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INTRA-REGIONAL COOPERATION IN DEVELOPMENT OF PLANTATION-BASED FOREST INDUSTRIES

DU/RAF/87/117

Technical report: Circular sawblade maintenance - Sawdoctoring techniques*

Prepared for the Preferential Trade Area
for Eastern and Southern African States (PTA)
by the United Nations Industrial Development Organization,
associated agency of the Food and Agriculture Organization
of the United Nations, which acted as executing agency
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* This document has not been edited.

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Table of Content

This manual should be read together with the 25 minute video "Sawdoctoring: Circular Plate Blades" prepared by Geoffrey Woods and Richard Hemmingway. They are the first of a series intended for use as vocational training aids for developing countries covering the maintenance and repair of woodworking cutting tools.

1. INTRODUCTION

Good sawdoctoring is all about producing and maintaining saws and other cutting agents to the highest possible standard which will enable the workforce and management to maximise production with the minimum of cost of both valuable raw material and expensive cutting agents.

As well as substantial savings in materials, sharp cutting agents require less power to drive them, less power to feed the material being machined be it mechanical or hand as well as making all operations much safer.

Well balanced saw blades and other tooling create less vibration and therefore the minimum of wear on expensive capital equipment.

We are therefore hoping that the video will assist both the sawdoctor to improve his skills and management to realise the importance of those skills so that they can supply the necessary backing to this vital section of their organisation in order to achieve the desired results.

This manual will cover and expand where necessary the subjects covered by the video.

2. CUTTING ACTION OF SAW TEETH

Wood is a fibrous material. The only way to achieve a clean cut is to sever the fibre across its length. We need to make cuts at many different angles to create useful shapes from wood, so we have to look at two distinct approaches. The first is along the grain, which is called ripping. The second is across the grain which is called cross-cutting. The rip saw is the one that creates PLANKING. The cross cut saw cuts it to length.

We have seen on the video how a knowledge of woodworkers hand tools can help us with the design and sharpening of machine saw blades and indeed other cutting agents. The basic idea of severing the fibres ACROSS their length is all important for both hand and machine tooling. SEE FIG 1 & 2.

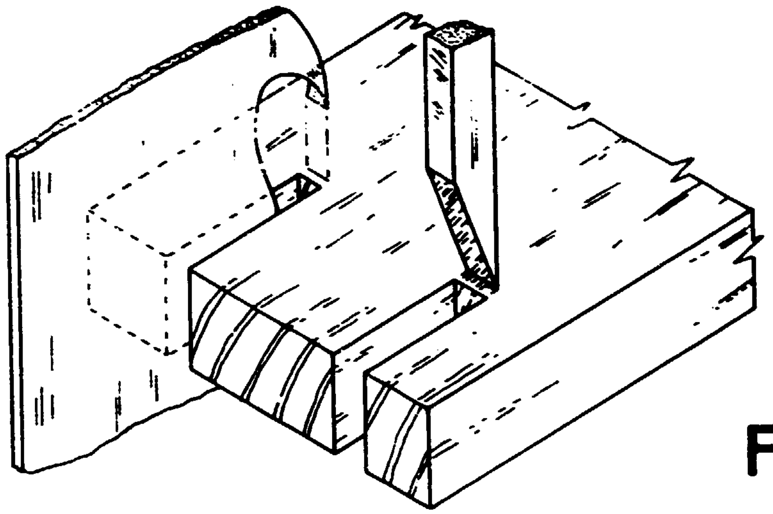


FIG. 1

CUTTING ACTION "RIPPING"

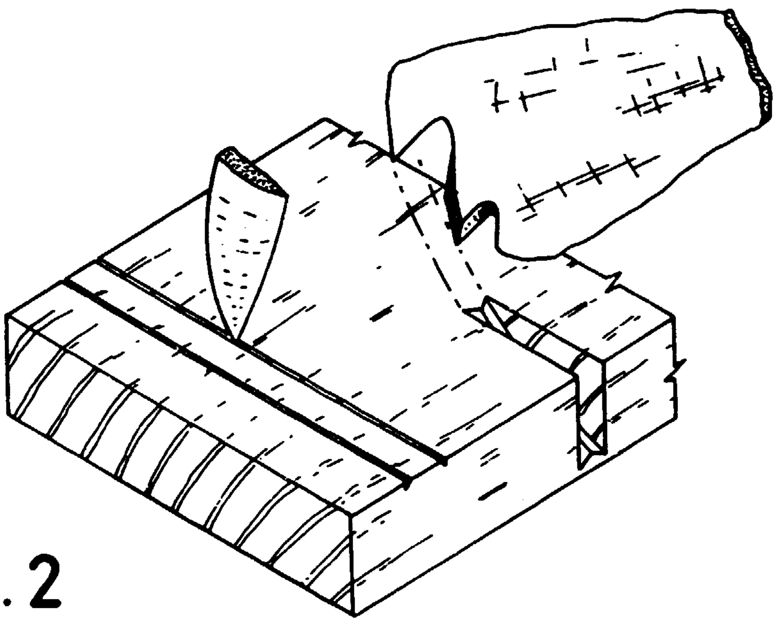


FIG. 2

CUTTING ACTION "CROSS-CUTTING"

What is different is the speed at which the machine tooling cuts. Circular saw blades which we are dealing with run at an average speed of around 3000 metres per minute or 50 metres per second. This high speed allows saw blades to cut reasonably well even if the teeth are not correctly designed or sharpened. The difference between a good and bad tooth design may not become apparent until difficult sawing conditions have to be overcome such as sawing extremely dense timber or when trying to increase feed speeds for increased production. However, we should always endeavour to get the design right to suit whatever criteria are important at the time even if it is only economy in blade life.

One of the most important aspects of sawing is achieving a good tooth bite for if it is too small the teeth will blunt quickly and need sharpening more often, increasing both the cost of maintenance as well as blade replacement. A minimum tooth bite of 0.5mm. for hardwood and 0.6mm. for softwoods should be aimed for but tooth bites of up to 3mm. are used where power and size of blades are exceptionally large. The experienced sawdoctor will collect a handful of sawdust from under the machine and be able to tell if the blade is cutting efficiently. The sawdust should be quite coarse and not a fine dust.

The tooth bite can be calculated using the simple formula:

$$b = \frac{fp}{s}$$

where:

f = feed speed (m/min)
p = tooth pitch (min)
s = blade speed (m/min)

for example : $b = \frac{12 \times 50}{2460} = 0.24$ mm

This is too small for a good tooth bite and several things can be altered to increase its size. i.e. The easiest thing to alter would be to increase the feed speed, it may be possible to reduce the blade speed and of course the tooth pitch could be increased. One or all of these would increase the tooth bite and therefore the efficiency of the cutting action of the machine.

3. TOOTH GEOMETRY

Tooth Pitch: We have seen on the video that the tooth pitch is the distance between successive tooth points and on circular saw blades it will determine the number of teeth on a blade. In practice it is the other way around as the manufacturer will punch on popular numbers of teeth such as 54 and 60 teeth for soft and hardwood ripping respectively and perhaps 80 teeth for cross-cut blades. Special blades for power feed edgers may have fewer teeth designed around a more efficient tooth bite but often we do not have much to choose from when ordering new blades from a standard range.

If we want to calculate the correct PITCH we change the formula to:

$$p = \frac{fb}{s}$$

for example: Using the same facts as before except for the tooth bite which we will change to 0.5mm. the resulting pitch will be:

$$p = \frac{2460 \times 0.5}{12} = \underline{102.5 \text{ mm}}$$

This is a bigger pitch than is usually found on standard plate blades. It is almost certain that the smaller pitches on standard blades allow for inaccurate hand filing when many teeth would not cut their equal share. For example if a tooth were low by as little as 0.5mm (the tooth bite) then it would not cut at all, thereby increasing the tooth bite and workload of the following teeth. A pitch of 100mm would not be unusual on inserted tooth blades for log resaws or edgers.

Hook Angle: The hook angle of rip-saw teeth is perhaps the most important angle for it determines how easily the teeth will sever the fibres. The more that the teeth lean forward the easier they will sever the fibres and cut through the timber using the minimum of power. A hook angle of up to 40 degrees can be used for blades cutting green softwoods but the angle may have to be reduced to give a stronger tooth profile for cutting dry dense harder timbers. Don't forget however that the gullet shape and depth have a great deal to do with tooth strength and rigidity. A large hook angle with a long deep face to the tooth as in Fig.3. could be a weak unstable

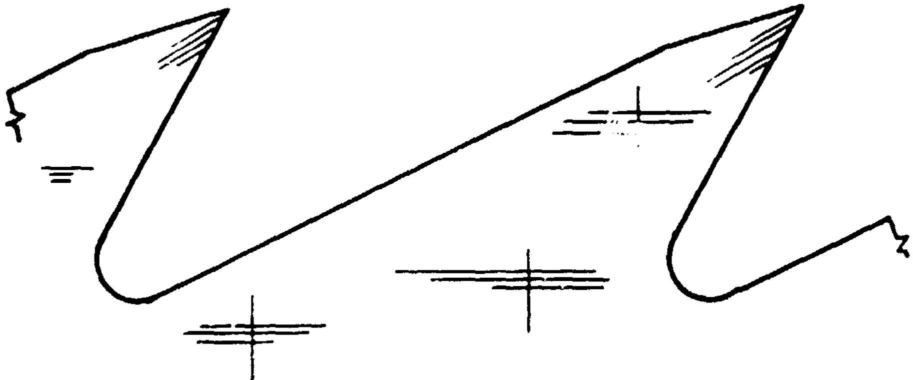


FIG. 3

tooth but we don't necessarily have to reduce the hook angle, we can alter the shape of the tooth as in Fig.4.

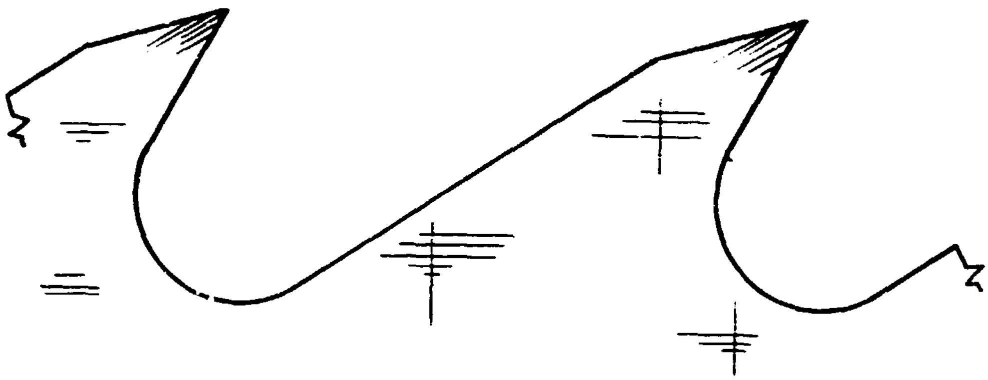


FIG. 4

Top Clearance Angle: The top clearance angle of the teeth is measured between the top surface of the tooth and a tangential line drawn from the cutting edge. If the angle is too small fast feeding of the timber will be impossible. If it is too large the teeth may be weakened and rapid blunting may occur. Normally this angle will be between 12 and 16 degrees for satisfactory performance. Again you may realise that the smaller angles around 12 degrees giving a stronger tooth could be more appropriate for the harder timbers whilst the larger angles around 16 degrees are usual for fast feeding of softwoods.

Sharpness Angle: On rip-saw blade teeth between the hook angle and the top clearance angle lies the tooth itself and its sharpness angle. An angle of 40 to 45 degrees is really strong enough for any cutting edge, for example high speed steel planer blades are usually ground to a sharpness angle of 40 degrees for planing hardwoods and wide bandsaw blades which are thinner than circular saw blades will operate most satisfactorily with a 44 degree sharpness angle. So why not circular saw blades?

I think that it has been more tradition to reduce hook angles for cutting hardwoods than good tooth design. A typical example found in books would be 20 degree hook 12 degree top clearance angle leaving a sharpness angle of 58 degrees. Not a very sharp tooth is it ! This gives a scraping action rather than a cutting action and should be avoided. So let us try keeping those sharpness angles SHARP and add strength where necessary by the shape of the tooth.

Gullet Area: The area between successive teeth is called the gullet. The work of the gullet is to carry away the sawdust produced by the cutting edge. The area can be increased or decreased within limits without enlarging the tooth pitch. If the gullet is too small the sawdust will spill out of the side of the teeth leading to friction and overheating of the blade.

Overcrowding of the gullet with sawdust is often not a problem but it has to be considered when the blade is cutting through considerable thicknesses of timber. For example let us consider a blade with a tooth bite of 1mm. cutting a piece of timber that is 200mm. deep. Each tooth will remove 200 square millimetre of solid wood;. Because this is loose material it will occupy a much larger space in fact two and a half to three times larger than solid wood. The minimum gullet area would have to be 500 square millimetres to cope without undue spillage. Note ; we are actually dealing with a volume of sawdust produced but since the volume is directly proportional to the saw kerf; for practical tooth design we only need to calculate the gullet area.

Now let us look at a typical 1200mm. diameter 54 tooth blade used for secondary log conversion in a small mill. The pitch of the teeth would be the circumferance of the blade divided by 54

$$\frac{c}{54} = \frac{3.142 \times 1200}{54} = 69.82 \text{ say } 70\text{mm.}$$

If this tooth had a depth of 35mm. then an approximate gullet area would be:

$$\frac{70 \times 35}{2} = 1225 \text{ mm.square}$$ SEE FIG.5.

$$\text{Area} = \frac{\text{Pitch x Height}}{2}$$

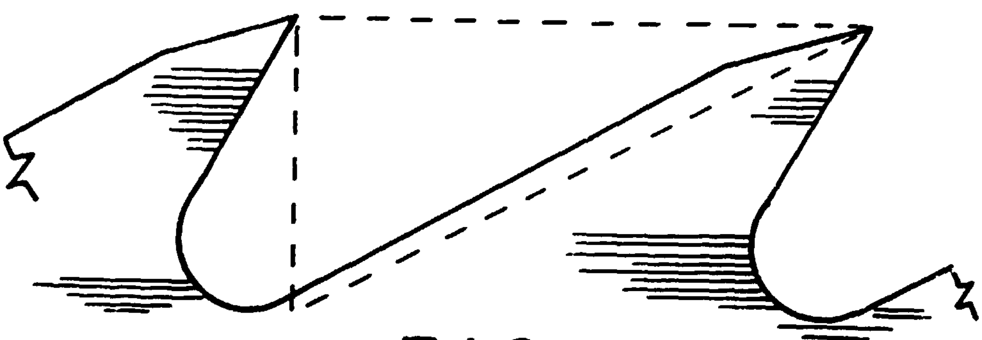


FIG. 5

Not all of this theoretical gullet area would be useful in carrying sawdust as the sawdust is forced up to the tooth face by the speed of the blade. It would therefore be safer to assume that only HALF of this area would be used before the sawdust would spill out past the sides of the teeth causing friction rather than being carried out in the gullet.

Returning to our example of 1mm. tooth bite cutting baulks of timber 200mm. deep giving 200 square millimeters of solid wood removed by each tooth, this would give 500 to 600 square millimeters of sawdust using a sawdust factor which has been found by experiment of 2.5 to 3 times. Our 70mm. pitch tooth would cope with this nicely but on deeper cuts we would start overcrowding the gullets with sawdust.

Face & Top Bevels: Before we leave the design of rip-saw teeth let us briefly discuss face and top bevels. Rip-saw teeth should NOT have any face bevel as this would only aggravate the spillage of sawdust past the sides of the teeth. However when feed speeds and tooth bites become large, if the teeth are spring set the a problem occurs with the INSIDE face of the teeth RUBBING to a depth of their penetration SEE FIG.6.

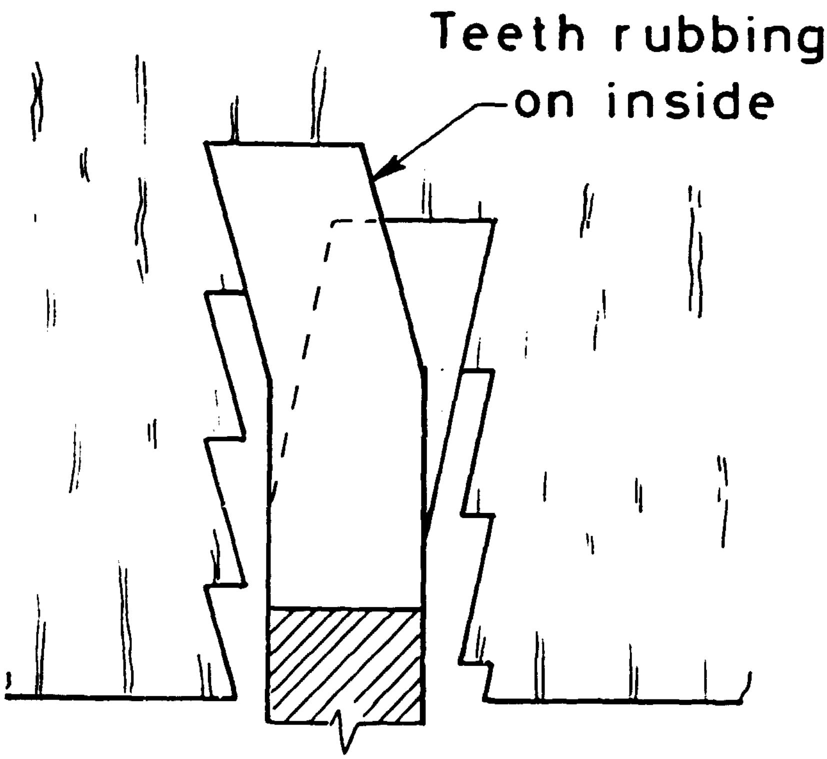


FIG.6

To overcome this a top bevel should be used, the bigger the tooth bite the bigger the bevel will have to be. Please remember though that this only occurs in high efficiency high speed sawing and in most situations rip-saw teeth are best sharpened square on all faces.

Cross-cut Teeth: We have seen on the video how we need a KNIFE like action to sever the fibres when cross-cutting and how we have turned the cutting edge of the teeth from across the thickness of the teeth for ripsaws to down the side on cross-cut teeth. This is achieved by doing away with the hook angle and replacing it with a face bevel to give the sharpness to the cutting edge. Note that the sharpness angle is seen in PLAN view for cross-cut teeth SEE FIG.7.

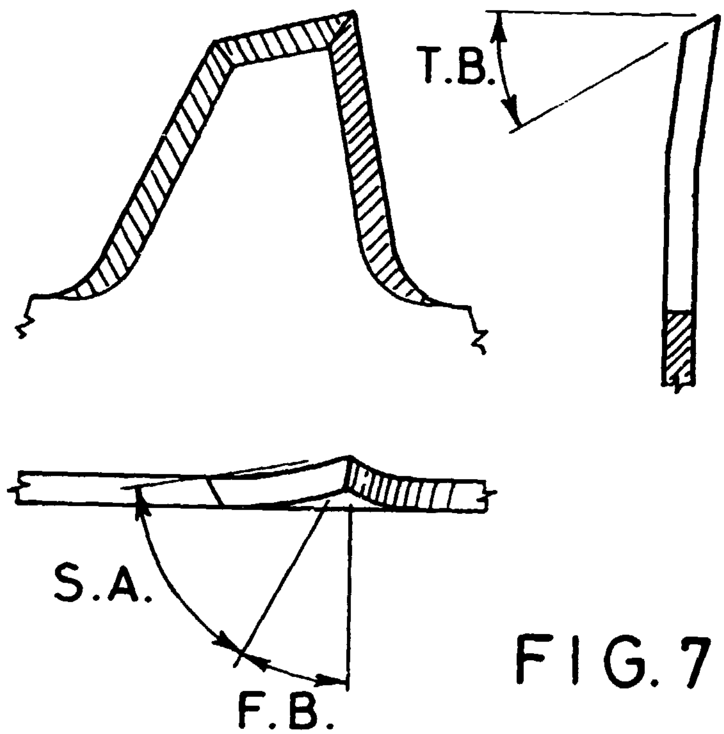


FIG.7

We also saw that a top bevel is necessary to allow deeper penetration of the cutting edge.

The tooth shape of a cross-cut blade had its origins in the shape of the triangular files used for sharpening hand saws. Some small circular saw blades can still be found with triangular shaped teeth. These can be useful for fine work such as mitring picture frames but are not appropriate for modern production tecniques because they blunt quickly. I also feel that this shape of tooth is more dangerous as it has a tendency to RUN ACROSS the timber being cut if used on radial arm and pendulum cross-cut machines. The normal 12 - 16 degree top clearance angle as used on rip-saw teeth is also preferred for cross-cut teeth as this will limit the tooth penetration making the machines much safer to use. SEE FIG. 8.

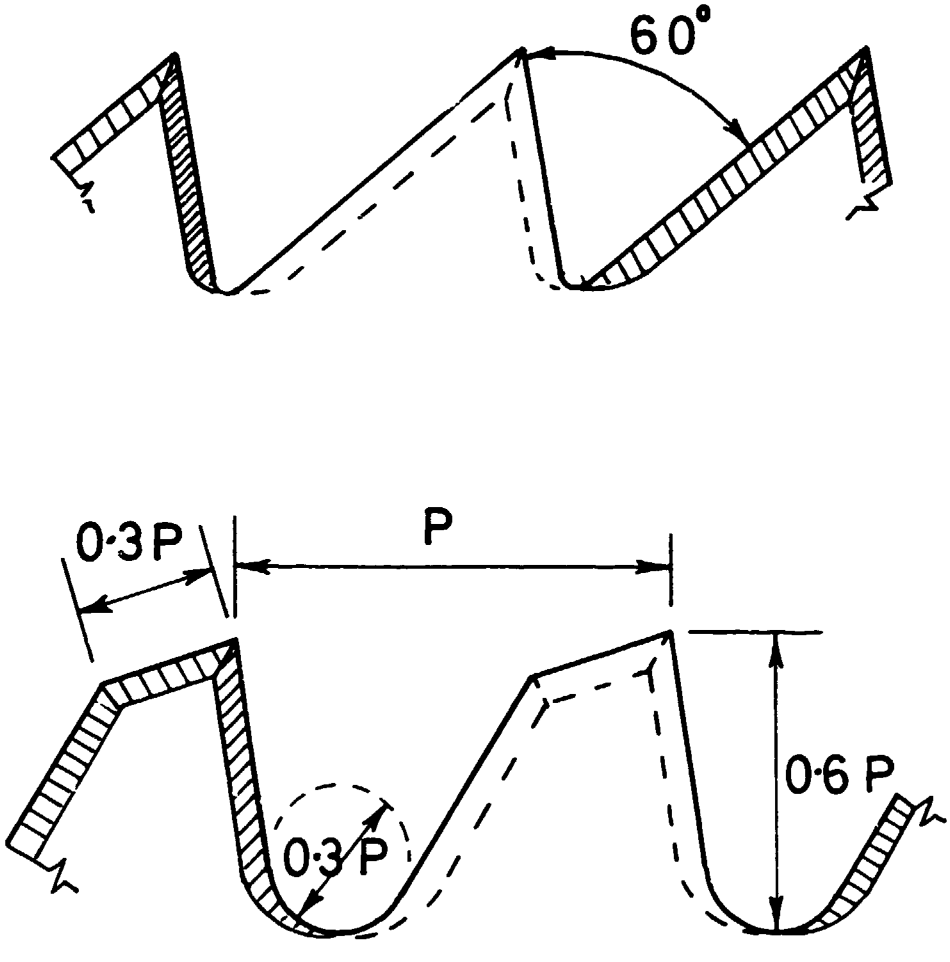


FIG. 8

4. BLADE SIDE CLEARANCE

We have seen that the saw kerf has to be wider than the blade thickness to prevent friction which in turn would produce heat causing the blade to expand and wobble thus setting up a chain effect of more friction and heat until the blade and work piece could be ruined. There are several methods used to obtain this necessary clearance which are as follows:

1) **Hollow grinding:** The outer rim of the blade would be the original thickness of the plate but with precision grinding the thickness is reduced towards the centre of the blade. This produces a very small clearance so hollow ground blades could only be used for cutting small sections. These blades are expensive to manufacture and such blades are now virtually obsolete.

2) **Swaging:** The teeth are squeezed wider (swaged) at the cutting edge using special tools or machines and SIDE-DRESSED to a uniform width. Although this method is still used on circular saw blades in some saw mills and is superior to spring setting we are not covering this in this video and manual as it is almost universally used on wide bandsaw blades and will be covered extensively when we deal with this subject.

3) **Inserted teeth:** The third method is to fit separate wider teeth to the plate, these can be in the form of INSERTED teeth as used in saw-milling or harder tips usually TUNGSTEN CARBIDE brazed onto the teeth. Again this is an extensive subject and will be dealt with separately.

4) **Spring Setting:** The fourth method and most widely used on circular plate blades is a method called spring setting where the teeth are bent slightly, usually alternately one to the left and then one to the right when A PAIR of teeth are needed to make up the full width of the saw kerf. The amount of SET put onto the teeth should always be the MINIMUM which will allow the blade to operate without overheating and jamming. If the set is too large the teeth will have to do more work than they need to which will be transmitted to the power needed to drive the blade and feed the timber. Also with a large amount of set there is an increased tendency for the sawdust to spill out from the gullets. All this is a waste of power and what is more important a waste of valuable raw material in the form of sawdust from the larger than necessary saw kerf.

The amount of set varies depending upon the following factors:

The diameter of the blade
The depth of cut
The type of timber being cut
Whether the timber is wet or dry
The flatness of the plate.

There is actually a fifth item which should not but often does affect the amount of set put on blades and that is the THICKNESS of the riving knives supplied with machines - which are often too thin. The work of the riving knife is not just to protect anyone from putting their hands onto the back part of the blade which is obviously important but more important is its main function of keeping the saw cut open so that the timber being cut does not bind onto the rear portion of the blade. This not only can ruin the otherwise good sawn finish made by the cutting teeth on their downward travel but may also cause the timber to be thrown back at the operator sometimes with FATAL results. The riving knife should be AT LEAST the same thickness as the saw kerf NOT the blade thickness. It is very easy to make a small saw cut into a scrap piece of wood then place it onto the riving knife to test the thickness when it should fit or be a little tight if correct. Sawyers may well ask the sawdoctor to put more set on a blade to overcome this dangerous situation but if we think about it no amount of set will stop timbers with internal stresses from binding onto the blade if that is the way they want to go. Only the correct thickness of riving knife will allow the sawyer to have confidence to know that if he feeds the timber as far as the riving knife the sawcut will be opened sufficient to stop the binding and be safe.

Several complicated formulae have been devised to calculate the amount of set but there is no way that they can take into account all the variables. We have agreed that the set should be the absolute minimum which will allow the blade to operate, but where do we start? A useful rough guide is to use one thousandth of the blade diameter as a starting point e.g. a 600mm. diameter blade would be 0.6mm. set and an 800mm. diameter blade 0.8mm.set.Having set and sharpened the blades the good sawdoctor will monitor the blades' performance to see if he can reduce the amount of set further, for it is only in this way that the correct minimum will be found and savings made in power and raw material.

We have seen on the video that there is a maximum amount of set which can be applied with alternate setting one left and one right before a gap appears between the teeth where part of the saw kerf is not covered by the two cutting edges. The maximum set is then HALF the blade thickness. On most blades of normal thickness this should not be a problem but on special SWAGE or GROUND OFF blades used in box and garden fence manufacture the cutting edge is so thin that a set of only half the blade thickness may not be enough. To overcome this every third tooth or even every other tooth can be left WITHOUT set. These unset teeth will cover the centre portion of the saw kerf and increase the maximum set to the FULL thickness of the blade. SEE FIG.9.

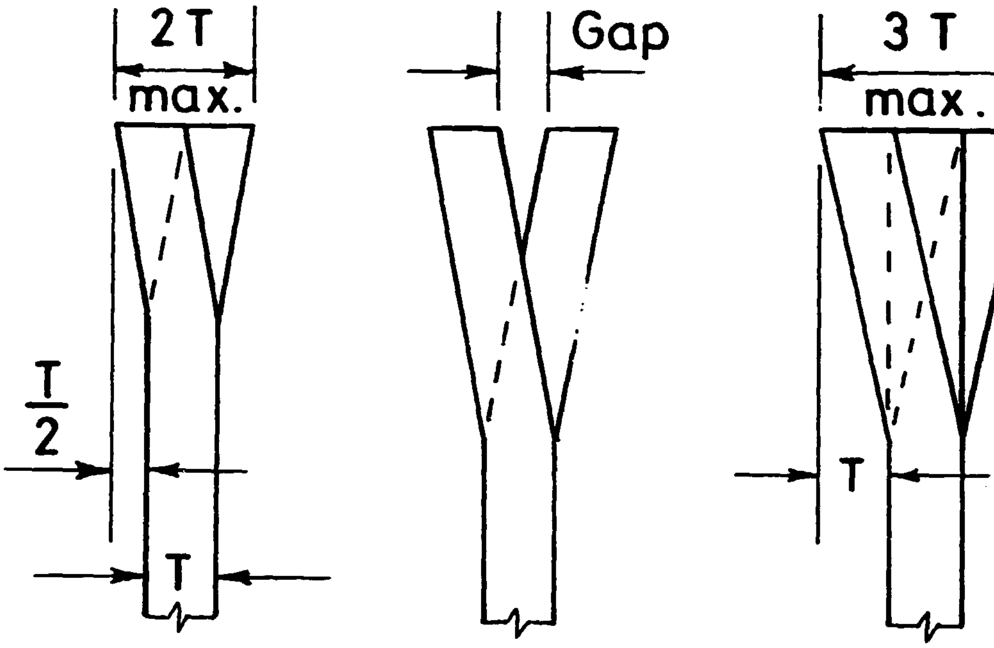


FIG.9

Methods of Applying Set: There are many different methods of spring setting circular saw teeth ranging from using a simple hand tool to very expensive fully automatic machines. The equipment used is not important but the method used should;

1) Give accurate results preferably within 0.05mm.

2) Not twist or bend the main body of the plate. This means the blade should be held firmly in a clamp as high up as possible near to the teeth which are being set.

The most common tool used for spring setting circular saw blades and the one shown on the video is the inexpensive GATE TYPE with one or two handles depending on the thickness of the blade being set.

The tool must be made of good quality steel and should be hardened and tempered so that the slots or GATES which fit over the teeth will remain an accurate fit on the various tooth thicknesses. Tools which do not fit accurately on the teeth cannot give good results and are dangerous to use since they can easily slip off the teeth. The tool must be used in conjunction with a GAUGE to measure the amount of set since guessing the amount of set is not good enough. Simple gauges can be made out of saw steel as shown in FIG.10. or a dial

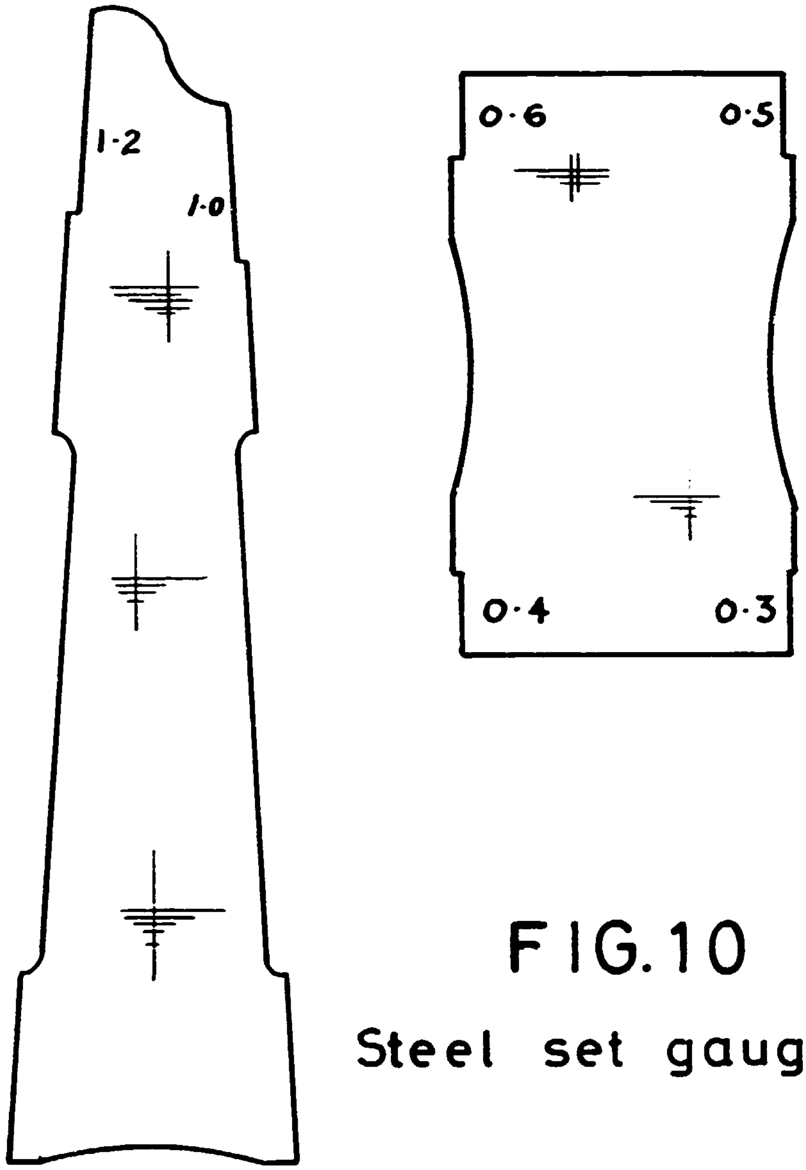
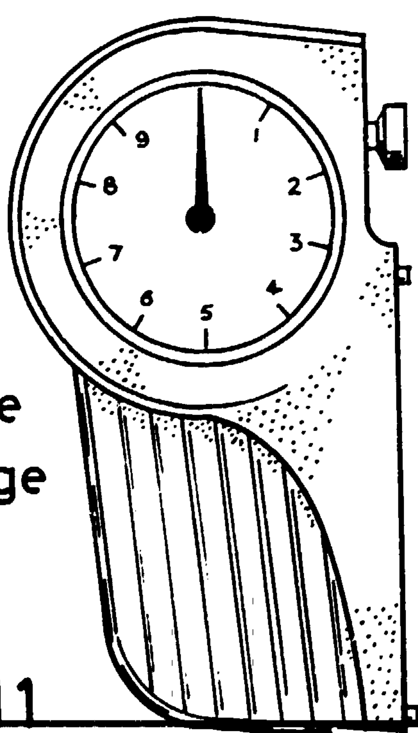


FIG.10

Steel set gauges

type set gauge purchased as shown in FIG.11.



Dial type set gauge

FIG 11

The dial type set gauge is very accurate showing up the slightest error in the amount of set, however, the simple gauges can give very accurate results if used correctly as follows:

Pass the gauge over the tooth to be tested, if the set is too much the gauge will CLICK as it drops back onto the surface of the blade. If there is no click see if the gauge will ROCK . If the gauge rocks the tooth needs more set. If neither happens the set must be accurate.

Most textbooks recommend that only the top third of the teeth should be bent. The usual reason given is that if all the tooth is bent cracks might occur in the gullets of the teeth. From experience it has been found that the teeth may be set near the base of the gullet if more convenient and teeth set lower will have the following advantages:

1) It is easier to set lower down the teeth with some systems especially when using the gate setting tool.

2) Teeth set from lower down nearer the base need only a slight bend to give the required amount of set. see FIG.12.

3) The sawdust produced is less likely to escape past the sides of the teeth when set lower down. see FIG.13.

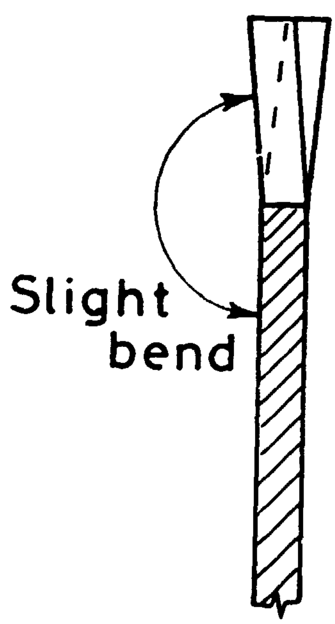


FIG. 12

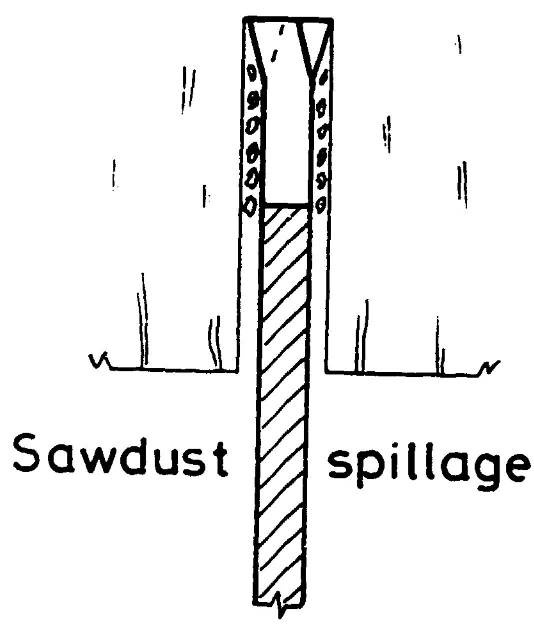


FIG. 13

4) The actual clearance is more when the teeth are set from lower down when using the same amount of set. see FIG.14.

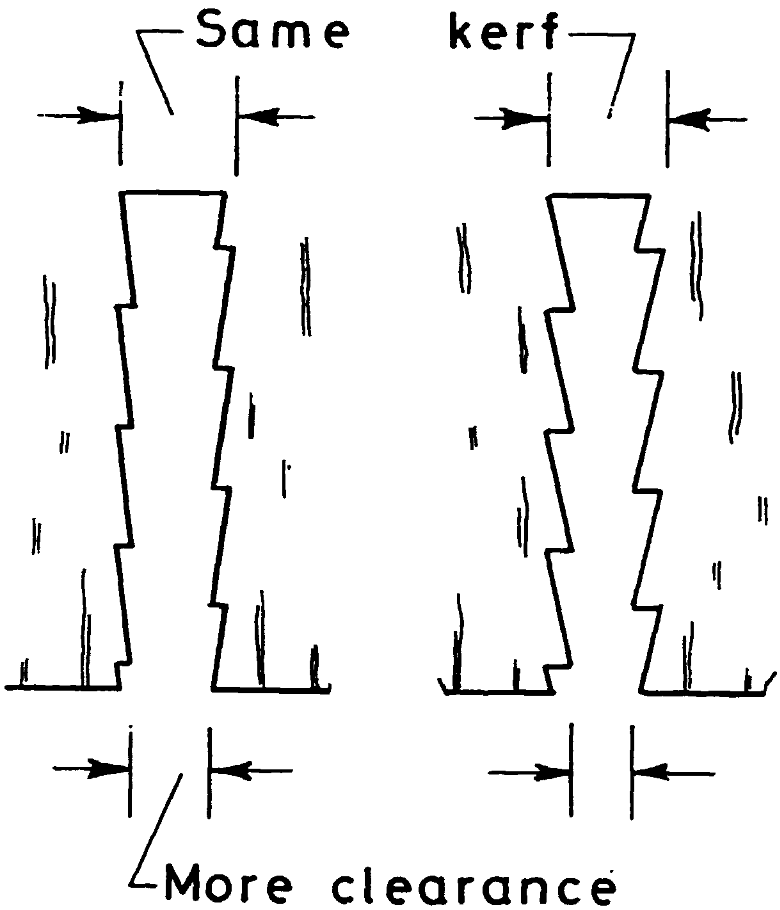


FIG.14

A method which will give a slight twist to the teeth rather than bending them parallel to the base of the gullets is to be preferred. This gives tangential (front to back) clearance as well as radial (top to bottom) clearance to the teeth which will help to reduce the friction between the sides of the set teeth and the cut surfaces. see FIG.15.

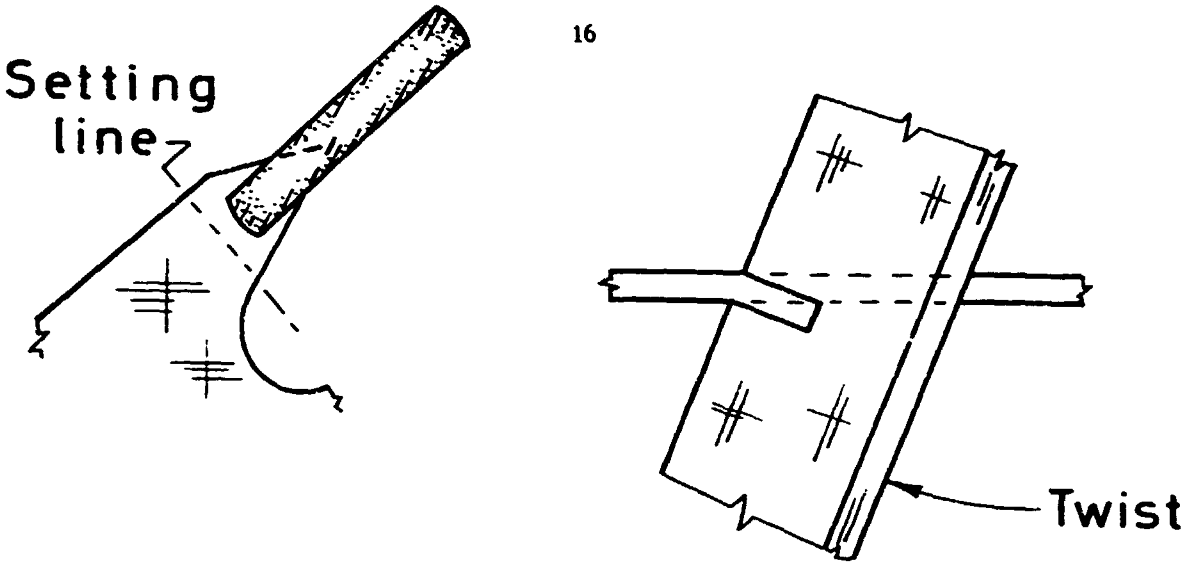


FIG.15

During the video we showed you a simple and quick method of spring setting using an anvil and hammer. It is surprising just how accurate it can be with practice by using a regular weight of blow and letting the weight of the hammer do most of the work. It also has the advantage of not bending the plate which using a gate setting tool can do. It all depends upon how much accuracy you need for the work in hand, certainly the method could be used for most cross-cutting operations.

Side Dressing: There are occasions when a better than normal sawn surface is required and often one or two spring set teeth will spoil an otherwise good surface because they are slightly out of line with the others. To overcome this it is possible to side dress the teeth using an oil stone as the blade rotates at its normal cutting speed in the machine. The idea behind side dressing is to remove the points of any teeth which are sticking out beyond the others because of inaccuracies in setting and/or in the flatness of the plate.

Side dressing is carried out after the blade is fixed in the saw bench and after any packings have been fitted and the machine is ready for normal use. A piece of thick paper is wrapped around the corner of the oil stone as shown in FIG.16.

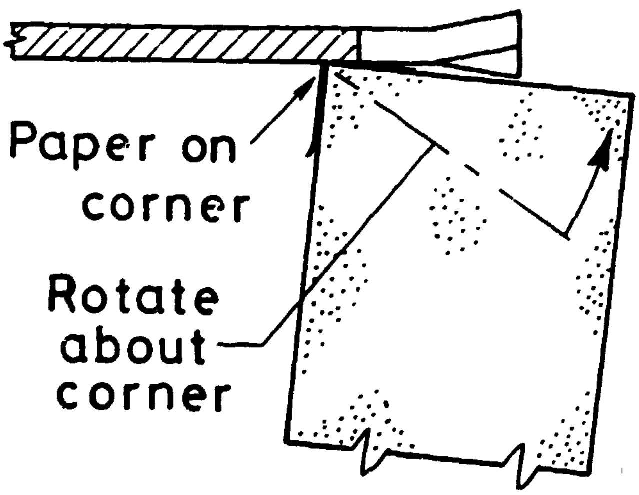


FIG.16

and with the machine running the oil stone is placed as shown with the covered corner touching the blade below the teeth near the gullets. The oil stone is then moved around the contact point until the side just touches the tips of the set teeth. This is repeated on the other side of the blade and the resulting sawn surfaces examined after a test cut. The process may need repeating on one or both sides.

This may seem to be a dangerous process but if care is taken and the person doing the side dressing stands to one side of and not IN LINE WITH the blade there is no real danger.

5. SHARPENING

The object of sharpening saw teeth is to restore the sharp cutting edges so that the blade will cut accurately, easily and safely. If we look at the tips of blunt teeth under magnification they will appear as in FIG.17. The most

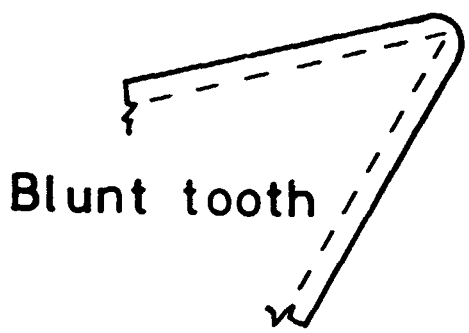


FIG.17

economical and therefore correct method of restoring the sharp edges is to file or grind approximately EQUAL amounts off the tops and faces of the teeth. The exact ratio will depend upon the shape of the teeth.

Some tooth shapes are more economical to sharpen than others, for instance the straight back tooth could in theory be maintained by sharpening the face only by pushing the teeth back round the blade in a very slow spiral instead of radially towards the centre. At the other extreme a tooth with a steep back and a large gullet would have to be sharpened more on the top to maintain the tooth shape. This would produce a much faster reduction in diameter and would be wasteful of blades but such tooth shapes are sometimes necessary in order to handle large volumes of sawdust in the gullet to meet production demands. SEE FIG.18.

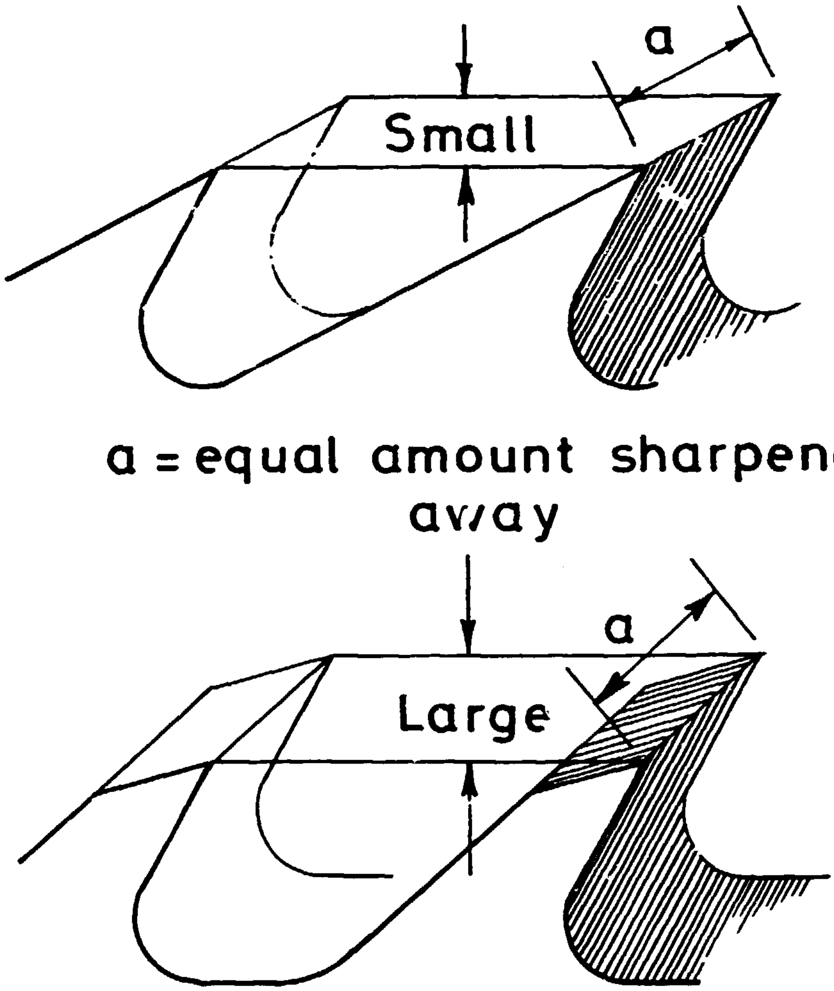


FIG.18

There are two main methods of sharpening, manual or by fully automatic machine.

Manual Sharpening: Manual methods vary considerably but it is most common to grind the gullets using a simple gulleting machine and hand file the tops. Whatever system is used we must try to ensure :

1) the blade is maintained perfectly round .

2) the pitch of the teeth is maintained equal

3) the height of the teeth is maintained equal.

4) the shape of the teeth is maintained equal.

Ranging: To ensure that the blade is maintained perfectly round so that all the teeth will do an equal amount of work the teeth should be RANGED by grinding the tooth points whilst the blade is fixed in the bench and running at its normal speed. This can be done by moving an oil stone or a piece of broken grinding wheel across the cutting edges, however, this method is both a little DANGEROUS and NOT VERY ACCURATE since the abrasive used becomes HOLLOW and therefore rounds off the vital tooth points. A much better method is to use a simple ranging jig made with an old grinding wheel as demonstrated on the video.

NOTE: It is NOT necessary to range down the teeth every time the blade is sharpened but every third or fourth time should be sufficient to ensure that the teeth are all cutting.

Gulleting: Although it is possible to file the bottom of the gullets and the backs of the teeth, files are expensive and wear out quickly so it is common practice to GRIND the gullets and maintain the shape of the teeth using a simple gulleting machine or even a bench grinder mounted with a suitable wheel. Many of these machines are fabricated locally or even in the sawmill itself and even those manufactured by specialists are very basic and leave much to the skill of the operator. Several features are important when choosing or making a machine as follows:

1) The mandrel on which the blades are mounted must be fitted with either self centring collars or individual accurately fitting bushes to fit the various bore sizes in use.

2) Either the grinding head should tilt or the mandrel should be adjustable sideways to give the various hook angles required.

3) An adjustable depth stop should be fitted to arrest the grinding wheel at the bottom of its travel. This is to maintain the gullet depths all the same to keep the blade in balance.

4) I have only seen one make of machine with an adjustable tooth stop as shown in FIG.19. but this simple addition

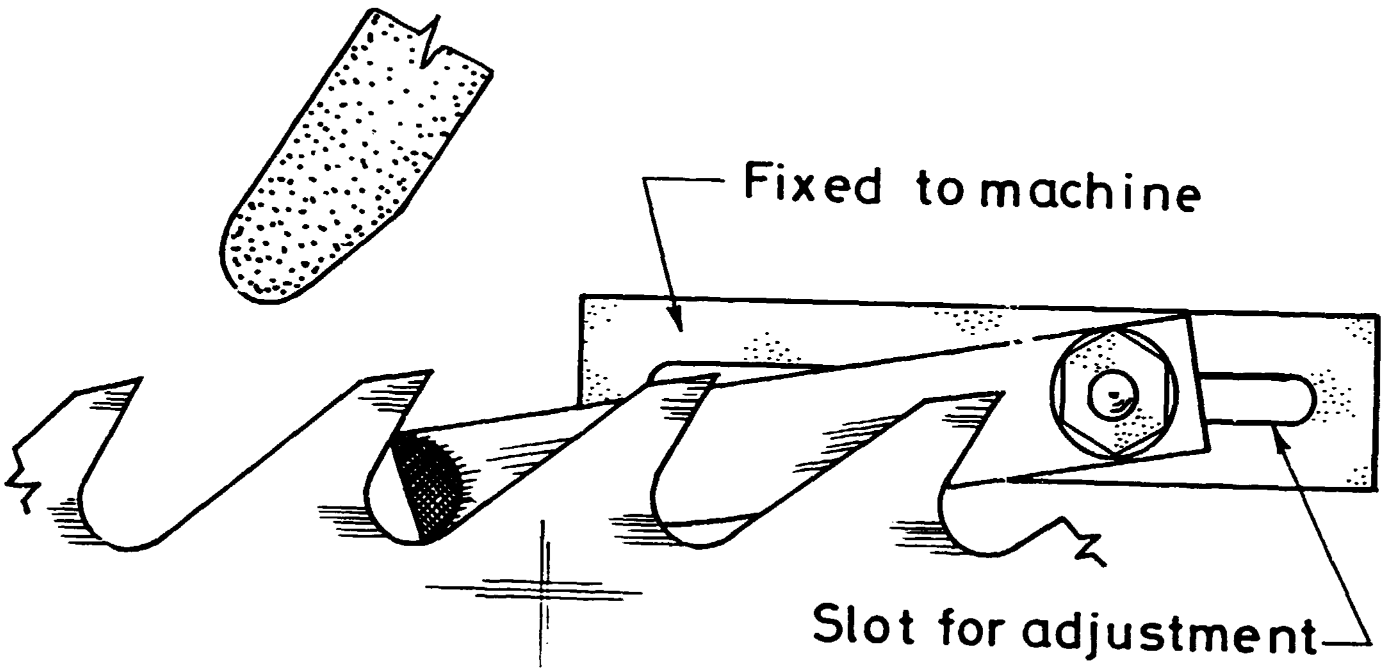


FIG. 19

removes all the guess work out of trying to maintain the PITCH of the teeth equal. It is well worth while to have one fitted to a new or existing machine.

The machine used for the video demonstration did not have a tooth stop fitted so just a word about its use. It should be adjusted so that it is one tooth back from the tooth to be ground and set on a tooth of the correct pitch. This will ensure that teeth with a large pitch will not be ground on the face but all small pitched teeth will be ground heavily so that eventually all the teeth will be corrected. Also note the 'D' shaped pawl finger which rests in the bottom of the tooth to give accurate positioning of the teeth. On blades with the correct pitch the tooth stop is set so that the grinding on the face of the teeth is very light, since the same amount will be removed for each revolution of the blade without further adjustment.

In the video I demonstrated two methods of gulleting First where I lowered the grinding wheel into the gullet and moved the face into the wheel for sharpening then proceeded round the base of the gullet and up the back of the tooth. The alternative method was to start near the top of the tooth moving down the back into the gullet and finally on to the face of the tooth. Both methods are equally correct.

The only other point to make is never to grind too heavily even when reforming the shapes of teeth as this may burn the gullets leading to a possibility of cracks forming in the gullets and may also EXPAND the rim of the blade with the tendency of pulling out the blades' tension.

The tops of the teeth can be ground using a straight edged wheel and grinding to a depth stop to maintain the height of the teeth but for various reasons it is more popular to file the tops of the teeth. To assist the filing, the length of the tops of the teeth should be kept SHORT certainly no more than a quarter of the pitch. This will save time, effort and files.

We demonstrated on the video how the blade could be angled on some machines to give the necessary face bevels to cross-cut blade teeth.

Filing: Filing saw teeth by hand is largely a matter of guessing the various angles and to retain these angles and the size of the teeth all the same is quite a skilful and difficult task. The successful filer will keep to a set procedure and the following points will assist in this respect:

1) File all the tooth faces first giving an equal number of equal weight strokes on each tooth.

2) File all the tooth tops giving each tooth an equal number of strokes or if the teeth have been ranged file down until the range marks just disappear and no further.

3) When filing the tops of the teeth WATCH THE TOP CORNER OF THE FILE in relation to the point of the next tooth. This will assist in keeping the top clearance angles all the same as demonstrated on the video SEE FIG.20.

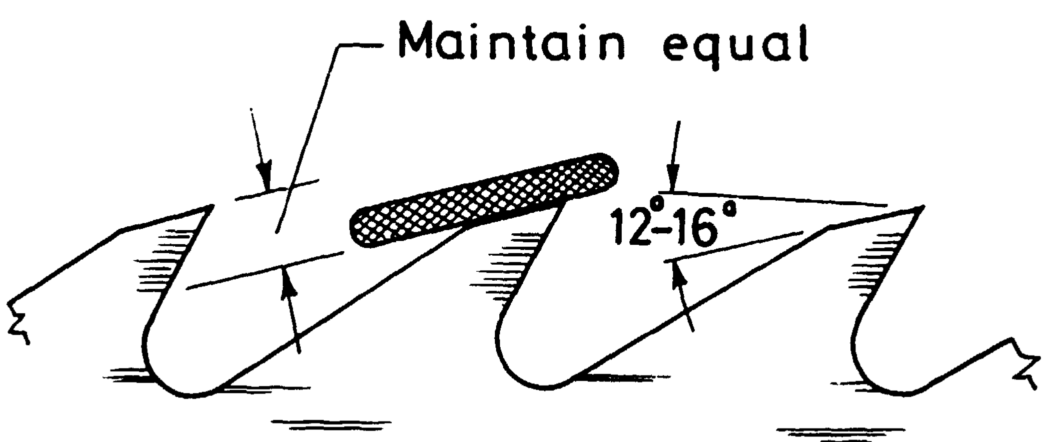


FIG. 20

4) Do not try to file too many teeth without moving them to the top centre of the filing clamp. I usually move three teeth at a time, the middle one of the three to be filed positioned in the centre of the clamp.

5) Although rip-saw teeth normally do not need a top bevel, in order to stop the file CHATTERING it is easier to file on five or ten degrees of top bevel.

6) Use long slow strokes when filing and try to use the full length of the file.

7) As with both grinding and filing it is advisable to clean the resin off blades so as not to clog up the cutting edges of grinding wheels and files. It is usual to keep the file clean with a wire brush or a special file card.

8) Cross-cut teeth should have between twenty and thirty degrees top and face bevel. If the tooth shape is maintained by gulleting square across, the full length of the tooth face need not be filed to a bevel as demonstrated on the video and shown in FIG.21.

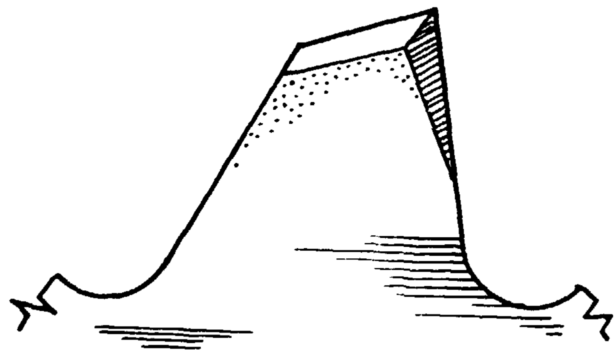


FIG. 21

Fully Automatic Machines: Certainly the best way to sharpen circular saw blades with solid teeth is to use one of the fully automatic machines which are designed for this purpose as demonstrated on the video. Although these machines are fully automatic and can produce perfectly sharpened teeth which are all exactly alike in shape, size and angles, the best results will not be achieved with the MINIMUM of blade wear unless the operator understands thoroughly how the machine works and how best to use it. Although machines manufactured by different companies vary there are basic principles which apply to them all, a knowledge of which is vital to produce the best results in the fastest time and with the minimum of blade and grinding wheel wear.

Before ordering a new machine it is essential to bear in mind that some specialist manufacturers produce a number of different models with different capabilities e.g. some may be more limited in the pitch of tooth and diameter of blade they can sharpen whilst others can only grind square across as for rip-saw teeth and cannot angle grind as demonstrated for cross-cut teeth. Many of the machines have two, three or four built-in cams which are not easily changed without stripping the machine down, therefore it is vital that you specify your tooth shapes by including drawings when ordering and not just rely on the manufacturer installing the right ones for your requirements.

Mandrel Position: The position at which the blade mounting mandrel is secured beneath the grinding wheel is important for two reasons:

The first is the smooth working of the pawl finger and second the position, if not in the centre, alters the hook angle of the teeth. If the mandrel is placed so that the centre of the blade is under the left hand edge of the grinding wheel, as demonstrated for sharpening cross-cut blades, and as the pawl finger must work one tooth back to maintain equal pitch of the teeth, the pawl finger will be working UPHILL as shown in FIG.22. The slide on which the pawl

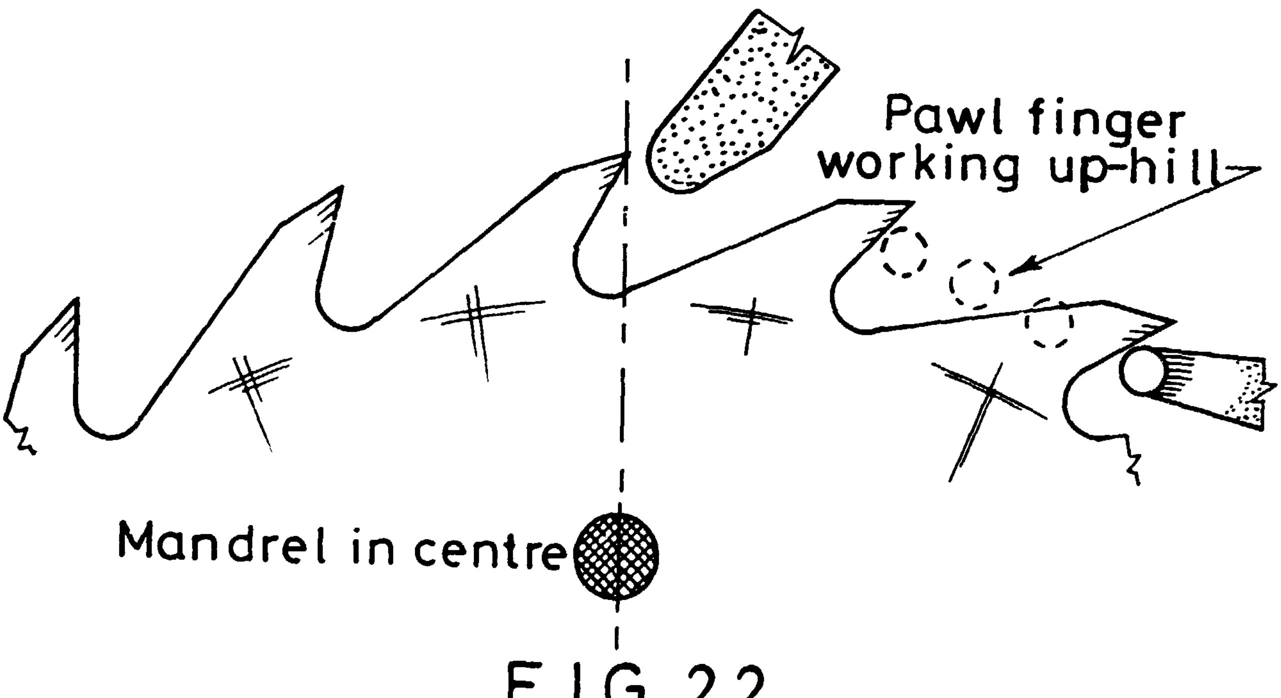


FIG. 22

finger moves may be adjustable to accommodate this and the pawl finger will then work nicely without sliding up and down the face of the tooth but there is a limit to this adjustment. If the mandrel is moved to the right the pawl finger will be pushing teeth which are not sloping so much uphill and the pawl finger movement being level is improved as shown in FIG.23. The reason why the pawl finger movement is so

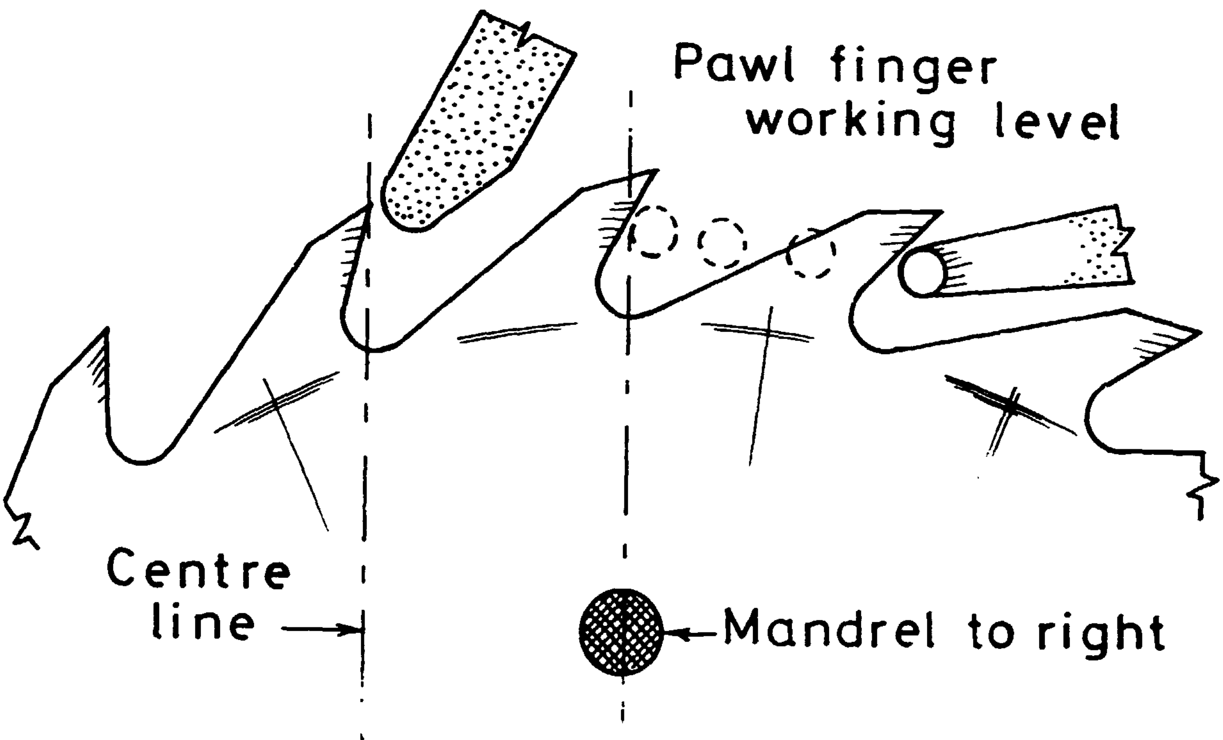


FIG. 23

important is that if it does slide up or down the tooth face as it pushes the teeth forward it may STICK on the rough ground surface and push the teeth inaccurately. i.e. to slightly different positions resulting in uneven grinding. In addition the pawl finger will wear more quickly and a worn face on the pawl finger can also result in inaccurate feeding of the teeth.

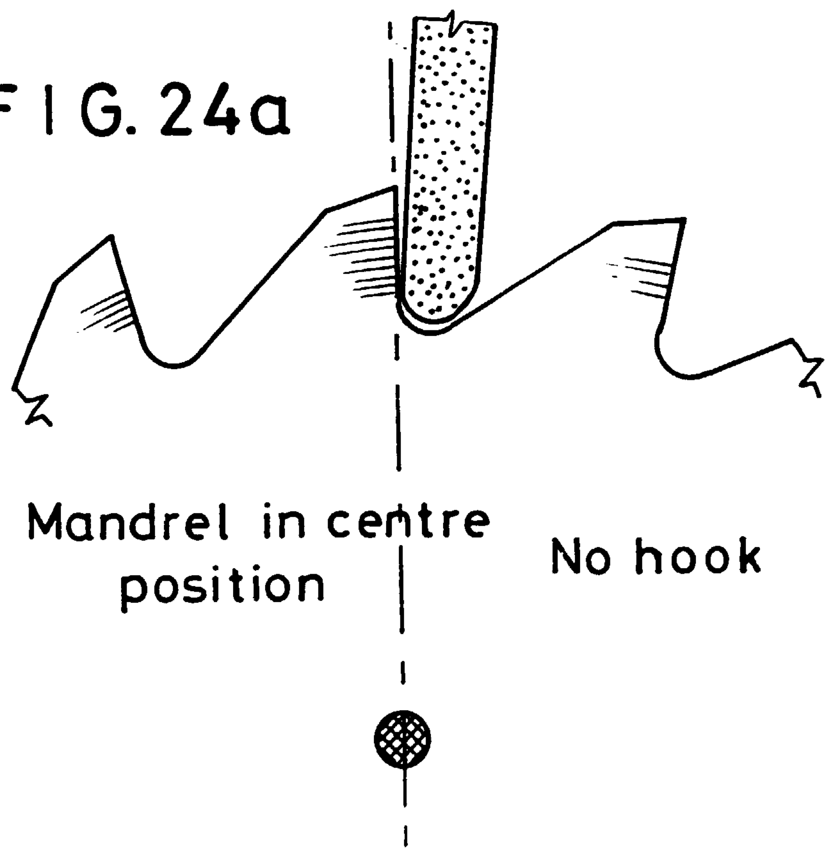
To facilitate this pawl finger movement so that it is smooth, manufacturers often recommend that the mandrel is positioned so that the blade is to the right by ONE TOOTH PITCH which roughly allows the pawl finger to move in a level line. Unfortunately, blades vary considerably in tooth pitch and diameter and if we use this system we will end up with various degrees of hook angle as a consequence of the APPROXIMATE positioning of the mandrel.

This positioning of the mandrel and its effect on the hook angle of the teeth must be thoroughly understood, so let us look at it in more detail:

If we assume that we have the grinding head vertical set at zero degrees the following would apply:

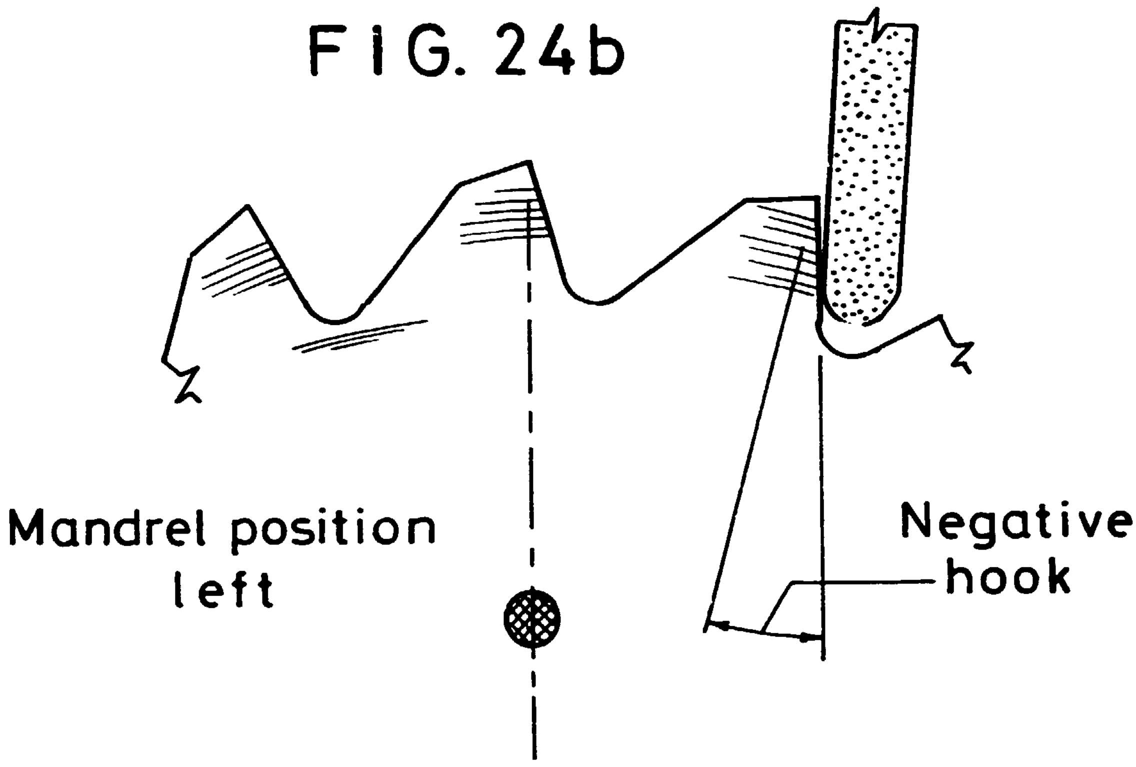
1) If the blade is positioned with the mandrel in the centre of the machine i.e. directly under the grinding wheel, then the resulting teeth will have zero degrees hook FIG. 24a.

FIG. 24a



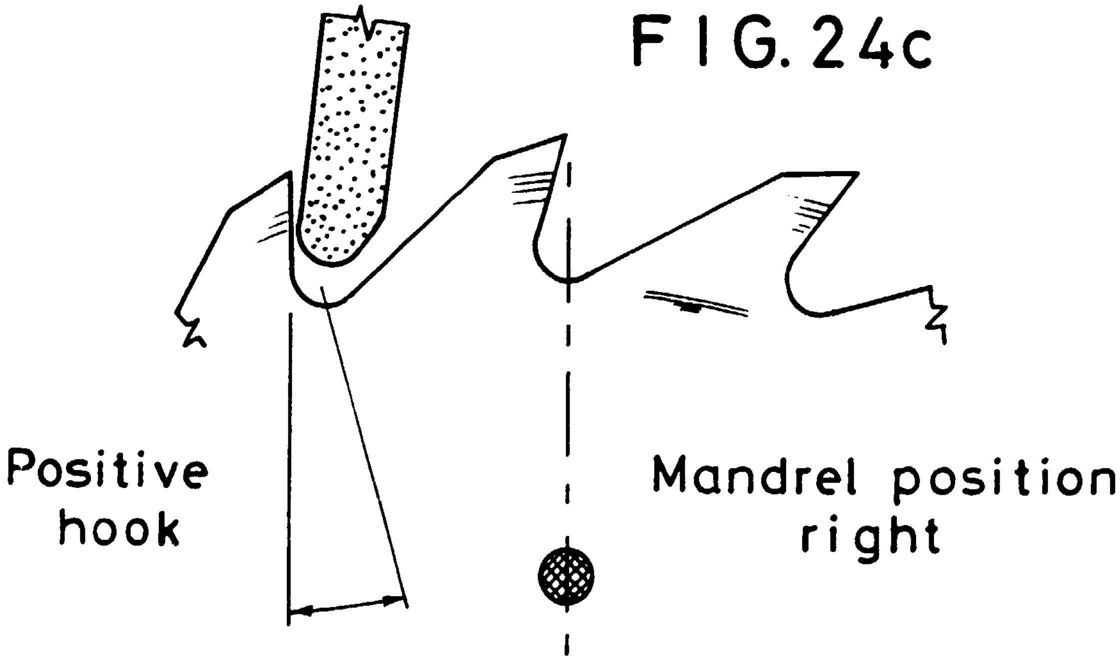
2) If the blade is secured to the LEFT of centre the resulting teeth will have some amount of NEGATIVE hook Fig. 24b.

FIG. 24b



3) If the blade is secured to the RIGHT of centre the resulting teeth will have some amount of POSITIVE hook angle see FIG. 24c.

FIG. 24c



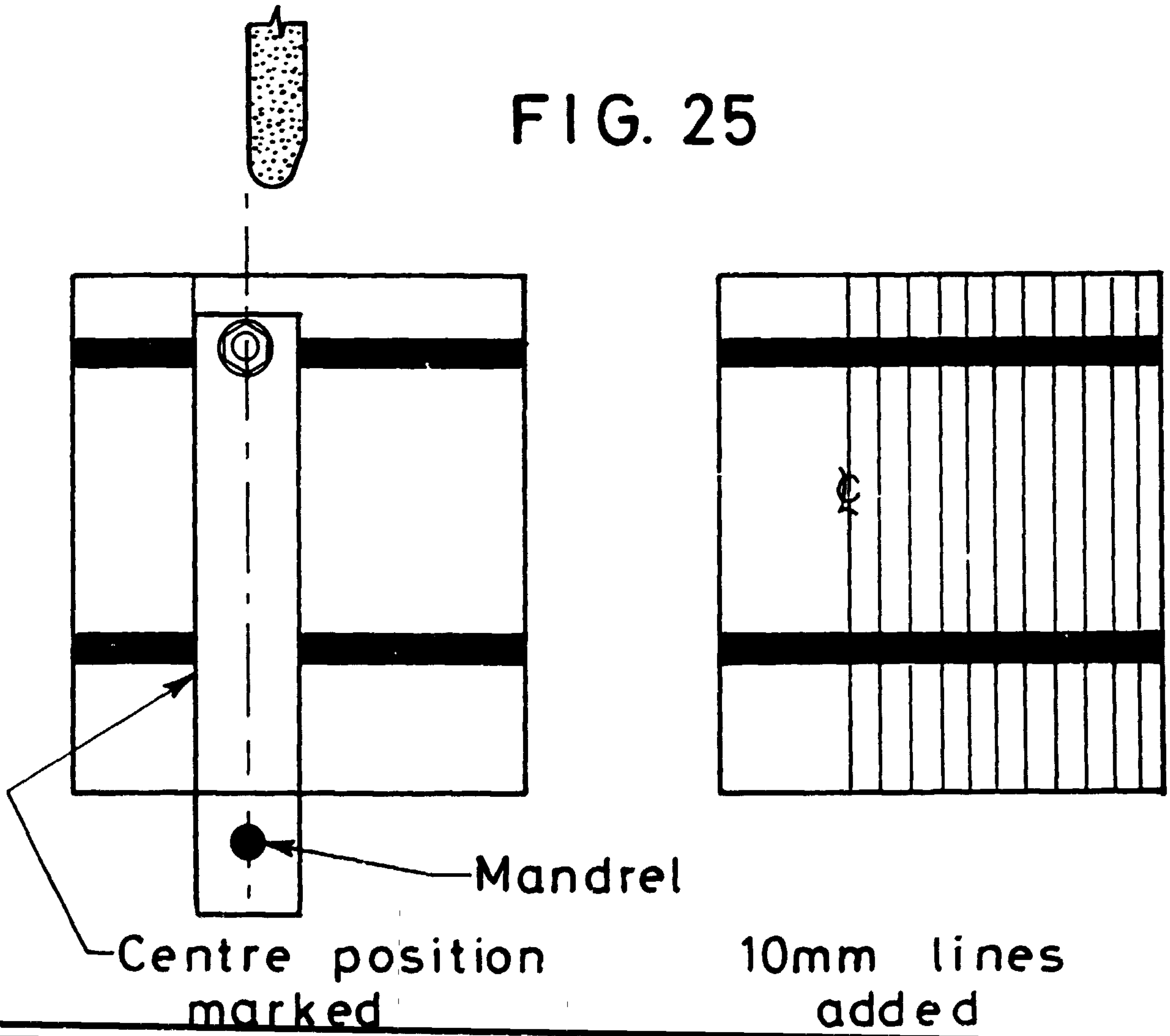
We therefore need a system which will give us the angles required as well as a smooth movement of the pawl finger. The method recommended is as follows:

For all cross-cut blades the mandrel is positioned in the centre, the slight slope on the teeth which are usually of small pitch is accommodated by tilting slightly the slide on which the pawl finger moves.

For all rip-saw blades which need varying amounts of hook the mandrel is positioned ten per cent of the blades diameter to the right for smaller blades, say up to 400mm. diameter, and five per cent to the right for larger blades. This will give for practical purposes ten and five degrees of hook with the grinding head set at zero. With this system we can then add the remaining hook that is required with the tilting of the grinding head e.g. as demonstrated on the video the 610mm. diameter blade was positioned to the right a full 30mm. giving five degrees and the grinding head was tilted a further twenty degrees giving a total of twenty five degrees hook angle which was required.

To facilitate this mandrel position setting the position of the mandrel should be marked when it is in the centre under the left-hand edge of the grinding wheel as shown in FIG.25.

FIG. 25



Then further lines should be scribed onto the machine in 10mm. divisions. The mandrel can then be positioned accurately enough without having to use a steel rule.

Blade Thickness Setting: Modern automatic saw sharpening machines have an adjustment to alter the position of the rear blade clamping plate so that the blade can be positioned exactly under the centre of the grinding wheel see FIG.26.

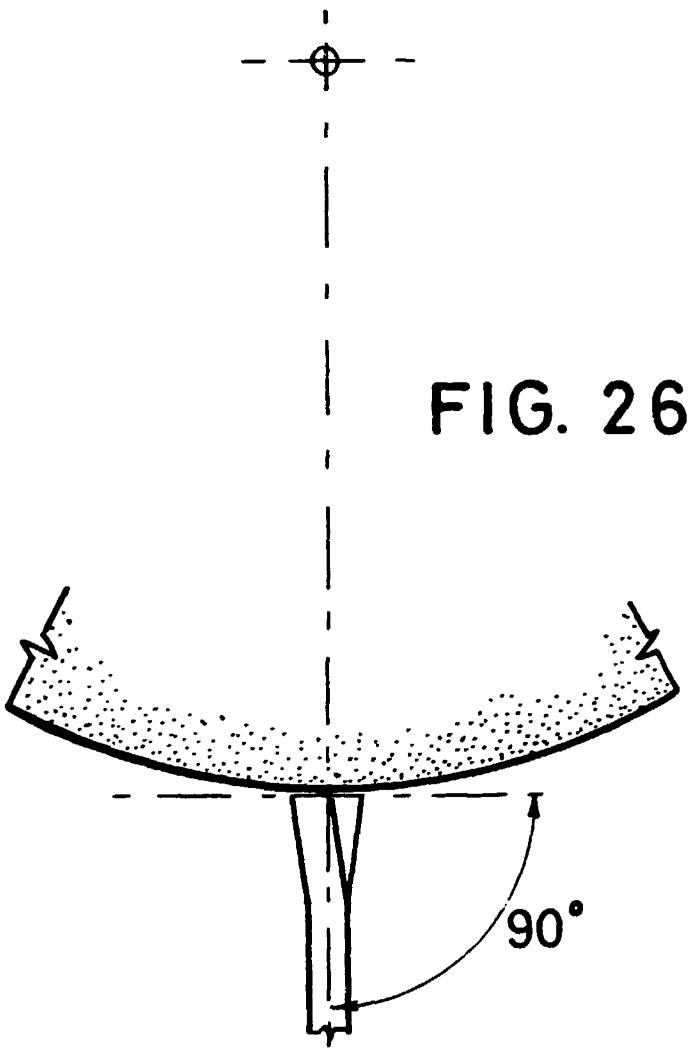


FIG. 26

If the blade is not centralised with the correct thickness setting the tops of the teeth will be ground out of square as in FIG.27. For rip-saw teeth this is not too critical but

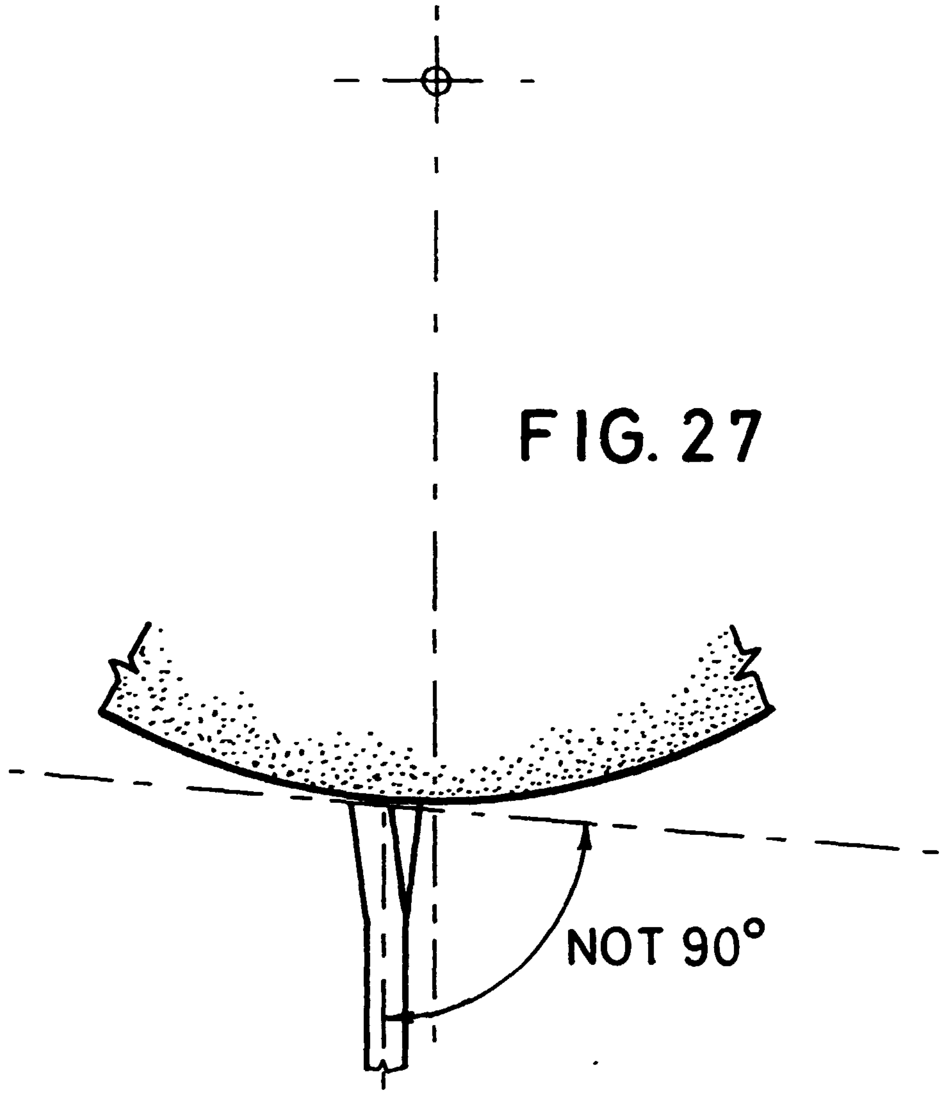


FIG. 27

could result in the blade cutting to one side, however, it is extremely important when sharpening cross-cut teeth since an error of as little as 0.1mm. will produce teeth which are longer and bigger on one side of the blade than the other. We showed on the video three types of tools which would measure the blade accurately so that the machine can be set correctly, namely the micrometer, the vernier caliper and the simple saw gauge. The one I used had both metric and imperial sizes next to the gauge numbers which is the best type. Most gauges have only numbers so in this case the actual blade thickness measurement will have to be taken from a chart see APPENDIX.1.

The only other point about this setting which will alter the accuracy needed is the fact that the clamp plates are bound to wear and need replacing from time to time. The good sawdoctor will nevertheless allow for this wear which he will observe when he makes this setting until new clamp plates are fitted.

Tooth Pitch & Height Settings: The scales on the machine for both pitch and height can only be a guide, as the various cams, size and shape of grinding wheels will all alter the actual settings to produce the shape of tooth desired.

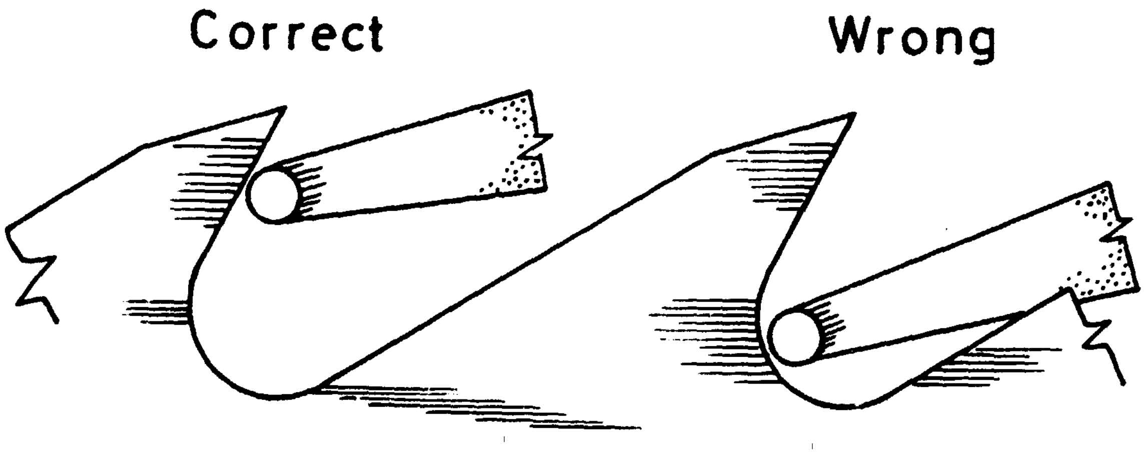
The initial setting for teeth which have not been sharpened before will usually be in the region of one and a half times the actual pitch and height of the teeth and these settings are reduced once the machine is started and the grinding wheel is moving safely up and down the tooth profile without grinding as demonstrated on the video. Whilst this is satisfactory and is used for unknown tooth profiles, once a tooth has been sharpened a system of recording these settings is highly recommended as was demonstrated when the cross-cut blade was sharpened.

On the tooth pitch setting the sawdoctor must understand that;

1) An increase in the tooth pitch setting increases the movement of the pawl finger and this will allow the grinding head to rise higher before the teeth are pushed forward and the wheel starts to grind the tooth back resulting in a stronger tooth shape.

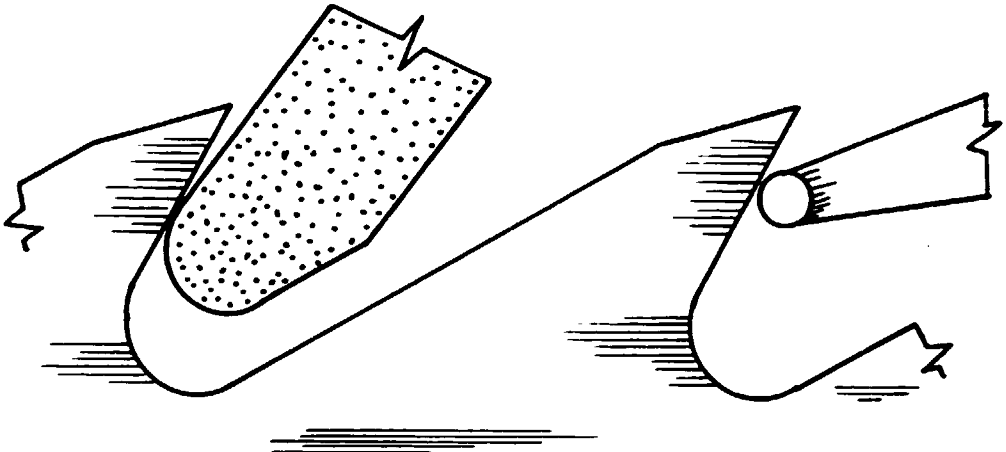
2) A reduction of the pitch setting reduces the movement of the pawl finger which will result in the opposite i.e. the teeth will be pushed forward sooner and more steel will be ground off the tooth backs resulting in a weaker tooth shape and a larger gullet area.

Pawl Finger Setting: The height of the pawl finger should be adjusted so that it works on the straight face of the tooth near the top about one third down and not on the curved part at the bottom of the gullet where it may slip and result in the teeth being incorrectly positioned so that the grinding wheel will grind heavier on some teeth than others See FIG.28.



It is also important to realise that on rip-saw teeth which lean forward, if the pawl finger is positioned higher or lower, the tooth will be pushed forward SOONER or LATER by this simple adjustment and so change the shape of the teeth in a similar way to using a larger or smaller pitch setting.

It is also ESSENTIAL that the pawl finger pushes one tooth back from the face of the tooth which will be ground next. See FIG.29.



Pawl finger one tooth back

FIG. 29

This is the only way that the pitch will be maintained equal as the teeth become smaller and the diameter of the blade reduces as a result of sharpening. This positioning one tooth back from the tooth being sharpened will also correct unevenly spaced teeth by grinding heavily on small pitched teeth and lightly or not at all on teeth which are larger.See FIG.30.

Loss of Desired Hook Angle: Correct mandrel positioning and angling of the grinding head will not GUARANTEE the desired hook angle if the grinding wheel is allowed to become worn on the face side i.e. the side which grinds the tooth face. This will come about if the pawl finger is adjusted so that the grinding wheel grinds heavily on the faces of the teeth. It must be understood that no matter how many times the blade goes around for sharpening the SAME AMOUNT will be ground off the faces of the teeth without adjusting the pawl finger. The correct setting is therefore to grind very lightly on the faces in the knowledge that a little more will be taken off every time the teeth come around.

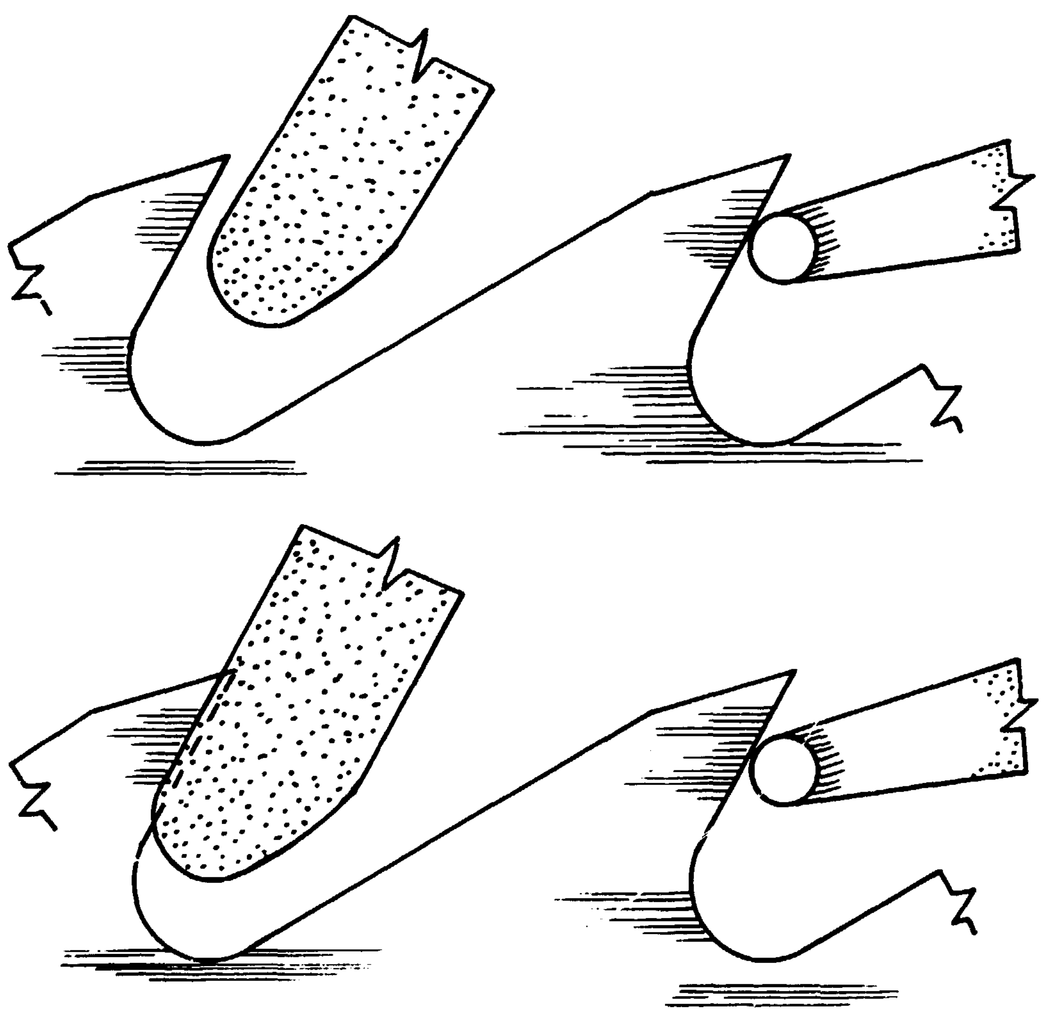


FIG. 30

On some of the better machines the grinding wheel is angled a few degrees to avoid the wheel wearing more than necessary.

Depth Stop Setting: Most machines are fitted with a depth stop which can be adjusted to stop the downward movement of the grinding head before it reaches the bottom of its travel normally governed by the tooth shape cam. Its use is to enable a flat bottomed gullet to be produced using any of the standard cams and although it is extremely useful care should be taken not to restrict the downward movement too much since when using this system the grinding wheel is STATIONARY at the bottom of the gullet for a short period of time and may cause problems by burning the points and gullets of the teeth. If a flat bottomed gullet is required regularly it is better to fit a cam which will produce this shape.

Face Bevel Setting: Automatic sharpening machines designed for sharpening circular saw blades should be able to grind alternate bevels on the face of the teeth of cross-cut blades as demonstrated on the video. The adjustment is simple, sometimes in steps of five degrees from 0 - 20 or even 30 to special order or infinitely variable between 0 and the maximum on other makes of machine. The fact that the wheel remains angled as it passes up and over the tooth backs and tops also gives a bevel to these parts of the teeth. The most important point to watch when using a face bevel is the blade THICKNESS setting because the slightest error in this setting will produce teeth which are larger on one side of the blade than the other as explained earlier.

For bevel grinding the blade must have an even number of teeth i.e. divisable by two. Care must be taken when lowering the grinding head into the first gullet to make sure that the grinding wheel is angled in the correct direction. If not, simply raise the head again and lift the pawl finger up so that it misses pushing one tooth forward then lower the head again which should then be angled the right way.

Use of Setting Chart: This is a method which I have developed over the years and found it to be invaluable especially when I ran my own saw servicing business which brought in dozens of different blade sizes and tooth shapes. The shapes I standardised as much as possible but this still left lots of sizes to cope with. By using a chart with all the settings recorded not only I but anyone in the workshop including apprentices could set the machines up EXACTLY as they were the last time that the blade came in for sharpening. This resulted in the absolute MINIMUM of time spent on both setting up and on the sharpening itself. With the chart system the blades do not need engraving with any of the settings as sometimes used, in fact all that is required from the blade is:

1) To measure its diameter.

2) To measure its pitch.

3) Recognise the tooth style for choosing the appropriate cam.

The chart shown in FIG.31. is easily drawn up and several photo-copies made. These should be glued onto plywood or hardboard so that they can be hung up by the machine and if possible covered in clear plastic to keep them clean. A separate chart is required for each tooth shape i.e. a minimum of one for ripsaw blades and one for cross-cut blades. The common settings are filled in first i.e. CAM NUMBER, HOOK ANGLE, FACE BEVEL, MANDREL POSITION and a sketch of the tooth shape. The variable settings are only recorded after the teeth have been sharpened and the tooth shape is satisfactory. The selected grinding wheel is numbered for the record and a gauge is made to its shape which is also given the same number.

FIG. 31.

CIRCULAR SAW BLADE MACHINE SETTING CHART

COMMON SETTINGS

SKETCH OF TOOTH

CAM SHAPE ....

HOOK ANGLE...........

VARIABLE SETTINGS				VARIABLE SETTINGS			
TOOTH PITCH	PITCH SETTING	HEIGHT SETTING	GRINDING WHEEL NUMBER	TOOTH PITCH	PITCH SETTING	HEIGHT SETTING	GRINDING WHEEL NUMBER
6				46			
8				48			
10				50			
12				52			
14				54			
16				56			
18				58			
20				60			
22				62			
24				64			
26				66			
28				68			
30				70			
32				72			
34				74			
36				76			
38				78			
40				80			
42				82			
44				84			

Note that the correct pitch setting will not necessarily correspond with the actual pitch of the teeth as it did on the video. You will record the setting which gives the desired tooth shape which could be bigger or even smaller than the pitch measurement.

The face bevel for crosscut blades will be STANDARDISED, often at 20 degrees. However, when changing any tooth shape including putting on face bevel on a newly formed tooth, it is better to do it gradually. A setting of 10 degrees could be used first, then 15 degrees and finally the full 20 degrees. Between these sharpenings the blade could of course be used if required.

Grinding Faults:

Fault 1. Loss of Hook on teeth.

Cause: Grinding wheel worn on side or mandrel position wrong. See FIG.32.

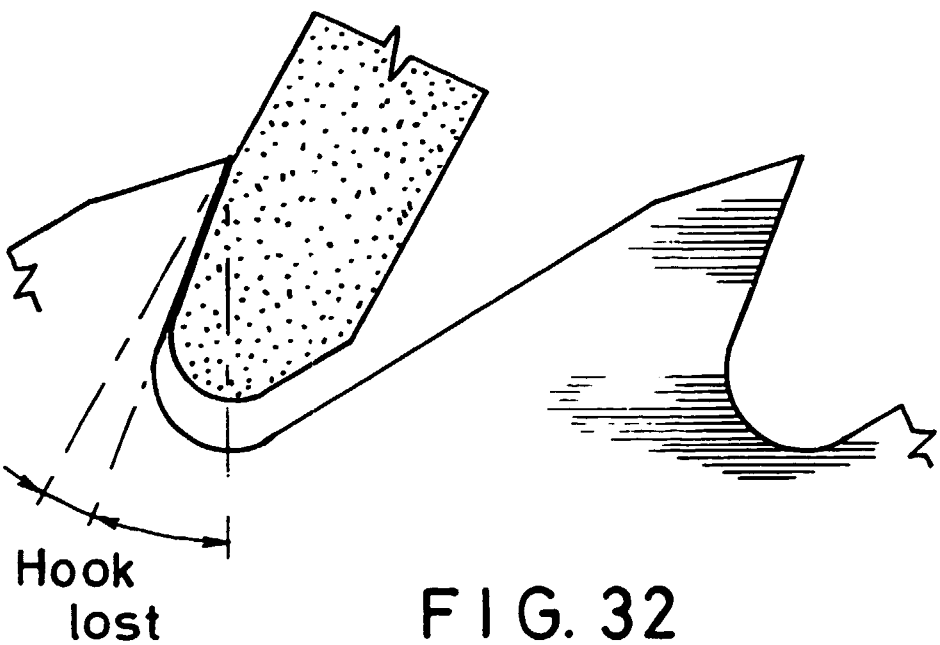


FIG. 32

Fault 2. Teeth become too narrow and weak. See FIG.33.

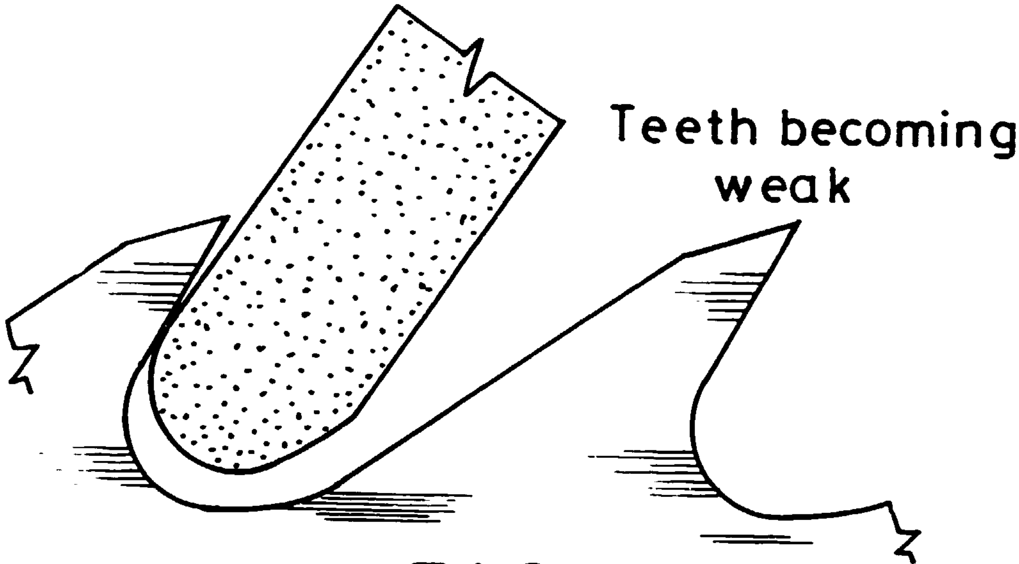


FIG. 33

Cause: Grinding wheel too wide on bevelled side or pitch setting too small or not reducing all the settings as the pitch of the teeth reduce as the blade is ground smaller in diameter. Use of chart will help considerably.

Fault 3. Teeth become too wide with reduced gullet space. See FIG. 34.

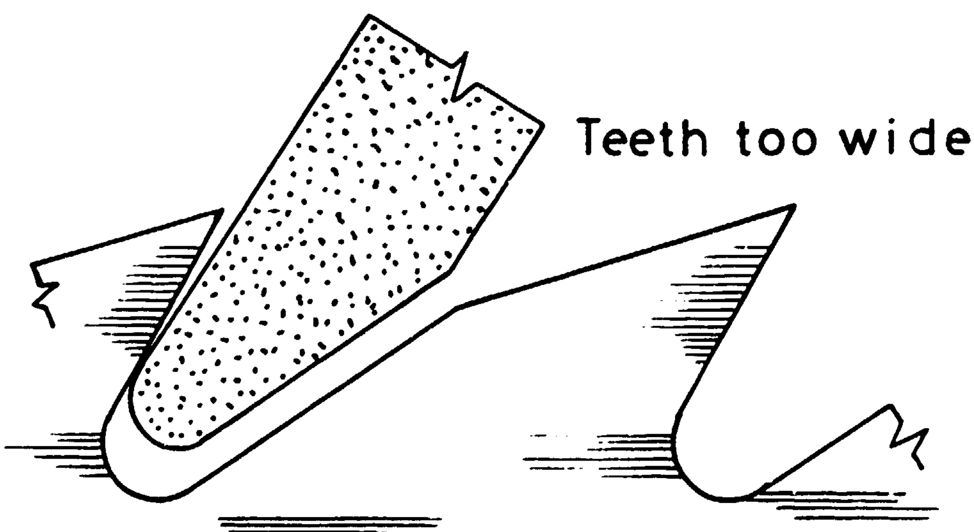


FIG. 34

Cause: Grinding wheel worn or dressed away too much on bevelled side or tooth pitch setting too big.

Fault 4. Gullets of teeth becoming too sharp in the corner.

Cause: Wheel not dressed to correct shape.Always use the gauge.

Fault 5. Teeth burnt in gullets and possibly along the remainder of the tooth profile.

Cause: Grinding wheel GLAZED and in need of dressing or grade of grinding wheel too hard or speed of grinding wheel too high.

Fault 6. Tips of teeth burnt.

Cause: Grinding too heavy on the face or tops of the teeth or side of wheel glazed.

Fault 7. Tops of teeth out of square.

Cause: Grinding wheel not over the centre of the blade. Correct by adjusting the blade thickness setting or replacing worn clamping plates.

Fault 8. Teeth with alternate face bevel (cross-cut teeth) one side smaller than the other.

Cause: Cause and correct as fault 7.

Fault 9. Face of teeth out of square.

Cause: Grinding wheel on the machine is not square with the blade when viewed from above. To correct re-adjust the 90 degrees setting on the grinding head or replace worn clamping plates.

Fault 10. Backs of teeth become hollow and correct shape is being lost. See FIG.35.

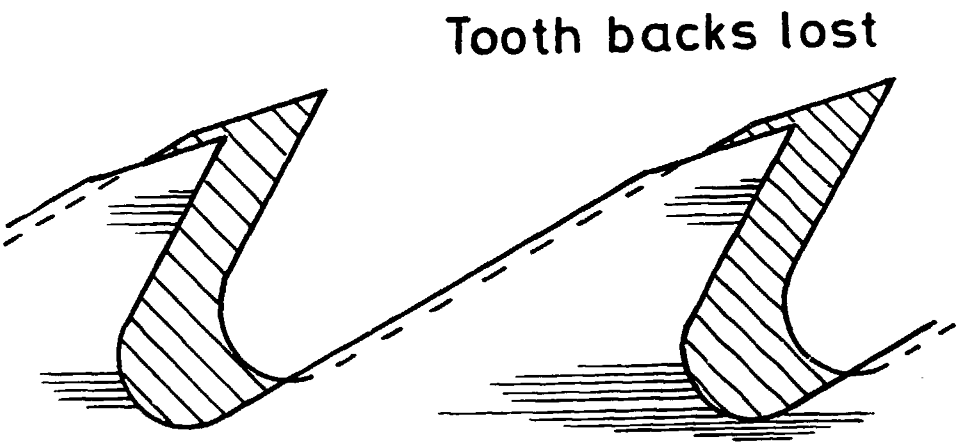


FIG. 35

Cause: Grinding too much off the face of the teeth. Correct by grinding more off the tops with the minimum off the face.

Appendix 1.

Table of Saw Guages measured by Birmingham or Stubbs Wire Guage					
Guage Number	Birmingham (or Stubbs)		Guage Number	Birmingham (or Stubbs)	
	Inch	Mm		Inch	Mm
0	0.340	8.636	13	0.095	2.413
1	0.300	7.620	14	0.083	2.108
2	0.284	7.213	15	0.072	1.828
3	0.259	6.578	16	0.065	1.651
4	0.238	6.045	17	0.058	1.473
5	0.220	5.588	18	0.049	1.244
6	0.203	5.156	19	0.042	1.066
7	0.180	4.572	20	0.035	0.889
8	0.165	4.190	21	0.032	0.812
9	0.148	3.759	22	0.028	0.711
10	0.134	3.403	23	0.025	0.635
11	0.120	3.048	24	0.022	0.559
12	0.109	2.768			