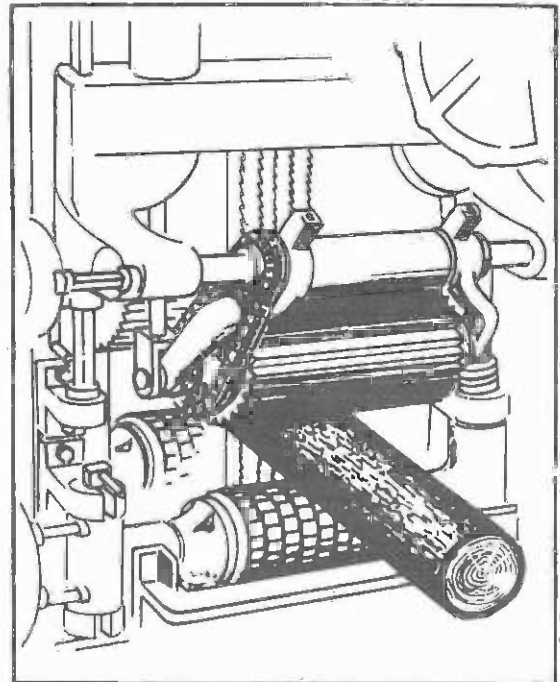
- the form of the material

LOG	or	CANT
that is round and has small contact surfaces against the feed rolls		that has two flat sawn surfaces against the feed rolls

- the hardness and surface of the material; for example, logs with bark on or off, frozen or unfrozen timber.

The demands on the function of the feed rolls are:

- that the timber is not damaged by pressures that leave marks on the sawn surface.
- that the log is fed evenly and steadily without slipping. Slipping results in the wrong relationship between feeding and overhang setting which results in poorer sawing and more strain on the blades.



For the feed rolls to function properly two things are required:

1. The right pattern for different conditions.
2. Satisfactory maintenance (as part of the preventive maintenance system) of the pattern of the feed rolls.

The roll pattern is made in one of two different ways:

- A. a roll core is provided with patterned rings, or
- B. the pattern is cut directly into the roll.

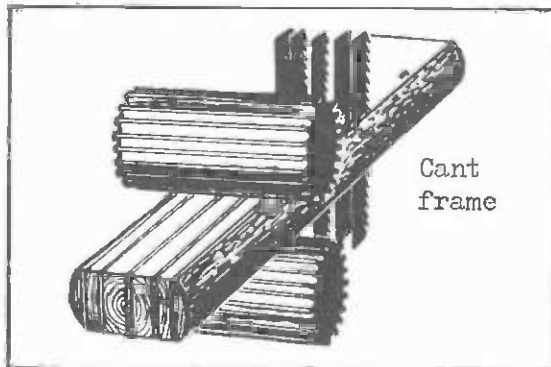
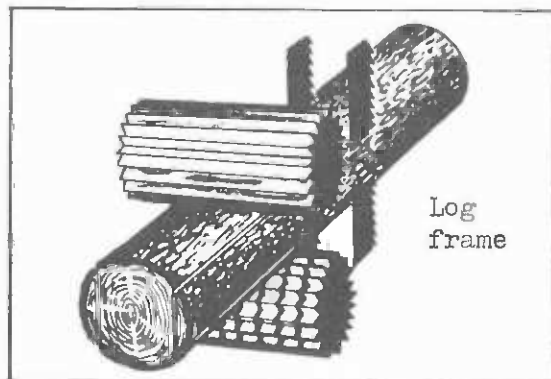
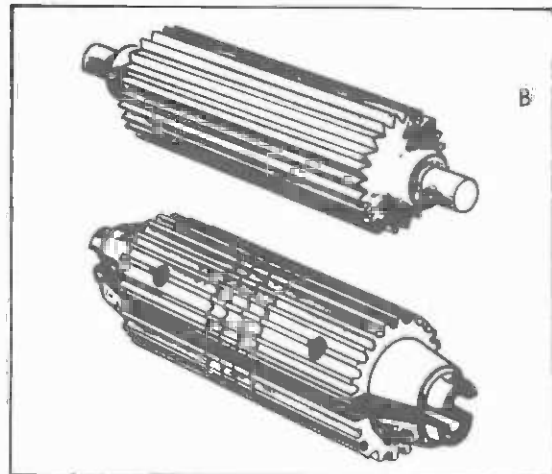
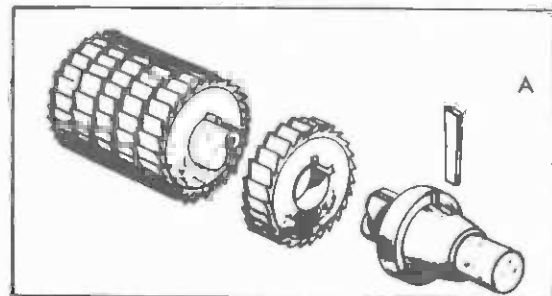
The roll pattern can, in principle, be of two different kinds:

- spiked or toothed, i.e. the contact points have been made pointed to grip the log better and reduce slipping between log and feed rolls to a minimum.
- flat or grooved, i.e. the contact points have been made smooth so as not to damage soft timber.

In the log frame the spiked pattern is usually used both for the upper and lower feed rolls.

Since the stresses are biggest on the lower feed rolls, these are usually provided with replaceable spiked rings, often with cleaning irons between them.

In the cant frame only feed rolls with a smooth pattern are used to prevent any roll marks on the surfaces of the sawn block. These surfaces are normally the final product surface.



In frames that are used for both log and cant cutting, the lower feed rolls are often provided with:

- one centre part consisting of spiked rings.
- side parts consisting of flat rings.

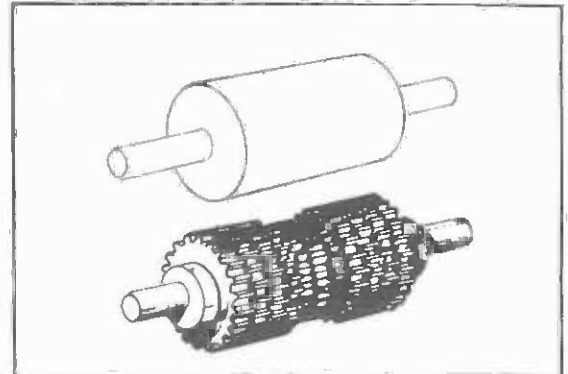
The spiked rings in the centre are positioned a little lower than the flat rings on the sides.

The form and pattern of the rolls depend upon what logs are to be cut and the climatic conditions, etc., during which sawing takes place.

2. The maintenance of the feed rolls must, regardless of their form and pattern, aim

to keep the pattern of the feed rolls in good condition.

This is done either by exchanging worn rings or by re-cutting or grinding feed rolls of fixed pattern.





## 8. Feed Mechanism

The feed mechanism is made for continuous feeding. This means that the log is fed when the blades are moving up as well as when they are moving down. It is done, as has been said before, by the lower and upper feed rolls.

The feed mechanism consists of a gear box with a friction drive mounted on one side stand.

The frame is said to be a right-hand or left-hand frame, depending on which side of the stand, right or left, the feeding mechanism is mounted.

The function of the feeding mechanism is to transmit a rotating movement from the crankshaft to the feed rolls.

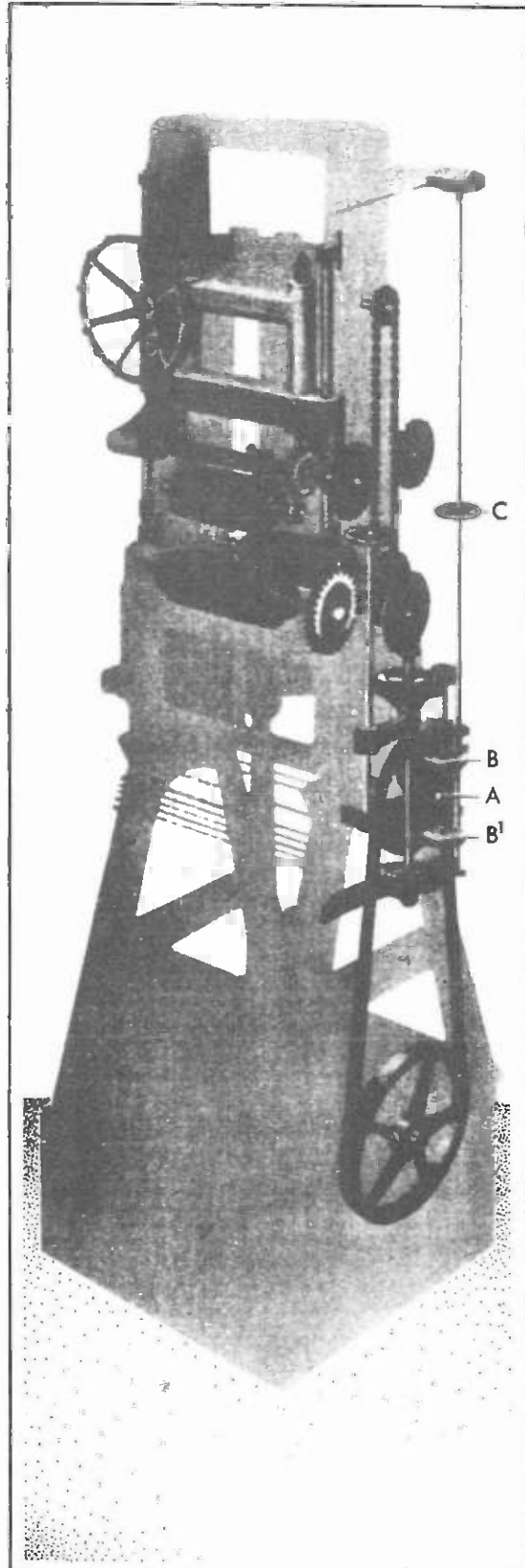
The friction drive consists of:

- a friction wheel A mounted on a horizontal shaft, and
- two fibre rollers, one upper B and one lower B', mounted on vertical shafts.

Both rollers can be moved against the common friction wheel.

The upper roller B is movable along a splined shaft and is used for the feeding. It is automatically pressed against the friction wheel by a spring device with a force that increases with the resistance to feeding. Contact between the roller and the friction wheel is made by means of a knob D close to the frame.

The lower roller B', mounted on its shaft, is only used for return feeding and is otherwise lifted from the friction wheel. It starts to work when a wheel-handle C is turned, thereby releasing a strong spring. This spring is mounted in such a way that it will press the friction roller against the wheel.



The function of the friction drive is to enable the feed rolls to turn at different speeds.

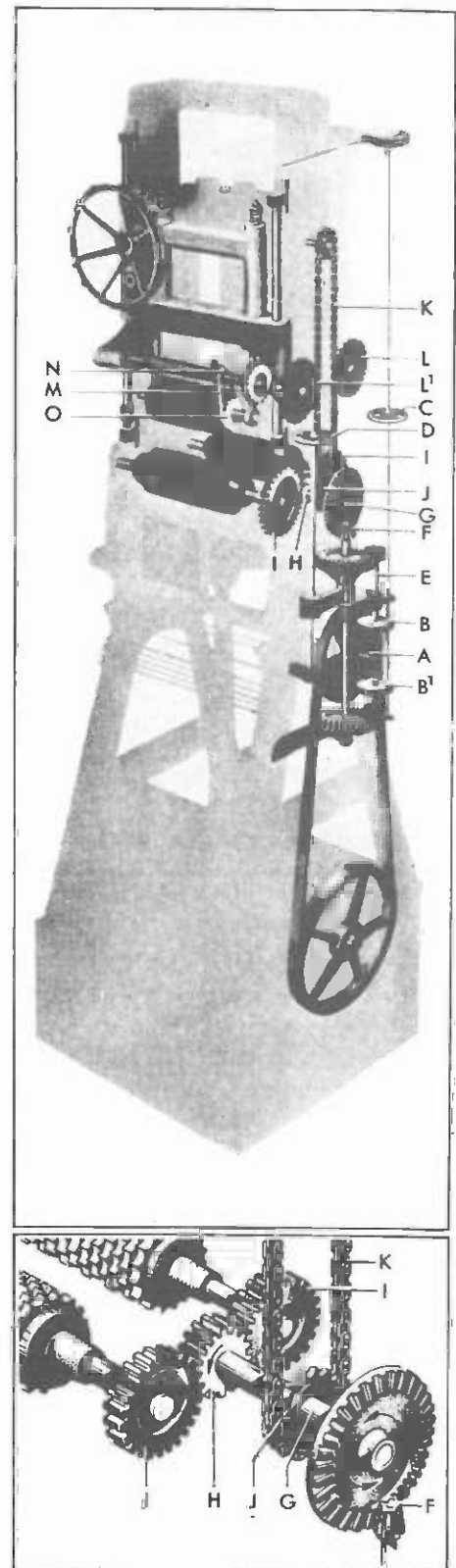
The speed can be varied from 10 to 40 mm/stroke (with special arrangements up to 50 mm/stroke).

The speed of the friction roller B can be adjusted by contact with a longer or shorter radius of the friction wheel A.

The speed is increased as the friction roller B moves towards the periphery of the friction wheel.

The transmission of power is done as follows:

- A belt from a driving wheel mounted on the crankshaft drives the friction wheel A.
- The wheel drives the friction roller B, which then starts to rotate together with its vertical shaft E.
- A mitre-wheel gearing F transmits the rotation from the vertical shaft E to a horizontal shaft G.
- On this horizontal shaft G are mounted both a cog wheel H that meshes with the cog wheels I of the lower feed rolls and a sprocket J that transmits the movement to the upper feed rolls through a driving chain K, the outside of which mesh with sprockets L and L'. These sprockets are mounted on horizontal shafts in the upper feed frame.
- The feed rolls are finally set to work by a driving chain M that runs over a sprocket N, on one of the horizontal shafts and also over a sprocket O mounted on the shaft of the feeding mechanism.



### Feeding mechanism m/Variator

The main parts of this feed mechanism are:

- 7.5 hp motor A which drives by means of V-belts.
- the variable drive consisting of two tapered discs (B and C). These discs transmit the movement through a V-belt D to two other tapered discs (E and F). These latter discs are mounted on a shaft G, which is connected to:
  - the gear drive H which, in turn, drives the feed rolls I of the frame saw.
  - the 0.25 hp motor J which changes the feed speed.
  - the stand K on which the parts of the feed mechanism are mounted and which is fixed to the frame by four bolts.

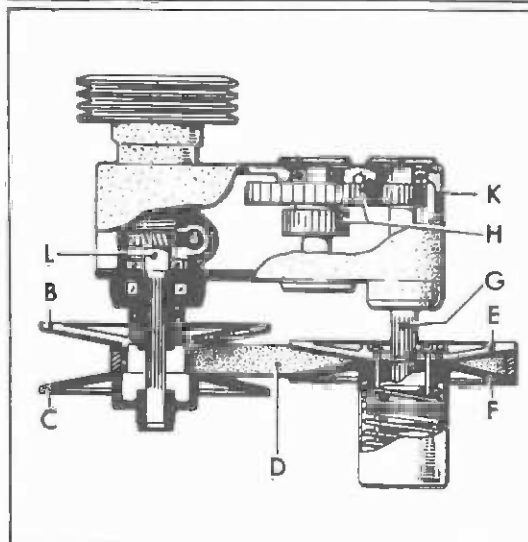
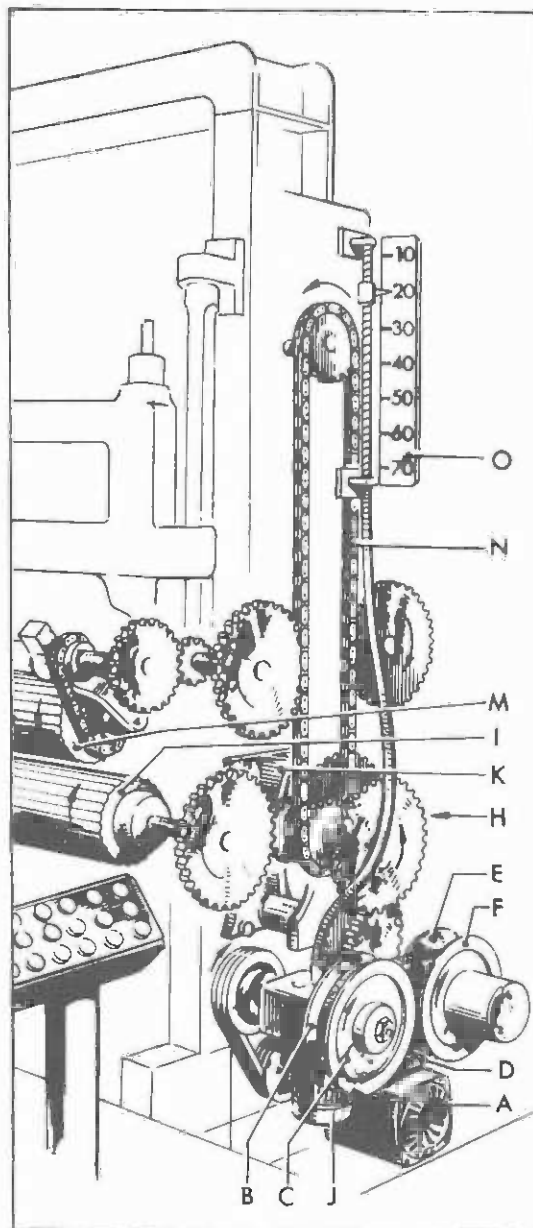
Both motors are controlled by a control panel placed on the log carriage or on a special stand.

It works as follows:

The motor of the feed mechanism drives, with V-belts, a shaft L. Two tapered discs (B and C) are mounted on this shaft. The inside disc B is fixed on the frame and cannot be moved sideways.

The outside disc C, however, is mounted directly on a movable shaft. By moving the shaft L the position of the outside disc C can be changed in the longitudinal direction of the shaft.

Between these two discs runs the wide V-belt D. The other end of the belt drives pulleys E and F on driven shaft G.



The inner of these discs E is movable along the shaft. In the longitudinal direction of the shaft (as seen outwards from the frame) this disc is spring-loaded by a coil spring inside the hub and is therefore always pressed against the outside disc. Through this the belt is stretched.

The driven axle G is in driving contact with the lower feed rolls I through a spur gear unit H. The upper feed rolls M are driven by a chain transmission N from the feeding mechanism.

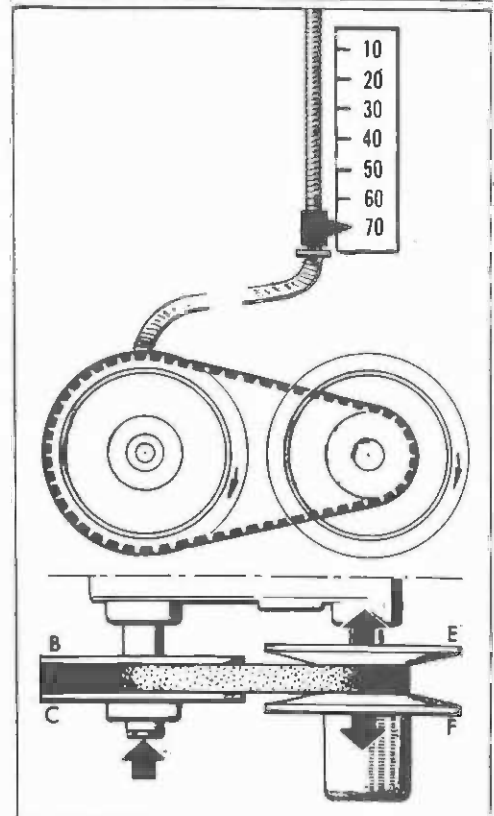
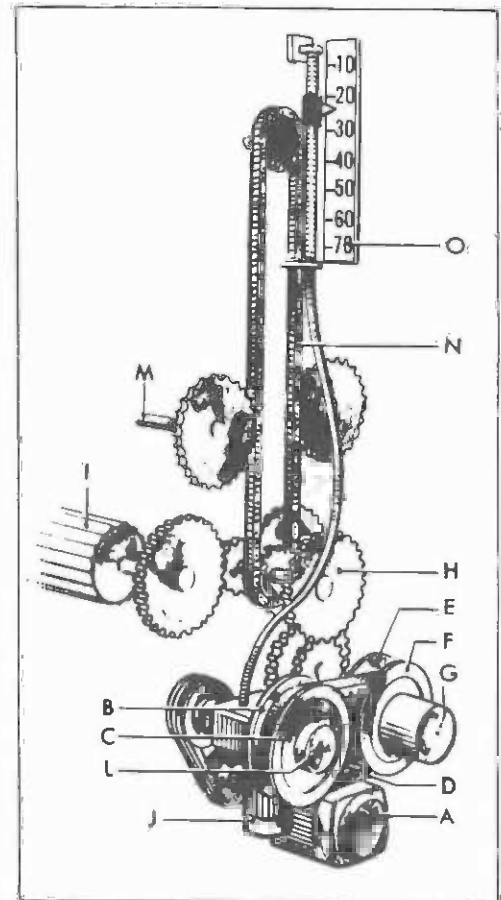
The feed speed is varied by changing the position of the outside disc C in relation to the inside disc on the shaft.

Through this the belt will run on a bigger or smaller diameter between the two tapered discs E and F. Since the length of the belt and the distance between the axles G and L are unchanged, the tapered discs E and F on the driven axle will automatically adjust themselves to new conditions by the spring load that acts on the inside disc.

If the discs B and C are pressed closer together the belt will run on a bigger diameter between discs E and F on the driven shaft. Through this the driven shaft G will rotate faster than the shaft L.

Since it is the driven shaft G that is connected with the feed rolls

the rotation speed of the feed rolls will increase when the outside disc C is moved closer to the inside disc B.



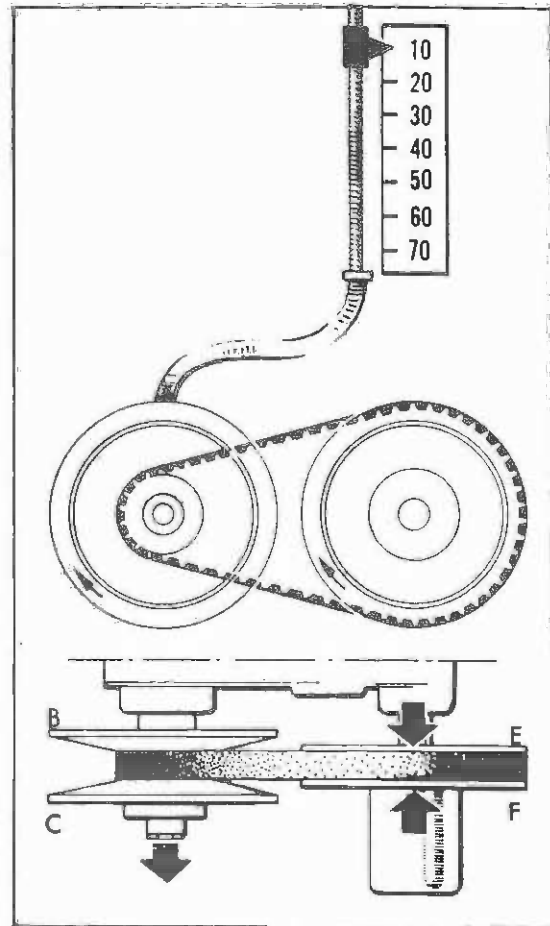
On the other hand, the belt will run on a smaller diameter if the discs B and C are moved away from each other. At the same time, the belt is running on a bigger diameter between the tapered discs E and F on the driven axle.

Since it is the driven axle G that is connected with the feed rolls

the rotation speed of the feed rolls will decrease when the discs B and C on the axle shaft are moved away from each other.

In this way the gear ratio between the engine of the feed mechanism and the gear box can be varied infinitely in the ratio of 1:7. This means that the feeding can be infinitely varied from 10 to 70 mm/stroke.

The adjustment of the feed speed is read on an indicating device placed above the feed mechanism.



## 9. Appendix

### Bearings

The bearings dealt with in this manual, viz:

- white metal bearings
- needle bearings, and
- spherical roller bearings

are all radial bearings, which means that they mainly take up stress working in the radial direction.

White metal bearings consist of:

- a bearing housing, made of one piece;
- a lining in the shape of a bush or two-cup halves;
- a lubrication device.

The bearing cups are made of bronze, which can stand a high bearing pressure and a high number of revolutions.

They are mounted in the bearing housing with a round fit. Taps and collars prevent them from turning with the axle

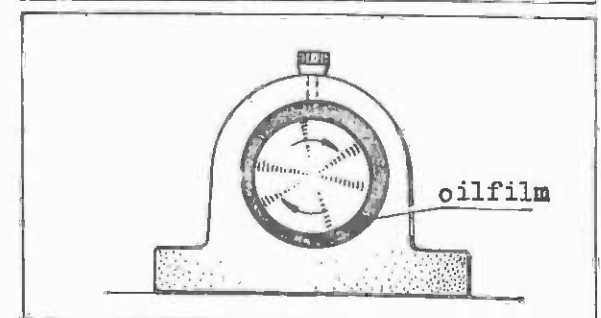
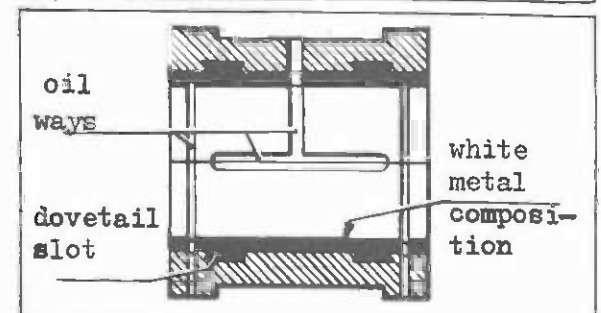
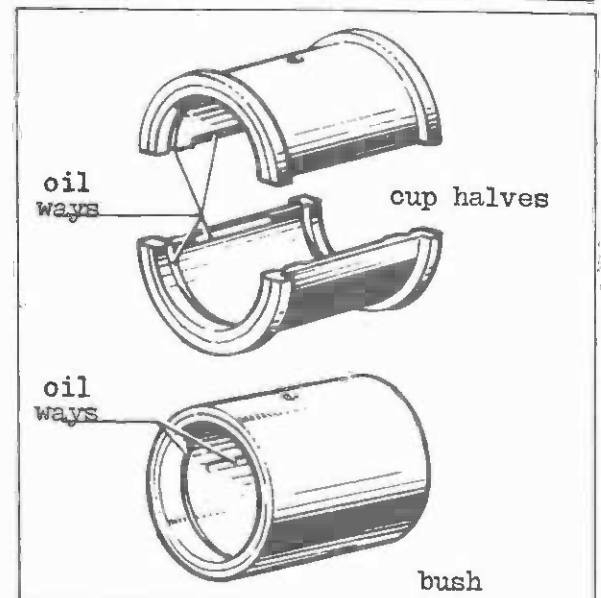
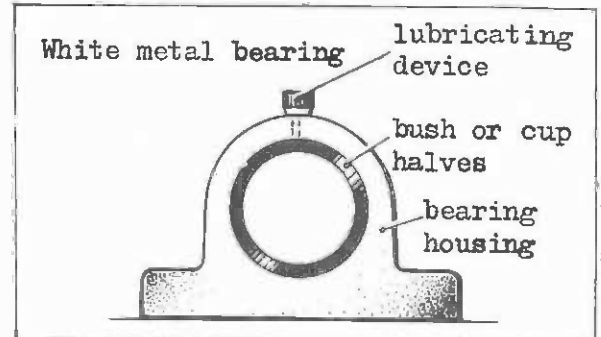
The lining cast into these bearing cups is made of tin, antimony, copper and lead. This composition metal is called white metal or babbit.

To fix the white metal properly on the bearing cup face a few shallow holes are drilled into the surface, alternatively, it is provided with a few dovetail slots.

Because white metal has a low melting point, any overheating means that only the metal lining is damaged and not the bearing. It is easy to cast a new metal lining.

The movement in a slide bearing is made while the shaft journal is sliding against the bearing cups. Friction then occurs but it is very much reduced by an oil film created between the two bearing surfaces by means of special oil-ways.

When the shaft starts to rotate in that bearing it brings with it an oil layer that is pressed in under the shaft like a wedge, which lifts the shaft from the lower bearing cup. The faster the axle rotates, the thicker the oil wedge. Therefore, it is important that bearing "play" is big enough to make it possible for the oil wedge to grow and lift the shaft.



Roller bearings is the comprehensive term for cylinder bearings and needle bearings.

These types of bearings consist of:

- outer ring
- inner ring
- rollers, and
- holders for the rollers, which keep them apart and in position.

The bearing pressure is absorbed by the rollers, positioned between the two rings. Roller bearings offer less rolling resistance than ordinary bearings and resistance is nearly independent of velocity.

These two types of bearings also require less lubrication and, at the same time, the risk of overheating is smaller. Contrary to white metal bearings, these bearings are lubricated with grease.

The lower connecting rod bearing and the bearings of the crankshaft pins consist of spherical double row roller bearings. The two rows of rollers have a common spherical roll conveyor in the outer ring, which makes them self-controlling and able to adjust themselves to the taper of the shaft.

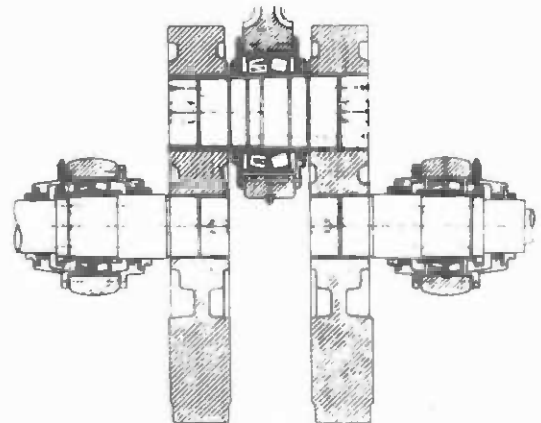
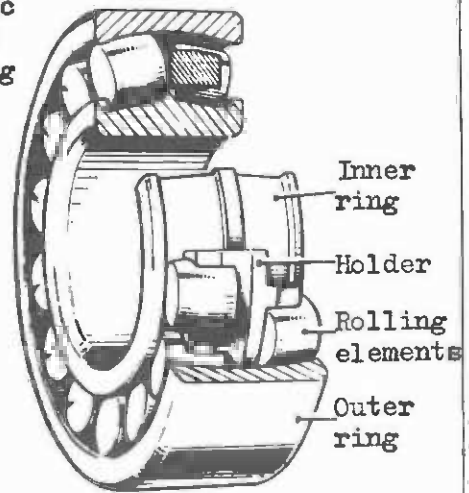
The upper connecting rod bearing consists of a type of needle bearing called gudgeon pin bearing.

The reason for having a needle bearing here is that this type of bearing is suitable when the movements are to and fro, which is the case for the upper end of the connecting rod. Needle bearings also have good resistance against shock loads.

Since the friction in a needle bearing is three times bigger than in a roller bearing, it is not suitable for the lower connecting rod bearing, where speed and friction are high.

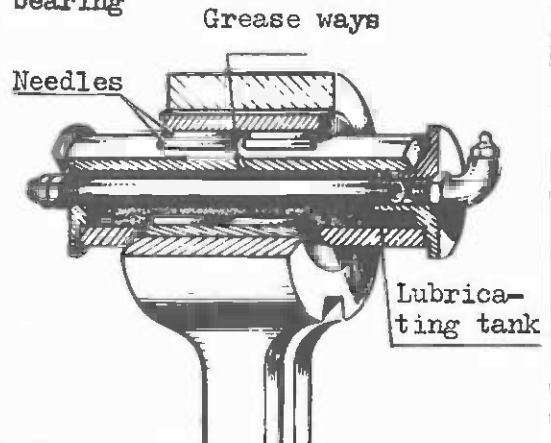
Instead of rollers the needle bearing has two rows of needles, each needle being 70 mm long and 6 mm in diameter. The gudgeon pin is holed and serves as a tank for the lubricant.

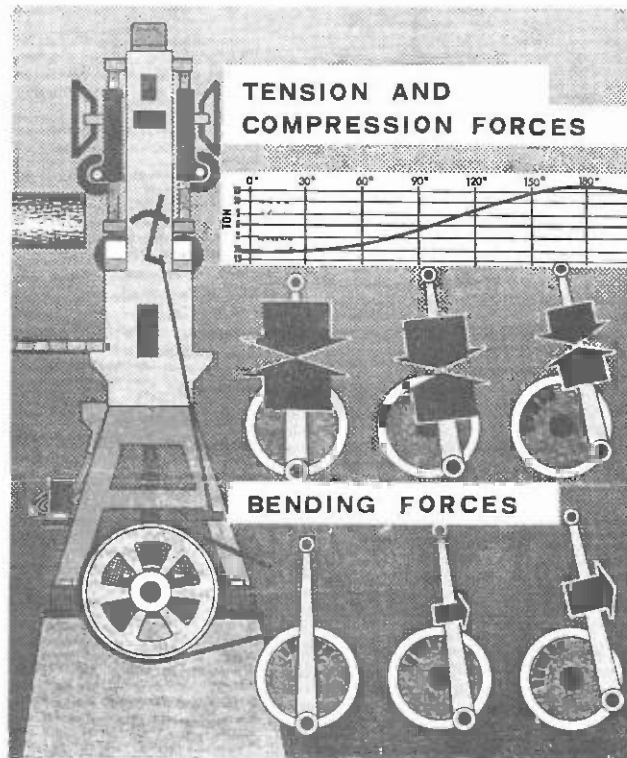
Spheric roller bearing



Lower connecting rod bearing and bearings of the crankshaft pins

Needle bearing





## PART II - FORCES AND MOVEMENTS

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## 1. Bodies, Motions and Forces

In mechanics a car or the sash of a gang saw is called a body.

- The weight of a body or, more correctly, its mass, is given in kilograms.
- A moving body has a certain velocity which is defined in metres per second (or minute) or in kilometres per hour.

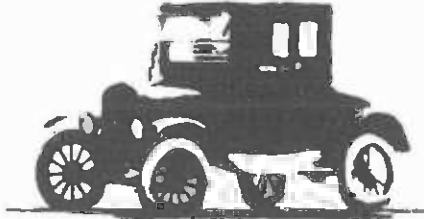
A change in velocity is called:

- Acceleration, if the velocity is increased, and
- Retardation, if the velocity is reduced.

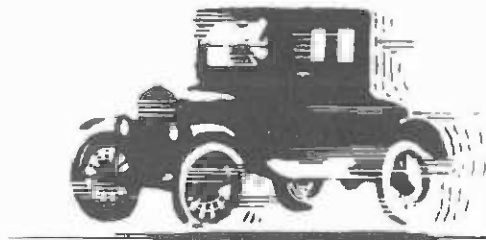
The acceleration or retardation is the change in velocity (e.g. m/sec) over a certain unit of time (each second). It is, therefore, measured in a unit that is metres per second, every second; so it consists of:

- a length unit, and
- a squared time unit. There is a unit for acceleration called "metres per second squared", written as  $\text{m/sec}^2$  or  $\text{m/s}^2$ .

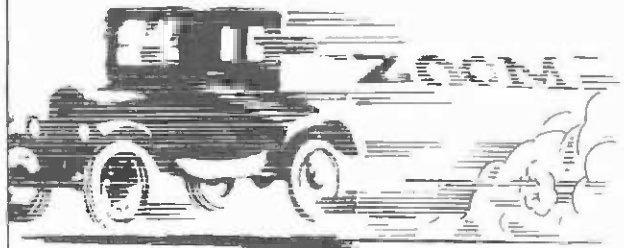
Mass



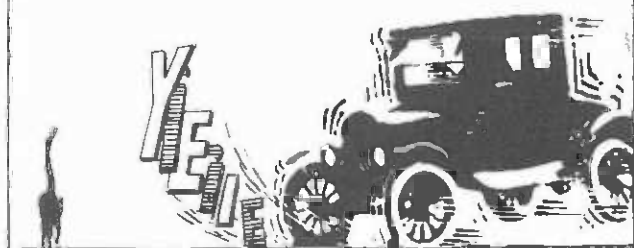
Velocity



Acceleration



Retardation



To make a body (a mass) accelerate or retard (accelerate negatively) a force is needed. The relationship between force, mass and acceleration is:

$$\text{FORCE} = \text{MASS} \times \text{ACCELERATION}$$

which is written:  $F = m \times a$

where:  $F$  = the force affecting the body or the mass;

$m$  = the mass of the body;

$a$  = the acceleration.

The unit for mass of a body is kilogram (kg).

The unit of force is the Newton.

1 N = the force that gives a mass of 1 kg an acceleration of  $1 \text{ m/sec}^2$ .

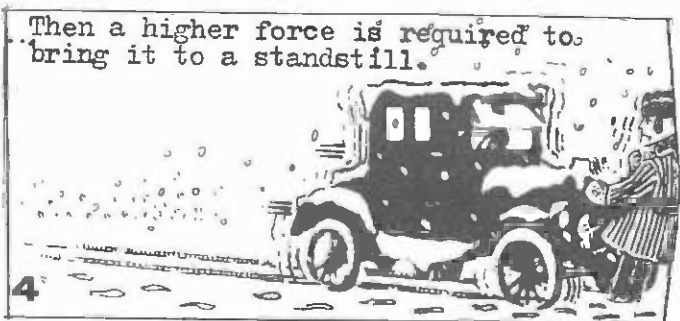
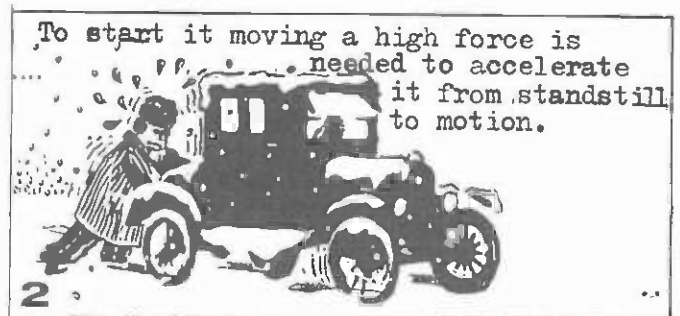
The unit for force used to be the poundal, which was the force required to give an 1lb mass an acceleration of  $1 \text{ foot/sec}^2$ . This text uses the metric Newton.

Any force that acts on a body always creates a resisting force inside the body.

A body is reluctant to change its state, whether it is at rest or in motion. If it is moving, it is also reluctant to change its direction.

For instance, if the movement of a car or a gang saw sash is to be changed in speed or direction, these bodies will try to maintain their existing velocity or direction. These resisting and internal forces are called inertia forces. They are given in Newtons.

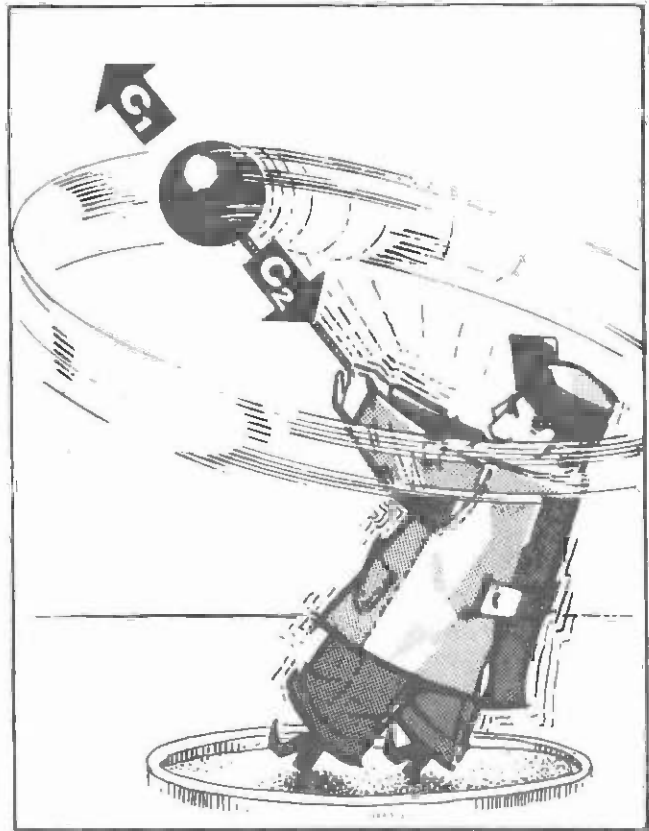
If one tries to change the velocity or the direction of, for instance, a car or a sash, such bodies will resist with forces called inertia forces, that are measured in Newtons.



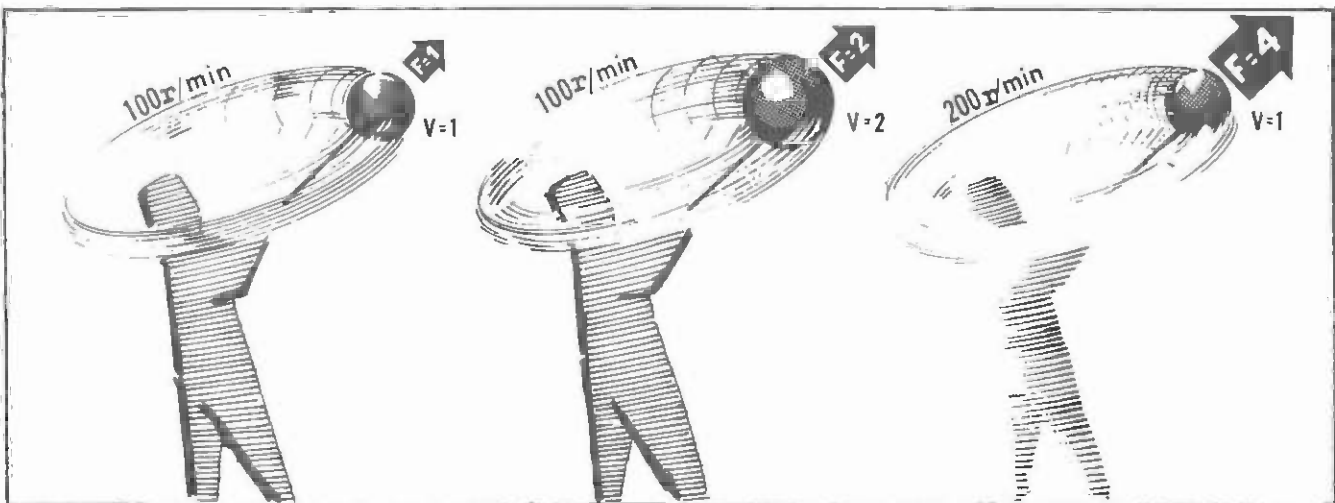
What we have dealt with so far are bodies with inertia forces in linear movement: i.e. trying to move straight ahead with unchanged velocity.

If a body, for instance, a weight attached to a rope, is swung in a circle it will, due to inertia forces, try to move straight ahead, i.e. to move away from the centre. This type of inertia force is called centrifugal force.

The magnitude of the centrifugal force depends on the mass of the moving body, the radius of the circle and the velocity of the body. If the velocity is unchanged, but its weight or the radius of the circle is made two, three or four times bigger, the centrifugal force will also become two, three or four times bigger. On the other hand, if the velocity (for instance the number of revolutions per minute) is doubled, trebled, etc., the centrifugal force will increase with the square of the velocity, i.e. it will become  $2 \times 2$ ,  $3 \times 3$  or  $4 \times 4$  times greater.



This means in practice that, for frame saws, it is the rotational velocity, i.e. the number of revolutions, that has the greatest influence on the magnitude of the centrifugal force. If the number of revolutions is doubled, the centrifugal force is increased four times.



A car has a weight of 1000 kg. We want to accelerate the car from standstill to a velocity of 72 km/hour in 10 seconds. What magnitude of mass force is required for this acceleration (presuming that the acceleration is uniform)?

The mass = 1000 kg

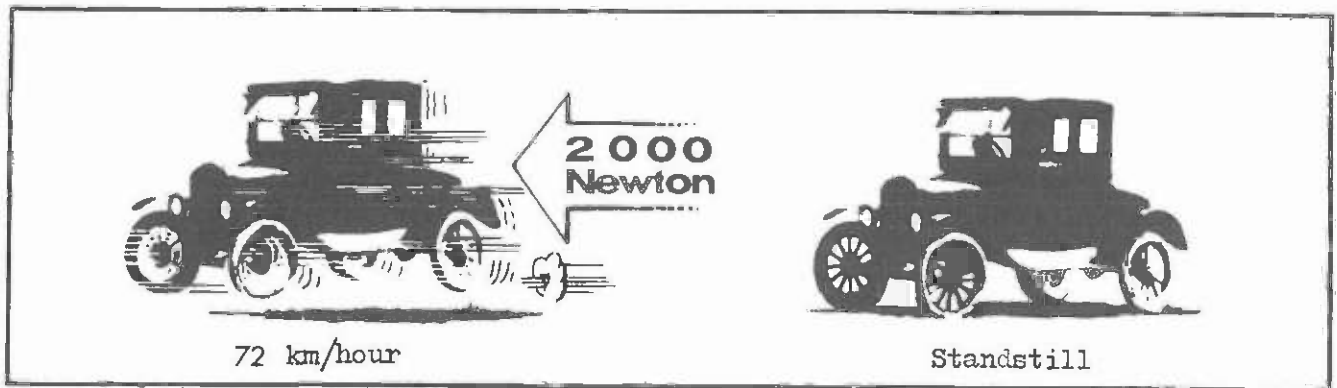
The velocity = 72 km/h = 20 m/sec.

The acceleration is:

$$\frac{\text{Velocity}}{\text{Time}} = \frac{20}{10} = 2 \text{ m/sec}^2$$

The required force is then:  $F = m \times a$

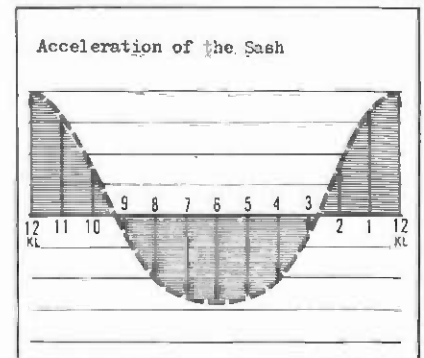
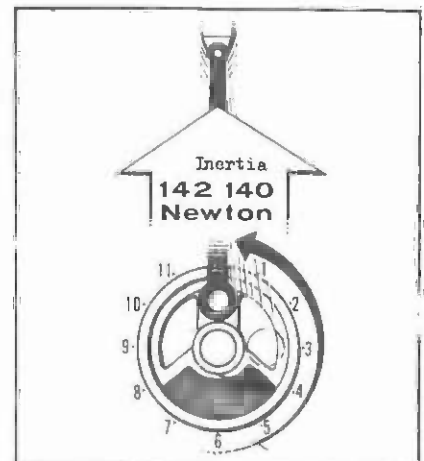
$$F = 1\,000 \text{ (mass)} \times 2 \text{ (acceleration)} = 2\,000 \text{ Newton.}$$



For comparison we can find out what force is required to accelerate a moving gangsaw sash weighing 345 kg from bottom dead centre where it is stationary (at 6 o'clock) to maximum velocity, which at 330 revolutions/min is equal to 10.3 m/sec and takes place at the 3 o'clock position.

The acceleration of a sash is not uniform as the acceleration of the car in the above example. This makes our calculations somewhat more complicated. Without going into details of how the calculations are made, the maximum acceleration at the upper turning point (at 12 o'clock) is 412 m/sec<sup>2</sup> (see figure alongside).

The required force is then: 345 (the mass) x 412 (the acceleration) = 142 140 Newton. This is the force that is transmitted by the upper crankshaft bearing. The magnitude of this force can be compared with the lesser force required in the car example.



## 2. Stress and Strain

All bodies consist of very small particles called molecules. These are attached to each other by certain internal forces in the material itself, so-called cohesive forces.

When a mechanical part is influenced by outside forces it undergoes a change of form or shape, usually so small that it cannot be seen or measured. These outside forces strive to change the location of the molecules (and so the shape). At the same time the cohesive forces inside the material resist to prevent these changes of location.

The external force is called a stress: it is the force on a body exerted over a given area. The internal force resisting the change of shape is called strain, and is measured in the same way, a force over a given area.

If the external forces are bigger than the internal ones, a change of form of the material takes place.

If the body recovers its original form completely when the stress is removed, the change of form is called elastic.

Depending on the material of the body and the magnitude of the force, a permanent deformation sometimes occurs. This change of form is then said to be plastic.

If the external forces are even greater, the change of form can go so far that the material will break. This is called fracture.

BOTH STRESS AND STRAIN ARE FORCES THAT ACT ON A GIVEN AREA OF THE MATERIAL, i.e. THE RELATIONSHIP  $\frac{F}{A}$ , WHERE F IS THE FORCE THAT ACTS ON THE CROSS SECTION A.

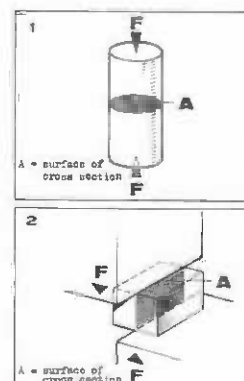
They are measured in  $\text{Newton/mm}^2$  or  $\text{Newton/cm}^2$ .

Note: Strain is a force induced as a reaction to stress: it is independent of the material under stress. This is distinct from structural strength, which is: THE ABILITY OF A BODY TO RESIST BREAKAGE OR DEFORMATION (CHANGE OF FORM) CAUSED BY EXTERNAL FORCES.

The structural strength properties of a material are usually given as limits that result in permanent changes of form or breakage. A given body has different structural strength for different kinds of stress, viz. tension, compression, bending, etc.

There are three main groups of stresses:

1. Primary stress, i.e. compression and tension.
2. Secondary stress, i.e. shear, where the stress is tangential to the stress (see figure alongside). Twisting stress - torsion is an example of shear.
3. Combined stresses occur when more than one stress acts at the same time. This group incorporates bending.



Primary stress: Compression

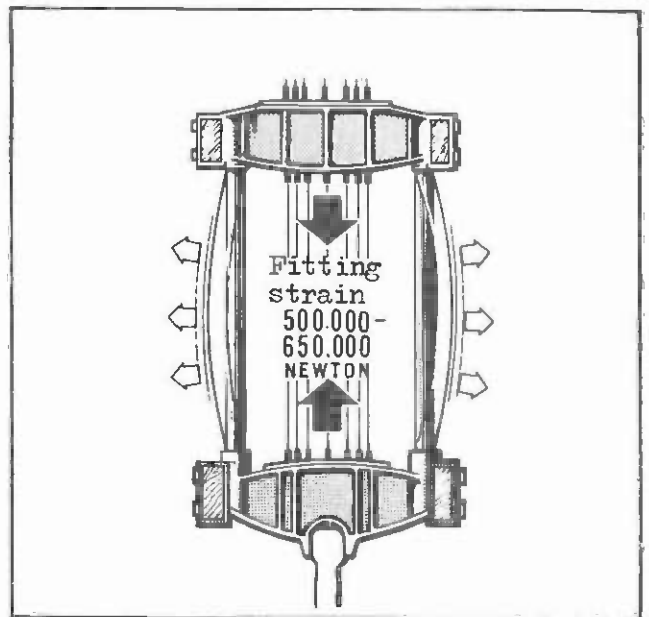
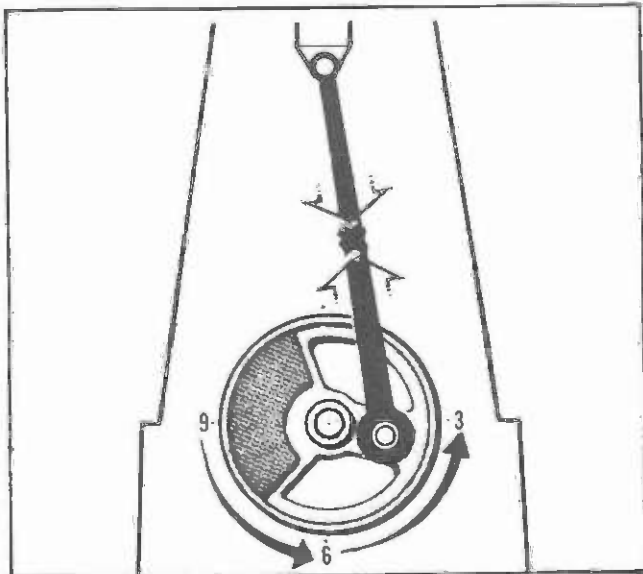
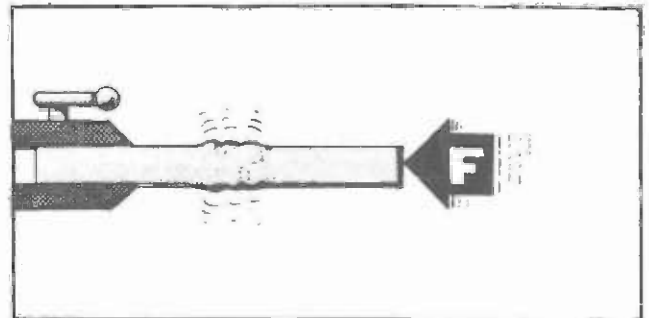
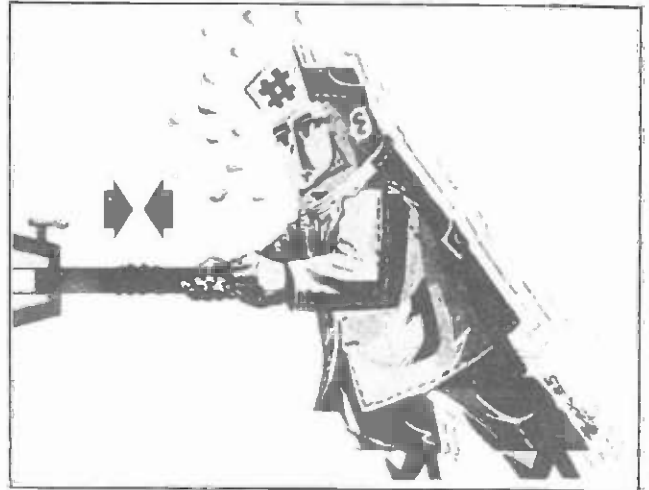
The figure to the right shows a part under compression.

A compression in any material is calculated by the following formula:

$$\text{Compression} = \frac{\text{The compressive force}}{\text{Sectional area of rod}}$$

Compression occurs in a saw frame in the following places:

- In the columns of the sash due to the tension from the inserted saw-blades.
- In the connecting rod when it reduces the downward movement of the sash, roughly between 9 and 6 o'clock, where compression is greatest. (See figure and appendix).
- In the connecting rod when it accelerates the sash upwards, roughly between 6 and 3 o'clock.



Primary stress: Tension

The figure to the right shows a part under tension.

The tension in any material is calculated by the following formula:

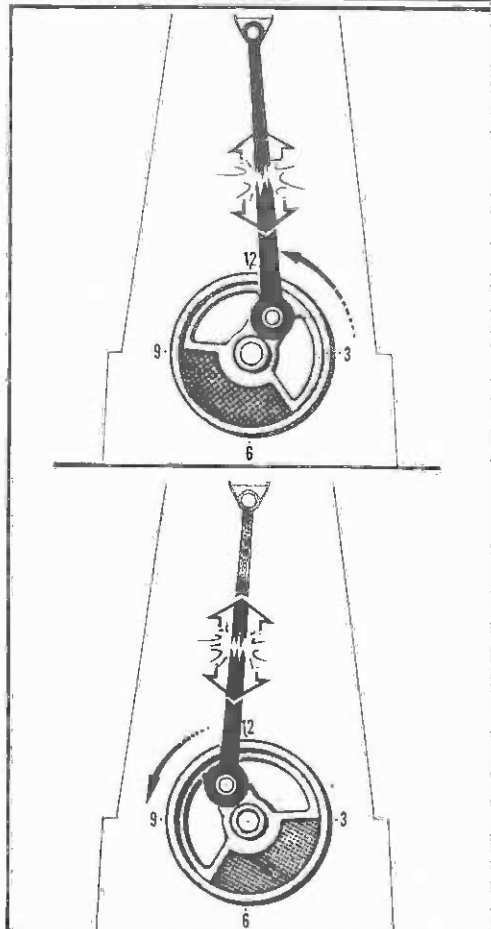
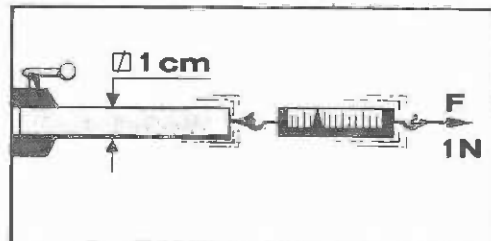
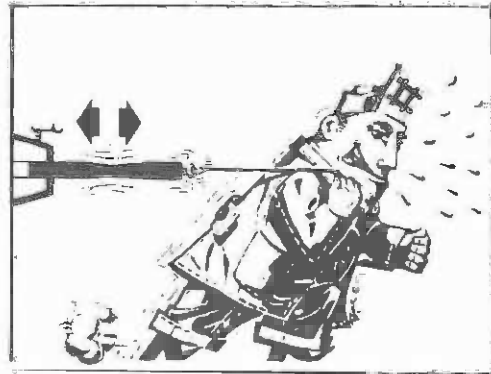
$$\text{Tension} = \frac{\text{The stretching force}}{\text{Sectional area of the rod}}$$

Applied to the above example:

$$T = \frac{1 \text{ Newton}}{1 \text{ cm}^2} = 1 \text{ N/cm}^2$$

For a saw frame the biggest tension stress is in the connecting rod:

- when the velocity of the sash going up is being reduced (retarded), which is roughly between 3 and 12 o'clock as it heads for the upper dead centre, where the tension in the connecting rod is greatest. (See figure and appendix.)
- when the connecting rod pulls the sash downwards, roughly between 12 and 9 o'clock.



Secondary stress: Shear

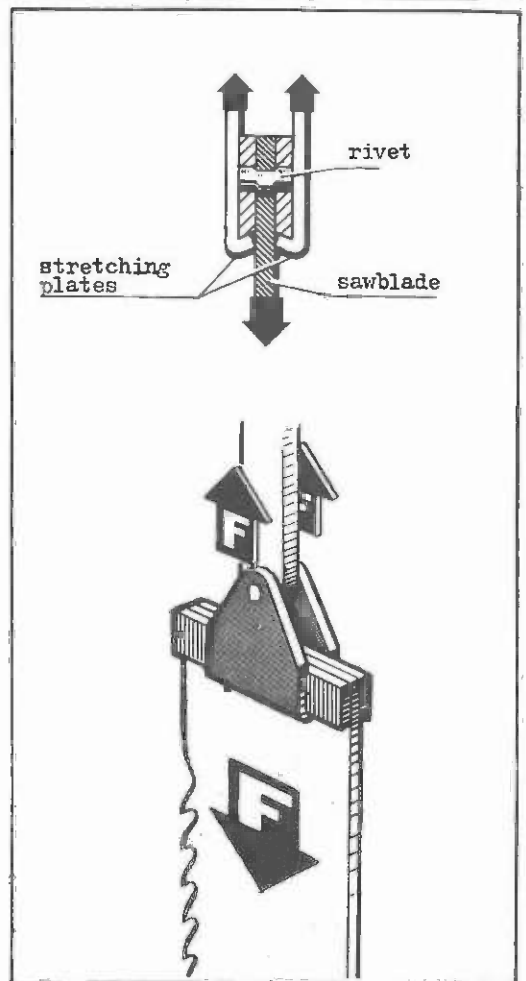
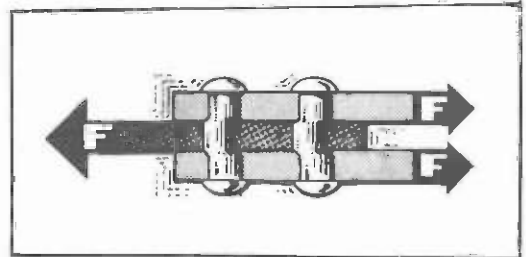
The figure to the right shows a part under shear stress.

These stresses arise when the acting forces occur in the planes of the surfaces concerned, so that two adjoining surfaces are pressed past each other, as when a pair of scissors are cutting.

This is often the case in riveted joints. In frame saws shear stress occurs in the rivets at the base of the sawblades.

Shear stress is calculated by the formula below:

$$\text{Shear} = \frac{\text{The shear force}}{\text{Area of the shearing material}}$$





### Secondary stress: Torsion

A special form of shear is twisting usually called torsion.

This stress occurs when, for instance, a shaft is subjected to a turning movement, for example, when a screw or bolt is tightened.

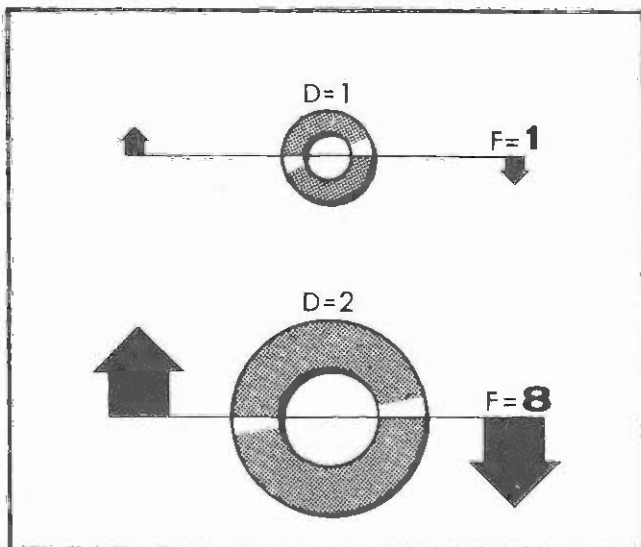
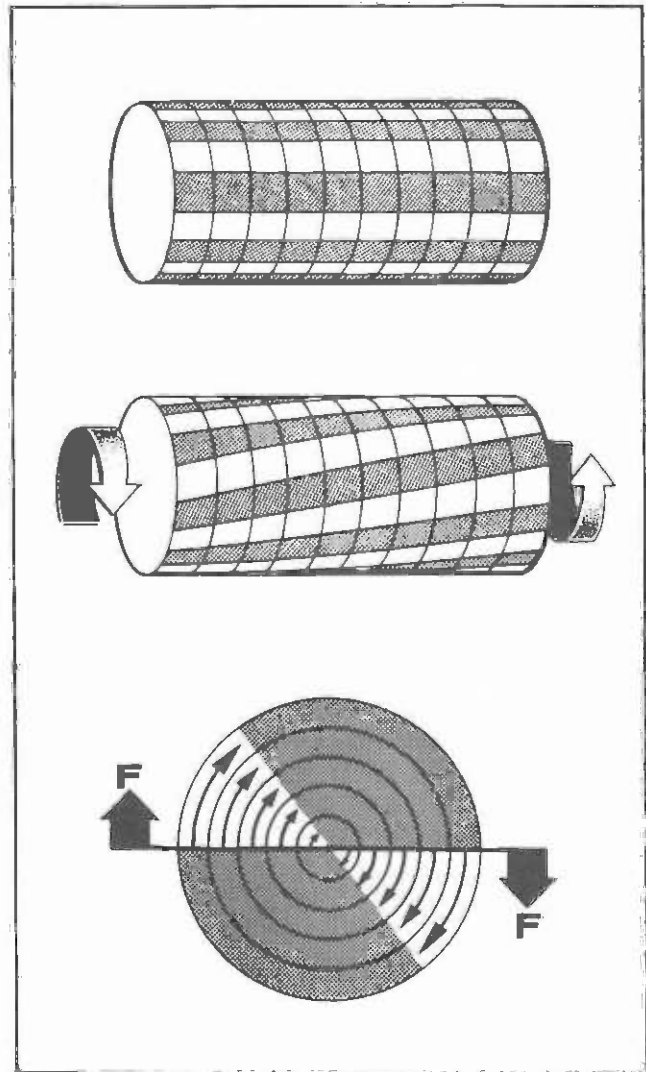
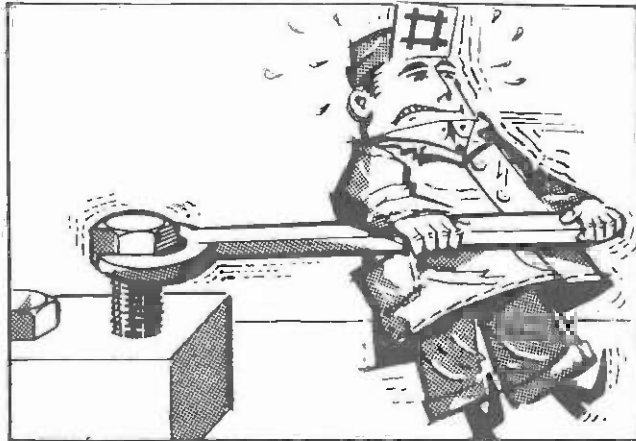
Imagine a shaft consisting of an infinite number of thin discs.

If such a shaft is turned, all these discs will turn slightly, which results in shear stress between the discs.

This type of shear is called torsion. The figure shows how torsion increases from the centre of shaft towards the periphery.

Because of this, shafts can be made hollow without significantly reducing torsional strength, yet markedly reducing weight.

Torsional strength is proportional to the cube of the diameter of the shaft. If we double the diameter, the torsional strength will increase eight times, which means that we can increase the twisting force eight times without increasing the stress on the shaft.



Combined stress: Bending

Bending stresses occur if, for instance, a bar is under pressure perpendicular to its centre line. Bending stresses are composed of both tension and compression.

- At the centre line the stress is zero.
- Above the centre line there is compression.
- Below the centre line there is tension.

To calculate the magnitude of the bending stress is complicated and it is not pursued in this manual.

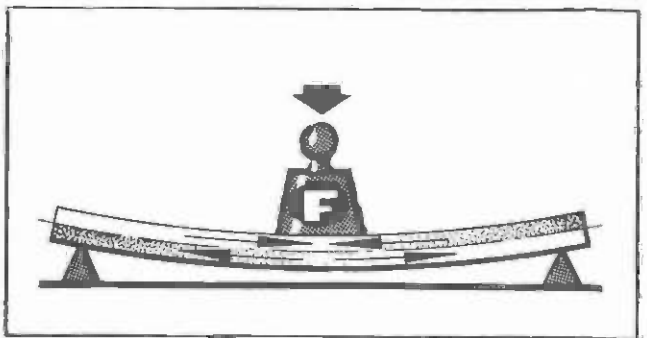
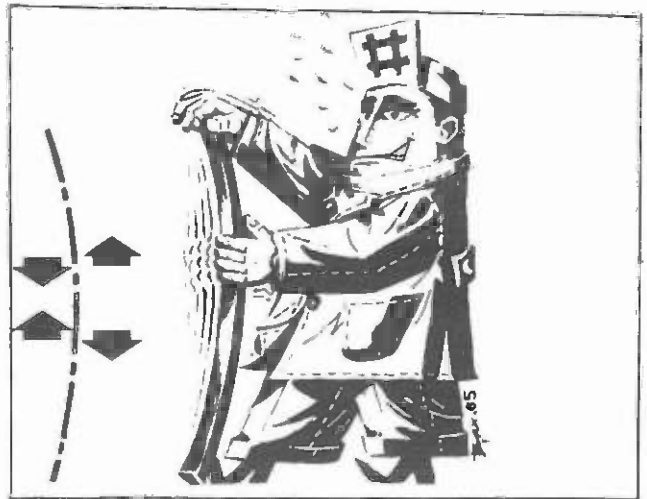
A practical example, however, can assist our understanding.

It is much easier to bend a ruler as shown in version A in the figure, than as shown in version B.

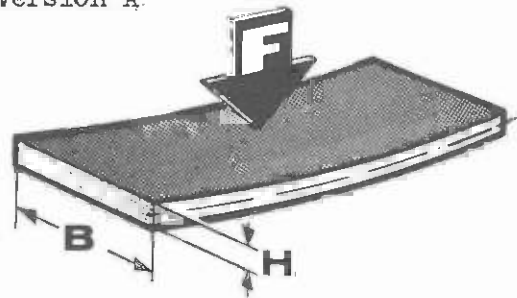
We can see that the measure H (taken in the same direction as the bending force) is more important to bending resistance than the measure B.

These two factors, i.e.:

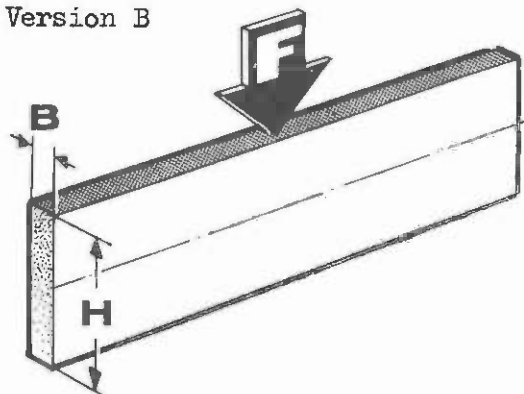
- the relationship of stress around the axle beam centre;
  - the influence of the measure H on the resistance to bending,
- are behind the design of the I-section beam, or I-girder.



Version A.



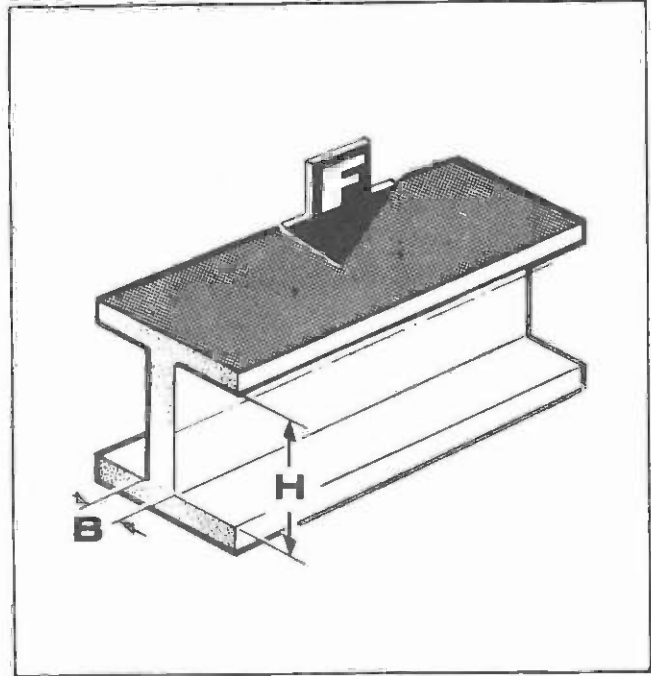
Version B.



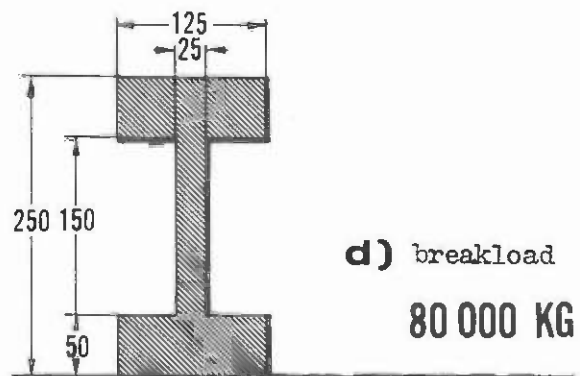
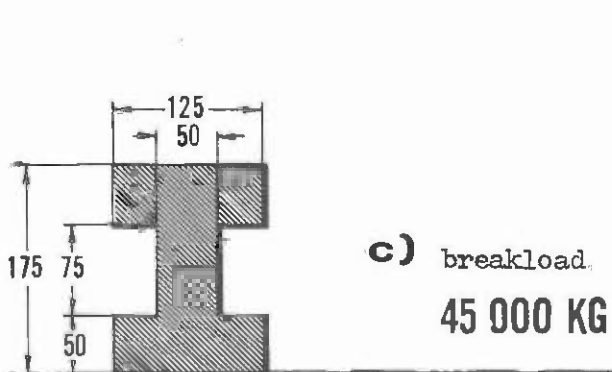
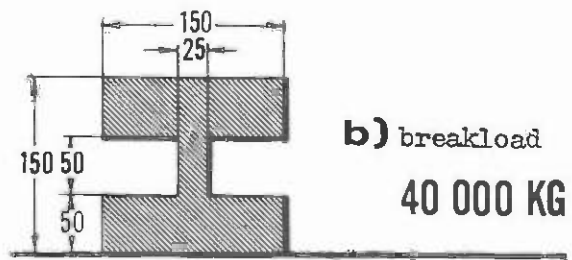
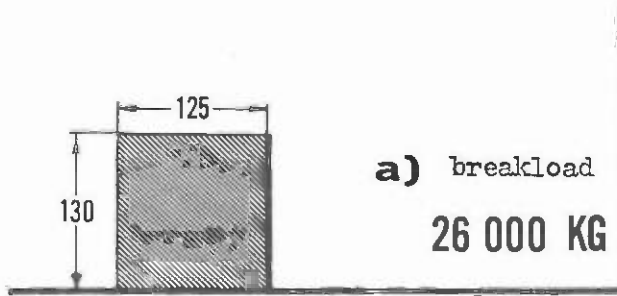
When constructing the I-girder the aim is to make the waist-line:

- narrow (measure B) to reduce the amount of material in those sections where it is not needed (the stress is minimal in the centre line), and
- high (measure H) to concentrate the mass of material as far away as possible from the beam centre, thereby locating as much material as possible to sections where the magnitude of tension and compression is strongest.

A given cross sectional area (see figure) of differing distribution, illustrates in this series of drawings how the structural strength of girders can vary. We have obtained a bending strength in d) more than three times stronger than the original one in a).



Weight KG/CM | in all alternatives  
**1,275**



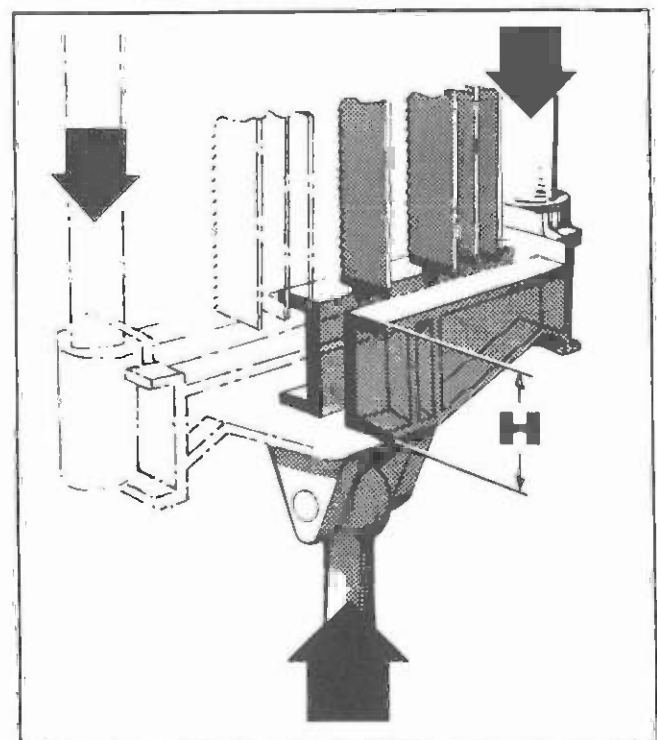
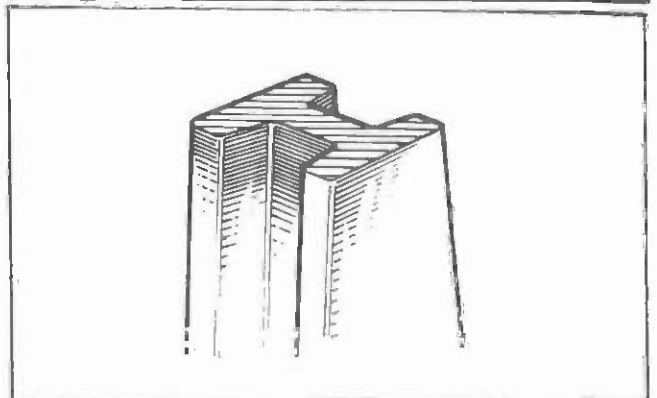
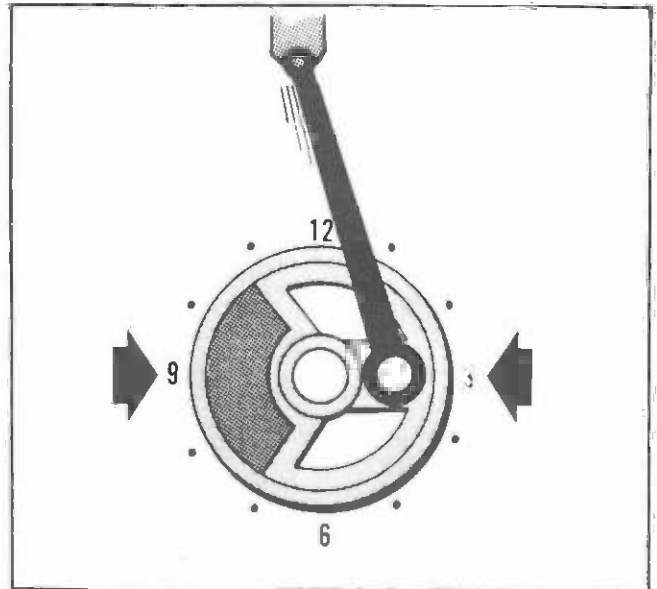
In a saw frame bending stresses occur in the connecting rod due to inertia that originates when the lower part of the connecting rod is forced to follow the rotating movements of the crank shaft journal. These stresses are strongest at the upward stroke at 3 o'clock and at the downward stroke at 9 o'clock. (See figure and appendix.)

The connecting rod must therefore be:

- as light as possible to reduce inertia.
- as strong as possible to resist bending stress.

For these reasons connecting rods are I-shaped in the cross-beams due to stress from sawblade tension (about 70-90 000 N/blade) and also from the inertia of the sash and the connecting rod (about 150-200 000 N).

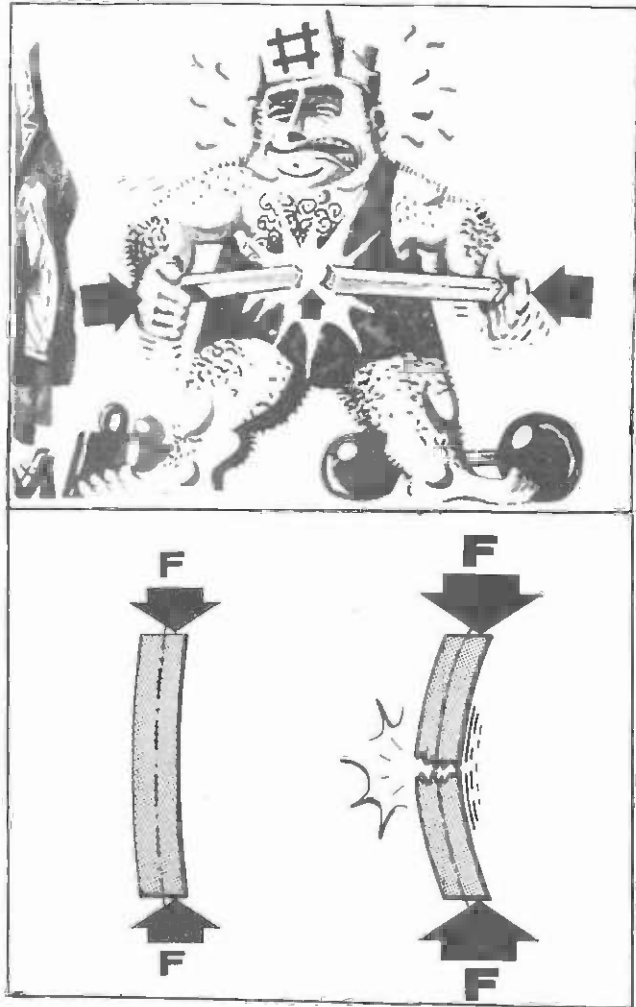
For the same reasons, applied to the construction of I-girders, cross-beams are made deep (measure H) in order to obtain the greatest bending rigidity.



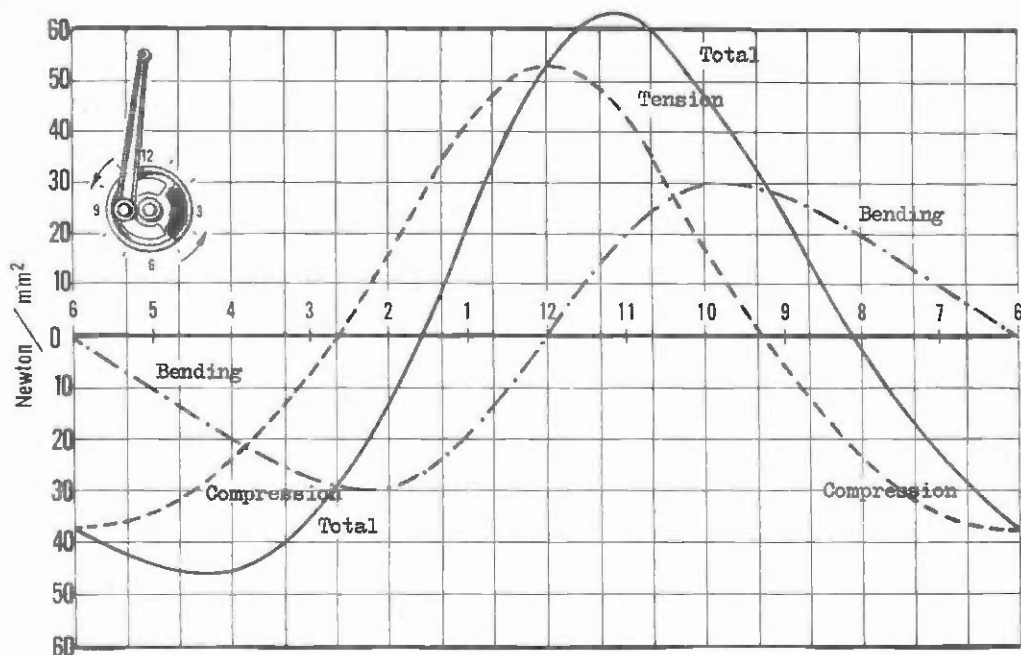
### Combined stress: Compression and Bending

Another example of multiple stresses is that which exposes a body to both compression and bending strains.

If a bar (for instance, a connecting rod) is long in relation to its cross-section and comes under influence of a compressional strain, the direction of which is not completely in line with the centre line of the bar, the bar will bow. If the stress is high enough, the bar might finally break.



### Strains in a Connecting Rod due to Tension, Compression and Bending

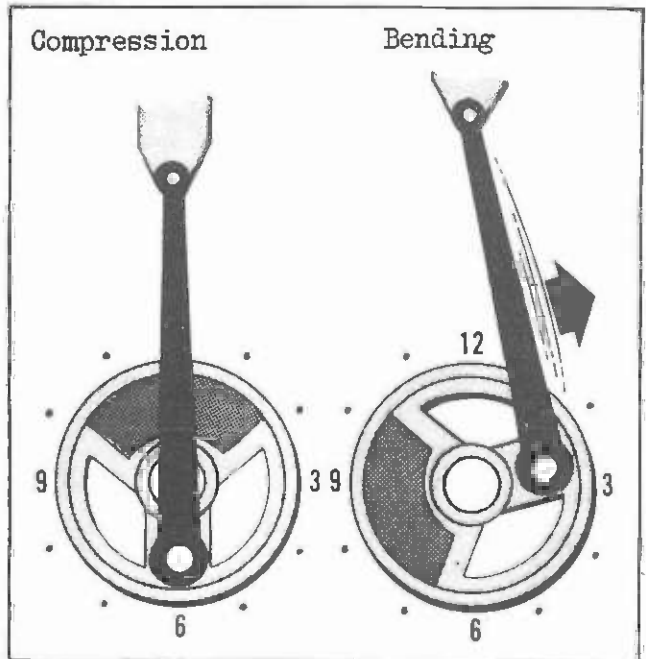
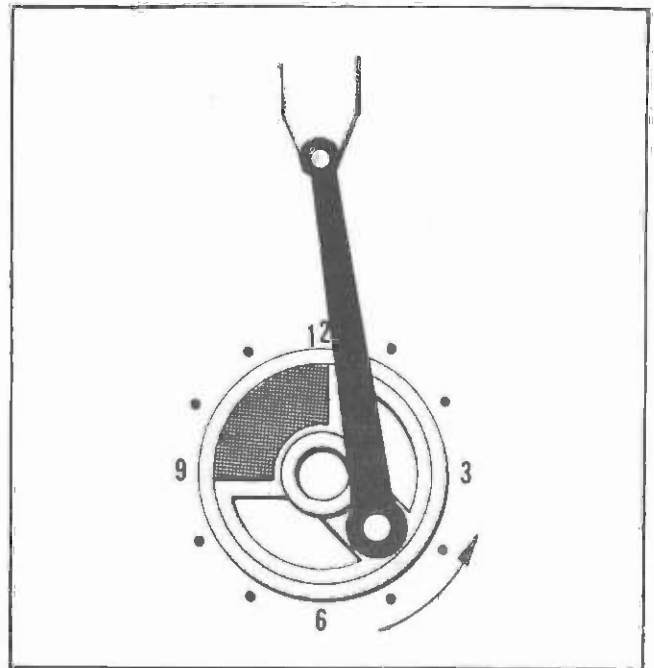


In a saw frame the greatest risk of this stress is in the connecting rod.

The risk of damage occurring is increased if, at the same time, bending forces are present in the connecting rod. As previously explained (see also appendix) in certain positions the connecting rod is subject to bending stress.

As can be seen from the figure, the maximum compression occurs at B.D.C. (6 o'clock), and decreases to zero at 3 o'clock. Maximum bending occurs between 3 o'clock and 2 o'clock.

The greatest risk of the combination is between 5 o'clock and 4 o'clock on the upstroke. (Figure and appendix.)



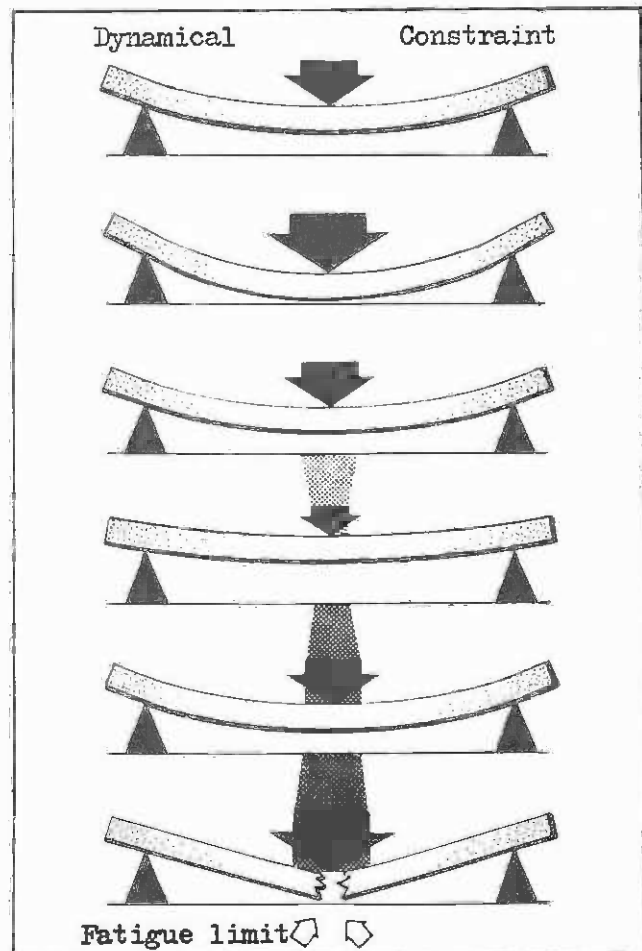
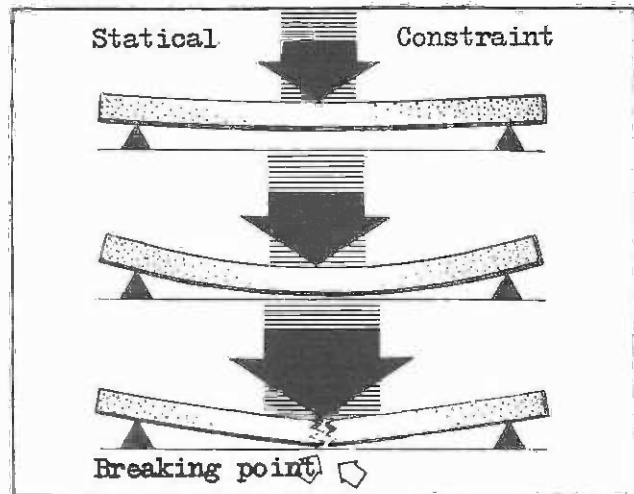
### 3. Static and Dynamic Stress

The force creating stress on a body can be of two different kinds, static or dynamic.

A static force maintains the same magnitude independent of time. If the force is increased, breakage will eventually occur. The actual force at which the material will fracture is called the breaking force and it occurs at breaking point.

A dynamic force is characterised by the fact that the magnitude of the force varies (pulsates) between two extremes, which means that the strains within the body also vary (pulsate) in the same way.

If a mechanical part comes under the continuous influence of a force that pulsates repeatedly, fracture might occur in spite of the fact that the magnitude of the force may be considerably below the static breaking point of the particular mechanical part. The pulsating stress finally strains the mechanical part so that it reaches the fatigue limit of that material.



The fatigue limit of a material is the maximum static and dynamic stress that can be put on a material without an unlimited number of pulsating stresses causing breakage.

The fatigue limit of any material is always well below its breaking point.

For materials frequently used in mechanics the magnitude of permitted stresses are known and tabulated.

One of the best examples to be found is the alternating tension/compression in the connecting rod and the lower cross-beam that is alternatively pushed and pulled.

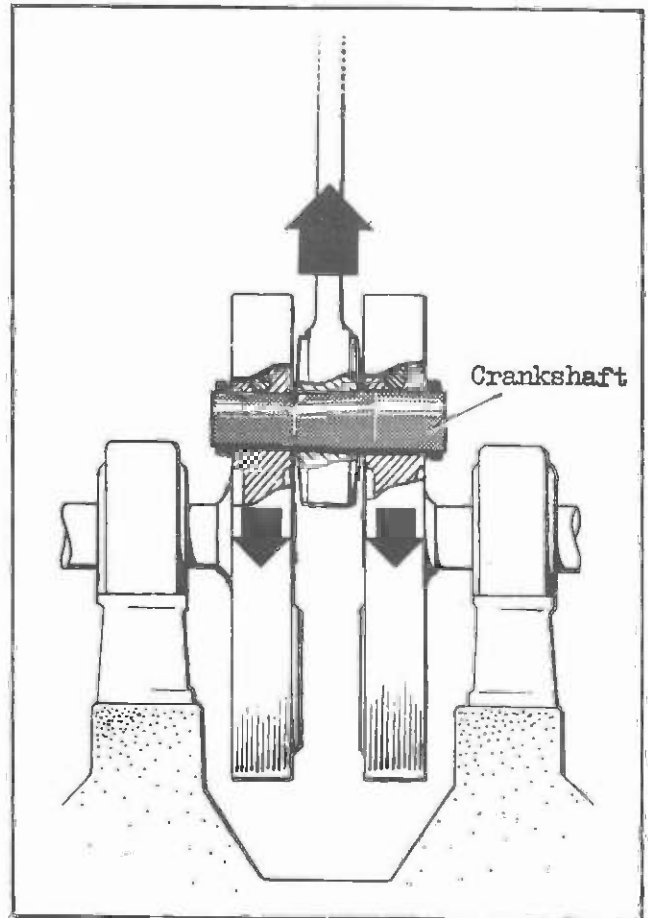
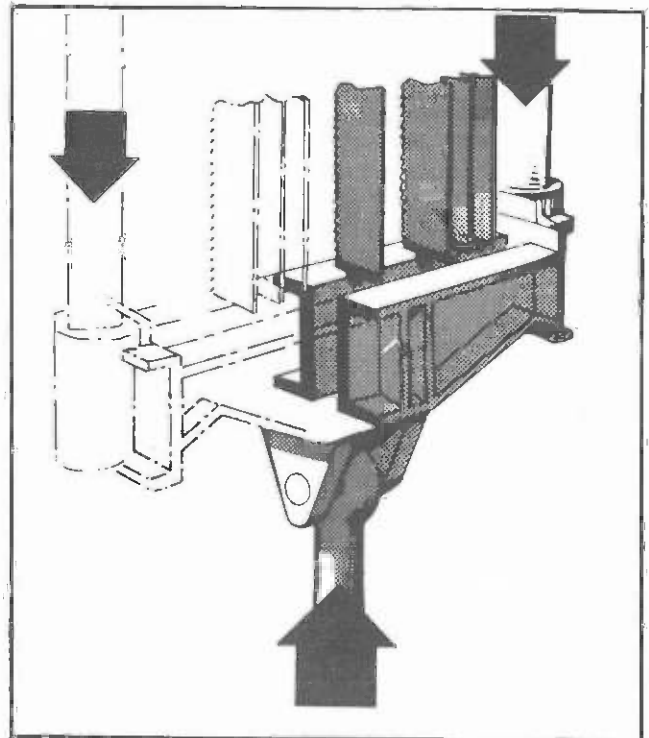
The design of mechanical components under dynamic stress is always much heavier than corresponding parts under static stress only.

This is the reason why the lower cross beam is so heavily dimensioned.

Another example of a component subject to fatigue is the crankshaft, which, in addition to torsion, is also under bending stress occurring each upward and downward movement of the sash and the connecting rod.

Referring back to bending stress, the upper half of the crankshaft is in tension and the lower half in compression. (See figure). But, as the crankshaft rotates, the part that was in tension will develop compression half a turn later.

For any given point of the crankshaft the stresses are constantly alternating from tension to compression: a typical example of a component subject to fatigue.





#### 4. Factors that influence Structural Strength

There are many different factors that influence the structural strength of a component, particularly against fatigue.

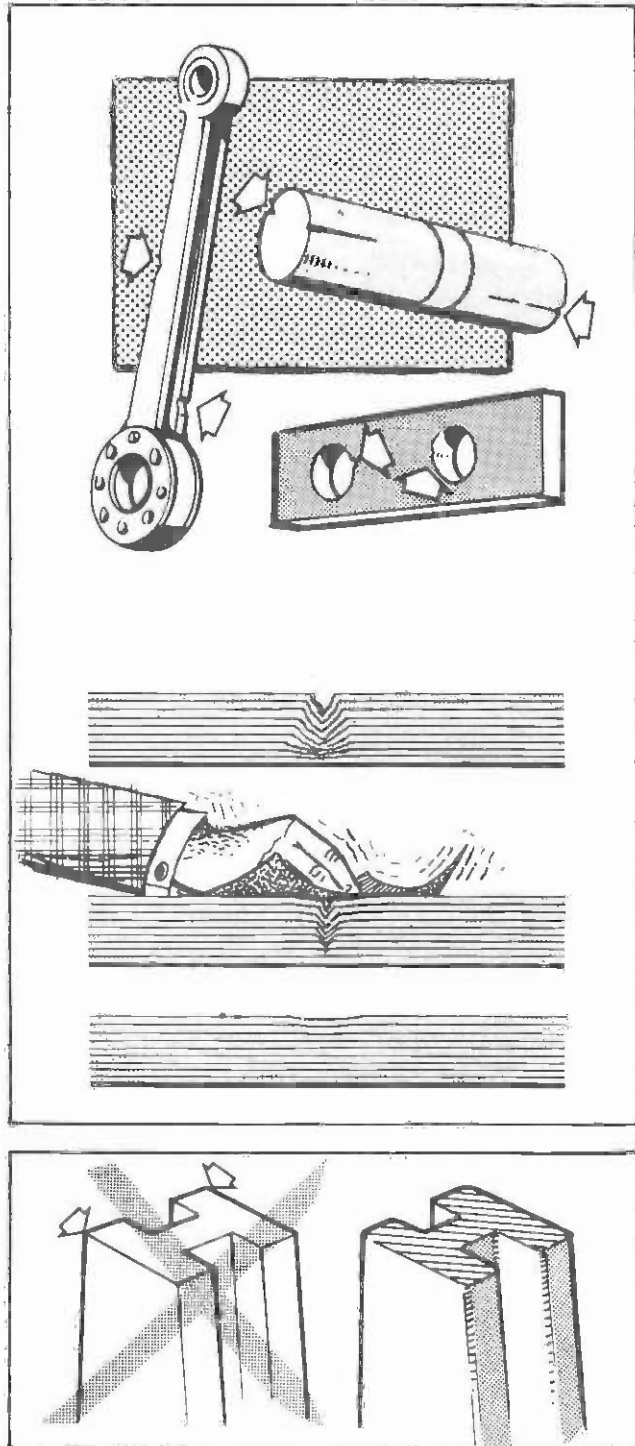
Some of the most important are:

##### Concentrated strains

Sharp corners, holes not properly drilled, different types of nicks, hack and uneven surfaces result in strains locally concentrated.

These cause abrupt restrictions in the transmission of force through the component. This leads to stresses greater than those only due to the reduced sectional area of the nick.

The surface of machine parts under dynamic strain must therefore have all corners and edgers well rounder, i.e. with large radius. (See figure.)



### Surface quality

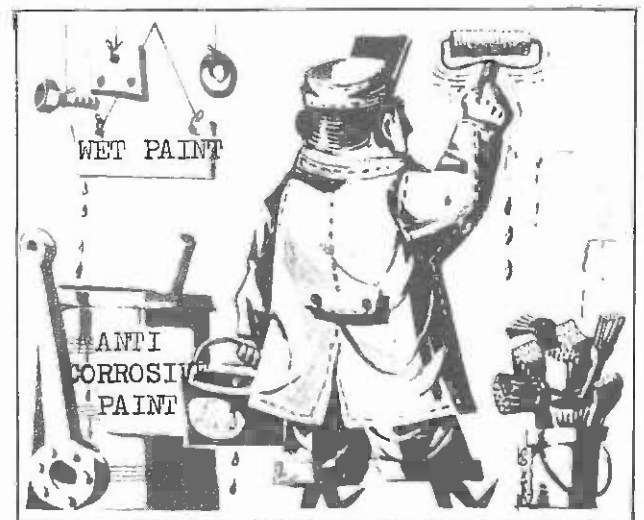
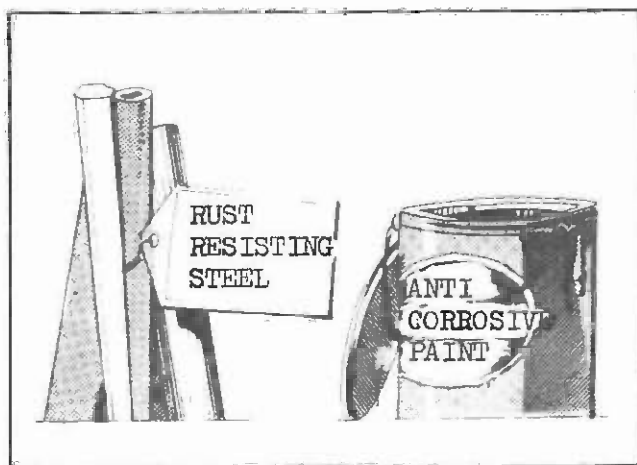
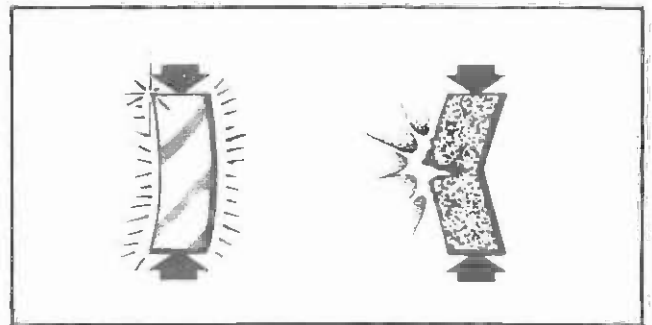
Bodies with polished and ground surfaces demonstrate more resistance and strength than bodies with rough, uneven surfaces.



### Corrosion

Rust and other chemical corrosion reduces structural strength considerably

This is corrected by surface conditioning, painting and the use of rust proof materials.



### Heat treatment

A metal part that has been repaired through welding usually has a lower fatigue limit due to:

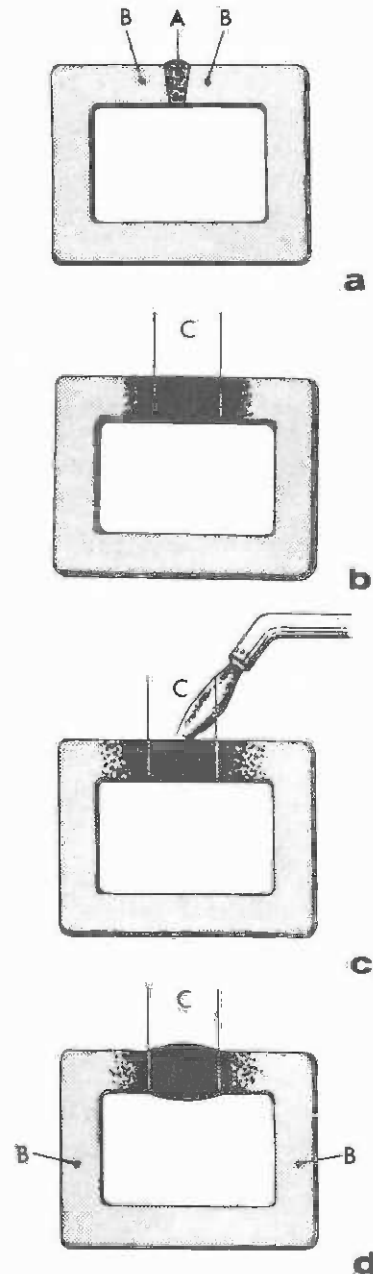
- unfavourable structure of the weld material.
- built-in heat stress in the material, following the welding.

Firstly, (figure a) the weld material A as well as the surrounding original material B, are heated up during the welding procedure above the temperature at which a structural change takes place in the materials.

In this, followed by uncontrolled cooling of A and B, a zone C usually results which is stiffer and more brittle than the original material B, which reduces its fatigue limit (figure b).

In order to retain the structure and improve the strength of the material in the weld joint, annealing is practised. This means that zones A and B are heated up to  $750 - 850^{\circ}\text{C}$  (depending on carbon content) for half to one hour, followed by cooling in normal air. (Electric welding, however, does not normally require this procedure.)

Secondly, when welding a given part (see figure c) the material heated at point C tends to expand. The rest of the material B is still cool and does not expand, but rather prevents expansion and strives to press together the material of the C zone which is plastic and workable due to high temperature and therefore causes bulging (figure d). Expanding and compressive forces more or less eliminate each other and the frame remains rectangular as long as C material is hot.

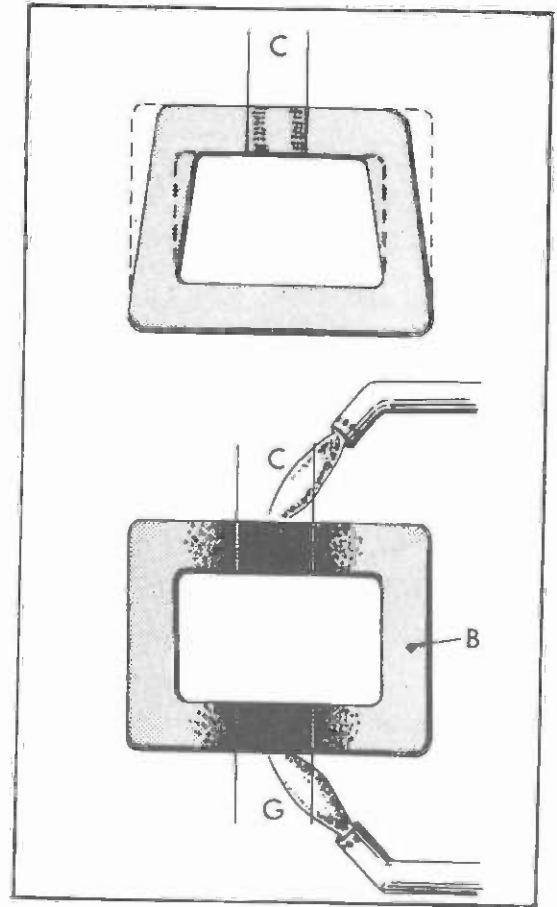


An example of how heat stress can occur when a machine foundation is welded together at point c.

But then the component cools off, the material around C contracts, which results in stress and shape change. To eliminate this, the component must be heated up in one of the following three different ways:

1. The material at G is heated up to approximately the same temperature as the material at point C. This creates a uniform expansion and compression.
2. The whole part is heated up to 5-600°C during the welding, which makes the material plastic so that stress is eliminated, so-called hot welding.
3. The whole part is stress-relief annealed at 5-600°C within a few hours after the completion of the welding.

Note: Welding of more complicated parts should be left to experienced workshops.

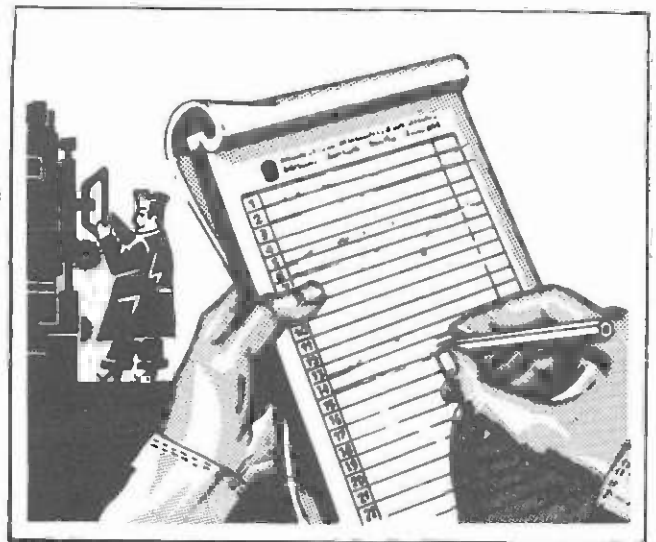


### Checks

As we have seen, the sash is under significant stresses and some components are more subject to fatigue than others. To ensure proper functioning of the frame saw, these vulnerable parts:

the lower cross-beam  
the connecting rod  
the crank pin  
the cranks

must be checked regularly and given maintenance.



Incorporate checks into the preventive maintenance programme

## 5. The Movement Mechanism of the Frame Saw

The oscillating movement mechanism of the frame saw is based on crank motion, i.e. a rotating movement is converted through a connecting rod into a to-and-fro movement.

The figure is an explanatory sketch of the moving parts of a frame saw where:

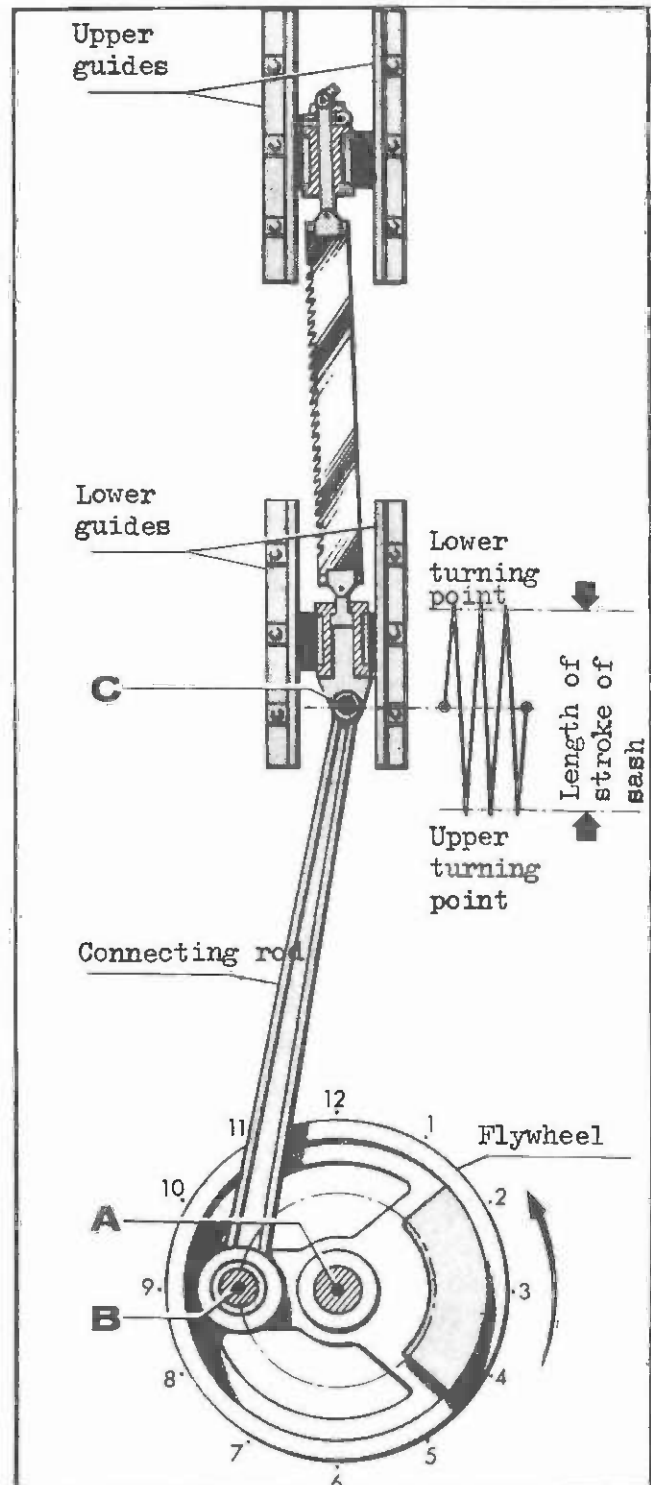
- A = the centre of the crankshaft
- B = the centre of the crank pin
- C = the centre of the sash pin.

Point A rotates at an even speed which is the number of revolutions of the frame saw, for instance 350 r/min.

Point B will then describe a circle around point A. This is done at an even speed, as B is directly linked to A.

Point C is given a movement that is identical to the movement of the sash as it can be regarded as a part of the sash.

At the same time it can be regarded as a part of the upper connecting rod bearing and the distance that it travels = the length of the stroke of the sash = (in our case) 600 mm. As the sash is steered in its guides, the rotating movement of A and B is transformed to a movement up and down.



During the movement of point C the speed at which it travels and its direction vary.

The figure shows the speed of point C. The horizontal axis has been divided into the 12 points of the clock face. The vertical axis shows the speed of C at a certain clock face position of B.

The speed is at its lowest, i.e. 0 m/min at:

- top dead centre (TDC), i.e. when B is at the 12 o'clock position and at:
- bottom dead centre (BDC), i.e. when B is at the 6 o'clock position.

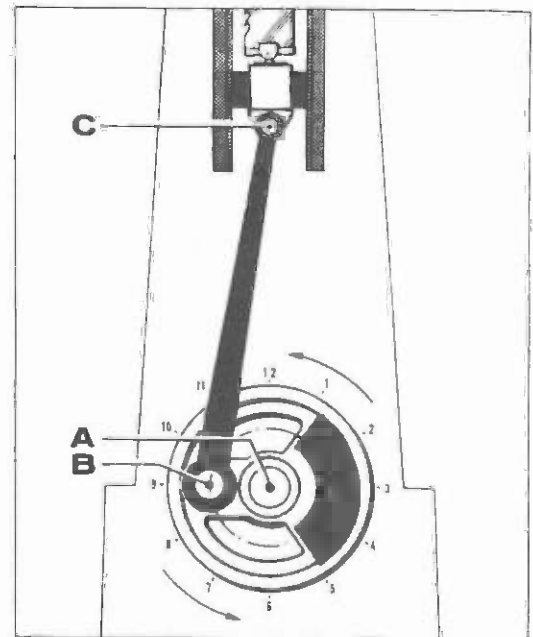
The speed is at its highest during:

- the downward movement when B is at the 9 o'clock position and during
- the upward movement when B is at the 3 o'clock position.

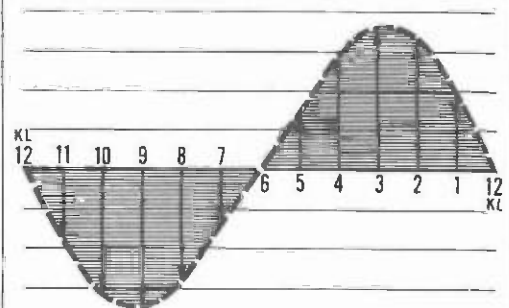
As the speed of movement of the sash changes during one revolution of the crankshaft, this means that the sash is alternatively accelerated and retarded.

The figure shows the acceleration of point C. It indicates that the acceleration

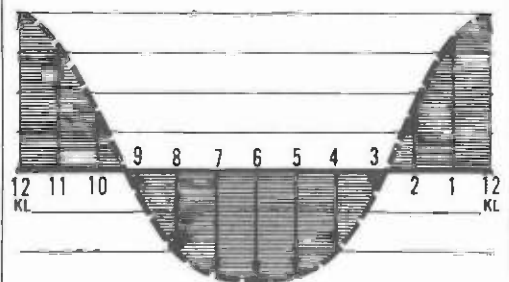
- is greater at the TDC and BDC, or the turning points, when point B is at 12 and 6 o'clock positions and that
- acceleration is greater at the upper dead centre (point B at 12 o'clock) than at the lower dead centre (B at 6 o'clock).



Velocity of Sash



Acceleration of Sash



6. Forces acting on the Sash, the Connecting Rod and the Crankshaft Journal

The sash and the lower cross-beam in particular are under forces that originate from:

- the moving parts of the frame saw (sash, sawblades and parts of the connecting rod), particularly the acceleration and retardation of the sash
- the cutting force at sawing.

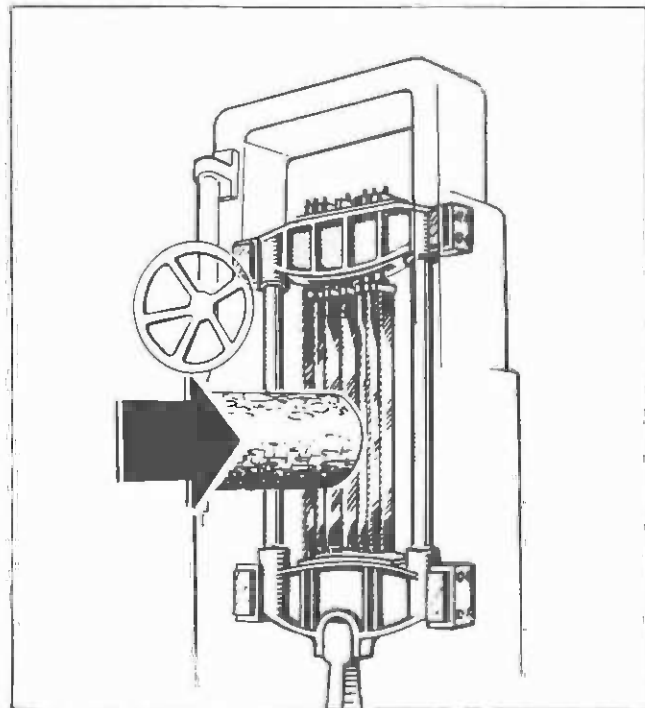
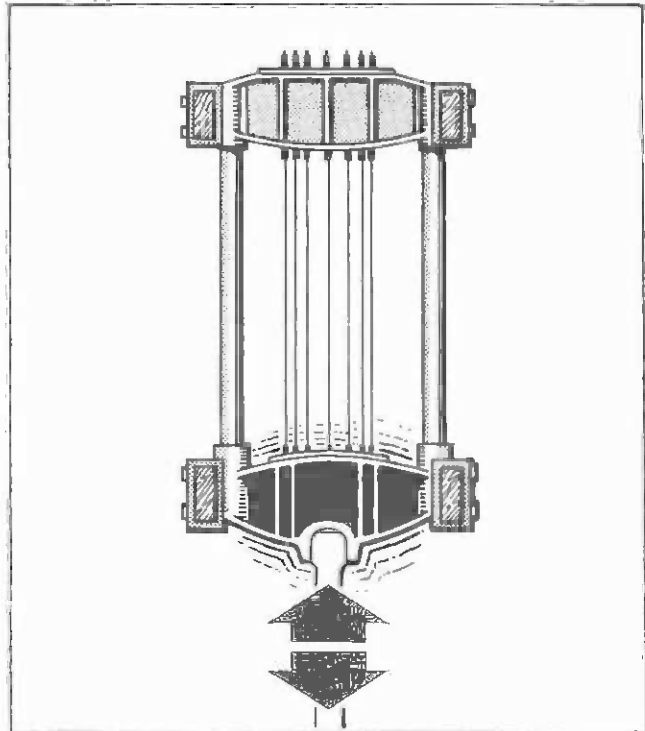
With inserted blades an 18" sash weighs around 245 kg, a 26" sash weighs 345 kg and a 34" sash 400 kg.

The upper end of the connecting rod moves up and down like the sash. Therefore a certain part of the mass of the connecting rod (around 55 kg) can be added to the mass that moves upward and downward.

We have seen earlier that:

$\text{Force} = \text{Mass} \times \text{Acceleration}.$

In this case, the total forces can be calculated by multiplying the acceleration of the sash at different positions by the weight of the sash plus the weight of the sawblades and the hangers plus 55 kg of the connecting rod.



By their weight the fitted sawblades increase the forces but they also influence the sash because of the fitting tension which can be 70,000 N or more for each blade. A frame saw that holds 9 blades thus has a fitting tension of 630 000 N in total. Apart from these forces, the sash is also subject to cutting forces that arise from sawing.

These forces, at least the ones that act at right angles to the sawblades, increase with the square of the feed speed. The stress on the blades is, strangely enough, greater while returning than while sawing.

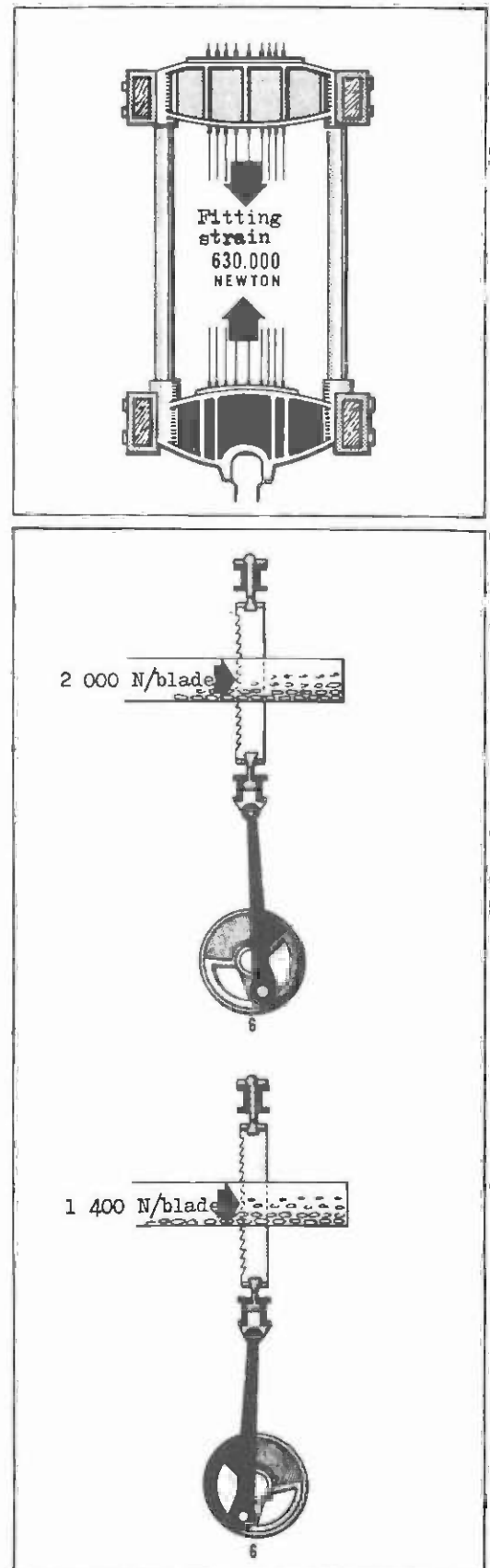
When sawing a 40 cm cant at a feed speed of 33 mm/stroke, the force that originates from feeding is 2 000 N at return sawing just after the turn of the stroke at the HDC.

Under the very same cant size and feed speed, the force at the cutting movement is biggest just before the HDC and reaches 1 400 N/blade.

The connecting rod is subject to forces that consist of:

- forces from the upward and downward moving parts (sash, blades and part of the connecting rod).
- cutting forces at sawing.
- inertia forces.

The first two of these inertia forces have already been dealt with. Here we discuss the third group of influencing forces.





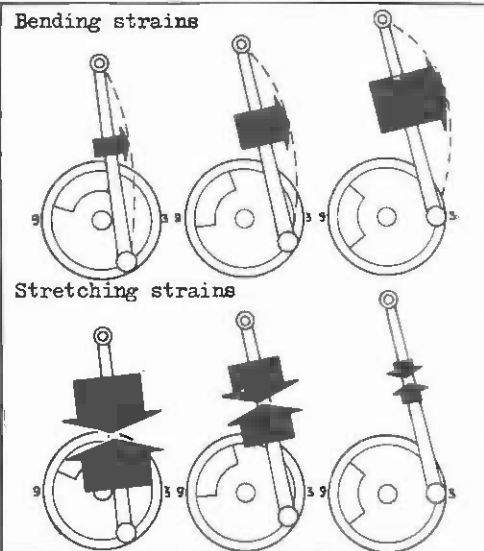
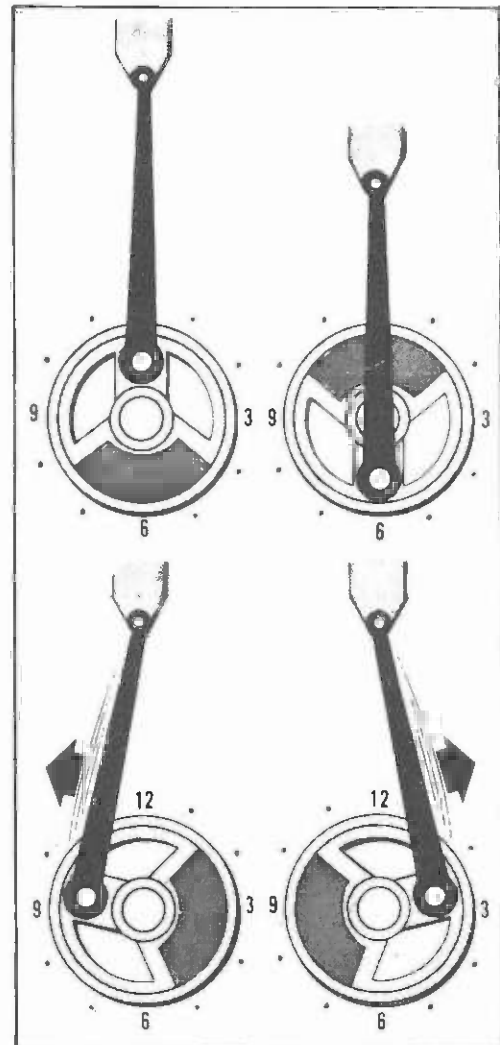
When the lower end of the connecting rod is rotating it is influenced by forces of inertia that strive to bend it.

These forces are spread along the connecting rod but, to make it simple, we can assume that they act from one point only, situated one-third down the length of the connecting rod from the centre of the crank pin.

The connecting rod is under maximum bending stress at this point. How the inertia forces that act on the connecting rod change their size and direction at different positions of the crank pin is given in the figure alongside.

From this figure we can see that these forces are zero at the turning points (12 and 6 o'clock), while they reach their greatest at a point situated roughly where the connecting rod and the radius of the flywheel form a right angle, which occurs just before the 3 o'clock and just after the 9 o'clock positions.

As indicated in the appendix, the other stresses on the connecting rod, tension and compression are smallest when the bending stress is largest. But on the other hand, tension and compression increase when bending decreases towards the dead centres.



The crankshaft journal is subject to all these forces, transmitted to the crank pin through the lower connecting rod bearing. The biggest force acting on the connecting rod bearing occurs at the upper dead centre, i.e. the 12 o'clock position.

The whole of this force is not transmitted through the crankshaft bearing to the base plate and the foundation but is reduced through counter balancing of the flywheel.

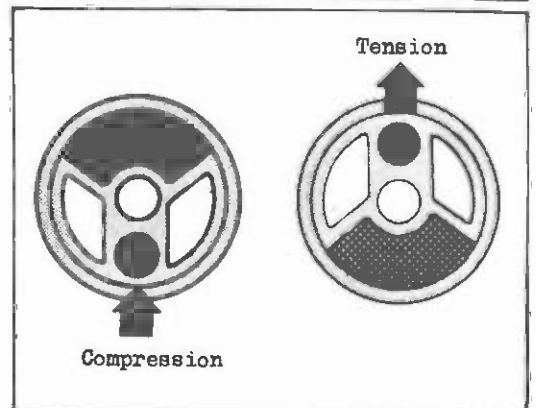
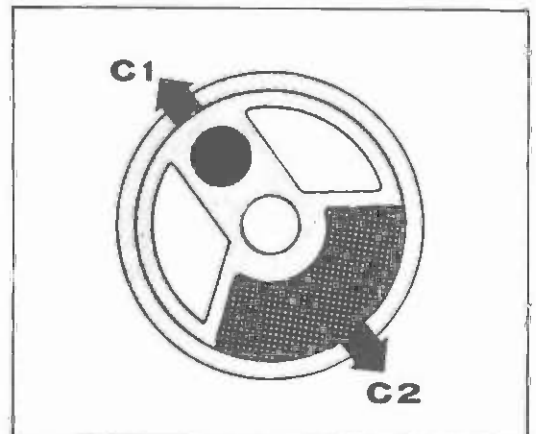
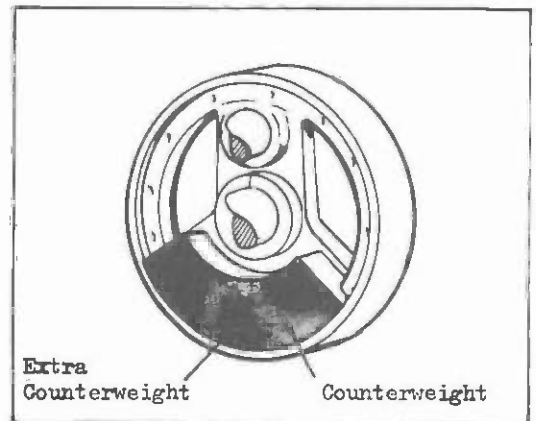
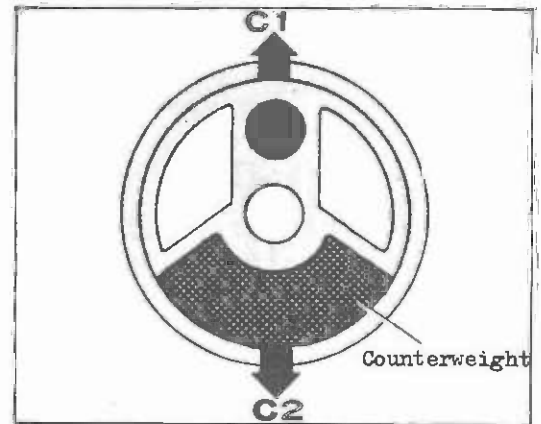
Flywheels are made with permanent counterweights placed on the opposite side of the crankshaft from the crank pin, which shifts the centre of mass towards that side. The distance from the centre of mass to the centre of rotation is thus modified so that all the rotating mass forces eliminate each other as much as possible.

As shown in the figures:

- C1 is the centrifugal force of the rotating part of the connecting rod, the connecting rod bearing and the crank pin, while
- C2 is the centrifugal force of the eccentrically placed counterweights of the two flywheels.

If these two centrifugal forces (C1 and C2) have the same magnitude, C2 will counterbalance C1.

When the crank pin is at the 6 and 12 o'clock positions, the upward and downward moving inertia forces of the sash and part of the connecting rod alternatively put compression and tension on the lower connecting rod bearing. (Appendix)



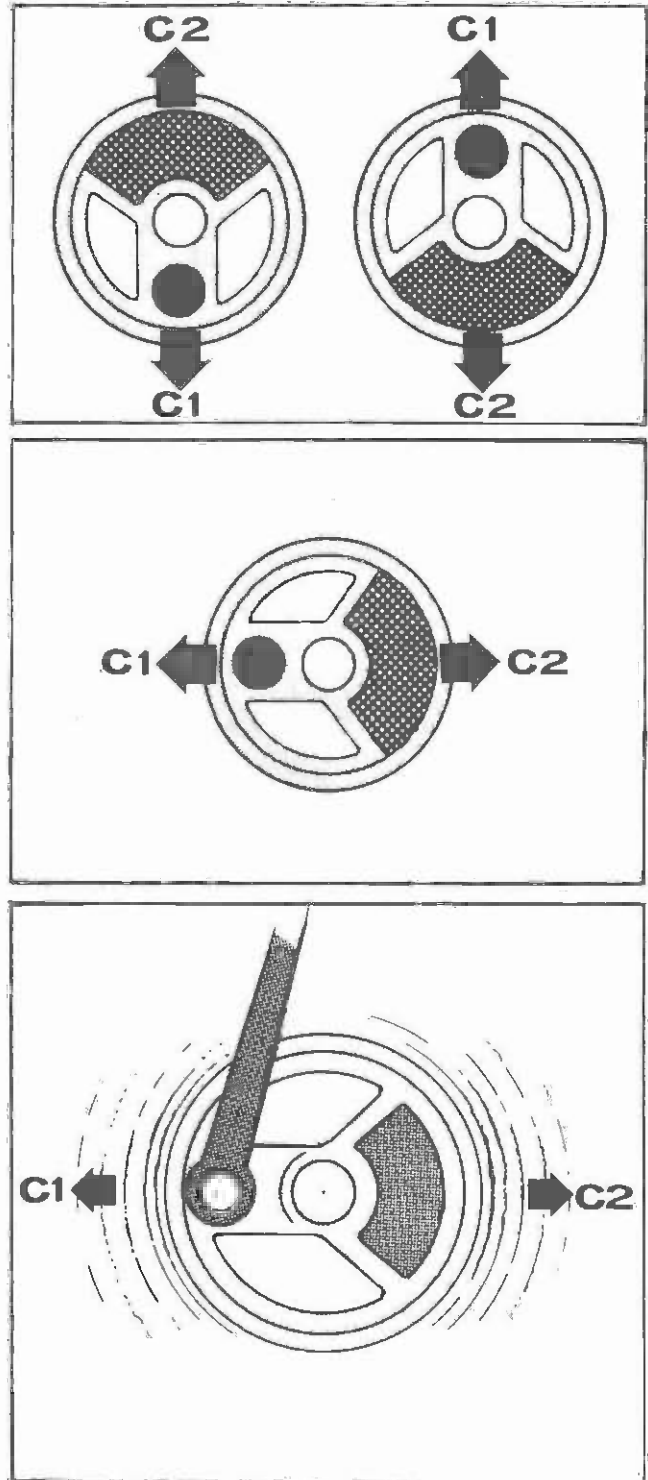
These up and downward acting inertia forces can be reduced, however, if the force C2 is made bigger than the force C1.

Part of the up and downward force F which is transmitted through the connecting rod from the sash and the up and downward moving part of the connecting rod will then be counterbalanced vertically. The force F, however, is zero at the 3 and 9 o'clock positions.

C2 can be increased by melting lead into specially provided holes in the flywheel.

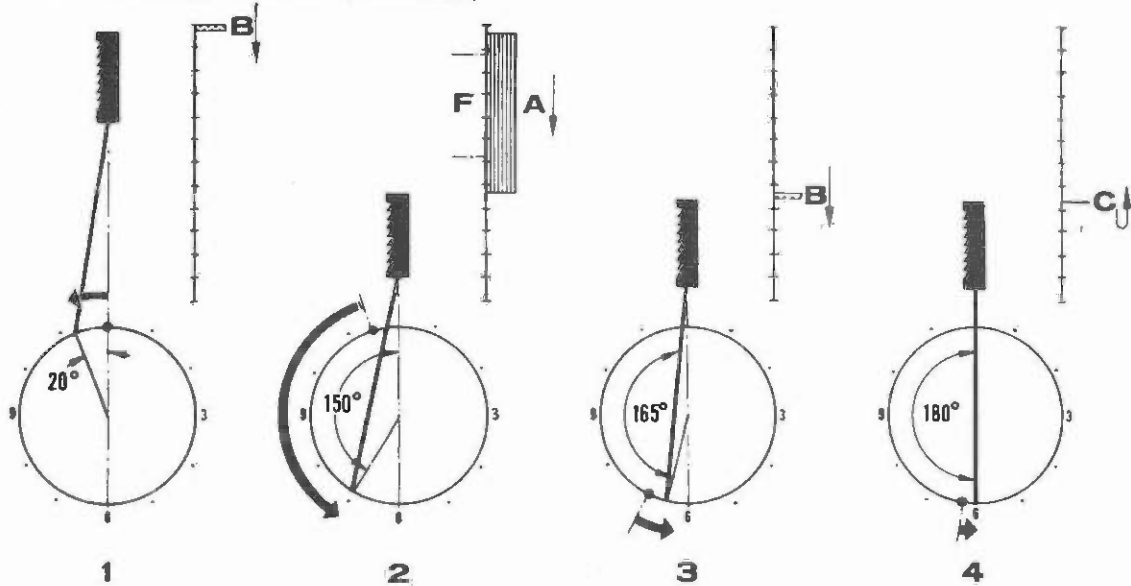
To obtain the best results from the counterbalance, the size of the lead weight must be tested individually for each frame saw.

The out-of-balance that this creates in the flywheel will cause forces that do not counterbalance when the crank tap is in the 3 and 9 o'clock positions where  $F = 0$ . This will cause some horizontal vibration but these are less than those that would occur if no balancing was done of the flywheel. The up and downward forces would then create very strong vertical vibration.



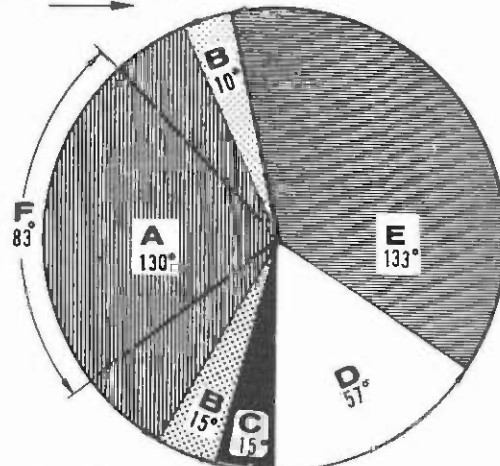
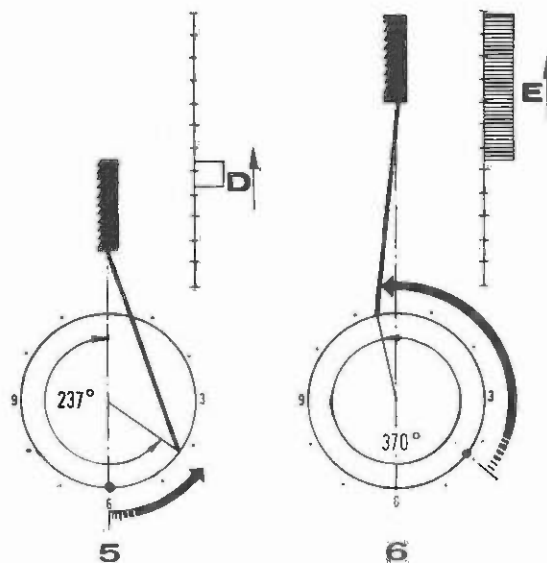
7. The Cutting Conditions of the Sash

The working stroke (cutting)



Direction of feed  $\rightarrow$

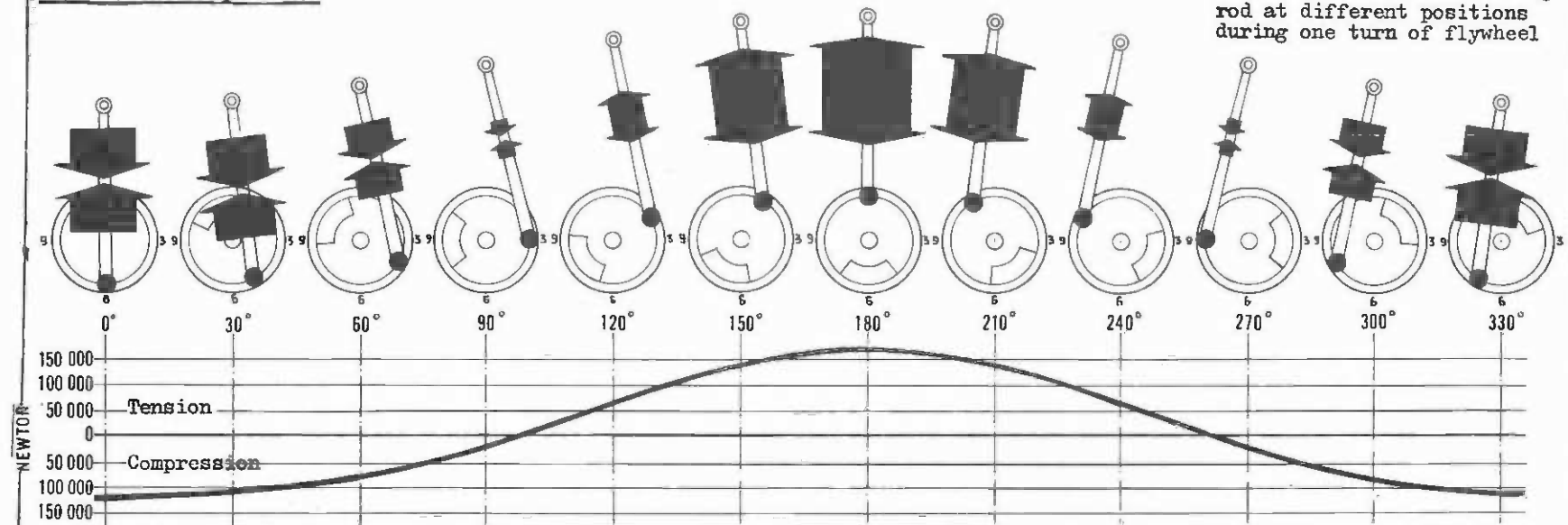
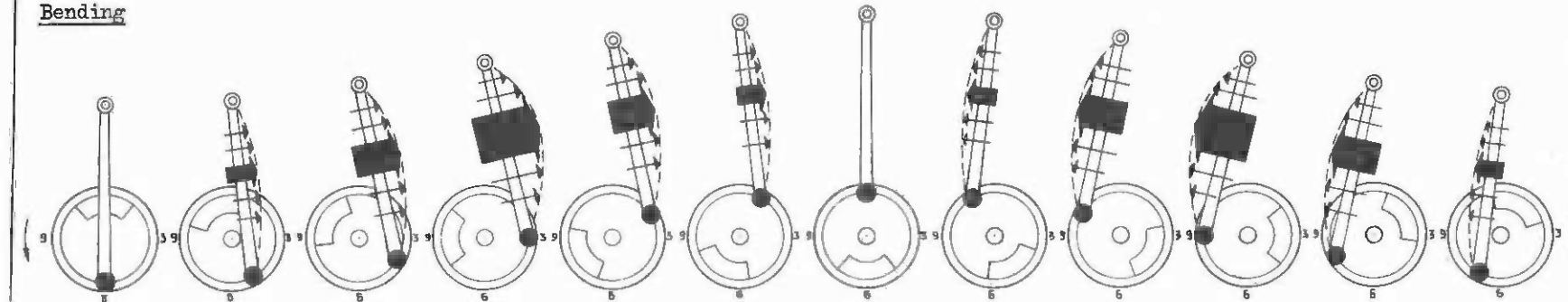
The return stroke (free wheeling)

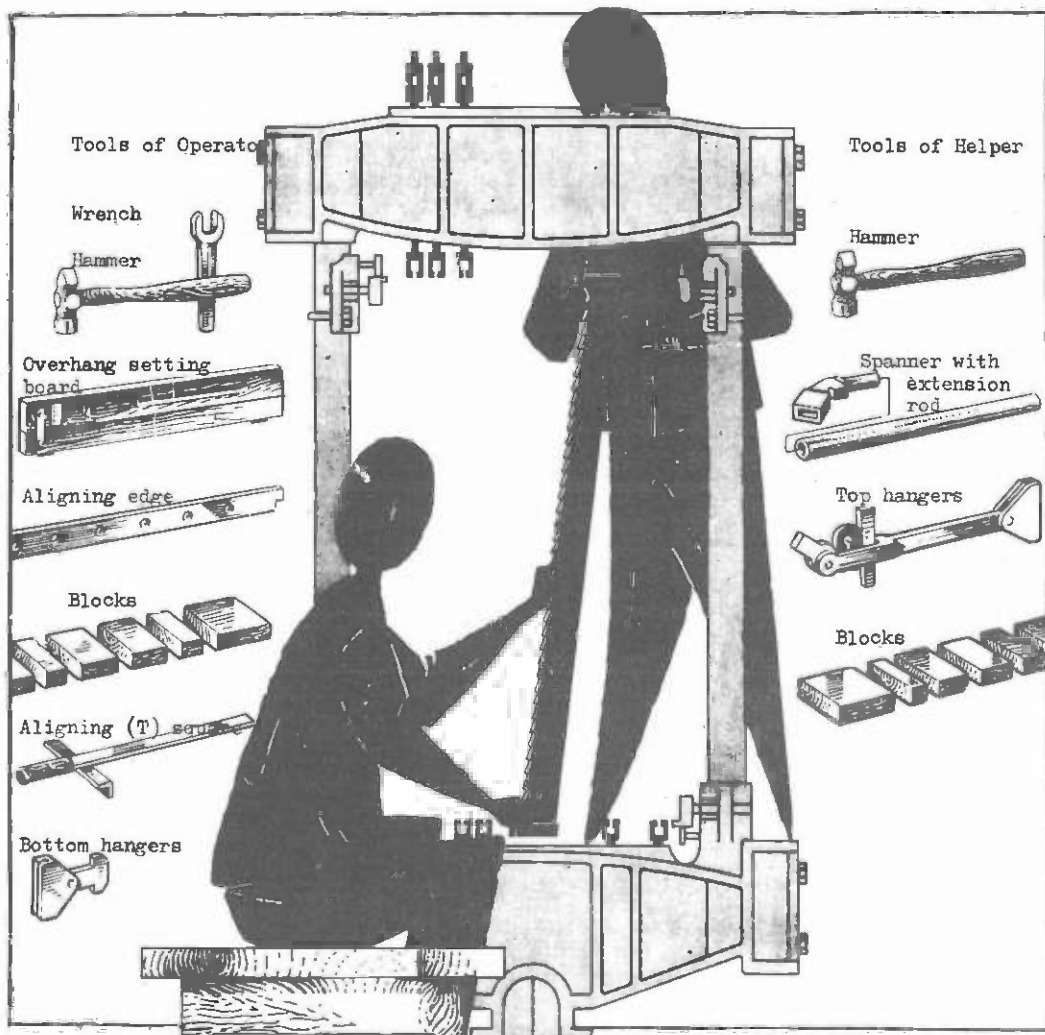


- A. Efficient cutting
- B. Less efficient cutting
- C. Wood crushing
- D. Return sawing
- E. Free wheeling
- F. Middle of the stroke - i.e. where cutting potential cannot be maximized.

Tension and Compression

The forces in the connecting rod at different positions during one turn of flywheel

Bending



### PART III - SETTING SAWBLADES INTO FRAME SAW SASH

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Setting right angle of a set of sawblades .....	75
Plumbing in a set of sawblades .....	76
Adjustment of splitters. (Knife guides.) .....	77
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The setting of blades can be divided into two main parts:

Removing blades from the sash.

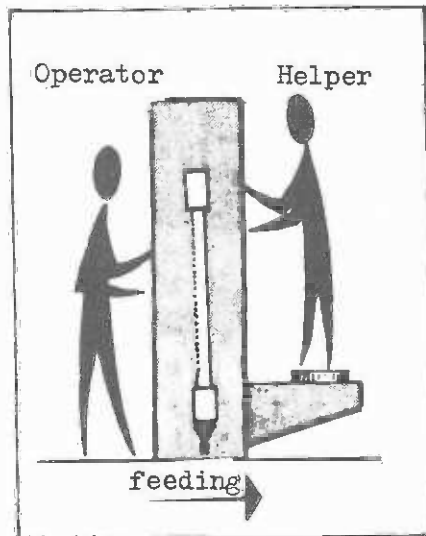
Setting blades into the sash.

Here the two jobs are described in sequence, as performed by an Operator (usually the sawyer or sawdoctor) and a Helper.

The sash must be securely locked in its upper position. Front upper and lower roll frames must be open. Switch off the current.

OPERATOR

stands in front of the sash.



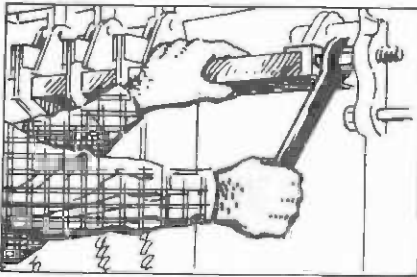
HELPER

is on the out-feed side of the frame elevated on a board that has been placed between the knife guides to enable him to loosen the top hanger.

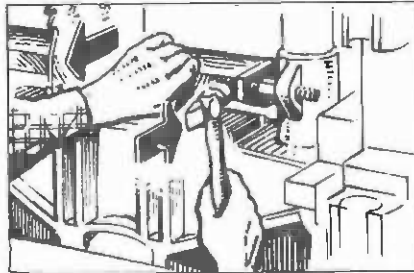
## REMOVING BLADES FROM THE SASH

### OPERATOR

1. Loosens upper and lower block attachments on the right-hand side, the upper ones just enough for blocks to remain in place.

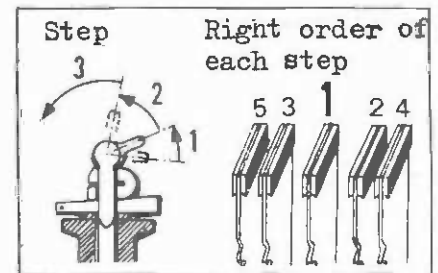


2. Knocks away right lower support block. Then takes away other blocks one by one from right to left, so that the blades are completely free.
3. Collects two or three blades together and pulls them out of the bottom hangers.
4. Takes the blades and puts them in the sawdoctor's box.



### HELPER

2. Loosens each hanger in three steps (otherwise there is a risk of breaking the hanger on the last blade). Starts with centre blade. Continues on alternate sides with each step.



2. Knocks away left upper support (seen from the Helper's position). Takes away the blocks one by one from left to right. Meanwhile, keeps remaining blocks in position by pushing side of last blade against them.
3. Collects the tops of two or three blades together (the same as the Operator) and pushes the blades out from top hangers.
4. Checks blocks. Discards if damaged. Cleans unbroken blocks and puts them in their respective boxes.

The blades have now been removed from the sash.



## SETTING BLADES INTO THE SASH

### Inserting the hangers

#### OPERATOR

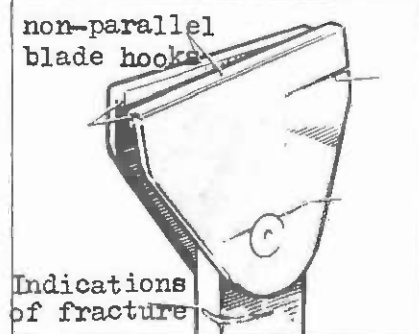


#### HELPER

1. Cleans the cross beams from sawdust, etc. Brushes carefully, or preferably uses compressed air. If a wearing plate is used on top of the upper cross beam, checks that it is in the right position.

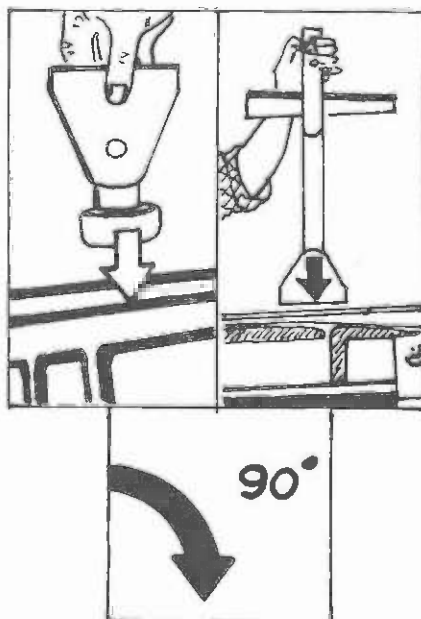
2. Checks hangers and makes sure the contact surfaces and the blade hooks are straight and parallel, the rivet is fixed, the opening between the blades corresponds to the thickness of the blades and that there are no indications of fractures.

#### Problems in a Hanger



2. Checks the hangers and makes sure the contact surfaces and blade hooks are straight and parallel, the rivet is fixed, the opening between the blades corresponds to the thickness of blades and that there are no indications of fractures.

3. Puts the bottom hangers through the lower cross beams from the top downwards (with the attachments first). Then turns them one-quarter of a turn to make the attachments come into contact with the lower side of the beam and lock into position.

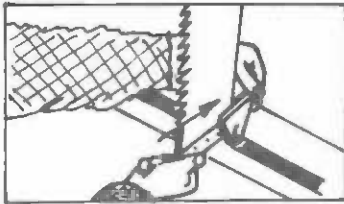


3. Puts the top hangers through the cross beam from the top downwards. Then turns them one-quarter of a turn so that the hanger wedges are straight across the beam. Turns the eccentric lever a little more than half-way down to make it easier to slip on the spanner.

# Inserting the sawblades

## OPERATOR

1. Takes the blades one at a time carrying the blade at the back with the left hand and balancing it with the right hand, holding the front at the bottom, (the teeth facing Operator). Passes upper end to the Helper.



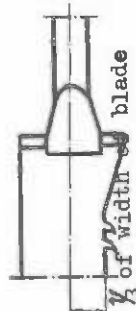
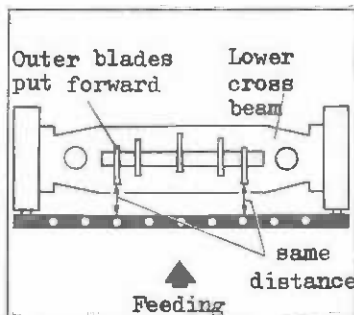
2. Inserts the bottom end of the blade into the left bottom hanger. Then continues with the rest of the blades.

Insert from left to right. When all the blades are inserted, position the blades (the hangers) sideways to the approximate position they will have later when the blocks are inserted.

3. Adjust the blades in the bottom hangers in the direction of sawing so that

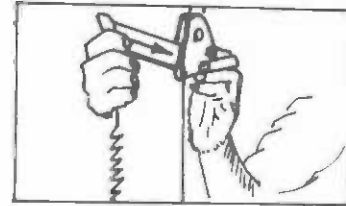
- the outside blades are a little forward of the centre blades, i.e. they will cut first.
- the blades are placed symmetrically.
- the whole set of blades is perpendicular to the direction of sawing.
- the fitting tension will be correct in the blades.

Since blades are positioned as above with a rule on positioning is possible centre of hangers should in figure, or the front of the hanger



## HELPER

1. Takes the blade by grasping upper end with the right hand. Holds the hanger with the left hand.



2. Inserts upper end of the blade into the corresponding top hanger. Adjusts the wedge in the top hanger so that the blade is located in the hanger. (If the blade is "standing" free it could fall forward onto Operator.)

3. Adjust the blades into the top hangers in the same way as the Operator does with the bottom.

and are often of different difficult to state. As far as coincide with a line as shown be in line with gullets.

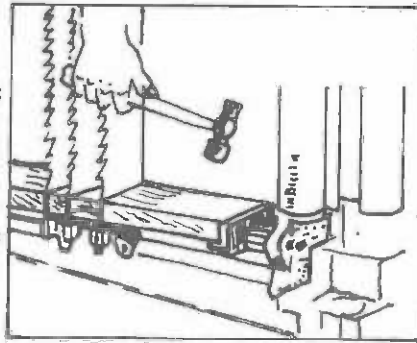
### Inserting of blocks

#### OPERATOR

1. Inserts with the left hand the lower left support block (i.e. on that side where the block attachments have not been touched and are therefore at right angles).

With the right hand presses the free blade against the block so that the bottom hanger is correctly positioned and the block is held in place.

Continues until all the blades and blocks are inserted. Finally inserts the last support block.



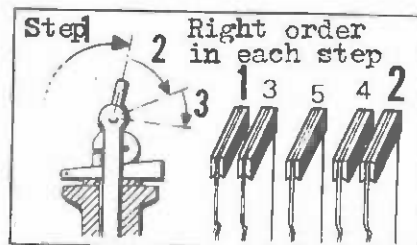
#### HELPER

1. With the right hand inserts the upper support block corresponding to that of the sawyer. Presses the blade with the left hand against the block to keep it in place. Taps the wedge with the hammer so that the blade is stretched a little - the block is then fixed and stays in position by itself. (The top hangers are now positioned a little to one side.) Continues like this until all the blades and blocks are inserted. Finally, inserts the support block.

The last support block is often a bit bigger than the distance allows. If the difference is small the support block can be tapped down (the Helper drives his block upwards). If the difference is big, the block attachment must be unscrewed. Never force the last support block with heavy blows. The support block could become deformed and be pressed so hard that later adjustment will be more difficult.

2. Tightens the upper block attachment a little when all the blocks are inserted so that they do not fall out.

At the same time, adjusts the blocks so that they are all in a horizontal line together.

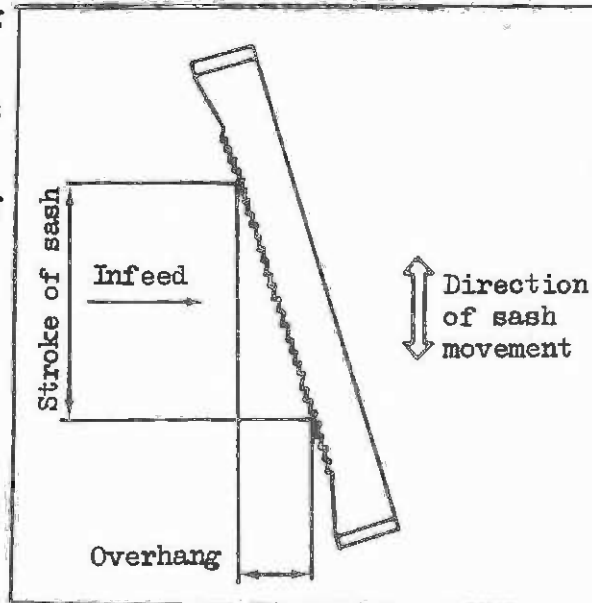


2. Loosens the eccentrics of the top hanger a little and adjusts the position of the top hangers sideways so that they are directly in line with the blade. Then completes the first step in the tensioning of the blades. At this stage also adjusts the hanger wedges. Starts with the outside blades and works alternately from left to right towards the centre.

Adjustment of overhang setting

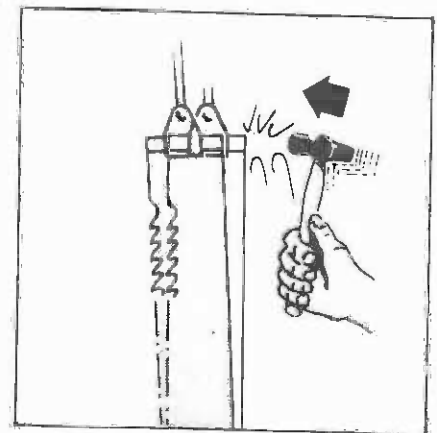
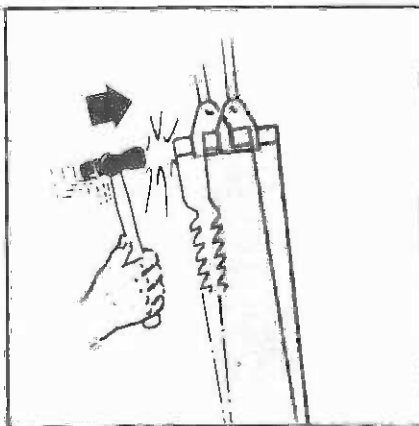
OPERATOR

1. Adjusts the right overhang setting on the overhang setting board. Holds the board against one blade at a time, presses against tooth line and taps with the hammer at upper end of blade in the direction of sawing, so that the right overhang setting is obtained.

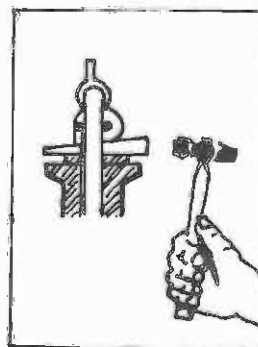


HELPER

If the overhang setting already adjusted is too small, gently taps out the blade at upper end.



At this stage the blades must not be stretched so much that they risk damage or that the stretching plates of the blades get jolted.

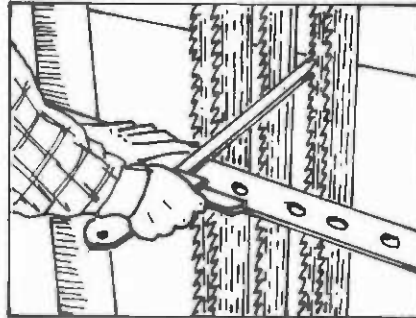


2. Taps top hanger wedges to achieve a slight stretching of the blades.

Setting right angle of a set of sawblades

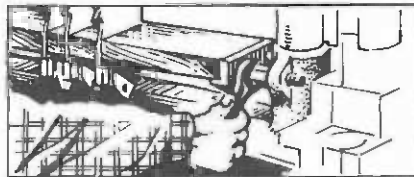
OPERATOR

1. Puts the aligning edge on the bearing pivot of the frame saw stand. Puts the aligning T square on the aligning edge. Checks by moving it against the sides of the blades that the blades are at right angles to the edge (i.e. parallel to the T square).



If the set of sawblades is not at right angles, adjusts the angles by tightening the front and back screws of the block attachments differentially. Do not use any force which might result in a deformation of the blocks without the blades reaching the right position. Then it would be difficult to continue setting the angles of the rest of the blades.

2. When all the blades are at right angles, tightens the right-hand side block attachment but makes sure that the setting does not change during tightening.



4. Checks the angle of the blades in the same way as in 1 and 2 above, when the sash has reached the lower position. The adjustment is made with the upper line of blocks.

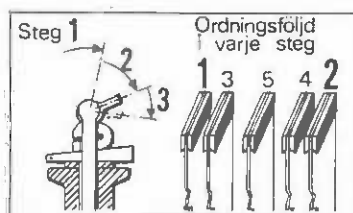
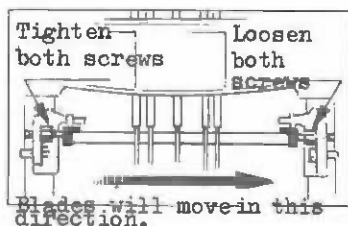
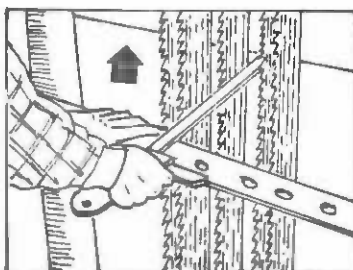
HELPER

3. Loosens the sash and pushes it to bottom dead centre.

# Plumbing in a set of sawblades

## OPERATOR

1. Holds the T square against the aligning edge with one edge of the square close to one side of a blade. The set of sawblades will be vertical if the side of the blade, when making its movement up and down, is always at the same distance from the fixed measuring point. If the distance to the side of the blade is not the same going up as going down, the upper block row must be adjusted sideways. Loosens both screws equally on that side of the block attachment where the set of sawblades needs adjusting and correspondingly tightens both screws at the other block attachment. The set of blades will move in the right way.



## HELPER

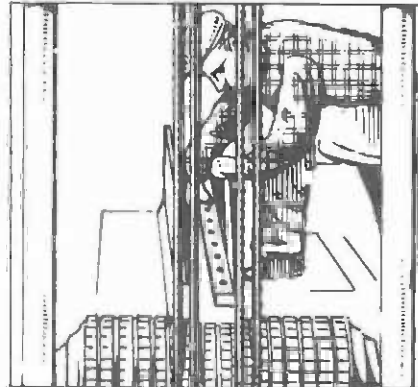
1. Pushes the frame to make the sash move slowly up and down.

2. Tightens the set of blades in stages. (Steps 2 and 3). Starts with the outside blades and works alternatively towards centre. Tightens centre blade last in every step. If sawing does not start until following day, delay tightening until sawing is to start, thus avoiding cross-beams and blades being under pressure for an unnecessarily long time. It is essential that all blades are equally tightened or load on cross beams will be unevenly distributed and result in curved sawing. Checks strain in blades by pressing each blade hard with hand.

### Adjustment of splitters (knife guides)

#### OPERATOR

1. Puts the aligning edge against inside of one of the blades sawing the main yield. (Note: For cant frames put the edge along the inside of one of the outside blades of the cant boards).
2. Indicates by signs already agreed upon how Helper must move the splitter so that it bears against the inside of the aligning edge.
4. Repeats this procedure with the other splitter.
5. Checks adjustment once more, see above.



#### HELPER

1. Loosens the splitters and moves them a little together.
2. Moves the splitter as directed by Operator so that it bears against inside edge of aligning edge.
3. Fixes and locks splitter.
4. Repeats this procedure with the other splitter.

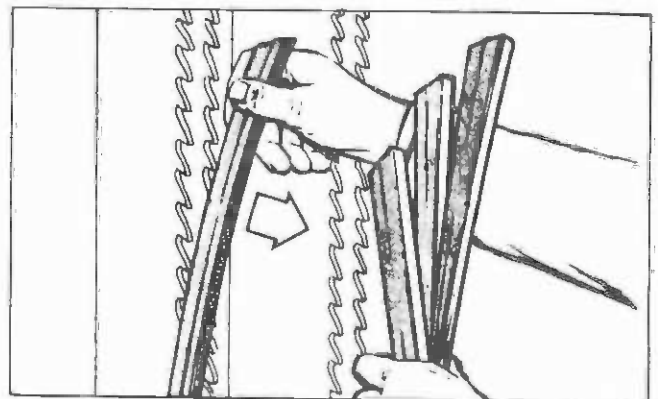
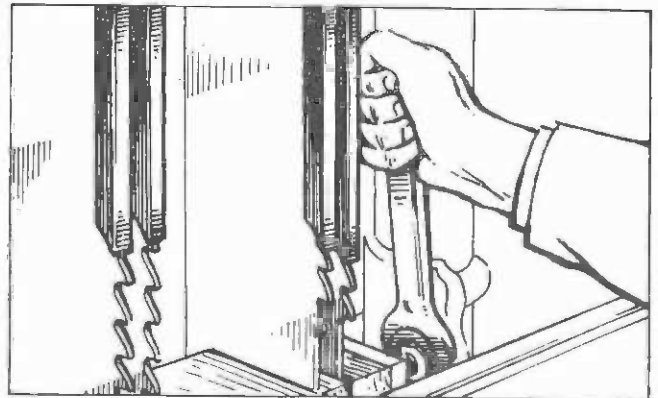
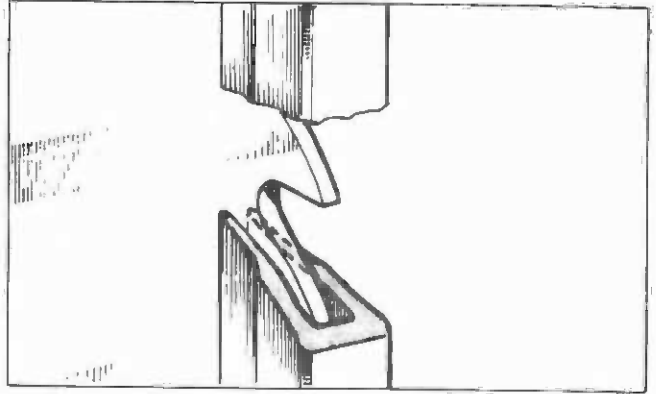
### Safety equipment

A newly sharpened blade is easily damaged even by gentle nudges and bumps. Contact with other objects can damage both edges and teeth setting.

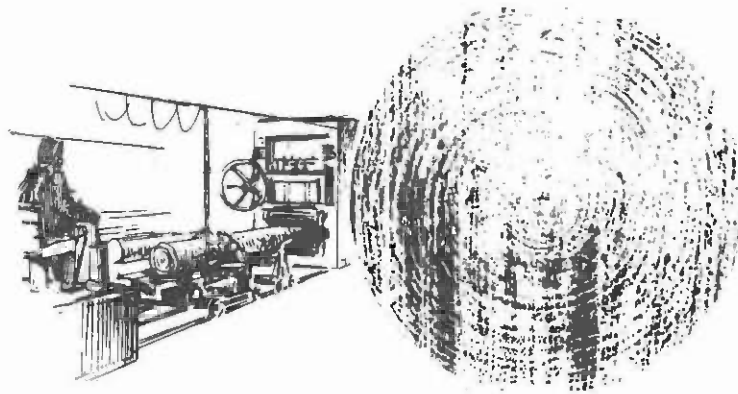
To avoid damage, the edge can be protected by strips of plastic that are placed over the teeth.

Even more easily damaged are the hands of the Operator, which can be cut when blades are handled, especially when the Operator is inserting blades, blocks or tightening the block attachments.

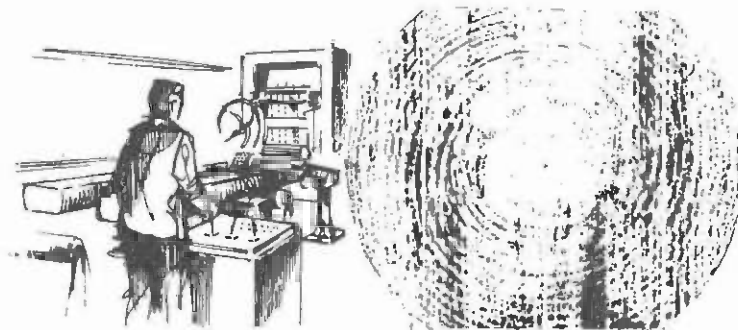
By using the plastic strips the Operator is protected during the whole procedure, except when the overhang setting is adjusted. The strips are easy to put on and take off.







HOW TO FEED LOGS INTO A FRAME SAW



PART IV - HOW TO FEED LOGS INTO A FRAME SAW

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# 1. Cant Sawing Principles

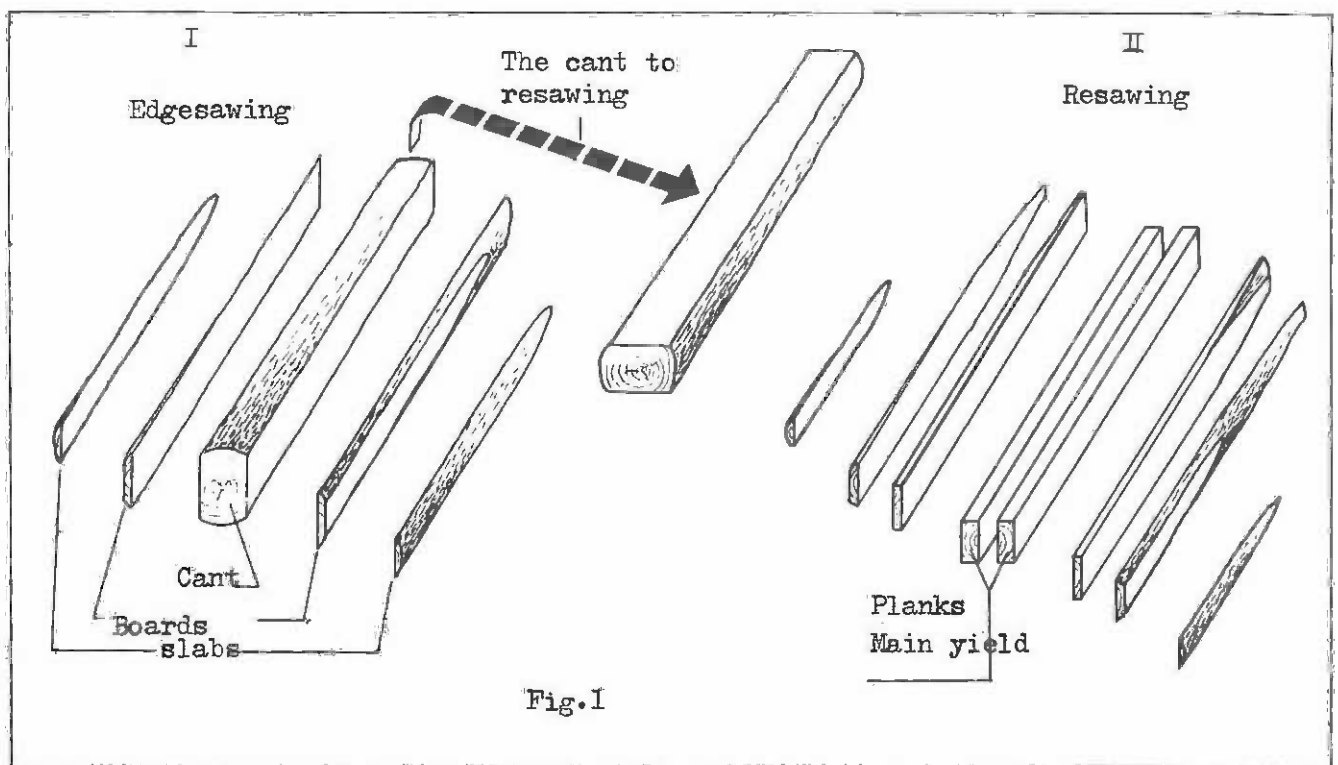
The principles of cant sawing consist of two steps (figure 1).

Step I. The log is edged in the log frame, which gives a cant and one or more boards on each side.

Step II. The cant is resawn in the cant frame which gives a main yield of planks, and a number of boards on each side.

The main yield has now been block sawn, i.e. the sawblades have touched all four sides and normally can be marketed as they are.

The boards from both steps are further processed in one or more edgers.



The sawing is usually done in two frames, one log frame saw and one cant frame saw, which operate one after the other.

The sawing, however, can be done in just one frame that is set up periodically for edging or resawing. In this case, the cants must be piled up between the two operations.

When processing the logs, the purpose is to achieve:

- a good result both as regards quality and quantity.
- the highest possible economic yield.

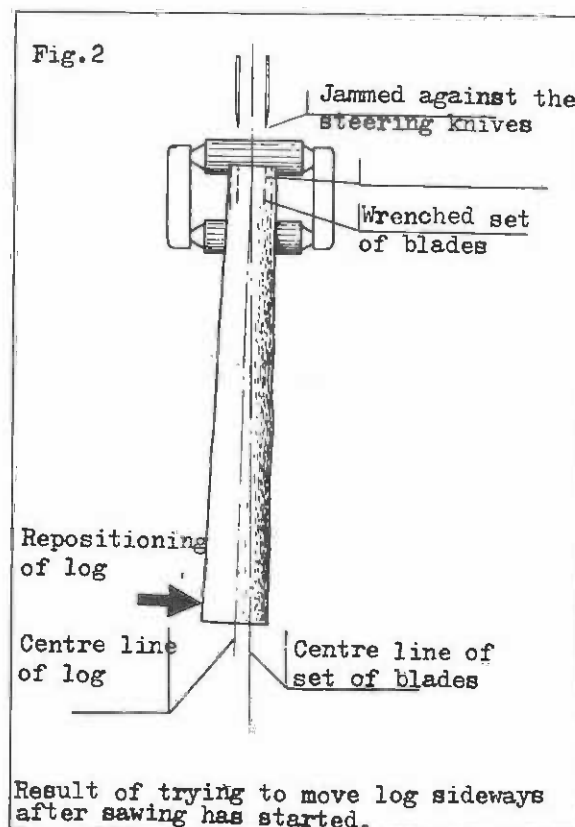
The logs must, therefore, be correctly fed into the frame saw.

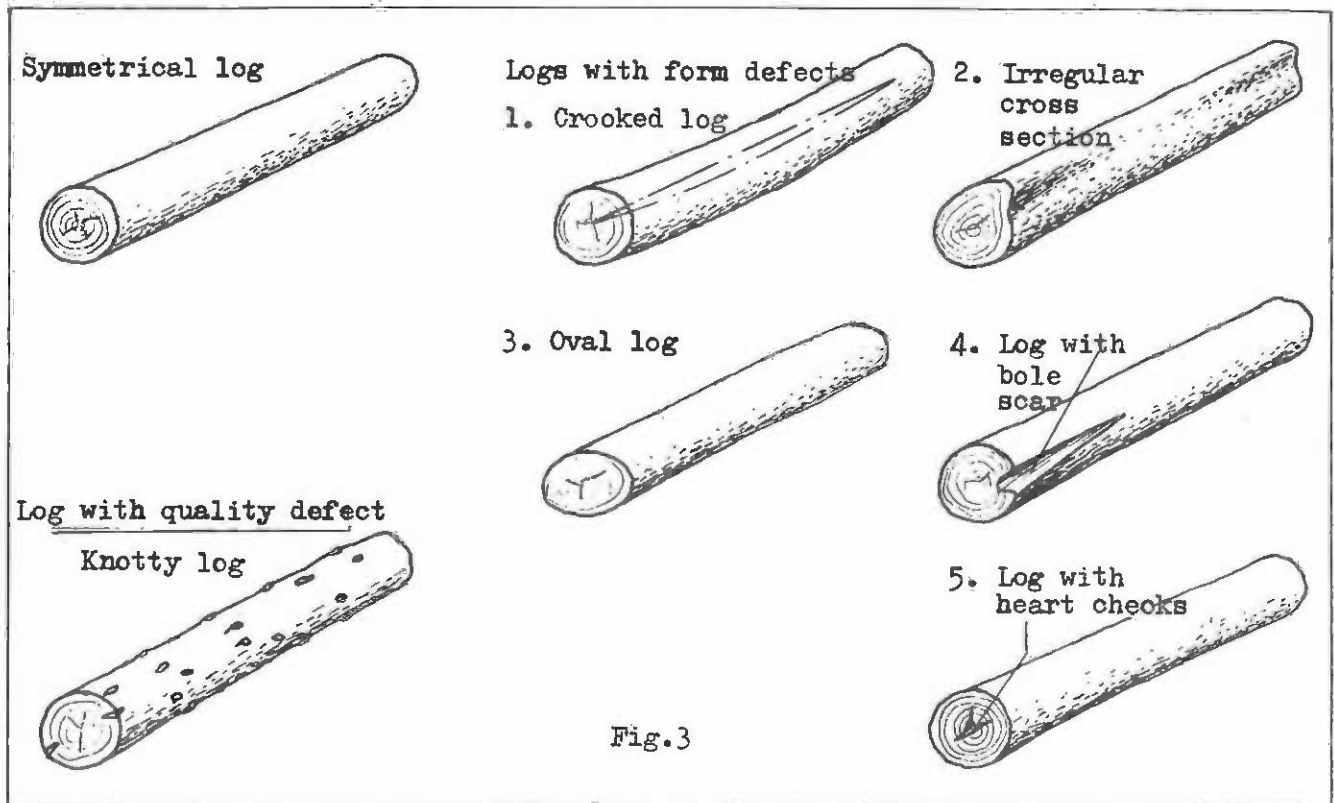
The log can be of:

- different size and tree species
- different form and quality, (see figure 3) and must be treated accordingly.

When the log sawyer or cant sawyer has each log or cant before him, he must make an assessment quickly and position the log, or the cant, for the sawing procedure, to ensure the best result possible.

Once the sawblades have started to cut into the log, there is no possibility of making any adjustment. Such action might very well cause a breakdown. (See figure 2 and 3.1.2 - Curve Sawing).





## 2. Sawing Symmetrical Logs (Figure 3)

A symmetrical log

- is round and straight without any form defects;
- has quality faults in the form of knots distributed evenly in number and size.

Infeed Rule for Symmetrical Logs in Log and Cant Frame:

Centre line of log or the cant shall coincide with centre line of the set of blades. (Figure 4).

Exception to rule: If, for instance, too small a log for the actual setting has been included, the sawn surface of the cant may be too small for the main yield.

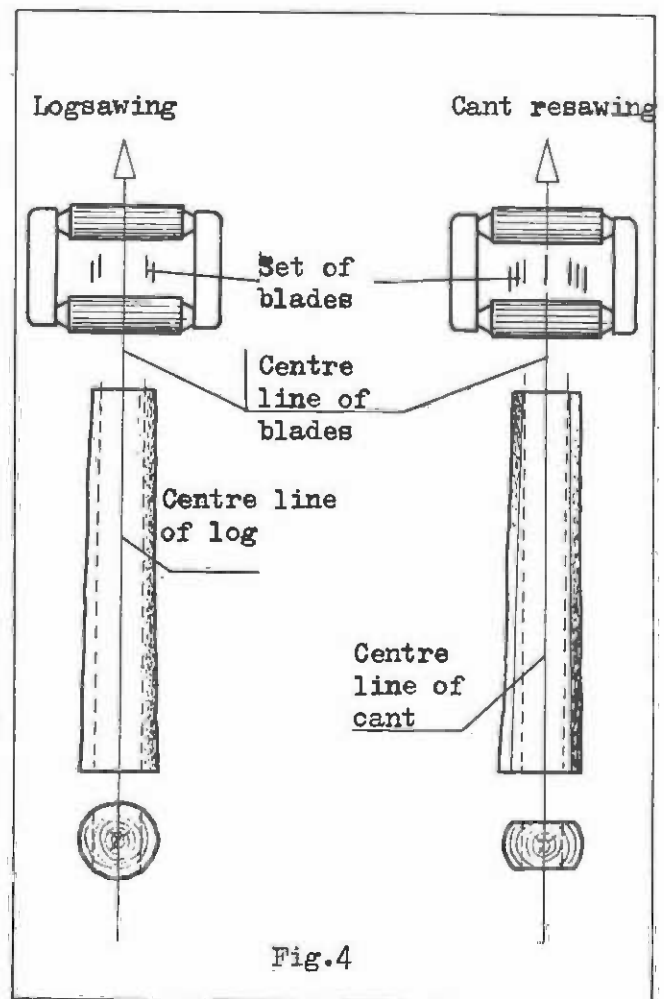


Figure 5a shows this case where the sawing procedure has followed the rule, i.e. the centre line of the cant follows the centre line of the set of blades. Both planks have got wane,

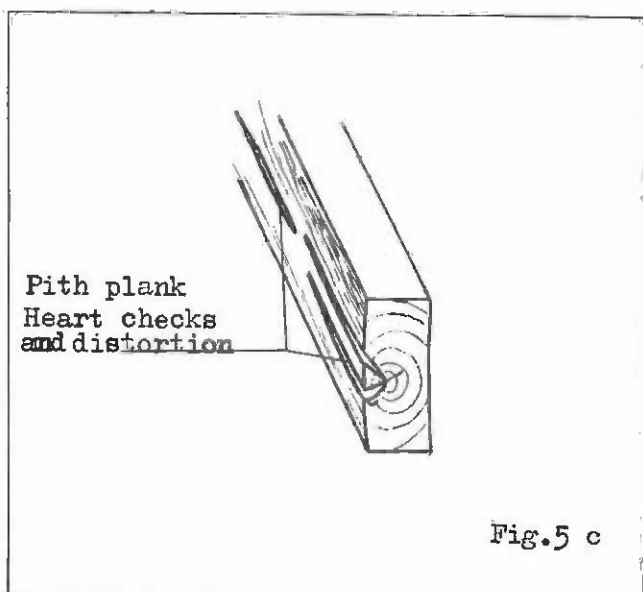
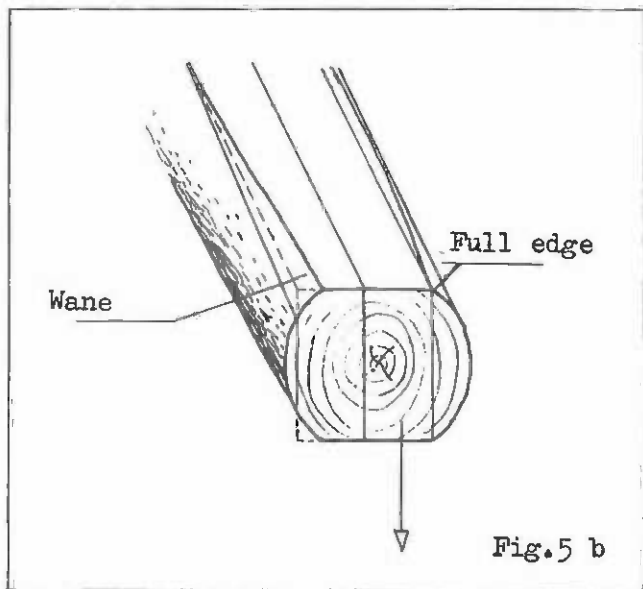
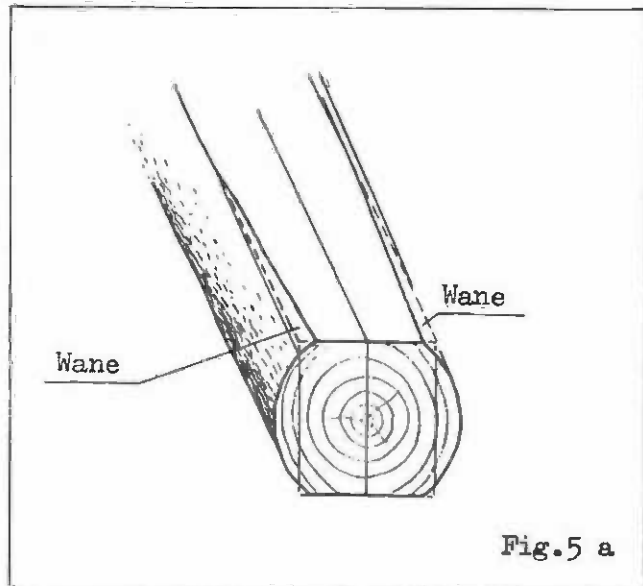
Figure 5b shows a side movement of the cant so that the two centre lines do not coincide.

This has resulted in one of the two planks being fully edged. The other one has got more wane but, due to the natural taper of the log, not markedly longer.

One drawback here, however, is that the full edged plank has become "pith-included". In some species distortion on drying is often worst in pith-included planks, therefore their value may be reduced. (See figure 5c).

Before aligning a straight cant with a sawn surface which is too small, one should bear in mind that:

- in some species the sideways movement (figure 5b) must not become so big that excessive distortion or pith cracks appear when the log is dried;
- alignment following the basic rule (figure 5a) is recommended when the log is of such a quality that knots, decay, blue stain, etc. make wane acceptable.



### 3. Sawing Logs with Form Defects

#### 3.1 Crooked Logs

The most common form of crookedness is "sweep" or "long crook". The sweep may not, according to previous Swedish log quality standards, exceed 25 mm for each 1.5 m. A 4.5 m long log could therefore have a maximum even sweep not exceeding 75 mm. (See figure 6).

#### Infeed Rule for Crooked Log, Log Frame:

Turn log so that the sweep is on downward side. (Seen from side in figure 7a). Then align log so that its centre line coincides with centre line of the set of blades. (Seen from above in figure 7b).

The cant from a crooked log sawn in this way is crooked but the surfaces are evenly sawn. (See figure 8)

#### Infeed Rule for Crooked Cant, Cant Frame:

Align the cant and saw it so that main yield just falls within sawn surface on inside of the sweep. (See figure 9a).

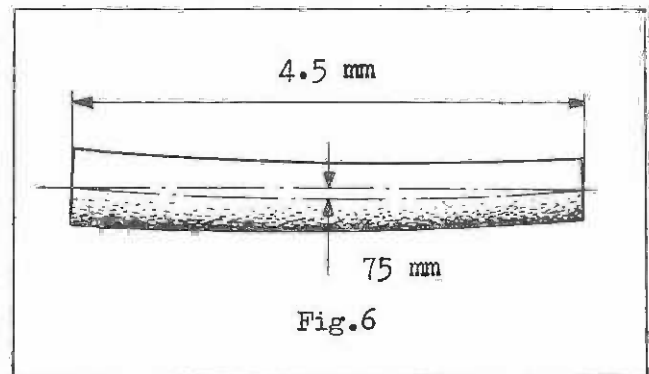


Fig.6

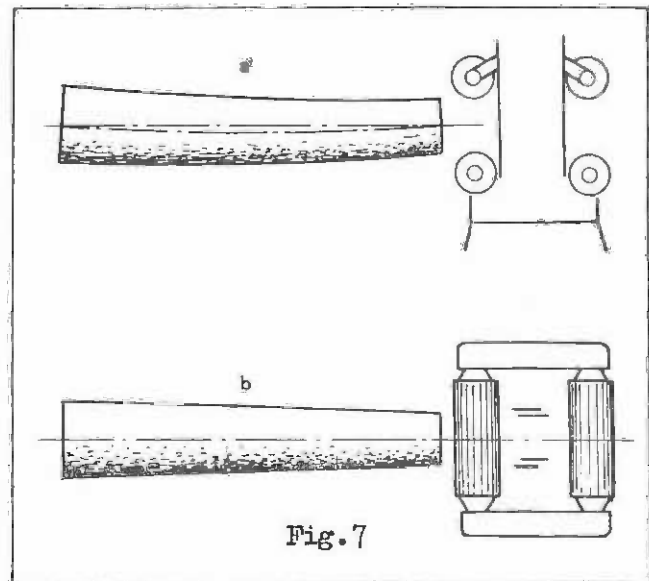


Fig.7

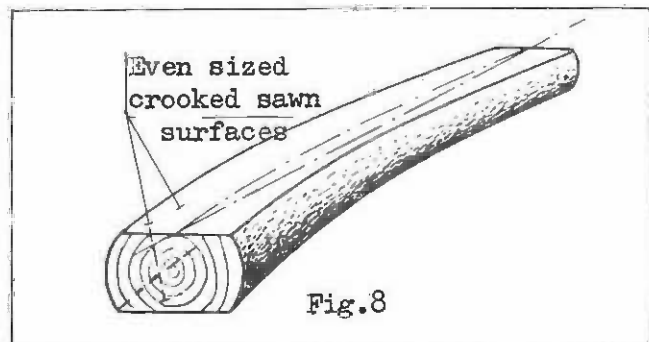


Fig.8

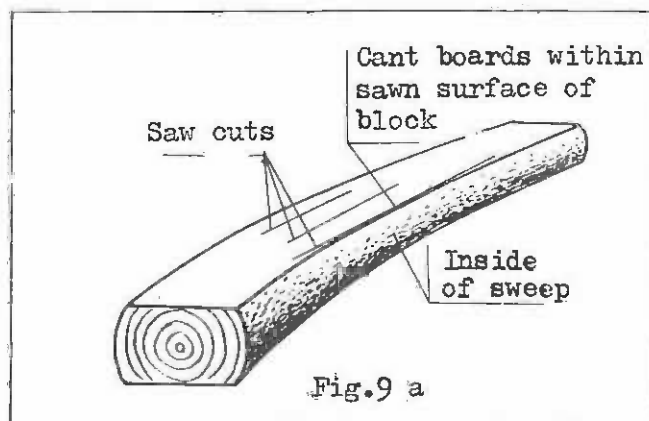
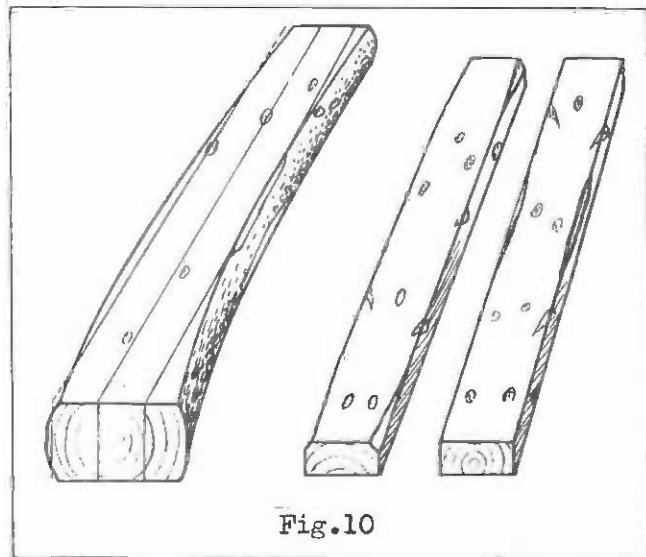
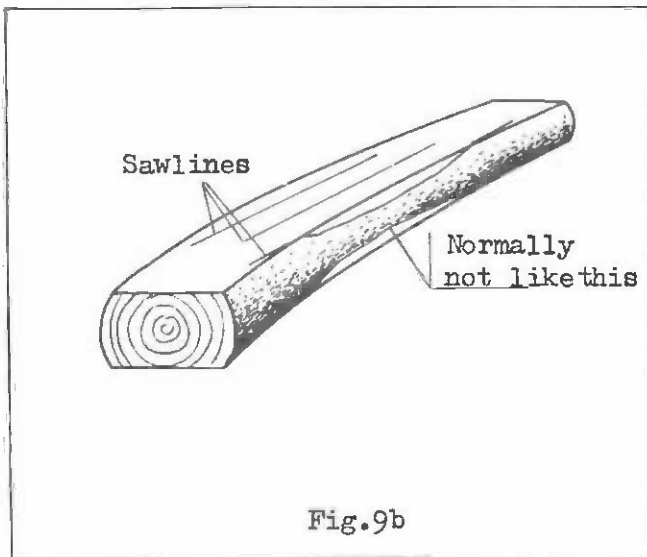


Fig.9 a

If one does not follow the rule and saws instead in accordance with figure 9b:

- wane will appear in the middle of one of the main planks but
- at the same time the amount of wane at the ends of the other plank will decrease.

If the quality of the log is low because of knots, blue stain, etc., such a sawing approach may be recommended. (See figure 10).

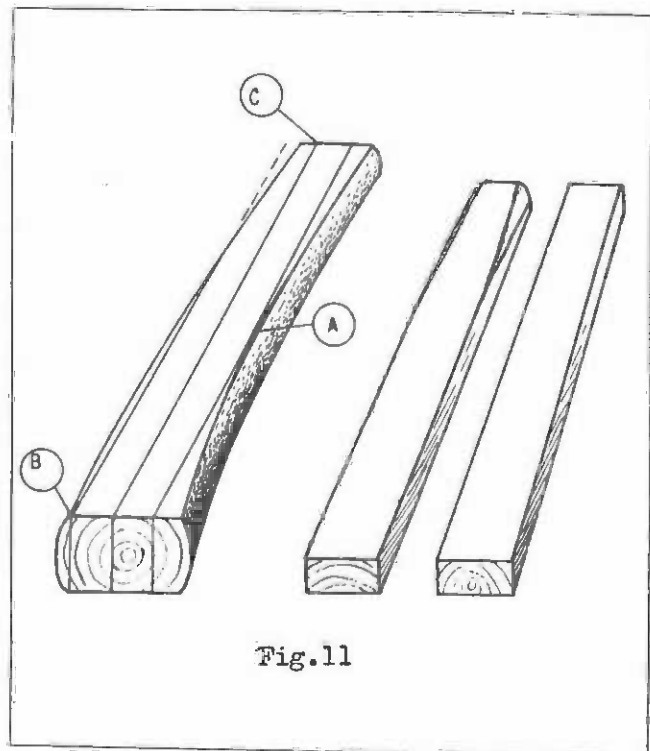


The rule is that the main yield should fall within the sawn surface in the inner sweep. If this rule is followed, resawing in the cant frame can be done in accordance with either of two principles:

### 3.1.1 Straight Sawing

The cant is sawn straight, i.e. it is fed through the frame so that the blades make straight cuts. The alignment is then made as indicated in figure 11,

The main yield should then fall within the sawn surface of the block, at the points A and B, and the middle cut should fall within the sawn surface in point C.



### 3.1.2 Curve Sawing

The cant is sawn curved, i.e. it is fed so that the saw cuts follow the sweep of the cant as in figure 12.

The possibility of doing this in a cant frame is limited depending on:

- the distance between the knife guides and the blades. (The closer they are, the greater the possibility.)
- the length of the knife guides;
- the distance between the separating plates for the main yield.

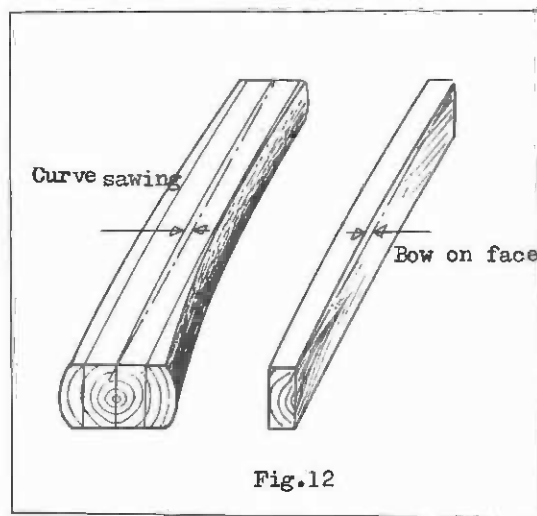


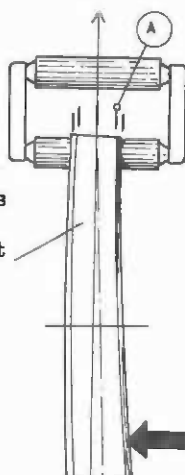
Fig.12

Fig.13 - Procedure for Curve Sawing

#### Position 1 - Infeed

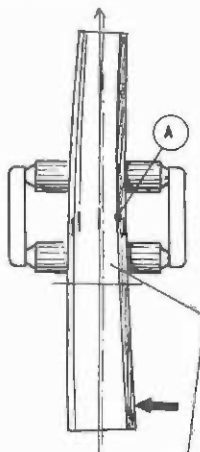
Blade A cuts within sawn surface of cant so main yield becomes fully edged. Direction of cant's butt end of block is moved sideways so centre line through top and butt ends is off-line compared to centre line through set of blades.

Sawing of first half. Butt end of cant is shifted sideways so that blade A follows edge of sawn surface of cant



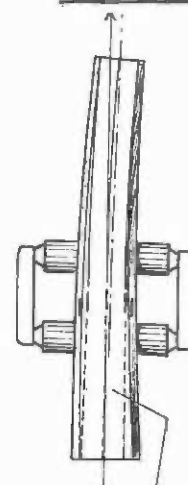
#### Position 2

Blade A now at edge of sawn cant. Centre line through top and butt ends of block is in line but shifted in comparison with centre line of set of blades.



Middle section is sawn with slight shift of the cant.

#### Position 3



Sawing of butt end is done without any shifting of cant. The cuts become straight. Sawn surface is wider here due to log taper, so straight sawing should not result in timber with wane.

3.1.3 A Comparison of Straight Sawing or Curve Sawing of cants from logs with sweep is made below.



### 3.1.3.1 Straightness

Straight sawing results in straight main yield,

Curve sawing gives main yield with bow.

The thicker the plank or board, the more important a defect bow becomes. During drying, restraint in a stack will tend to straighten bowed pieces.

### 3.1.3.2 Positioning of the pith

Straight sawing results in spread and therefore poor positioning of the pith in the main planks as it falls inside both planks, which can lead to distortion and cracks during drying.

Curve sawing can more favourably position the pith, which reduces risk of distortion and checks.

### 3.1.3.3 Wane

Straight sawing usually results in more wane on one of the main planks.

Curve sawing reduces the wane and, if the sweep is not too great, wane can be eliminated, resulting in full edged main yield.

### 3.1.3.4 Practical performance

Straight sawing is simpler than curve sawing. Curve sawing may, therefore, slow production levels unless there is special infeed equipment to simplify the procedure. Whether crooked cants are straight or curve sawn at the cant frame is up to the individual sawmill. By applying curve sawing, however, it is possible to increase the sawn timber recovery.

## 3.2 Logs with Irregular Cross Sections

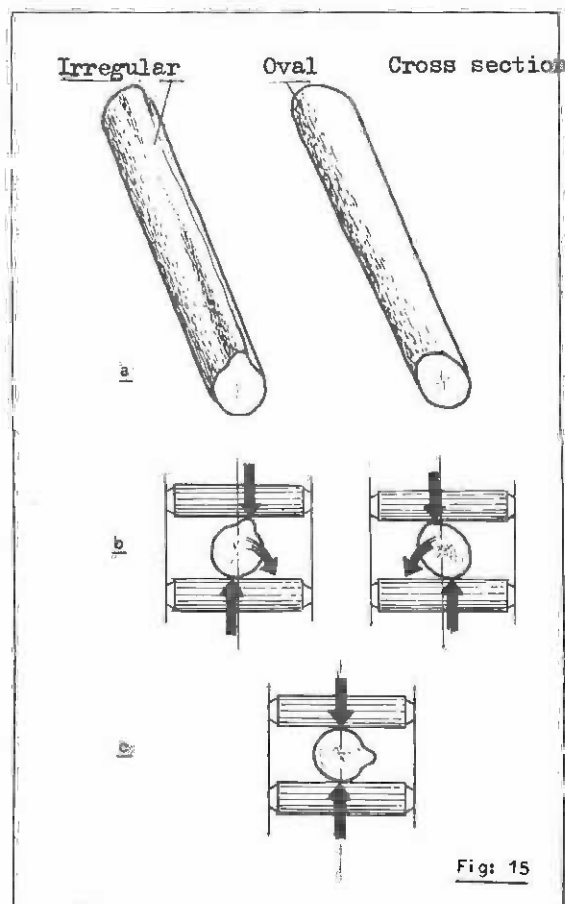
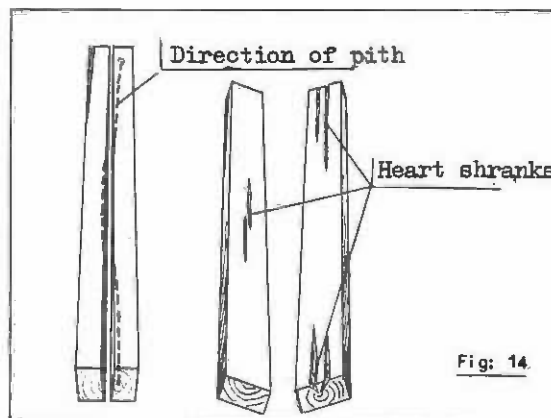
In figure 15a logs with irregular cross sections are shown, one being oval, the other irregular.

If these logs are positioned in the way that is shown in figure 15b, where each is resting against points on the upper and lower rollers that are not in a vertical line, the log will turn during sawing, resulting in a twisted cant.

### Infeed Rule for Log with Irregular Cross Section, Log Frame:

Align log so that contact points between log and upper and lower rollers form vertical line. (See figure 15c)

This gives the log the safest steering through the frame.

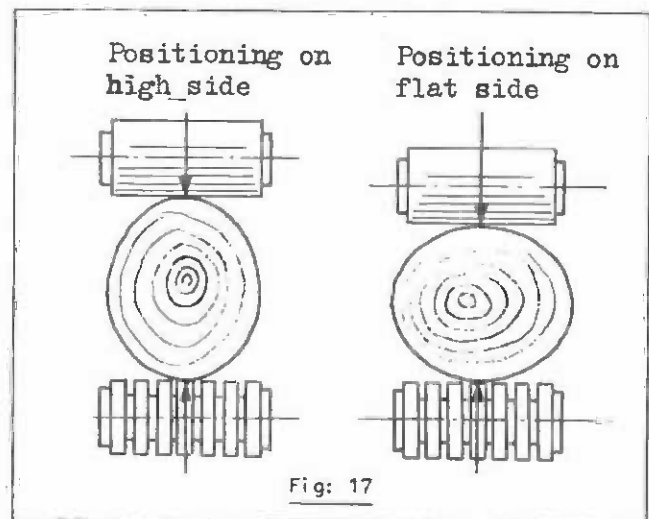
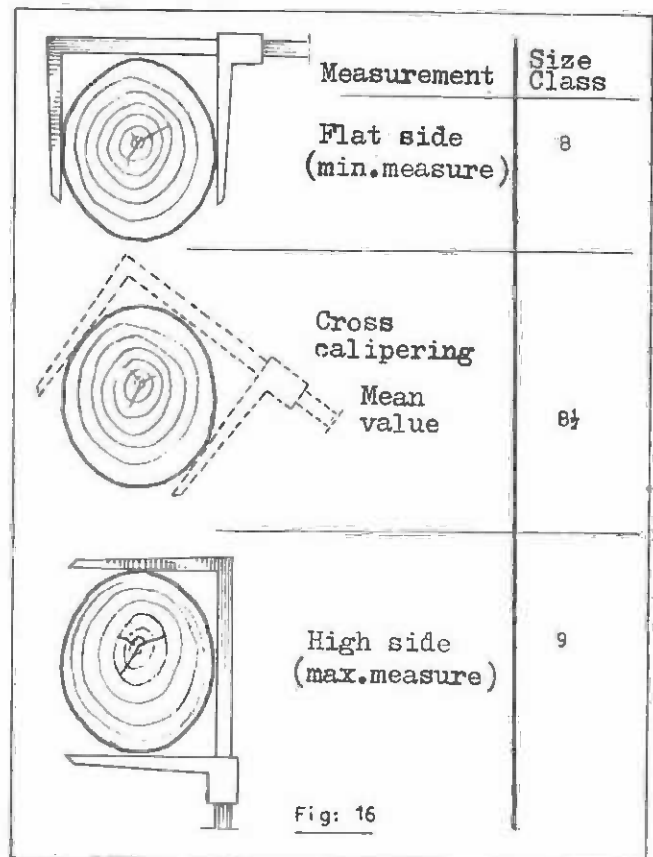


### 3.3 Oval Logs

When measuring an oval log, different diameters can be recorded depending on how the measurement is done. (See figure 16). The log can therefore be designated for different size classes.

To avoid this, oval logs must be measured by cross measurement. In practice, one measurement is made of the maximum diameter and one of the minimum diameter, following which the mean value is calculated and used.

To prevent an oval log from turning during the sawing process, according to the infeed rule for logs with irregular cross-sections, it can only be positioned resting either on its flat or high side. (See figure 17).



In figure 18 the top side of an oval log is shown:

- positioned on its high side,
- positioned on its flat side.

In the figure lines have been drawn that indicate 125, 150 and 175 mm wide planks, as well as 50, 63 and 75 mm plank thickness. The intersection between any of these two lines shows how the corner of a cant board will fall in relation to the top area of the log.

The table in figure 18 indicates:

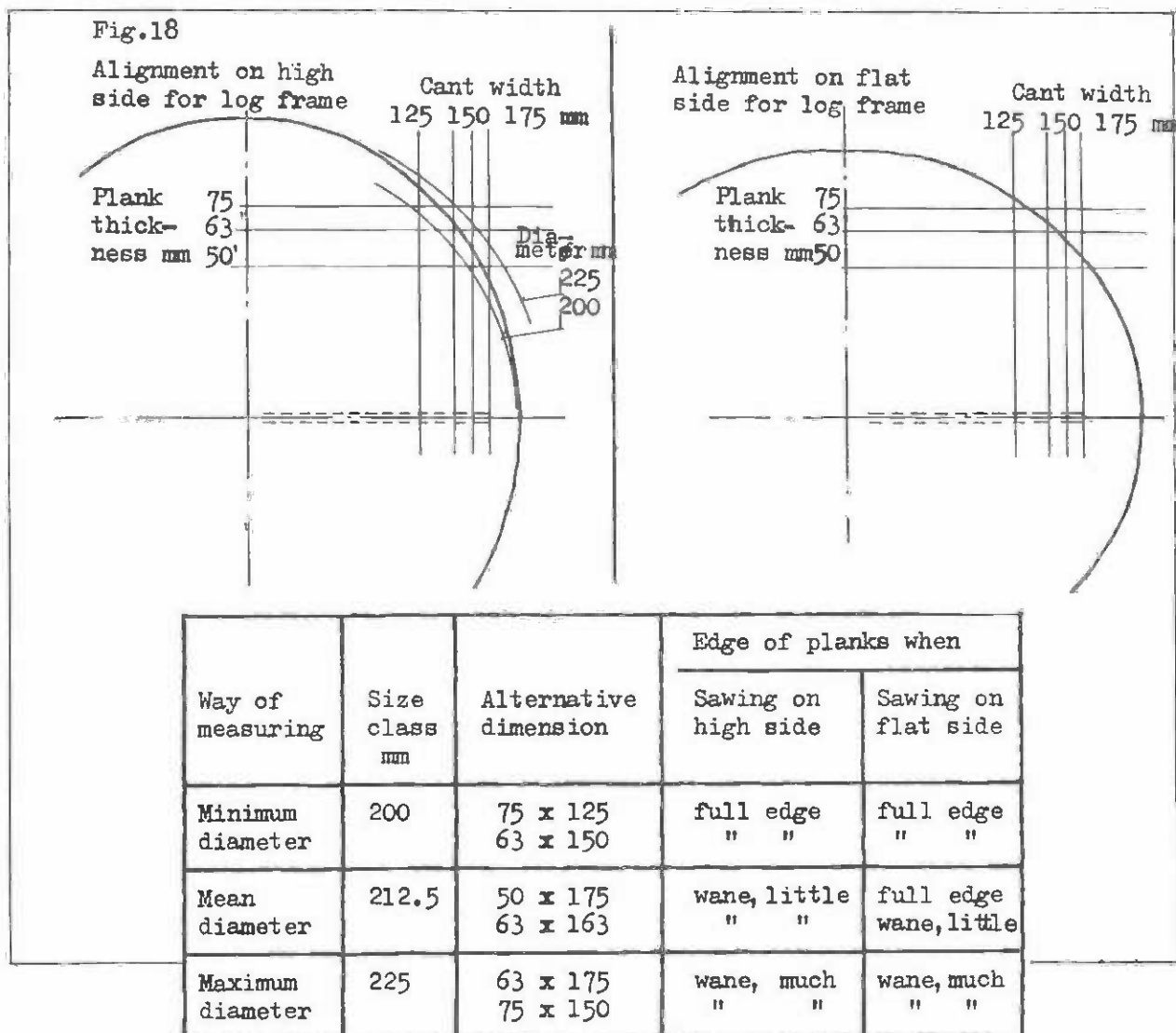
- the different ways to measure logs, and
- to which size class the log would have been assigned depending on the results from these. In addition, we can see:
- alternative dimensions for the different size classes and a description of the edge of the main yield.

We can draw the following conclusions from the table:

- Measuring the maximum diameter results in the highest amount of wane no matter how the log is positioned.
- Measuring the minimum diameter gives the greatest certainty of full edged main yield.

Positioning the log on its flat side gives an advantage in one case only, when cutting 50 x 175 mm.

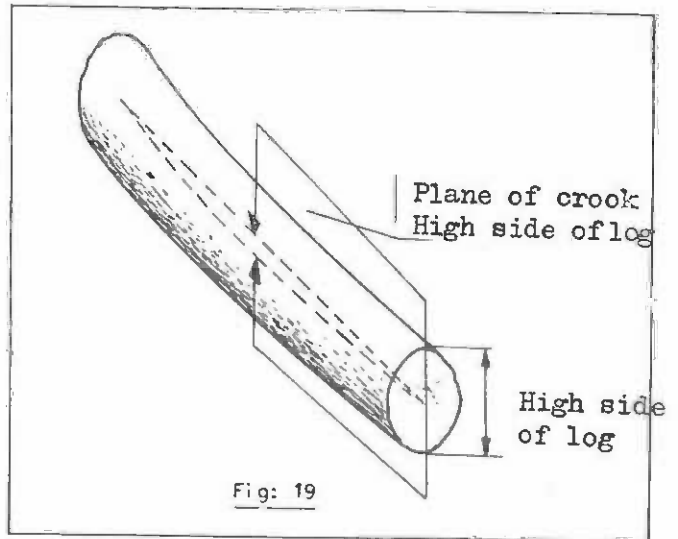
To position the log on its flat side, however, necessitates that the log is straight if any benefit is to be gained.



It is, however, common that oval logs also have sweep. A softwood tree that grows crooked forms "compression wood", on the low side of the log, resulting in an oval stem. Figure 19 shows how crookedness and ovality occur at the same time in a log. If the crook is placed downwards, the oval is on its high side.

Infeed Rule for Oval Log, Log Frame:

The log is normally positioned on its high side. In addition, adjust log so that resting points between rollers and log are in a vertical line. (Figure 15.)



4. Sawing Logs with Bole Defects

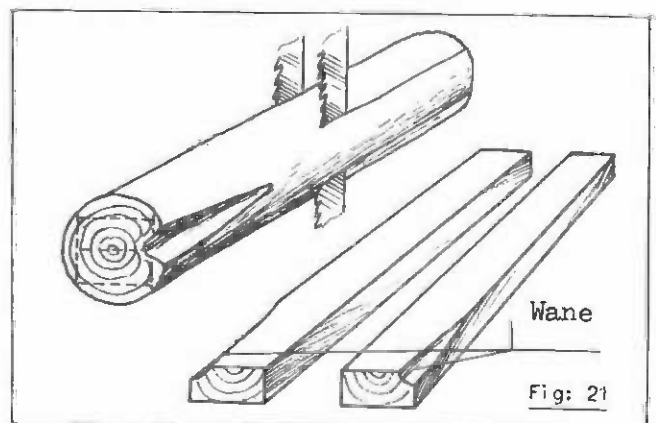
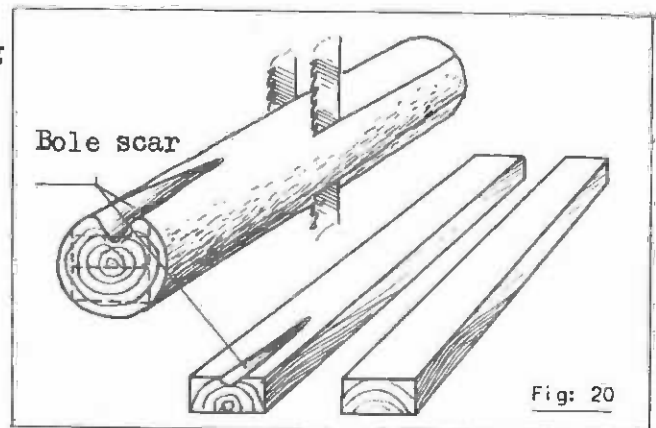
A bole scar will occur on a standing tree following external damage and subsequent healing.

The bole scar usually takes the form of a depression in the log which can be so deep that the main yield is affected.

Infeed Rule for Log with Bole Scar, Log Frame:

Turn log so that the bole scar is on the top side. (See figure 20.)

If the log is positioned with the bole scar on the side, both planks can be affected so that they need cutting. (Figure 21.)



## 5. Sawing Logs with Heart Shakes

Heart shakes occur mostly in large diameter logs. They originate in the standing tree. As the heartwood gets older and dries, it may shrink to the stage of checking. If such logs are stored in water, the cracks will swell up and disappear, only to widen again when the sawn timber is dried.

### Infeed Rule for Log with Heart Shakes, Log Frame:

Position the log so that the biggest crack lies horizontally. (See Fig.22.)

If the log is positioned with the heart shake vertically, it will affect both planks after resawing. (Fig.23.)

## 6. Sawing Logs with Quality Defects

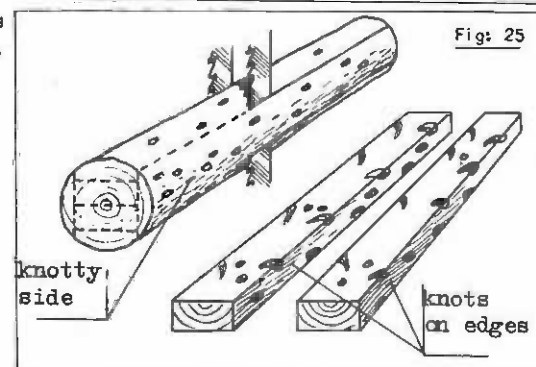
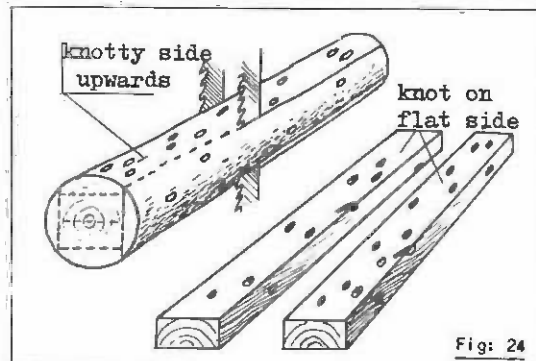
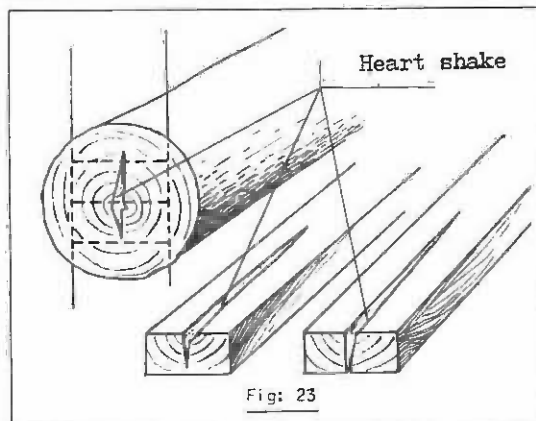
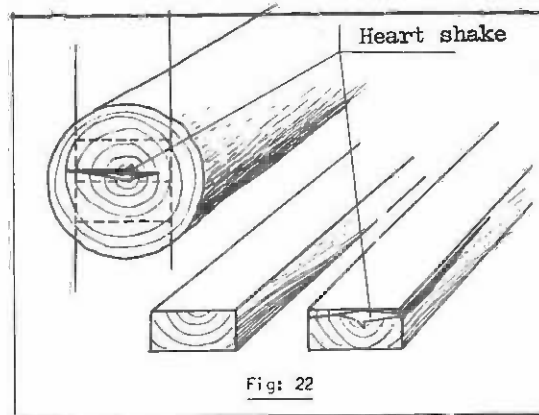
A log with knots distributed evenly over the surface must be positioned primarily according to its form.

Very often, however, a log has most of its knots concentrated on one side. This can be due to the fact that the tree has been growing next to an open space so that the branches have developed more on that side. Or the tree might have been crooked and the branches have developed more on the opposite side in order to even out the load distribution.

### Infeed Rule for Log with most knots on one side, Log Frame:

Turn the log so that the worst side is upwards. (Figure 24.)

The smaller cross section of the knots will then appear on the face of the planks. If the log is positioned with the worst knots to one side, larger cross section knots (or wing knots) will appear on the face of the cant boards, depressing quality more.



The above rules describe the procedure for aligning logs with only one defect at a time. But a log can have many different defects at the same time, so it is necessary to determine which of these defects will have the greatest influence on the sawn yield.

PART V - MAINTENANCE

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In order to achieve an effective production the frame saw has to be maintained regularly: daily check-ups should be carried out and repairs made by skilled personnel and with original spare parts.

Detailed maintenance and greasing instructions must be provided by each frame saw manufacturer. Below are some more general statements on frame saw maintenance.

There are two kinds of maintenance:

- pre-maintenance, such as greasing, oiling, controls and adjustments.
- minor repairs or services to eliminate previous disturbances in production.

Pre-maintenance is of the utmost importance in order to reduce the rate of breakdown.

## Check-ups

### 1. Daily

#### a) Before starting the machine, check:

- the lubricating system, ensuring that grease flows into the sash guides.
- the water cooling device, fan and pump.
- the play between guides and sliding blocks.
- that the sawdust evacuation slope is open.
- that the roll frames are locked into position.
- that the opening between upper and lower roll frames is set according to log dimensions.
- that the blade setting is correct.
- that greasing has been done following grease instructions.

#### b) While sawing:

- adjust feeding speed according to instructions.
- if the speed of the sash is reduced when feeding logs through, infeed has to be stopped and the reasons for the disturbance found.
- if a piece of wood is wedged between blades or between blades and sash columns, the frame must be stopped and the piece removed; ignorance of this might cause accidents or overheating of blades.
- if greasing or cooling of the guides is not satisfactory, a certain smell from the sliding blocks can be noticed; if this happens, the reason has to be found and rectified. Cooling water must not be passed through overheated sliding blocks until they have cooled off.

### 2. Weekly

The temperature of the lower connecting rod bearing should be measured and registered.

The cross beams, columns and connecting rod should be cleaned and checked for damage. To achieve the best result an electric or pneumatic brush should be used. The connecting rod should be brushed lengthwise. Damages or nicks on the cross beams are easier to discover when the blades in the sash are tightened.

Smaller nicks should be grounded down with an emery or a polishing cloth.

3. Monthly

Adjust all chains and check for wear and tear.

Check shafts and bearings of the feed rolls.

Check the wear of the sliding blocks.

Check and tighten all bolts, including anchor bolts.

4. Every Three Months

The lower connecting rod bearings should be washed and cleaned.

5. Twice a Year

The bearing play of the upper and lower connecting rod bearings should be measured. If it exceeds the recommended limits, the bearing must be replaced.

6. Once a Year

The frame saw should be thoroughly checked; all worn parts should be replaced; bolts should be tightened and bearings cleaned.

The connecting rod bearings should be washed.

The guides should be cleaned and checked.

The movement of the sash should be controlled.

The alignment of the frame saw should be checked so that any changes in foundation or base plate may be noted.

7. Lower Connecting Rod Bearing

This bearing is one of the most important and has to be maintained carefully. Grease types and working/greasing intervals can be found in the manufacturer's recommendations.

Important to note when greasing:

Before greasing, grease nipples, and the grease pump muzzle should be cleaned to avoid dirt getting into the bearing. Greasing should be done immediately after the frame has been stopped. The temperature of the connecting rod and the bearing caps should be checked. Maximum allowed temperature is 60°C. At least once a week the inside temperature of the bearing should be measured. This temperature and the temperature in the sawmill should be registered. Increased temperature is normally an indication of bearing pollution or of wear and tear. By studying the registered temperature variations it is possible to maintain or repair details before complete breakdown.

Increased temperature can also be caused by faulty mounting of the guides resulting in abnormal sash movement or vibrations. If the reason for increased temperature cannot be detected, the bearing has to be washed and greased several times before the result is satisfactory.



#### 8. Upper Connecting Rod Bearing

The gudgeon pin of this needle bearing should be checked and cleaned once a year.

The brake should be locked when the sash is in its top position.

The sash should be fixed in its upper position by using a pulley.

The infeed guide bolts should be loosened and the guides pulled back as far as possible.

The bolts in the crank pin brackets of the lower cross beams should be loosened.

The slots in the pin brackets should be widened to release the pin.

Using the pulley, the sash should be adjusted so that the pin can be removed.

To prevent the bearing needles from falling out a provisional pin should be inserted when removing the original pin.

#### 9. Guide Control

The guides should be controled and aligned once a year.

The infeed guides are checked by using a straight edge at least as long as the guide and an insert knife measuring device. If the play exceeds recommendations, the guide must be exchanged or repaired.

The outfeed guides should be checked using a straight edge long enough to cover upper and lower guides simultaneously. The check-up should be made having the guides mounted in the frame. For maximum play allowed between straight edge and guide, see manufacturer's recommendations.

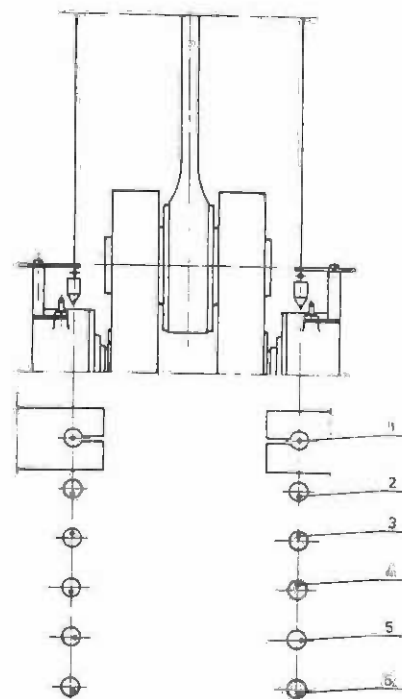
To align the guides when mounted in the frame, use a plumb line from the upper to the lower guides and compare with allowed deviation. If this control indicates that the base line of the frame, for any reason, has been changed, correction should be made by adjusting the base plate.

#### 10. Control of Sash Movement

This should be carried out once a year but also if abnormal vibrations in the frame are noticed.

There are two ways of controlling this:

1. Open the caps of the lower connecting rod bearing and measure the distance between the rollers and the outer ring. The distance should be the same for any position of the sash.
2. A more accurate result is achieved using two plumb lines and two metal sheets with a hole in the centre. See figure below.



- 1 Good  
2-3 Accepted  
4-6 Correction required

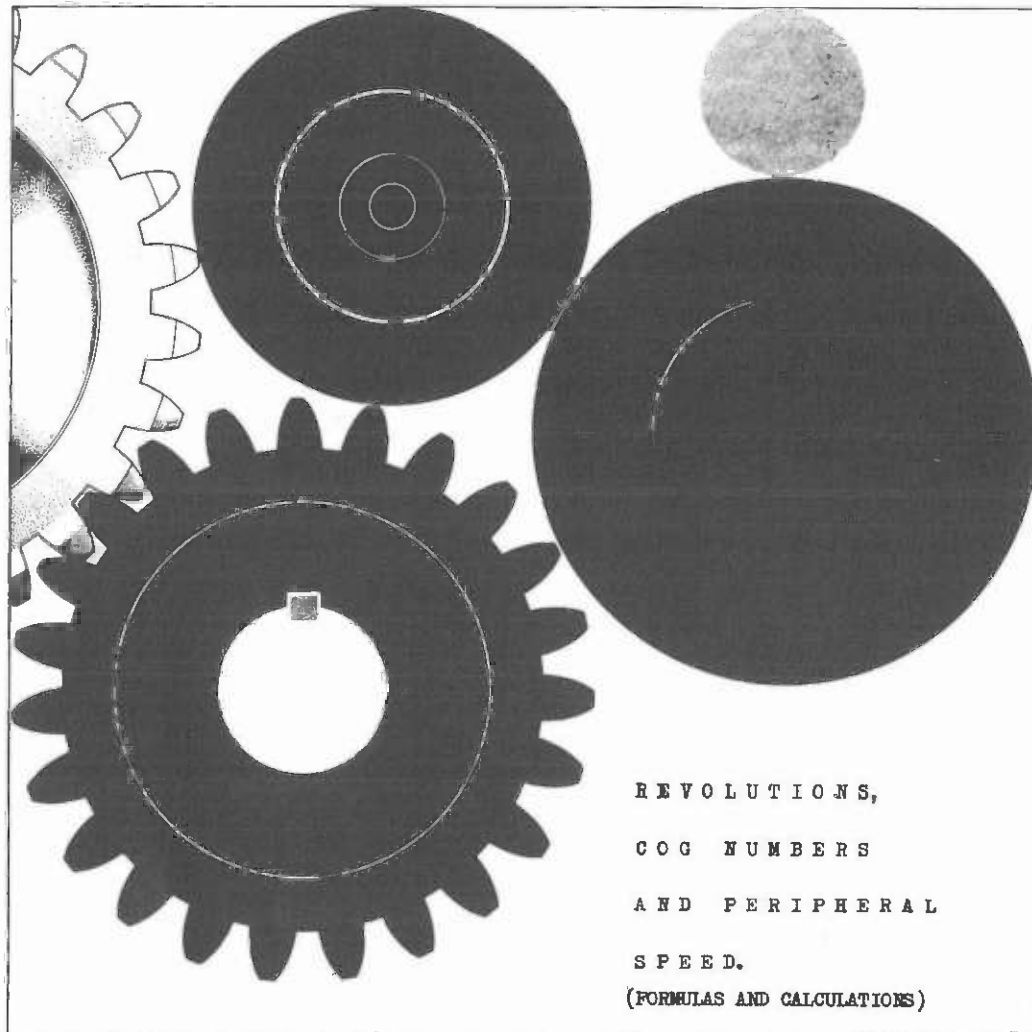
- Attach the two metal pieces to the crank shaft bearing housing as shown in figure.
- Pull the plumb lines through the holes in the metal pieces and attach the line to the lower cross beams of the sash and vertical to the holes. The sash should be in its top position.
- Adjust the metal pieces to centre the plumb line in the hole.

Using a file, mark the position of the plumb lines of the lower cross beam.

- Lower the sash to its bottom position and attach the plumb lines to their previous position, using the file marks.
- If the movement of the sash is incorrect this can be seen from the position of the plumb line in the hole. The figure shows some typical faults of which some can be accepted and some have to be corrected.

#### 11. Guide Cooling System

Regular control of the cooling system efficiency is recommended. It is easily carried out by measuring in and outgoing water temperature. Maximum allowed outgoing temperature is 65°C and maximum allowed difference between in and outgoing water temperature is 15°C.



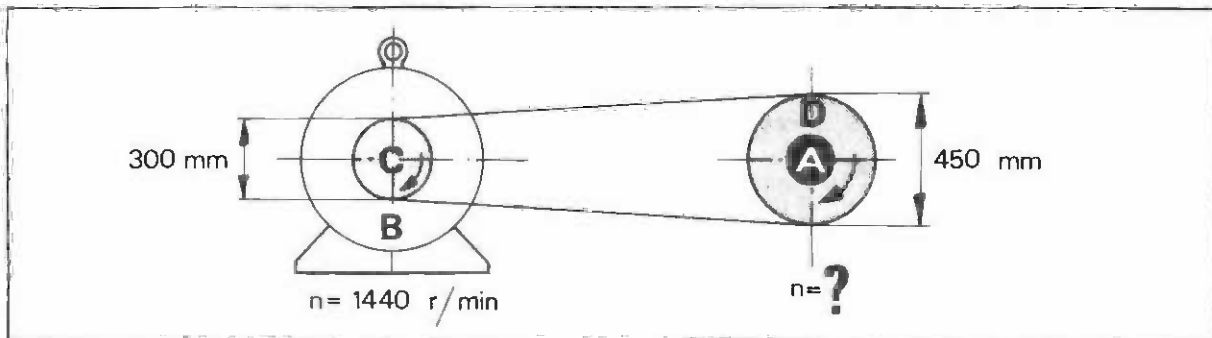
PART VI - REVOLUTIONS, COG NUMBERS AND PERIPHERAL SPEEDS

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3. How to Calculate the number of Revolutions of a Shaft.

- i) TASK: To find the number of revolutions of the driven shaft A in the figure below



- ii) INITIAL POINTS: We start from what we know:

- that the engine B runs at 1440 r/min.
- that the pulley C has a diameter of 300 mm.
- that the pulley D has a diameter of 450 mm.

- iii) CALCULATIONS: To find out the unknown number of revolutions the following calculations are made:

- The number of revolutions of the engine is multiplied by the diameter, in mm, of the pulley of the engine.
- In this case it is  $1440 \times 300$ .
- This figure is divided by the diameter of the driven pulley, which gives the unknown number of revolutions, i.e.

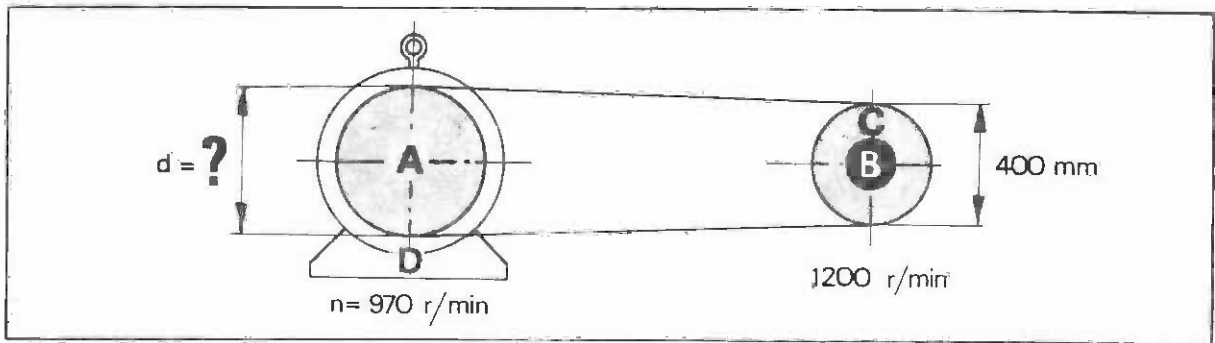
$$n = \frac{\text{engine speed} \times \text{diameter of driving pulley}}{\text{diameter of driven pulley}} = \text{unknown number of revs.}$$

In this case the answer is:

$$n = \frac{1440 \times 300}{450} = 960 \text{ r/min}$$

#### 4. How to Calculate the Diameter of a Pulley

- i) TASK: To find the suitable diameter of pulley A in the figure below.



- ii) INITIAL POINTS: We start from what we know:

- that the driven shaft B has a pulley C, the diameter of which is 400 mm.
- that this shaft needs to rotate at 1200 r/min.
- that the engine D runs at 970 r/min.

- iii) CALCULATIONS: To find the unknown diameter the following calculations are made:

- To start with, we calculate the gear ratio between the pulley and the engine. This is done by dividing the number of revolutions of the pulley by the number of revolutions of the engine, i.e.

$$\frac{\text{number of revolutions of pulley/min}}{\text{number of revolutions of engine/min}} = \frac{1200}{970}$$

- Then, this ratio is multiplied by the diameter of the driven pulley C, i.e.

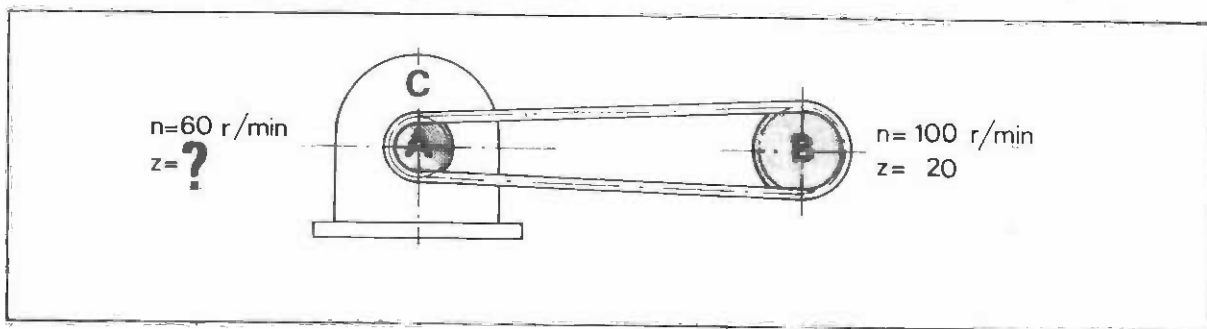
$$d = \frac{1200}{970} \times 400 = 495 \text{ mm.}$$

This result can be rounded off to the higher figure of 500 mm which is a standard diameter.

5. How to Calculate the Number of Teeth required on a Sprocket

To calculate the gear ratio for chain drives or cog transmission, i.e. the relationship between the number of teeth or cogs of the driving and the driven sprocket, the same procedure can be used as in the previous example. The only difference is that instead of using the diameter of a wheel, the number of teeth or cogs is used.

- i) TASK: To find the necessary number of teeth of the driven sprocket A in the figure below.



- ii) INITIAL POINTS: We start from what we know:
- that the conveyer roller B will do 100 r/min.
  - that its sprocket has 20 teeth
  - that the engine C does 60 r/min.
- iii) CALCULATIONS: The following calculations are made according to the general formula:

$$\frac{\text{speed of cog wheel A}}{\text{speed of cog wheel B}} \times \text{the number of teeth of cog wheel B} =$$

= the unknown number of teeth of cog wheel A.

Applied to our example:

- divide the speed of engine A by the speed of conveyor roller B, and
- multiply the result by the number of teeth of the chain wheel B, i.e.

$$\frac{\text{engine speed A/min}}{\text{conveyor speed B/min}} \times \text{number of teeth of wheel B} =$$

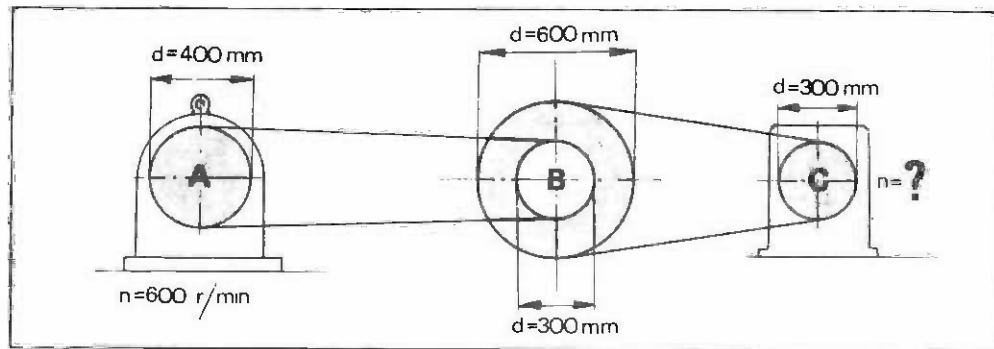
= unknown number of teeth of wheel A.

With figures inserted

$$Z = \frac{60}{100} \times 20 = 12 \text{ teeth}$$

6. How to Calculate the number of Revolutions of a Shaft when Power is transmitted over several intermediate Shafts

- i) TASK: To determine the rotation speed of machine C when power is transmitted through an intermediate shaft B from the driving wheel A, as illustrated in figure below.



- ii) INITIAL POINTS: We start from what we know:

- that the speed of the driving wheel A is 600 r/min.
- that the diameter of the driving wheel A is 400 mm.
- that the driven wheel of the intermediate shaft B has a diameter of 300 mm.
- that the driving wheel of the intermediate shaft B has a diameter of 600 mm.
- that the diameter of the disc of machine C is 300 mm.

- iii) CALCULATIONS: To find the unknown number of revolutions, the following calculations are made:

- the number of revolutions of the intermediate shaft B is first calculated as follows:

$$\frac{\text{diameter of driving wheel}}{\text{diameter of driven wheel}} = \frac{\text{number of revs of driven wheel}}{\text{number of revs of driving wheel}}$$

Note: Make sure which wheel is driven and which is driving.

With figures inserted:

$$n = \frac{400}{300} = \frac{\text{number of revolutions of B}}{600}$$

$$\text{the number of revolutions of B} = \frac{600 \times 400}{300} = 800\text{ r/min.}$$

- the number of revolutions of C can be calculated using the same formula:

$$n = \frac{600}{300} = \frac{\text{number of revolutions of C}}{800}$$

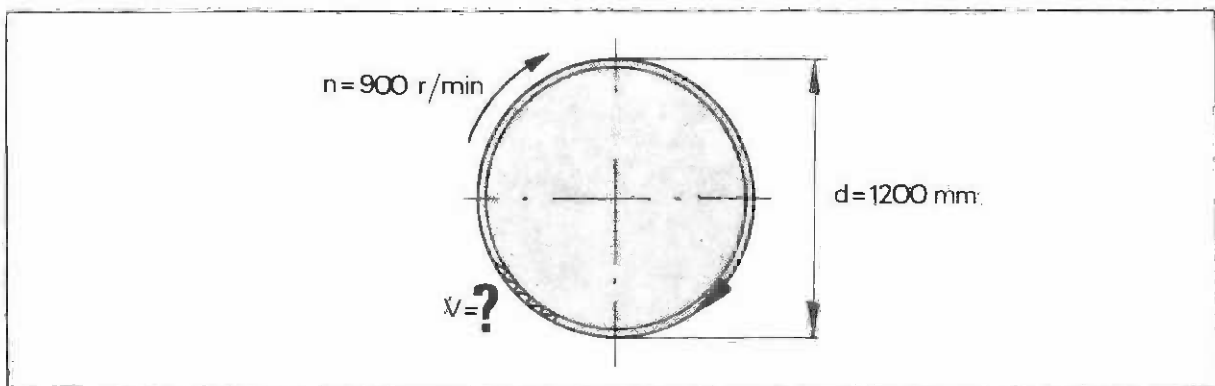
$$\text{the number of revolutions of C} = \frac{600 \times 800}{300} = 1600\text{ r/min}$$



## 7. How to Calculate Peripheral Speeds

Peripheral speed (henceforth marked with the letter  $V$ ) is the speed of an imagined rotating point situated on the circumference of the rotating shaft. It is usually expressed as metres per second (m/sec).

- i) TASK: To find the peripheral speed ( $V$ ) of the tooth points of a circular sawblade. (See figure below).



- ii) INITIAL POINTS: We start from what we know:

- that the diameter of the sawblade is 1200 mm.
- that the sawblade does 900 r/min.

- iii) CALCULATIONS: To find the unknown peripheral speed, the following general formula is used:

- The circumference of the sawblade ( $c$ ) (in metres) is multiplied by the number of revolutions of the sawblade (in r/sec).

- Using the formula for the circumference of a circle ( $c = \pi \times d$ ), we calculate the circumference of the sawblade:

$$c = \pi \times 1.2 = 3.14 \times 1.2 \text{ m} = 3.77 \text{ m}$$

- The circumference,  $c$ , is then multiplied by the number of revolutions per second of the sawblade, i.e.

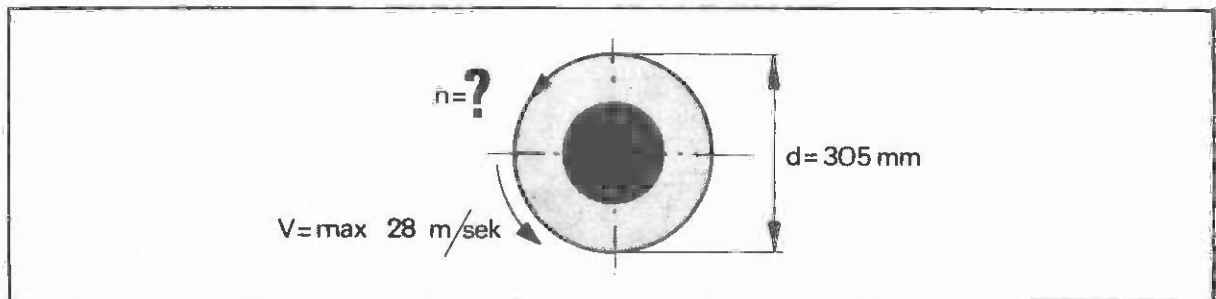
$$V = 3.77 \times 900 \text{ r/min} = 3.77 \times \frac{900}{60} \text{ r/sec} = 57 \text{ m/sec.}$$

$$(\text{Note } \text{revs/second} = \frac{\text{revs/minute}}{60})$$

## 8. Some Practical Examples

A. How to calculate the maximum number of revolutions of a grinding disc.

- i) TASK: To install a new grinding disc in a grinder mounted on a circular saw we need to know the maximum number of revolutions of a disc of a given diameter. (See figure below.)



ii) INITIAL POINTS: We start from what we know:

- that when grinding free-hand with a ceramic disc, as in this case, a maximum peripheral speed of 28 m/sec is allowed.
- that the diameter of the disc is 305 mm.

iii) CALCULATIONS: The unknown number of revolutions (n) can be calculated from the formula:

$$\text{peripheral speed } V = \text{circumference } c \times \frac{\text{number of revolutions (r/min)}}{60}$$

In this example  $V = 28 \text{ m/sec}$

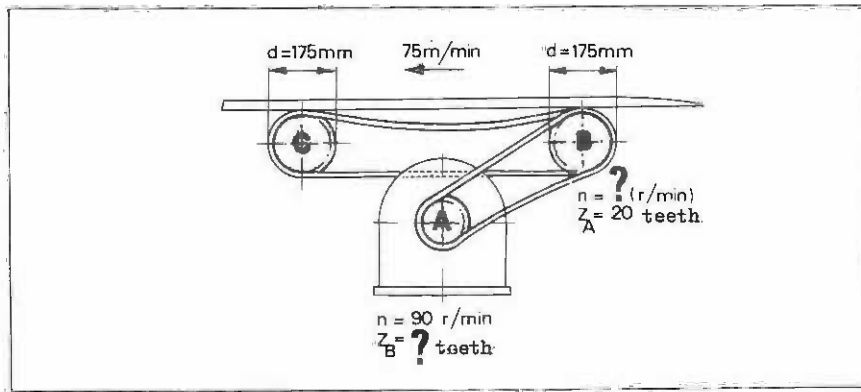
$$c = \pi \times \text{diameter of disc} = 3.14 \times 0.305 = 0.96 \text{ m}$$

Inserted into the above formula we find:

$$n = \frac{28 \times 60}{0.96} = 1750 \text{ r/min.}$$

B. How to calculate the necessary number of teeth of a sprocket.

- i) TASK: To calculate the required number of teeth on the sprocket of motor A (in figure below) to make the roll conveyer work at a desired speed.



ii) INITIAL POINTS: We start from what we know:

- that the required speed of the roll conveyer is about 75 m/min.
- that the sprocket on motor A does 90 r/min.
- that the driven sprocket B has 20 teeth ( $Z_B$ ) and diameter of 175 mm.

iii) CALCULATIONS: This problem is solved by using the formula

$$\frac{\text{number of revolutions of sprocket A}}{\text{number of revolutions of sprocket B}} \times \text{number of teeth of sprocket B} = \text{the unknown number of teeth of sprocket A.}$$

To be able to use this formula we must first calculate the number of revolutions of sprocket B.

We know that the peripheral speed of B must correspond to the desired peripheral speed of the roll conveyer, i.e. 75 m/min. By using the formula below we can therefore calculate the number of revolutions of B:

Peripheral speed  $\pi$  x diameter x number of revolutions.

With figures inserted:

$$75 = \pi \times \frac{175}{1000} \times n$$

$$n = \frac{75 \times 1000}{\pi \times 175} = 136 \text{ r/min. (Note: } 175\text{mm} = \frac{175}{1000} \text{ m)}$$

We can now calculate the necessary number of teeth of driving sprocket A by using the first formula:

Unknown number of teeth ( $Z_A$ ) is

$$Z_A = \frac{90}{136} \times 20 = 13.25 = 13 \text{ teeth (rounded off to nearest whole number)}$$

By checking this example for  $Z_A = 13$  teeth we find that roll conveyor will work a little faster than 75 m/min.