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WOOD PROCESSING AND WOOD PRODUCTS

Technical report: Sawdoctoring techniques

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* This document has not been edited.

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PREFACE

Wood processing is carried out in virtually all countries, whether or not they are endowed with forest resources of their own. The wide range of products encompasses builders joinery, doors and windows, flooring, furniture and built-in fitments, as well as a great variety of minor household and utility items. The construction industry is itself the greatest user of wood which ranges from planed all round studs to huge glued-laminated beams for sports halls and industrial buildings.

All require the use of cutting tools for manufacture.

With increased global competitiveness and recognition of higher quality standards comes the need to maintain cutting tools sharp and in good (safe) condition in order to produce the required surface finish and precision of manufacture. Automatic and numerically or computer-controlled machining absolutely requires such conditions.

The experience of UNIDO over more than 25 years of work with the wood processing and wood products industries of developing countries has been that this is one of the most neglected areas with the greatest scope for improvement in many countries. Sawdoctoring or saw filing combines the skill of a technician with the feel and instincts of an artist and requires years of training and practical experience to achieve the high levels of competence needed by the industry of today. A normal sawdoctoring course in the UK takes three years before the required skills are fully developed. There are few suitable training opportunities in developing countries for such training and a general lack of appreciation of the key place that this function should occupy in production.

This manual is intended to contribute to improving the situation. It should serve as an aid to trainers and even for non specialists who can help existing sawdoctors to upgrade their skills. It is planned eventually to produce a three-hour video covering the same material that would constitute a complete training package suitable for incorporation into the curricula of wood industry training centres and polytechnical schools. The author has been a UNIDO consultant in many countries and has established sawdoctoring centres in a few. He set up his own commercial service centre in the UK following some 20 years of international work and this manual represents his comprehensive knowledge of the subject.

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CHAPTER 1

Setting & Sharpening Circular Saw Blades:

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.

Because of the small numbers involved the training of sawdoctors has been in general very poor with many of the skills being jealously guarded rather than shared or only handed down from father to son. Many of the skills acquired were based on trial and error and were not necessarily technically correct like the glaring example I have often encountered of the over-straining of wide bandsaw blades to make them cut because the blades were not tensioned, either because of the lack of knowledge or the necessary equipment or both.

We are therefore hoping that this book 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.

Cutting Action of Saw Teeth:
Wood is a fibrous material and the only way to achieve a clean cut is to sever the fibres across their length. Most sawing is done either along the grain, which is called ripping or 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.

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. 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 is important at the time so that we achieve maximum periods between sharpening and so economy in blade life together with safety in the use of the machines.

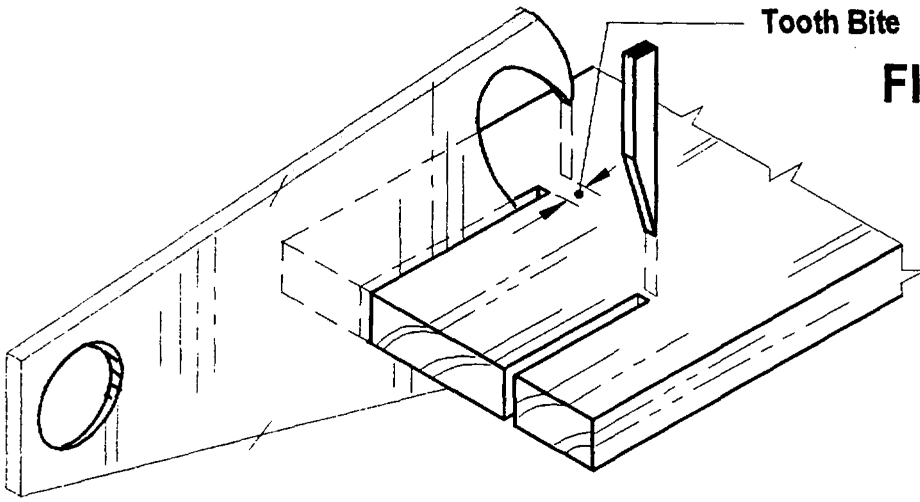


FIG.1.

CUTTING ACTION "RIPPING"

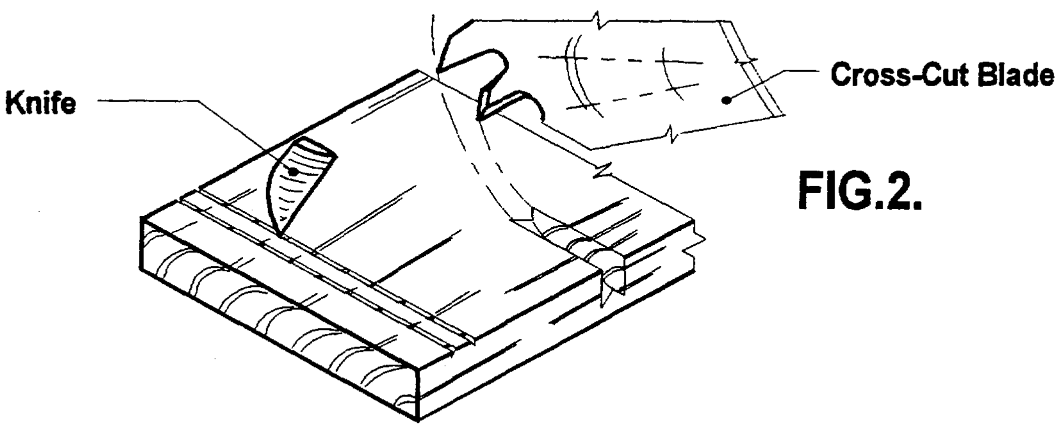


FIG.2.

CUTTING ACTION "CROSS-CUTTING"

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, 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 which would indicate that the tooth bite is too small and the blade not cutting efficiently.

The tooth bite can be calculated using the simple formula:

$$b = \frac{f\,p}{s}$$

where :- p = tooth pitch

b = tooth bite in mm

s = blade speed m/min.

f = feed speed m/min.

$$= \frac{12 \times 50}{2460}$$

$$= \underline{0.24\text{mm}}$$

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.

TOOTH GEOMETRY

Tooth Pitch:

We all know 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:

$$p = \frac{s\,b}{s}$$

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

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

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 l00mm 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 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.3.

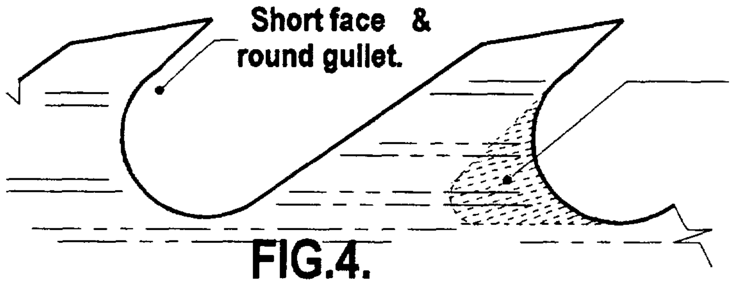


FIG.4.

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 circumference of the blade divided by 54

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

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

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

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

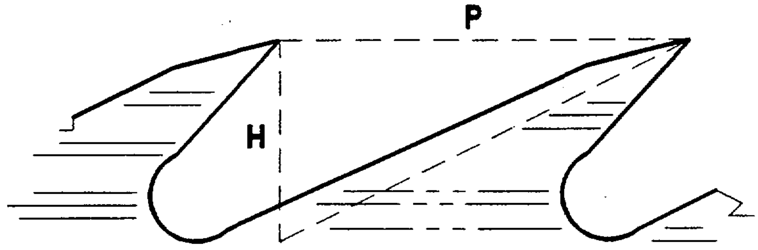


FIG.5.

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 millimetres of solid wood removed by each tooth, this would give 500 to 600 square millimetres 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 then a problem occurs with the INSIDE face of the teeth RUBBING to a depth of their penetration SEE FIG.6.

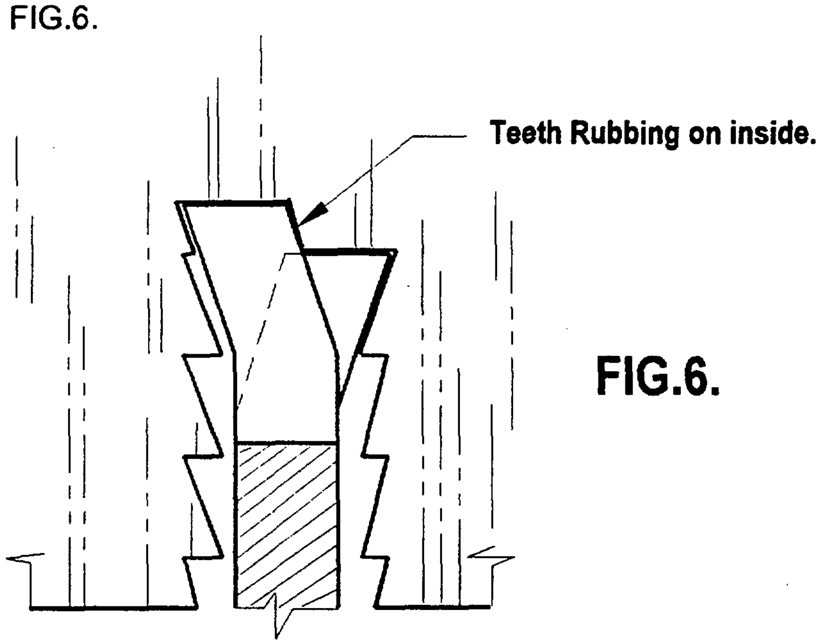
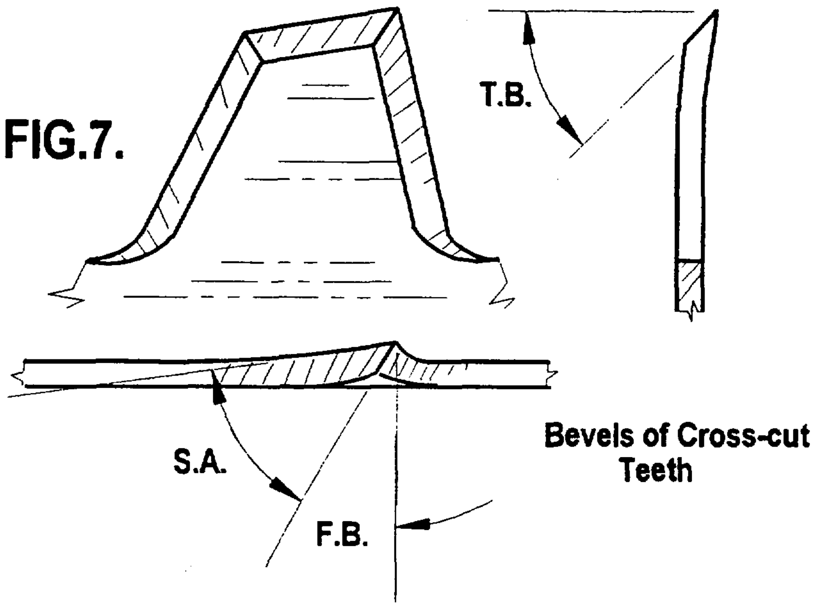


FIG.6.

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 from Fig.2.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 techniques 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.

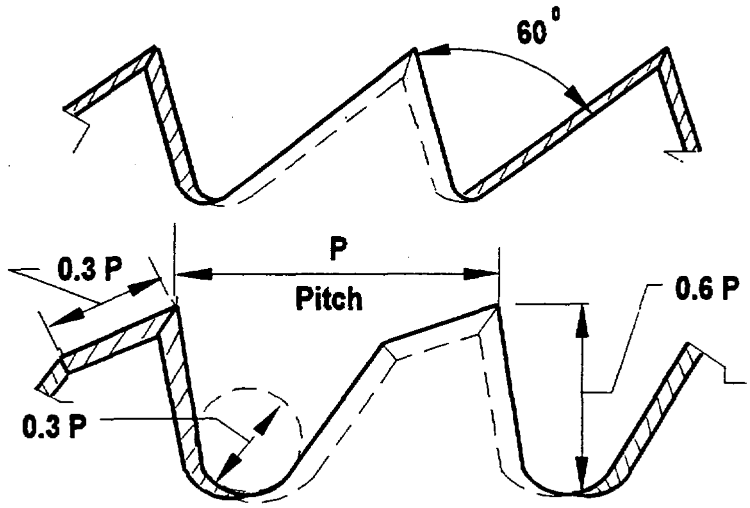


FIG.8.

CROSS - CUT TEETH

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) The blade may be hollow ground. The outer rim 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) The second method is to SWAGE the teeth using special tools or machines. The teeth are squeezed wider at the cutting edge 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 chapter as swaging is almost universally used on wide bandsaw blades and will be covered extensively when we deal with this subject in a later chapter.

3) 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.

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:

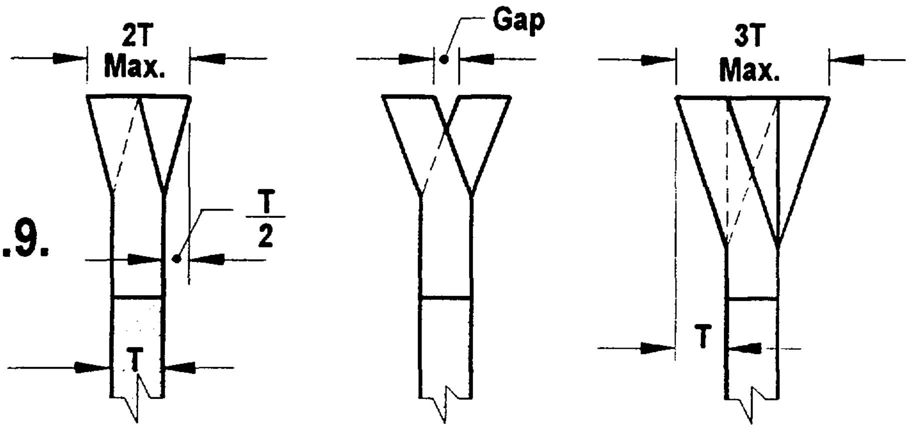
1.The diameter of the blade
2.The depth of cut
3.The type of timber being cut
4.Whether the timber is wet or dry
5.The flatness of the plate.

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 its main function is to keep open the saw cut 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.

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 and if all the teeth are set like this the blade will not cut as well as it should. The maximum set using alternate teeth 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.



SPRING SETTING

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;

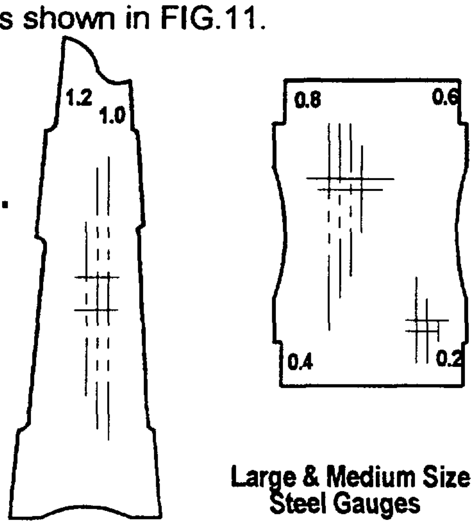
1) Give accurate results preferably within 0.05mm.
2) Not twist or bend the main body of the plate.

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 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 type set gauge purchased as shown in FIG.11.

FIG.10.



Large & Medium Size Steel Gauges

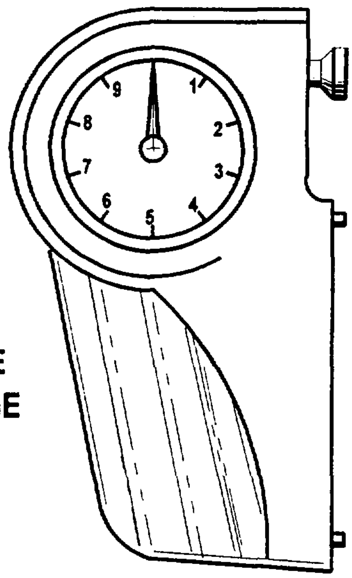


FIG.11.

DIAL TYPE
SET GAUGE

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 passed the sides of the teeth when set lower down. see FIG.13.

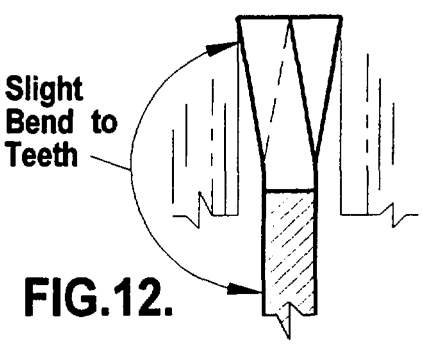


FIG.12.

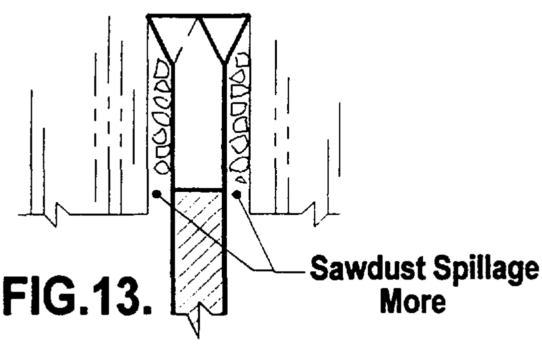
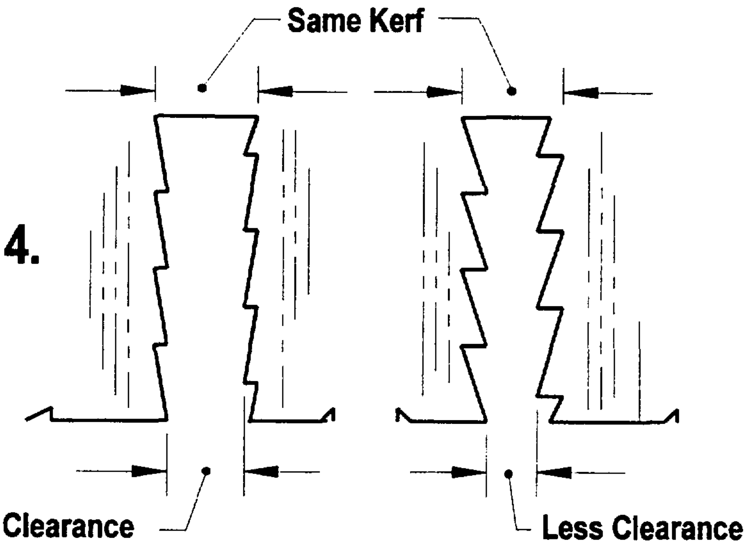


FIG.13.

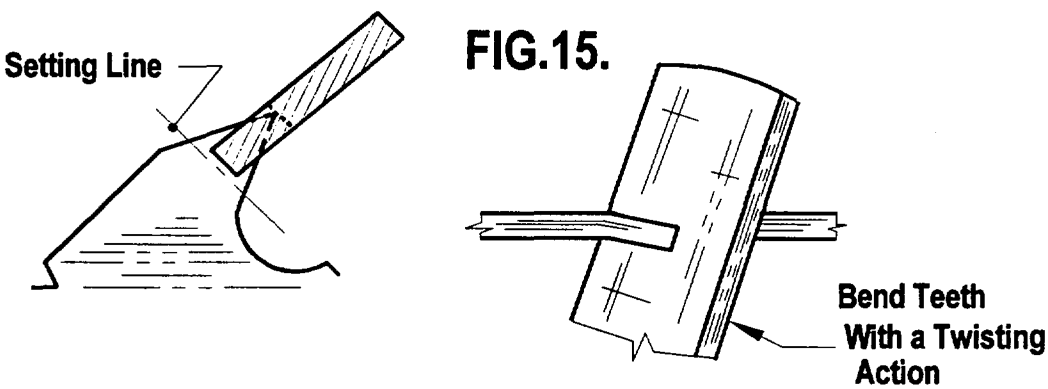
(4) The actual clearance is more when the teeth are set from lower down when using the same amount of set. see FIG.14.

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.



One of the most simple and quick methods of spring setting is to bend the teeth over the edge of an anvil with a hammer and 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. The anvil which can be any size, infact I have seen pieces of railway line used, should have a rounded corner for the teeth to bend over. The method has the advantage of not bending the plate which is a danger when using a gate setting tool. It all depends upon how much accuracy you need for the work in hand but certainly the method could be used for most cross-cutting operations in sawmilling.

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. 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.

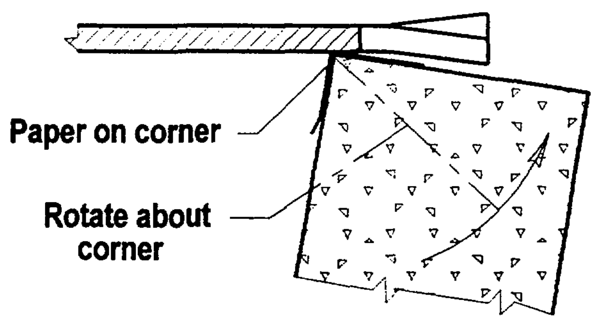


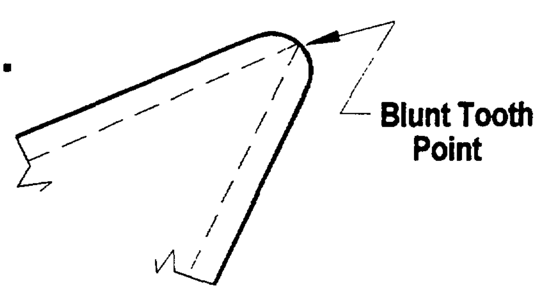
FIG.16.

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.

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 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.

FIG.17.



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

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.

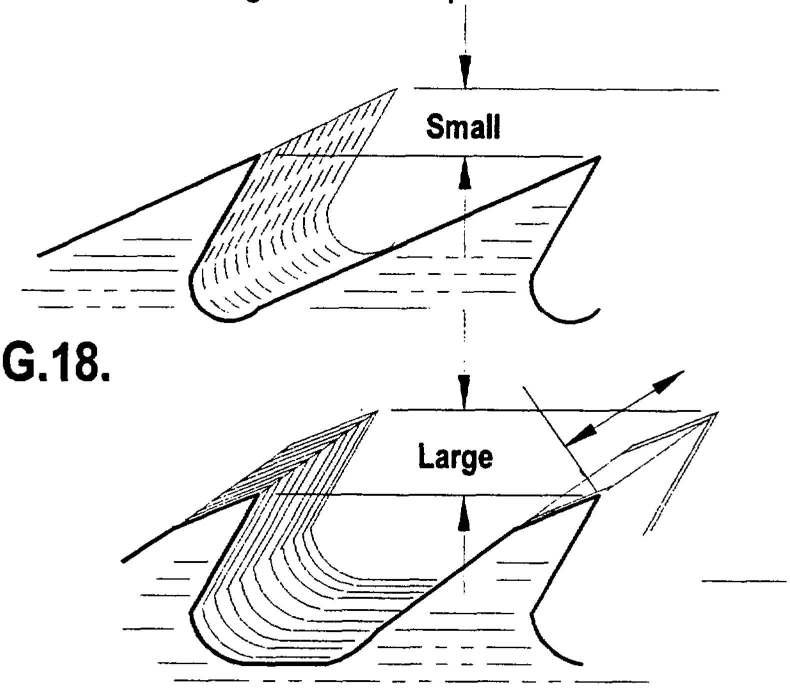


FIG.18.

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. See Plate 1.

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:

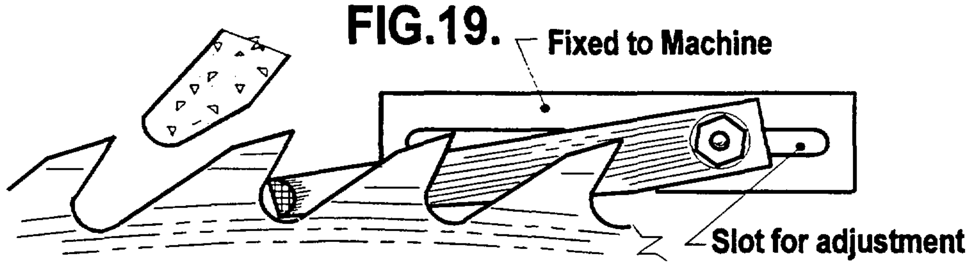
1) The mandrel on which the blades are mounted must be fitted with either self centring collars or individual accurately fitting bushes to fit the various bore sizes in use.

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 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.

FIG.19.



If you have a machine with a tooth stop fitted or might fit one a word about its use will be useful. First 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.

There are two methods of gulleting, first where the grinding wheel is lowered into the gullet and the tooth face moved into the wheel for sharpening then the blade moved so that the grinding proceeds round the base of the gullet and up the back of the tooth. The alternative method is 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.

On some machines the blade can be angled 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. SEE FIG.20.

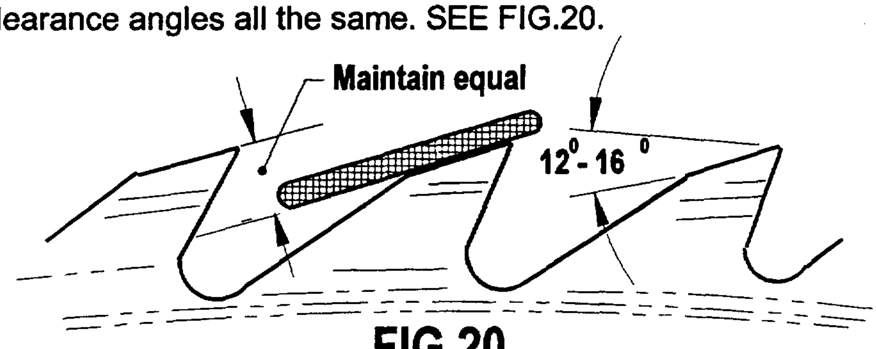


FIG.20.

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.

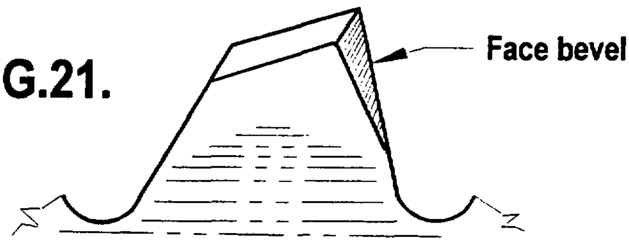
5) Although rip-saw teeth normally do not need a top bevel, in order to stop the file CHATTERING it is easier to file on five or ten degrees of top bevel.

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 shown in FIG.21.

FIG.21.



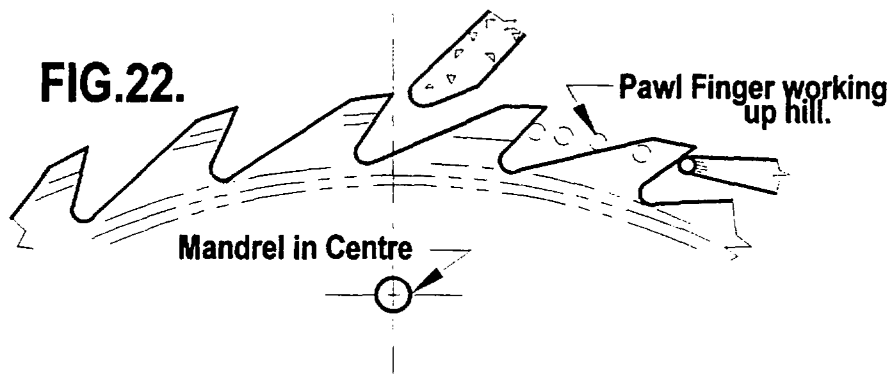
Fully Automatic Machines:
Certainly the best way to sharpen circular saw blades with solid teeth is to use one of the fully automatic machines which are designed for this purpose. Although these machines are fully automatic and can produce perfectly sharpened teeth which are all exactly alike in shape, 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:

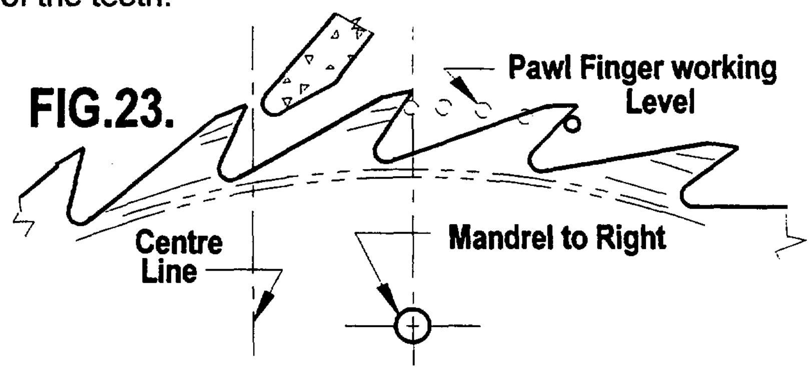
The first is the smooth working of the pawl finger and second the position, if not in the centre, alters the hook angle of the teeth. If the mandrel is placed so that the centre of the blade is under the left hand edge of the grinding wheel, as demonstrated for sharpening cross-cut blades, and as the 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 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.

FIG.22.



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 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.

FIG.23.



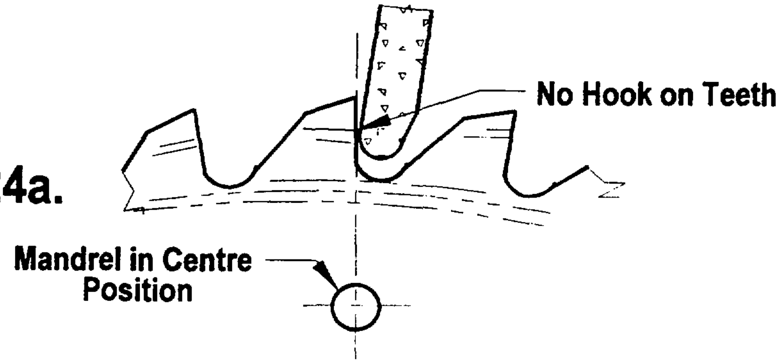
To facilitate this pawl finger movement so that it is smooth, manufacturers often recommend that the mandrel is positioned so that the blade is to the right by ONE TOOTH PITCH which roughly allows the pawl finger to move in a level line. Unfortunately, blades vary considerably in tooth pitch and diameter 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:

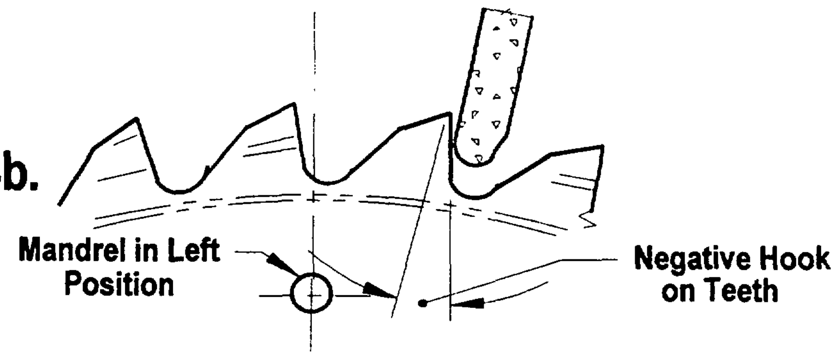
1) If the blade is positioned with the mandrel in the centre of the machine i.e. directly under the grinding wheel, then the resulting teeth will have zero degrees hook FIG. 24a.

FIG.24a.



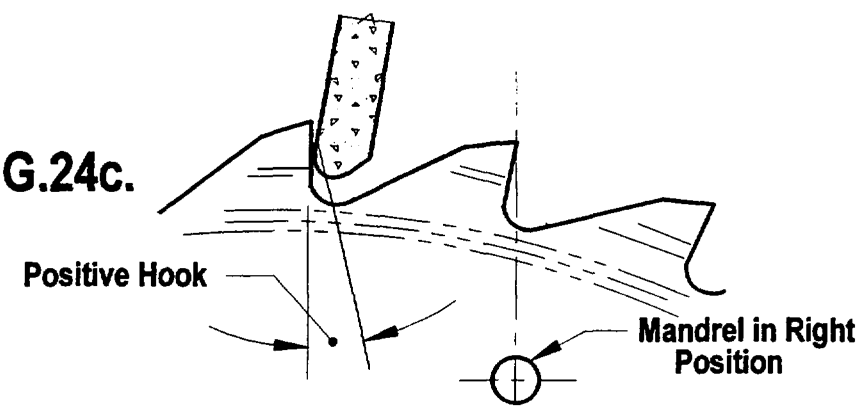
2) If the blade is secured to the LEFT of centre the resulting teeth will have some amount of NEGATIVE hook Fig. 24b.

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:

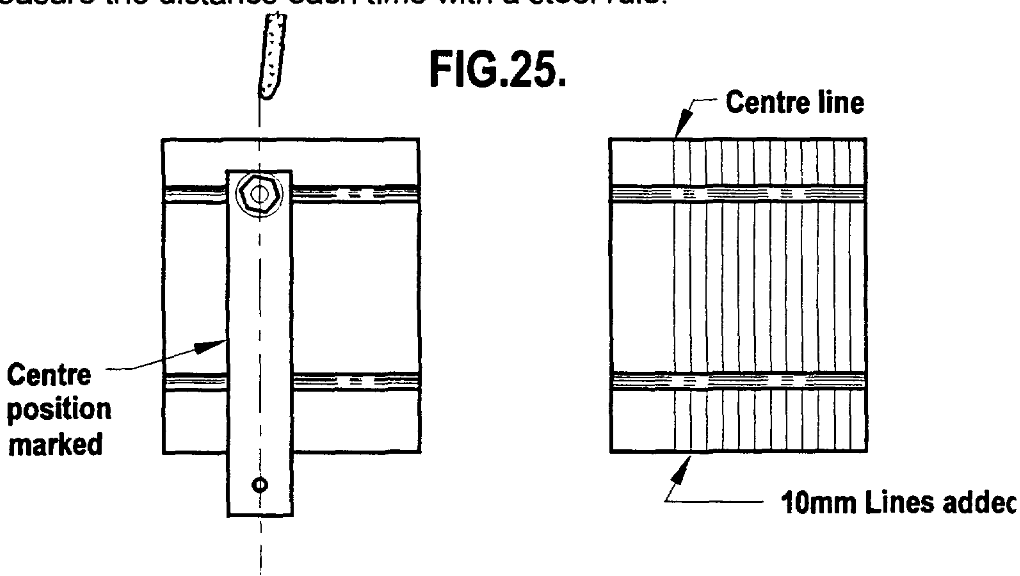
For all cross-cut blades the mandrel is positioned in the centre, the slight slope on the teeth which are usually of small pitch is accommodated by tilting slightly the slide on which the pawl finger moves.

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.

For example; if we have a 600mm. for sharpening we would set the mandrel position to the right of centre by 30mm. which would give five degrees of hook, then if we required 25 degrees of hook would tilt the grinding head a further twenty degrees to give the total angle required.

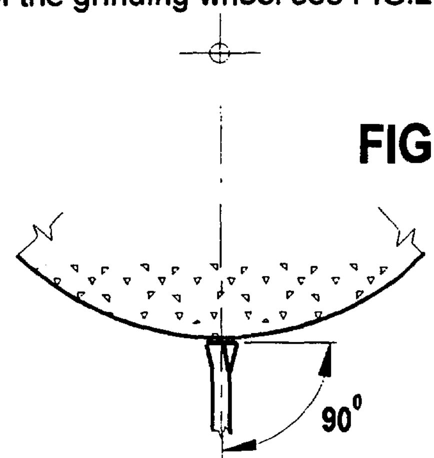
To facilitate this mandrel position setting the position of the mandrel should be marked when it is in the centre under the left-hand edge of the grinding wheel as shown in FIG.25. Then further lines should be scribed onto the machine in 10mm. divisions. The mandrel can then be positioned accurately enough without having to measure the distance each time with a steel rule.

FIG.25.



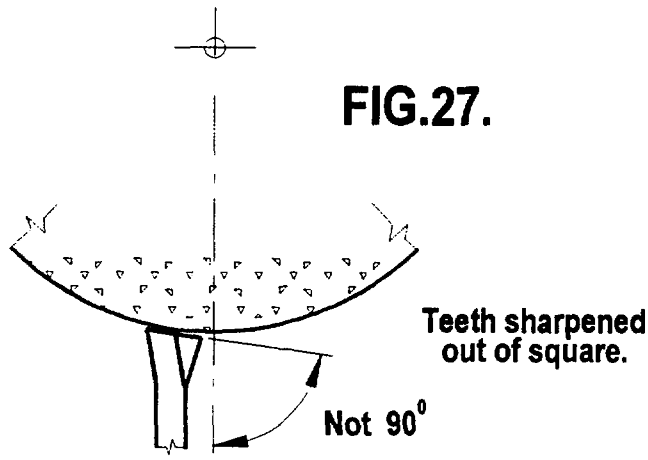
Blade Thickness Setting:
Modern automatic saw sharpening machines have an adjustment to alter the position of the rear blade clamping plate so that the blade can be positioned exactly under the centre of the grinding wheel see FIG.26.

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 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.

FIG.27.



There are three types of tools which would measure the blade accurately so that the machine can be set correctly, namely the micrometer, the vernier calliper and the simple saw gauge. The one I use has both metric and imperial sizes next to the gauge numbers which does away with the need to look up sizes on a chart. For those with gauges having only gauge numbers a chart is included at the end of this chapter as Fig.36.

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.

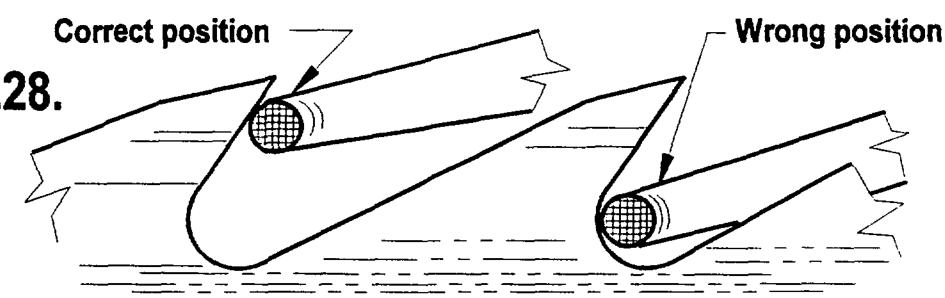
The initial setting for teeth which have not been sharpened before will usually be in the region of one an a half times the actual pitch and height of the teeth and these settings are reduced once the machine is started and the grinding wheel is moving safely up and down the tooth profile without grinding. 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 and will be explained later but first 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.

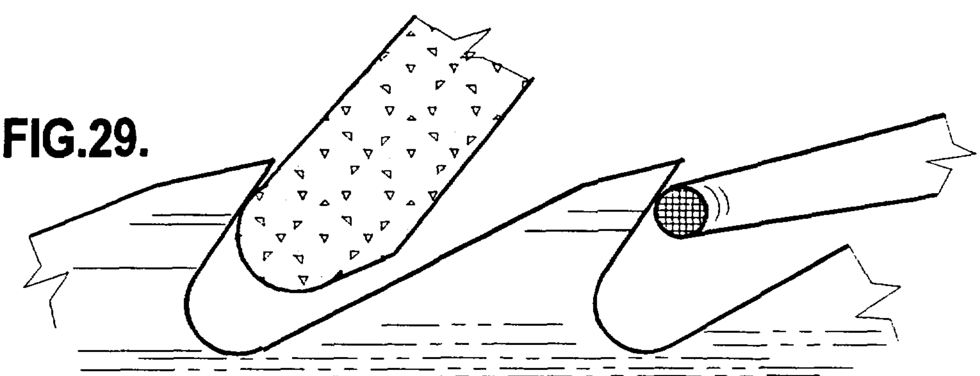
FIG.28.



Pawl finger setting

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

FIG.29.



Pawl Finger setting One Tooth back

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.SeeFIG.30.

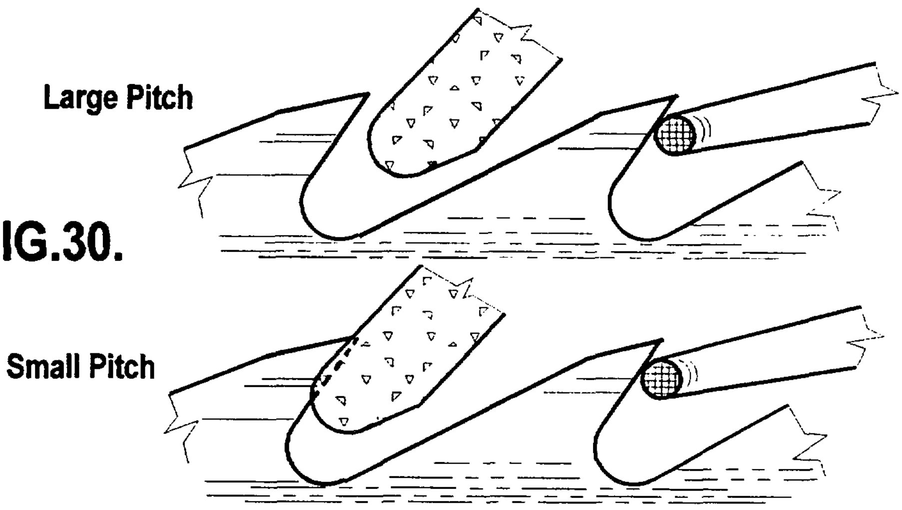


FIG.30.

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.

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. 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 some 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. divisible 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.

Note that the correct pitch setting will not necessarily correspond with the actual pitch of the teeth. 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.

FIG. 31.

CIRCULAR SAW BLADE SETTING CHART

COMMON SETTINGS

SKETCH OF TOOTH

CAM SHAPE............................
HOOK ANGLE..........................
FACE BEVEL............................
MANDREL POSITION................

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			

Grinding Faults:

Fault 1. Loss of Hook on teeth.
Cause:Grinding wheel worn on side or mandrel position wrong. See FIG.32.

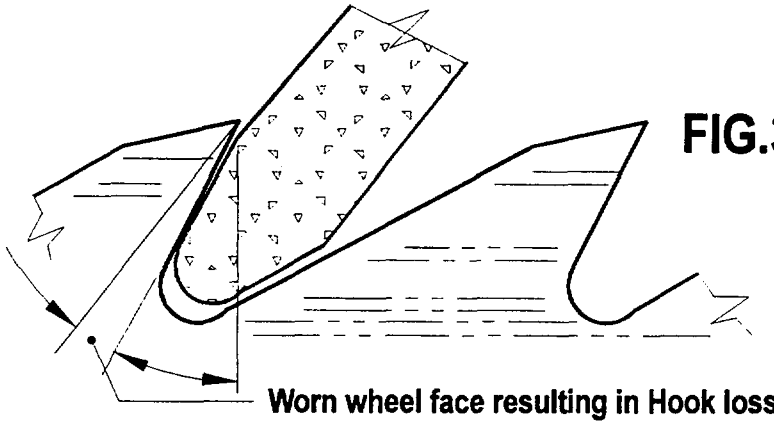


FIG.32.

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

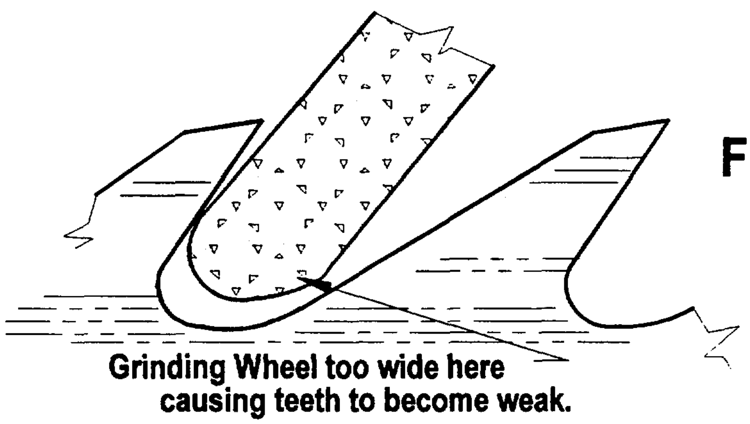


FIG.33.

Fault 3. Teeth become too wide with reduced gullet space.
Cause: Grinding wheel worn or dressed away too much on bevelled side or tooth pitch setting too big. See FIG. 34.

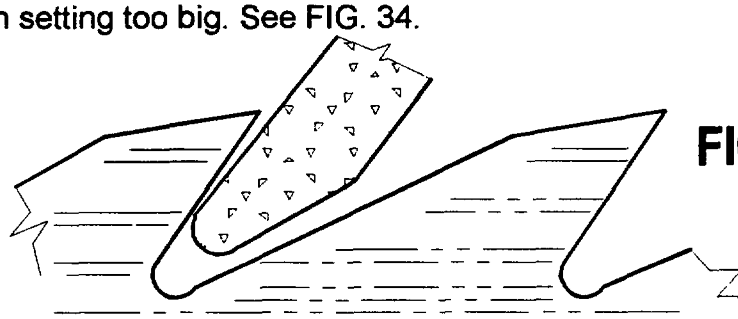


FIG.34.

Grinding Wheel dressed too narrow causing teeth to be too wide.

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.
Cause: Grinding too much off the face of the teeth. Correct by grinding more off the tops with the minimum off the face. See FIG.35.

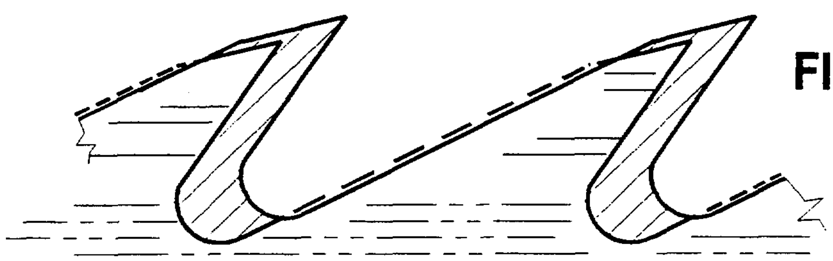


FIG.35.

Tooth backs lost.

FIG.36.

Table of Saw Gauges
measured by Birmingham or Stubbs
Wire Gauge

Gauge Number	Inch	Millimetres	Gauge Number	Inch	Millimetres
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	0.599
12	0.109	2.768			

CHAPTER 2

Tungsten Carbide Tipped Circular Saw Blades:

In Chapter 1 we dealt with the basic circular plate blade with the teeth formed onto the blade itself and whilst this is satisfactory for many types of production the steel of which the blade is made has to be *TOUGH* as well as *HARD* and therefore there is a limit to the hardness to which the steel can be tempered and consequently a limit to the cutting life of the teeth. Various ideas of attaching separate teeth made of harder materials are used but the most successful must be the use of *Tungsten Carbide* which because of its extreme hardness is now almost always used for the resawing of dry hardwoods and cutting of man made fibre boards etc. when the production between sharpenings may be up to fifty times more than with ordinary carbon steel teeth.

Tooth Geometry:
All that we demonstrated in Chapter 1 about the cutting action and geometry of ordinary teeth apply equally to tungsten carbide teeth except that we must realise that tungsten carbide is extremely *Brittle* and therefore the sharpness angles of cutting edges need to remain strong, in other words we cannot sharpen tungsten carbide to a fine knife like cutting edge without the risk of it breaking down.

Having said that, for all rip saw tooth profiles there is no problem, for if we take an extreme example of 35 degrees hook angle and 16 degrees top clearance angle the remaining sharpness angle is still 39 degrees and is still quite strong. See Fig. 37.

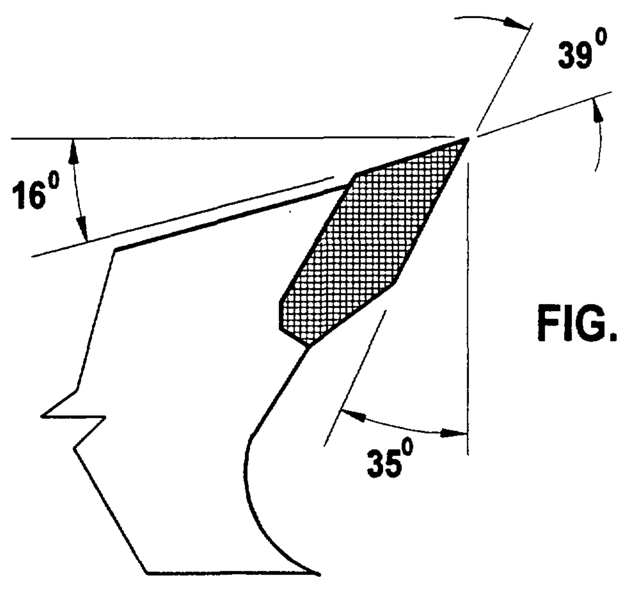


FIG.37.

On the other hand if we wanted to increase the strength of the tip, for say the fast cutting of softwood which had hard knots in it, then we could use *TWO* top clearance angles one for the tip of say 12 degrees and a larger angle of say 16 degrees for the tooth behind the tip. See Fig. 38.

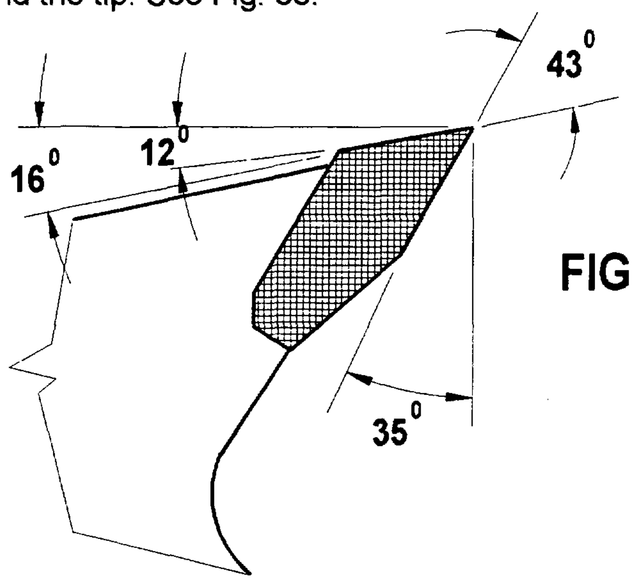


FIG.38.

In the chapter on ordinary plate blades we explained how sometimes we used a top bevel on ripsaw teeth to prevent the insides of spring-set teeth from rubbing. These top bevels are not necessary on tipped teeth because both sides of each tip have their own side clearance. Cross-cut teeth, if you remember, need a good face bevel to provide a knife like cutting edge down the side of the teeth and a good top bevel to assist deeper penetration of the cutting edge and this still applies when they are tipped but we should not exceed 20 degrees for each of the bevels as beyond this the remaining point would become too weak. See Fig. 39.

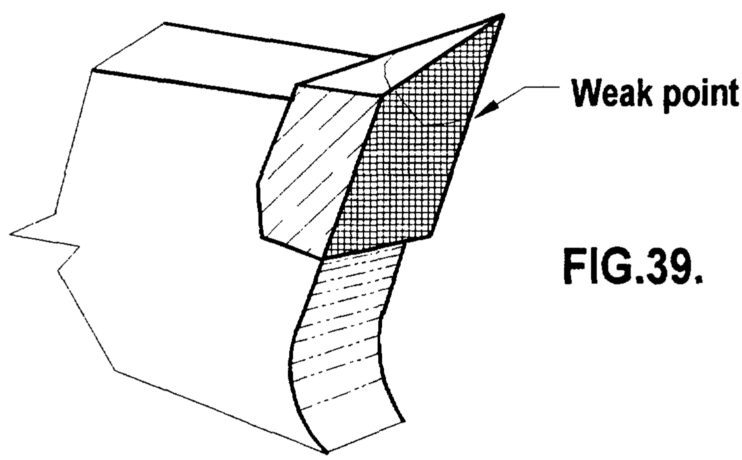


FIG.39.

Tooth shapes to which the tips are secured should conform to the rules of design as illustrated in the first video. i.e. any shape which gives a good support to the carbide tip, has a suitable gullet area and shape to carry and eject the sawdust generated and a height no more than half the tooth pitch or no more than ten times the thickness of the plate whichever is the smaller.

There is one possible difference which is that the straight face of the teeth *SHOULD* have a length at least equal to the length of the tips plus the *WIDTH* of the diamond wheel face so that the wheel can fully pass the tips when grinding the faces. See Fig. 40.

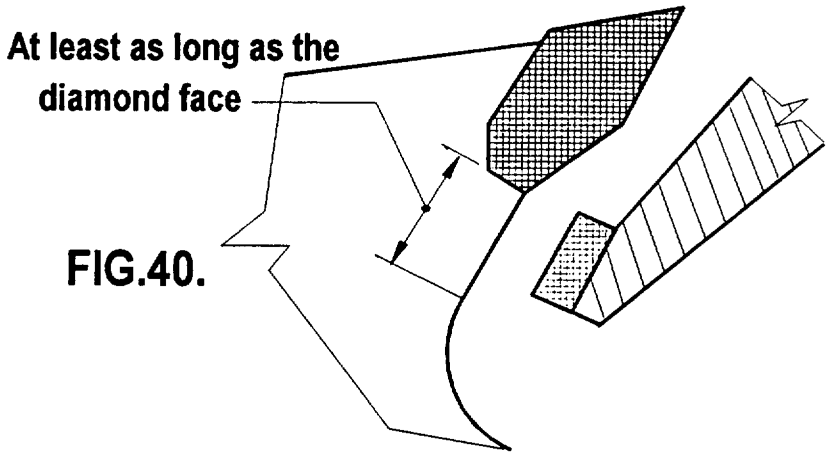


FIG.40.

Blade Side Clearance:
Blade side clearance is simply obtained by fitting tips which are *WIDER* than the plate. The tips normally project on one or both sides of the plate although they can be flush on the non-cutting side on cross-cut blades as shown in Fig. 41.

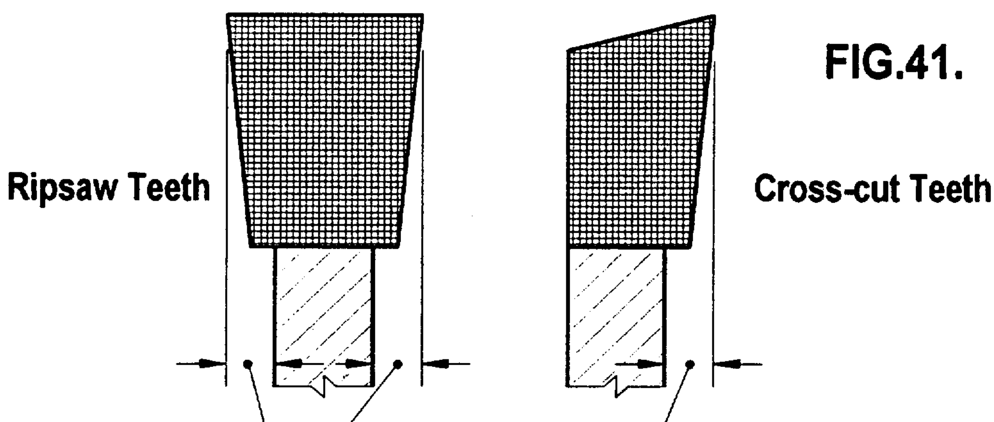


FIG.41.

Each tip has its own side clearance ground on normally in two directions i.e. *TANGENTIALLY* and *RADIALLY* the amount is usually about 3 degrees in both directions.

Because of this ground on side clearance on the tip itself, the actual amount of clearance will reduce as the top is sharpened on the face and / or tops therefore radial and tangential side clearances should always be kept to a minimum when side grinding new or replacement tips See Fig.42. Even when the amount of side clearance is reduced with sharpening the teeth should *NEVER* be sprung set. This would ruin the accuracy of the plate and spoil the blade which could otherwise be re-tipped and made as new again.

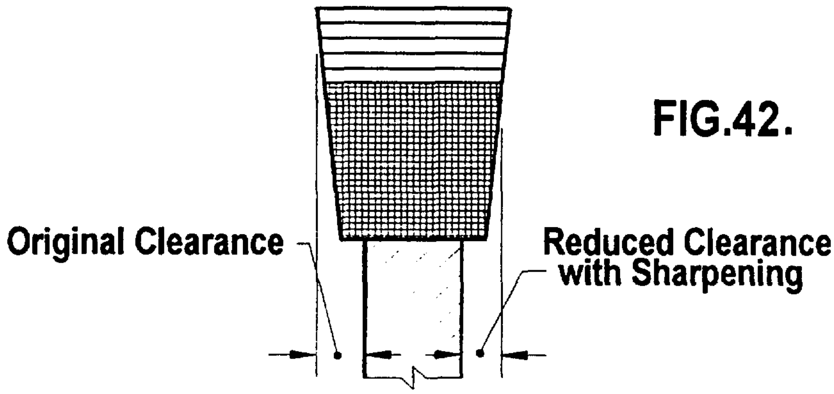


FIG.42.

Tungsten Carbide Tips:

Tungsten carbide tips are manufactured not by melting the ingredients as with steel but by compressing the materials, which are in powdered form, under tremendous pressure to form various size and shaped blocks which are used as cutting agents in many industries. These blocks are *SINTERED* i.e. fired in an oven in a similar way to house building bricks so perhaps we may realise why the tips are so *BRITTLE* and have to be handled with much more care than do other cutting agents such as carbon and high speed steels. If a tip is accidentally knocked say when putting a blade into its machine the brittle sharp cutting edges will be damaged often resulting in the tip having to be replaced. It is therefore sensible practice to keep blades in their original boxes or secured to pieces of plywood or hardboard when not in use and when being transported to and from the machines.

Manufacturers can and do improve the toughness of some of the tips at the expense of some of the hardness and this results in there being various *GRADES* of tips. The most common grading system is shown in APPENDIX 1. Often the small user will not have a choice of grades only a choice of sizes, however providing that you state the material to be cut when ordering blades or tips you should receive a suitable grade.

The quality, size and shape of tips do vary considerably from different manufacturers and Fig 43. shows good and poor shapes and what to look for when purchasing new blades or tips.

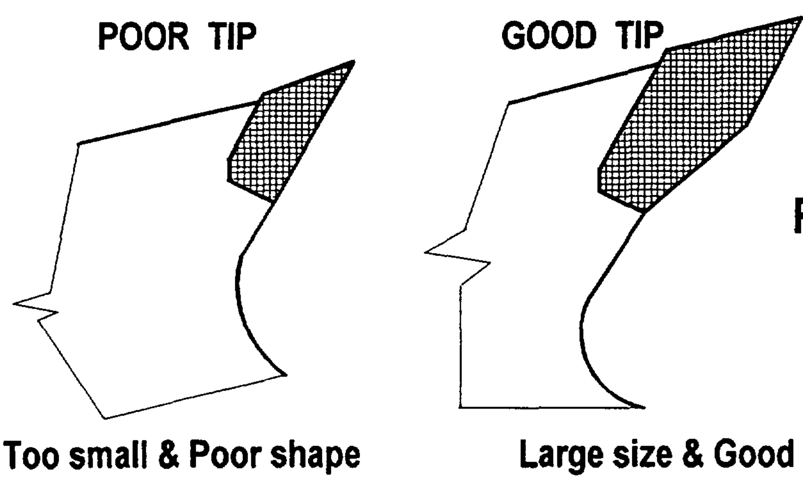
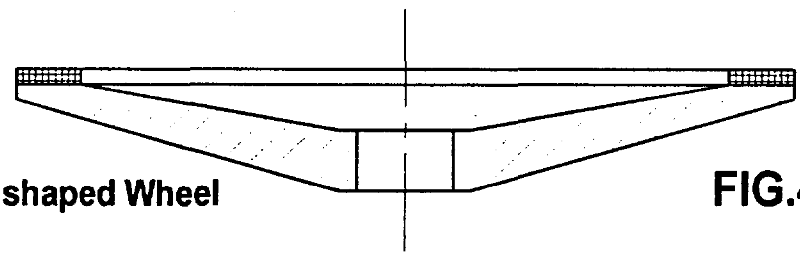


FIG.43.

As well as a big range of sizes some tips supplied for the repair of blades may also have the tangential side clearance moulded onto the tips, this does save time and materials when side grinding so this type is preferred to those with square sides. Again the tips may be *Tinned* which will assist when brazing, if they are tinned they will look silvery in colour and not dull grey/black which is the normal appearance of tungsten carbide. Also tips may be pre-coated with a blob of silver solder by some manufacturers and this may be useful although I prefer to use plain or just tinned replacement tips.

Sharpening:
Sharpening has to be done using special grinding wheels the cutting parts of which are made of industrial *DIAMOND* which can be either natural or man-made synthetic diamond. Both these materials are extremely expensive and so will only form the cutting face of the wheel, the body of the wheel being made of alloy or plastic.

The body of the wheels are made in many shapes and sizes but the most common shape used for saw sharpening is saucer shaped as shown in Fig. 44.



Saucer shaped Wheel **FIG.44.**

The cutting portion will vary in both width and thickness and will alter the price of the wheel. It is usually cheaper to purchase one wheel with a 3mm thick face than three wheels each with 1mm thickness of diamond, however sometimes it is necessary to purchase a wheel with a thin face to get into narrow gullets although it will usually be possible and more economical to use wheels which have worn down for this work

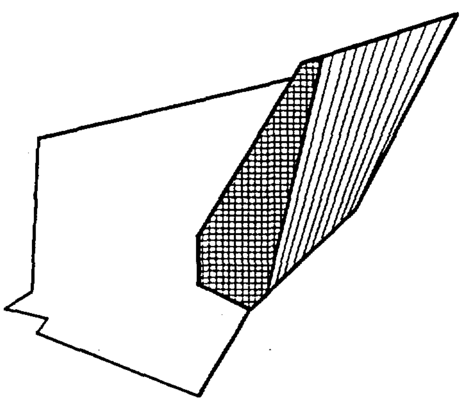
Although sharpening can be carried out dry, the fine dust particles released into the atmosphere around the machine are a serious health hazard and for this reason alone the use of a grinding coolant is highly recommended. In addition by using a coolant finer grade grinding wheels can be used which will give a superior finish and longer life to the cutting edges.

The long cutting life and superior finishes which are possible with tungsten carbide tooling when they are new will only continue if the sharpening is carried out on good quality *WELL MAINTAINED* machines. This does not mean that the machines have to be the most expensive fully automatic type, these are only necessary if the volume of production warrants their high cost, but they should be well made with all moving parts protected from wear. Particular attention should be paid to choosing and maintaining tooth stops and perfectly fitting hardened steel mounting bushes are preferred to tapered cones for blade mounting as it is these two parts of the machine which greatly affect the accuracy of sharpening and subsequent cutting efficiency.

The wear on tungsten carbide cutting edges is the same as we illustrated for plate blades and the rounded cutting edges will be most easily restored by grinding roughly equal amounts off the face and tops. However there are other considerations to be made which affect the chosen method of sharpening. First if new blades are easily available at reasonable prices then sharpening more off the tops of the teeth including grinding away the steel behind the tips then throwing the blade away may be the most economical method, however in many countries with large sawmilling industries new blades and often foreign currency to buy them are not easily available and so the body of the blade becomes much more valuable and reducing the diameter by grinding away the steel behind the teeth may not be a good idea. In other words we may grind away only the tips without touching the plate and when they are worn down too small they can be removed and the blade re-tipped as new, the tips being easier and cheaper to import than whole blades.

This brings us to *TWO* different basic methods of sharpening with a third which is a combination of the two.

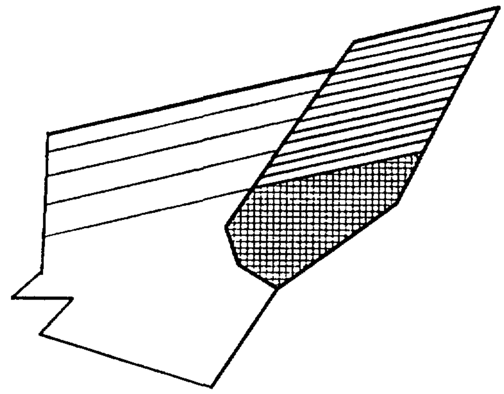
First we may sharpen only on the faces of the teeth but gradually decreasing the hook angle very slightly each sharpening to increase the number of sharpenings possible without touching the body of the blade as shown in Fig. 45.



Sharpening the Face only

FIG.45

The second method is to grind mainly or entirely off the tops of the tips and every three or four sharpenings relieve the steel behind the teeth using a normal grinding wheel. See Fig.46. Note that diamond wheels should *NOT* be used to grind the backing steel as this will tend to clog the face of the wheel.



Sharpening the Tops only

FIG.46.

There are of course variations of these two methods in fact combinations of the two and the actual method can be developed to suit the situation and the facilities you have for sharpening and repair.

Replacement of Broken Teeth:
Because of the brittle nature of tungsten carbide teeth often become damaged by accidentally getting knocked or by hitting a foreign object whilst cutting such as a nail or screw hidden in a piece of wood. It may not be necessary to replace a single damaged tip as often a single missing tip will not affect the efficiency of the blade and small chips off tips will eventually grind out after a few normal sharpenings. However, often several tips grouped together will be damaged and for example if three teeth are damaged together the following fourth tooth will have to do the work of four teeth i.e. take out a tooth bite four times its normal amount. In this case the teeth will need replacing.

The damaged tips are easily removed by melting the brazing solder using an oxy-acetylene torch fitted with a small nozzle and adjusted to a neutral flame. What is *MOST* important is that the absolute *MINIMUM* heat is applied to the blade itself otherwise the blade will distort and may be impossible to straighten out and have to be scrapped. Having warned you about this actually there is no problem providing that the flame is directed *AWAY* from the blade.

Having removed the broken tips, some may be worth keeping for replacing small tips, the blade around where the tip has been removed has to be thoroughly cleaned using a file or abrasive cloth. The seatings, both sides and the top of the teeth all have to be cleaned in fact everywhere you want the brazing solder to adhere to has to be perfectly clean. Sometimes a small piece of tungsten carbide will remain stuck to the seating, if this happens it may be easier to just grind it off using a diamond wheel.

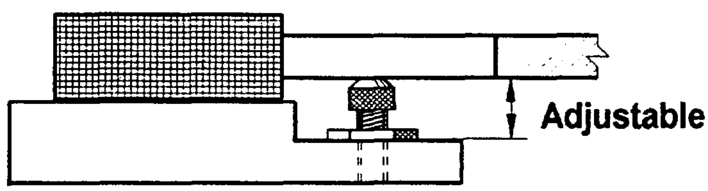
The process of brazing relies very much for its strength on everything being scrupulously clean, the cleaned parts must not even be touched with your fingers, so after the contact surfaces of the tips have been cleaned, the tips are best handled with a pair of tweezers.

The brazing material used for retipping should have a low melting point similar to the silver solder as used for brazing wide bandsaw blades. Standard brazing wires can be used but they will usually have a higher melting point than a good quality silver solder and so if used will require more heat and so have a tendency to overheat the blade which could cause distortion of the plate. The correct materials with a higher silver content will usually be more expensive and come in the form of either a very thin narrow flat foil mainly used in conjunction with electrical brazing machinery which can be manual or fully automatic or in the form of a paste which includes the necessary flux and this I find is the easiest to use for occasional repairs especially when using an oxy-acetylene torch to supply the heat. The only drawback with the paste is that it may dry up and become hard in its tube if it is not used within a few months.

A suitable Flux has to be used in conjunction with most other wire forms of brazing material although there are some wires which have a coating of flux but these are usually general purpose brazing wires and are not necessarily suitable for our work.

Some means of holding the tips against the seatings and *CENTRAL* on the plate so that the tips stick out an equal amount each side is required and this may be part of a special machine or a simple jig purchased or fabricated in your own workshop. A simple set-up is shown in Fig.47. This has two adjustable set screws which the blade sits on and controls the projection of the tips.

FIG.47.



Now for the actual replacement of the tips, the procedure varies slightly depending on the brazing material used but let us assume we will use paste:-

(1) Select suitable size tips slightly larger than the tips they are replacing.

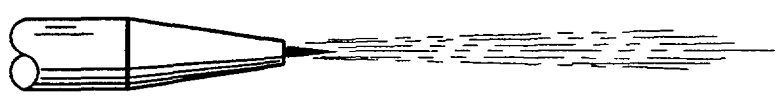
(2) Clean the seatings, tips and brazing material if it is foil or wire.

(3) Place blade in the jig and adjust if necessary.

(4) Put a small blob of paste on the back of the tips.

(5) Light up the torch and adjust to an oxidising flame i.e. one with slightly more oxygen than acetylene and giving a pointed inner cone see Fig. 48.

FIG.48.



Oxidixing Flame

(6) Put a tip in place and hold it using an old file or similar steel rod.

(7) Heat up the tip first to dull red colour, then move the flame to the bottom of the seating, watch the solder and as it starts to melt move the flame up the back of the tip and then slowly raise the torch away but keeping the joint warm with the outer part of the flame for about five full seconds. This slow cooling is vital otherwise the carbon steel behind the tips will harden and become brittle and may break off with disastrous results.

(8) Repeat the process for all the teeth to be replaced, however for small pitch teeth which are close together, it may be a good idea to move to different parts of the blade so that the heat does not build up in one part of the blade.

(9) When the tips are all replaced and have cooled down, reheat each tip for about five seconds, more for big teeth on thick plates. This annealing the steel again is to be on the safe side. The correct temperature for the annealing process is around 300 degrees Celsius or in practical terms enough to turn bright steel blue. If you want to be fairly sure of the timing clean off a tooth behind the tip with abrasive cloth or a file then reheat until blue counting in seconds the time it takes.

(10) The strength of the braze may be tested by gently tapping the teeth with a piece of wood although once you have gained confidence in your brazing this will not be necessary as any faulty brazes will show up during the sharpening when the tooth will come off so the chances of them coming off during use is fairly small.

(11) Surplus silver solder and flux should be removed next, a file and abrasive cloth can be used but after you have acquired the skill of applying just enough silver solder and flux to do the job and no more then the best way is probably to use a power wire brush 150mm or 200mm diameter attached to a bench grinder. The manufacturers use a sand blasting cabinet where an abrasive, not sand, is blasted onto the blade around the toothed rim at high pressure with compressed air.

(12) Sharpening comes next with the faces being sharpened first. This is essential to ensure the tooth stop will have a good face to locate onto so that all the grinding that follows will be accurate. When damaged tips are replaced it is important that the replacement tips are ground down to the same size. This is to ensure both balance and cutting efficiency as several large tips together could cause imbalance and just one tip left too large would ruin the finish of the other teeth. Sharpening this time means not only the faces and tops but also the sides which we will now deal with as a separate subject heading.

Side Grinding:
We said earlier that the sides of tungsten carbide tips will normally have about three degrees side clearance ground onto the sides in two directions i.e. *Tangentially* & *Radially*. These two angles are achieved in different ways depending upon the type of side grinding machine available. The main

difference between the designs of machines is that some use a small diameter cup wheel usually 50 - 60 mm diameter whilst the others use the edge of a small straight wheel usually about 100mm diameter. The reason for both wheels being small is the need for the wheels to grind at an angle close to the blade without touching the sides of the plate. The smaller the wheel the less efficient it usually is therefore machines using the usually larger straight wheel are the most popular.

Machines using cup wheels have to be designed so that the grinding head can be angled in two directions to give the two angles required but the machines using the straight wheels need only one adjustment for the *Radial clearance* the *Tangential* clearance being obtained by offsetting the wheel as shown in Fig. 49.

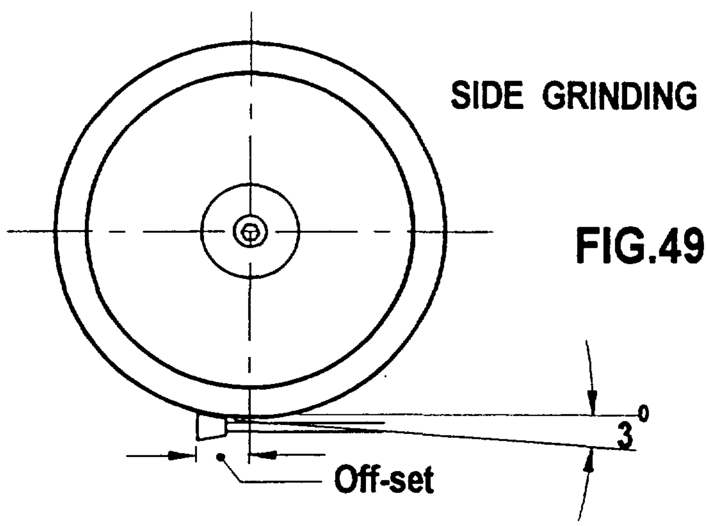


FIG.49.

The actual grinding is straight forward enough with each tip being ground down until the side clearance measures the same as the other original tips. This has to be done very accurately say within 0.05mm therefore a dial type set gauge must be used for checking the results. Sometimes a similar gauge is attached to the machine to measure how much is being removed as the grinding proceeds. It may be possible to rely on these built-in dial gauges if tips are finished off with a light grinding but they are often set up to measure how much the grinding head has been lowered and not set to measure the tips' actual clearance. However the best method can only be found with experience with your particular make and model of machine.

Occasionally you may come across special blades when the *RADIAL* side clearance angle on some teeth is not the usual three degrees, these could be *PLANER* blades or blades with special *WIPER* slots when the tips have no radial angle i.e. they are ground at zero degrees or may even be angled the opposite way as on one design of planer blade. If such blades are used in your factory then a side grinding machine that can be adjusted for these other angles is essential unless a universal Tool & Cutter Grinder is also available which could possibly be used.

Finally on side grinding, if we measure the projection of the teeth from the side of the plate then we are relying on the *FLATNESS* of the plate for the accuracy of the finished replacement teeth or set of new teeth. The alternative method is to mount the blade between an accurate pair of collars, as with the fully automatic machines used by the blade manufacturers and grind the tips down to the same setting on the machine's scale and so not relying on the plate's flatness.

Complete Retipping:
As we said earlier you may be in a situation where replacement blades are not easily available and the complete retipping of blades with worn out tips becomes an economic proposition, providing of course that the plates have been cared for and are in good condition.

Now let us assume that we are going to retip a blade and that we have already removed the worn out tips. We have also checked the plate for being level and having some tension if required as it is better to do any hammering before the new tips are brazed on even if final tensioning is done afterwards.

We will also assume that we have been grinding down the steel behind the tips and therefore the teeth will need reforming and the seatings for the tips regrinding.

The blade is set-up on the automatic saw sharpener as described in the first video with the only difference being that the pawl finger should be set a little lower down just below the old seatings where the location will be more accurate. The tooth shape is not so important so long as it is a *STRONG* shape to give good support to the tips and has the necessary length to the straight face as explained earlier. As soon as the shape is satisfactory stop grinding as we need to reduce the diameter of the blade as little as possible.

Next the seatings will have to be deepened to fit the new replacement tips and this may be carried out on various machines depending upon what is available. The machines which can be used for this simple operation include, the gulletting machine, the universal tool and cutter grinder and the same automatic machine we use for sharpening.

To do this right is perhaps the most difficult part of the operation as a large amount of steel has to be removed compared with normal sharpening. See Fig. 50.

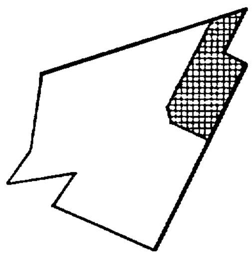


FIG.50.

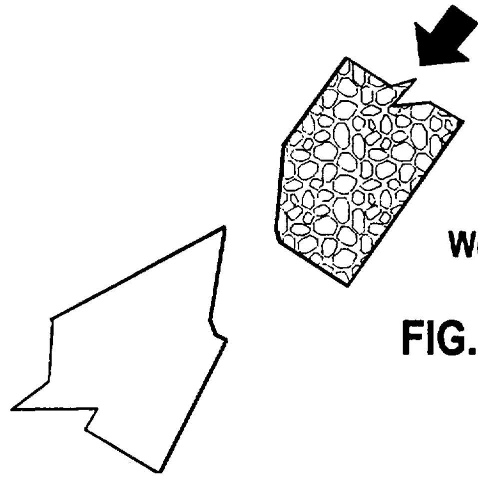


FIG.51.

In addition it is made more difficult by the fact that the area of grinding wheel used, just the corner, is so small that it quickly looses its shape and so in turn changes the shape of the seatings. See Fig.51.

Providing that we understand this we can do something about it. First we must use a harder grade of grinding wheel than we would for normal sharpening when we are trying not to overheat the steel. Now we are not worried if the seatings become hot even blue'd since they will become much hotter when brazing on the tips. The second thing we can do if we are grinding the seatings on the automatic sharpening machine is to increase the clamping pressure to combat the tendency for the blade to move away from the grinding wheel. The other possibility is to grind in from the *SIDE* of the grinding wheel which will at least double the area of wheel doing the work. See Fig. 52.

The brazing on of the tips is just the same as previously described except that some care should to taken to ensure that the plate will not become too hot and distort. To assist with this a sequence of brazing should be adopted which will allow the blade to cool and not build up heat in one place. See Fig. 53

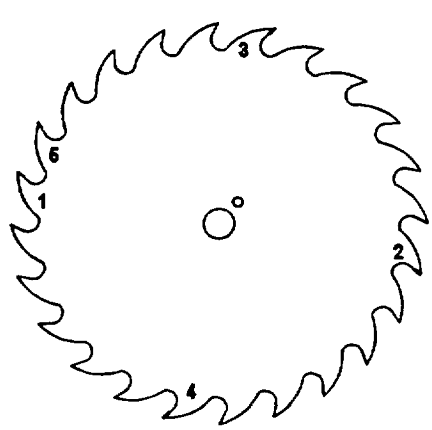
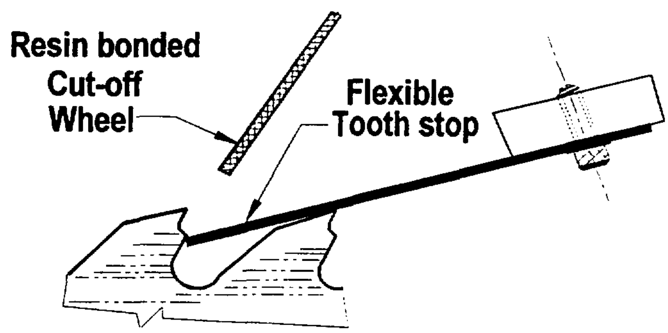


FIG.53.

First mark four teeth at 90 degree intervals then braze a tip on at number one position and then at the other three 90 degree positions. Repeat the same sequence one tooth to the right or left so that the plate has time to cool down on one side whilst working on the opposite side. After cleaning off the brazes the plate should be checked for level and tension including testing for true running on a mandrel.

FIG.54.



Special Tooth Shapes & Other Features:

Triple Chip Teeth:
This design is a product of the engineering industry the teeth being sharpened so that each tooth only removes a portion of the saw kerf. The reason for this is, that unlike sawdust, all metals and plastics being homogeneous materials shear off in one piece when cut and the resulting *SWARF* as it is called curls up like a spring in the gullet and being in one piece the full width of the kerf will jam in the gullets shearing off the saw teeth.

Basically every other tooth projects slightly above the others and these high teeth have their corners removed at 45 degrees so that only the centre third is left to cut. The following lower teeth are left square and only cut on the outsides of the kerf so that the swarf is broken up into three pieces and so is free to fall out of the gullets without causing any damage. On smaller cut-off blades for engineering the design is sometimes simplified. All the teeth are the same height with alternate corners removed so that the swarf is broken into two pieces.

Now you may wonder what this has to do with the woodworking industry, well the triple chip design can be used to help overcome blades wandering in the cut when used for edgers and similar work in the sawmilling industry, the leading pointed tooth having a stabilising effect on the cut. A typical tooth for this type of work is shown in Fig. 55.

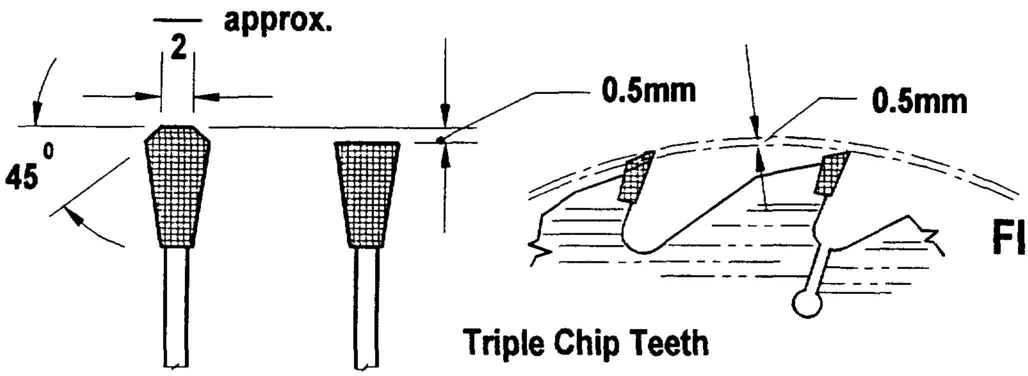


FIG.55.

Again in Australia where they have some extremely hard timbers they have found that by removing the corners from all types of teeth by filing or grinding the blades stay sharp longer. The reason being that the sharp 90 degree corners dull quicker than do corners of 135 degrees. We may also find other uses once we have the knowledge. For example to increase the tooth bite of a blade which has too many teeth. We can of course lower every other tooth so that they do not cut alternatively by removing half the tooth width with a 45 degree bevel on alternate sides the remaining half teeth would have virtually double the tooth bite.

If you have such blades to maintain please remember that not all sharpening machines can be adjusted to grind at 45 degrees so take care when ordering new machinery.

Expansion Slots:
Nearly all tungsten carbide tipped blades have what are called Expansion Slots, these are to allow the blade to expand around the rim without causing the blade to wobble. See Fig.56. On ordinary plate blades slots would get in the way of sharpening as the teeth move backwards around the blade. However on tipped blades, which are not really designed to have much of the plate removed by sharpening, the slots reduce or even eliminate the need for tensioning.

EXPANSION SLOTS

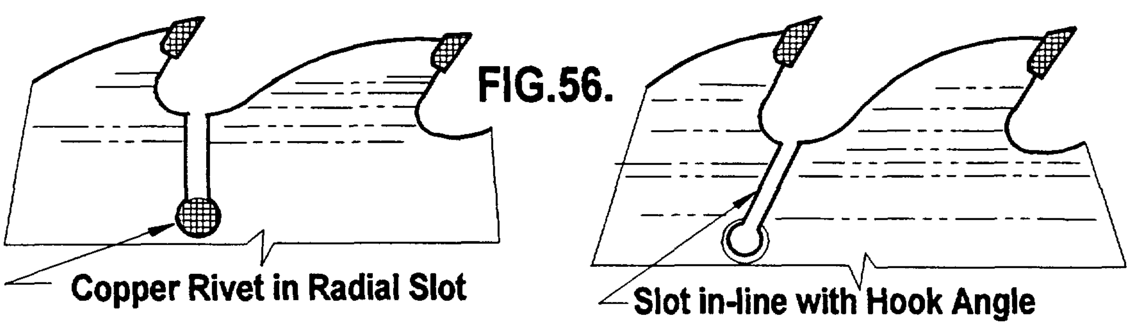


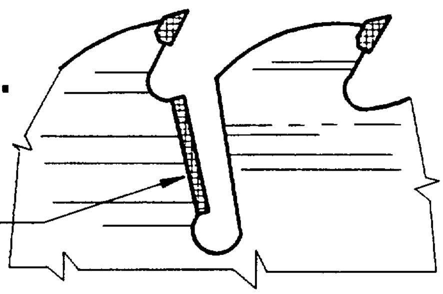
FIG.56.

If we intend to use a method of sharpening and re-tipping which reduces the plate diameter, then expansion slots which slope at an angle are better than those which radiate to the centre.

The round hole at the bottom of the slots which is to prevent cracks may or may not be filled with a copper or alloy rivet just to make sure that slivers of wood do not get caught in the hole.

Wiper Slots:
I don't know who invented it but I suspect that the wiper slot is an extension of the expansion slot. This is a similar slot in or near the rim of the blade which has a long carbide tip attached to help *WIPE* the saw cut free of sawdust and slivers of wood. Fortunately these do not need to be sharpened as they are sharpened lower than the cutting teeth by the manufacturer to allow for the reduction in side clearance as the normal teeth are sharpened See Fig. 57.

FIG.57.



Tooth Bite Limiters:
On all hand fed machines ideas to make their use safer are always being sought. Tooth bite limiters on saw blades and chip limiters on cutterblocks are often used and in some countries are a legal requirement. On saw blades they help to prevent snatching and kick backs. A typical *GUARD TOOTH* as they are sometimes called is shown in Fig.58. Their height below the teeth should be maintained fairly accurately otherwise the teeth will not cut if too high or if the guard is too low the safety feature will be lost.

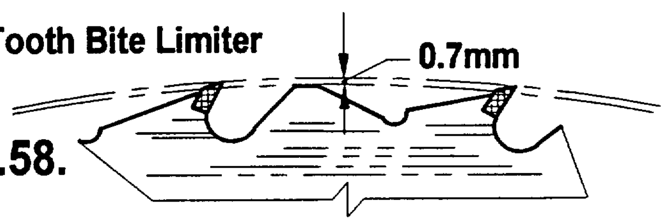


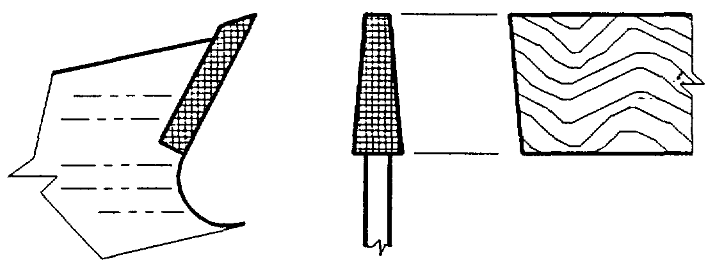
FIG.58.

Planer Blades:
Ever since mechanical saw blades have been used woodworkers have wished that they could purchase a blade which would leave a planed finish to the sawn surfaces. For general sawing operations this to date is not possible although many of the tipped blades when new can give very good sawn surfaces.

The best practical application of this idea is in the use of *SPLITTING SAWS* as used on Four Side Planing & Moulding Machines. The reasons being that first the blades used are small in diameter and so are stiff and free from wobble and second the high volume of production from the machines means that time spent on maintaining and setting up special blades can be well worthwhile.

Whilst ordinary tipped blades can and do produce reasonable results if used for this work, the finish is still sawn and not planed. Two types of blades have been invented which actually scrape or plane the surfaces after sawing. The first uses reverse taper teeth usually 32mm long with 3mm cutting edges which saw the timber and the gradually widening teeth *SCRAPE* the sides of the cut and give a planed finish. There are two limitations to this design which are a limit to the depth of cut and of course the sides of the sawn timber are not perfectly square. Also because of the scraping action of the teeth, the fronts are sharpened square, there must be a tendency for the teeth to blunt quickly. See Fig. 59.

FIG.59.



Reverse Taper Tooth

The second type designed by me in 1962 uses separate ripping and planing teeth so that each type of tooth can do their work efficiently. The ripping teeth are normal although they do not have radial side clearance and they project higher than the planer teeth so that they always work first. The planer teeth, sharpened with a 30 degree face bevel,. come along later and actually *PLANE* the sawn surface since they project sideways slightly to take off an extra shaving. The resulting planed surfaces are square and the blade works well up to 45mm depth of cut which is adequate for the process of splitting. See FIG.60.

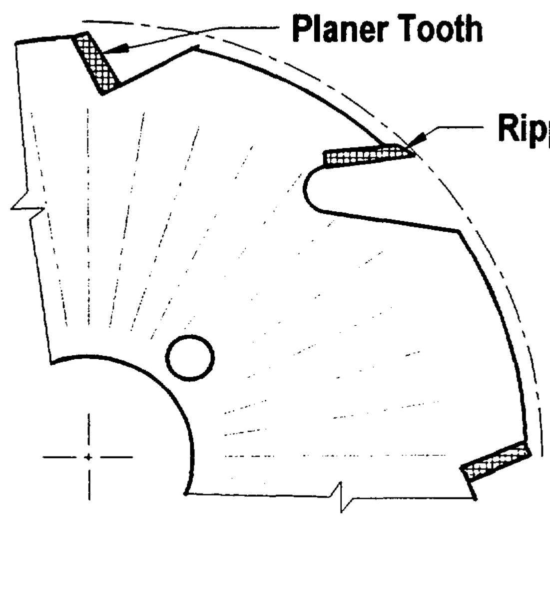


FIG.60.

'WOODSAW'
Planer Blade

Both of these blades should only be sharpened on the face of the teeth and on the *'WOODSAW'* equal amounts must be sharpened from ripping and planer teeth to ensure efficiency of the design.

CHAPTER 3

Levelling & Tensioning of Circular Saw Blades

Introduction and Theory:
The levelling and tensioning of blades is perhaps the most skilled part of the work of the sawdoctor and the most difficult to learn to do correctly. The reason for the difficulty in learning the skills is the fact that unlike other operations where you can see what is happening, for example when sharpening teeth, with levelling and tensioning you cannot see any difference in the appearance of the blade after hammering or rolling, at least not until we hold the blade in a special way and test for results using special gauges.

If a circular saw blade is not levelled and tensioned correctly it will not run true and so waste valuable timber in the form of a wider than normal saw kerf but when a blade is correctly tensioned it may run slightly irregular when cold and not cutting but as soon as it starts to cut will run true without wobbling and saw in a straight line producing good quality lumber with the minimum of waste. Correct tensioning is particularly important when trying to increase feed speeds to improve production.

Tensioning:
To try to understand the tensioning process as it applies to circular saw blades let us do a little experiment using a piece of strong paper or thin cardboard. First cut out a circle of about 200mm diameter and then make a radial cut from the centre to the outside as shown in Fig.61.

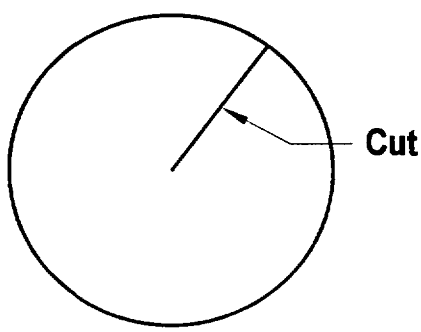


FIG.61.

Now at the rim where the teeth would be, pull the cut edges together so that they overlap by about 10mm and hold between finger and thumb. The rim has now been shortened and is quite stiff as a blade will be when tensioned. Now push the raised side of the paper circle through to the other side and back again several times, it will spring in and out as a tensioned steel blade should do. Next open up the cut so that there is a small gap and now the rim will be all loose and floppy and if you try to press the paper blade flat the surplus will keep popping up somewhere around the rim just like a real blade would do if the rim were too long.

Now the real blade will not work when its edge is too long and floppy, nor will it work if its edge is too short so that the blade is dished as in our paper experiment, However if the shortening of the rim is just enough to compensate for the expansion that takes place during cutting so that the blade is a perfectly flat plate when working then this is what we want to achieve when tensioning.

Very simply then, tensioning of circular saw blades is the pre-expansion of the middle part of the blade to compensate for the expansion of the tooth edge that takes place when the teeth become hot when cutting.

Levelling:
For various reasons blades will acquire lumps and ridges which will cause the blade to knock and run noisily as the lumps hit the blade guides. More harmful than the noise is that the blade may overheat at these places causing unwanted expansion. The lumps and ridges have to be removed by hammering or rolling and this process is called *LEVELLING*. The lumps or ridges may be caused by slivers of wood jamming in the packings or even by a small lump getting hot and expanding setting up a cycle of more heat and more expansion and before the blade can be stopped the spot has become so hot that it blues the steel and is known as a 'black-eye". Of course incorrect hammering or rolling can and is a common cause of lumps.

Terms used:
Various special terms have evolved which the sawdoctors use the meanings of which are as follows:

Loose: Part of the blade which falls away from the straight edge or tension gauge.

Tight: Part of the blade which touches the straight-edge or tension gauge and holds off the rest of the blade which might otherwise fit the gauge.

Dished: Part of the blade which has too much tension and has been pushed through to one side of the blade and stays there so that it shows convexed on one side and concaved on the other.

Methods Used:
There are two methods which can be used to tension circular saw blades or a combination of the two. These are:

1) Tensioning using special heavy duty tensioning rolls.
2) Tensioning by hammering.

Although hammering in tension is a very crude system when you think about it, hammering is still the most widely used method for circular saw blades. This is because many of the smaller diameter blades and thicker blades which normally come tensioned from the manufacturer need very little routine tensioning making the investment in the expensive stretcher rolls unwarranted. In addition to this stretcher rolls were not available until around the 1960's and only then from one manufacturer in the U.S.A. where they are now used fairly extensively in the larger sawmills. The equipment for hammer tensioning is still required for perfecting the tension and for levelling.

Equipment Required:

1) Stretcher rolling machine when use justifies the investment.

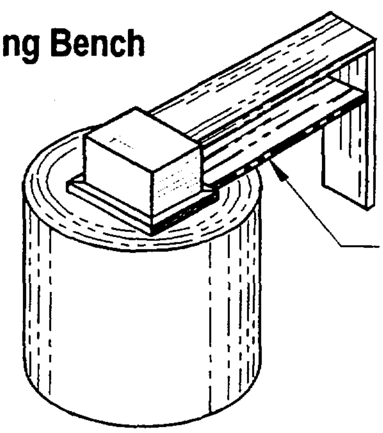
2) Tensioning bench incorporating a heavy-duty anvil. See Fig.62.

3) A set of special hammers.

4) Various length straight edges.

Tensioning Bench

FIG.62.



Stretcher Roll: As I have already said, as far as I am aware there is only Armstrong Manufacturing Co., U.S.A. who make stretcher rolling machines for re-sale, blade manufacturers such as Spear & Jackson used to make their own for their own use, therefore there is little choice in fact just one modified bandsaw stretcher for blades up to about 600mm diameter and one specially designed machine for blades up to about 1500mm diameter.

Anvil: This is a special anvil with a slightly convexed top and they come in two sizes the smallest having a top of about 250mm x200mm and weighing about 55kg. They used to be cast steel with a 'Chilled' face but are now made with a tool steel plate about 25mm thick welded to a cast steel base.

Tensioning Bench: In its simplest form the bench is an anvil sitting on a short piece of log or concrete block with the top of the anvil at the height of your fingers when the hand is held out in front of your body. It is usual to sit the anvil on something soft like insulation board so that it will bed down on top of the base and nail a frame around the base to prevent the anvil moving during use.

A backboard about 200mm wide the length of which should be at least half the diameter of the largest blade should be fixed about 10mm lower than the top of the anvil. This is to rest the blades teeth on when lifting the blade to test for tension. Behind this should be a low window or light to make it easier to see the gap underneath the straight-edges.

Underneath the backboard it is useful to fix a wooden shelf on which to place hammers conveniently when putting them down to pick up straight-edges to test for tension or lumps.

A rack for other hammers not in use is also useful perhaps on the wall behind the bench.

Finally for use with large blades 900mm and over it is very useful to have a hook fixed to an upright near to the bench to hang the blades on during testing and marking for lumps.

Hammers:
I have visited dozens of sawmills all over the world and I have very rarely come across hammers ground to the correct shape. If they are ground the wrong shape they will either damage the surface of the blades if they have too sharp a curve, or not expand the blades where necessary if they are ground too flat. We will return to their shapes later.

There are three hammers in a set, one called *DOG HEAD,* one *CROSS-FACE,* and one *TWIST-FACE.* The size of the hammers vary considerably and go by weight, the heavier hammers are used for thick blades and the lighter ones for thin blades. In choosing hammers the practical test should be to see if the hammer will do the work with the minimum of effort by the user. i.e. they should not be too heavy to work with nor should you need to strike the blades hard to move the metal, in other words the weight of the hammer should do the work. A guide to weight would be to use 0.8 kg for each 1mm thickness of blade. Example: For 11 gauge blades which are 3mm thick weight of hammer = 3 x 0.8 = 2.4kg Say 2.5kg.

The complete set of hammers is not always necessary, in fact most if not all of the work can be done without the twist-face hammers which I assume where originally designed and produced for removing twists from wide bandsaw blades. Having said this, some sawdoctors use the twist-face in preference to the cross-face hammers on circulars feeling that hammering from the side is more comfortable and gives a better view of the place being hammered.

The Dog Head Hammer:
This hammer is used for most of the tensioning since the shape of its face spreads the steel the same in all directions. It can be used for levelling round lumps but since most lumps are usually in the form of ridges and not round spots the cross-face hammer is more effective for levelling.

Cross Face Hammer:
This is used for levelling small lumps and short ridges using which-ever face corresponds to the direction of the ridge or shape of the lump. Again some sawdoctors will sometimes use this hammer to put in tension quickly since its sharper face will stretch the steel quicker but its use is much more likely to mark the blade and look bad.

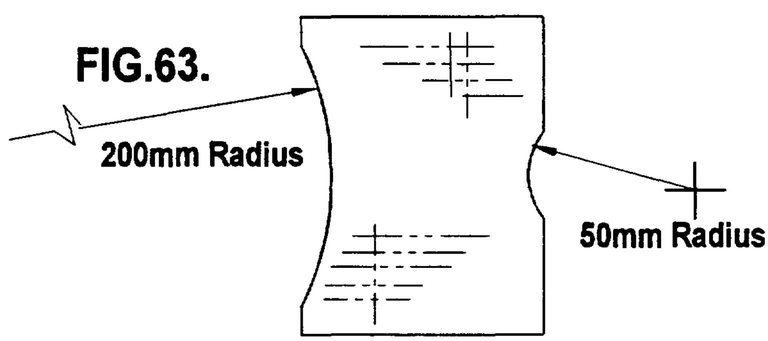
Twist-Face Hammer:
This hammer has its faces at 45 degrees to the shaft and as already stated was, I believe, originally designed to be used to remove twists from bandsaw blades.

The Shape of Hammer Faces:
The most important part of the hammer is its face which must be ground to a shape which will not mark the blade with sharp indents. The shape of the dog-head hammer's face should be part of a *SPHERE* so that it is just like a ball falling on a surface. In other words no-matter at what angle the blade is struck with the hammer the shape of the indent made will be the same round shape, but if correctly ground almost invisible.

Cross & Twist-Face Hammers:
The faces of these hammers are ground to spread the steel more in one direction than the other and could be thought of as being shaped as part of a car tyre i.e. a large circle being the diameter of the tyre and a smaller circle being the diameter across the width of the tread. The shape of the indent made with these hammer faces is oval or elliptical and again difficult to see with no sharp indents when ground correctly.

The actual radii of circles to which the faces are ground are not critical i.e. it does not matter if it is say 50 or 60mm across the cross-face but it *MUST* be a part of a circle and not any other shape. To ensure that the shapes are correct a special gauge should be made as shown in Fig. 63. and suitable hammer shapes are shown in Fig. 64.

FIG.63.



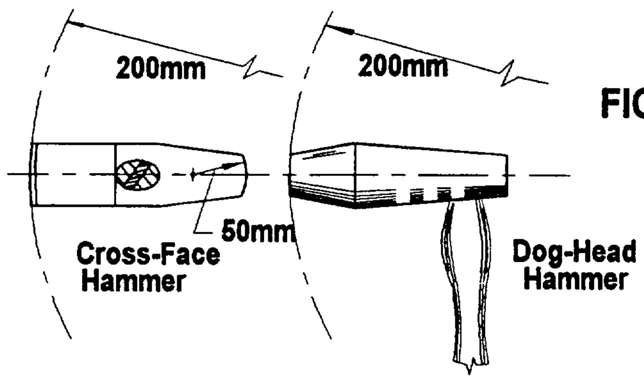


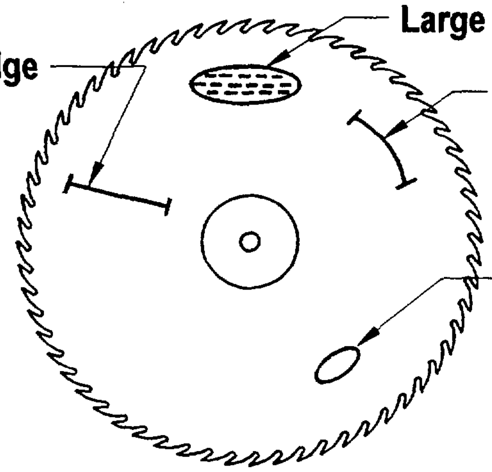
FIG.64.

Levelling:
In general levelling should be done before tensioning because with lumps in a blade accurate testing for tension is impossible. In addition to this any hammering of lumps will stretch the blade even if only slightly and will affect the tension. However sometimes a blade may be in such a bad condition that it will need hammering to get the tension roughly right before the blade can be tested for lumps and levelled.

Unlike tensioning where the aim is to stretch the steel of the blade, levelling is to push or knock lumps or ridges down *WITHOUT* stretching the steel, or doing so as little as possible, so gentle hammering is what is required not heavy blows. For very bad lumps that need hammering down a piece of leather placed underneath the blade will allow the lump to be pushed down more easily and cushion the blows so that no or very little stretching takes place.

Normally circular saw blades are held vertically when testing for lumps, this is to ensure that the tension is not curving the blade as it might, for example, if placed on top of the anvil when accurate results would be impossible. The exception to this is when small diameter blades which do not reduce in size such as T.C.T. or inserted tooth blades as used say on gang saws when the quantity all the same size make it worthwhile purchasing a special round levelling plate for that size of blade, then testing and levelling can be done on these plates horizontally as we do band and framesaw blades. Lumps and ridges must be accurately marked before hammering or rolling otherwise any hammering outside the faults will only cause a lump or ridge on the other side of the blade at these places. The blade should be marked as shown in Fig.65. usually using chalk. This does not mean that the expert cannot find a small lump and without taking his eyes off the spot hammer it successfully without marking it, or just make a mark with his thumb on the slightly oiled surface, they have to do the work the quickest and easiest way possible. However the point that I wish to make is, that to hammer or roll in the wrong place only makes more work and there is no short-cut to accuracy.

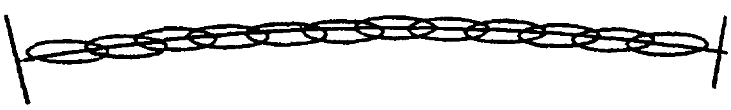
FIG.65.



The method of hammering down lumps and ridges is important and is as follows;

> commence to hammer at one end and with overlapping blows continue until the end of the ridge is reached then stop and test. *DO NOT* hammer haphazardly anywhere along the ridge going over it several times and perhaps hitting the same place more than once and missing some places altogether. See Fig.66. If the lump is still there it will often have moved so that the next series of blows will be required in a slightly different position.

FIG.66.



Over-lapping Hammer Blows

Tensioning:
Unlike bandsaw blades, circular saw blades do not need tensioning every time they are used, first because they are usually much thicker and second they are not subjected to the tremendous strain like bandsaws need to keep them stiff and on the pulleys which in itself has a tendency to pull out the tension. Some very thick small diameter blades may almost never need tensioning only keeping level whilst thin large diameter blades may need checking frequently. Blades which have solid teeth which are gradually sharpened away will need tensioning more often than blades with tipped or inserted teeth simply because the short tensioned rim is gradually sharpened away and may also be expanded permanently by too heavy grinding during sharpening.

Amount of Tension:
The correct amount of tension can only be found by trials because the working conditions will vary considerably. What can be said is:

1) Larger blades will need more tension than smaller blades.
2) Thinner blades need more than thicker blades.
3) Blades running hotter at the rim because they are working harder i.e. because they are cutting faster or are cutting harder materials, will need more tension than blades doing less work.

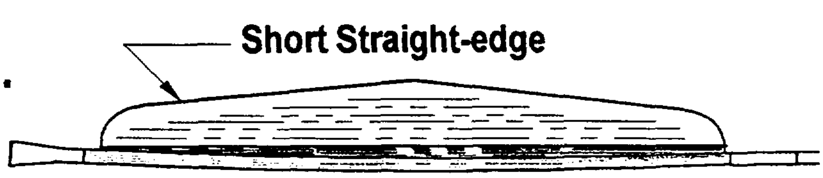
Measuring Tension:
Although tension gauges for circular saw blades can be made to fit one size of blade I have never come across them in all the sawmills that I have visited, I suppose for the same reason that special size levelling plates are not often seen in use. i.e. there is such a large variety of diameters which can change with sharpening together with different blade thicknesses all of which could change the tension gauge needed for each size of blade. I suppose if the situation warranted a special levelling plate, then a special gauge for use with those blades would be the kind of situation where they could be used.

The fact is that the correct use of simple straight-edges is extremely accurate and they are fully universal only a selection of different lengths is required to cover all your blades.

The tension is measured by the gap underneath the straight-edge, the bigger the gap the more tension is said to be in the blade. To measure the tension the blade is raised off the anvil by one hand and with the teeth opposite resting on the back-board the blade is suspended from these two points and if there is tension in the blade the middle of the blade will drop through and show a gap underneath a straight-edge held at *RIGHT-ANGLES* to the supporting points. This gap is measured in two different ways, first using a long straight-edge to get a general idea of the tension and to see if both sides of the blade are equal as in Fig.67. and for more accurate testing with a shorter straight-edge, still at right-angles, stretching from the centre to the teeth. See Fig.68.

FIG.67.

FIG.68.



This accurate testing with the short straight-edge is started at one point marked with chalk and repeated radially in small segments around the blade until all the blade has been covered and then repeated on the opposite side marking any faults accurately with chalk so that they may be corrected by hammering or rolling. Note that small diameter blades may not drop through to show the tension without some pressure from the hand holding the straight-edge.

Tensioning New Blades:
We do not normally have to tension new blades, although I did spend some time in a North Korean factory where they actually made their own blades and I suppose there are large sawmills who may order steel blanks to make up T.C.T. blades and will need to roll or hammer tension in from the flat plate. Also we do come across blades that have lost all their tension and as blades without irregular faults are the easiest to tension we will start with these.

First let us do the work using a roller. A radial chalk mark is drawn from rim to the centre and a series of rolls starting just outside the collar area and about 40mm apart are made outwards to within say 50mm of the gullets (depending on the size of blade.) See Fig.69.

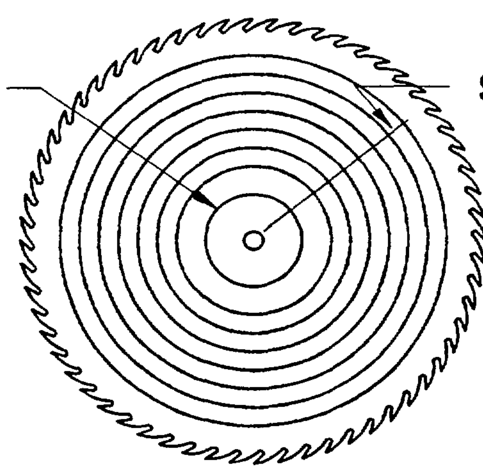


FIG.69.

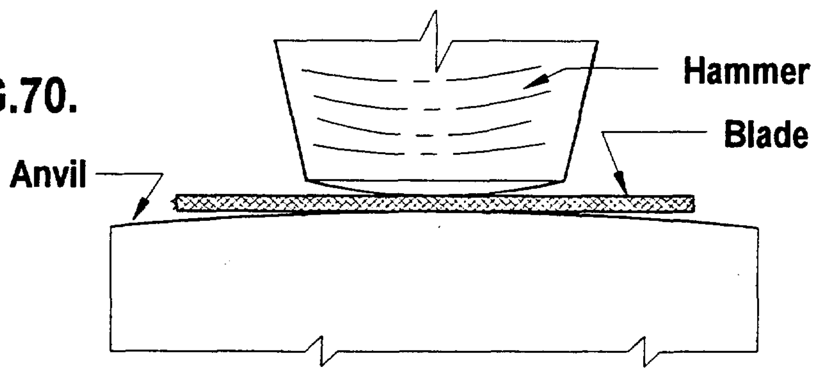
Great care must be taken at the start and end of each roll or too much tension will result at this place and will be difficult to remove if the rolls are allowed to overlap where they start and end. It is much easier to add a little tension at this place afterwards than it is to remove some if there is too much.

An idea of the tension may be gained using a short straight-edge without removing the blade from the stretcher but the blade will need to be removed from the stretcher for a full inspection, first with the long straight-edge on both sides, then if there is a reasonable amount of tension then more accurately with the short straight-edge. Next the area around the start and finish chalk mark is examined and any tight places marked ready to be corrected with short rolls or a few hammer blows.

If another series of rolls is required they should be placed in-between those already made and to ensure that the tension is even on both sides it is safer to turn the blade over onto its other side for the second series of rolls.

Now the same blade using hammers. This time much more marking is needed to guide the dozens of hammer blows that will be required. The reason for this is that the effect that the hammer blow has on one side of the blade is different to the effect that the much flatter anvil has on the other side See Fig.70. In theory then what our aim must be is to place an identical hammer blow *EXACTLY* over the blow placed on the other side of the blade otherwise we will just fill the blade with dents and lumps.

FIG.70.



The skilled sawdoctor doing this work regularly might be able to rely on lightly oiling the surfaces of the blade and by placing hammer blows radiating to say every other tooth, which will provide even spacing, then on turning the blade over can see marks in the film of oil where the first series of blows landed on the other side and so be able to hammer exactly in the right place.

For the learner or sawdoctor who only does this work occasionally it is better to mark the blade as shown in Fig. 71. using the straight-edge to first mark the radial lines, usually to every second, third or fourth tooth. Then with chalk marks on the straight-edge as a guide, mark the positions of the places to hammer. When marking the other side use the same teeth as before and the same marks on the straight-edge so that the hammering will be done as near as possible on the same spot every time.

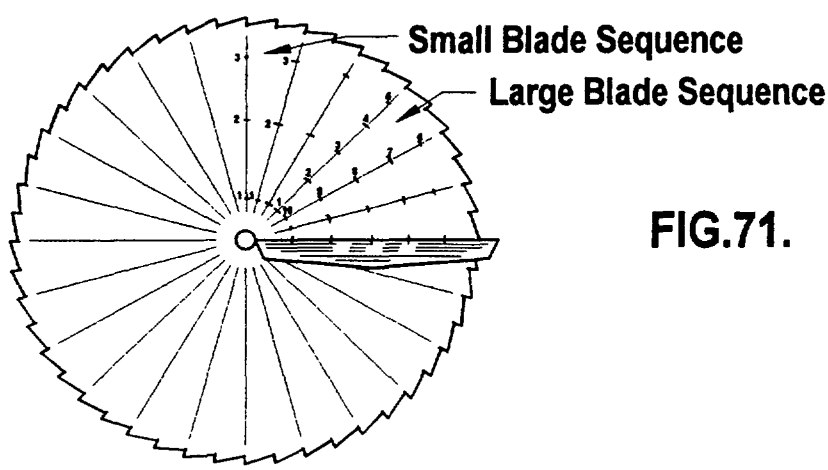


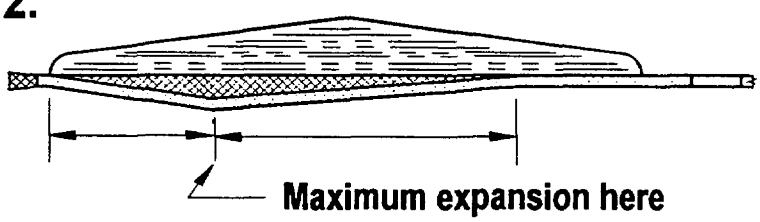
FIG.71.

The sequence of hammering for small blades can start near the centre and work out to the teeth, but for larger blades, to cut down the movement of the blade in and out over the anvil since all hammering should be done over its centre, hammering is first done alternatively outwards then back in towards the centre again as shown in Fig.71.

Now let us look where the stretching to combat the expansion at the toothed rim is required. First there is no need for any at the area covered by the blades collars, this can remain flat. then very little is needed next to the collars but will gradually increase towards the rim then sharply reduce again to leave the tooth edge short, tight and in tension . See Fig.72.

This sketch clearly shows another reason why straight-edges are used to test for tension and not special tension gauges, unlike tension gauges used for bandsaw blades which are a true segment of circle and as such can be ground accurately on a machine, a circular saw gauge would need to be a special shape not possible to be ground automatically.

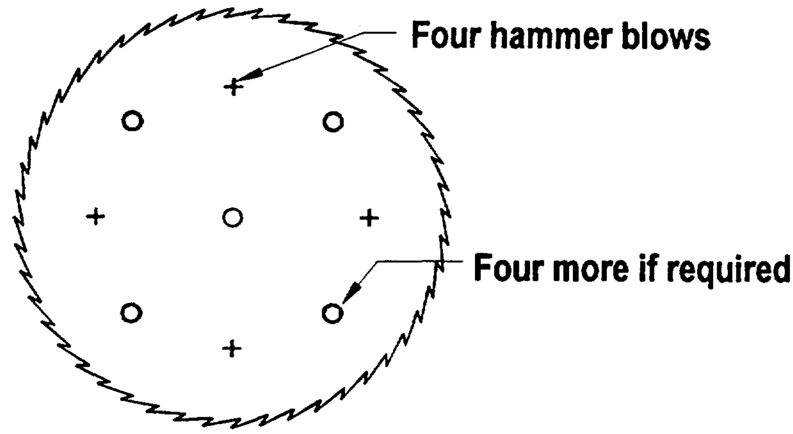
FIG.72.



In Fig.71 we show the *BASIC* pattern for hammering and you may notice that we are likely to put in more tension near to the collars since the number of hammer blows are the same as out near the rim but are much closer together. In practice we are likely to need more than these first series and the additional blows can be placed perhaps in-between the two outer rows only to add the extra stretching where it is needed nearer to the rim. This brings me nicely to the next very important point which is. It is much better to hammer in a small amount of tension at a time with few hammer blows or light blows which can be added to easily than to put in too much making a lot more work to remove the excess.

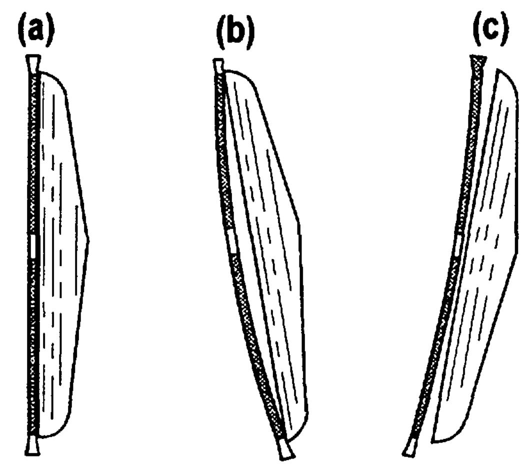
Having hammered both sides with dozens of blows it is quite likely that the tension on one side will be slightly different to the other, this will show up with the long straight-edge as a slightly bigger gap on one side than the other. this can be corrected by as little as *FOUR* blows placed at 90 degrees from each other on the side with the smaller gap. If this is not enough add four more in between the first four as shown in Fig.73.

FIG.73.



Plumbing-Up:
This is the name given to the final process of tensioning and it is carried out with the blade in a vertical position hand-held or hanging on a hook. If hand-held the blade *MUST* be upright as in Fig.74.(a) for the slightest leaning of the blade will allow the tension to fall through as shown in Fig.14 (b) or (c).

FIG.74.



With the blade held upright and using the long straight-edge also held upright every part of the blade is tested for being flat. If any part shows raised the area is marked, any parts showing hollow are ignored until the other side of the blade is tested when they too will show as round or raised places. With older blades I always look for lumps in these areas first for by levelling the smallest lump in a raised area it will often correct the fault. If no lumps exist then test the area for tension and add one or two more hammer blows in the tightest place you can find. The whole process is repeated all over the blade on both sides until the blade will stand upright and fit the straight-edge all over.

Levelling & Tensioning Used Blades:
Used blades may develop all kinds of faults and as we have said already levelling of lumps and ridges generally comes first unless the blade is *DISHED* i.e. shows hollow on one side and round on the other, no-matter which way it is held. In this case some tension will need releasing by

hammering near to the rim. Do not be fooled into thinking that all the hammering has to be done on the round side for often the dish will be equal, it has to spring out to one side and can sometimes be pushed through to the other side quite easily. Therefore releasing some of the tension near the rim will be required on both sides.

Most ridges on circular saw blades will run around the blade in segmental shapes not in straight lines, others will radiate from the centre in straight lines so the short straight-edge must be passed over the surface held in all directions to find the exact shape of the lumps or ridges. After testing and marking for lumps the blade may look like the example already shown earlier in Fig.65.

Tension will also become uneven and this can be marked in a similar way to ridges. The start and end of tight places needing more expansion can be marked with a simple short radial line and the exact location with a short line at the beginning where you will start to roll or hammer. Again *EXACT* locations need to be marked as wrong positions will only make more work later.

After careful marking lightly hammer the faults, *THEN TEST* to see the effect of the hammering, you can always add more if the condition is improving, but should you have made a wrong decision then you can think again and correct before too much damage has been done. You must also always have an idea in mind as to what you are trying to achieve, for example, more tension or less tension and do not carry on if you become tired or just fed-up if it is not going right, find some other work for awhile and come back to the tensioning later.

Finally, inserted toothed blades must be tensioned with the teeth in, as the tightness of the teeth in their sockets stiffen up the rim and affect its tension.

CHAPTER 4

Blade Fitting, Circular Saw Blades:

All the work done by the sawdoctor can be a complete waste of time if the blade is not fitted into the machine correctly. Although it is not normally the work of the sawdoctor to fit the blades into the machines it is in his own and the companies interest that he should understand thoroughly the fitting faults which can occur and the possible faults that can exist with the machine and its maintenance.

Machine Spindle:

If the machine spindle is not running true because it is bent or its bearings are worn then the blade cannot be expected to run true. If the blade does not run true then only some of the teeth will cut and do the work reducing the efficiency of the blade considerably.

The blade could be made to cut efficiently if the blade could always be placed onto the spindle in the same position as it would if the inner collar were fitted with a drive pin, or if the blade and spindle were marked in some way. Then the blade could be ranged down in the machine and sharpened by hand to those range marks so that all the teeth would cut. If sharpening is done by automatic machine then the fault in the spindle or bearings will have to be repaired to obtain full benefit from the accurate sharpening.

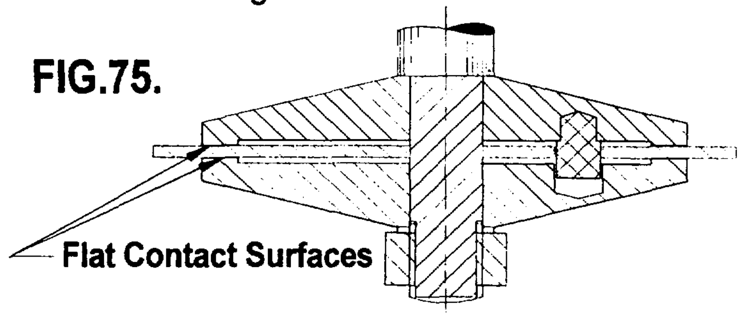
Blade Collars:

On most machines the blades are held on the spindle by two collars, one *FIXED COLLAR* that is, it is fixed to the spindle, and one *LOOSE COLLAR* which is held onto the spindle with a nut. This nut should screw onto the spindle in the opposite direction to the rotation of the blade and this is why many nuts are threaded *LEFT-HAND*. The reason for this is to prevent the nut becoming loose should the blade move backwards slightly under pressure of cutting. Because of this safety design it is *NOT* necessary to over-tighten the nut as is often done, it is far more important to keep the threads clean so that the nut can be removed easily without resorting to hammering the spanner which in turn could easily damage the spindle or its bearings.

Both collars must be the same diameter and have perfectly flat narrow contact surfaces which hold the blade and these *MUST* be kept perfectly clean if the blade is to run true. For large production saw benches the contact surfaces may be machined slightly undercut by 0.1mm to further ensure true running of the blades. See Fig.75.

The fixed collar must run true on the spindle for if there is the slightest wobble on the contact surface the blades will never run true no matter how good the sawdoctor's levelling and tensioning is. This inner contact surface should be tested with a dial gauge and if not perfect should be machined true on its shaft, it is no use removing from the shaft to do it.

FIG.75.



Collars which are not true may actually dish the blades when tightened, if this is suspected remove all packings and tighten up the nut by hand and test the flatness of the blade with a long straight-edge. Next tighten up the nut fully as normal and test again for flatness across the blade.

Heat from Spindle Collars:
Sometimes bearings may run hot either because they are worn or sometimes simply because they have been over-filled with grease and this will soon transfer to the collars then to the blade itself. If this happens a blade which is running true for a short time may start to wobble because of the expansion which takes place because of the conducted heat. Of course the faulty bearing or greasing has to be corrected to put this right.

This knowledge of how heat affects the tension of a blade is sometimes used by experienced sawyers who will deliberately tighten packings to heat up the blade in use, either at the centre or near the rim, to increase or decrease the tension at the cutting edge. This treatment can be a temporary cure to get a blade which is wobbling and needs tensioning to cut straight but the additional friction on the blade is not good and the tension should be corrected as soon as possible.

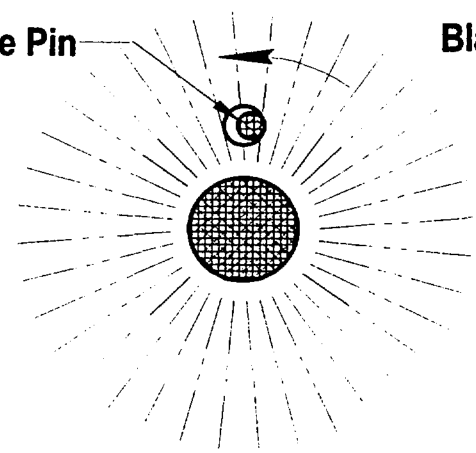
Blade fit on the Spindle:
The bore of the blade must fit the spindle without any play otherwise the blade will run eccentrically and only some of the teeth will be working reducing the blades efficiency considerably.

If the bore is more than say 1mm too big then it should be bored out larger and a correct size bush fitted. If the fit is just slightly loose then usually it can be corrected by hammering around the hole close to its edge with a ball pein hammer.

Drive Pins:
On machines that use blades above around 450mm diameter the fixed collar will be fitted with a drive pin to prevent the blade slipping backwards with the force of cutting. Do not remove the pin for blades which have no drive pin hole, but instead have the blades drilled out using a drill with a slow speed. The size this time need not be a perfect fit, in-fact they will usually be bored out one or two millimetres too big so that when fitting a blade it is easy to

locate it onto the pin. The blade should be pulled back onto the loose fitting pin before tightening the retaining nut. See Fig.76.

FIG.76.



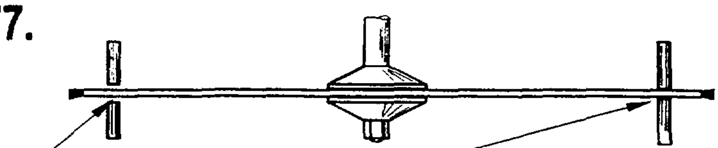
Blade Packings:
Although a blade which is correctly set, sharpened and tensioned to run true will cut in a straight line, most blades above 450mm diameter used for ripping need some form of guide to steady the blade and prevent it being forced away from the line of cut by such things as knots, irregular grain and sideways pressure from the timber or logs. These guides vary considerably from simple wooden pegs to elaborate white-metal guides for gangsaw blades without the support of the usual collars. This last type are very specialised and are outside the scope of this manual but we shall cover the principals of fitting the basic types.

The term *PACKING* as opposed to just a guide refers to the type of guide used on hand and power-feed saw benches used for re-sawing when the gap in the bench top is completely filled with the guide material. This is to prevent slivers of wood jamming down in-between the blade and the bench top. Simple wooden blocks with the end grain to the blade as used on large log conversion machines act as a guide on the cutting end of the blade and at the rear act only to steady the blade and prevent it from hitting the metal parts of the machine should the blade start to wobble for some reason. Although these are only guides they are usually referred to as " Peg packings." We shall deal with this type first.

These pegs should be made of dense hardwood with the end-grain surface towards the blade as this wears more evenly and will more easily soak up oil applied to the peg to cut down the friction between the pegs and blade.

The arrangement of these peg packings is shown in Fig.77. The two rear pegs only prevent the blade hitting the steel frame of the machine should the blade start to wobble for any reason and so can be set with a good clearance of about 3mm between their ends and the blade. The front two pegs must be a much better fit actually touching the blade but not gripping it, which would cause unwanted friction. One method to ensure there is no friction is to set the pegs with a piece of paper in-between the peg and the blade which will give about 0.1mm clearance.

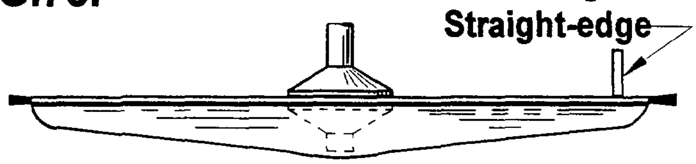
FIG.77.



The first peg to be adjusted is the inside front and it is vital to get this one correct otherwise the blade could be trying to straighten itself *AGAINST* the wrongly positioned peg all the time that it is running. As well as creating unwanted friction and heat at the rim this could also cause the blade to cut to one side. The correct procedure then is to hold a straight-edge tight against the blade whilst positioning the first peg as shown in Fig.78. It may be that after this procedure has been carried out once, an accurate measurement can be taken between peg holder and end of the peg and this used to set the peg to with the blade out of the machine and out of the way. Even better than this would be to make a steel gauge for the sawyer to work to.

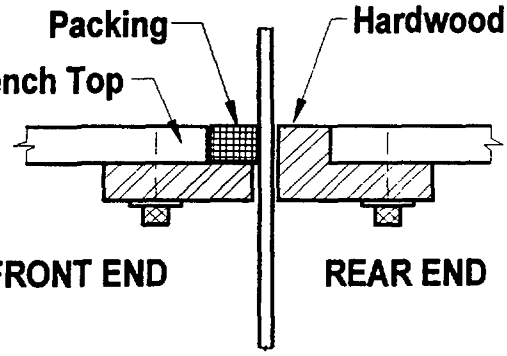
The inner rear peg could be positioned in the same way to find a measurement to work to then the outer two pegs can be positioned knowing that they will be correct.

FIG.78.



Now for packings as used on re-saw benches with solid bench tops: The bench top will have a slot machined into it usually about 30mm wide to allow the blade to fit through. Underneath the steel top are then fitted strips of hardwood to form a rebate at the front to hold the strip packings and at the back to fill the gap and protect the blade from striking the steel of the bench should the blade wobble for any reason. See Fig.79.

FIG.79.

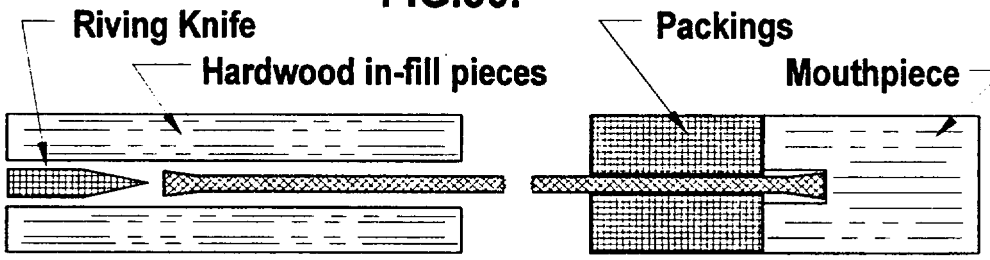


A replaceable piece of hardwood called a *MOUTHPIECE* is fitted to the front end around the teeth and if maintained a good fit can help to prevent spelching which is important on some types of production.

The packings themselves vary in the materials that are used but the idea of them is to (a) guide the blade. (b) fill the gap in the bench top. and because this has to be done with the minimum of friction the materials used will be able to absorb a lubricant. The easiest material to use is a special dense thick felt from which you can cut slices just the correct width to fit the gaps each side of the blade but this is not always available in developing countries. Perhaps the most widely used, because the materials are nearly always available, is a packing made by wrapping string around a small section of wood planed to the correct size. A soft wood is best so that if the packing is too tight when fitted it can be hammered thinner to fit, the string bedding into the soft wood and compressing more easily than it would if it were hard wood.

The arrangement of the mouthpiece, packings and hardwood protection pieces is shown in Fig.80.

FIG.80.



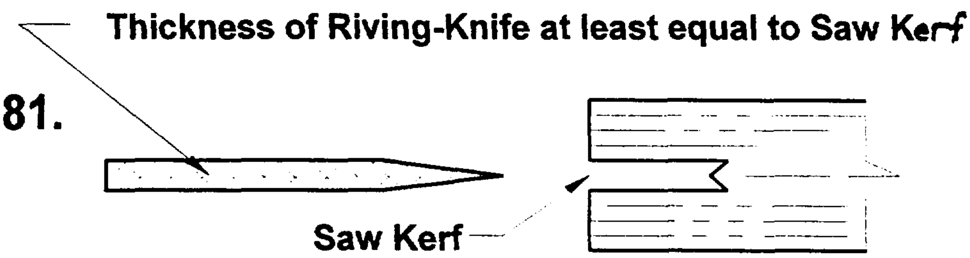
The same principals apply to strip packings as to peg packings i.e. they must not push the blade to one side so check the blade with a straight-edge when fitting the inner packing and the packings must not grip the blade too tight which might overheat the blade and upset the tension.

Riving Knife:
In many countries it is illegal not to fit a riving knife to the rear of circular saw blades to protect the workers from accidentally putting their hands on this otherwise unguarded part of the blade. Although this is very important, it is not the only reason for fitting them. The main reason from a technical point of view is to hold the saw cut *OPEN* so that the teeth coming up at the back of the blade; (a) do not throw the wood being cut back at the sawyer, a cause of fatal accidents when wood has pierced the stomach and (b) do not spoil the cut surfaces made by the teeth which cut the timber at the front of the blade.

These last two reasons are not always covered in the regulations and both rely on the riving knife being of the correct *THICKNESS*. Perhaps because the regulations do not always cover this we find that most riving knives supplied with the machines are not thick enough. They should be at least the same thickness as the *SAW KERF* and if smooth sawn surfaces are required from the production, then the riving knife must be a little thicker. A simple test for this is to make a cut in a piece of scrap wood and try it on the riving knife.

See Fig.81. Also shown in Fig.82 and Fig.83. are the measurements to be adhered to for the regulations covering riving knives in the U.K.

FIG.81.



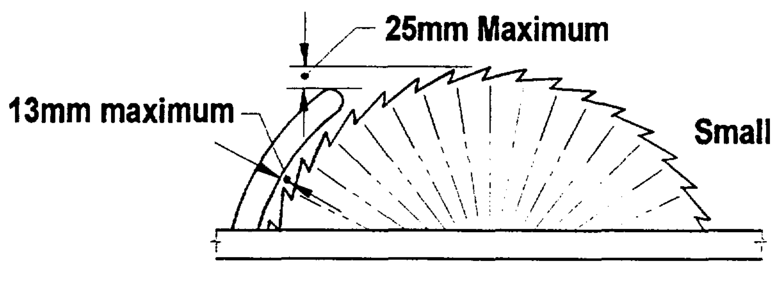


FIG.82.

Small Sawbench Rêgulations

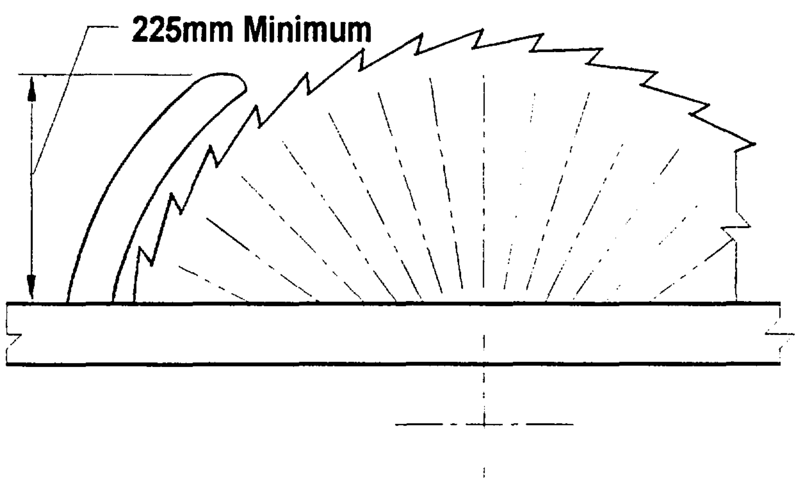


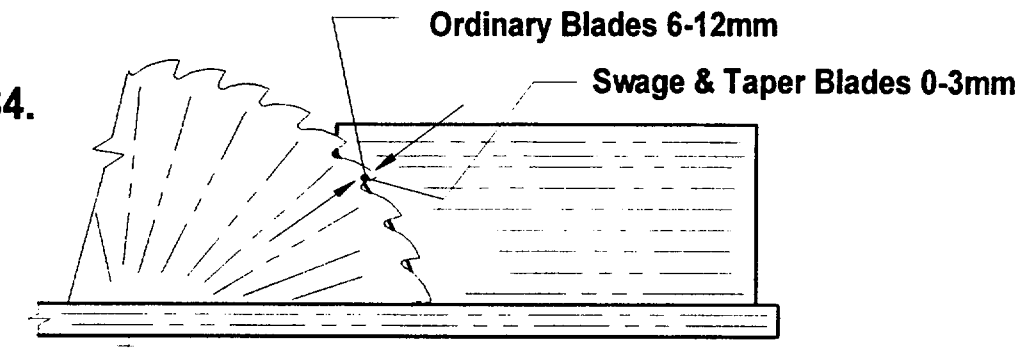
FIG.83.

Large Sawbench Regulations

Fence Alignment:
Two things may be wrong with the ripping fence on re-saws which may give the impression that there is something wrong with the blade and so the sawdoctor should also know about these.

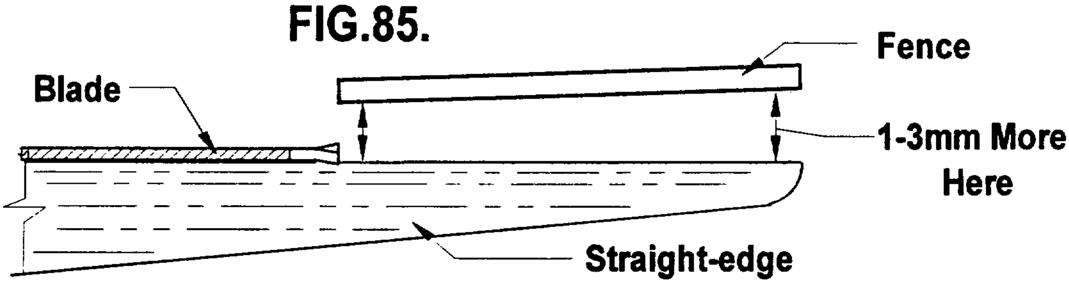
First the fence may be positioned too far past the teeth of the blade preventing the cut timber from being able to bend away from the blade and this can cause over-heating and of course upset the tension of the blade. See Fig.84. for the setting of a solid fence. For the larger roller fences on power feed re-saws the first roller may have to be positioned a little further forward to guide the last curved bit of the cut but only if this is a problem and then only the minimum amount that will overcome the problem.

FIG.84.



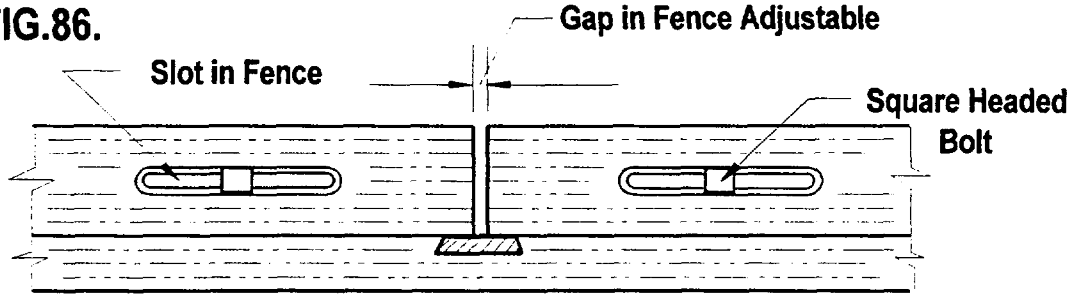
Next looking down on the fence from above the fence has to be aligned correctly. On very small machines not used for resawing the fence may be parallel to the blade, (not necessarily the side of the machine's bench top.) For larger machines used for resawing and log conversion the fence should be set out of parallel as shown in Fig.85. This is to allow for the roughness and slight curves of the surfaces placed against the fence which in practice hold off the timber and gradually *TAPER* the timber being cut. The actual amount set out of parallel will vary depending upon the size and type of machine from about 1mm to 3mm in the length of the fence.

FIG.85.



Cross-Cut Fence Maintenance:
More often than not cross-cut fences are neglected and thought of as being unimportant. This may be so in sawmills where accuracy and clean square cutting is not so necessary but in factories cutting up timber for manufacturing purposes two things become important. First good clean square cuts from the cross-cutting machines can do away with second trimming on other machines later and so save timber. Then because small pieces are often cut off the ends, these can jamb in the fence causing damage to the fence and blades and even accidents to the operators. For these reasons the back fence in these situations should be maintained with a minimum gap the width of the saw kerf and no more. This is best achieved by having a good hardwood fence in two parts one each side of the blade which can be adjusted up to the blade when worn and a new cut made by the machine's blade. See Fig.86.

FIG.86.



On radial arm cross-cuts the bench top underneath the blade also becomes worn and in consequence the timber being cut will spelch underneath. As the bench top is often a substantial piece of timber in one long length this problem is best solved by fitting a hardwood strip at this point which can easily be replaced when worn. The insert is best dovetailed into the bench top rather than nailed or screwed into position. See Fig.87.

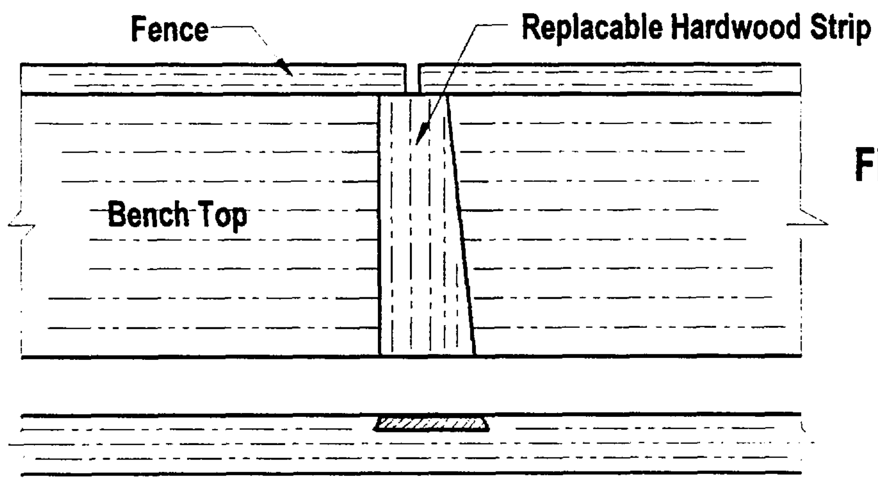


FIG.87.

CHAPTER 5

Joining of Wide Bandsaw Blades (Part 1)

Brazing:
Because of the high carbon content of the steel used to manufacture wide bandsaw blades, which made welding them extremely difficult, the original method of joining was by making a brazed scarfed joint and this was the accepted method for many years and is still used in many sawmills in developing countries. In all modern sawmills brazing has become obsolete and there are several good reasons for this, first the equipment for brazing is very expensive, second the work in making a *GOOD* brazed joint is extremely skilful and third, unlike welded joins which can be repaired, if a brazed joint starts to open up it cannot be repaired but will have to be completely re-made. Finally over the years various welding techniques as well as new equipment for welding have been developed now making welding easier and very successful. However for those still using the system of brazing we shall go through the essential steps to make a successful joint. Before we commence, although the term *SCARF* meaning a *TAPERED LAP* for the name of the joint is technically correct, the basic term *LAP* is used in sawdoctoring.

Successful brazed joints can only be made if:
(a) The joint is prepared very accurately to the correct size and shape.

(b) Everything in and around the joint is kept spotlessly clean.

(c) All the equipment used in making the joint is also clean and maintained properly especially the brazing irons which must be perfectly flat.

(d) The correct sequence and techniques are strictly adhered to. There are no short cuts to making successful joints.

List of Equipment:
(1) Brazing clamp with a pair of special non-scale alloy steel brazing irons.

(2) Electric furnace or other means of heating the brazing irons to 950°c.

(3) Lap Grinding Machine. Note: Joints can be prepared by filing but it is difficult and suitable files are expensive.

(4) Miscellaneous Tools including files, try squares and scribing tools.

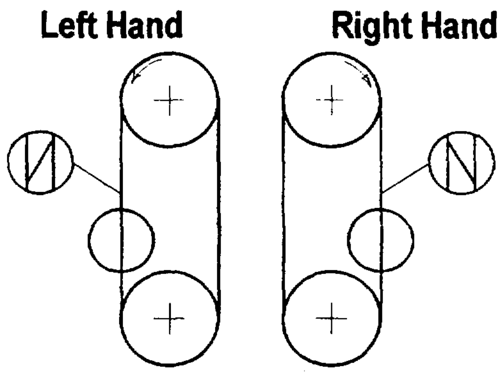
(5) Special low melting point Silver solder 0.003" thick 1/2", 5/8" and 3/4" wide or metric equivalent and a suitable Flux.

(6) Filing saddle.

Left and Right-Hand Machines:
Because of production layouts, log bandmills and band resaws are made in Left and Right-Hand versions and it is better to have the trailing edge of the joint approaching the pulleys than the leading edge. This means grinding the bevels on the correct sides and should be dealt with at the setting-out stage so that mistakes are eliminated later when grinding.

A machine is said to be Left-Handed when the log or timber is fed in on the left-hand side when looking from the in-feed side and Right-Handed when fed in on the right-hand side. See Fig.88.

FIG.88.



Steps to be Followed:
(1) Find out if the machine on which the blade is to be used is left or right handed.

(2) Mark out the joint as shown in Fig.89a. Left-Hand, or Fig.89b. Right-Hand.

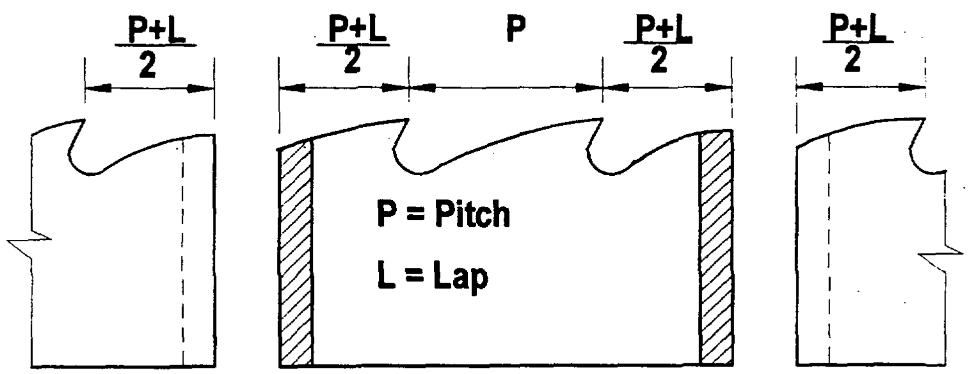


FIG.89a. FIG.89b.

(3) Cut the ends to the correct length and grind or file them perfectly square and during this squaring up make them 0.5mm short of the pitch plus the lap as shown in Fig.90. This is the width of the line of braze which will be seen on the finished joint.

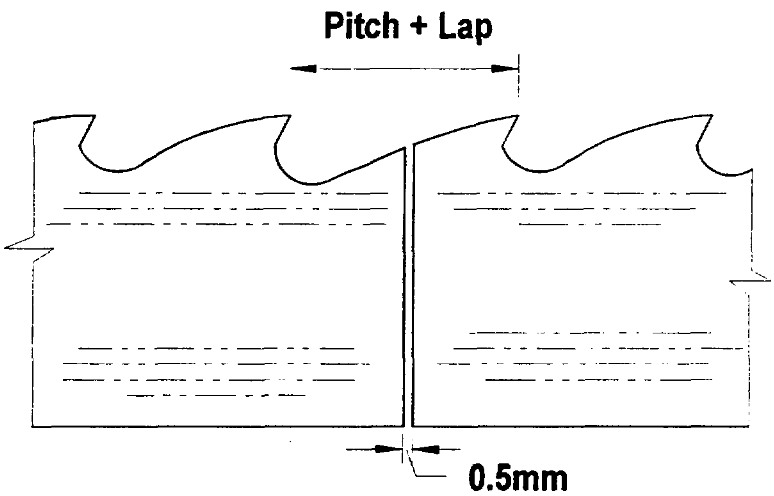


FIG.90.

(4) Level the ends of the blade so that they will lie perfectly flat in the lap grinder otherwise grinding of the laps will be uneven.

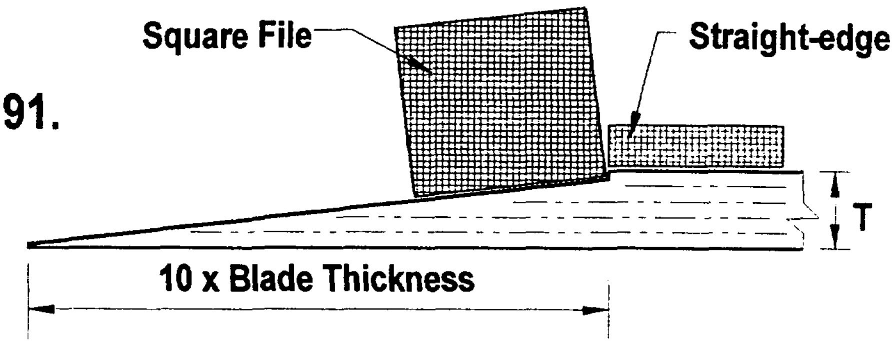
(5) Check that the brazing irons are clean, they should be cleaned immediately after use so that the flux does not eat into their surfaces. Also ensure that they are flat, if not they need grinding or at least rubbing flat on a piece of abrasive cloth placed on the levelling plate. This flatness of the brazing irons is *VITAL* to successful joins and can only be achieved by using the correct expensive steel brazing irons. Other steels will almost certainly scale with the high temperature every time they are used and so are useless.

Before the brazing irons are put into the furnace, with a piece of scrap blade clamped in the brazing clamp, put the bottom iron on the wedge and push into position and adjust so that it overhangs equally on both sides of the blade. Mark this position on the wedge with chalk. This is to ensure that everything will be correct when the red hot irons are placed into position to make the join. Just in case there is a difference in the thickness of the two irons don't mix them up. Instead note the position of this iron in the furnace and use the same one on the bottom when they are ready.

(6) Grind the bevels leaving the ends approximately 0.1mm thick. If the bevels are ground too thin at the ends then they will curl up and burn when the hot brazing irons are applied.

(7) Finish off the bevels with a new clean file making sure that they are perfect in every respect and now for the *SECRET* of obtaining that thin straight line. With a piece of scrap bandsaw blade clamped over the end of the blade with the bevel just showing, cross-file a very shallow rebate as shown in Fig.91. This is to allow the 0.1mm thick ends of the bevels to remain intact for as soon as they are filed away when cleaning up the braze afterwards the thin line of the braze will become a wavy line spoiling the appearance of the finished braze.

FIG.91.



You will notice in Fig.4. that the length of the bevels is 10x the blade thickness. By using this formula all the bevels on different thicknesses of blade will have the same *GRINDING ANGLE* so that the lap grinding machine can be set to one angle and not altered. Originally the bevels were given lengths of 1/2" 5/8" or 3/4" depending on the *WIDTH* of the blade, probably before lap grinders were invented, but if you think about it, it is more correct to use the thickness which remains the same throughout the life of the blade and also gives a constant angle on the bevels.

(8) If the bevels are perfectly clean, immediately coat with flux to prevent any oxide forming and cover them with clean paper to keep them free from dust. If you suspect that the bevels may not be perfectly clean, then clean them using spirits of salts (Hydrochloric Acid).

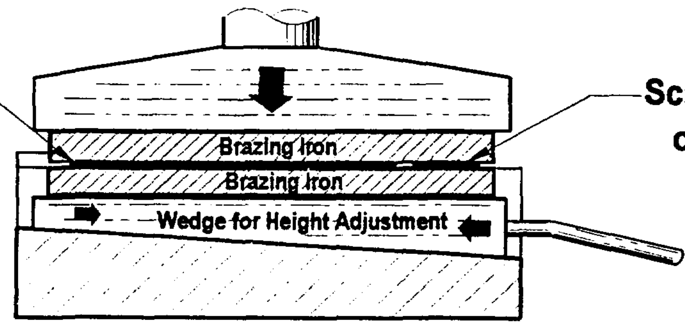
(9) Clean a strip of silver solder with a new piece of abrasive cloth or with spirits of salts and cut it off 10- 15mm longer than the joint. Coat with flux made into a paste and place on clean paper. During all this procedure you must only hold the silver solder by its edges for even normal finger marks will ruin the braze.

(10) Place the ends to be joined in the brazing clamp and check the tooth pitch and back edge for straightness.

(11) Open the lap by raising the end of the blade which is on top and slide something under it to keep the joint open so that the silver solder can be slid in place without scraping all the coating of flux off. The width of the silver solder should be no more than 1mm wider than the laps otherwise there will be too much surplus to remove afterwards by filing.

(12) Double check the set-up and when the irons are 950°c place them below and above the joint in that order and apply the pressure and release the side clamps so that the blade can expand. There is no need to overstrain the equipment by adding a lever to the tightening down wheel, if the irons are flat then the join will be good. Fig.92. shows the complete clamp set-up. Note the piece of scrap blade of the same thickness used to fill up the full length of the brazing irons when brazing narrow blades. This is necessary to ensure even pressure all across the joint.

FIG.92.



(13) Remove the brazing irons soon after they have turned black, I found that leaving them for just two minutes after they turned black gave a good result. This timing is important for if the irons are removed too soon the silver solder may not be set and so the join may open up. If the irons remain around the join for too long then the surrounding steel of the blade will be fully annealed (softened) and the area will never hold its tension.

(14) Flux is corrosive so it should be removed from the brazed joint and the brazing irons right away even if the joint is left till later to be finished off. A good wire brushing may be enough to do this.

(15) When the braze is removed from the clamp it will be found that the area in the middle of the join will be very tight i.e. short, and until this is corrected the blade cannot be bent over the filing saddle without stressing the join. First remove any surplus silver solder, we don't want it hammering into the surface of the steel, a mini angle grinder will get in the hollows and is good for this. When roughly clean, start hammering on and close to the lap in the middle until when tested, *AS FOR TENSION*, with the straight-edge the joint is flat. It need not have tension at this stage but must be flat so that the joint will lie flat when bent over the filing saddle.

(16) Before filing up the braze just realise that the blade on each side of the narrow strip of the lap is *ALREADY THE CORRECT THICKNESS* therefore filing anywhere other than on the lap area will make the blade *TOO THIN.* It is quite difficult to file only the lap without touching the area on each side but this must be your aim and the only way to do this is to file a little then hammer a little working on one side then the other pushing any low parts through to the other side to be filed. This is very time consuming but is the only way to achieve a really good brazed join. When the filing looks finished test the thickness of the blade at the lap with a micrometer or pair of callipers and if correct finish off the braze using medium then fine abrasive cloth to give a polished finish.

(17) The join must now be tensioned to the same as the rest of the blade, if it is a new blade this will be done last. Although it is possible to very carefully put some light rolls across the joint it is safer, especially when learning, to tension the area around the joint using the dog head hammer. This is because this area will always be softer than the rest of the blade.

(18) Finally to remove some of the stresses put in by all the hammering, the area around the join should be *VERY SLOWLY* brought up to a straw colour using an oxy-acetylene torch and when cool should again be checked for tension.

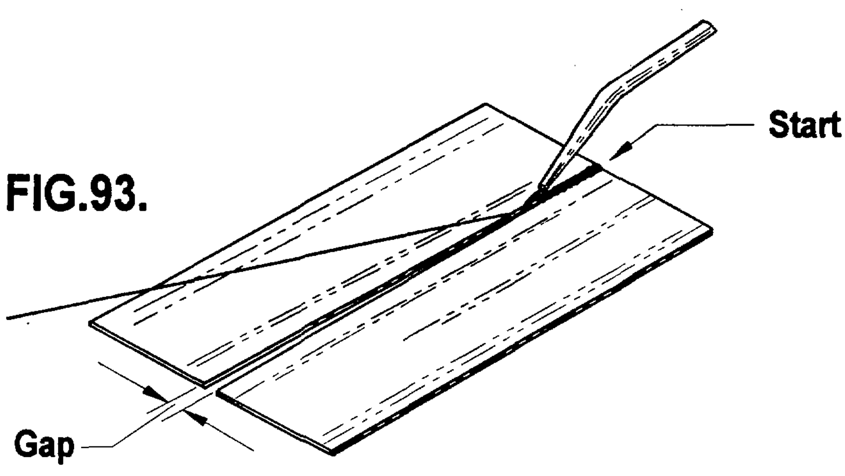
Joining of Wide Bandsaw Blades (Part 2)

Oxy-Acetylene Welding:
As stated in part 1, because of the high carbon content of bandsaw steel, in the early days joining by welding was considered too difficult and the joining of bands was done by brazing. However over the years both new techniques and new equipment have been developed so that today there are several welding methods available to the sawdoctor. The first to be developed used oxy-acetylene equipment and is still very popular simply because the oxy-acetylene equipment is nearly always available in sawmills and factories for general maintenance purposes therefore needing only a small investment for the additional equipment. With the introduction of M.I.G. & T.I.G. welding, dealt with later, oxy-acetylene welding although better than brazing is a poor option and fast becoming obsolete the same as brazing. However for the reason given above it is still used extensively so needs to be covered.

A Little Theory:
As we have said already bandsaw steel because of its high carbon content and other elements is very difficult to weld. This is because it is an *AIR HARDENING STEEL* i.e. it does not need quenching with oil or water to harden it but will automatically harden in air unless we cool it slowly. It also seems that the better the quality the steel the more difficult it is to weld no-doubt because of the slightly higher quantities of improving elements in the steel. On top of this when our weld is finished the back edge of the blade must be straight and this creates a real welding problem.

If an industrial welder was asked to join two pieces of steel plate together say 150mm wide he could place the two pieces touching at one end but with a gap at the other end as shown in Fig.93

FIG.93.



The distance of the gap he would estimate from experience knowing that it would close up as the weld proceeded from the closed end. Any slight error in the gap he would overcome by speeding up or slowing down his progress across the weld so that the ends came together correct at the finish. He would also weld without stopping to avoid oxides forming. Using this technique the finished weld would be free from internal stresses because the weld was free to move and because the enveloping flame would have protected the weld pool and filler rod all the time during the welding there should be no oxide inclusions to weaken the join.

Unfortunately if we joined a bandsaw blade using this method and the back edge was not straight at the join, the joint would have to be cut out and done all over again for only a very small amount of error can be corrected by rolling, therefore we have to have some means of clamping the ends in the correct position firmly enough so that the forces pulling the ends together during welding are overcome.

This need for clamping the ends causes serious welding problems which need to be understood thoroughly if good welds are to be made which will stand up to the tremendous stresses bandsaws have to withstand.

In bandsaw welding then, the ends to be welded are clamped as shown in Fig.94. with a sufficient gap between the ends so that when the steel expands the two ends meet but do not ride up and overlap to ruin the join.

This size of gap is critical and has to be found by tests. Too small and the join will not be level and too big the extra gap will need filling with filler rod not necessarily as good a material as the blade resulting in a join perhaps less than full strength.

If the steel expands say 1mm to fill the gap, when it cools it wants to shrink back 1mm and these thermal stresses are so strong that they will easily crack a good weld unless something is done about it. This led to forging the weld bead down into the weld before it had time to cool thereby setting up opposite stresses to counteract the shrinkage.

This is all right and in fact forging the weld bead refines the steel and improves it but it also meant that only short runs of weld could be made before the weld would cool and crack. Every time the weld is stopped and started oxides form and are included in the weld reducing its strength which is no good for bandsaws, so what can we do to improve our welds?

When I first started to experiment the only commercially made clamp that I had come across in industry was the one made by Armstrong Mfg. Co. U.S.A. and is a good clamp and no-doubt suitable for use with the big log bandmill blades as used in their industry when these clamps were first designed, but for the thinner gauge blades as used today and for re-saw blades the 60mm square anvil leaves too big an area of blade to get hot and expand during welding.

I tried two things to improve the situation. First I found some 20mm x 6mm mild steel which I placed underneath the blade to reduce the gap and to help take away some of the heat as shown in Fig.94.

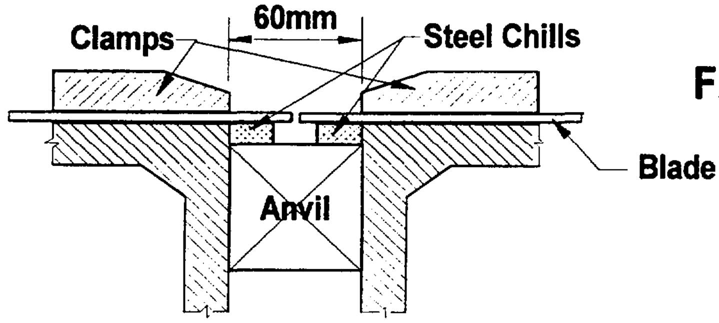


FIG.94.

Then I also tried a single wider piece with a 10mm groove ground into its surface, similar to a copper *CHILL* as used sometimes by welders to take away the heat when electric welding. This is shown in Fig.95. Note; you cannot use copper for oxy-acetylene as the copper takes away too much heat from the flame. Although these chills helped they still allowed too much blade to get hot and still would not prevent the ends curling *UPWARDS* if they wanted to.

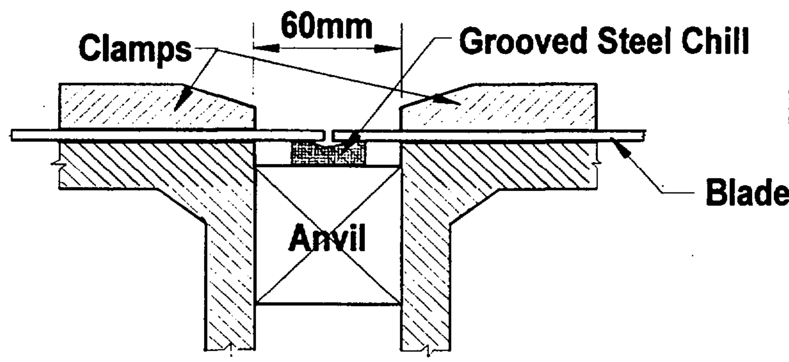


FIG.95.

The answer seemed to me was to reduce the width of unsupported blade with a clamp with a narrower anvil and I designed and had several made over the years ending up with the gap down to 30mm which is just wide enough to get a small hammer in for forging and will reduce the expanding/shrinking problem by about half. See Fig.96. This smaller gap, giving much less shrinkage, meant that I could weld most bandsaw steels without having to resort to stop/start welding and forging with its oxide problems. The steel chill is still used to take away some of the heat and should be fitted with a stout wire handle so that it can be removed quickly and replaced if necessary without burning your fingers. See Fig.97.

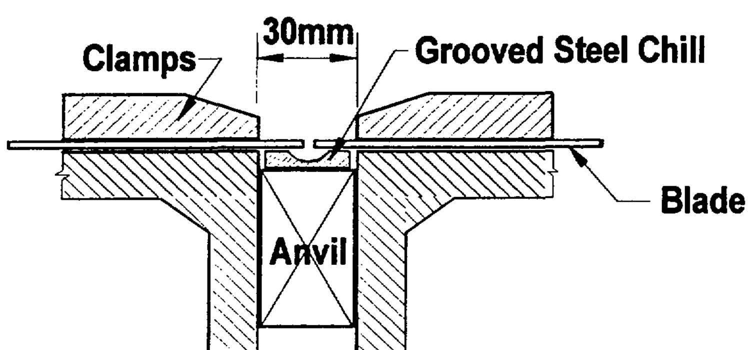
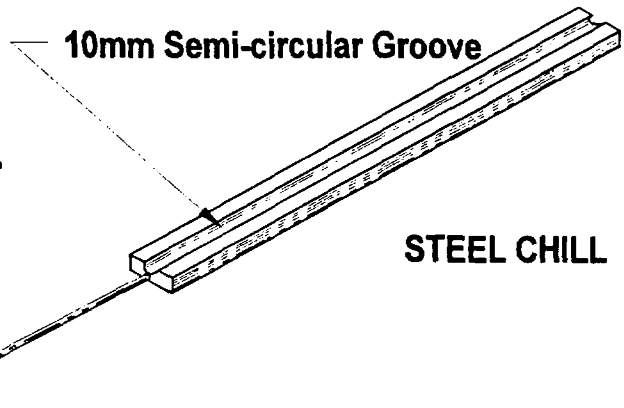


FIG.96.

FIG.97.



Welding Techniques:

Nozzle Sizes:
Nozzle sizes 1, 2, 3, & 5 which use 1, 2, 3, & 5 cubic feet of gas per hour or 29, 57, 86, & 140 cubic litres per hour will cover all bandsaw thicknesses from 20 - 13 gauge (0.9mm - 2.4mm). The actual size will depend upon the set-up and can only be determined with tests as there are so many variables not least the skill of the welder. My advice is to choose a nozzle size that will penetrate the steel with the same set-up and at the same time allow a long *QUIET* flame to be used. A harsh noisy flame is not going to give the smoothness to the weld bead essential to a weld free from undercutting which will reduce the strength of the weld. See Fig.98. and too small a nozzle will not penetrate fully as shown in Fig.99.

Always clean the nozzle before commencing to weld, it will be too late once you have started to weld if the flame goes wrong.

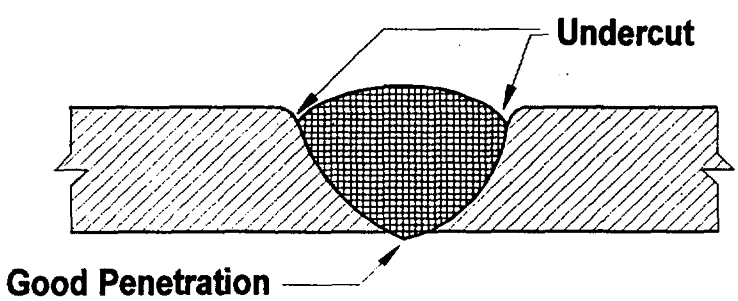


FIG.98.

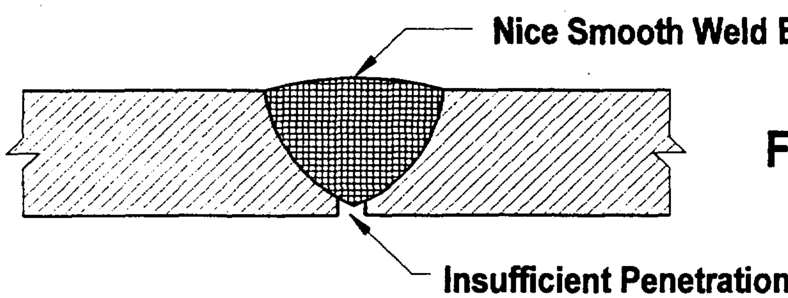


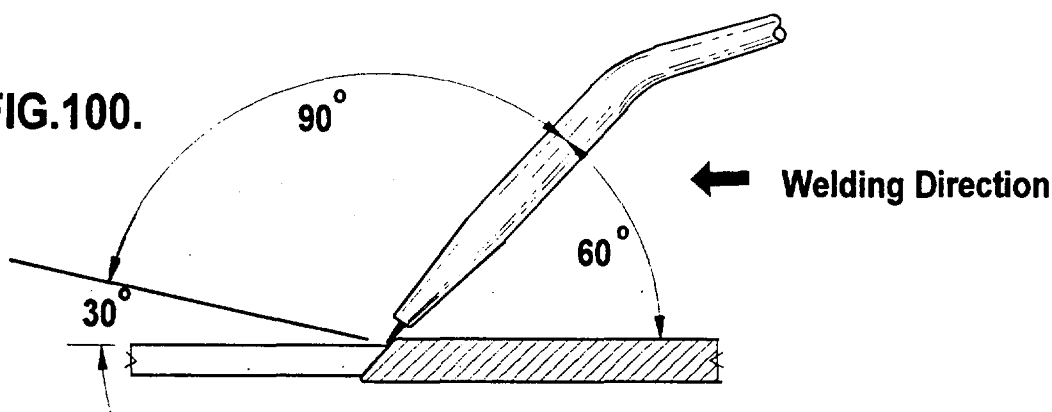
FIG.99.

Regulator Settings:
Regulator setting should control the flame not the knobs on the torch which should be nearly fully open in use. This means that a low pressure setting is required at the regulators and should be the same for oxygen and acetylene as

we require equal amounts of gas and oxygen to produce a *NEUTRAL* flame. A setting of 3lb/in. sq. or 0.14 bar is all that is needed for blades up to 1.47mm thick.

Leftward Technique:
I have seen many variations of the leftward technique successfully used but the generally accepted angles and technique are as follows; The torch is held between 60° - 70° to the horizontal and the filler rod is held at 90° to the torch as shown in Fig.100. The torch and the filler rod *MUST* be at 90° to the surface of the blade in the other direction. The filler rod is *NOT* melted off with the flame, which is a common fault, but should be dipped into the molten pool in a steady rhythm where it will melt into the weld pool. The movement in and out must be very small as the end of the rod must *NOT* leave the outer enveloping part of the flame were it would oxidise in the air and then this oxide would be included into the weld.

FIG.100.



Torch Movements:
The torch needs very little movement sideways when working the molten pool, this is because of the thinness of the material we are welding. Two standard patterns are used one circular motion and one criss-crossing motion and these are shown in Fig.101. For the thinner blades no sideways movement is necessary and even on thicker blades the weaving should be very small say no more than 3mm our aim being to create a weld bead as smooth as is possible so that when forged down into the weld it should be smooth and free from indents.

FIG.101. **Torch Movement Patterns**

Forging:
The forging process is to set up expansion stresses to counteract the shrinking that wants to take place as the weld cools and also to refine the structure of the weld, similar to the rolling process when steel is manufactured. I do not fully understand why but an *oxy-acetylene* weld seems to have no strength without it. The method I recommend, working on 20mm at a time, is to raise the temperature of the weld to almost molten for the first hammering continuing right across the

blade, then repeat the hammering again heating the weld to a bright red and again for a third time bringing the weld only to a dull red this last time. Do not take the torch away when hammering but continue to heat the next area. Hammering should be light the first time gradually increasing the weight of blows for the second and third forgings. When this is complete the weld should be nice and smooth needing very little grinding off afterwards. The skill of hammering and of course the smoothness and correct shape of the hammer face is vital, for it is easy to end up with dents from the hammer in the surface when the steel is soft.

Tempering of the Weld:
When the forging is finished the whole weld should be re-heated to a dull red and allowed to cool. This is *NORMALISING* and should be done with the torch held higher so that the heat is spread wider than when forging. Then the weld should be re-heated again to a dull red and this time cooled quickly using a blower or a rag soaked in oil. This is to *HARDEN* the weld. Finally the weld must be *TEMPERED* otherwise it will break in two, to do this clean an area with abrasive cloth or just rub with a piece of broken grinding wheel so that when re-heated again you will be able to see the cleaned parts turn *DARK BLUE* which is the tempering colour for 350°C which we need.

After the weld is cleaned off and levelled and tensioned I feel that this can create more stresses inside the steel and so I usually re-heat yet again, this time to a *STRAW* colour and covering a wider area now that it is out of the clamp, usually about 150mm wide, 75mm each side of the weld. Hold the torch well away from the blade so that the end of the flame only contacts the blade, do this on both sides or at least move the flame away so that the air can get at blade otherwise it will not oxidise which provides the colour that you are waiting to see.

Equipment required:
(1) Set of lightweight oxy-acetylene welding equipment including, lightweight torch with several small size nozzles and preferably lightweight hoses.

(2) A pair of good quality two stage gas regulators preferably graduated for low pressures since these will be more accurate at the low pressures used.

(3) Sets of nozzle cleaners essential for maintaining good shaped flames.

(4) Welding clamp suitable for the width and thickness of blades to be welded.

(5) Small hammer with a smooth slightly rounded face size depending upon blade thicknesses to be welded, usually about 1/2 kg.

(6) Miscellaneous tools including files, abrasive cloths, a set of engineers feeler gauges and very important, welding goggles with *LIGHT COLOURED* lenses.

(7) One or even two 100mm or 110mm small angle grinders with a good supply of 30 grit course grinding discs and a rubber backing disc with 60 grit or finer paper abrasive discs for finishing and polishing the weld. These are much better than

using files and more economical in the long term as files have become very expensive.

The Welding clamp:
Apart from the oxy-acetylene torch, gauges etc. which must be of good quality and in good condition, the quality of welding clamp is very important.

The anvil should have a cam underneath to raise the anvil for forging and to lower it for welding. This can be operated either by a hand lever or by a foot peddle.

The clamping plates themselves have to be very strong to resist the movement of the ends which want to move together as explained earlier. The Armstrong clamping plates are made of cast steel ground flat on the underside and then deliberately bent to a slight curve so that when screwed down tight they provide pressure all across the width of the blade and not just near the bolts, this is a very good feature.

Filler Rods:
Good quality bandsaw steel has about 3% nickel in it to assist cold working, essential for the deforming process of swaging. When I first started welding bandsaws in the 1960's, two British companies manufactured a 3% and a 3.5% nickel filler rod for oxy-acetylene welding which were ideal but which have both been discontinued. The other alternatives which all seem to work well are; copper coated mild steel welding rod, thin strips of bandsaw blade cut with the shears and hammered straight, single strands unwound from heavy steel cable as often found lying around in sawmills and probably the best now, coils of copper coated wire used with M.I.G. welding which are available in good qualities and very thin wires which is ideal for our work.

Whatever type is used it *MUST* be cleaned before use and several pieces prepared ready so that if you stop welding, say to forge a tack weld, you can pick up a clean piece and not use the oxidised blob on the end of the used rod. This should always be cut off and the end cleaned again before being used.

Procedure:
(1) Cut the ends of the blade in the middle of the pitch and file or grind square so that when butted together the back edge is straight. During squaring up of the ends reduce the pitch by approximately half the blade thickness to allow for the expansion which takes place during welding.

(2) Check that the cut ends are flat and if necessary hammer out any faults. The use of a piece of leather underneath will assist in hammering down any bad kinks made with a poor shears. This levelling is essential so that the ends to be welded will lie perfectly flat when clamped in the welding clamp.

(3) Clean both ends with abrasive cloth for at least 20mm to remove any oil, dirt or rust which would contaminate the weld.

(4) Pre-heat the anvil next using a large nozzle like a No.10. or place in a furnace until about 200°C is reached. If using the torch, test the temperature by placing a small piece of clean blade on the anvil and if it turns straw colour it will be hot enough. This pre-heating of the anvil is to prevent the anvil from having a quenching effect on the weld when the anvil is raised for forging and also to provide some heat to slow the cooling down during welding.

(5) Place the ends in the clamp and tighten down the securing bolts leaving the correct gap between the ends. If you have access to narrow bandsaw steel or steel banding, you might be able to find a thickness suitable to place in between the two ends and this will greatly assist when trying to get the gap correct at the same time as tightening up the bolts. Next check the back edge for straight with a steel rule or a special thin straight-edge made from thinner bandsaw steel. The bolts must be tightened down firmly and evenly and any swage on teeth of old blades will have to be removed by hammering flat otherwise the ends will move during welding. Finally check the height of the two ends where they meet to see if they are level, if not knock down any high place or prise up any low place until the ends are level.

(6) Put the steel chill in place and raise the anvil up tight which must remain tight up to the blade during welding or the chill will not work. This can be held by an assistant or by the welder with a foot peddle. Place two small pieces of scrap blade, one at the back edge and the other in the gullet, these are to commence welding on at the back edge and to run onto at the tooth edge. If you find these move cut them wider and put them under the clamping plates.

(7) Light the torch and adjust the flame to *NEUTRAL* this is equal parts of oxygen and acetylene with a rounded tip to the inner blue cone. To be sure that it is correct first adjust to show the slightest trace of a feather (excess acetylene) then remove it using the regulator on the gas bottle which is more accurate than using the knob on the torch. See Fig.102.

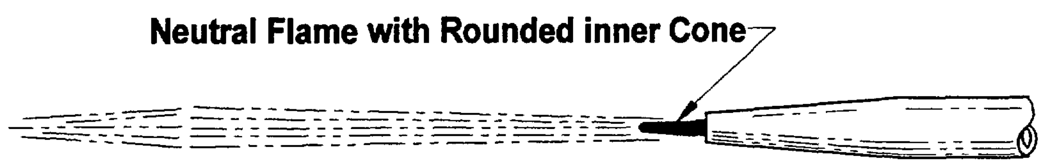


FIG.102.

(8) When you are satisfied that the flame is perfect start to weld 10 -15mm from the tooth edge and run out into the scrap piece in the gullet, this may or may not need lightly forging to stop it from cracking, but don't forge it unless you have to. *IMMEDIATELY* start to weld from just inside the scrap piece at the back edge and continue right across and *INTO* the tack weld at the tooth edge, You can even continue and re-weld the tack to make sure it is good. As soon as the weld is complete an assistant *MUST IMMEDIATELY* slacken off the two clamping bolts slightly on one side of the blade so that the blade can now expand and contract

for the remaining work. You also must immediately move the torch back to the start of the weld, which will be cooling and could crack at this stage and re-heat to a bright red ready for forging.

(9) Forge three times as described earlier starting very hot with light hammering, reducing the heat and increasing the weight of hammering for each pass.

(10) Normalise by heating to a dull red evenly across the whole width of the blade and allow to cool.

(11) Re-heat to a slightly brighter red and cool quickly with air or oil to harden the weld.

(12) Brighten the area and re-heat to a dark blue colour to temper the weld.

(13) Grind and polish up the weld, a small 100mm or 110mm angle grinder is best for this work infact I used to have two one with a 30 grit abrasive disk and the other with a rubber backing disk with 60 grit paper for polishing.

(14) Level and tension to fit the same tension gauge as the rest of the blade and of course check and correct the back edge if necessary.

(15) Finally stress relieve the area 150mm wide around the weld by re-heating to a straw colour.

Joining of Wide Bandsaw Blades (Part 3)

Electric Arc Welding:
Introduction:
There are three types of electric arc welding and two of them have revolutionised the welding of wide bandsaw blades. These three methods are:

(1) Manual Metal Arc (M.M.A.)
(2) Metal Inert Gas (M.I.G.)
(3) Tungsten Inert Gas (T.I.G.)

The first method is the one most widely used for general construction purposes and although I did once see it used for welding bandsaws in a sawmill in Australia it is not really a suitable method especially when the other two are available so we shall not discuss this but concentrate on the other two.

Both M.I.G. and T.I.G. methods use an inert gas to shield the weld and surrounding area from the air which would otherwise form the harmful oxides in the weld. Different shielding gases are used for welding different materials but for bandsaw welding we only use *Pure Argon* which is quite expensive but the resulting welds are so clean and of such excellent quality that these are the only methods of joining and repairing wide bandsaw blades worth considering when setting up a new plant. The only possible problem is that in some developing countries these shielding gases may not be available.

Again both methods are the same in how they provide the heat to melt the steel and make the weld. The blade or steel welding bench is connected with one cable and the welding current jumps (arcs) across from the electrode attached to the welding torch providing an intense heat far greater than that provided by oxy-acetylene. This heat is so localised that the steel at each side of the weld bead stays quite cool. With the aid of a copper chill the troublesome expansion of the blade in-between the clamping plates is reduced to a minimum. In addition to this, the resulting weld is so good that it does not need forging but has excellent strength without this lengthy process making the welding much quicker and easier. There is also *NO* distortion of the blade at the join after the welding and it is a pity that we may create a little carrying out the heat treatment using some type of gas torch afterwards. This is necessary because the weld bead will harden on cooling and even though the affected area is not much wider than the bead itself it would still break if moved out of the camp without tempering.

The difference between M.I.G. and T.I.G.:
Metal inert gas welding uses the filler wire as the electrode and this comes in the form of long coils which are fed by the machine down the centre of the torch and are melted off into the weld pool. The rate of feed is controlled by machine settings so that once set the size of weld bead should be constant if the torch movement is also constant. This has led to M.I.G. being chosen to be used in commercially made welding benches for bandsaw blade joining and repair some of which use a motor driven torch passing across the weld at a variable controlled

speed making the work semi-automatic and so very popular with blade manufacturers and large sawmills.

Tungsten inert gas welding uses a non-consumable electrode and separate filler rods or wire. The electrode which is fitted in the centre of the torch is made of tungsten or similar material which will withstand the terrific temperatures without burning away and it is from this that the system gets its name.

The cost of a small 150 Amp. T.I.G. machine is usually much higher than the same size M.I.G. machines that are available, perhaps because they are usually slightly more sophisticated with more control of the arc at the beginning and end of the welding. For example, by selecting a setting on a dial the power can be *sloped up* and *sloped down* at the beginning and end of welding, This can be timed so that you have say two seconds from zero to full power to run onto the blade from a scrap piece and say three seconds to run off at the end when the power will be decreased. I used to set the slope down for the end of welding so that I released the switch on the torch three seconds before the end of the weld and the current gradually faded to zero allowing me to run out without using a scrap piece in the gullet or burning a hole there. This is especially useful to save time when repairing cracks.

I chose to purchase a T.I.G. machine for my servicing business mainly because, from my oxy-acetylene welding experience, I had felt that the best filler rod was strips cut from scrap blade and I wanted to be able to use this if necessary with the new machine. In the end I finished up using a good quality M.I.G. wire which is much more convenient so perhaps the extra cost of the machine was not necessary although I was very pleased with the investment and still think that the T.I.G. machine is better for general repair of blades and the occasional making up of a few new blades. Of course new machines are being developed all the time and both types should be considered when making new investments.

T.I.G. Welding:

The Electrode: For welding steel including bandsaw steel, Tungsten electrodes with 2% *THORIUM* are recommended and these are identified by the colour code red. They are about 150mm long and are made in various diameters the choice of which depends on the thickness of the material being welded. As a guide choose a diameter about the same as the blade thickness, for example, for welding 19 gauge blades 1.1mm thick a 1.2mm diameter electrode is suitable.

The end of the electrode has to be ground to a point the length of which should be 1-3 times the electrode diameter. See Fig.103.

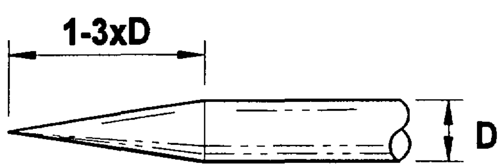


FIG.103.

Electrode Point

When learning the point may be damaged if it touches the workpiece or is touched by the filler rod. It will also be damaged if you forget to turn on the gas supply and will need re-grinding fairly often during the learning period.

Once the operator has become skilled, the point should keep its shape providing that the *CURRENT, GAS FLOW and ELECTRODE DIAMETER.* are correct. If the electrode diameter is too small it will burn and lose its shape quickly, if it is too large for the current used the arc will be unstable.

The Ceramic Nozzle:
Surrounding the electrode is a ceramic nozzle available in various shapes and bores and it is the size of the bore or hole in it that controls the area covered by the gas shield. For our work a nozzle with a bore diameter of 6mm is large enough, a larger size would only need a higher gas flow and cover too wide an area and so be wasteful of gas.

The Gas Shield:
As stated earlier, the correct gas for bandsaw welding is *PURE ARGON.* The amount of gas used should be the minimum which will shield the weld pool from the air and so prevent oxidisation of the weld plus a narrow strip each side of the bead. The amount of gas is controlled by a gas flow meter usually attached to the gas cylinder and 5-6 litres per minute gas flow will normally give enough coverage for bandsaw welding. Too little gas flow will result in a black looking weld and too much flow will stir up the weld pool and make it difficult to obtain a smooth weld bead free from undercutting at the edges.

Filler Metal:
One of the advantages of T.I.G. over M.I.G. is that there is a wide choice of filler rods that can be used as well as the wires made for use with M.I.G. Also for our work there are thin strips of bandsaw steel which we can cut with the shears as well as all those other wires mentioned in part 1 for oxy-acetylene welding.

This influenced me when I purchased a T.I.G. machine but after experimenting with various filler metals I ended up using what the manufacturers use with their M.I.G. machines i.e. a good quality mild steel wire with 0.2% carbon content. This wire which is available in various diameters is so convenient if a coil is placed underneath the welding bench it can be pulled out when required without cutting it off and so there is practically no waste at all.

By using the 1.2mm diameter wire, which is thinner than the thinnest welding rods, the wire can be laid down on top of the gap between the blade ends and the torch simply passed over it and the resulting weld bead is perfect for medium thickness blades. For very thin 20 gauge 0.9mm thick blades the same technique can be used but by slowly pulling the wire away from the torch a little less wire is used.

A copper coated wire is preferred so that it will not rust, an important point since for repair work a coil could last for years. The copper coating should however be cleaned off with wire wool or abrasive cloth before use as well as the ends of the blade to be welded.

Welding Technique:
The technique for welding complete joins for new or damaged blades is very similar to that used for oxy-acetylene welding. The ends of the blade are prepared in the same way and by experiment the correct minimum gap is found. The blade ends are secured in a welding clamp or jig in the same way and in fact the welding clamp with a 30mm gap between the clamping plates is ideal. The only difference is that this time a copper chill is used with a much smaller groove in it to actually assist in controlling the weld penetration. The size of groove is a 3mm semi-circle as shown in Fig. 104.

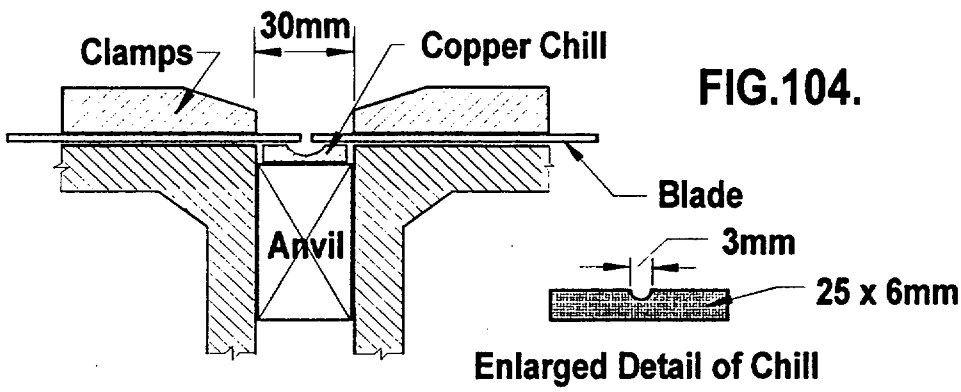


FIG.104.

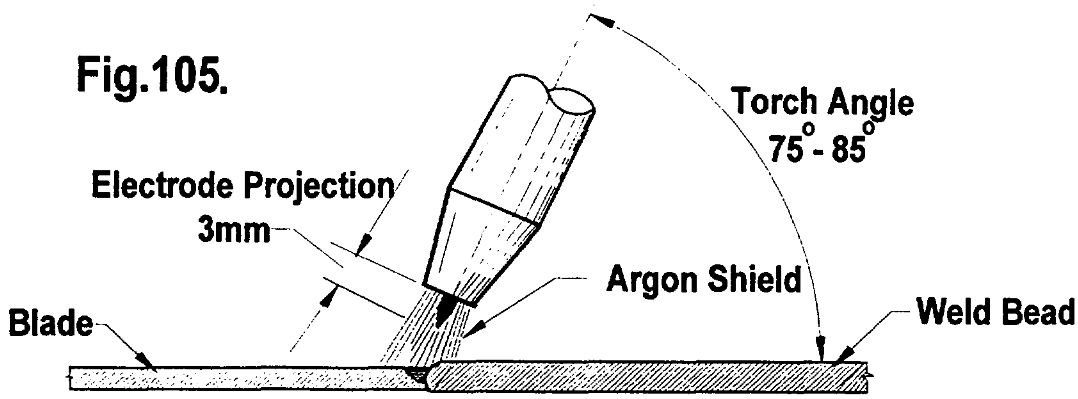
Although a welding clamp as we know it with a rise and fall anvil is ideal, because the weld is not forged an anvil as such is not required. However the rise and fall movement is very useful making it easy to remove the copper chill for the tempering process. If making up a clamp, a wedge similar to the ones on brazing clamps would be easier to construct instead of a cam mechanism and would allow the chill to be removed easily. Some form of adjustment for height is better than a fixed groove because the copper chill can then be filed or machined thinner to recondition the chill when the groove gets worn.

The welding clamp should be pre-heated to around 300°C to prevent the weld cooling too quickly perhaps creating cracks unseen to the naked eye. I always preferred to weld up new blades after a session of repairing cracks so that the clamp was thoroughly heated beforehand.

Pieces of scrap blade are placed to run onto the blade at the back edge and to run off at the gullet, although with practice the one in the gullet may not be required if the slope down timing and skill in protecting the edge with the filler wire is perfected.

The torch is held more upright than the oxy-acetylene torch and very close to the weld pool. This angle is between 75 and 85 degrees as shown in Fig.105. There should be no weaving movement sideways, the torch being passed over the join in as straight a line as possible and the resulting weld bead should be no wider than 3-4mm.

Fig.105.



When the weld is complete one clamping plate should be slightly released *immediately* to allow the blade to contract on cooling and expand when re-heated for the heat treatment. The other plate should also be slackened as soon as convenient.

Heat Treatment of the Weld:
I am not a metallurgist and know very little about the subject but for those sawdoctors who perhaps know even less I would like to try to explain in simple terms what I understand about the heat treatment of bandsaw and similar carbon tool steels without using technical terms such as Ferrite, Austenite etc.

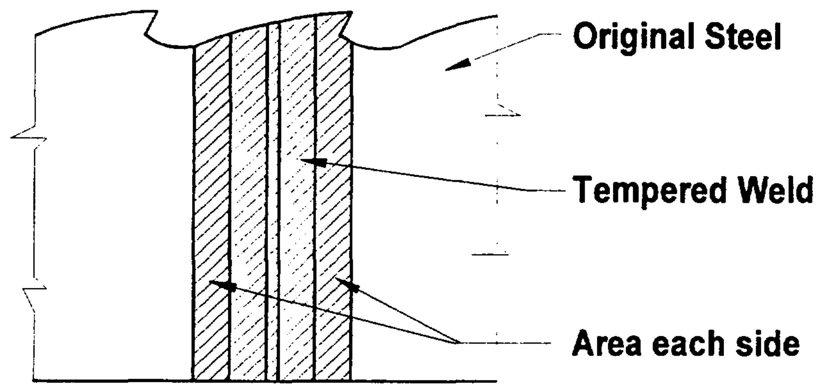
When we raise the temperature of steel we change its structure and when we get it so hot that we melt it for welding we have gone way past what is known as the upper critical point (u.c.p.) which is about bright red and having gone beyond this point, on cooling the steel will harden. If we want to fully harden a steel to its maximum we would *QUENCH* it, i.e. cool it quickly using water. For slightly less hard a result we could cool it slightly slower by quenching it in oil. So when we say that our steel is air hardening it has to cool fairly quickly and even then would not be as hard as if we quenched it in oil or water but still far too hard and brittle to bend without breaking.

So to harden steel we get it red hot and quench it.
A piece of hardened bandsaw or tool steel would be so brittle that it would break very easily and like a carpenters wood chisel or an engineers cold chisel some of the hardness has to be removed to increase its toughness and make it useable. This is called *TEMPERING* and is achieved by letting out some of the hardness by re-heating to various temperatures *below* the u.c.p.. The higher the temperature the more hardness we release and the softer and tougher will be the resulting steel.

To fully *SOFTEN* a tool steel we again have to heat it above the u.c.p. (get it red hot) but this time cool it as *SLOWLY* as possible. One practical way, say when an engineer is making a tool, is to heat the steel in a furnace and then switch off and leave the steel in the furnace over night to cool down really slowly. This is called *ANNEALING*.

So we have Hardening, Tempering and Annealing.
When we heat treat a welded join we are trying to get the steel back to its original tempered state or as near as is possible, but unfortunately there are always two strips each side of the welded area that are neither as the original steel nor as the treated weld area. See Fig.106.

FIG.106.



To overcome this we would need a very big furnace to put the whole blade in for heat treatment and as this is not possible our heat treatment is never perfect and is always a compromise.

Two methods recommended by metallurgists, although different, seem to be successful the first I covered in Part 2 and so I will cover the other this time.

The following method is different than that suggested when we covered oxy-acetylene welding in that it does not first harden the weld and so is in some ways safer because when we harden even with just a blower we risk cracking the weld. This second method can also be used for oxy-acetylene welds so you will have a choice to see which works best for you.

For this heat treatment the welding bench should be in a dark corner of the workshop to enable us to see the dull red of the hot steel not visible in good light. This means having a spotlight over the welding bench for the welding but which can be switched off for the heat treatment process.

As soon as the welding is complete and both clamps have been slackened slightly, the whole weld is re-heated using a gas/air torch or an oxy-acetylene torch to a very dull red only visible in poor light. This dull red temperature must be maintained for a full minute, not guessed but timed. The torch is raised slightly and the dull red allowed to just turn black but still keeping the weld very hot for another timed minute. The torch is raised again for a third time this time only the very end of the flame touching the weld and again maintained for another full minute.

This Time and Temperature is very important, the higher the temperature the shorter the time needed and the lower the temperature the longer the time needed. To be safe always give longer than a shorter time but if you experiment and find a satisfactory system time it accurately and keep to it.

This slow cooling is a bit like annealing but without first heating to above the u.c.p. after the weld has cooled. This process is called *NORMALISING* and will leave the welded area softer than the original steel but at least it will be strong with the only possible problem being that it may loose the tension around the weld sooner than in the rest of the blade.

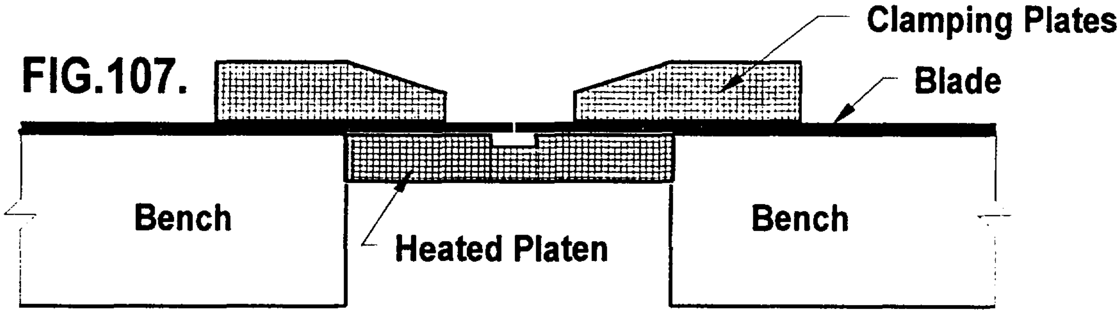
Equipment Required:
(1) T.I.G. welding unit 150 Amp capacity or bigger.
(2) Small Supply of Tungsten electrodes Thorium grade 1.2mm diameter.
(3) Coil of M.I.G. welding wire 1.2mm diameter 0.2% carbon.
(4)Welding clamp with small gap between the clamping plates 25-30mm complete with copper chills.
(5) Electric Arc welding mask with the lightest but safe shade of lenses.
(6) Spare clear protection lenses for the above mask.
(7) Gas torch for heat treatment.
(8) iscellaneous tools including files, abrasive cloth and engineers feeler gauges.
(9) One or two 100mm or 110mm small angle grinders with supply of 30 grit grinding discs, rubber backing disc with 60 grit or finer paper abrasive discs for grinding and polishing the weld.

Manual Inert Gas (M.I.G.) Welding:
As we have already stated the M.I.G. welding system uses the filler wire as the electrode and as it is melted off the wire is fed into the weld pool at a controlled speed which can be varied to increase or decrease the size of the weld bead in conjunction with a choice of various thicknesses of filler wire.

This automatic control of the weld bead by the machine has led to this system rather than T.I.G. being used in the design of fully automatic and semi-automatic machines for wide bandsaw welding. In the fully automatic machine the welding torch is passed over the join on a straight guide rail again in a controlled speed which can be varied to suit the welding. The semi-automatic machines do not have this but the torch is hand held and its speed over the weld is controlled by the operator. Also I can see no reason why the M.I.G. equipment should not be used with a welding clamp constructed on the lines previously described for oxy-acetylene welding.

With the commercially made clamps two other features have been added, these are; first a long table fitted with toggle clamps so that the back edge of the blade can be positioned accurately against a fence or set of stops making it easy to set the blade in the clamp straight before the clamping plates are tightened. The other feature is a system of pre-heating the blade to prevent shrinkage and cracking on completion of the welding. This is achieved with either a heated grooved plate on which the welding is done *OR* with a gas pipe with fine holes in it placed under the weld to shield the underside from the air and at the same time pre-heat the blade and maintain the heat again to prevent shrinkage and cracking. The set up for this is shown in Fig.107.

FIG.107.



This has also led to the use of the same heat to anneal the weld on completion so that a separate gas torch for this purpose is not needed.

There is very little difference in the process of welding a join using M.I.G. to using T.I.G. in fact it is the same if using an ordinary welding clamp. The only difference being if the equipment has the pre-heating facility then this precedes the welding. A temperature of 350-400°C is recommended which will turn the blade light grey colour and will be seen after straw, purple and blue colours have been reached in that sequence.

Annealing of the weld:
On completion of the welding the heat is maintained for about five minutes so that the weld never cools below the pre-heat temperature. The clamps can be removed and the weld allowed to cool slowly on the welding bench.

Final Comments:
Welds made by the T.I.G. and M.I.G. methods are far superior to those made by oxy-acetylene equipment and not needing any forging to give good strength removes most of the distortion that is attributed to forging. Cracks repaired with T.I.G. and M.I.G. generally need only one short roll under the weld to correct the tension whereas oxy-acetylene repaired cracks often pull the back edge out needing extensive rolling to correct, T.I.G. and M.I.G. repairs generally leave the back straight.

Once you have found a satisfactory system it is as well to write it down, especially machine settings which should not change. When problems arise with the welding as they do, check the machine settings then look for operator errors. I found that the most common fault was the earth connection between the blade through the welding bench, if this is not good the arc will not function correctly and the welding will suffer.

CHAPTER 6

Levelling and Tensioning of Wide Bandsaw Blades:

Introduction:
Levelling and tensioning of wide bandsaw blades is perhaps the most skilled part of maintaining these blades and the most difficult to learn to do correctly. The reason for the difficulty in learning the skills is the fact that unlike other operations where you can see what is happening, for example when sharpening teeth, with levelling and tensioning you cannot see any difference in the appearance of the blade after hammering or rolling, at least not until we hold the blade in a special way and test for results using special gauges.

Tensioning:
A wide bandsaw blade will not cut straight unless the toothed cutting edge is stretched tight between the top and bottom pulleys. During cutting the tooth edge becomes hot and expands becoming longer than the rest of the blade and in consequence no longer tight and so will not cut straight. To overcome this the middle and back parts are pre-stretched so that when cutting and hot the whole blade is equally tight across its width and so should cut straight if all other criteria are correct. The process is not called stretching but *TENSIONING* because the stretching of the middle of the blade puts the back and front edges under *TENSION,* i.e. they are being pulled by the longer middle portion of the blade. The tension then is not where we roll to do the stretching but in the unrolled edges which are left their original length.

Levelling:
For various reasons blades will acquire lumps and ridges which will cause the blade to knock and run noisily as the lumps hit the blade guides. More harmful than the noise is that the blade may overheat at these places causing unwanted expansion. The lumps and ridges have to be removed by hammering or rolling and this process is called *LEVELLING.* The lumps or ridges may be caused by dirty pulleys, slivers of wood jamming in the guides or re-saw bench tops or even by incorrect hammering or rolling.

Terms used:
Various other special terms have evolved which the sawdoctors uses the meaning of which are as follows:

Straight Back: When the back edge of the blade is fitted to a straight edge.

Crown Back: When the back edge of the blade is fitted to a concaved back gauge.

Loose: Part of the blade which falls away from the tension gauge when the rest of the blade fits the gauge.

Tight: Part of the blade which touches the tension gauge and holds off the rest of the blade which might otherwise fit the gauge.

Dished: Part of the blade which has too much tension and has been pushed through to one side of the blade and stays there so that it shows convexed on one side and concaved on the other. The same part of the blade will not lie flat on the tensioning bench.

Equipment Required:

1) Stretcher rolling machine.
2) Tensioning bench including levelling plate and anvil.
3) Back gauges.
4) Short straight edges.
5) Working tension gauges.
6) Master tension gauges.
7) A set of special hammers.

Stretcher Rolls:
This MUST be a good quality machine and be maintained in perfect condition otherwise if worn will often cause serious problems with the blades tensioned by rolling in faults rather than correcting them. Main points to look for when buying and maintaining are:

(1) Both top and bottom rollers should be driven. On some old machines only the bottom roller was driven and the top rollers could slip causing 'dishing.'

(2) The diameter and shape of both rollers must be exactly alike with no side movement of their position on their shafts. Any difference in shape will cause dishing and any movement so that the rollers are not exactly over each other could cause twists in the blades.

(3) The curved surfaces of the rollers will wear flat in the centre and this will result in having to apply more pressure or a greater number of rolls to achieve the desired amount of tension. The slight flattening of the rollers is difficult to see or measure and may only gradually become apparent when the sawdoctor realises that he is having to work harder to do the work. Re-grinding to a radius of a circle usually between 200mm and 250mm is best carried out by the machine manufacturer so a spare pair of rollers is a good investment so that the machine is not idle whilst the rollers are sent away for grinding. See Fig.108.

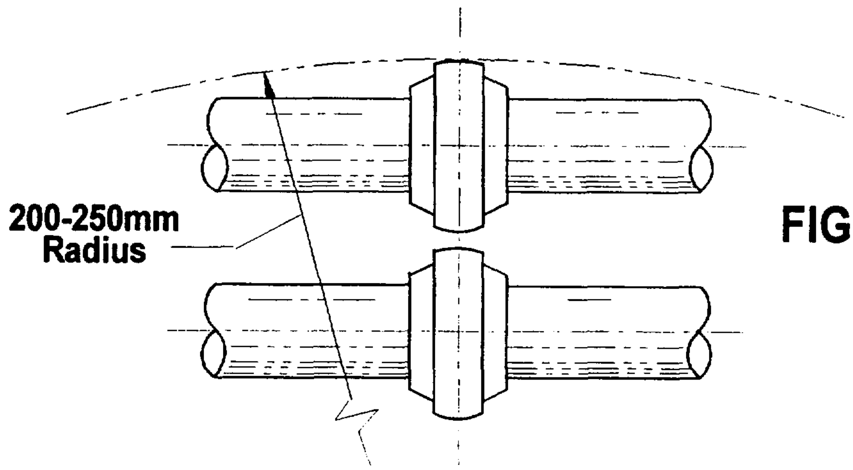


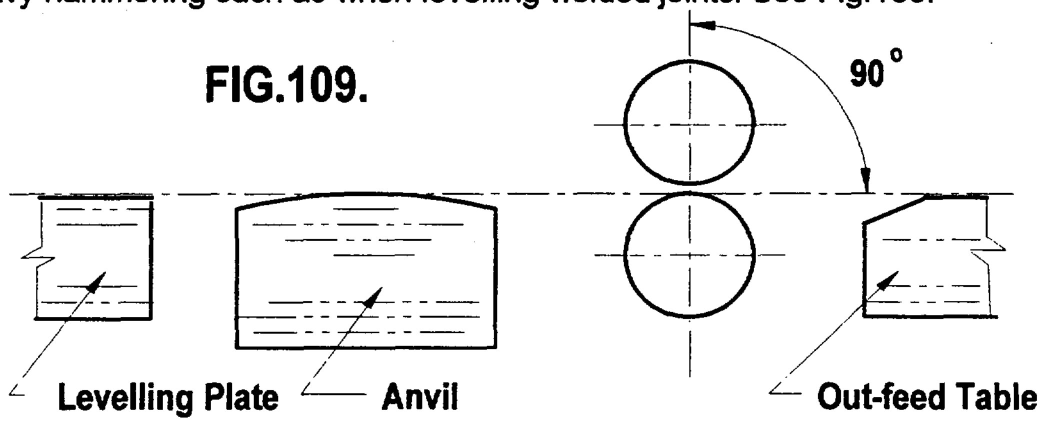
FIG.108.

(4) For blades up to 150mm wide a machine with fixed rollers is satisfactory for it is easy to move the blade in and out to roll near the back and front edges but for wider heavier blades a machine that has rollers which can be moved in and out across the blades which stay in one position on the bench is much better and even essential for blades above 200mm wide.

(5) Some machines have a facility to angle the top roller to take out twists from blades this is useful but not essential.

Tensioning Bench:
The bench must have a perfectly flat working surface in which a steel levelling plate is fitted. The levelling plate has a machine ground surface on which the work of levelling is done. i.e. the hammering and testing for lumps. The old cast-steel chilled-faced (hardened) levelling plates which would withstand light hammering for many years without wear I believe are no longer made, instead good quality rolled mild steel plates which have two working surfaces are now common on which light hammering is possible and which can be re-ground after both sides have been used and become worn. A separate anvil can be incorporated into the bench on which to do all the heavy hammering such as when levelling welded joints. See Fig.109.

FIG.109.



The construction of the bench itself may be of wood or preferably of steel with sets of wooden or now plastic rollers to guide the blades around as they pass through the stretcher rolls. The positioning and alignment of the guide rollers is most important and is often not satisfactory so that the sawdoctor has to

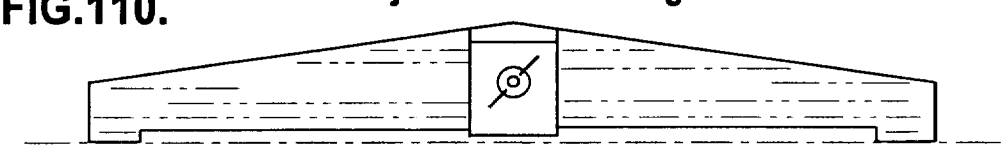
FIGHT the rollers to get the blades to pass through the stretcher rolls in a straight line. To achieve this the brackets which hold the rollers should be adjustable so that they can be aligned square off the back of the bench or if necessary at a slight angle to guide the blades through the stretcher rolls against its guide with the minimum of effort by the sawdoctor. A good test is to run a blade through without touching it.

Blades have to be worked on on both sides and although the smaller blades can be turned inside out to achieve this the tensioning bench should be designed so that they have two sets of rollers one above and one below the bench to enable the work to be carried out on both sides without turning the blades.

Stretcher Rolls/Bench Alignment:
Although the smooth passing of the blades around the bench is important from the ease of operation and efficiency point of view. Much more important is the way the blades *MUST* pass over the bench top and through the stretcher rolls in a *STRAIGHT LINE.* The levelling plate bottom roller and out-feed table must be in line, the anvil should be 1mm lower to avoid the teeth catching it. See Fig.109. If the bottom roller of the stretcher is too high in relation to the bench top then all the blades will become dished *UPWARDS,* and if the bottom roller is too low then eventually all the blades will become dished *DOWNWARDS* i.e. round on the underside.

Back Gauges:
Part of the tensioning process is to either keep the back edges of the blades *STRAIGHT* or *CONVEXED* (i.e. slightly round) and this has to be done very accurately otherwise the blades will oscillate on the machine pulleys and in and out of the timber during use. To test the shape of the back edges special gauges are used and may be of three different designs. The first is usually 60mmx3mm steel about 1500mm long with one edge ground straight and the other ground concaved 0.4mm or 0.8. in its length. The next type is usually about 1000mm long and has three points which touch the blade, one each end and one in the middle. The three can be in line for straight backed blades or the middle point slightly lower to give round or *CROWNED* backs to the blades. See Fig.110. These can be made with the centre point adjustable or not. It is quite easy to make your own out of a length of bandsaw steel. The third type usually about 1500mm long uses three points of contact but the centre point is in the form of a dial gauge which is extremely accurate showing up the slightest error. All three types will give good results if used correctly.

FIG.110. **Adjustable Back Gauge**



Short Straight Edges:
Various length straight edges are required to test for lumps and can be used to test for tension. The lengths will vary from just under the width of the widest blade used to about 60mm long for locating small lumps.

Tension gauges:
Various tension gauges will be required the length of which should be approximately the same width as the blades to be tensioned with one edge straight and the other convexed to suitable diameters of a circle. These are known as C & S gauges when ordering and are working gauges which will need re-grinding from time to time to ensure that they remain accurate. If gauges wear out of shape, as they will, and you continue to use them you will be rolling faults into the blades instead of correcting them. The usual range of sizes available are 8 to 20 metres diameter (27 to 60 feet.) diameter.

Master Tension Gauges:
If you do not have the equipment to grind your own tension gauges, it is very useful to have master gauges to test your working gauges with to see when they are worn and need re-grinding. They can also be used as a pattern to file the gauges to shape when worn although grinding on a special machine or, as I used to do, on a tool and cutter grinder using my own home-made jig is far more accurate and quicker. Master gauges or C & C gauges as they are called when placing an order, have both edges curved, one concaved and one convexed. They can be any length providing that it is at least as long as your longest working gauge and of course ground to the same diameter of a circle as the gauge being tested. They are also very useful for testing the shape of the bandsaw pulleys when re-grinding or just to give an idea what tension gauge to use on blades for that machine.

Hammers:
I have visited dozens of sawmills all over the world and I have very rarely come across hammers ground to the correct shape. If they are ground the wrong shape they will either damage the surface of the blades if too sharp a curve or not expand the blades where necessary if too flat. We will return to their shapes later.

There are three hammers in a set, one called *DOG HEAD,* one *CROSS-FACE,* and one *TWIST-FACE.* The size of the hammers vary considerably and go by weight, the heavier hammers are used for thick blades and the lighter ones for thin blades. In choosing hammers the practical test should be to see if the hammer will do the work with the minimum of effort by the user. i.e. they should not be too heavy to work with nor should you need to strike the blades hard to move the metal, in other words the weight of the hammer should do the work. A guide to weight would be to use 0.8 kg. for each 1mm thickness of blade. Example: For 17gauge blades which are 1.47mm thick weight of hammer = 1.47 x 0.8 = 1.18kg. Say 1.25kg.

The complete set of hammers is not always necessary, in fact most if not all of the work on bandsaw blades can be done with a fourth type of hammer called a *COMBINATION.* This combines the face of the Dog Head on one end with the end of a cross-face which is at right-angles to the shaft at the other.

The Dog Head Hammer:
This hammer is used for tensioning areas of the blade which are too small for the stretcher rolls, for example around a brazed or welded joint or weld repaired crack. It can be used for levelling but since most lumps are usually in the form of ridges and not round spots the cross-face hammer is more effective for levelling.

Cross Face Hammer:
This is used for levelling small lumps and short ridges using which-ever face corresponds to the direction of the ridge or shape of the lump.

Twist-Face Hammer:
This hammer has its faces at 45 degrees to the shaft and was originally designed to be used to remove twists from bandsaw blades but methods of rolling out twists have been developed which are far superior to having to hammer all around the blade, *ON BOTH SIDES,* to remove a twist with a hammer. This development has more or less made this hammer obsolete.

The Shape of Hammer Faces:
The most important part of the hammer is its face which must be ground to a shape which will not mark the blade with sharp indents. The shape of the dog-head hammer's face should be part of a *SPHERE* so that it is just like a ball falling on a surface. In other words no-matter at what angle the blade is struck with the hammer the shape of the indent made will be the same round shape, but if correctly ground almost invisible.

Cross & Twist-Face Hammers:
The faces of these hammers are ground to spread the steel more in one direction than the other and could be thought of as being shaped as part of a car tyre i.e. a large circle being the diameter of the tyre and a smaller circle being the diameter across the width of the tread. The shape of the indent made with these hammer faces is oval or elliptical and again difficult to see with no sharp indents when ground correctly.

The actual radii of circles to which the faces are ground are not critical i.e. it does not matter if it is say 50 or 60mm across the cross-face but it *MUST* be a part of a circle and not any other shape. To ensure that the shapes are correct a special gauge should be made as shown in Fig.111. and suitable hammer shapes are shown in Fig.112.

FIG.111.

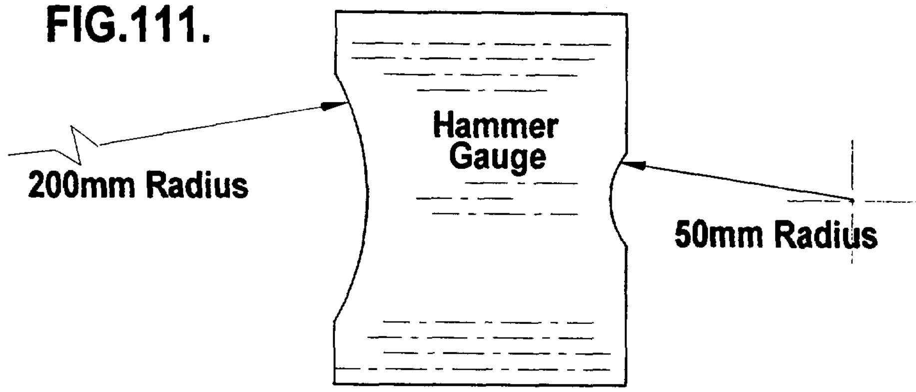
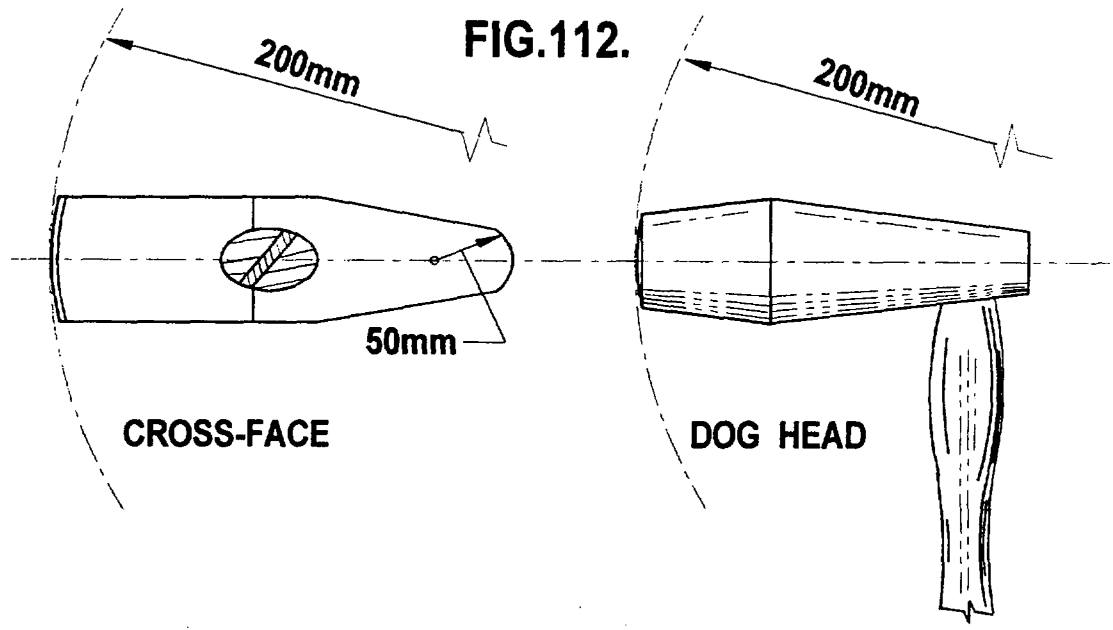


FIG.112.

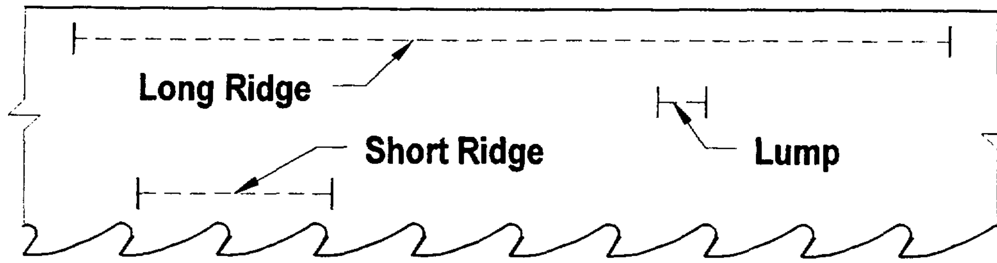


Theory of Levelling:
In general levelling should be done before tensioning because with lumps in a blade accurate testing for tension is impossible. However sometimes a blade may be in such a bad condition that it will not lie flat on the levelling plate and may need rolling first to get the tension roughly right so that the blade will lie flat and then can be tested for lumps and levelled.

Unlike tensioning where the aim is to stretch the steel of the blade, levelling is to push or knock lumps or ridges down *WITHOUT* stretching the steel, or doing so as little as possible, so gentle hammering is what is required not heavy blows. If rolling out ridges, minimum pressure should be applied just enough to move the blade through the stretcher. For very bad lumps that need hammering down a piece of leather placed underneath the blade will allow the lump to be pushed down more easily and cushion the blows so that no or very little stretching takes place.

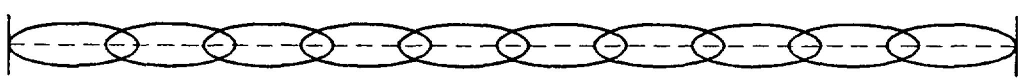
Lumps and ridges must be accurately marked before hammering or rolling otherwise any hammering or rolling outside the faults will only cause a lump or ridge on the other side of the blade at these places. The blade should be marked as shown in Fig.113. usually using chalk. This does not mean that the expert cannot find a small lump and without taking his eyes off the spot hammer it successfully without marking it, they have to do the work the quickest and easiest way possible, but it must be realised that to hammer in the wrong place only makes more work and there is no short-cut to accuracy.

FIG.113.



Hammering a ridge which is too short to roll must be done by commencing to hammer at one end and with overlapping blows continue until the end of the ridge is reached then stop and test. *DO NOT* hammer haphazardly anywhere along the ridge going over it several times and perhaps hitting the same place more than once and missing some places altogether. See Fig.114.

FIG.114.



Over-lapping Hammer Blows

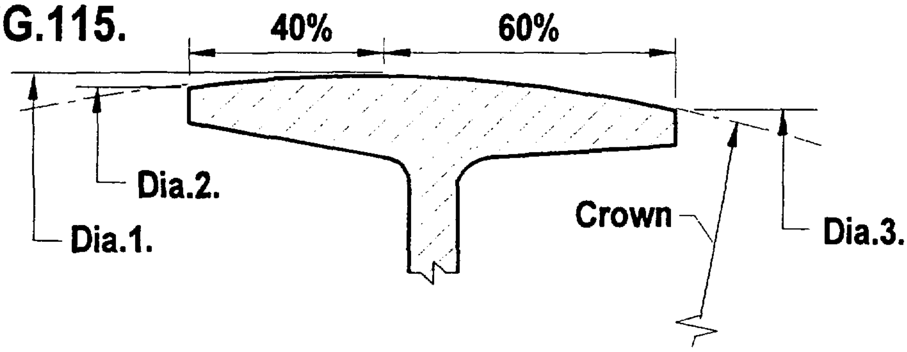
Hammering of any kind should be kept to the absolute *MINIMUM* and rolling out ridges is to be preferred. The method works like this; the blade is lifted up, by hand or by mechanical means, and the fact that the top roller makes more contact with the now curved blade pushes the ridges down. Even short 100mm long ridges can be rolled out on lighter re-saw blades which can be lifted and lowered quickly by hand. On heavier blades that need lifting by mechanical means, usually a lever or hydraulic operated roller placed in front or just behind the stretcher rolls, the speed at which they can be raised and lowered is slower and so the length of ridges rolled out will be longer.

Theory of Tensioning:
This is a practical skill which can only be learned by hours of *CONCENTRATED* practice. I emphasise 'concentrated' because as soon as you feel tired or just fed-up with the work, especially if it is not going right, then you should take a break and do some other work for awhile. It is not a skill which can be learned from a book but some basic examples which can be referred to will help.

First a little essential theory about the shape of machine pulleys and the gauges we use to measure the amount of tension we are putting into a blade.

Nearly all pulleys on which the blades run are ground slightly convexed or *CROWNED.* This follows the knowledge that any flat belt will stay on a crowned pulley much better than on a flat one and a wide bandsaw blade is like a flat belt. The amount of crown is very small and in theory is part of a true circle with a given diameter or radius. In practice however, after the initial grinding by the manufacturer, the re-grinding will more often than not be carried out in the sawmill to an approximate shape using circumference measurements at the front and back edges plus a third just forward of the middle. See Dia.1, 2, and 3. Fig.115. Concaved master gauges may or may not be used to test the shape in conjunction with the circumference measurements.

FIG.115.



The amount that the high point is off-centre allows for (a) the overhang of the teeth and (b) the reduction in width of the blade from sharpening so that on average the middle of the blade is running on the highest point of the pulley. It will usually be about 40% from the front edge as shown.

In Fig.116. we see in theory a blade without any tension on a crowned pulley. This would be tight in the middle only and would have difficulty staying on the pulleys running idle and would certainly not stay on cutting timber.

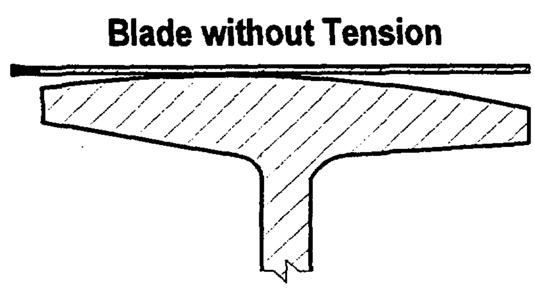
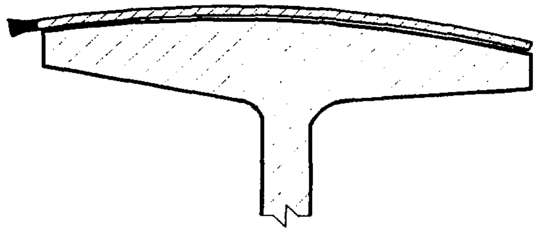


FIG.116.

In Fig.117. we see how the blade would fit if tensioned to the same diameter as the pulley. This would run satisfactorily running idle but as soon as the tooth edge became hot with cutting and so *longer,* the blade would not grip on the front edge and would be pushed back onto the pulleys damaging both the teeth and the surface of the pulley.

Blade with some Tension

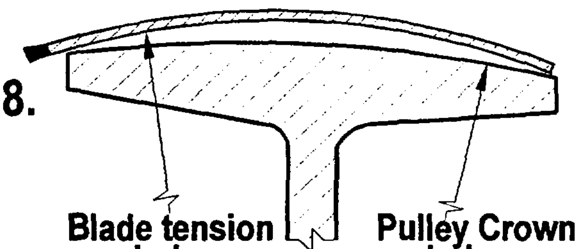
FIG.117.



In Fig.118. we see how the blade should be tensioned to a *SMALLER* diameter tension circle which will allow for both the shape of the pulley and a little extra for the expansion caused by heat generated when the blade is cutting. Then when at cutting temperature the blade should fit the pulley as in Fig.117. so that the full width of the blade is taking its equal share of the strain.

Blade with correct Tension

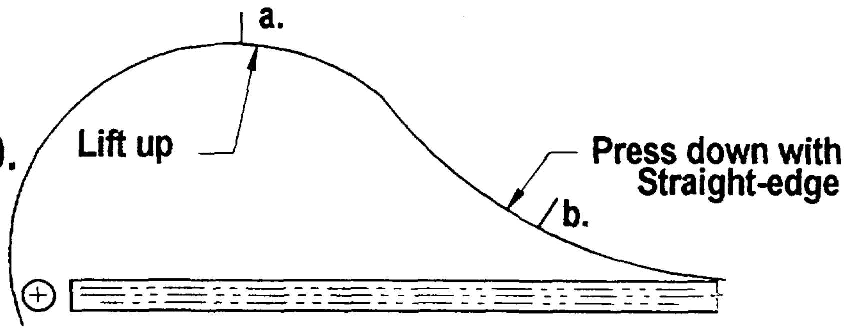
FIG.118.



The correct reduction in tension gauge diameter to give the extra amount of tension can only be found by trials because cutting conditions can vary considerably. For example in the kind of timber being cut i.e. hard, soft, dry or wet. Then the different blade and feed speeds used and whether or not water is used to cool and lubricate the blade. All these can affect the amount of heat generated in the tooth edge and the resulting expansion. What can be stated is that the minimum of tension should be the aim for if the blade is taking too much of the strain on its edges then cracks in these edges are more likely to occur. What I would suggest in practice would be to find the curvature of the pulley using master tension gauges then start tensioning the blades using a tension gauge of 10 % smaller in diameter, for example if the pulleys were ground to 15 m then a 13.5 m could be used to start with, increasing or decreasing the tension after trials on the machine.

Measuring Tension:
When a blade has been stretched in the middle to put tension into its edges the middle will be longer than the two edges. This is perhaps difficult to believe but if we lift a tensioned blade off the tensioning bench as shown in Fig.119. at (a) and place a straight edge on top across its width the longer centre will spring up and be higher and show up as in Fig.120.

FIG.119.



If we do the opposite i.e. push the raised blade *DOWN* with the straight edge as at Fig.119. (b) the longer middle will spring down to the underside which is now the round side and the straight-edge would show up as in Fig.121.

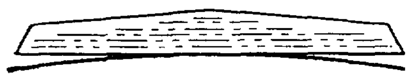


FIG.120.

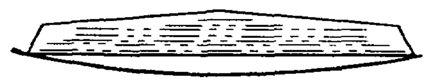


FIG.121.

If the gap underneath the straight edge is small then the tension in the edges will be small. If the gap increases, as it would if we roll and stretch the middle some more, then the tension is increased. Small gap, *small tension.* Big gap, *Big Tension.*

Many sawdoctors only use straight edges to test for tension, guessing when the amount of gap is correct and accurate results can be achieved if the correct technique is used, however an accurate tension gauge will not only test for the right amount of gap, but also that the shape is correct all across the width of the blade which should be a gentle curve without flat places.

The tension gauge must be pressed down onto the blade with as much pressure as can be applied by hand, this is to simulate as near as possible the pressure of the pulley against the blade. A gentle pressure will not show up small tensioning faults such as tight places which need more rolling. The gauge must also be held at 90 degrees to the surface of the blade otherwise false readings will be obtained if the gauge is not perfectly flat. Finally to ensure that all the tiny faults can be easily seen a light is usually fitted to the tensioning roller so that gaps under the gauge are lit up clearly.

Back Edge of the Blade:
Since it is only the front tooth edge, except on double cut blades, which gets hot and expands during cutting and becomes longer it will pull the back edge *HOLLOW.* We cannot test this when the blade is running we just have to accept it as being so. This means that the back edge is tighter on the pulleys than the front edge which is doing the work and is opposite to what we need. Because of this the back edge must *NEVER* be allowed to become hollow when we are tensioning and blades must either be perfectly straight or very slightly crowned i.e. fitted to a concaved back gauge giving a curve of between 0.5 mm and 1mm in about 1.5metres. (1/32" or 1/64" in 5 feet).

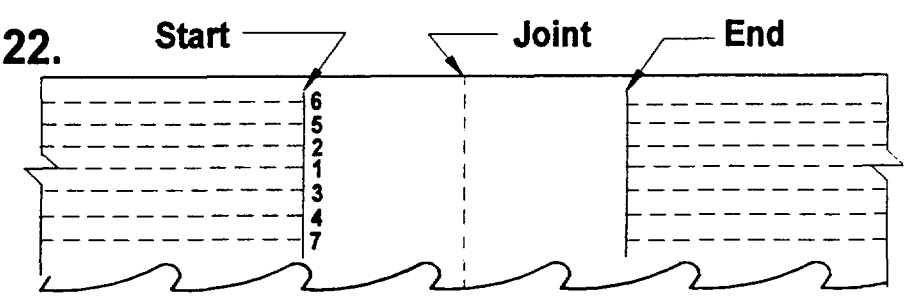
When to Tension:
All new blades need tensioning either by the manufacturer or in the sawmill and they are the easiest to work on since they should be free of serious faults. Correctly tensioned blades should not lose their tension quickly, even so they should be checked *EVERY TIME* they come in for sharpening for if a fault is missed it could lead to cracks to be repaired which is much more work than a routine tension check and maybe a couple of quick rolls around the blade.

Tensioning Examples:
The example drawings are of a re-saw blade of about 150mm wide. Wider and narrower blades would need more and less number of rolls to achieve similar results.

Let us start with tensioning a new blade. First mark about 100mm each side of the join which normally being softer needs treating separately. Rolls are then made all the way round the blade from chalk mark to chalk mark without rolling the 200mm at the join. Having said that, when experienced, some rolls can continue across welded joints although not across brazed joints. This is to put some tension in the weld but final tensioning of this part of the blade is done separately.

Rolls are placed evenly across the blade at about 10mm to 20mm (1/2" to 3/4") apart. Usually the stretcher rolls will either have the bar on which the blade guide slides marked in equal divisions or on machines where the rollers move mechanically across the blade, one or two turns of the wheel will usually move a convenient distance and is perfect for tensioning new blades. Commence in the middle of the blade working outwards towards the edges stopping 10mm to 20mm from the edge. These un-rolled outer strips will become the short tensioned edges which is the object of the exercise. See Fig.122.

FIG.122.



The *FULL PRESSURE* of each roll *MUST* start and end on the lines. If the pressure is applied gradually taking say 300mm of rolled blade before the full pressure is reached then this part of the blade will have uneven tension in it which will be difficult to correct afterwards. In other words when pulling on the pressure with handle or wheel, it must be done quickly.

After completing one series of rolls across the blade, test for tension and if not enough make a second series which should be in-between the first series of rolls. Several series of lighter rolls are better than one or two very heavy series of rolls, the tension will be more even and the steel less stressed.

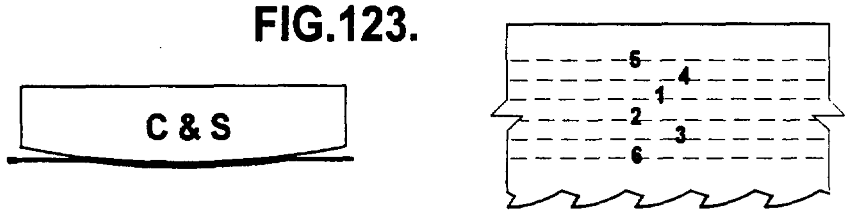
I would suggest that only enough pressure is applied so that at least two and even four or more series of rolls are required to reach full tension. This is because even though in theory the tension rollers should put the same amount of tension in both sides of the blade in practice doing a lot of work on one side can result in the blade dishing to one side. To make sure this does not happen, half of the tensioning should be done with the blade above the bench and half below the bench to even out any slight differences in the rollers or bench alignment.

Tensioning Used Blades:
If the sawyers and machine maintenance staff do their work well and blades are changed as soon as they show signs of blunting, i.e. as soon as they start to run back on the pulleys from their correct position, blades should not suffer much damage and maintaining the tension should not be much more than adding a few rolls right around the blade and a spot of levelling and tensioning around the join. If on the other hand pulleys are dirty, guides are out of line and blades are run too long, then the blades will develop ridges and lumps and tension will be pulled out causing hours of work to correct. This is because the blade can no-longer be rolled all the way around but faults will have to be corrected in individual patches which is considerably more work.

Individual tension faults will have to be marked in the same way as lumps and ridges as shown in Fig.113. starting at the join and working around until the entire blade has been corrected. Now let us look at some tensioning faults which may or may not go all the way around the blade.

Fig.123. shows a blade with insufficient tension, i.e. the edges are still 'loose' and falling away from the gauge. To correct roll as shown.

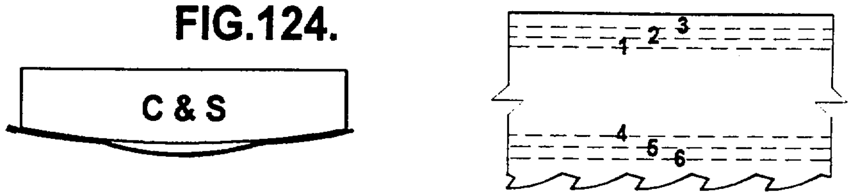
FIG.123.



Insufficient Tension

Fig.124. shows a blade 'loose' in the middle third but fitting the gauge on the outer thirds. Roll to remove the excess tension as shown.

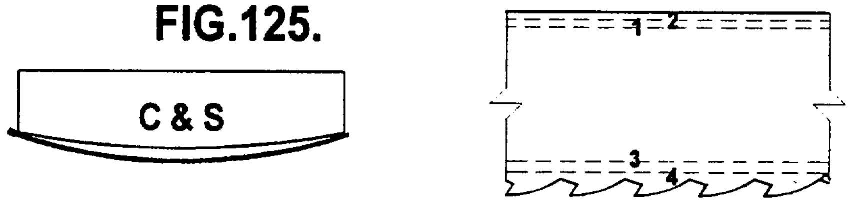
FIG.124.



'Loose' in the middle

Fig.125. shows a blade with just too much tension i.e. it would fit a smaller diameter gauge. This is a fault to avoid because we have to roll right at the two edges to correct and if the pressure is too high we end up as in Fig.124. again.

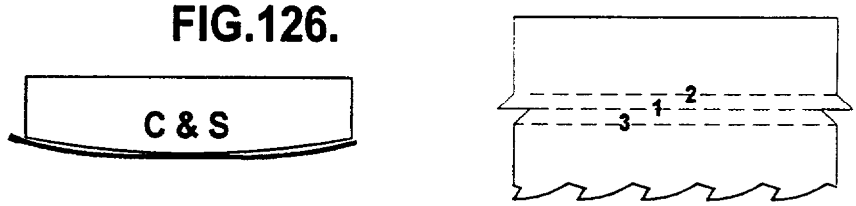
FIG.125.



Too much Tension

Fig.126. shows a blade which is 'tight' in the middle and will need rolling as shown.

FIG.126.



'Tight' in the middle

Twisted Blades:

During the working period bandsaw blades run around the machine several thousand times and if anything goes wrong to throw the blade out of line the blade may become twisted in seconds. Even guide blocks slightly out of parallel with the pulleys or tensioning bench not perfectly level with the stretcher rolls can slowly twist a blade over a period of time and this may not be noticed until you realise that the blades will not stand upright on the workshop floor. A severely twisted blade will not stand up at all and will fall over whereas slightly twisted blades will lean in opposite directions when viewed from one end.

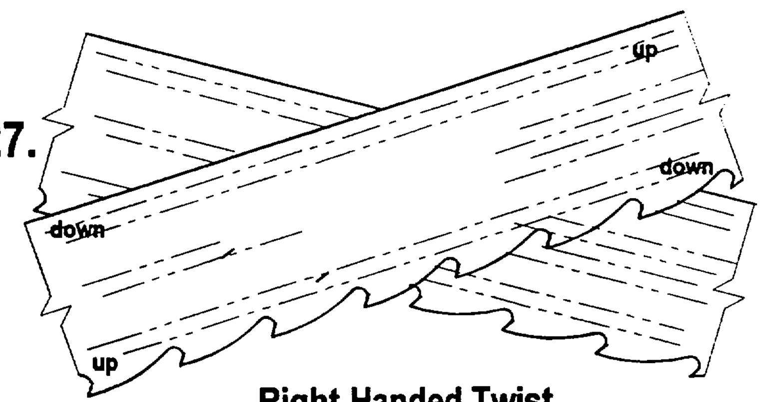
Traditionally twists were removed with hundreds of hammer blows placed diagonally on each side of the blade using the special twist-face hammer or by two people stood about a metre apart twisting the blade in the opposite direction to the twist with a pair of wooden levers like small cricket bats with slots for the blade the middle. I have tried both methods and although they do work, they are very time consuming and as I have said before too much hammering should be avoided and looked upon as poor sawdoctoring.

A much better system is to devise some way to pass the blade through the stretcher rolls *TWISTED* in the opposite direction and since it is better to spend more time on trying to avoid blades twisting than correcting the fault a simple method is all that is needed. A roller which can be angled either way just in front or behind the stretcher rolls will do the job and for the occasional twist and when I have been in a sawmill helping them with problems I have simply used the end of a broom handle to lever the blade up on one side whilst someone passes the blade through the rolls using just enough pressure to propel the blade. The rolls should start on one side of the blade and move across about 20mm apart and, like tensioning, if more rolling is required then roll in-between the first series of rolls.

Perhaps the most difficult thing about twists is to decide in which direction is the twist and more important which way to twist the blade to put it right. What I would suggest is to learn to recognise what is termed a Right-Hand twist and a Left-Hand twist then simply make a record of which way you twisted the blades on your bench to correct the fault having once thought it out.

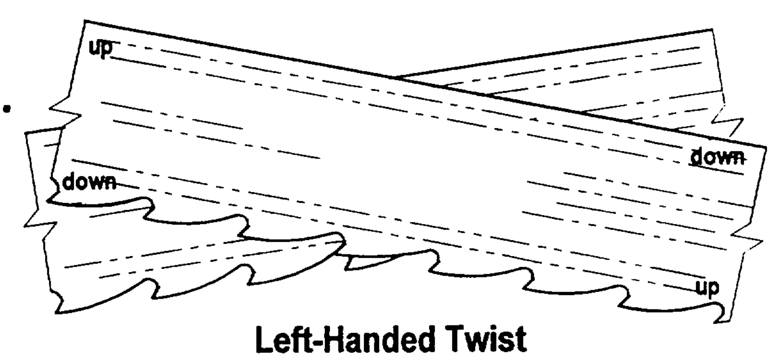
To do this stand the blade on a level part of the workshop floor and put a weight on the top of blade in the middle. Where the blade crosses it will look either like Fig.127. or Fig.128. If you compare the direction of the top half of the blade to a screw thread on a bolt then the twists can be thought of as Right-Handed if it lies in the same direction as a normal right-handed bolt as in Fig.127. or left-handed if in the opposite direction.

FIG.127.



Right-Handed Twist

FIG.128.



Left-Handed Twist

You will find that if you press the top half of the blade where I have marked them *DOWN* the blade will tend to straighten itself and stand more *upright*. This is the way you will have to twist the blade as it comes out of the stretcher rolls i.e. you will force the blade up by some means on the side marked up.

As we have already said all rolling is done with light pressure, we are not tensioning. The number of rolls will depend upon the severity of the twist, but a few rolls can always be added to which is better than over doing the twisting and ending up with the blade twisted in the opposite direction.

Although most twists will run all the way around the blade a severely damaged blade i.e. one that has come off the pulleys during use, may be twisted in one or more places for a certain length. These places will need finding and marking to correct as individual pieces of blade.

In conclusion remember that a twisted blade is a damaged blade and the cause should be found before other blades become twisted.

CHAPTER 7

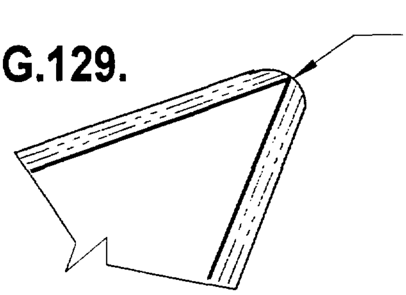
Sharpening, Swaging & Side Dressing of Wide Bandsaw Blades:

Because these two subjects are interrelated in practice we have combined them into one chapter and as in practice we will start with sharpening and deal with swaging and side dressing or shaping later. The terms Side-Dressing and Shaping refer to the same process, the first is the British term and the second is the American.

Sharpening:

The points of the teeth with normal wear if viewed under some form of magnification would appear as shown in Fig.129. and It can be seen from this that the most economical way to restore the sharp cutting edges would be to grind approximately equal amounts off the tops and faces of the teeth.

FIG.129.



In practice to obtain new sharp cutting edges we may be able to grind more off the faces than off the tops and so reduce blade wear by pushing the teeth backwards around the blade instead of down across its width. This should always be our aim but it will depend upon the shape of teeth that we choose to use whether or not this will be possible. Let us look at some of the different shapes and see how they affect the economy of sharpening and the other features which influence our choice.

Tooth Geometry:

Tooth geometry has been fully explained in the first manual on circular saw blades and all that was stated then equally applies to the teeth of wide bandsaw blades. However several factors which apply much more to bandsaw blades than to circular saw blades do have a big influence on the shape of bandsaw blade teeth, these are :-

(a) The ever increasing desire to reduce waste both to increase profits and to preserve our natural resources which in turn has resulted in the use of thinner and thinner blades .

(b) The almost universal use of either swage set or stellite tipped teeth which are always sharpened square on top.

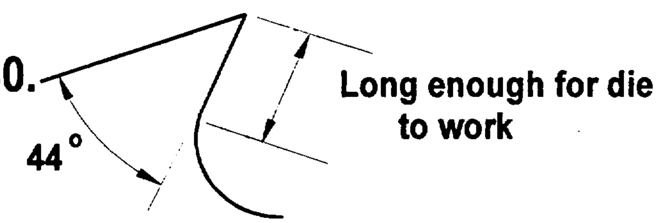
(c) Wide bandsaw blades are not used for crosscutting and so never need to have face bevels to produce a knife like cutting edge.

(d) Although I have seen wide bandsaw blades sharpened by freehand grinding in primitive sawmills, this is rare and normally they will be sharpened on automatic machines.
(e) Bandsaw blades, unlike circular saw blades, are subjected to bending stresses as they bend around the pulleys and straighten between the pulleys.

First let us consider the influence of using thin bandsaw steel, down to 20 gauge (0.9 mm) for resawing. If we use the rule of ten times the blade thickness which is advisable to retain tooth stability the *HEIGHT* of the teeth is very limited usually resulting in a small tooth height in proportion to the pitch.

Swage setting in itself demands two things of the tooth shape, first the sharpness angle has been proven to be best for the swaging process if it is 44 degrees or as near to this as is practical, secondly the straight face of the tooth from the tip to where it starts to curve must be long enough to accommodate the size of the swaging die used. See Fig.130.

FIG.130.



Because bandsaw blades are not often sprung set there is no need for top bevels to prevent the inside edges rubbing to the depth of the tooth bite, this together with the fact that they are not used for crosscutting is the reason why automatic sharpeners specifically designed for wide bandsaw blades are not provided with bevel grinding facilities which are needed to grind top and face bevels on circular saw blades.

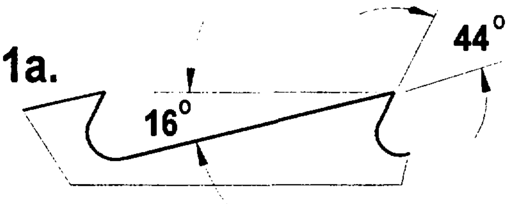
The continual bending and straightening of bandsaw blades is an additional stress which circular saw blades do not have and this must contribute to the problem of gullet cracks which bandsaw blades are prone to. One idea to assist in trying to prevent cracks is to use flat bottomed gullets to spread this bending stress over an area instead of being concentrated at one low point in the gullet. See Fig.131c.

The tooth pitch of bandsaw teeth are mostly standard sizes punched onto the strip steel by the manufacturers and are seldom calculated to give a desired tooth bite at a given feed speed which would be the correct procedure for high efficiency sawing. Standard pitches for resawing are:- 45mm and 50mm and for log conversion 50mm, 55mm, 60mm, and 75mm or their inch equivalents. Generally speaking these pitches coupled with the 10x blade thickness tooth height rule result in teeth which have a ratio of pitch to height in the region of 4 :1 whereas the thicker circular saw blades often have tooth heights which are half the pitch.

The three basic angles which we can use for nearly all wide bandsaw teeth are:- 30 degrees Hook, 44 degrees Sharpness angle and 16 degrees Top clearance angle. These angles coupled with the right tooth shape will cope with most sawing conditions and if changed should only be modified slightly.

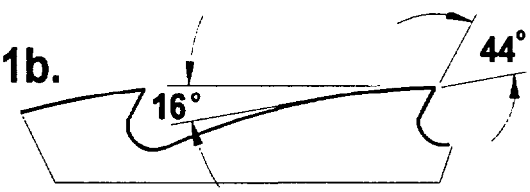
The most economical tooth shape to sharpen is the straight backed tooth as shown in Fig.131a. Almost all the sharpening can be done on the face without loosing the tooth shape. This is a very popular shape for softwood resawing when the minimum gullet capacity which it provides is not a problem.

FIG.131a.



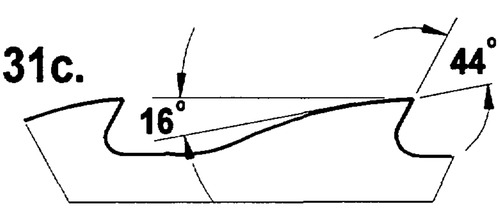
The next most common shape, still based on the same angles, is the round backed tooth the shape of which can vary considerably depending on the depth of gullet and variations in cams and machine settings used. The advantage over the straight backed tooth is the larger gullet capacity but more has to sharpened off the tops of the teeth to maintain their shape. See Fig.131b.

FIG.131b.



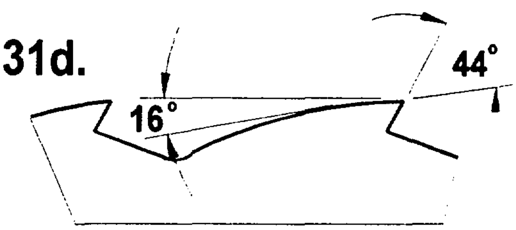
Still using the same angles the next shape is the flat bottomed gullet with straight or round back although a round back gives more control of the angles. This shape can best be achieved by using a special cam or with a normal cam combined with arresting the downward movement of the grinding head using a depth stop as fitted to some machines. See Fig.131c.

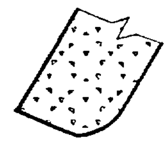
FIG.131c.



Another idea to try to combat the incidence of gullet cracks is to place the lowest point of the gullet as far away from the stressed area around the tooth point as possible. The shape can be achieved by using a wide grinding wheel with a square edge with only a very slight rounding of the corner and an angle on the other side to grind the back portion of the teeth. See Fig.131d. This tooth shape is very rigid and is most suitable for sawing dense timbers. The top clearance angle may be reduced to 12 degrees if necessary to give a stronger profile. The problem with this shape and all shapes with a steep angle to the back is that they are very uneconomical to sharpen needing more grinding off the tops than the faces to maintain the correct tooth shape. This results in losing the width of the blades quicker than when using a more economical tooth shape such as the straight backed tooth shown in Fig.131a.

FIG.131d.





Wheel Shape

The Sharpening Machine:
There are lots of machines to choose from which are capable of sharpening bandsaw teeth some which are comparatively inexpensive but often the main problem with these inexpensive machines is that the moving parts are not protected from the grinding dust and may also be made of poor quality materials resulting in disappointing performance at an early date perhaps within the first year.

On the other hand the machine need not be very sophisticated and there is a lot to be said for the American type machine which is designed to sharpen one to a maximum of three different tooth profiles without any further adjustment at all being possible. The use of extra large cams, easily replaced nylon bushes and simple but very practical design ensures long trouble free service. They are particularly suitable for use in sawmills where perhaps some of the maintenance staff are only semi-skilled as all adjustments are reduced to the minimum.

The following points are worth considering when choosing new machinery:-

(1) All moving parts should be protected from grinding dust and those which are impossible to cover should be easily replaceable.

(2) All blade support stands should be easily adjustable for height with some form of scale to work to for the different blade widths. Centrally connected adjustment systems are expensive but worth considering. Again all parts subjected to wear should be of good quality and easily replaceable.

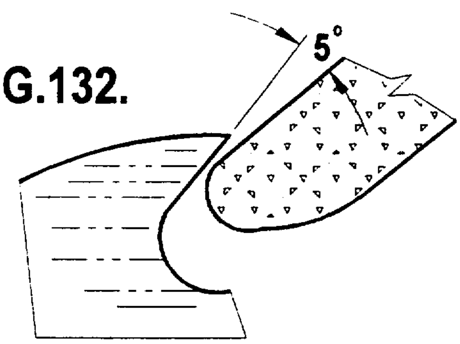
(3) Smooth blade movement is essential to accurate sharpening and to this end all machines should be fitted with rear feed mechanisms to push or pull the blade around. When machines are not fitted with a rear feed there is always a tendency for the tooth to spring back slightly from the position to which it was pushed and the additional strain on the single feed mechanism must be considerable especially on wide heavy blades.

(4) The pawl finger should push the teeth in a *STRAIGHT LINE* with *NO* movement up or down the face of the teeth. To facilitate this the slide on which it runs should be adjustable for level.

(5) The rear blade clamping plate or rollers must be adjustable so that different blade thicknesses can be accurately positioned under the grinding wheel and also to take up wear on fixed hardened steel plates where these are fitted. Some designs do not have this feature but instead arrange for the grinding head itself to be adjustable in or out. Ideally this adjustment should have a scale to work to especially if more than one blade thickness is to be sharpened on the same machine.

(6) All blade sharpening machines should have the grinding head angled a few degrees so that the side of the grinding wheels do not touch the tooth face on the downward travel otherwise the side of the wheel will wear resulting in loss of hook angle and a constant battle to overcome this by dressing the wheel which is a very wasteful process. See Fig.132.

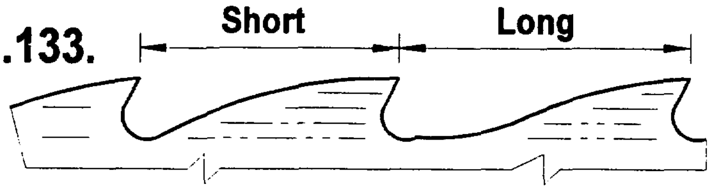
FIG.132.



(7) The facility of being able to fit a second pawl finger although not essential is very useful especially in sawmills where teeth are often damaged by hitting metal hidden in the logs. If a single tooth is damaged to the extent that it cannot be pushed with the pawl finger, instead of having to weld repair it, fitting a second pawl finger will allow the blade to be sharpened either until the tooth can be conveniently repaired or until it becomes full size again. A second use is for sharpening new blades fully explained next.

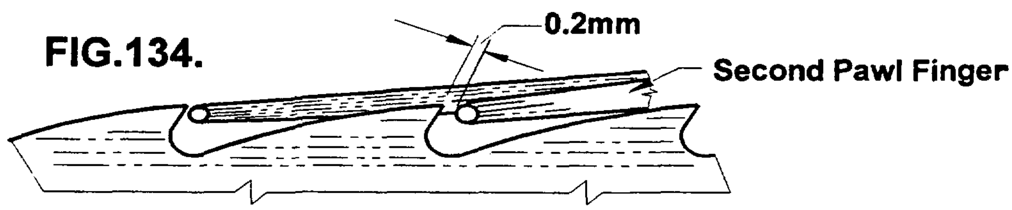
Sharpening New Blades:
New blades and blades which have been re-toothed for some reason may have teeth which are not absolutely perfect in pitch i.e. easily 0.5 or 1mm out. Although in theory because bandsaw teeth are fed with the pawl finger pushing the face of the tooth to be sharpened, even if the pitch of the teeth are not all equal, the tooth points should all be sharpened to the same height with only the shape of the tooth backs being different to compensate for the difference in tooth pitch. See Fig.133.

FIG.133.



However in practice I have found that sharpening teeth with uneven pitches never seems to give perfect results and shows up especially on swaged teeth which become unevenly sharpened on their faces. To avoid this problem which would otherwise continue throughout the life of the blade I think it is well worth while to always sharpen blades with newly punched teeth the *FIRST TIME* using a second pawl finger set 0.2 mm away from a tooth which measures correct. See Fig. 134.

FIG.134.



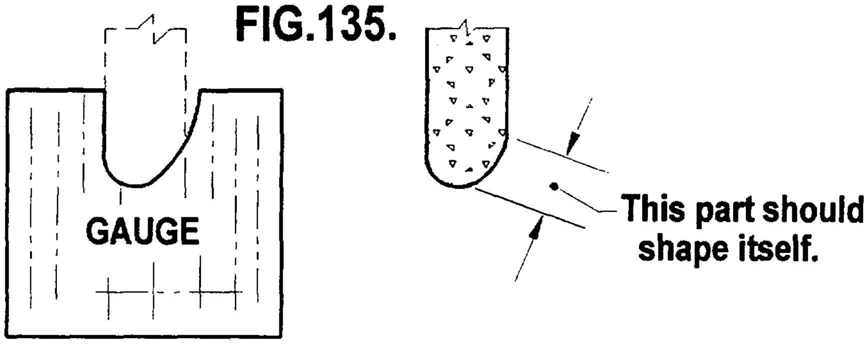
Or if a second pawl finger cannot be fitted, then it might be possible to correct slight errors in pitch by sharpening the first time with the pawl finger set to push one tooth back as used for circular saw blade sharpening.

As soon as the teeth pitches are even the pawl finger settings should be changed back to the normal position and the sharpening continued for one or two more rounds of the blade before swaging.

Sharpening Faults:
Fault 1. Loss of hook on teeth.
Cause: Grinding wheel worn on side which grinds the face of the teeth.

Fault 2. Teeth lose their shape.
Cause: Providing that none of the machine settings have been changed then the probable cause will be a change in the shape of the grinding wheel. Always make a gauge to test the shape of the dressed wheel. Do this after the wheel has found its own working shape on the tooth back side. See Fig.135.

FIG.135.



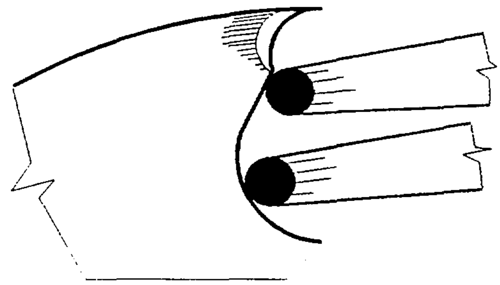
Fault 3. Teeth are burnt on their points or in the gullets.
Cause: Grinding is too heavy or the grinding wheel is glazed and needs dressing, or if dressing does not correct the blueing of the teeth then the grade of the wheel is too hard and needs to be changed.

Fault 4. Tops of the teeth are out of square.
Cause: Blade not centred under the grinding wheel. Correct by adjusting the blade thickness setting, or replace worn rear clamping plate. See Fig.137.

Fault 5. Faces of the teeth are out of square.
Cause: Grinding wheel or entire head out of square alignment, looking from above. Correct by adjusting. Also check that the rear clamping plate is not worn so that the blade is fed under the grinding wheel at an angle. Replace if necessary.

Fault 6. Sharpening of the swaged teeth uneven i.e. more taken off the faces of some than others.
Cause: The feeding is at fault. First check that the pawl finger is pushing the teeth at the right place which is just below the swage. See Fig.136. Do not push the teeth in the swage or on the rounded part of the gullet. Next observe if there is any movement of the pawl finger up or down the face of the teeth as it pushes the teeth forward, this can cause the finger to stick sometimes at a different spot on the tooth face resulting in uneven grinding. If there is movement then re-align the slide on which the pawl finger moves. Finally observe if there is any springing back of the blade from the position to which the teeth are pushed. This often occurs when there is no rear feed fitted to the machine and there is no satisfactory solution only to try to see that all the rollers etc. on the support stands are lubricated and running free.

FIG.136.



Pawl finger Position

Swaging & Side Dressing

Swage setting is a method of providing side clearance to the sides of teeth. It is widely used on wide bandsaw blades because it is much more efficient than spring setting for rip sawing as each tooth has clearance on both sides enabling each tooth to take out a full saw kerf whereas spring set teeth need a pair of teeth to cover the full kerf.

Basically each tooth point is *SQUEEZED* between an Anvil and rotating Die to make the cutting edge wider, then to ensure that all the cutting edges are the same width the teeth are side dressed or shaped by a second process giving clearance to the swage itself and strengthening the sides of the deformed steel.

The equipment available varies considerably from basic hand operated tools through pneumatic assisted hand tools to fully automatic machines. However it is the basic principles which, if fully understood, will enable the sawdoctor to achieve good results and overcome swaging problems which *WILL* arise no matter what type of equipment he has to work with.

The actual operations of swaging and side dressing look very simple but to obtain good results so that the blades cut efficiently and can be resharpened four or five times before re-swaging becomes necessary requires a lot of skill. The skill is not so much in using the tools or machines but in adjusting and maintaining them correctly and equally important in preparing the teeth correctly which we will deal with first.

Condition of the Teeth:

(1) The teeth should be ground to a sharpness angle of 44 degrees or as near as is practical. This angle allows the squeezing process to work best although slightly larger angles can be used if necessary. The straight face must be long enough for the die not to touch the curve of the gullet. See Fig.130.

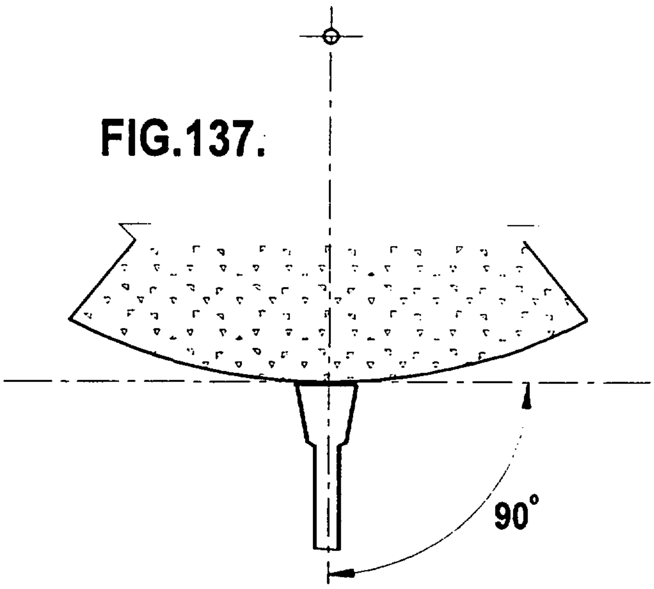
(2) The teeth *MUST* be ground square both on the tops and their faces otherwise the swaging will pull to one side and become uneven and in extreme cases the swaging may even bend the teeth to one side. See Fig.137.

(3) Teeth which are bent must be straightened before sharpening.

(4) Although it is ideal to leave the remaining worn swage on teeth to be swaged, if it is uneven i.e. more on some teeth than others or more on one side than the other then it will be found easier to remove all existing swage by the sharpening process or by rubbing the swage off from the sides of the teeth with an old fine grinding wheel.

(5) If the teeth have been stellite tipped then all traces of the stellite must be removed otherwise the anvil and die of the swaging tool will be damaged by the hard stellite.

FIG.137.



(6) Grinding burrs must be removed otherwise the swage may become uneven 4 i.e. larger on the side with the burr.

(7) All resin or gum should be removed from the sides of the teeth otherwise the clamping screws will slip resulting in small swages. If some teeth are clean and others not the clamp screws will slip on the dirty teeth and uneven swaging will result.

(8) A blade which has damaged teeth should have all traces of the damage sharpened away to ensure even swaging. Teeth with rounded corners will not swage properly.

(9) Finally the faces of the teeth should be lubricated to allow the die to rotate smoothly and with minimum wear to the die. A dry lubricant such as chalk is better than oil which tends to hold bits of surplus steel from the swage and which in turn clog up the die and spoil the swaging process.

Condition of the Tools:
For our purpose we will assume we are talking about basic hand operated tools.

The Anvil:
The anvil is a simple block of hardened tool steel which can be Tungsten carbide tipped although plain steel is more common. The working end of the anvil will wear with use and may be re-ground to keep it working correctly. However the original shape *MUST* be maintained *EXACTLY* as ground by the manufacturer otherwise it will not work properly. A new sample should be kept as a pattern or an accurate drawing made to work to. Free-hand grinding as I have often seen practised is likely to cause more problems than it solves, for example an anvil slightly out of square sideways will create a swage which is bigger on one side than the other and may cause hours of work trying to find the reason. Instead a simple jig for use on the tool and cutter grinder should be made for the work of re-grinding. The design of the jig will of course depend on the type of anvil in use.

The Die:
The dies are usually a hardened steel rod ground to an eccentric shape so that when rotated it applies pressure to the tooth point and squeezes it against the anvil so that the tooth is widened. When it becomes worn it cannot be re-ground like the anvil but can be moved sideways to an unworn part of the rod. To obtain maximum life from the die the amount by which it is moved is important and should not be guessed but measured and should be equal to the width of the wear usually 3mm to 4mm.

Two basic shapes are manufactured as shown in Fig.138a and 138b. the first is a cylindrical rod ground off-centre to a larger radius. This produces a fairly sharp corner which does the work and when new works well. However because of its fairly sharp edge it wears quite quickly. The life of the working corner can be prolonged by rounding the corner with an oil slip. The more complicated *CAM* shaped dies may work a little slower but are superior in that they maintain their true shape without wear much longer. European manufactured dies are usually 10 mm diameter but American manufacturers make a wide range of sizes from 5/16" to 7/8" diameter to cover the wide range of tools made to swage the large variety of blades used from thin bandsaws to thick circular saw blades.

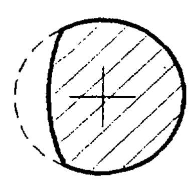


FIG.138a.

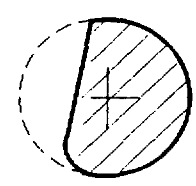


FIG.138b.

Clamping Screws:
The squeezing action of the swaging tool relies on the tool not moving away from the face off the tooth as the pressure is applied to swage the tooth. If the tool slips because of worn clamp screws the resulting swage will be smaller than it should be. Should only one clamping screw be worn, and this can be a common fault when one clamp screw is stationary and the other rotates to apply the grip, then the swage will pull to one side resulting in uneven swage

and even bent teeth. I have often seen semi-skilled staff carelessly brushing the entire tooth with oil before swaging. It does not need much thought to realise that the clamping screws are bound to slip if the sides of the teeth are coated in oil. Only the faces of the teeth should be lubricated and as previously stated chalk is preferred to oil.

Because of the special ringed shape there is not a lot that the sawdoctor can do with the ends of worn clamping screws and a good supply of spares should be stocked so that they can be changed when worn.

Shaper or Side Dressing Tools:
Several designs exist and most of the working parts cannot be reconditioned by the sawdoctor so that when parts wear they have to be replaced with new ones. One exception to this is the shaper dies on the older models of American tools which have simple bevelled ends. These can be re-ground using a supplied jig or more accurately held in a machine vice on the Tool & Cutter Grinder. Again it is important to maintain the original angles.

The Continuous Side Dressing Tool:
All original side dressing tools were designed to give both top to bottom and front to back clearance to the sides of the swaged teeth but around 1968 the Forest Products Research Laboratory in U.K. came up with the idea of using pairs of bevelled roller bearings to *ROLL* on the shape to the sides of swaged teeth. This system gives only top to bottom clearance but is quite satisfactory. The rolling action uses the area all around the circumference of the roller to do the work and so the working parts have a very good life span before they need replacing. The side dressing process is extremely fast and is excellent for thin blades of 18, 19, and 20 gauge but over this I suspect the tool would be too hard to push.

Swaging::

Clamp Screws:
(1) Adjust the fixed clamp screw so that the blade is central in the body of the swaging tool.

(2) Clamp the tool onto the blade and re-fit the handle to the most convenient position. This depends on the decision whether or not to *PUSH* or *PULL* the tool and is mainly a matter of personal preference although large tools used on thick blades which need a lot of strength to operate the die lever are better pulled than pushed.

Anvil:
(1) Rotate the body of the swage so that the anvil sits on the top of the teeth as shown in Fig.139. The slight difference in angle is to pull the tooth point down slightly so that the tooth backs and tops can be sharpened without grinding away the top of the swage.

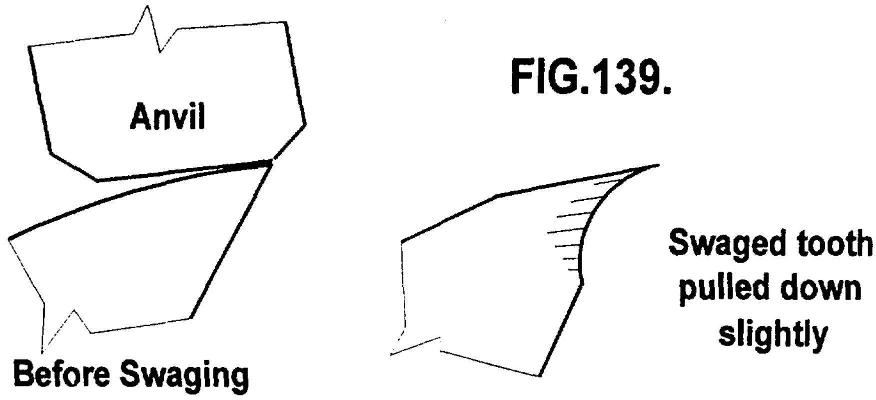


FIG.139.

(2) Screw down the anvil until it just touches the die when it is rotated to its highest point. This adjustment is most critical as raising or lowering the anvil by as little as 0.01 mm can make a lot of difference to the quality of the swage. Note: This setting is so important that Armstrong Mfg. Co. U.S.A. provide a setting gauge to match the die used to ensure this setting is correct.

Swaging Die:
(1) Fit the die into the die lever so that the flat on the die is opposite the handle and be sure that it is the right way round on cam shaped dies.

(2) Rotate the die until it touches the anvil and if fitted adjust the die lever stop so that the die stops just before it touches the anvil to prevent the die and anvil damaging each other.

(3) Adjust the die lever back stop so that the lowest part of the die is opposite the tooth face. Trial swages should be made and slight adjustments made as necessary until the maximum bite is obtained by the die. Note that the correct setting will allow very little free movement of the die before it starts to squeeze the face of the teeth.

Side Dresser Adjustments:
Because these tools vary so much in design and are usually fairly simple to adjust I shall not attempt to cover the adjustments here. Normally these will be covered adequately by the manufacturers handbook.

Swaging & Side Dressing Faults:
(1) Swage pulled too far down or up as shown in Fig.140. Correct by adjusting the body of the swage.

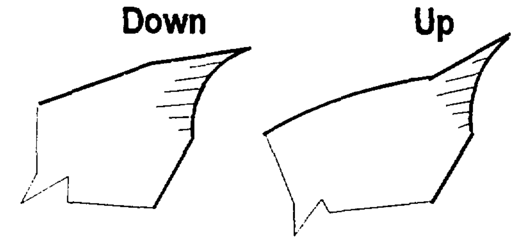


FIG.140.

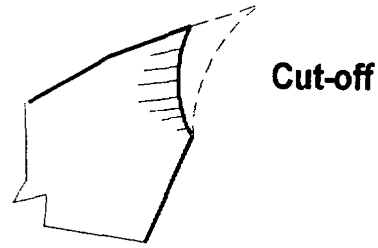


FIG.141.

(2) Swage cut-off too low as shown in Fig.141. Correct by raising the anvil slightly or re-setting to the setting gauge if provided.

(3) Swage not squeezing out wide enough at the cutting edge. Correct by lowering anvil slightly.

(4) Teeth pull to one side when swaging. Check the following:

(a) Tops and face of teeth for being ground square.
(b) Anvil for being ground square.
(c) Clamp screws for wear especially the moving one attached to the clamping handle. A clue to this fault is that the teeth will be pulled to the opposite side to the worn clamp screw.
(d) Check the blade for resin on one side.
(e) That the blade is clamped centrally in the swage body.

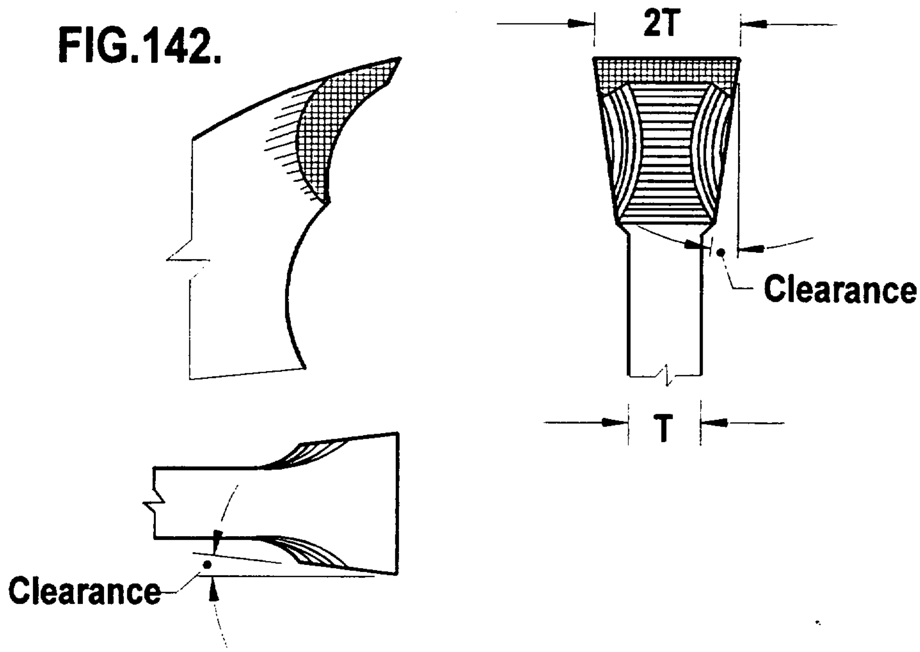
(5) Swage is not big enough. Note that teeth which have no swage will often need swaging twice to gradually build up the swage to the full size. If this is not the case check the following:
a) The die for wear, move to a new position or replace altogether.
b) Check for worn or slipping clamp screws.

Shaping or Side Dressing:
Shaping or side dressing is the process of squeezing the swaged teeth points to a uniform width so that all the teeth have the same cutting width and also that each side of the teeth will have the same set or side clearance. In addition to this the side dressing process also gives strength and clearance to the sides of the swage which would otherwise be a thin wire edge which would breakdown in use. See Fig.142.

It will be seen from Fig.142. that the finished width of the swage should be in the region of 2x the blade thickness. This means that the swage width has to be 2.5 to 3x the blade thickness to allow the side dressing to strengthen up the sides of the swage as shown.

Exact sizes will depend on individual requirements i.e. if maximum number of sharpenings between swaging and side dressing is important or if a smaller saw kerf is required to reduce timber waste.

FIG.142.



Swaging & Side Dressing Procedure:
(1) Thoroughly clean the sides of the teeth of resin, oil and dirt.

(2) Grind the teeth Square on the face and tops making sure not to burn the tooth points. Check the sharpness and other angles from time to time.

(3) Remove the grinding burr from the rough side of the teeth using an oilstone or old fine grinding wheel keeping the oilstone *FLAT* on the side of the blade. Do not angle the oilstone.

(4) Lubricate the face of each tooth using soft school chalkboard chalk or if only oil is available try not to apply too much which will run down the side and cause the swaging tool to slip.

(5) Swage once on teeth which have some swage remaining or twice if necessary on teeth with no swage. Light grinding between each swaging is sometimes needed to allow the swage to bite a second time when building up a new swage. Note all teeth should normally be swaged except the one at the joint of the blade if it is Brazed, It should be possible to swage the teeth at welded joints if care is taken and the welded tooth is tempered properly, however if swaging proves difficult leave the tooth at the joint without swage but do not file it lower, this will only throw twice the work onto the following tooth whereas a tooth without swage will at least take out the centre of the kerf.

(6) Since conventional side dressers rely on a tooth stop to locate the tool on each tooth, for accurate results the blade should be lightly sharpened so that the stop locates on a uniformed tooth point, i.e. not on the thin wiry edge of the unsharpened swage. When using the continuous type side dressing tool this is not necessary and is one of the advantages of this tool.

(7) Side dress all the teeth.

(8) Sharpen the teeth until their tops are just ground down to the pulled down swaged cutting edge and the faces are ground until a strong cutting edge is obtained across the tops of the teeth and slightly down the sides of the swage as shown in Fig.142. The aim of the first sharpen is to leave most of the hollow, which is formed by the swaging and side dressing, showing on the face of the teeth. This is quite acceptable providing that the cutting edge has been sharpened. It is most important to realise that sharpening beyond this is only reducing the number of sharpenings between the swaging process. The number of times that the blade can be sharpened before the minimum clearance is reached and re-swaging is necessary depends upon the skill of the sharpening machine operator, the accuracy to which the machine is capable of grinding and whether or not the blades encounter dirty timber to cut or other damage. Of course hitting a small stone embedded in the timber may be no one's fault but it can mean that the whole swaging process has to be repeated after only one run with the blade.

CHAPTER 8

Repair of Wide Bandsaw Blade Cracks & Damaged Teeth:

Introduction:
The occurrence of cracks in the gullets of wide bandsaw blades and occasionally in the back edge is one of the most common problems facing the sawdoctor.

The bandsaw blade is usually strained up tight on the pulleys with a force of 10,000.lb/sq.in. or 7kg/sq.mm which is equal to *ONE TWENTIETH* of the breaking strength of 90 tons / sq.in. or 140 kg / sq.mm.

This safety factor of 20 : 1 would seem to be more than enough to cope with any errors in the use and maintenance of the blades but the blades have many other forces to contend with which together often reduce this to zero then cracks occur. Whilst we need to know how best to repair cracks when they appear it is much better to do all that we can to avoid them in the first place for repairing and levelling and tensioning afterwards is a lot of extra work which we can well do without but also a repaired blade is never quite as good as it was before it was cracked.

Reasons for Cracks:
The reasons for the additional strains which overcome the tremendous strength of the steel and cause it to crack are numerous and can be divided into four categories,

(1) Those which cannot be avoided.
(2) Poor blade maintenance.
(3) Poor machine maintenance.
(4) Incorrect use of the machine and blade.

The most common of the additional strains are as follows:
Those which cannot be avoided:
(1) The continual bending and straightening of the blade during the running period both whilst idle and when cutting.
(2) The additional strain of cutting.
(3) The additional strain of commencing each cut.
(4) The effect of having teeth on the cutting edge which concentrates the stress on every gullet at the lowest point.

Poor Blade Maintenance:
(5) In addition to the stress being concentrated in the gullets, the grinding may leave a rough edge where the stress could be concentrated further.
(6) Grinding with the wrong grade or glazed wheels may burn the gullets and on cooling harden them making them almost certain to crack.

(7) The additional strain of an over tensioned blade. This will throw extra stress on the edges if the centre portion is made too long by rolling in too much tension.
(8) Other tensioning and levelling faults which can throw extra strain on parts of the blade.
(9) Choice of too thick a blade for the size of machine pulley will cause additional bending stresses, a thickness ratio of 1000 : 1 maximum should be adhered to. Example: With a pulley diameter of 1200mm the blade thickness should not exceed 1.2mm.

Poor Machine Maintenance:
(10) Dirt on the pulleys and slivers of timber trapped between the blade and the pulley throwing extra strain on specific parts of the blade. Items at fault include: shear boards, scrapers, cleaning pads, and wooden inserts on resaw tables.
(11) Worn pulley faces, common on the front edge, will leave too much of the toothed cutting edge unsupported and subject to vibration during cutting.
(12) The straining mechanism not working properly i.e. not reacting quick enough to jolts on the blade as when commencing a cut in a log too quickly.
(13) Pulleys out of line so that the blade overhang has to be more on one pulley than the 3-4mm recommended.
(14) Incorrect guide adjustment, too tight or out of line causing extra heat or too worn giving no lateral support to the blade.

Incorrect use of the machine and blade:
(15) Running the blades too long. This is often a major problem.
(16) Leaving the blade to cool down with the strain on i.e. during tea and lunch breaks and over night. I suspect this could be a major cause if the blade has been running hot for some reason (pressure guides or faults) coupled with a straining mechanism which is clogged up with sawdust or just worn and sluggish.
(17) Applying either too much or too little strain.
(18) Running the blades after they are blunt. This is a major problem getting the sawyers to recognise as soon as a blade starts to run back on the pulleys. It can be after a very short period of use if the teeth are damaged by cutting metal, stone or just dirt on the timber or logs.
(19) Entering the cut too quickly.
(20) Commencing to cut before the blade has reached full speed on starting up.
(21) Blade allowed to run back on the pulleys and back edge rubbing on part of the machine causing hardening and cracking of the back edge.

There are other possibilities but as I said at the beginning these are the most common faults to be found and when cracks start to appear a full check on all aspects of both machine and blade maintenance is required immediately. This is because it is much better to prevent cracks than to have to mend them although preventing them is not at all easy especially if you have no control over machine maintenance or the way that the sawyers treat the blades.

Temporary Repairs:
Short gullet cracks say up to 12mm long can be sometimes stopped from getting worse by various means such as punching and drilling holes at the base of the crack. This may be until there is time to make a weld repair or perhaps in the hope that the cause can be located quickly and the damaged blade or blades used carefully until the cracks have been ground out by routine sharpening.

There are lots of ideas about how to try to stop cracks increasing in length but if we expect to grind out the crack I feel that drilling holes is not ideal since the hole may end up at the tooth point and if we intend to weld later a temporary repair by punching is sufficient.

An indent by a single centre punch is not recommended since the crack may easily run around it and continue. Three indents are better but the best way is to make a crescent shaped punch as shown in Fig143. If you use this on both sides of the blade there is a good chance of stopping the crack providing that what caused it in the first place is eliminated.

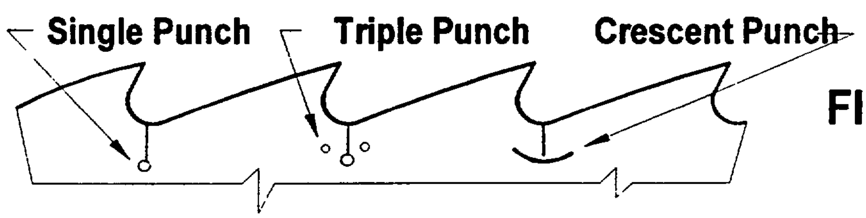


FIG.143.

Permanent Repairs by Welding:
Weld repairs of cracks can be done using any of the welding systems already discussed but if oxy-acetylene is used the weld has to be forged to give it strength and this causes expansion of the forged area and will usually pull out the back edge of the blade making correcting by rolling necessary. If T.I.G. or M.I.G. is used there is no need to forge and the finished weld will need perhaps one short roll just below the weld to correct the tension.

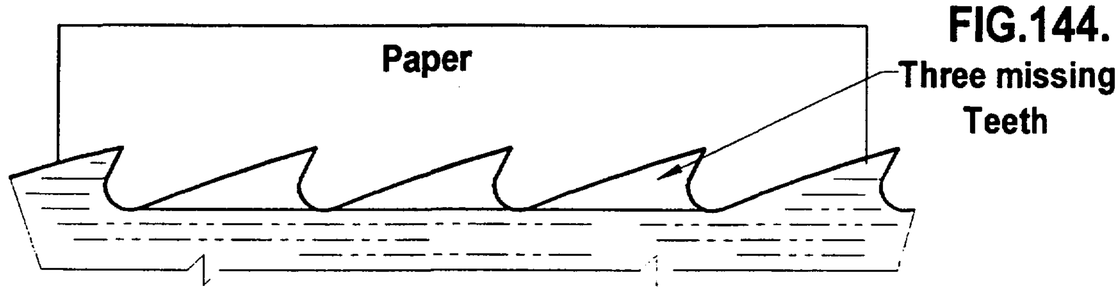
The technique is the same as for welding a complete join except that we start to weld at the bottom of the crack and as we approach the edge of the gullet we shield the edge with the filler rod to prevent blowing a hole in the edge. For M.I.G. welding that does not use a separate filler rod a run on piece placed in the gullet may be required. With both M.I.G. and T.I.G. the slope down of the welding current is used if available.

If a long crack has to be repaired, because we cannot leave a gap for expansion to take place, it will often be necessary to tack the edge at the gullet to prevent the edges overlapping as they expand.

Repair of Sheared-off Teeth:
Often during log conversion blades run into metal objects buried inside the logs and as a result sometimes the teeth are just severely blunted but often teeth will be sheared-off completely. When this occurs they can successfully be replaced by welding using any of the welding systems but perhaps most easily using T.I.G. equipment.

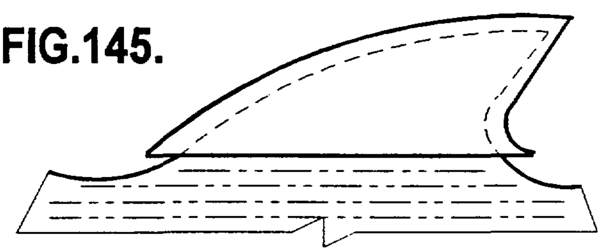
First the base of the sheared-off teeth are hammered flat if at all bent and the base line filed or ground straight to receive new teeth.
Next place a piece of plain paper behind a part of the blade with good teeth and draw around the profile of two or three teeth. Then place the drawn teeth behind the missing teeth as shown in Fig.144.

FIG.144.



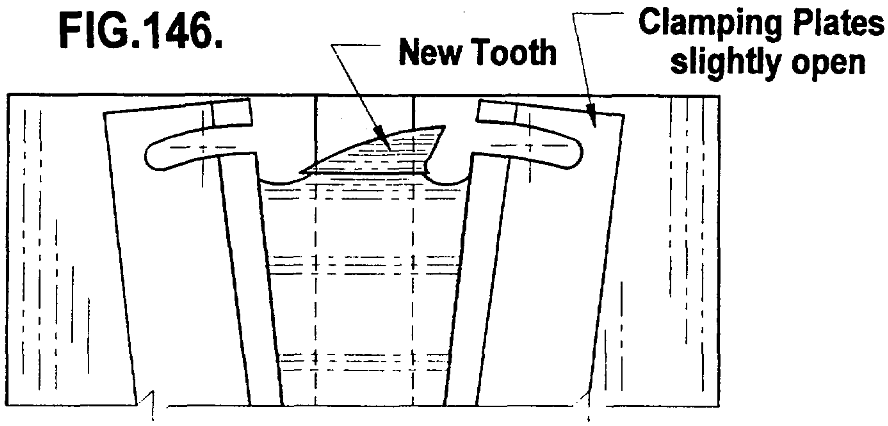
With the drawing as a guide cut and grind to approximate shape pieces of bandsaw steel to fit the missing teeth but leaving them slightly larger all round by about 1mm. See Fig.145. Do not leave the pieces too big as this will only create more work later on in grinding them to shape. The new teeth are now ready for welding on.

FIG.145.



The blade is placed in the welding clamp with a missing tooth over the anvil an the clamping plates tightened down. I must admit that this is the only limitation to having a 30mm wide gap between the clamping plates as previously described in Chapter 5. However if necessary leave the plates not pushed fully into their slots at the front to give more space to work. See fig.146. You may either secure the end of the new tooth under one of the clamping plates or get an assistant to stop the tooth moving by holding it with the tang of a file.

FIG.146.



A special chill is now required with a groove *ACROSS* its width, it can be ground into the back of the normal chill or a separate one made. The new tooth is then welded on in one or two steps depending on its length and finished off as a welded join.

On completion of welding on all the missing teeth, they are ground to as near as possible the correct shape and size using a small angle grinder with the drawing as a guide to shape and spacing. The *PITCH* of the teeth is the most important part as if wrong will cause a lot of extra work on the sharpening machine to get the pitch good enough for swaging. The replaced teeth should be treated as normal and swaged and sharpened to the same height, for although it is all right to leave the odd tooth without swage, to leave several not working fully would only throw extra work on the following tooth. For example if three teeth were replaced and not swaged then the following tooth would four times as much timber to remove on the sides where the swage should be.

Finally make absolutely sure that the repaired teeth are perfectly straight, if they are leaning at all they are likely to be sheared-off again!!

CHAPTER 9

Stellite Tipping of Wide Bandsaw Blade Teeth:

Introduction:
There are some timbers which blunt normal bandsaw saw teeth so quickly that it is uneconomical to cut such timbers because of the necessity to change the blades so often for sharpening. Two types of timber are responsible for this rapid blunting; those which are extremely dense and hard and others which may not be quite so hard but which have *CALCIUM* (stone) deposits within the pores of the timber and this blunts the teeth very rapidly indeed.

To overcome the problem two methods have been developed:

(1)To harden the tips of standard teeth using special electrical high frequency hardening machines.

(2) To face the teeth with an extremely hard abrasive resistant cobalt based alloy known by the most popular trade name of "Stellite".

The first method of hardening the tips of teeth has not proved very popular perhaps because it is more suitable to normal non-abrasive medium density timbers and not the very troublesome abrasive timbers like "Iroko." On the other hand stellite tipping has become so popular that often it is being used in sawmills where it is not really necessary cutting normal soft and medium density hardwoods. This can cause a problem of its own, for tipped blades which stay sharp longer are then often run too long before changing causing cracks to develop which may not otherwise have occurred.

No-doubt much of its initial popularity was due to the fact that stellite could be applied to the teeth with no additional equipment, although special side grinding machines have since been developed which are now considered necessary to obtain the maximum benefit from the process.

Background & Developments:
Sometime back in the 1950's a U.K. sawmill had imported some "Iroko" logs from West Africa and on trying to covert them into lumber found that the blades blunted after cutting only about 300mm into the logs. To cut a long story short they started experimenting with "Stellite" which is a Trade Name for a cobalt based alloy used for hardfacing engineering tools and such things as bulldozer blades. A suitable grade was found and the teeth tipped with it and the logs were converted into lumber.

Please note that there are other makes of alloy with the same or similar composition but since "Stellite" was the first used for this purpose the name stellite has stuck within the sawmilling and woodworking trade ever since. Even the machine manufacturers and experts from all over the world use the trade name of stellite to describe the hard facing alloy used to tip saw teeth so we shall do the same.

Since stellite was first used to saw those "Iroko" logs, many developments have been made by the machine manufacturers. The first and most important big development was the side grinder or equalising machine to grind the sides of the stellite tips to the same projection or side clearance. Now several models are available to choose from using either cup or straight wheels. At least one of these can be easily converted to side dress circular saw blades by fitting a simple inexpensive cone attachment to mount the blades on. This is a very useful feature for the sawmills who might find it useful for edger blades etc..

Several attempts were made to make gadgets and machines to try and *FORM* the molten stellite as it cooled but these never seemed to work very well and I have certainly seen several commercially made machines in sawmills not in use.

It wasn't long before the machine manufacturers started developing machines which would automatically or semi-automatically deposit the stellite onto the teeth. The latest idea from the U.S.A. in the mid 1980's was a machine capable of welding pre-formed stellite tips to the teeth thereby reducing the waste of stellite to a minimum. The percentage of stellite wasted must be substantial using previous systems that weld a long rod to the tooth which is then cut-off and shaped afterwards.

Despite all these developments hand depositing of the stellite is still the most widely used system in the sawmills and so we shall mainly deal with those techniques involved with this and just touch on a few points concerned with machine depositing.

Equipment Required:

(1) Oxy-acetylene welding equipment as used for welding bandsaws.
(2) A supply of 3/32" (2.5mm) diameter rods of Grade 12 "Stellite" or its equivalent.
(3) Automatic Side Grinding Machine.
(4) Set of rollers on which the blades can be hung and easily moved around for the depositing process.
(5) The usual bandsaw sharpening machine and swaging tools etc..
(6) Automatic or semi-automatic tipping machine. (optional extra).

The Manual Application of 'Stellite':

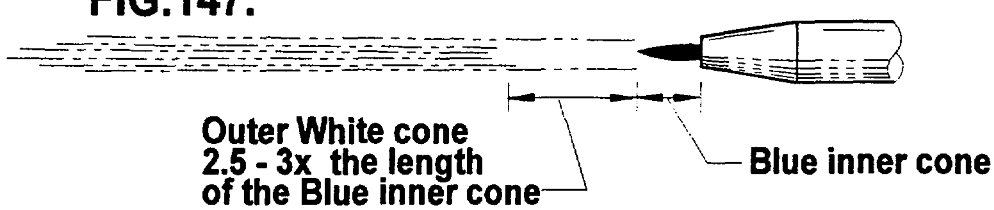
(1) The teeth are sharpened in the normal way and if previously tipped all traces of stellite must be removed before the teeth can be swaged.
(2) The teeth are swaged but not side-dressed.
(3) The stellite is deposited on the teeth and as the steel tooth point cools down fairly quickly it can harden and become very brittle, the stellite and adjoining tooth is re-heated to temper the steel behind the stellite to prevent the teeth breaking off behind the tip. Note it is not the stellite that Is affected by the quick cooling but the steel of the teeth.

(4) The teeth are then sharpened in the normal way on their tops and faces with the pawl finger of the sharpener pushing just below the deposit of stellite.
(5) The stellite is ground to give an equal projection on each side of the blade usually with a compound clearance angle of 3° top to bottom and 3° front to back.

Depositing the Stellite:
The blade has to be hung so that a portion of it with 20 -30 teeth is vertical and at a height that the welder can sit comfortably on a stool in front of it to do the work. In its simplest form the blade is hung on a roller above a set of rollers on the floor on which most of the blade rests and the blade pulled round by the welder after depositing stellite on a few teeth. Alternatively there are special commercially made benches that have in addition to the rollers a simple foot operated mechanism to move each tooth forward as it is finished so that the depositing is done at the same convenient height each time.

The oxy-acetylene flame can be adjusted in three different ways, equal parts of gas and air giving a *neutral flame,* excess oxygen giving an *oxidising flame* and excess of acetylene giving a *carburising flame.* This last type of flame using more acetylene than air is the one used for depositing the stellite. The flame is correct when the white feather is 2.5x-3x longer than the inner blue cone. See Fig.147. Just the same as when we are welding bandsaws, the flame should be a soft quiet flame and not harsh and noisy. This would blow the stellite away.

FIG.147.



To try to explain the very skilful process of depositing stellite on the tiny tips of bandsaw teeth is impossible, to watch someone do it then try is difficult enough but there are some points that can and should be made which are important.

(1) First using the outer white flame, raise the temperature of the swaged hollow until it *Sweats,* that is looks shiny on the surface when viewed through the welding goggles. Too much heat and the teeth will burn and too little will not allow the stellite to stick to the swaged hollow.

(2) When this condition is reached, attach the end of the stellite rod to the bottom of the hollow i.e. the end away from the cutting edge, the rod being heated at the same time as the hollow. The molten rod is then pulled towards the cutting edge and *CUT-OFF* to the right size using the flame and immediately the severed blob is moulded to shape with the flame. A very skilled refinement of this is: Attach the stellite to the bottom of the hollow then pull it to one side slightly to give a wider shape to the future cutting edge, cut off and re-

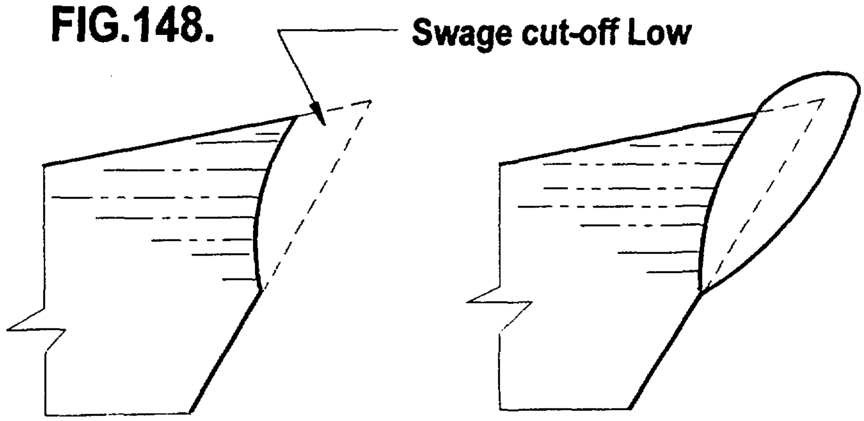
attach the stellite to the other side about half way up the swage and pull out again to the other side and cut off and mould together with the flame. It is essential to count in seconds the time each deposit takes and to get a rhythm going for the process.

I have seen the shaping of the stellite done so skilfully in the far east that side grinding was almost unnecessary. I suppose this was born of necessity since many of the small sawmills using stellite did not have side grinding machines. Even if you have a side grinder the technique is still worth trying as it will both speed up side grinding and save on stellite and side grinding wheels.

(3) After all the teeth are tipped, the steel behind each tip has to be tempered by re-heating to what would bring a cleaned surface to blue colour. Obviously we do not have time to clean off every tooth and blue it so we need a practical way to achieve the same result. This is achieved by counting in seconds the time that it takes to blue each of three or four trial teeth that have been cleaned with abrasive cloth or a file. Usually a time of about four seconds is sufficient for each tooth. A neutral flame is correct for this part of the process and will also save on acetylene.

Swaging for Stellite:
When we swage teeth to be used without stellite the idea is to pull the tooth points forward as much as possible so that we do not have to grind away too much of the tooth face before the cutting edge is sharp. When swaging for depositing stellite the anvil may be lowered slightly to cut off the swage sooner as shown in Fig.148. This will allow the stellite to be wider at the top to allow a greater number of sharpenings before re-tipping becomes necessary.

FIG.148.



Sharpening the Face & Tops of the teeth:
Although the normal grade of grinding wheel can be used for sharpening stellite you will find that it is much harder than the blade steel and will wear the wheels and cause them to lose their shape quickly. Therefore a slightly harder grade is required and special grades have been developed by the grinding wheel manufacturers. It is also vital that the grinding wheel is angled slightly to the downward travel of the grinding head as explained in Chapter 1. otherwise the

side of the wheel will lose its shape very quickly and make it impossible to maintain the correct hook angle on the face of the stellite and teeth fronts.

Side Grinding or Equalising:
There are two types of side grinding machines those which use straight wheels and those which use cup wheels. There are advantages and disadvantages to both types. With cup wheels the size and therefore the cutting speed stays the same throughout the life of the wheel. Cup wheels also produce angles which are true angles as set on the scales of the machine.

The straight wheels are usually slightly larger in diameter and when new will remove stellite more quickly, but this does not last for they do lose their diameter as they wear down. The angles too are not accurate since they rely on the curve of the wheel to give the clearance angle on the sides of the teeth, in fact the angles have to be estimated. However the rocking movement of the grinding head is so simple doing away with slides that this is worth considering. The straight grinding wheels are cheaper so that in the end there is not a lot to choose between the two types.

It always surprised me when visiting sawmills to find more often than not that the side grinders were set to larger clearance angles than is necessary. Large angles are not necessary and to grind at say 6° in both directions complicates the movement of the heads and invariably means that the wheels end up touching the body of the blade behind the teeth. There is no need ever to give more than 3° in each direction and I am pretty sure that in many cases less than this would work and give smoother sawn surfaces. The continuous side dresser has proved that we do not need a compound side clearance angle on saw teeth.

Of course the main reason for keeping the side clearance angles to a minimum is to increase the *LIFE* of the stellite. The smaller the angles the wider the stellite remains as it is sharpened away. Compare Fig.149a. & 149b. to see the difference.

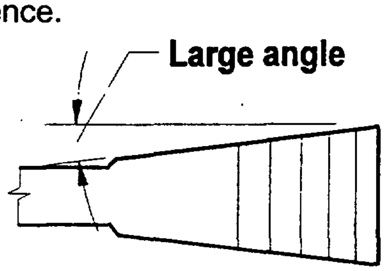


FIG.149a.

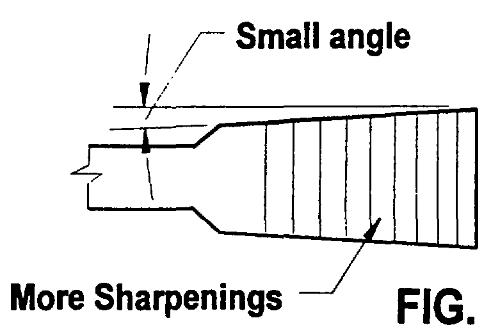


FIG.149b.

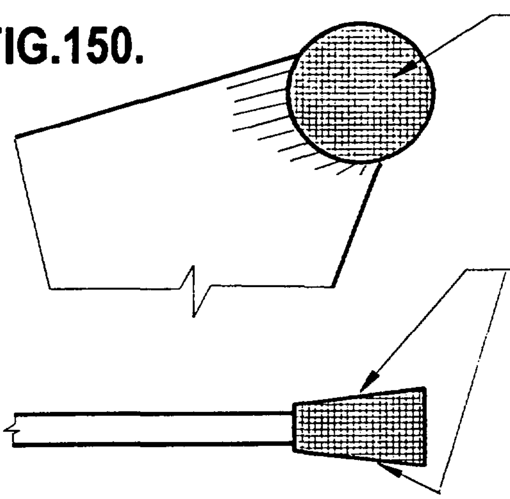
Although our aim is to get as many sharpenings as possible from one application of stellite, for the whole process is quite a lot of work. We must not end up with too big a tip that will be both wasteful of timber and will throw a bigger strain on the thin bandsaw blade which is already prone to cracking. A maximum tooth point width of 2.5 times the blade thickness is recommended.

The Semi-automatic Stelliting Machine:
I have only used one type of machine that electrically welds stellite to bandsaw teeth. This was a Swiss made machine which I came across in Guyana and it worked very well after I had had half a day to get to know it. The problems I encountered are worth mentioning as I can imagine semi-skilled staff in other sawmills making the same mistakes.

The machine was a type that uses lengths of stellite rod with a diameter of about 6mm. These are fed sideways across the bandsaw and pressed into the tooth points at the same time as the tooth point is melted and the two fused together. Then the piece welded to the tooth is cut off using a standard angle grinder attached to the machine on an adjustable slide. This is fitted with a very thin (about 0.5mm thick) resin or rubber bonded wheel in order to waste as little as possible of the stellite rod.

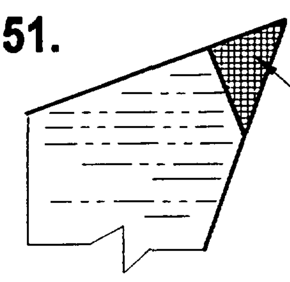
The angle grinder is set at an angle similar to the side grinding angle so that the cut side of the stellite is already approximately the correct shape. After the next tooth is moved into position the rod is moved across by hand against a stop and rotated 180° so that the other side is also approximately the correct shape. The welded on stellite then looks like Fig.150.

FIG.150.



The bandsaw teeth are sharpened in the usual way but before stelliting the points of the teeth must be removed as shown in Fig.151. A very hard grinding wheel can be used for this on the sharpening machine itself for it would not matter if the tooth points overheated, even turned blue, as they will be melted in the following process.

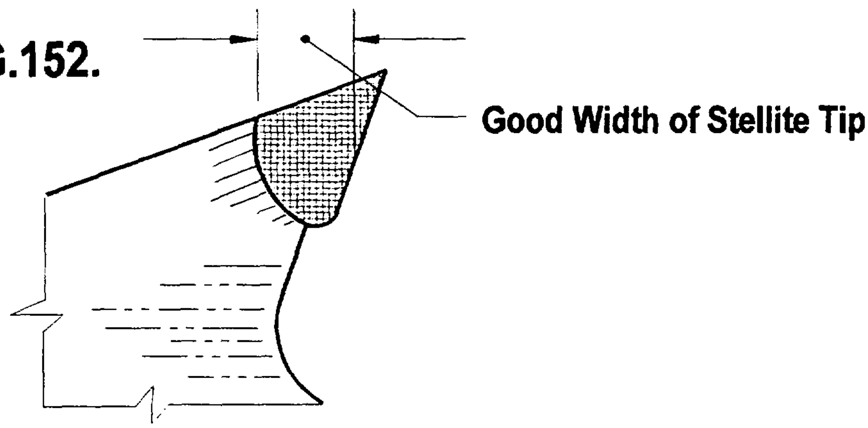
FIG.151.



If this is not done, which was the case before I arrived at this sawmill, the extra material that should be removed from the point spreads out sideways making a very rough join between tooth and stellite and as I soon discovered could push out upwards on some teeth and catch on the pawl finger as it returns to feed the next tooth pulling the tooth back to the wrong position. The result was disastrous i.e. the grinding wheel came down on top of a tooth and we were lucky not to break the grinding wheel.

When the process was carried out correctly the resulting stellite tips were excellent being very deep from front to back and after reducing the side clearance angles on the grinder the potential life of the tips were really good. See Fig.152.

FIG.152.



CHAPTER 10

Wide Bandsaw Blade Fitting & Machine Maintenance:

Introduction:
The sawdoctor who does not know about blade fitting and the maintenance of the machines on which the blades run will find himself in trouble when sawyers complain about the blades not working properly as they will from time to time. It may be that the blades are at fault but often there are faults with the machine set-up which can cause poor sawing and additional stress on the blades sometimes ending in the appearance of cracks or lumps or twists all needing extra work to correct.

Likewise management will wonder why there is so much down-time on machines and why they have to replace blades long before they are worn away from normal routine sharpening. This less technical and perhaps uninteresting module can make the difference between profitability and non-profitability since we are really discussing lots of money in damaged blades, loss of production in down-time of machinery, loss of profit from valuable raw material by the reduction of poor yield percentages because of poor quality and inaccurate sawing. Last but not least the additional cost of valuable sawdoctors time which is being wasted on repair work instead of being spent on trying to perfect his blades so that they cut straighter and faster.

Blade Tracking:
When the blade is first put on the pulleys and the strain applied, if the blade is not in the correct position i.e. more on one pulley than the other, the tremendous strain will throw stress onto the edges unevenly causing the blade to *STRETCH* at the front edge on one pulley and stretch at the back edge on the other pulley. It is vital therefore that the blade is positioned as near as possible to its correct position in the first place and then with the pulleys moved apart to tighten the blade, but before any strain is applied, the pulleys should be turned around to allow the blade to settle onto the pulleys in the correct position.

The blade should be tracked so that only 3-6mm projects beyond the gullets, 3-4mm for most of the thinner gauged blades and up to a maximum of 6mm for the really heavy gauge log bandmill blades of 14 gauge (2.11mm) and over.

The reason for this projection must be kept in mind which is to try to prevent the gullets of the teeth wearing the front edge of the pulleys. This wear will result in the blades not getting full support at the vital toothed edge and a very costly re-grind of the pulleys to correct the wear. Blades *WILL* run back when entering the cut, when sawing too quickly and when the teeth are getting blunt and the sawyer should see to it that the blade does not run back more than the 3-6mm of overhang after which wear of the pulleys will occur. He must ensure this by keeping an eye on this overhang *ALL THE TIME* that he is sawing. Machine manufacturers usually provide a window in the top pulley guard so that the sawyer can see the overhang. On machines not provided with these guards and boxed around by the sawmill carpenter in plywood make sure that there is a hole cut in it for this vital purpose.

The Straining Mechanism:
Straining mechanisms vary considerably from manufacturer to manufacturer and there is also a difference between modern hydraulic mechanisms and the older simple levers and heavy weights. However the principal of being able to safely apply around 10,000 lb./in.sq. or 7kg/mm.sq. as a standard strain applies to all systems. This gives a safety factor of 20:1 because the breaking strength of the bandsaw steel is 90 ton/in.sq. or 140kg/mm.sq. Some manufacturers introduced "High Strain" on some of their modern machines which simply means that they are putting more strain on the blade than 7kg/mm.sq.. This is to try to improve on feed speeds to increase production. If you are running this type then it will be a modern machine and hopefully no problems will arise if you keep to the manufacturers recommendations, the problems that do arise are usually with the simple lever and weight systems of which there are thousands in daily use.

Time and time again I have visited sawmills where the sawyers have wound up the straining mechanism until it has lost all or much of its effectiveness by raising the lever arm far too high thinking that they were putting on that extra bit of strain necessary to cut with inferior maintained blades. I once lifted all the weights off a band resaw whilst the sawyer, looking very worried, kept on sawing. He had wound up the lever arm so high that it was tight against the frame of the machine and the weights were doing no good at all and of course there was no give in the system to protect the blade from sudden jolts which is why the complicated straining mechanism is there in the first place.

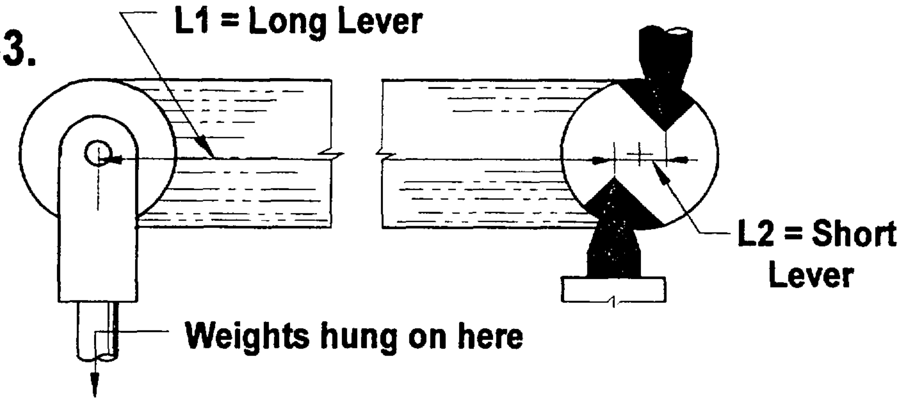
The sawyers must be made to understand that the straining mechanism normally works best when the lever arm is *HORIZONTAL.* and to avoid any misunderstanding the machine should be clearly marked where the lever should be raised to.

Unfortunately many manufacturers do not fasten a plate to the machine giving the number of weights to be used for a certain size of blade as do Stenner and Robinson of U.K.. They seem to think that it is sufficient to mention these things in the manual which invariably is left in the office or is lost altogether or the sawyer cannot understand anyway because of language differences. If this information is not available the calculations are not difficult once you are able to measure *ACCURATELY* the lever arm sizes. Once someone can calculate the strain for one size of blade it is easy to calculate for all sizes in steps of say 10mm and then make a chart to be fixed to the machine for sawyers to adhere to.

The Calculations:
The lever arms of the straining mechanisms vary in design but most of them revolve around a solid bar of steel machined out at each end with two vee's in which four knife edges work. The bottom two knife edges act as a fulcrum or

pivot for the lever arm and the upper two transfers the force to the top pulley to provide the strain to the blade. The lever arm mechanism looks like Fig.153. and this shows the measurements needed to carry out the calculations.

FIG.153.

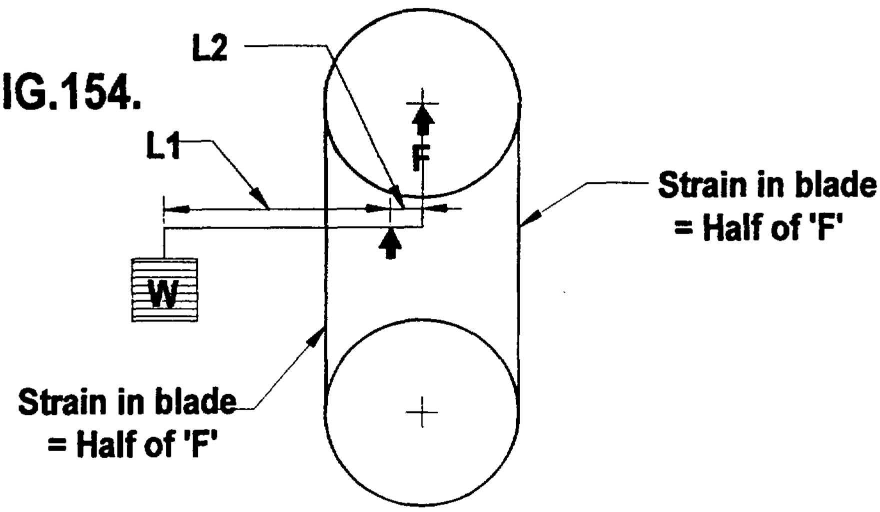


Please note that it does not matter what shape the long lever arm is, it is the *HORIZONTAL* distance that is important and measured.

You will see that the space on each side of the machined out 90° vee's shown in red are equal on each side of the knife edges, this is when the lever is in its correct position giving maximum movement up or down for the lever. If there is no mark on the machine for the height of the lever then it should be marked when the lever is in this position. The weight of the lever arm itself and usually one fixed weight on the bottom of the rod which carries the loose weights has to balance the weight of the top pulley, then the additional loose weights are the ones that give the strain.

The basic lever arm system for calculation purposes is shown in Fig.154.

FIG.154.



The leverage ratio $R = \frac{L1}{L2}$

Sectional area of blade = bt

Blade width $b = \frac{WR}{2St}$

Force $F = WR$

Strain $S = \frac{WR}{2A}$

Weight $W = \frac{2SA}{R}$

FIG.155.

Canali Log Bandmill BBSV 1800			
Blade Width	Blade Thickness		
260mm	64 kg	72 kg	80 kg
250mm	62 kg	69 kg	77 kg
240mm	57 kg	67 kg	74 kg
230mm	55 kg	64 kg	71 kg
220mm	54 kg	61 kg	70 kg
210mm	52 kg	58 kg	65 kg

Example:
A machine has a lever arm 640mm long (L1) and the two knife edges are 16mm apart (L2) and the blade in use is 180mm x 1.2mm Calculate the weight required to be hung on the lever arm to give a strain of 7kg/mm sq.

Ratio = 640 ÷ 16 = 40 : 1

$$W = \frac{2SA}{R} = \frac{2 \times 7 \times 180 \times 1.2}{40} = \underline{75.6kg}$$

To check the result and to give another practical example:

$$Strain = \frac{WR}{2A} = \frac{75.6 \times 40}{2 \times 180 \times 1.2} = \underline{7kg}$$

A typical straining chart to be fixed or painted on the machine is shown in Fig.155. Please note that I calculated this chart for a Canali BBSV 1800 and the values shown will not apply to other makes or even sizes and models. It is included only as a guide to the layout and weights must be calculated for your machines using the details of your blades and your machine's lever arms.

The efficient operation of the straining mechanism relies on the machined vee's being kept free from sawdust which, if never looked at hidden behind their covers, will clog up and become quite compressed and solid and so will not allow the lever to move freely. The knife edges too need re-sharpening from time to time as they eventually wear round and lose their sensitivity. If you undertake this yourself be sure that the edges are square and do not remove too much metal or you may easily remove the hardened and tempered end and your new sharp edges may not last if they are soft. Because the knife edges carry all the weight of the top pulley and all the strain it is much safer to return the knife edges to the manufacturer for re-conditioning if at all possible.

Guide Adjustment:
After our blade is safely tracked and strained up the next item which is not given enough attention is the maintenance and adjustment of the blade guides. You just cannot expect a thin bandsaw blade which you can easily move sideways by hand to cut logs or even small planks in a straight line without really good support from the guides. If you can grip a 200mm wide blade and move it sideways in the guides say 1mm then think how much that blade could run out in the length of a 6 metre log!

There are two types of guide, those which hold the blade in a straight line in-between the two pulleys which we will call *STANDARD GUIDES* and the more modern *PRESSURE GUIDES* which deliberately hold the blade out of line of the pulleys to give a much stiffer blade for high speed sawing.

Special materials are available for use as guide blocks and any of these are good, however most sawmills still use hardwood for the blocks and this too is perfectly satisfactory providing that a close grained wood is chosen and, to ensure even wear, the *END GRAIN* is used as the contact face.

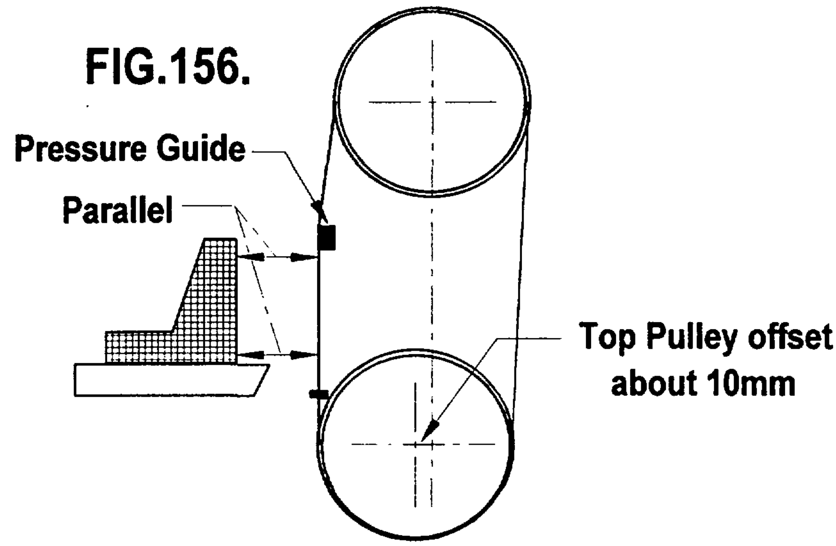
Standard Guides:
Because this type of guide should hold the blade in a straight line, altering individual worn guide blocks is not a good idea. Periodically, perhaps once a week, the blocks should be removed and trued up on their ends and re-set carefully. The inside bottom blocks are adjusted first making sure not to move the blade sideways, starting with the front block first as this is always the most important being next to the teeth which do the work. Next set the outside blocks up tight to the blade but with a piece of thin paper in-between the blocks and the blade. This is to ensure that the guides do not grip the blade and throw extra strain on the power driving the pulleys. The same procedure is carried out with the upper guide blocks, again making sure not to move the blade sideways with the positioning of the first inside blocks. The front guide should be 3-6mm back from the gullets the same as the overhang on the pulleys, then as the blade moves back on entering the cut etc., the teeth do not cut into the guides.

Pressure Guides:
The construction of pressure guides is much stronger than the standard type so do not try to adjust standard guides as pressure guides.

The details of pressure guides will vary slightly with different manufacturers but the principal of how they work is the same and in the end what is important is that the portion of the blade that is doing the work *MUST* be parallel with the resaw fence or the log bandmill carriage knees. See Fig.156.

Outside guide blocks are not necessary on the top pressure guide although they are fitted to the bottom guide if these are not under pressure as in Fig.156.

FIG.156.

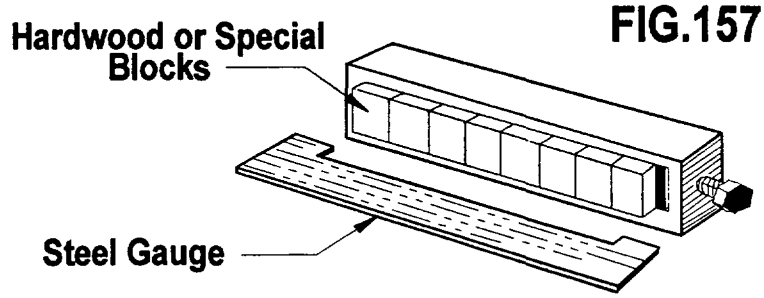


As I said earlier designs vary with different manufacturers and we cannot cover all makes but I suspect that if we describe one system it will suffice to show the principles involved in setting up the guides correctly. This system moves the top pulley to apply the pressure to the top guide and the amount of off-set can be varied with this system. The top pulley may alternatively be fixed and in this case the top pressure moves out and must be plumbed up with the fence or knees. This will be for a fixed amount usually around 10mm.

It can be seen from Fig.156. that the top pulley is not over the bottom pulley when the machine is working, but for guide setting it is moved out and in line and parallel with the resaw fence or knees on the log carriage. When the top pulley is moved inwards to apply the pressure to the top guide, the top guide *MUST* hold the blade in that exact same position. It is vital that this guide is maintained in *PERFECT* condition since the blade will, under the sideways pressure, form to the shape of the guide blocks and if they are worn and curved then the blade will be curved and will not cut straight.

Having found the exact projection of the blocks from their holder, I thought it best to make the sawyer a gauge to set the blocks to so that they could be adjusted with the blade off the machine and out of the way. This is shown in Fig.157.

FIG.157.



The sequence of setting is as follows:-

(1) True up any worn guide blocks making sure that the one nearest the teeth is perfect and fit them to the gauge. Also ensure that the first block is the correct distance back from the gullets i.e. the 3-6mm as the overhang.

(2) Set the top pulley out towards the fence or carriage with the eccentric. This will probably be marked at zero See Fig.158.

(3)With a blade strained up on the machine, and all guides moved away adjust the top guide holder so that the blocks just touch the blade without moving it from its vertical position. Note that with using a gauge to set the blocks to, this adjustment can be eliminated although the basic setting of the blade being vertical should be checked from time to time because of possible wear or adjustment needed on the top guide's slide. See 1. Fig.159.

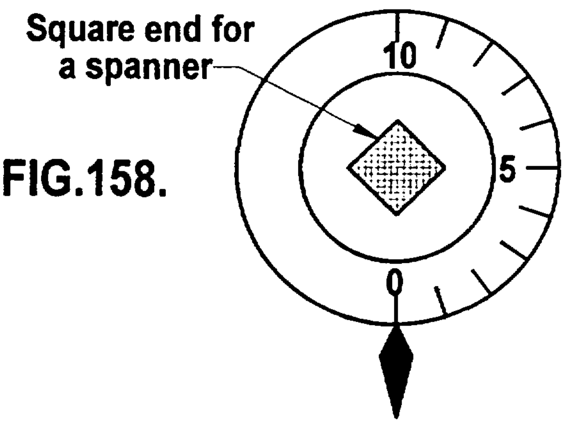


FIG.158.

(4) Adjust the bottom inside guide next making sure not to move the blade out of line. See 2. Fig.159. This too should be the correct 3-6mm back from the gullets.

(5) Now adjust the outside guide blocks to a piece of thin paper set against the blade to ensure that the guides are not gripping the blade. See 3. Fig.159.

(6) Finally move the top pulley inwards to put the top guide under pressure. This is done by turning the eccentric to the recommended number which maybe 5 for resaws and 7 for log bandmills according to the manufacturers recommendations. See Fig.160.

FIG.159.
Guide setting sequence

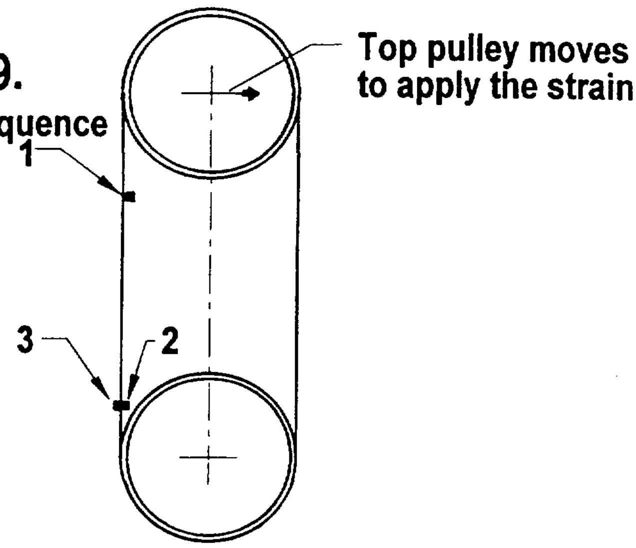
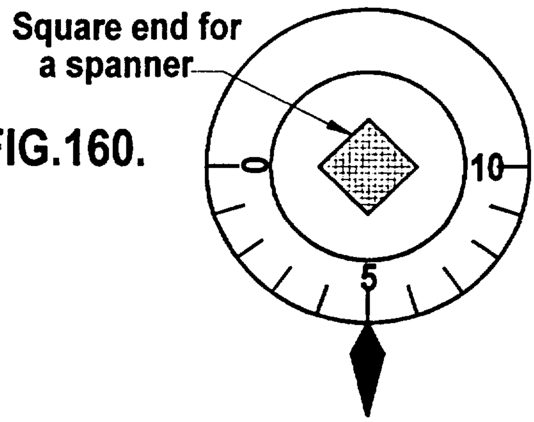


FIG.160.

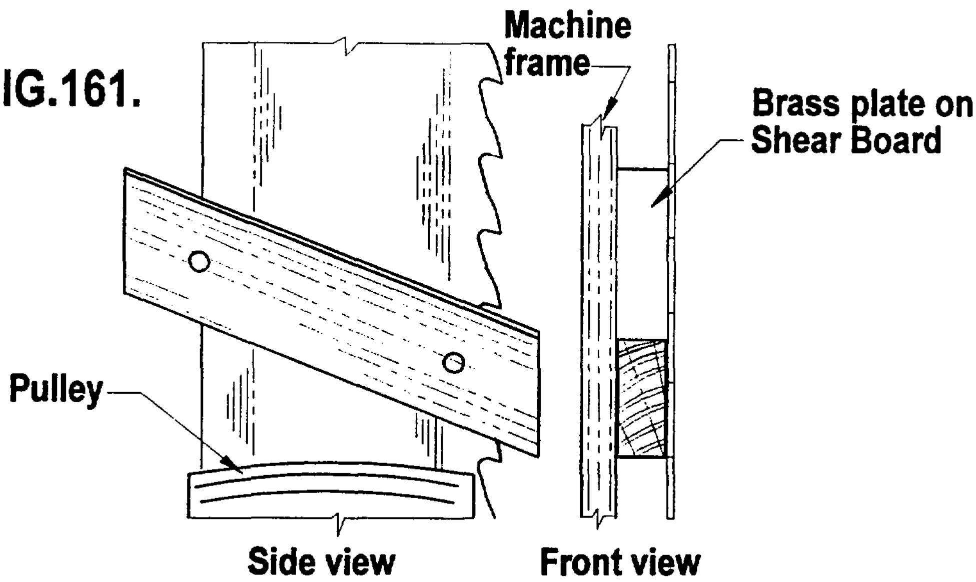


Scraper, Cleaning and Shear Board Maintenance:

Shear Boards:
I do not know where the name shear board came from for its function is to *DEFLECT* the sawdust which leaves the teeth at the exit of the cut so it would seem more appropriate to call it a sawdust deflector. Anyway it does not matter what we call it as long as we understand what its function is and why it is necessary. As you know as the sawdust leaves the gullet it is thrown forward as the teeth leave the cut and if not deflected outwards, some would end up trapped between the pulley and the blade and being compressed in that position will often stick to either the blade or the pulley. If this sawdust is not removed by scrapers and cleaning pads it will continue to run around and would build up and eventually cause lumps and possibly cracks in the blades. The shear board is then placed at this point to deflect the sawdust forward away from the pulley and is shown in Fig.161.

The angle of the top surface is usually about 60° to the travel of the blade and the front end, to do its job properly, projects beyond the teeth. Because of this projection and the force of the sawdust striking it the area around the teeth suffers quite a lot of wear. To minimise the wear very hard timber is used and for additional protection against wear the top surface can be covered with a soft metal such as brass or aluminium or even a plastic such as "Formica". The thickness of the shear board is critical and must just fill the gap between the machine casting and the blade to prevent the sawdust entering down the gap at the side. If too thick so that it touches the blade the blade might rub and get hot. Shear boards normally last a long time before they need replacing especially if they have the metal plate on top, however they eventually wear away so that they no longer prevent the sawdust entering the danger gap and must be renewed. Tell tale signs for the sawdoctor of this wear and of scrapers not working are when blades come from the machines with sawdust stuck to the inside.

FIG.161.



Pulley Scrapers:
Both pulleys are fitted with a soft metal or plastic scraper to remove any sawdust that has stuck to the pulley. These are often neglected especially the one hidden underneath the base for the bottom pulley. In fact I have often found these completely worn away and when pointed out no-one knew that they ever existed! Two things need attention, first the fit against the pulley must be maintained and second the pressure, whether it is by weight or spring, must be adjusted so that the scraper is able to remove sawdust stuck to the pulley but not too strong that the scraper wears away too quickly.

Cleaning Pads:
On well built machines felt cleaning pads are usually fitted to both pulleys and to the blade and they are lubricated to assist in the cleaning process usually by paraffin or diesel oil. This oil is for *CLEANING* and not to lubricate the blade although it does no harm in this respect. The point is that lubricating systems need not pour lots of oil onto the blade they only need to keep the cleaning pads moist to help remove resin or gums from the blade and the pulleys.

On cheaper machines not fitted with these cleaning facilities, sawyers usually have a bucket of oil next to the machine and with a rag on a stick slosh quantities of oil onto the blade and pulleys on start up and again from time to time whilst sawing . This is all right providing that they understand why they do it. It is to clean and not lubricate! In other words they generally overdo it and waste too much oil and might even cause the blade to slip on the pulleys.

Sawdust Accumulation under the Machine's Base:
Sawdust especially if it is wet will accumulate underneath the base of the machine and from time to time will drop down sometimes in large lumps. If this occurs over the pulley the sawdust can easily drop into the vee between the pulley and the blade and will almost certainly cause damage to the blades. To avoid this and costly repairs to blades, routine cleaning at least once a week but preferably every shift is much less costly.

Final Comments:
Most of what we have stated in this chapter is common sense if we think about it. Unfortunately many sawyers are not properly trained and don't think about it. Why should they? They have been shown how to feed timber into the machine and the faster they do it often the more they get paid. What if the blades crack, they just call for a new blade and for all they know cracked and damaged blades are inevitable and *NORMAL!!* They are not!!

It is the responsibility of *MANAGEMENT* to ensure that the necessary cleaning and maintenance is carried out and that someone is made responsible for each of the various jobs and that they understand *WHY* those jobs have to be done so that they are done in the right way. It is no use for instance relying on labourers to do machine cleaning unless the work is supervised and inspected. Or even rely on semi-skilled sawyers to maintain their own machines without the necessary training. After all we don't normally let people drive cars without a driving licence yet we are often quite happy to allow yesterdays labourer to drive our multi-thousand dollar log bandmill with little or no training at all!

CHAPTER 11

Straight Knife Grinding:

Introduction:
The use of the modern straight knife grinding machine is perhaps the most straightforward of the machines encountered by the sawdoctor and it does not matter very much what size the machine is or how big or small the blades are that you have to sharpen it is mainly the various angles which we choose to suit the various materials to be machined that is most important.

Blade Terminology:
The term blade is usually used to refer to thick (9mm and above) carbon steel blades which may or may not have tips of various alloys for the cutting edge whereas the term knife is used for thin blades usually without a backing material. The term cutter will usually be used for tooling which is used for shaping wood as opposed to straight planing or slicing.

Materials to be ground:

1. **High Carbon Steel**: This was the first material used for blades in solid form or backed by a low carbon or mild steel backing. These days it is seldom used in woodworking having been superseded with harder materials which stay sharp longer. High carbon steel, apart from being perhaps the cheapest material, still has one advantage over other cutting agents in that it will more easily sharpen to a razor like edge. This is useful for cutting some materials such as paper and is therefore still used for guillotine blades for this purpose. Grinding can be carried out using ordinary Silicon carbide grinding wheels of suitable grade.

2. **High Speed Steel:** The majority of blades, knives and cutters used in our woodworking industry as well as the larger engineering industry are made of this alloy. Unlike carbon steel which will lose its hardness if over heated, the temper of H.S.S. is not affected by heat and will retain its sharpness when hot. It also has the ability to stay sharp longer than carbon steel especially when cutting harder and dry timbers. H.S.S. will take a fairly fine cutting edge. Again Silicon carbide grinding wheels are used for grinding.

3. **Tungsten Carbide:** This is not a steel but a product of powdered metallurgy which means that the ingredients are not melted as in the production of steel but are crushed into powder which is compressed under tremendous pressure to form various sized blocks and strips. These blocks already formed to the correct shape are *SINTERED* i.e. fired in an oven in a similar way to house bricks and clay roof tiles to make them into solid items suitable for use as cutting agents. Just like bricks and tiles, tungsten carbide cutters are very *BRITTLE* and because of this are not made in long lengths which would easily break when handled. Because of this, if long blades are needed, they have to be made up of short lengths brazed or welded to a low carbon steel backing. Again because of the brittleness blades tipped with tungsten carbide must be handled with extreme care otherwise they are very easily damaged. Tungsten carbide tipped (T.C.T.) blades will not take a fine

cutting edge because of the brittleness of tungsten carbide therefore an angle of 40° is generally used as standard. Tungsten carbide tipped blades also need special *DIAMOND* grinding wheels to sharpen them.

4. **TMC45:** This is the product of a new development by Fritec Ltd. U.K. of an existing technology called friction welding and the knives, blades and cutters manufactured by this development are proving in U.K. trials to have significant advantages over H.S.S. and even T.C.T. in the woodworking and other industries. The two main advantages are in longer cutting edge life (between 2 and 20 times longer) and the fact that the material can be sharpened using silicon carbide grinding wheels which in itself can be a tremendous saving on the expensive diamond wheels necessary for sharpening T.C.T. tooling.

Hollow and Straight Grinding:
Most if not all modern straight knife grinding machines use cup, ring or segmental grinding wheels. This is because, unlike straight wheels which reduce in diameter as they wear and so lose their efficiency, they do not lose their efficiency as they wear away. However we need to briefly cover the difference in the effect on the cutting edge of hollow grinding.

Straight grinding wheels if used will produce a *HOLLOW* grind as shown in Fig.162. The smaller the diameter of the wheel the more pronounced will be the hollow. The only advantage of hollow ground edges is that if honing the cutting edge after grinding the oil stone may be held flat on the grind and since it will only touch on the two high points honing will be easy and the correct angle will be maintained. The big disadvantage is that the cutting edge can have a much smaller and *WEAKER* angle than the overall grinding angle because of the hollow grind. See Fig.163.

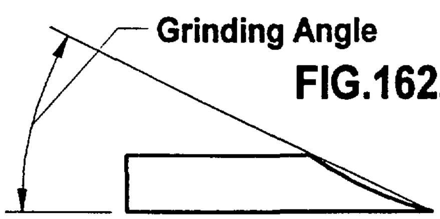


FIG.162.

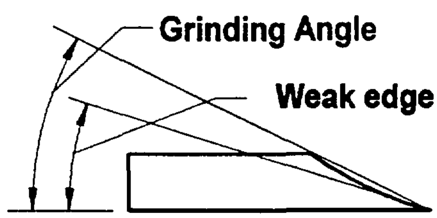


FIG.163.

Cup, ring and segmental grinding wheels will for all practical purposes produce *STRAIGHT* grinds as shown in Fig.164. although in theory if the grinding head is tilted at an angle then the grind becomes very slightly elliptical or hollow but not sufficient to alter the grinding angle in practical terms as set on the machine's scale. Actually cup wheels should always be tilted slightly usually 2°-5° so that only one side of the wheel works. Usually it is recommended that the side which is turning *INTO* the cutting edge is used as shown in Fig.165. but more about this later.

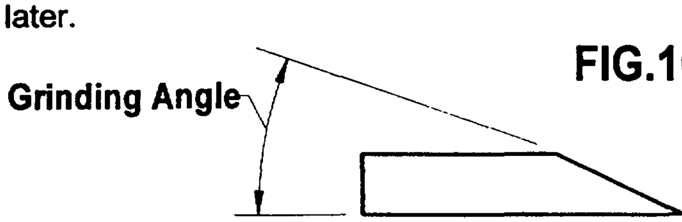


FIG.164.

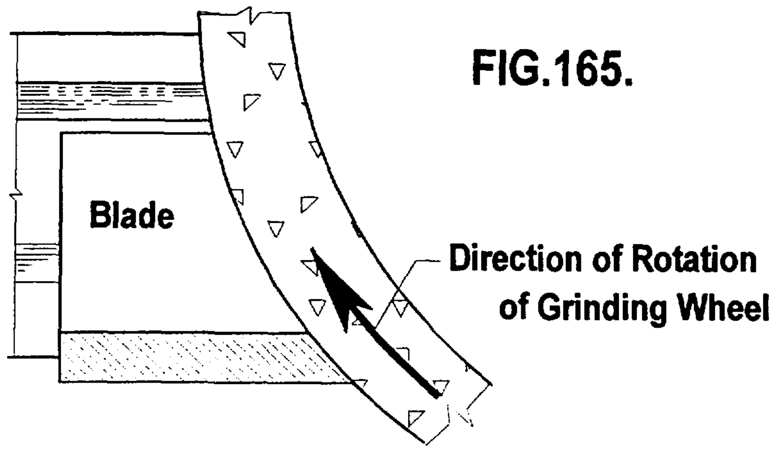
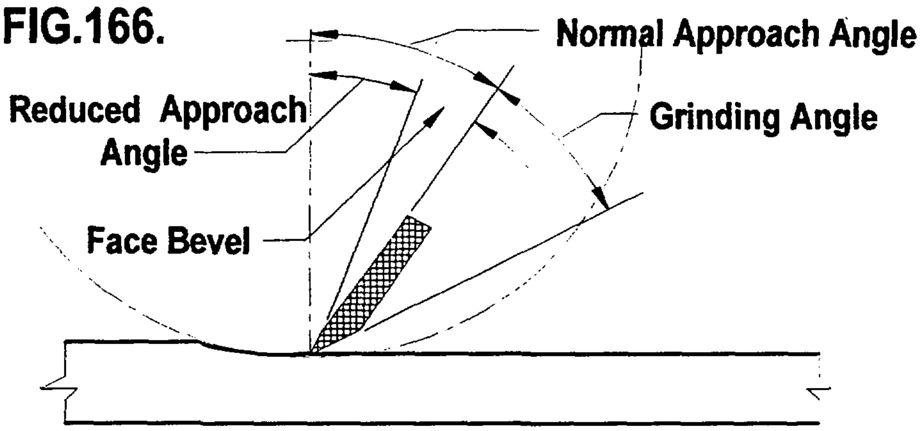


FIG.165.

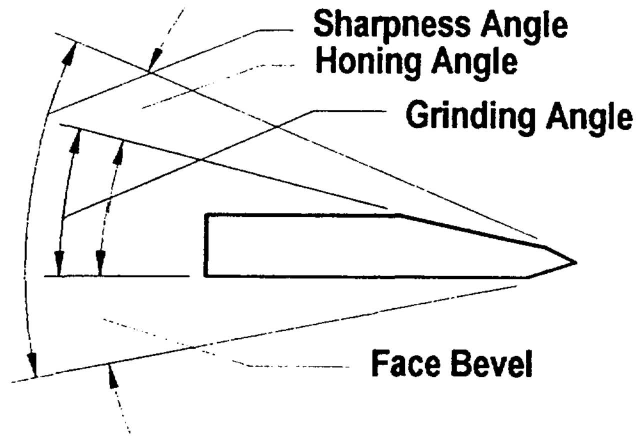
Angle Terminology:
The sawdoctor should understand the terms used for all the angles as applied to woodworking, these are illustrated in Fig.166. and are as follows:-

FIG.166.



1. Cutting or Approach angle: For rotating cutterblocks it is the angle made by the face of the cutter and a line from the cutting edge to the centre of the block. This can be reduced if a Face bevel is applied to the cutter.
2. Grinding angle: This is the angle as ground onto the cutter and shown in Fig.162. and 164.
3. Honing angle: This on straight ground thick blades is usually a guessed 5° extra added to the grinding angle to make honing easier. For example if we are preparing blades for planing softwoods we may use a grinding angle of 30° plus a honing angle of 5° to give a Sharpness angle of 35°.
4. Face Bevel: This may be applied to the face of planer blades and knives to reduce the approach angle to improve the quality of the planed finish when planing interlocked grained hardwoods such as Sapele. For example if the cutterblock in use gives an approach angle of 30°, a face bevel of 5° or 10° reducing the approach angle to 25° or 20° will often prove successful in preventing the plucking out of the grain which is against the direction of cut.
5. Sharpness Angle: This is how sharp the cutting edge is and is basically the grinding angle but may or may not be added to by a Honing Angle and a Face Bevel. For example 30° + 5° + 5° = 40° as shown in Fig.167.

FIG.167.



It is true to say that the smaller the sharpness angle the easier the blade will cut, but unfortunately blades with very small angles will blunt more quickly than blades with larger and more obtuse angles. Because of this the correct angles for a particular application are always a compromise between nice thin cutting edges which will cut easily and larger angles which will stay sharp for a practical length of time. Our aim should be to use the smallest angles possible which give reasonable cutting edge life. Some typical examples will illustrate this best.

1. Guillotine blade for cutting paper, this will often be as small as 18°.
2. Guillotine blade for rotary peeling softwood veneer, 30°.
3. Planer blades for planing softwoods, 35°.
4. Planer blades for planing hardwoods, 40°

This covers all the range that we are likely to come across as anything less would be too thin and weak and anything bigger than 40° would gain nothing in retaining the sharpness and would also increase power consumption.

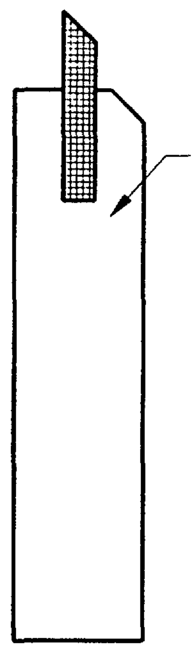
Honing the Cutting Edge:
If we finish off our grinding by stopping the down-feed of the grinding head and continue to pass over the ground edge for a few more passes the resulting finish on the grind will be improved and even with a course 30 grit wheel the finish can look very good. However if we placed the cutting edge under a microscope we would be amazed how rough and irregular the edge would be. It has been proved that these rough edges turn in on themselves and break down more quickly than a smoother sharper *HONED* edge, therefore the sharper the cutting edge is the longer it will retain its sharpness before it needs re-sharpening. It is therefore well worth the extra time taken to hone all cutting edges making them as sharp as we can. One thing which is not always appreciated is the fact that no-matter how long you hone a cutting edge it will never become really sharp unless the face of the cutter is also honed smooth. In other words a sharp cutting edge is made up of *TWO* surfaces and if one is rougher than the other the edge will only be as sharp as the roughest surface. Because of this the face of the cutter needs honing just the same as the ground edge. This is especially true on new blades which may take a lot of rubbing on the flat faces before they are smooth enough to take a really sharp edge.

Honing is best done with a special *ROUND* oil stone. These are made with a groove around the edge to place the fingers in to ensure that they are safe and because the hone is round it will stay flat and not become hollow as rectangular shapes do. They are usually made with one side fine and the other coarse. Finally there will often appear what we call a wire edge on the cutting edge, and this needs removing otherwise it will turn in on itself and immediately blunt the sharp edge. Joiners strop their chisels to remove this on the palm of their hands but for our purpose perhaps the best way is to drag a small scrap piece of softwood along the cutting edge and when the wire is removed give the edge a final light rub on both sides.

For narrow knives which are awkward to hold, a wooden holder as shown in Fig.168. is well worth making.

The Machine:
The straight knife grinding machine is a fairly straightforward piece of machinery but there are a few points worth mentioning in case someone is thinking of investing in a new one.

FIG.168.



1. Like most machinery the heavier the machine is the better it is likely to perform all other things being equal.
2. The rails on which the grinding head runs should have easily replaceable steel strips on top to protect the surface from wear.
3. The grinding head should have automatic down-feed which can be varied to suit the blades being ground.
4. The larger the grinding wheel the better as large wheels cut more efficiently than smaller wheels. The segmental type as fitted to the larger machines is much better than ring or the cup type although these will often be fitted to the smaller machines.
5. A fixed diamond dresser to dress the new wheels or segments is a very useful item as large wheels will otherwise take time to dress themselves to the correct shape and until they do the machine will not work at top efficiency. Note that if the correct grade of wheel is used further dressing should not normally be needed as the wheel should break down to offer new grains as the worn grains become dull.
6. The grinding head should have adjustable tilt so that the few degrees needed to ensure that the wheel grinds in one direction can be adjusted. This is to enable slight hollow grinding if necessary but also I found that it was useful to increase the angle for thin knives to prevent overheating of the knives which could occur when the full width of the segments were contacting the thin H.S.S. knives. This is instead of relieving the edge of the wheel by dressing.
7. A reversible grinding head motor might be useful if available for although standard practice is to rotate the wheel towards the cutting edge as shown in Fig.165. I found that with grinding thin angles for guillotine blades for the

paper industry, if the head rotated inwards it carried worn broken off grains into the delicate cutting edge and damaged it and when we reversed the motor this solved the problem.

8. The grinding head should be fitted with a pumped supply of coolant which must be sufficient to *KEEP* the cutting edge cool, not cool it after it has become hot. The coolant pump must have an efficient filtration system to filter the coolant so that old abrasive grains from the wheel are not sprayed with the coolant onto the cutting edge being ground.
9. Although an expensive extra, electro-magnetic clamping of the blades is an extremely useful addition which speeds up considerably the securing of the blades to the machine. The extra cost of magnetic clamping is only justified if you are involved in grinding many different sizes and thicknesses of blades and knives as in servicing and maybe in very large factories.

Rebating Cutters:
Some planing machines have the facility to do rebating on the end of the cutterblock and the cutters for these and for smaller cutterblocks used for rebating need to have clearance ground onto the ends to prevent burning. This may be done in several ways, first with a compound angle of about 3° in both directions as shown in Fig.169. This will give the best clearance but if the timber is fed using a high rate of feed then the side of the rebate cut by the end of the cutter will have a similar finish to a sawn surface.

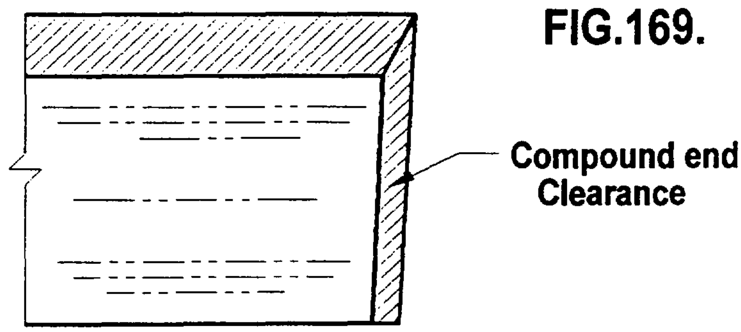


FIG.169.

For a better finish the end may be ground with a single clearance angle leaving the end square which will scrape the side of the rebate smooth but may have a tendency to spelch off corners of the wood as the cutter end leaves the rebate. This is shown in Fig.170.

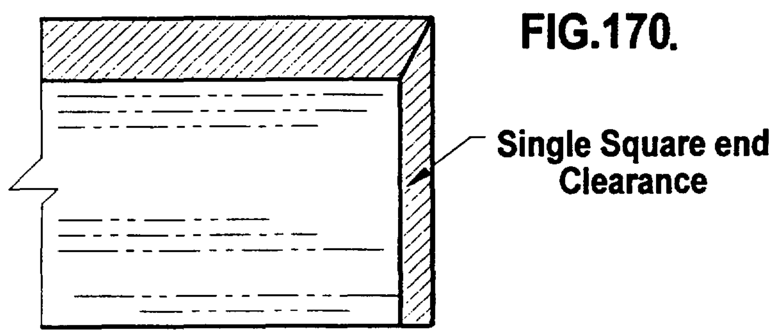
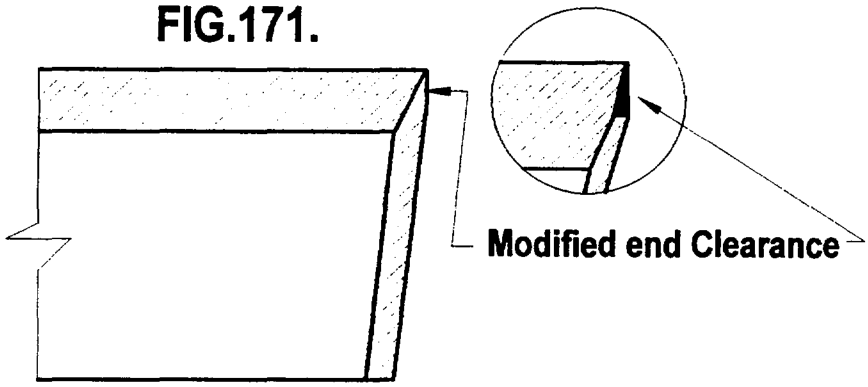


FIG.170.

A method which combines both of these is shown in Fig.171. This I feel is the best solution with the small square end being long enough to cover the feed forward of the timber usually no more than 1-2mm so that a square end with a length of 3-4mm will be quite adequate.

FIG.171.



Balancing of Blades & Knives:
All blades knives and cutters that rotate at high speed as on planing and moulding machines must be balanced. This not only means that the weight must be the same but the *DISTRIBUTION* of the weight must be the same. In other words it is no good having a pair of cutters that weigh exactly the same if one is heavier at one end and the other is heavier at the opposite end, this would cause vibration and possible damage to the machines bearings. Because of this normal weighing scales are no good for balancing sets of blades and a special cutter balancing stand is needed. By placing cutters to be balanced on the balancing stand against the end stops and turning them around into different positions any discrepancy can be found and the position of extra weight located. A visual idea of the amount needing to be removed can be obtained by adding small weights such as small nails on top of the lightest cutter until it balances.

With thin H.S.S. planer knives the material is so uniform in structure that if the knives measure the same in all directions so that they are identical in all respects then it is almost certain that they will balance when tested. Therefore with these, and in fact all types, the first thing is to maintain all blades which are in sets to the exact same dimensions. Thick heavy blades as used on square cutterblocks even when maintained to the exact same dimensions are often not perfectly balanced this is due to imperfections in the brazing on of H.S.S. cutting faces and differences in the size and shape of slots for the cutterbolts. These heavy blades must be balanced in sets and after ensuring that the overall sizes are identical any difference in balance is best corrected by grinding small amounts from the inside of the slots. Cutters supplied in sets will normally have an identifying number stamped on and so care should be taken to keep them in the same set if possible. Other sets not marked by the manufacturer should be marked in the workshop to prevent them being mixed up and re-ground to match other sizes.

CHAPTER 12

The Universal Tool and Cutter Grinding Machine:

Introduction:
The name of this machine is misleading since if implies that it is capable of sharpening all types of tools and cutters, this of course is not true but the machine is capable of grinding a wide range of cutting agents for both the woodworking and engineering industries but only if the necessary attachments to hold the various cutting agents are purchased. Because of the wide range of attachments available they are not often supplied with the machine but have to be specified as extras, so take care when ordering as the basic machine by itself may be almost useless.

Machine Capacity:
Machines are available in several sizes and their capacity is measured by:-

1. The movement of the main table sideways,
2. The cross-movement of the table towards and away from the grinding head,
3. The height at which the grinding head can be raised above the main table,
4. The height above the table of the centres or the workhead. The main table movement governs the length of cutter which can be ground. Whilst the other three govern the diameter of tooling. See Fig.172a. & b.

FIG.172a.

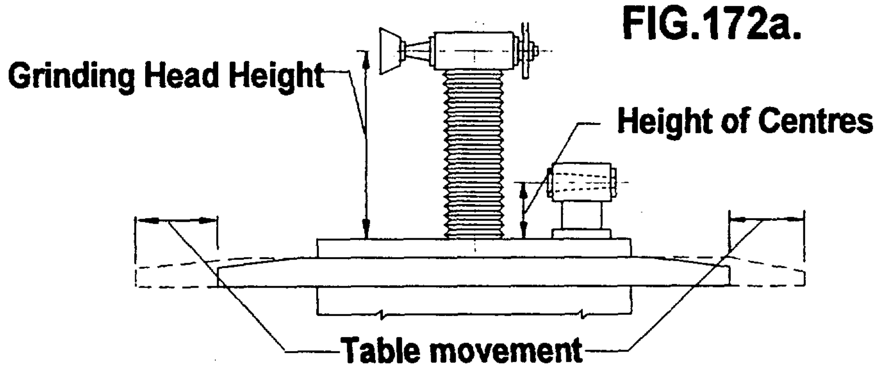
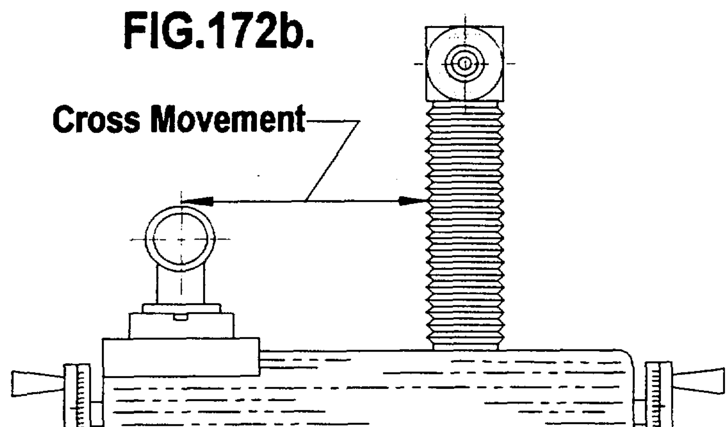


FIG.172b.



Grinding Head:
The grinding head should swivel through 360 degrees and is best if it can be fitted with grinding wheels at both ends of its spindle. In addition more than one spindle speed is desirable so that different diameter grinding wheels can be run at their most efficient speed which is around 1800m/min. It is also desirable that the spindle can be run in both directions, i.e. clockwise and anti-clockwise, controlled by a switch in the electrical circuit.

Work Table:
The sliding table on which all attachments are fixed may or may not have a top half which can also swivel through 90 degrees. This feature allows small tapers to be ground very accurately, important on engineering tooling and also allows the workhead to be swung away from the grinding head thus increasing the capacity for large diameter cutterheads often used in the woodworking industry.

Centres:
The first attachment is a pair of centres, one for each end of the work table, on which tools that have centres at each end such as engineering slot drills may be mounted and sharpened. Also cutterblocks mounted on centred spindles can be held in this way for grinding. In addition, one of the centres may be used in conjunction with the workhead to give extra support to heavy cutterblocks. The height of the two centres above the work table governs the maximum diameter of cutterblock which can be ground. Example, if the height of the centres is 150mm, then the maximum cutterblock diameter would be 300mm. The centres should be *MATCHED* pairs so that they align with each other perfectly in all directions when attached to the work table. If used in conjunction with the workhead, this too should be matched to the centres. On good quality machines these items will be stamped with a number to show that they have been matched and because of this it is best to order these three items at the same time.

Workhead:
These vary considerably from simple fixed heads with no movements to heads which will turn through, up to 360 degrees, in both the horizontal and vertical planes. The workheads are bored out to receive various spindles or arbors on which the cutters to be ground are fixed. The arbors having a taper at one end to ensure the necessary accuracy when fitted and drawn up tight into the bore of the workhead. These tapers are standard tapers known by their numbers and names, for example, No.50 International, No.4 Morse etc. Accurate sleeves to reduce the size of the tapered holes can be supplied so that tooling with Morse taper shanks can be fitted to the workhead. Obviously, the larger the hole in the workhead the better, for it will accommodate a wider range of arbors.

The workhead should be capable of being fitted with indexing attachments. These usually take the form of hardened steel rings accurately machined with various numbers of slots equally dividing up into the 360 degrees of their circumference. The most useful indexing ring for the woodworking industry has 24 slots thus dividing the angle between each division to 15 degrees. With this ring fitted to the workhead, cutters with 24 teeth can be sharpened accurately moving the cutter one slot at a time. By indexing more than one slot cutters with 2, 4, 6, 8, and 12 teeth can be sharpened using the same indexing ring. Obviously mistakes can be made if indexing more than one slot at a time possibly causing damage to cutter and grinding wheels and even injury to the operator if a wheel breaks. Because of this ideally the indexing ring should have only the same number of slots in it as the cutter being sharpened.

Machine Movement:
The main worktable slides on some form of roller bearing so that the cutter being sharpened can move past the grinding wheel smoothly and easily in order to give a smooth finish to the ground surface and so a sharp cutting edge to the cutter. On the better machines the cross-slide movement and grinding head height adjustment are controlled with handwheels situated on both the front and the back of the machine. This enables the operator to choose his working position which may be better in different positions for different grinding set-ups. Both these movements should be provided with finely graduated scales in metric or imperial measure as used in the country. On the better machines, these scales can be zeroed (i.e. set to zero) at the start of grinding so that the amount of cutter removed can be read off the scale more easily and more important be return to zero for the next cutting edge to be sharpened when a tool has more than one cutting edge.

Choosing a Machine:
All the points so far discussed should be considered when choosing a machine for it would be disastrous to find you had purchased a machine which would not accommodate the largest cutterheads or less seriously the indexing disc did not match up with the number of cutting edges on your tools.

Finally on machine selection, as with all machines, a heavy machine is always better than a light machine, all other things being equal, since there will be less vibration when the machine is running which in turn will give smoother and therefore better results with your sharpening.

Safety:
Accidents can easily occur if the workpiece or moving part of the machine crashes into the grinding wheel resulting in a broken wheel, damaged cutter or even injury to the operator if a grinding wheel shatters and is flung in all directions. To avoid this happening the operator must always *THINK* what the consequence will be before making any adjustments especially when the grinding wheel is rotating. They must *ALWAYS LOCK* the slide of the main work table before making any adjustments with spanners etc. They must *ALWAYS USE* the guards provided to cover the grinding wheel and attach them in such a position so as to give maximum protection. They must be very careful not to use the high spindle speed of the grinding head with large diameter grinding wheels as too high a peripheral or rim speed could cause harmful vibrations and even may cause a wheel to shatter. Grinding dust is very harmful if breathed into the lungs over long periods. Tungsten carbide dust is especially dangerous and can completely ruin workers' health. It is essential

that during grinding operators should wear masks and ideally if grinding tungsten carbide tools the machine should be equipped with a pump to supply coolant to the cutter being ground so that the dangerous dust is washed away. Last but not least in importance the operator should always use shatter proof grinding goggles, then in the case of an accident these can easily be replaced but *EYES* cannot.

Getting to Know the Machine:
When confronted with a new or strange machine it is a good idea for the operator to familiarise himself with all the various adjustments of the machine without trying to sharpen anything, this will help to prevent mistakes and accidents later when tools and cutters are placed in the machine for sharpening. Having done this, it is then sensible to start on old cutters which if the results are not perfect the damage is not so serious.

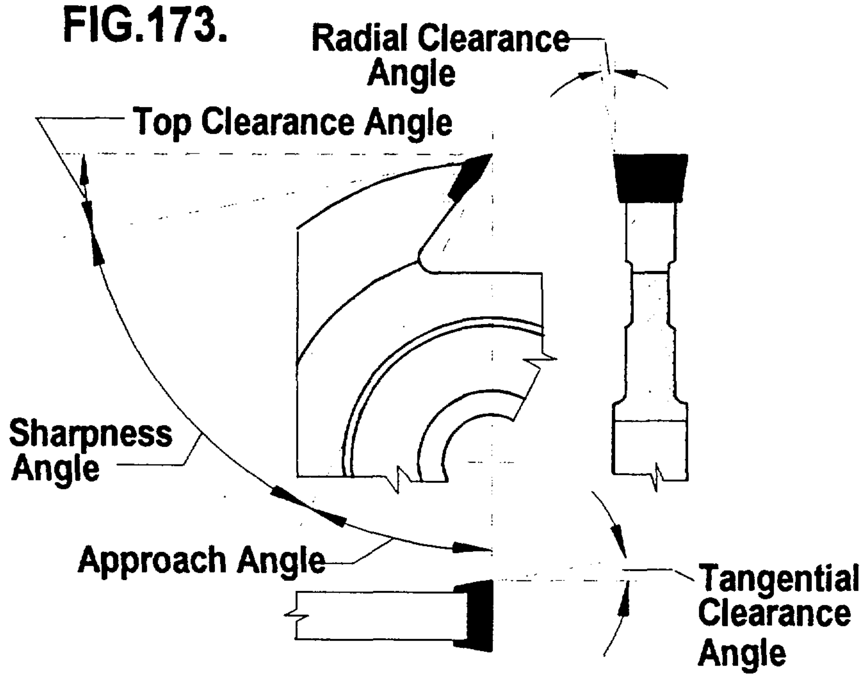
Care of the Machine:
It is vital that all grinding machines are kept as clean and free from abrasive dust as is possible. This dust generated when grinding must contain abrasive particles from the grinding wheels being used and if they will grind tool steels they will certainly wear away moving parts if they are allowed to accumulate on the machine. It is therefore good practice to clean off the machine every time a set-up is changed from one type of tool or cutter to another. Tapered arbors on mounting spindles for both tools and grinding wheels should always be cleaned before fixing to the machine. This not only prevents wear but must be done to ensure that these parts revolve accurately, if not, grinding wheels will vibrate and give a poor finish and tools will wobble and so be sharpened out of true. Care of the sliding table is very important since all grinding relies on this for smooth surface finishes. The bearings and sliding surfaces are protected from grinding dust but cannot be sealed entirely, therefore operators should not clean down the machine with a blower or compressed airline as this will blow grinding dust into the vital moving parts. Instead, simply brush down the machine or ideally use a vacuum cleaner to remove the dangerous abrasive grinding dust.

Tool Cleaning:
Before mounting any tool on the machine for sharpening it must be cleaned to remove resin and wood dust which if left on the tool would clog up the grinding wheels causing them to glaze and burn the surface being ground. Although water, paraffin and diesel oil and special solvents can be used to soften resin and gums on tools before they are cleaned it is less messy to scrape off all resin from flat surfaces using a simple scraper made from an old flat file or piece of wide bandsaw steel and for difficult shapes such as router cutters these can very quickly be cleaned with a revolving wire brush attached to a bench grinding machine. Again goggles must be worn and the operator should not stand in-line with the wire brush when doing this work.

Angles defined:
Before we discuss methods of sharpening specific types of cutting agents it will be as well to define the basic angles used on woodworking cutting tools. In

general the angles used are much greater than those used on engineering tools. See Fig.173.

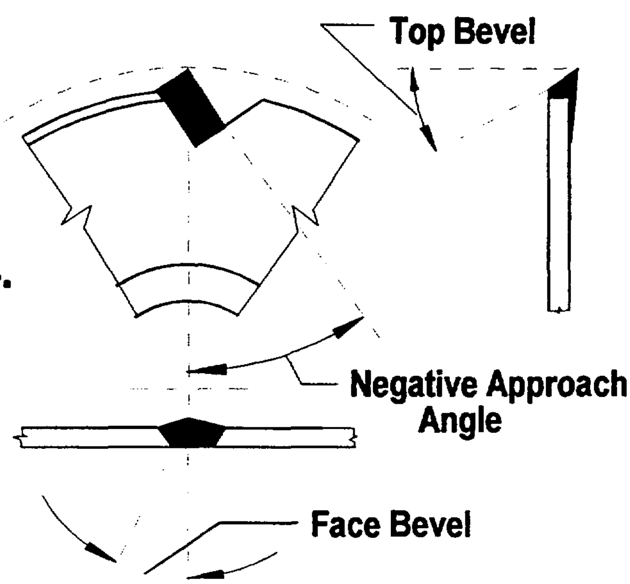
FIG.173.



Cutting or Approach Angle:
This is the angle at which the face of the cutter approaches the work and usually varies between 10° and 35° we call it the *HOOK* angle on saw teeth. Tools will cut more easily and use less power when cutting angles are large and are generally used for machining softwoods. Small cutting angles are generally used for difficult interlocked grained hardwoods helping to prevent tearing out of the grain and so giving better machined surfaces.

Negative Angles or Rake:
Some-times the front or face of a cutter may lean or rake backwards giving it a *NEGATIVE* cutting angle. The angle may vary between 6° and 30°. For example, 6° negative hook may be used on tungsten carbide tipped saw teeth for cutting plastic or aluminium and these blades are sometimes used in the woodworking industry.
Larger negative cutting angles are used on *SCRIBING* or *SPUR* cutters which score the surface before a main cutter comes along and removes the wood. These spur cutters are essential to prevent *SPELCHING* on boring tools, trenching and grooving cutter-heads working across the grain. See Fig.174.

FIG.174.



Clearance Angles:
The tops and sides of cutting edges must be ground at an angle to prevent these surfaces rubbing on the wood being cut otherwise heat will be generated by friction causing both cutters and wood to burn (turn black) and in the case of saw blades may cause the blade to wobble and be damaged. The clearance angle on rotating cutters has to be quite large in order to allow the high feed speeds used in the woodworking industry. The top or main clearance angle will usually be 15° for tool steel and H.S.S. cutting edges and reduced to 12° for the more brittle T.C.T. cutters. However the backing steel behind tungsten carbide tips may often be relieved with a few degrees more to give better clearance. In this case we have two clearance angles known in engineering as *PRIMARY* and *SECONDARY* clearance angles. In engineering the width of the primary clearance (called the *LAND*) is kept to a very small size usually no more than 1mm and we can do the same on large T.C.T. tips but on saw tipped teeth the whole tip could be one angle and the backing steel another. Clearance on the sides of saw teeth and of cutters called *SIDE CLEARANCE* can be fairly standard at 3°. These may be further defined as *RADIAL* and *TANGENTIAL* side clearance angles and are shown in Fig.173.

Sharpness Angle:
The sharpness angle is the remaining material of a cutting edge when cutting and clearance angles have been ground on. For example a cutter with a cutting angle of 30° and a top clearance angle of 15° would have a remaining sharpness angle of 45°. This is also shown in Fig.173.

Top and Face bevels:
Some saw teeth and cutters may be sharpened out of square on their faces and tops this we call *Face* and *Top bevel*. The reason for these extra bevels may be to give a shearing cut or to turn the cutting edge to another edge as for crosscutting or for scribing cutters. See Fig.174.

Obviously we cannot cover all the angles found on such a wide range of cutting agents as used in the woodworking industry with exact rules therefore when confronted with a new type of cutter it should be sharpened as near as possible to the makers angles and these angles recorded for future use. An experienced operator may modify and improve the original angles of the manufacturer but usually the makers angles will be correct and normally should be adhered to.

Recording angles:
It is essential that angles ground on cutters are recorded, this will enable the operator to repeat the angles on cutters which have proved to cut satisfactorily and to change angles on those cutters which are not cutting as they should. This means that guessing the angles is *WRONG* and must be avoided. It is true that when a new cutter is secured to the machine for sharpening, the operator has to arrive at the correct angles by trial and error i.e. until his newly ground surface matches up with the original surface. However he must have some method of knowing what the angle is once it matches up with the original ground surface so that he can record it, otherwise slight errors could multiply

during the life of the cutter and the original angle could be lost resulting in a gradual deterioration in the cutter's performance without anyone knowing why.

Sharpening Methods and Examples::
Two methods are in common use which will enable the operator to set the desired angles accurately, these are the *Angular Method* and the *Linear Method*. A knowledge of both methods is desirable so that the operator can choose the most suitable for the tool being sharpened. A necessary tool for both methods is a *Centre Height Gauge* the height of which is the same as the height from the machine table to the centre of the workhead or centres. See Fig.175. With this tool the operator can set a tooth or cutter point on the centre line. See Fig.176.

FIG.175.

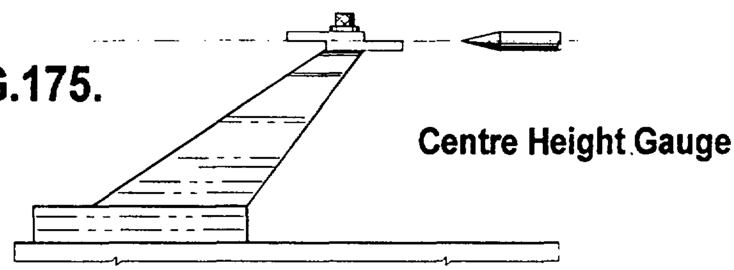


FIG.176a.

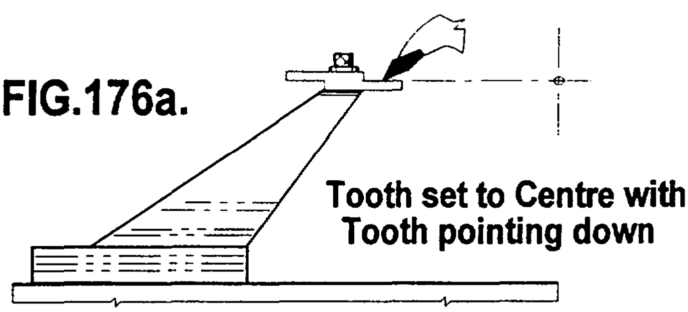
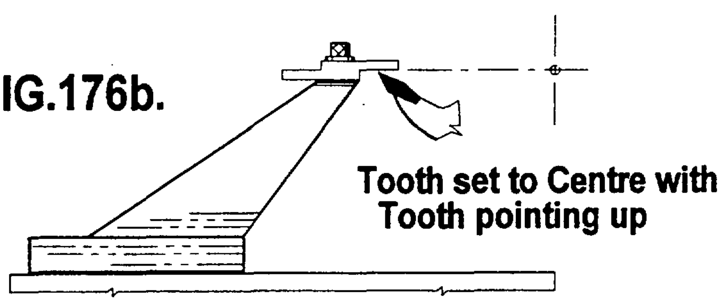


FIG.176b.



Angular method:
This method uses the protractor scale of degrees which is etched accurately onto the revolving part of the workhead. The method is equally useful for teeth or cutters moved from the horizontal line up or down to give the required top clearance angle and to grind the face of teeth or cutters moved from the vertical line giving the required cutting or approach angle. See Fig.177a. & 177b.

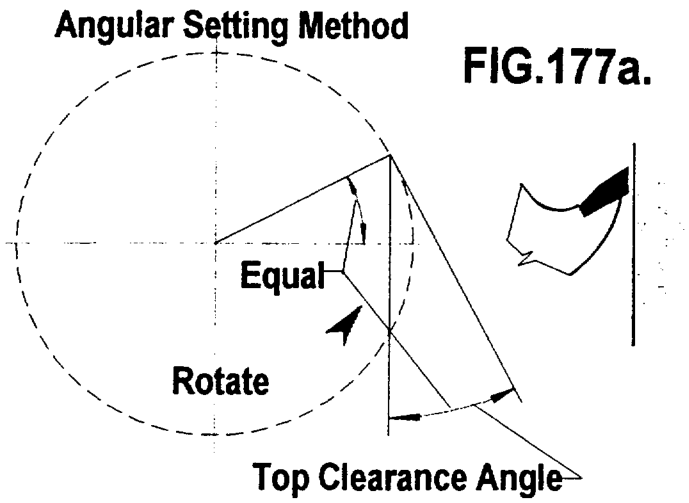


FIG.177a.

FIG.177b.

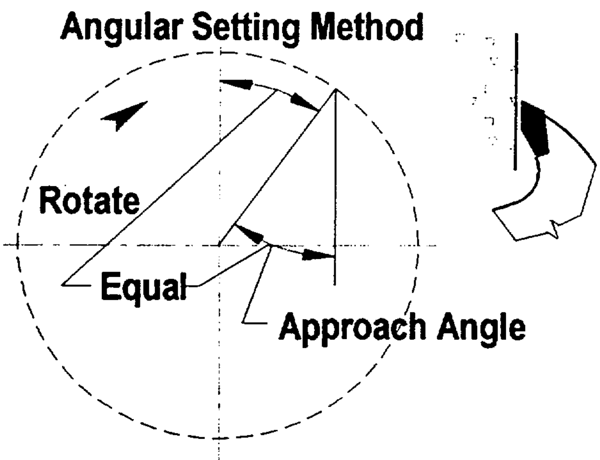


Fig.178a. & 178b. shows the practical application of the method. First, the saw tooth or cutting edge of the cutter is adjusted until it is on the centre line using the centre height gauge. If it is intended to use the indexing disc the plunger is located in the nearest slot and the adjustment completed with the fine adjusting screws. If a tooth rest is to be used the workhead mandrel is locked to hold the tooth on the centre line. Next, the workhead scale is set to zero from which the tooth or cutter can be rotated the required angle. Again when using the indexing attachment move the plunger into the nearest slot and complete the adjustment with the fine adjusting screws. Note: If the angle required is an equal divisor of the disc in use e.g. 15 degrees is the distance between each slot on a 24 disc, then no fine adjustment is necessary. If using the tooth rest the workhead is locked again in the new position until the tooth rest is fixed to hold the tooth or cutter face against. The tooth or cutter is ready for grinding.

FIG.178a.

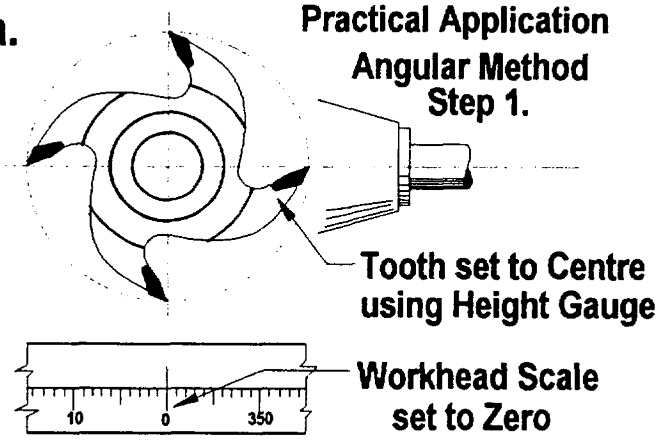
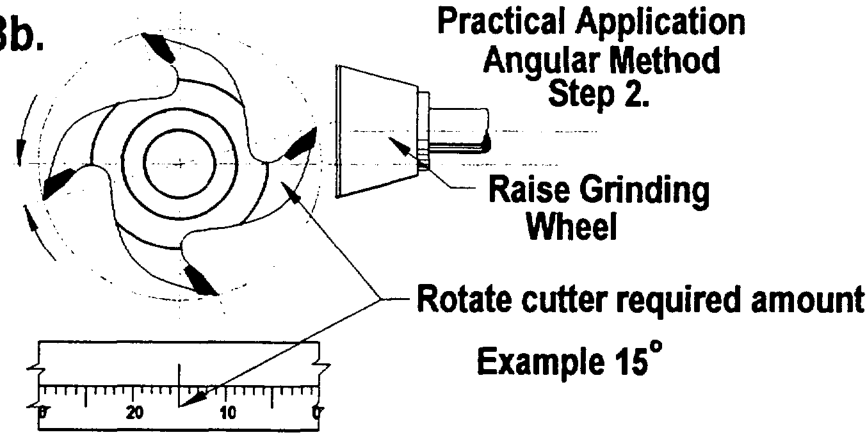
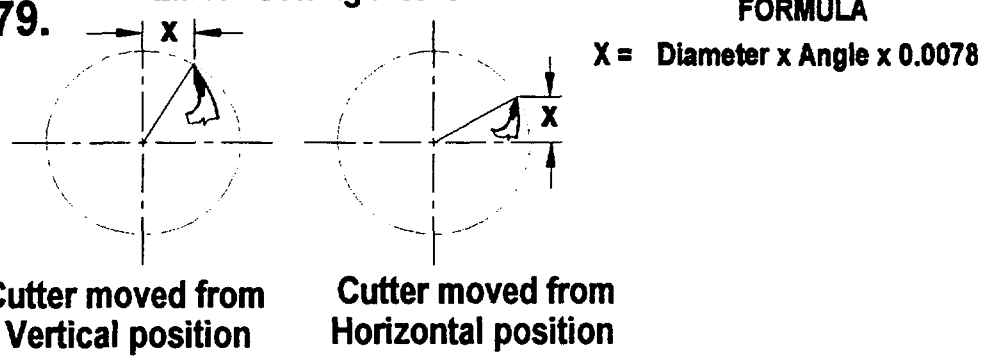


FIG.178b.



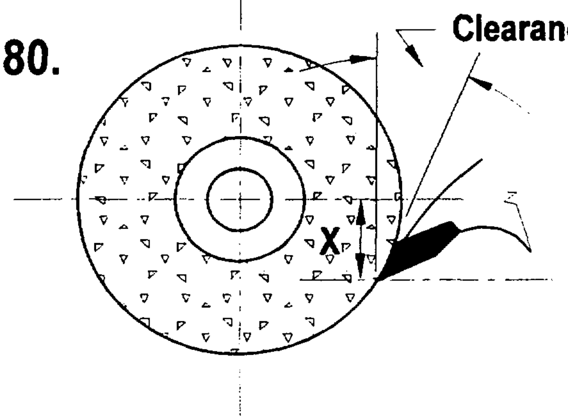
Linear method:
This method uses a simplified formula to calculate one of the sides of a right angled triangle as shown in Fig.179. The formula uses the diameter, angle and the constant 0.0078. The application to cutters is exactly as previously described with the angular method i.e. hook angles and clearance angles can be ground to desired angles. In addition, the method is very useful in assisting to grind clearance angles with the use of the periphery of a straight or similar wheel in which case the diameter at the wheel is used in the calculation and not the diameter of the cutter. See Fig.180. In practice, the calculated distance is moved accurately using the cross-slide for horizontal distances and the grinding head movement for vertical distances above or below the centre line.

FIG.179. Linear Setting Method



Use of Straight Grinding Wheel

FIG.180.

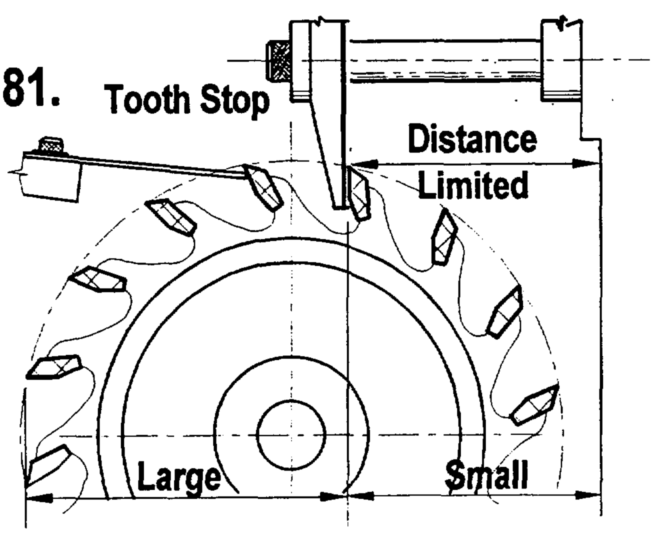


Sharpening a grooving cutterblock:

The cutterblock is first cleaned of all resin from the teeth and where collars grip the sides to hold it on the mandrel. If this is not done a speck of sawdust or dirt could throw the cutterblock out of true and so it would be ground out of true. Of course the collars themselves have to be equally clean and checked periodically for damage especially if they have been accidentally dropped onto the floor.

The cutterblock may be mounted with the teeth nearest the grinding head pointing up or pointing down each way having advantages and disadvantages. These will be explained now and so need not be repeated for other example set-ups. If you have a cutterblock with a number of teeth not matching any of your indexing rings, a tooth rest or stop can be used. To grind the faces, which should normally be done first, the teeth should point up so that the tooth stop can be fixed to the machine as shown in Fig.181.

FIG.181.



This way round has one important advantage in that the distance the grinding wheel has to project over the cutterblock is smaller, again shown in Fig.181. In fact with large cutterblocks it may be impossible to reach over to the face to be ground even with the grinding wheel mounted on an extension spindle. The disadvantage of this way round is that when changing over to grind the tops it will be necessary to reverse the cutterblock so that the teeth point down so that the tooth rest can be positioned underneath the tooth to be ground which is both easier and more accurate.

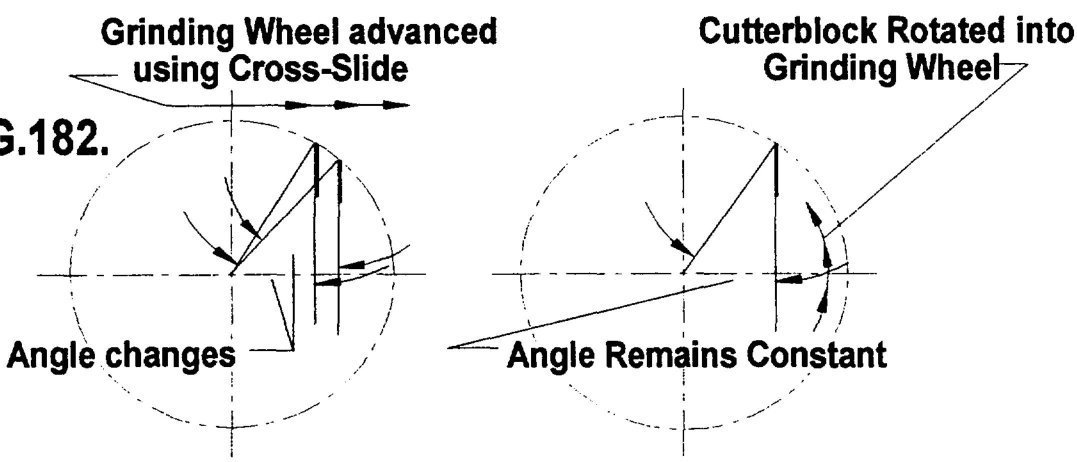
You will notice that when grinding the faces the tooth rest has to be one tooth away from the tooth being ground in order that the grinding wheel can get into the gullet. If the tooth rest is positioned more than one tooth away from the tooth to be ground, then any inaccuracy in the tooth pitch could be multiplied causing problems in sharpening, but being one tooth pitch away this will help to maintain equal pitch between each tooth or cutter.

When grinding using the indexing attachment on the workhead less problems arise, in fact it is much the easier method. The main consideration is; can the grinding wheel reach the face of the cutter to be ground if the cutterblock is put on the mandrel teeth pointing down? If so the same wheel may be used to grind both the faces and then the top thus saving time by not having to change the wheel and the mounting of the cutterblock.

There may be other reasons however why you want to change the grinding wheel such as; a thin dish wheel may have to be used on the faces to get into small gullets and the life of such a wheel is limited. Whereas if you can use a cup wheel or a straight wheel to grind the tops, these have a much longer life before they are worn away and can both tolerate heavier grinding, in fact grinding against the side of a wheel is not good practice even though a dish wheel is designed for that purpose. Too much side pressure can break a thin wheel and so is always a potential danger.

Maintaining the Correct Angles:
We have already discussed how to set the cutters to the correct angles but it is now time to discuss how to ensure that they do not alter when grinding. Fig.182. shows that the angle ground onto the cutter would change if we continued to grind parallel to the face of a cutter, that is, if we just continued to move the cutter into the grinding wheel using the machine's cross-slide which is the easiest way to do it.

FIG.182.

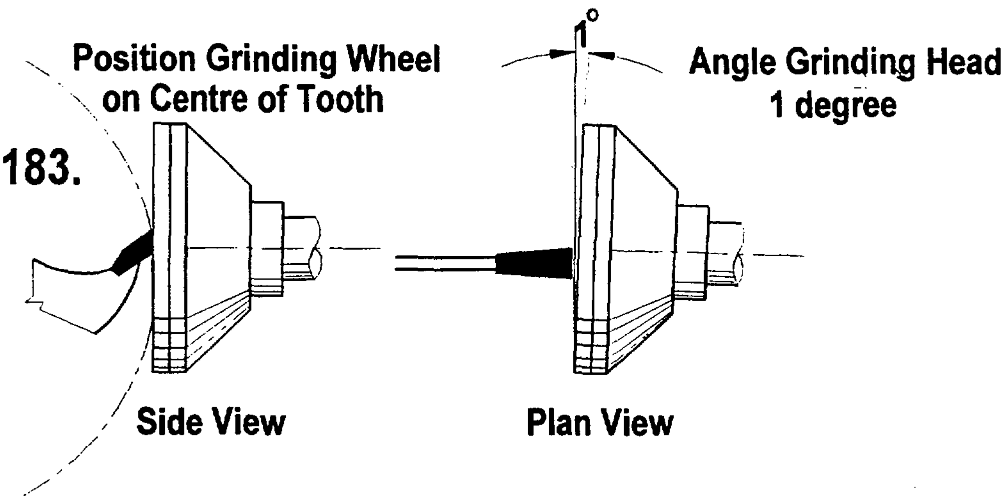


Of course, if we grind off minute amounts and re-set the cutter to the correct angle each time then the small difference in the angle will not be a problem, however, if we just guess the angle by matching the ground face to the grinding wheel and then use the cross-slide we would increase the angle considerably during the life of the cutter. <u>This is a common mistake.</u>

The correct way is not to advance the grinding wheel into the cutter but to rotate the cutter into the wheel. Unfortunately this can only be done if the dividing head is fitted with a fine screw adjustment or, if using a tooth rest, if the tooth rest holder is fitted with a fine screw adjustment.

In the set-up shown in Fig.181. the grinding head would not be angled or only angled half of one degree because the wheel is working on its bottom edge. However, to grind the tops of the teeth using a cup wheel as shown in Fig.183.

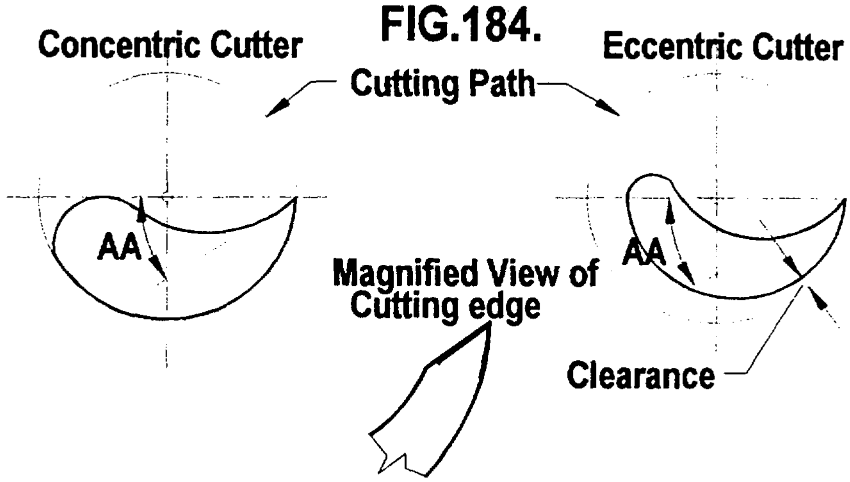
FIG.183.



the wheel is working on its centre-line and should be angled <u>one degree</u> so that only one edge works. Normally the edge rotating downwards is used for two reasons. First when using a tooth rest the action of the wheel will hold the cutter on the rest and the other is that it is safer even if the operator is wearing goggles, to have the grinding sparks directed down onto the machine table instead of up into the air. Note that if bigger angles than 1 degree are used the working edge of a cup wheel becomes elliptical i.e. curved and this could alter the angles ground on cutters.

Sharpening a Single Flute Router Cutter:
Single flute router cutters are manufactured in two different types with their outer circumference ground concentrically or eccentrically. If the concentric cutters were to be used in a normal concentric chuck their outer surface would rub during cutting and so would become very hot and burn. Because of this concentric cutters must be used in eccentric chucks and eccentric cutters i.e. those with clearance ground onto the cutter in an eccentric curve are designed to be used in concentric chucks. Fig.184. shows both types.

FIG.184.

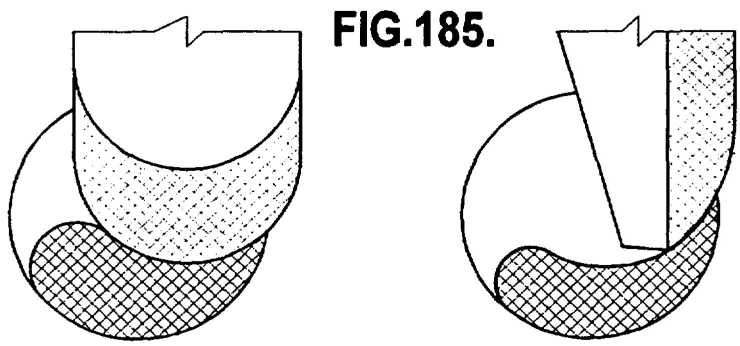


You will see that both cutters should only be sharpened on the inside since sharpening on the outside would both reduce the diameter of the cutter and in most cases loose the vital clearance on the outside, again causing the cutter to burn. You will also see that the eccentric cutter will gradually become smaller as it is sharpened thus reducing the size of holes and slots which it will cut. Methods to overcome this problem exist but need not concern us in this manual.

The approach angle for router cutters is usually fairly large being from 30-40 degrees and the desired angle may be set by either the angular or linear method.

The original flute (hollow) ground into the cutter to produce the cutting edge is done with special shaped wheels, to re-sharpen a H.S.S. or even T.C.T. cutter small diameter wheels with semi-circular edges are available and so the entire flute can be ground when re-sharpening as shown in FIG.185. however this is not really necessary and a modified wheel shaped as shown need not fit all the flute exactly but will work well and fit more than one size of cutter and so be more useful.

FIG.185.

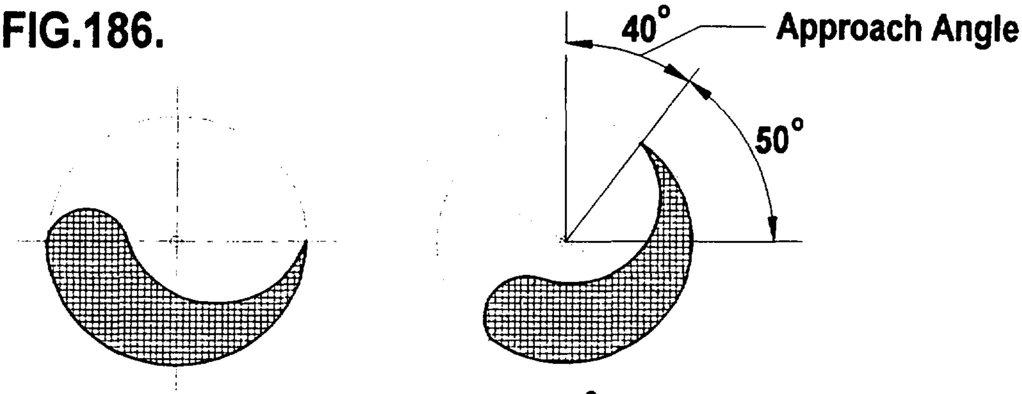


Half round Grinding Wheel Modified Standard Grinding Wheel

To set any size of cutter at the correct angle using the angular method. First, set the cutting edge on the centre line in the normal way but with extra accuracy which is necessary on small cutters. Then rotate the cutter upwards say 50 degrees which will give a 40 degrees approach angle. See Fig.186.

ANGULAR METHOD

FIG.186.

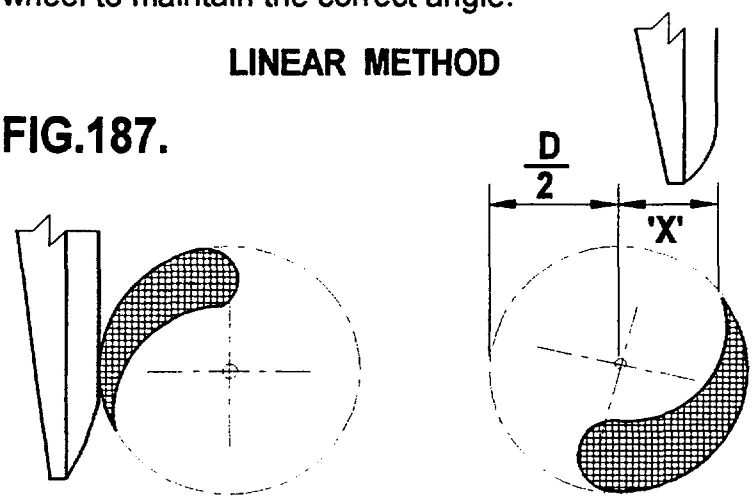


Cutter set to Zero **Cutter rotated 90° minus the Approach Angle**

To set the cutter using the linear method; first, traverse the cutter until its outside diameter just touches the grinding wheel. Next, calculate the offset and traverse the cutter in towards the wheel by the calculated amount plus half the cutter diameter. See Fig.187. Move the cutter underneath the stationary grinding wheel and rotate the cutter until the cutter face just touches the wheel and lock in this position. Next adjust the indexing-ring, *NOT THE CUTTER,* with the fine screw adjustment until the plunger fits into the nearest slot. Lower the grinding wheel the required amount and grind the cutter rotating the cutter into the face of the wheel to maintain the correct angle.

LINEAR METHOD

FIG.187.



Set Cutter to touch the Grinding Wheel **Move Cutter Half Diameter plus calculated distance 'X'**

Router cutters which are used to bore into the wood to the required depth before they start working, have to be sharpened so that they will cut on their ends as well as their sides. Again it is best to try to maintain the manufacturers angles on complicated shaped cutters. The end of single flute router cutters have a primary and secondary clearance angles ground on so that they can bore into the timber. An angle of 10°-15° is sufficient for the primary angle with a large secondary clearance angle of around 45°. Because grinding has to follow the curve of the *INSIDE* of the cutter these ends will have to be ground free-hand unless special eccentric jigs are available. This free-hand grinding is quite satisfactory leaving the primary clearance angle no more than 1mm wide.

See Fig.188a. The end may be ground out of square by about 10° as shown in Fig.188b. or square as in Fig.188c. if a smooth finish is required to the bottom of the cut. When having to grind these ends free-hand, the easiest way would be to grind a short part of the end square and the rest at an angle as shown in Fig.188d.

SINGLE-FLUTE ROUTER CUTTER END GRINDING

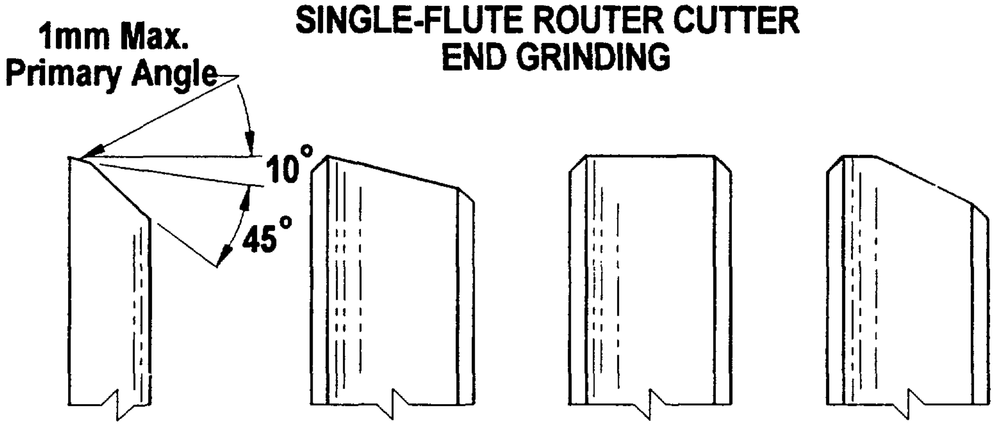
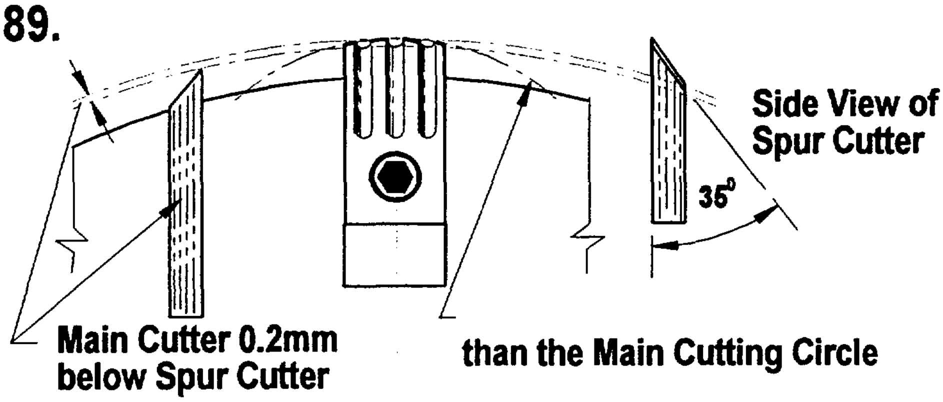


FIG.188a. FIG.188b. FIG.188c. FIG.188d.

Sharpening tools with Scribing Cutters:
Unlike metals and plastics wood is a fibrous material and those tools which cut across the fibres or grain need special knife like cutters called scribing or spur cutters to sever the fibres in *ADVANCE* of the main cutters which remove the bulk of the wood. To achieve this sequence the spur cutters project slightly beyond the main cutters and therefore are always working in front. The amount of projection should be between 0.2mm - 1mm. Typical tools using spur cutters are Tenoning and Trenching Heads, Boring tools and Grooving heads. You will notice that the tenoning head spur cutter projection is very small since a large projection would weaken the tenons whereas a boring tool can be larger. The designs are too numerous to cover in detail and each new tool should have its various angles recorded when first brought into the toolroom for sharpening including the project of the spur cutters. Fig.189, 190, and 191. show some typical spur cutter shapes and how they should be sharpened.

TENONING & TRENCHING HEADS WITH ADJUSTABLE CUTTERS

FIG.189.



GROOVING HEADS WITH FIXED CUTTERS

FIG.190.

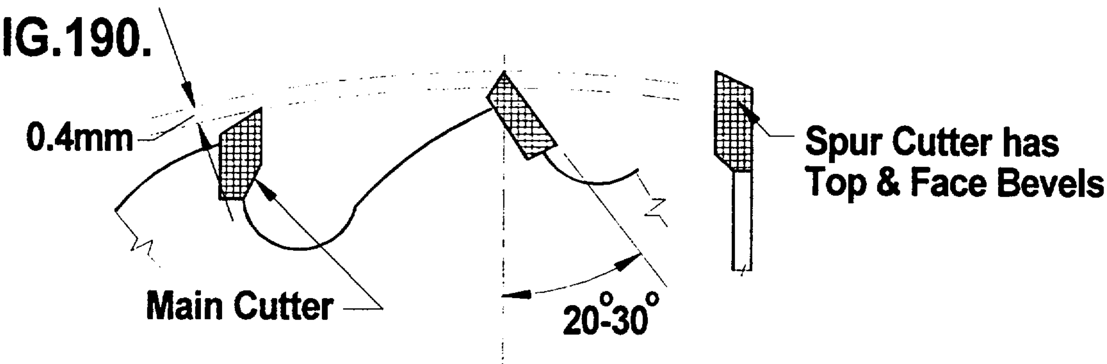
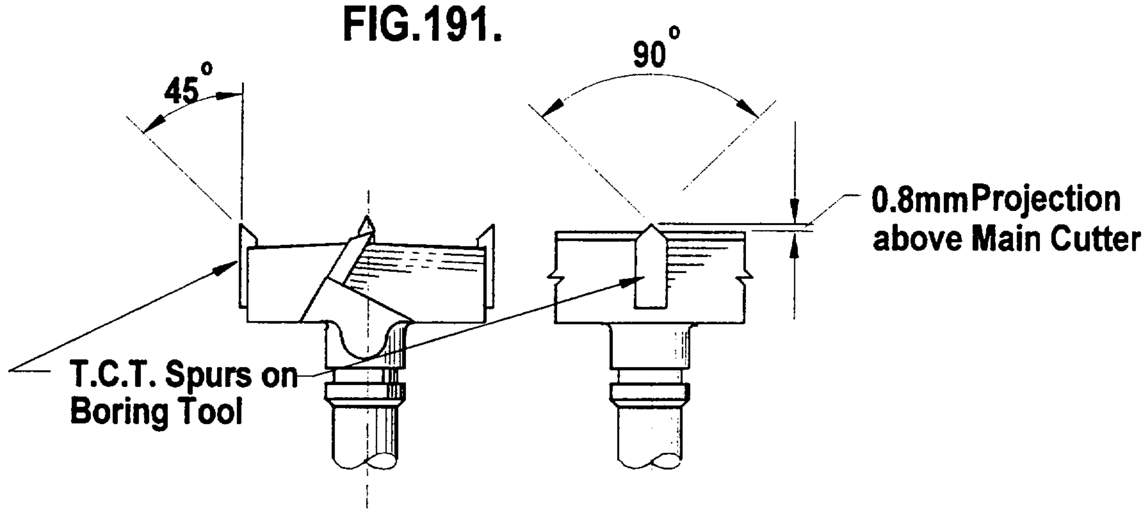


FIG.191.



Sharpening Helical and Shear-Cut Cutterblocks:
Fortunately the woodworking industry does not normally use helical shaped cutters but do sometimes have cutterblocks in which the cutters cut in a shearing action i.e. one end of a cutter starts to cut in advance of its other end therefore reducing the impact of the cutter as it hits the wood.

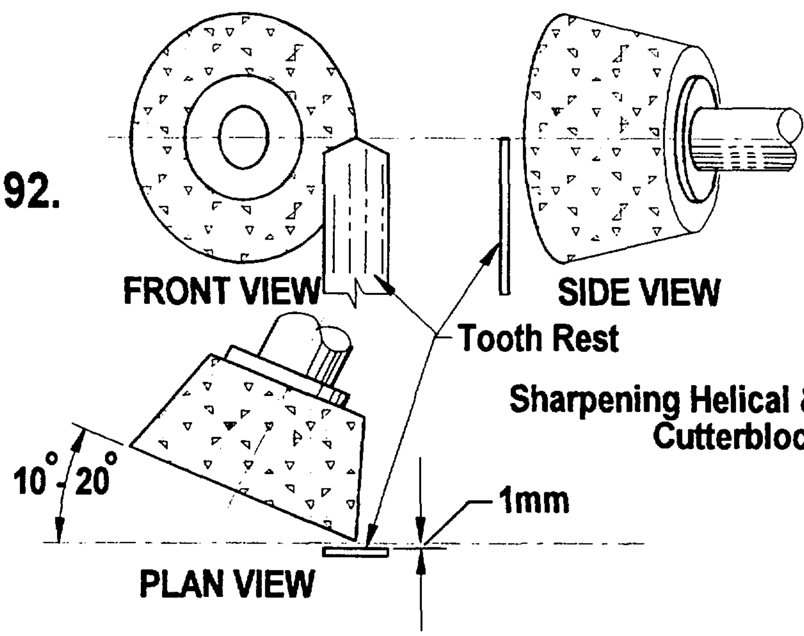
The most common such cutterblock is used on tenoning machines and the geometrically developed cutting edge of the cutter is very slightly elliptical. This means that if cutters are removed from the cutter-block for grinding on a straight knife grinder, they will have to be curved slightly by hand honing if they are to produce straight and parallel tenons. This method can be quite successful but is quite laborious thus making the alternative of leaving the cutters on their blocks and grinding them on the tool and cutter grinding worth considering.

The main problem with the set up is that the cutter face has to rest and slide along a tooth rest which is made difficult since woodworking cutters and tenoning cutters in particular have large approach angles causing the cutter to slide down in-between tooth rest and grinding wheel. This can prevent the cutter sliding freely and spoil the result. However, the system can work and since other shear cut tools such as rebating cutterblocks may turn up for grinding we must cover the technique which has to be used.

The cutterblock is mounted on a mandrel between centres or in the work-head and is left free to rotate. If the workhead is used and it is a heavy cutterblock, the outer end should be supported with a centre.

A large cup wheel, up to 150mm diameter if available, is mounted on the grinding head and a tooth rest positioned on its centre line also fixed to the grinding head and not to the worktable as with previous set-ups. The grinding head is angled 10 - 20 degrees but the tooth rest is set parallel to the worktable as shown in Fig.192. Note that the tooth rest is pointed or rounded on its top to allow the cutter to rest on the highest point which must be opposite the working corner of the grinding wheel. The slopes up to and down from the highest point are to allow the cutter to enter and be removed from the rest smoothly.

FIG.192.



Sharpening Helical & Shear-Cut Cutterblocks

Rest the cutter on the tooth rest and raise or lower the grinding head (with the rest) until the cutter is on the centre line measured with the height gauge. Next calculate the amount needed to give the required clearance to the cutters using the cutterblock diameter. For example: 150 diameter block, 15 degrees clearance;

Linear amount - 150 x 15 x 0.0078 = <u>17.55mm</u>

Lower the grinding head by this amount which will lower both grinding wheel and tooth rest, lock grinding head and traverse cutterblock up to grinding wheel until cutter sits on the tooth rest but does not yet quite touch the grinding wheel. Traverse the sliding table the full length of the cutter keeping a light pressure on the cutter to make sure it stays in contact with the tooth rest. Set the table's end stops and the cutterblock is ready for grinding.

Note that tenoning heads will almost certainly be in left and right handed pairs which will probably mean a left and right hand set-up for sharpening. Finally some tenoning machines have their tenoning head mandrels deliberately out of parallel to each other so that the shoulders on the cut tenons will be slightly undercut to facilitate a good fit. In this case, the cutterblocks must be ground slightly tapered. This is easily done by setting the top table on large machines to the desired taper. On small machines the workhead would have to be angled.

Two small but very important points must be mentioned for successful sharpening of shear-cut or helical shaped cutters. First the tooth rest has to be thicker than normally used to prevent it being deflected sideways by the wedging action of the cutter against the grinding wheel and tooth rest. Second the top of the rest must be very smooth and preferably hardened so that cutters will not dig in but slide over the rest smoothly.

CHAPTER 13

Grinding Wheels

Introduction:
Although *"grind stones"* made out of natural stone and other mined natural abrasives still exist in circular and rectangular forms for grinding and honing tools, modern grinding wheels and honing blocks are made from man made abrasives, therefore when we talk about these tools we should no longer refer to them as stones but as wheels or abrasive slips.

The grinding wheels which we use can be divided into two main types; first those moulded into wheels of varying shapes consisting of the abrasive particles and a bonding material and secondly wheels made of non-abrasive material such as plastic or alloy and because of their high cost, only faced with an abrasive such as diamond or cubic boron nitride, abbreviated (CBN).

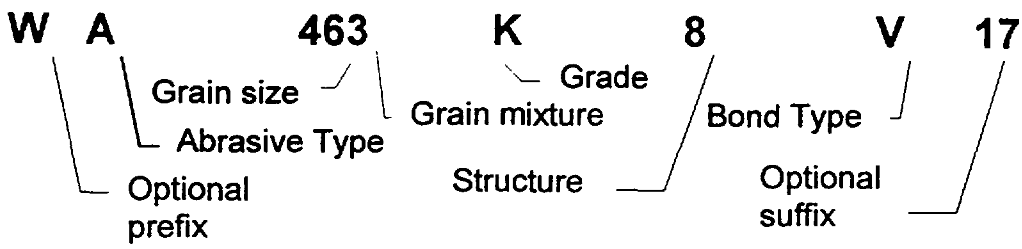
The first group are by far the most widely used and are made of either the abrasive ALUMINIUM OXIDE, SILICON CARBIDE or the new abrasive ALUMINA /SOL. This recent development around 1993 has special engineering applications as a superior product to Aluminium Oxide and is very expensive and so need not concern us.

Aluminium Oxide is suitable for grinding high tensile strength materials such as tool steels whilst Silicon Carbide is used for grinding low tensile materials such as brass, aluminium and non-metallic materials and so is not generally used in our industry for grinding, however since silicon carbide is harder than aluminium oxide we do use it in rectangular blocks as Dressing Sticks and the Green grade can be used for rough grinding of tungsten carbide although diamond wheels are more suited to our work.

Because these abrasives are not natures products like sand, as in "sandpaper" but are manufactured, the process can be controlled and altered to produce various qualities of abrasives to suit specific grinding applications and we can recognize some of the sub-types by the variations in colour of the wheels which can be grey, blue, green, white, red, pink or a mixture of these colours in the same wheel. In addition to various qualities there are of course differences in the size of the abrasive grains so that we have wheels made of large grains used for rough grinding and others made of fine grains which will give mirror like finishes and of course all grades in between.

If we consider that various types of bonding materials can be used and the density of the abrasive and bond varied, then we can start to realize that the manufacture of grinding wheels and the understanding of their specifications is a complex subject. However as users we need to learn something about the specifications used by the manufacturers and how the various parts affect the grinding quality of wheels so that we can first order wheels correctly and make sensible changes to specifications if necessary.

Bonded Wheel Specifications:
The marking of specifications on wheels may be different from various manufacturers of wheels but they usually follow a pattern adopted by the British Standards Institute and a typical specification is shown below which we can work through to gain our understanding of the subject.



The four main items in a grinding wheel specification are:-

1. The type of the abrasive used to make the grinding wheel, as A for Aluminium oxide in our example.
2. The size of the particles of abrasive called Grains which has a range from an extremely course grain of 4 to the finest of 1200. 46 in our example.
3. The grade of the grinding wheel is governed by the strength of bonding material used to hold the abrasive grains together and varies from very soft to very hard and is given a letter from A - Z i.e. A being the softest and Z the hardest grade. K in our example.
4. The type of bond used to hold the abrasive grains together such as V for vitreous bond as shown in the example.

Three of the four optional symbols which may or may not be used do not follow any standard and vary from manufacturer to manufacturer, The first if used describes the sub-type of the abrasive and sometimes follows its colour, in our example the W stands for white but another manufacturer uses A A for white aluminium oxide whilst another one uses the number 38 A to describe their white aluminium oxide. This prefix before the abrasive type can also show that the abrasive is mixed, for example; DA by one manufacturer means that Blue and White Aluminium Oxide grits are mixed together to combine their separate qualities in one wheel.

The second non-standard optional symbol is a number from 1 - 6 sometimes added after the grain size. This is confusing as it appears that the grain size is very fine in our example 463. However the bulk of grain size is still 46 but the 3 tells the manufacturer that there is a certain mix of grit sizes in various percentages added to the wheel.

The third non-standard optional symbol comes as a suffix at the end of the specification after the bond type and tells the manufacturer exactly any variation in the bond's own specification. Our example shows a number 17.

The optional symbol which follows the British Standard 4481 describes the "Structure" of the wheel and is quite important. It uses a number from 0 - 14. A low number tells us that the grains of abrasive are close together and a high number says they are spaced further apart giving a wheel which will cut cooler but would not give as smooth a finish on the surface being ground.

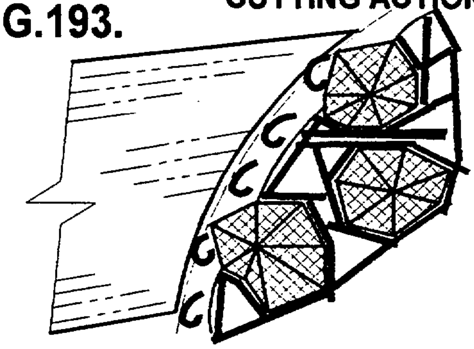
In the sawmilling and woodworking industries we only use a small fraction of the full range of specification and wheel types which are made so this at least simplifies the task a little and if we understand the meaning of the specifications of the wheels which we use, then at least we can inquire if a softer or harder wheel is available if the one in use is either burning (too hard) or wearing away too quickly (too soft).

Again if we find a satisfactory wheel then we should always give the full specification when we place our order.

Grinding Action:
Before we go a little deeper into understanding specifications it is necessary to look at the action of a grinding wheel.

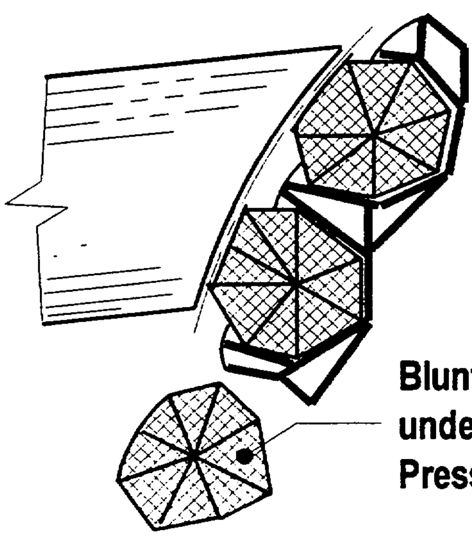
Suitable grains bonded into a wheel are rotated and each grain at the surface cuts a CHIP out of the object being ground or in our case sharpened, See Fig.193.

FIG.193. **CUTTING ACTION OF GRINDING WHEEL**



When these outer grains become blunt the extra pressure on them should, on an ideal wheel, cause the blunt grains to fall out exposing new sharp grains to continue the grinding. When this happens we say that the wheel is self dressing. See Fig.194.

FIG.194.



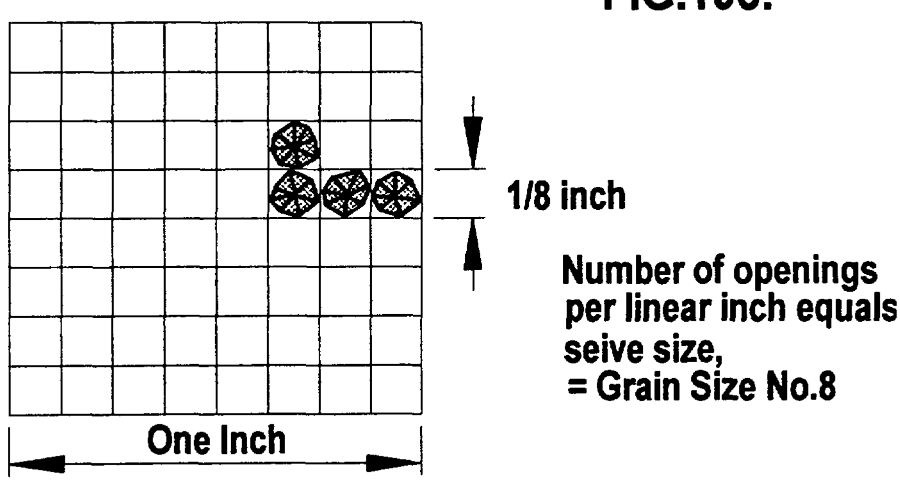
If the grains blunt and do not fall out by normal grinding pressure then the wheel will overheat the metal being ground or teeth being sharpened and the wheel will have to be dressed to expose new sharp grains. If this dressing has to be done too often then the wheel's specification is not correct and in some way is too hard and needs changing. If on the other hand the grains fall out too soon without doing a reasonable amount of work then the wheel is in some way too soft and the specification needs changing towards a harder wheel.

Assuming that the type of abrasive is correct, and we can only be guided by the manufacturer or our own experience on this, then we should look towards the "Grade" and "Structure" in order to select a more suitable wheel.

The Abrasive:
Because we are grinding steels in our work the wheels which we use will usually be made of Aluminium Oxide and as it is important not to overheat our saws and cutters the sub-grades such as white and pink which cut more efficiently are more popular than the old "Grey" aluminium oxide which has a tendency to overheat.

The size of the grains we use fall into the Medium range with sizes from 30 - 46 for segments used in large straight-knife grinders, 46 - 60 for saw sharpening and tool and cutter grinding. As well as a mixture of types a mixture of two grain sizes may be used then this would be shown for example as 46/60. The size of the grains or grit comes from the Imperial measure of one inch of the mesh used in the sieve used for sizing the grains. A sieve with a mesh of 8 holes per linear inch would give a grit size of 8 or the size of the grit would be approximately 1/8 inch across. See Fig.195.

GRAIN SIZE **FIG.195.**

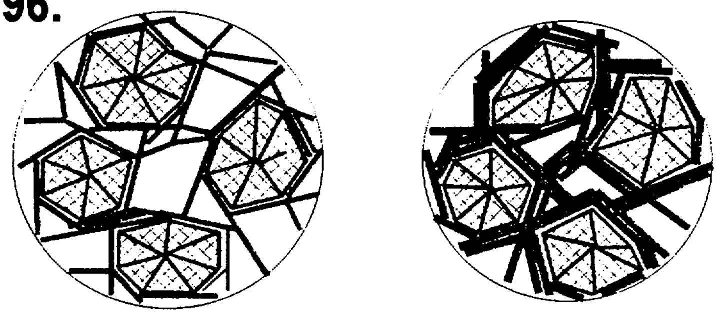


Although the size of grain has a big influence on the quality of the ground finish the spacing of the grains called the "Structure" also alters the possible finish i.e. if the grains are spaced far apart then the finish will be rougher than if they were closer together.

The Grade of a Grinding Wheel:
If we think of GRADE as the strength of the bond either by using a stronger or weaker material or more or less of the bonding material a visual idea would be as shown in Fig.196.

VISUAL IDEA OF GRADE

FIG.196.



Weak Bond (Soft Wheel) **Strong Bond (Hard Wheel)**

A practical range for most purposes is shown below and the grades we use in our industry tend to be soft to medium around K and L.

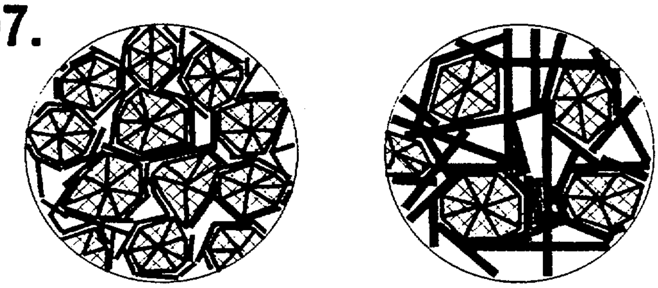
GRADE

Very Soft	Soft	Medium	Hard	Very Hard
E, F, G,	H, I, J, K,	L, M, N, O,	P, Q, R, S,	T, U, W, Z.

The Structure of a Grinding Wheel:
The structure of a wheel is the variation of the Spacing of the abrasive grains as shown in Fig.197.

VISUAL IDEA OF STRUCTURE

FIG.197.



Dense Structure **Open Structure**

We can appreciate that if the grains are close together we should get a smoother finish to our grinding and if they are spaced further apart the finish for the same size of abrasive grains would not be as good. In addition to this effect on finish, a wheel with a wide spacing of grains will cut with less heat generated an important factor when dry grinding as used for most saw sharpening and tool and cutter grinding. The full range of structures used is shown below.

STRUCTURE

Close Spacing	Medium Spacing	Wide Spacing
0, 1, 2, 3,	4, 5, 6,	7, 8, 9, 10, 11, 12, 13, 14.

The Bond of a Grinding Wheel:
There is very little variation in the type of bonds used for our work of sharpening and most wheels will have a Vitreous Bond. However I have used wheels with a Resin bond for automatic saw sharpening and these were cool cutting and so excellent. Resin bond, being more flexible than vitreous bond, is used for thin Cut-off wheels 1mm to 3mm thick which, although not designed for the purpose, I found very useful for sharpening saw blades with fine teeth such as narrow bandsaws, handsaws and circular cut-off saws for cutting steel. Rubber bonds are the most flexible and are only used for super thin wheels which may be as thin as a piece of paper.

Fibre reinforcing of resin bonds is used to give added protection against wheels breaking on portable and hand held machinery like angle grinders which we may use for grinding weld repairs on our blades. The full range of symbols for bonds used in the British Standard are shown below.

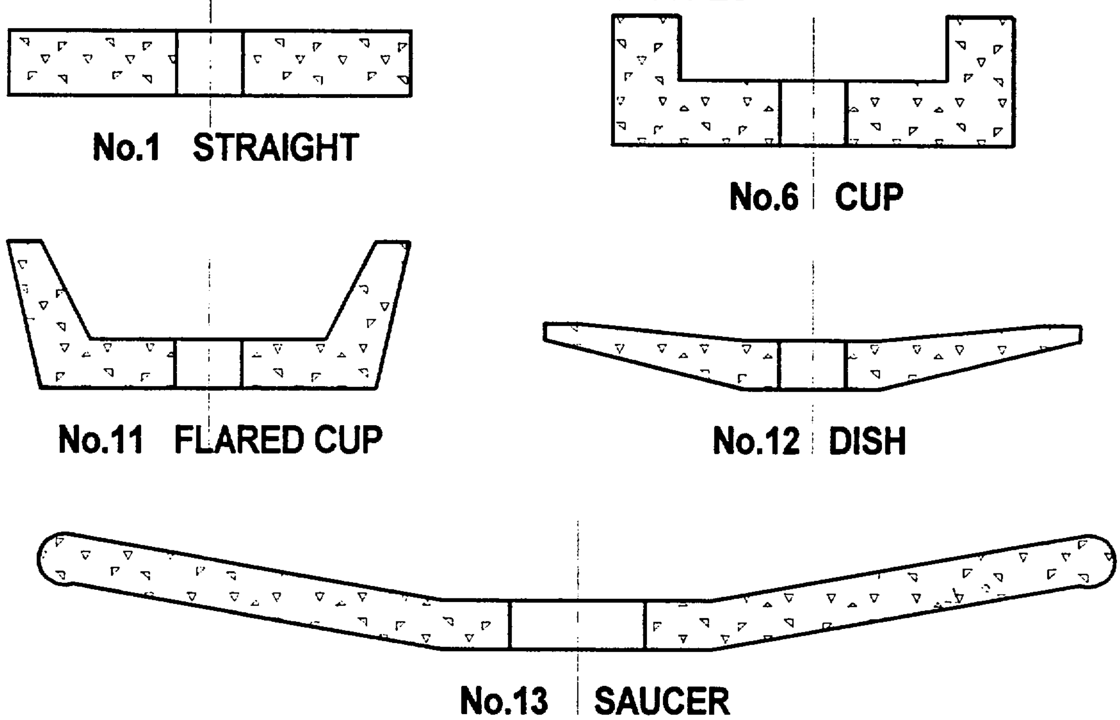
V = Vitrified: A glass-like bond used for over 75% of grinding wheels.
R = Rubber: Used for very thin cut-off wheels thinner than 0.8mm and for special purposes.
RF = Rubber and Fabric.
B = Resinoid: Used for most cut-off wheels and high speed wheels.
BF = Resiniod and Fabric: Used for thin wheels used on angle grinders etc.
E = Shellac: Used for special wheels for light work and for high grade finishes.
Mg = Magnesia: An old bond not used these days by the majority of manufacturers.

Wheel Shapes:
There are 13 different British Standard grinding wheel shapes numbered from 1 to 13 of which we in the sawmilling and woodworking industries only use about five and these are shown in Fig.198. together with their numbers. Shape No.13. "Saucer" looks as though it might have been designed for use on saw sharpening machines with the face of the wheel angled so that it does not wear away with the resulting loss of hook on the teeth. Unfortunately this shape is not easily available no-doubt because of the small demand and so No.1 Straight wheels have to be used.

When ordering wheels either the shape number or shape name or both should be included with the size and specification and for all shapes other than straight it is best to include a drawing giving the important measurements. Sizes should be given in the correct order preferably copied off an existing wheel. For example:- the sizes of a straight wheel might be as follows:- 250 x 16 x 20 mm and this would mean that the outside diameter was 250mm, the thickness 16mm, and the bore which always comes last was 20mm. Therefore the full details required for ordering straight wheels could be as follows:

Quantity:- 36,
Shape:- No.1. (straight)
Size:- 300 x 20 x 30mm
Specification:- 35A36 - M-10 - BB2

FIG.198. **GRINDING WHEEL TYPES**



Safety:
Grinding wheels can shatter if run at too high a speed for their design or of course if there is an accident like a wheel coming down on top of a tooth instead of into the gullet, a not uncommon problem when sharpening damaged wide bandsaw teeth. When this happens the machine operator will often be too close for comfort and may even be very close looking at the teeth being sharpened. It is therefore vital that operators are provided with good eye protection in the form of goggles or face masks which should be comfortable to wear or they will not be used .

Even if all accidents can be avoided minute particles of the abrasive grains are flying off the working wheel all the time as they self dress or are dressed by the operator and if these grains which are designed to have sharp edges will cut steel then they will certainly damage unprotected eyes.

Correct wheel mounting is very important and should follow the following procedure:

1. First all wheels should be examined for damage and possible cracks. Vitrified bonded wheels as well as visually inspected should be "Rung" i.e. held loosely with a finger through the bore and tapped gently with a piece of wood or plastic usually the handle of a screwdriver or similar tool . A normal wheel will "Ring" whereas a cracked wheel will give a duller sound. Of course cracked wheels must not be used as they are likely to shatter even without an accident.
2. The bore of a wheel must fit the machine's spindle without play otherwise the wheel will drop to one side on the spindle and run out of true, perhaps causing enough vibration to damage the machine's bearings or even for the

wheel to shatter. Too tight a fit may also cause the wheel to crack if the wheel is forced onto the spindle, instead the bore should be reamed out to fit correctly.

3. The wheel's maximum speed should always be shown on the wheel or its blotter and this should be checked against the machine's spindle speed or speeds. Normally wheels supplied for a machine will be correct but a danger arises when the spindle speed can be increased to improve the wheels cutting action as the diameter of the wheel reduces as sometimes featured on some automatic saw sharpeners. In other words make sure the speed is put back to the slow speed when changing a worn down wheel for a new one. Tool and cutter grinders also normally have more than one speed to suit different wheel diameters and so care must be taken not to use the wrong speed with the larger wheels.
4. Do use all the guards and extension pieces provided with the machine, they are there to protect you from accidentally putting your hand on the revolving wheel and also to reduce the damage if a wheel does shatter.
5. Correct size collars, usually at least one third of the wheel's diameter, must be of equal size and recessed to give a good grip around their perimeter. This contact face must be kept clean to ensure that the wheel will run true.
6. Circular discs of soft thin cardboard called "Blotters" usually supplied with the wheels must be fitted to each side of the wheel to prevent the collars possibly cracking the wheel when they are tightened up. Note that on most machines the securing nut for holding on the collars will have a LEFT or RIGHT hand thread whichever will tend to tighten up rather than slacken against the rotation of the wheel, therefore there is no need to over-tighten this nut and risk cracking the wheel.
7. Wheels should be stored carefully or they could be damaged before they are taken out for use. Storage is mainly common sense but generally thin wheels are stored flat (without their blotters) so that they don't warp and larger wheels stored upright in racks. Diamond and CBN wheels being so expensive are normally supplied boxed and should be kept in their boxes or placed on pegs on the wall near the tool and cutter grinder when they are changed frequently.

Wheel Dressing:

There are two reasons for wheel dressing:-

1. To shape the wheel to suit the work, for example to fit a tooth's gullet, or
2. To open up the cutting face if it becomes "glazed" i.e. when the grains become blunt or when the face becomes clogged with material such as resin.

Various tools are made for wheel dressing and the results from them vary considerably. By far the best tool is a "Diamond" dresser as usually used on tool and cutter grinders held in a tool holder and traversed across the cutting face of the wheel or moved in special holders to produce true hollows and rounds. When this tool is used, the wheel is dressed perfectly round and in consequence will grind using all its cutting surface and grains and so work 100% efficiently and this makes a big improvement to the grinding and is superior to all other types of wheel dressing. In addition the speed of traverse across the wheel when dressing can either give the wheel a rougher or smoother surface and so change the finish the wheel gives to the work being ground. The tool itself should be rotated from time to time so as not to wear away its bond all at one side, also before the diamond becomes too blunt it can be returned to the maker for turning to give it new life. The diamond dressing tool can be used freehand held at about 15° angle away from the direction of wheel rotation as it would be if held in the special tool holder.

Silicon Carbide dressing sticks are perhaps the most popular dressing tool used in our industry as they are comparatively inexpensive and often supplied with a new machine and so become the tool to use. As with all freehand dressing the tool should be held against some part of the machine as a rest otherwise, if held freehand without support, the tool will have a tendency to bounce off the high parts and dig into the low parts of the wheel and instead of improving the wheel's roundness and balance will make it worse. The Silicon carbon dressing stick has a tendency to smooth off the face of the wheel rather than pluck out the grains so after using it to shape a wheel held against a rest I usually rough up the surface afterwards by stabbing at the wheel's surface a few times with the dressing stick.

Star wheel dressers are sometimes used and these are designed to pluck out the worn grains as they rotate against the wheel. The main problem is the need to replace the wheels frequently as they wear away quite quickly.

Huntington dressers are a silicon carbide grinding wheel held on a spindle supplied with two knobs for handles and this is held against the wheel at a slight angle and as the grinding wheel and dressing wheel both rotate the action dresses the softer grinding wheel. Although they work quite well it is difficult to hold these, because of their size, against some part of the machine as a rest and so they may not help to keep the grinding wheel true and round.

Diamond & Cubic Boron Nitride Grinding Wheels:

Introduction:

Diamond grinding wheels are necessary for grinding Tungsten Carbide tips on saw blades and other tooling simply because of the hardness of the tungsten carbide which is almost as hard as diamond the hardest natural material known to man.

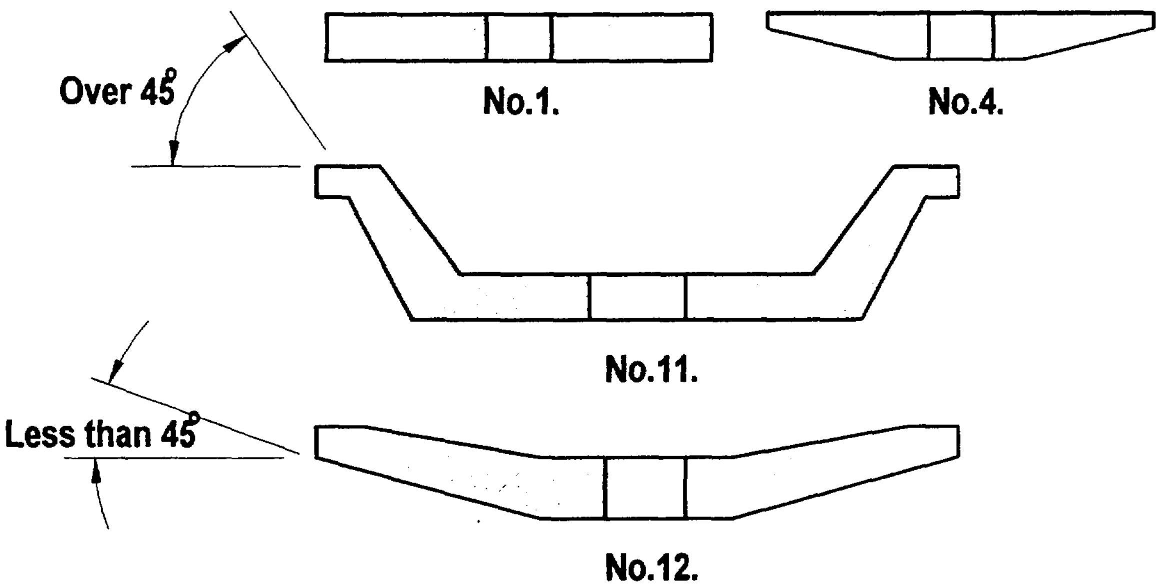
The diamond used to make grinding wheels is what is known as industrial quality and is either a natural mined product or an artificial man made diamond. Cubic Boron Nitride (CBN) is man made and is a fairly recent development and is used for grinding extremely hard and tough steels not tungsten carbide and so would not normally be used in sawmills and the woodworking industry in general although may be used for specialised work in manufacturing or maintenance for our industry.

Because of its high cost the diamond is only used on the cutting face of the wheel with the rest of the wheel being made of either plastic or aluminium alloy.
The correct choice of diamond wheels is quite complicated and in the first instance and when grinding problems arise it is best to seek the advice of the manufacturer. Give them the full details of the machinery used for grinding and if coolant can be used with the machine. Give the grade of Tungsten Carbide

being ground and state if backing material has to be ground as well as the Tungsten Carbide.

Specifications:
To understand the specifications used for diamond wheels, the specification is perhaps best divided into two parts. First all those items to do with the shape of the body of the wheel, then second all those items to do with the diamond itself. The first part is learning the meaning of the codes used by the manufacturers which usually follow the British Standard 5831 in which there are 15 basic body shapes and 25 shapes that the diamond may be formed into on the wheel. The manufactures usually follow this standard in their catalogues and once we have found suitable shapes to fit our machines and grinding needs the wheel shape codes need not change and that part is easy from then on. Four of the commonest shapes used in our industry are shown in Fig.199.

FIG.199. DIAMOND & CBN WHEEL TYPES

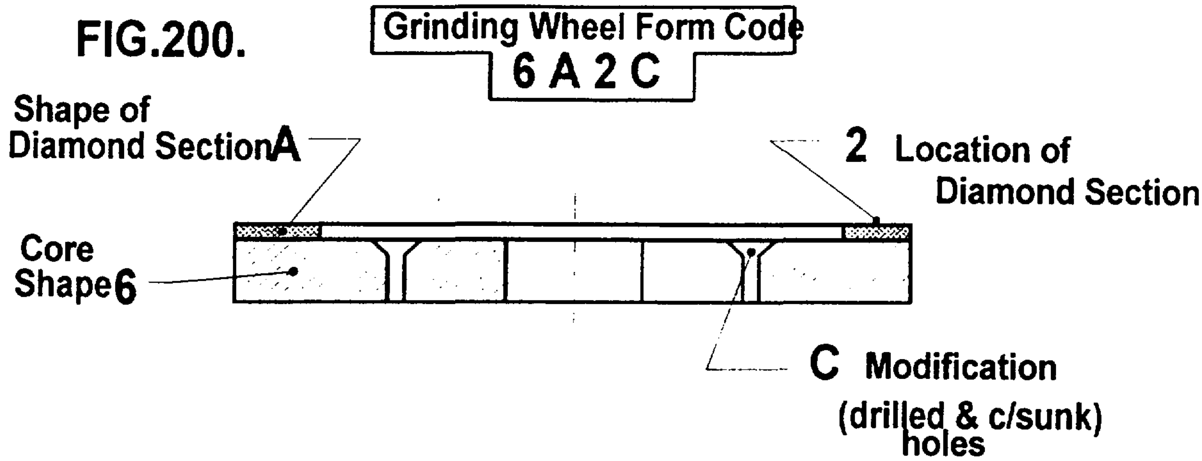


These code letters and numbers are:-
1. The wheel shape which is given a number.
2. The diamond shape which is given a letter or letters.
3. The diamond position on the wheel which is given a number.
4. Any modification to the wheel for fixing i.e. bolt holes for which there are standard letter codes.

Note that bore sizes vary so much that they do not follow any standard but of course you must provide the bore size when ordering. Often a manufacturer will have suitable wheels in stock which he can bore out to your requirements if necessary.

These code letters and numbers are best explained with a drawing of a typical wheel as shown in Fig.200.

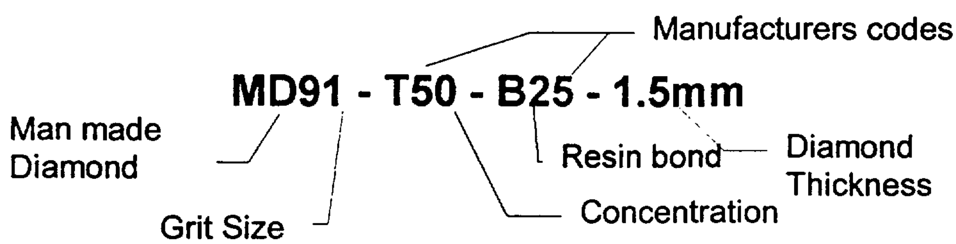
FIG.200.



Now for the cutting material itself, five items need specifying as follows:-

1. The material i.e. Diamond. (D for naturally mined and MD for man made).
2. The grain or grit size. (see Table 1 for full details).
3. The concentration of the grain is 100, 75 or 50. and 100 con. = 25% by volume.
4. The thickness of the diamond.
5. The type of grinding i.e. Wet or Dry as this will affect the bond type which the manufacturer will supply.

A typical specification could be as follows:-



Combining all the details for an example order could be as follows:-

Quantity; 10 number wheels.
Wheel Type; 12 A 2.
Wheel Size; 125mm x 25mm x 20mm bore.
Specification; MD76 - R50 - B22W 3mm. (Note the W stands for wet grinding).

The concentration of the diamond will affect the price of the wheel as will the Shape and Thickness of the diamond layer which is usually 1mm, 1.5mm, 2mm, or 3mm thick. Thin layer wheels are needed to get into the gullets to grind the face of tungsten tipped fine toothed saw blades used for cross-cutting plywood or for cutting metals and plastics although wheels which are partially worn down can be used.

The concentration tends to be higher for the courser grits used for rough grinding and less for the finer grits used for finishing which may be opposite to what we would expect.

Typical specifications showing this are as follows:-

MD150 - T100 - B25 for roughing.
MD181 - T75 - B25 for medium fine finish.
MD76 - T50 - B25 for fine finish.

You will note that in the newer F.E.P.A. units used, the finer grits have the smaller numbers this is because the units used are Microns (μ) i.e. 1/000mm and so 100μ is bigger than 50μ. In the old system of mesh sieve sizes the higher the number the finer the wire mesh to sieve the grit and so the finer the grit size.

TABLE No. 1.

DIAMOND AND CBN GRIT SIZES

	F. E. P. A. SIZE IN MICRONS	OLD MESH SIZES PER LINEAR INCH
COARSE	427	46
↑	357	54
	302	60
	252	80
	181	100
	151	120
	126	150
	107	180
	91	220
	76	240
	64	280
↓	54	320
FINE	46	400

CHAPTER 14

Framesaw Blade Types, Tooth Geometry, Setting & Sharpening.

Introduction:
Framesaw blades are like a thick piece of wide bandsaw blade usually between 1.05 and 3 metres long held tight or *STRAINED* inside a *FRAME* similar to a carpenter's bowsaw.

The cutting action is the same as the bowsaw in that the whole frame plus the blade moves forwards and backwards across the wood being cut. This is called a reciprocating movement.

Machines which use this type of blade differ quite considerably. First there is the old-fashioned type of machine which uses a single blade working horizontally then there are the modern vertical framesaws using any number of blades usually between 5 and 24 all at the same time strained up inside a very strong frame.

These machines are given various names throughout the world such as gangsaws when they use more than one blade but let us just call them VERTICAL FRAMESAWS and HORIZONTAL FRAMESAWS.

Types of blades:
As far as the sawdoctor is concerned, there is one big difference between these two types of machine which is; the horizontal framesaw cuts in *BOTH* directions i.e. forwards and backwards and the vertical framesaw blade only cuts on the *DOWNWARD* stroke into the log or baulk of timber.

On the upward stroke the vertical framesaw blade is arranged so that it travels free without cutting.

This means that the types of teeth used on the blades for each type of machine are different since the horizontal blades cut in both directions and the vertical blades only in one. Typical blades for both machines types are shown in Fig.201. Both types of blade may be fitted with steel plates riveted to both ends of the blade, these are called *TABS* and are used to fix the blades into the frame.

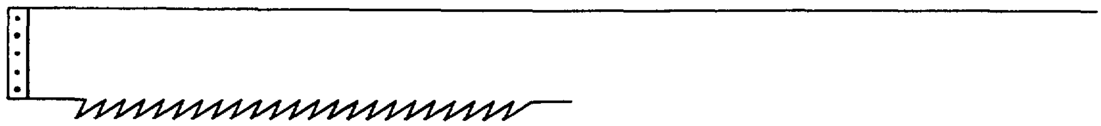
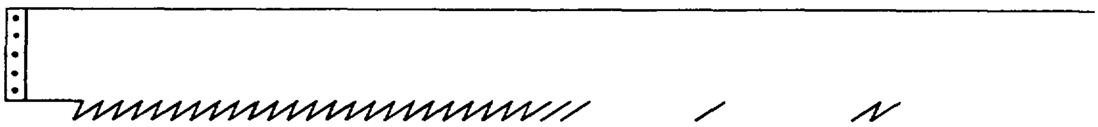


FIG.201. **Horizontal Framesaw Blade**



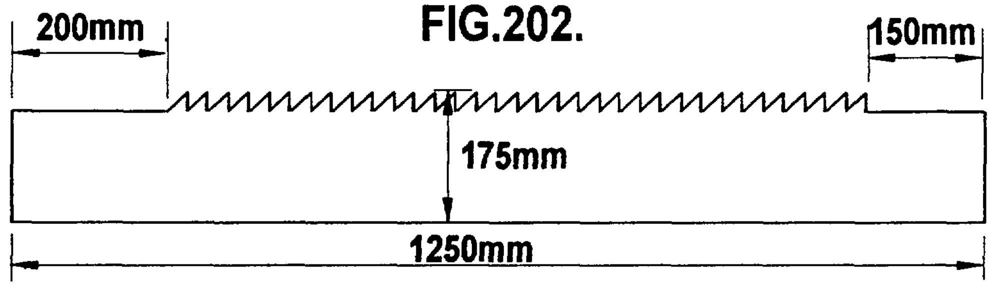
Vertical Framesaw Blade

Ordering New Blades:

There are two types of steel used to make framesaw blades. The cheapest is a plain carbon steel which is satisfactory for blades which are to be sprung set. The better quality steel contains 3% nickel which improves its cold working property and so makes it the correct choice for blades which are to be swage set. The better steel is also suitable for spring setting.

When ordering it is best to include a drawing of the blade showing all the important sizes as shown in Fig.202.

FIG.202.

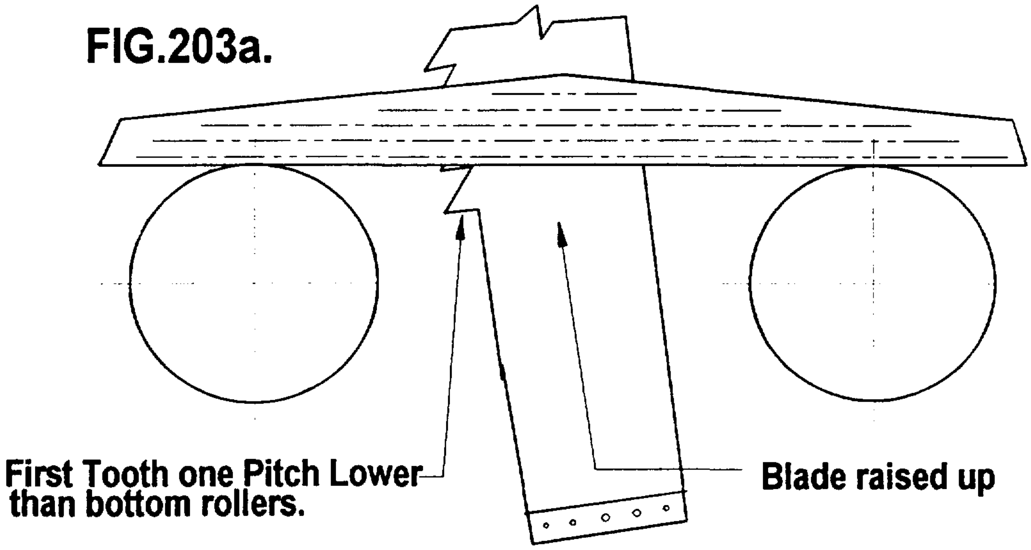


Sketch showing overall Length, Width & Toothing Length

All these sizes can usually be found in the machine's instruction manual or taken from a new blade which is known to be correct. If these details are not available or are suspected of being wrong, the correct toothing length can be found as follows:

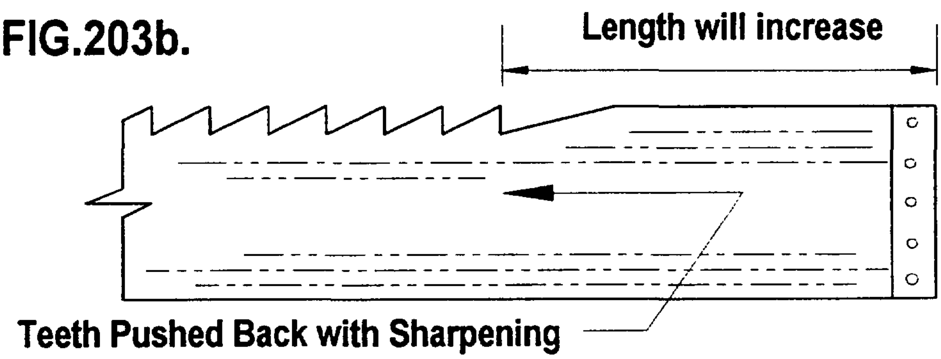
1. The distance of the first tooth from the end of the blade can be found by stopping the machine at the top of its stroke and with a straight edge placed across the bottom feed rollers, mark the blade and deduct one tooth pitch from this measurement as shown in Fig.203a.

FIG.203a.



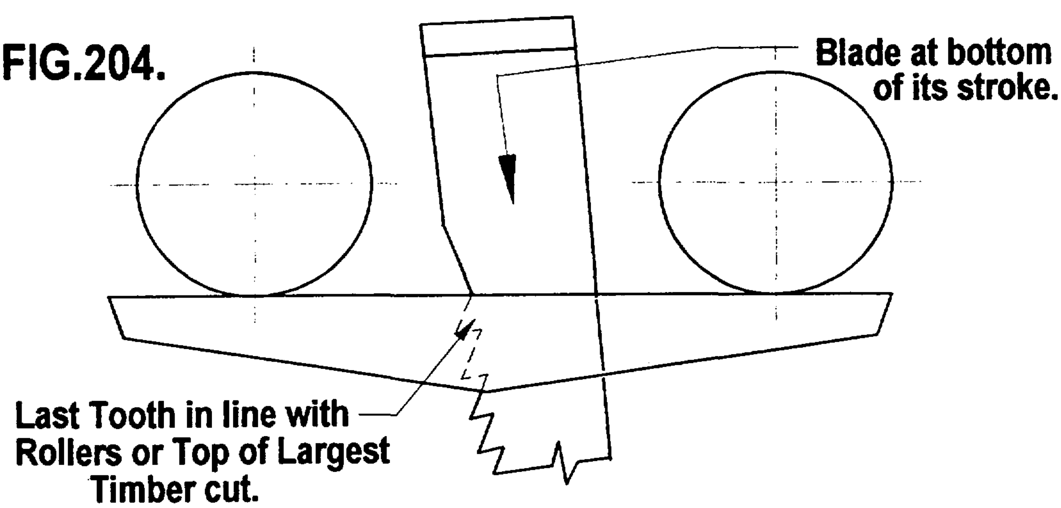
This extra tooth which will not work for some considerable time is to allow for the teeth being pushed back as the blade wears down as shown in Fig.203b.

FIG.203b.



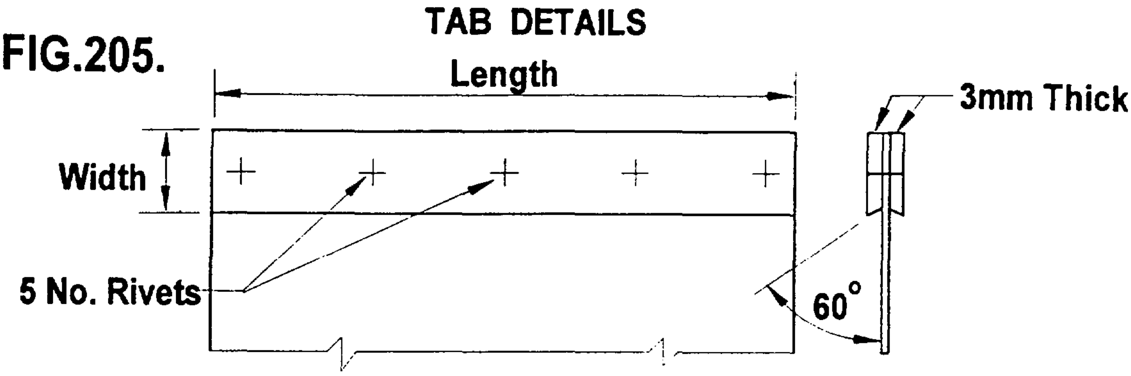
The distance of the last tooth from the other end of the blade is found by stopping the machine at the bottom of its stroke and with a straight edge mark the position of the last tooth as shown in Fig.204.

FIG.204.



If tabs are fitted to the ends it is very important to give full details in a drawing as several different patterns exist, a sample drawing is shown in Fig.205.

FIG.205.



Even without tabs on the ends of blades details of securing holes should be included with the order as shown in Fig.206. This can either be a drawing or can be a rubbing taken from an existing blade.
Finally a drawing or rubbing of the tooth shape must be included with the order with the pitch marked clearly as shown in Fig.207.

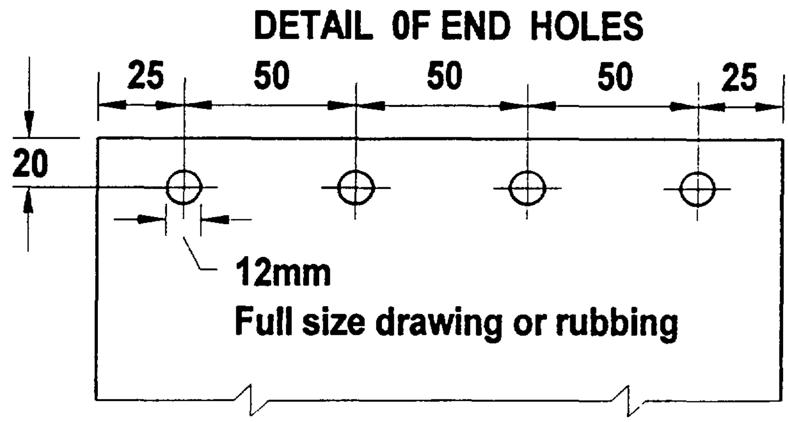
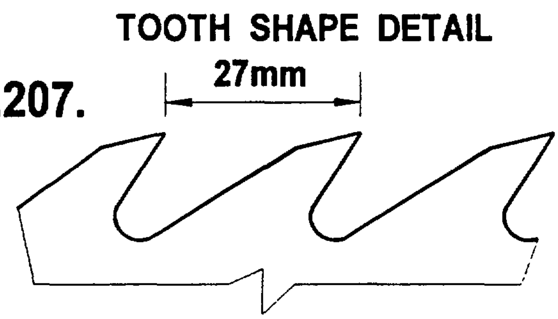


FIG.206.

All sizes in Millimeters

FIG.207.



Full size drawing or rubbing

Tooth Geometry and Sharpening Methods:
Tooth geometry or design was extensively covered in chapter 1 on circular saw blades and all the principles, calculations and nomenclature apply to all types of blades including framesaw blades. However as bandsaw blade teeth differ from those used on circular saw blades, framesaw blade teeth have their own shapes to fit blade and feed speeds, tooth bites and volumes of sawdust to be carried in the gullets. These in turn govern their size and their shape.

Because of the reciprocating movement of all framesaw blades the blade speed is generally less than both circular and bandsaw blades which only have to move in one direction. This slower blade speed together with the teeth being traditionally sprung set usually results in smaller tooth pitches being supplied by the manufactures and often accepted without question by the sawmills. These pitches are mostly in the region of 25mm to 32mm.

The tooth height using the formula: maximum height not to exceed 10x the blade thickness results in teeth fairly tall in relation to their height as blade thicknesses are usually in-between those of circular and bandsaw blades. The hook angles generally used are quite small and I suspect that this has a lot to do with historically poor maintenance in the days before machine sharpening and swage setting were available and this would often result in blades running out of line with disastrous results unless hook angles and tooth bites were kept to a minimum.

As we know, if we swage set teeth, each tooth then takes out a full saw kerf so that we no longer need a pair of teeth to complete the cut, this means that we can double the pitch providing that the gullet will hold the sawdust produced. Because of the tremendous loads on framesaws carrying multiple blades it is absolutely vital that the sawdoctors should make every effort to:-

1. Increase tooth pitches.
2. Decrease saw kerfs to a minimum.
3. Increase hook angles to the maximum that will still cut straight.
4. Use the minimum blade thickness that will still cut straight.

Of course all these suggestions to help reduce the load on the machine will only work in conjunction with improved blade maintenance especially correct and regular blade tensioning which in many sawmills is sadly neglected or not practiced at all. To run thin blades at higher feed speeds it is necessary to give the same attention to levelling and tensioning as we do to bandsaw blades. Some typical tooth shapes are shown in Fig.208.

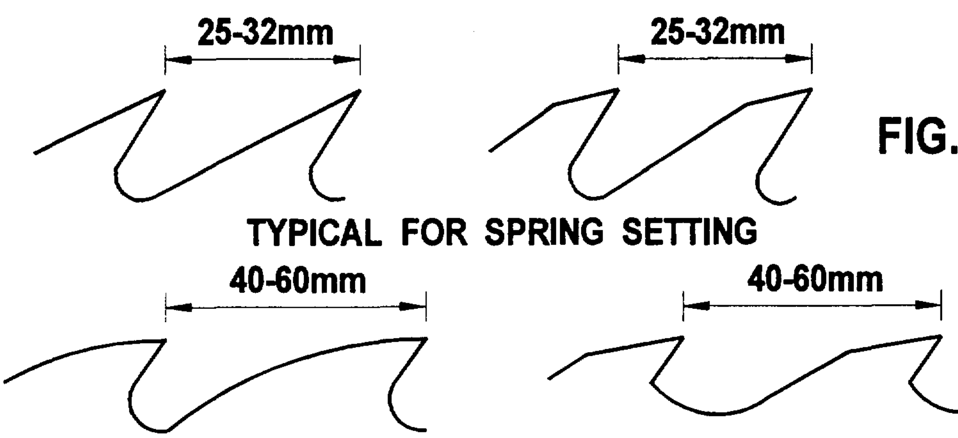


FIG.208.

Sharpening Methods:
Methods of sharpening vary considerably from simple hand filing or grinding freehand to machine sharpening where, on the most advanced type, everything is fully automatic after the blade has been clamped into the machine until the blade is completely sharpened having passed the grinding head any number of

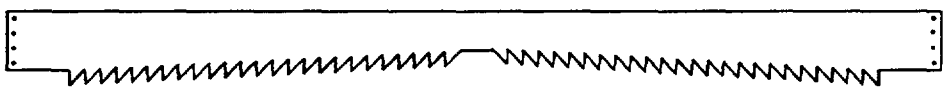
times which is predetermined by the setting of a dial on the machine.

Simple hand sharpening methods are suitable when only one or two blades have to be sharpened each day. Fully or semi-automatic machines would be needed in sawmills where one or more multiple bladed vertical framesaws are in use requiring many blades to be sharpened daily.

Obviously we cannot cover every type of sharpening machine and every variation of hand sharpening that exists so we will try to set down all the important points in the general process of renewing the sharp cutting edges.

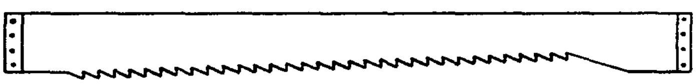
Whichever method is employed the cutting points of the teeth must be maintained in a *STRAIGHT LINE*. With machine sharpening this should be achieved automatically but with hand sharpening there is sometimes a tendency to try to save time by only sharpening the part of the blade that is actually cutting, which may be as little as a third of its toothed length. I have seen blades as shown in Fig.209. as a result of trying to save work and this fault throws out completely the overhang setting and so the cutting action of the teeth.

INCORRECT SHARPENING



Horizontal Framesaw Blade

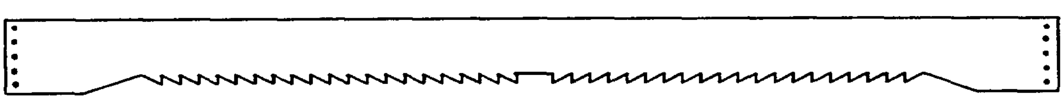
FIG.209.



Vertical Framesaw Blade

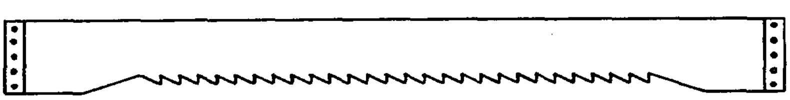
The toothed cutting edge must also be maintained *PARALLEL* to the back edge so that measurements taken from the tabs will be correct when setting overhang of the blades, discussed later. The blades as they wear down should be as shown in Fig.210. To assist in cutting away the blade at each end near the tabs a suitably shaped punch in a heavy duty fly-press is the best and quickest tool to use.

SHARPENING PARALLEL TO BACK EDGE



Horizontal Framesaw Blade

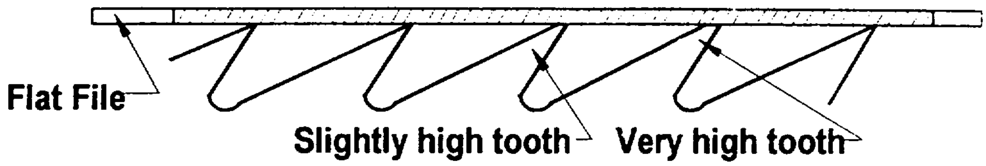
FIG.210.



Vertical Framesaw Blade

Any form of hand sharpening, i.e. filing or grinding, should be preceded with ranging down of the tooth points to guide the sharpening in a straight line. This will show up any high and low teeth as shown in Fig.211. and assist in ensuring that all the teeth cut and do an equal amount of work.

FIG.211. RANGING DOWN TEETH



A hardwood file holder as shown in Fig.212. is easy to make and will ensure that the tops of the teeth are filed square, if not the teeth could all end up long on one side resulting in the blade cutting to one side.

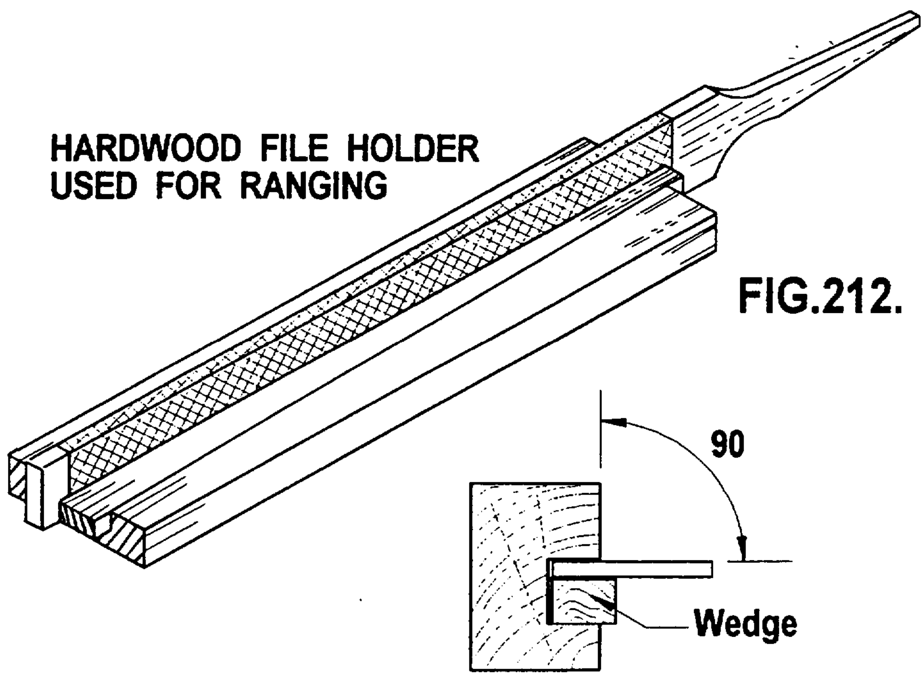


FIG.212.

Good quality files are not always easy to obtain in developing countries and in any case are expensive and slow at removing steel so are not often used other than for light topping of teeth. One of the best methods I have seen for hand sharpening for framesaw and even bandsaw blades is to make a bench of a board about 200mm wide set at an angle to a grinding wheel, the angle being equal to the hook angle required on the teeth. The blade is placed on the bench and the face of the teeth are ground to the correct angle and the shape of the wheel takes care of the gullet shape. The back of the teeth, usually straight, are ground to the flats produced by the ranging process and it is surprising how good the results can be. We ran eighteen blades in a frame quite successfully in Sri Lanka using this method of sharpening.

Machine sharpening is much the same as bandsaw sharpening previously covered and the same principles apply in trying to push the teeth back along the blade rather than down across it thereby prolonging the blades life as much as possible. The success of this largely depends upon the tooth shape. One point about this is, that with the gradual movement of the teeth back along the blade, a new tooth must be formed to replace the first tooth as it moves up the blade. That is unless the first few teeth are surplus to requirements and never enter the cut.

The one big difference with bandsaw sharpening is having to start and stop at each end of the blade not an easy task requiring some skill if the machine is not equipped with a pitch bar for the pawl finger to work on instead of the teeth. The grinding head must be fitted with a bar which is attached at one end to the head and to the rear of the pawl finger at the other. This connection allows the pawl finger to be raised or lowered in and out of the gullets (or pitch bar) to stop or start the movement of the blade automatically as the grinding wheel is raised or lowered to stop or start grinding. Also very useful are an adjustable stop on the slide bar to position the first tooth to be sharpened and a height setting stop to set the height of the blade to save time in lowering the grinding head down to start sharpening.

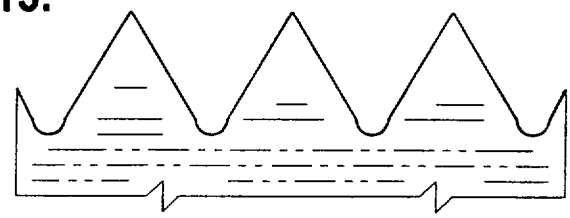
When using the simplest form of automatic sharpener without a pitch bar the pawl finger should push the tooth one pitch back from the tooth being sharpened, this is to ensure that the pitch of the teeth remain equal as practised on circular saw blades. The last tooth to be sharpened has to be positioned by hand after sharpening is complete and the grinding wheel lowered into the gullet to maintain its true pitch or alternatively this tooth can be sharpened off the machine on a bench grinder fitted with a suitable wheel, perhaps an old one from the automatic machine.

If purchasing a new machine for framesaw blade sharpening the blade holder attachment should be the type fitted with a pitch bar for this feature makes sharpening much easier at the start and end of sharpening each blade and is well worth the extra cost of the pitch bar or bars to suit your blades. You must of course specify the pitch of your teeth which you intend using when ordering.

The sharpening of horizontal framesaw blades needs some additional explanation since the fact that they cut in both directions complicates both the tooth profiles used and the sharpening of those profiles.

There are three ideas used to try to solve the problem of trying to design a tooth profile which will cut in both directions *EFFICIENTLY* which of course is impossible. The oldest method is to use cross-cut type teeth which are known as *PEG TEETH.* but without any face bevel as shown in Fig.213. These cut equally well in both directions but without a positive hook angle cannot cut efficiently as the teeth have a scraping action. The only good thing in their favour is that they are the easiest of the three types to sharpen.

FIG.213. PEG TEETH

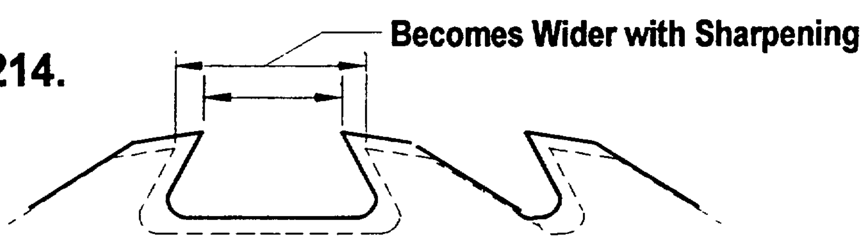


Next there is the idea of pointing all the teeth on one half of the blade in one direction and the other half in the opposite changing at the centre of the blade. These teeth are now of a ripsaw profile and at least will cut efficiently when they are travelling in the right direction but which is only for half the time.

Sharpening by machine is not too difficult but it does mean that only half of the blade can be sharpened then the blade has to be turned around to sharpen the other half. The height of the teeth on each half of course must be sharpened to the same height and as the two teeth at the centre are pushed closer together as the sharpening progresses one tooth must be lost and a new one formed at the end of the blade, first on one half then the other, to keep the blade's two halves balanced, i.e. the same number of teeth.

The third idea is quite complicated using what are known as *CLUSTER TEETH.* They usually take the form of a cluster of about seven ripping profile teeth pointing in one direction and then a cluster pointing in the other alternatively across the full length of the blade. This is perhaps the most efficient of the three ideas but of course is the most difficult to sharpen but can be successfully sharpened using an automatic sharpener providing that you have at least an attachment with a pitch bar and all the built-in height gauges and end stops. Clusters of teeth facing each other move wider apart with sharpening as shown in Fig.214. and the backs move closer to each other over a period of time and like the previous type need new teeth forming and each cluster sharpening to the same height. Vollmers of West Germany do make a fully automatic attachment for cluster teeth but the blade still has to be turned around after half the teeth are sharpened.

FIG.214.



CLUSTER TEETH

Blade Side Clearance:
As we have stated earlier most framesaw blades seem to be sprung set, or at least in those sawmills which I have visited in developing countries. There is nothing wrong with this except that we are then tied to using small pitched teeth as we need two teeth to cover the complete saw kerf.

Again as we mentioned earlier, we must find by trials the *MINIMUM* amount of set that will give enough clearance to the blades and stick to this especially if we are running multiple blades. This is not only to save timber, which can be quite considerable when running multiple blades, but to keep to the minimum the load on the machine's bearings and other working parts.

Accuracy of setting is especially important on framesaw blades used in sets as if a blade cuts to one side the whole frame of blades may have to be slackened off to remove the offending blade for correcting.

Although all the teeth on each blade should be sharpened to keep the blade parallel, if the top part of the blade never enters the cut because of cutting small logs or baulks, the teeth not working can of course be left without set.

Swage setting is to be recommended when running multiple blades for the following reasons:-

1. Half the number of teeth can be used i.e. teeth with twice the pitch. This will improve gullet capacity and reduce sharpening time.
2. Teeth which are swage set are less likely to run off in the cut than sprung set teeth.
3. Combined with a good tooth shape and increased hook angle swage set teeth should be capable of faster feed speeds resulting in larger tooth bites and with this more efficient cutting action of the teeth an increase in production can be expected from each set of blades.

The process of swage setting is fully covered in the manual on wide bandsaw blades and all that was said then applies to framesaw blades however if ordering new swaging and side dressing tools they should be purchased from one of the specialist firms like Armstrong U.S.A. who can supply tools specially designed for framesaw blades. These tools are both stronger for the thicker gauge of framesaw blades and shorter in length to work nearer to the higher ends of worn blades. For thick blades they may recommend tools powered by compressed air which they can also provide.

When inquiring about such tools be sure to give the gauge of the blades used and the shape of the tooth profile so that they can supply the correct size of swaging die as they manufacture a wide range of diameters from 5mm to 22mm.

CHAPTER 15

Framesaw Blade Levelling and Tensioning

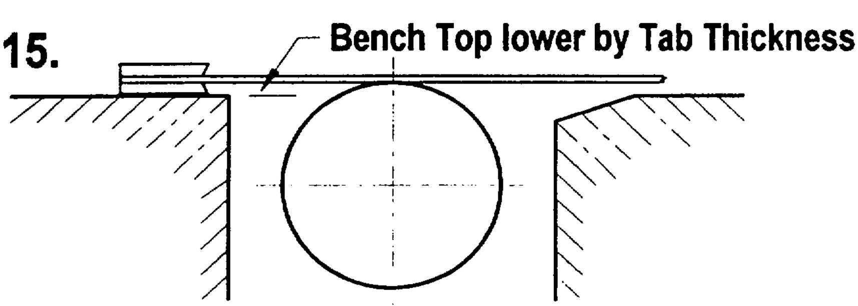
Introduction:
As we have already stated, in many sawmills the processes of levelling and tensioning are sadly neglected. It would appear that by doing everything *WRONG* i.e. using thick blades, little hook, large amounts of set, no tensioning and low feed speeds, framesaw blades will cut lumber! and so it is very difficult to persuade semi-skilled sawdoctors to take on the extra work of levelling and tensioning, which can be considerable, especially when blades have been neglected. It is equally difficult to persuade management to invest in the equipment needed if it does not exist. All we can say is that with everything done correctly including using thinner gauge tensioned blades, the stress on the machine should be reduced benefiting in lower machine maintenance in such things as bearings etc. and of course more yield from logs which can be quite considerable if saw kerfs are reduced for every blade in a set of say eighteen blades cutting thin boards.

The principals in levelling and tensioning of framesaw blades is the same as for wide bandsaw blades therefore we will not repeat the basic theory which was covered in detail in the module on wide bandsaw blades.

The Tensioning Bench:
Although framesaw blades can be tensioned on the same bench as used for bandsaw blades, if there is sufficient work for a separate bench or if bandsaw blades are not used then a different design of bench should be constructed with the following points in mind.

1. There is no need for the top and bottom rollers needed for bandsaws the framesaw blades pass through the stretcher rolls at one level and have to be pulled back each time at the same level for the next roll .
2. A long outfeed side to the bench is required to support the blades, the stretcher rolls being placed in the middle of the bench with both the infeed and outfeed sides of the bench being slightly longer than the longest blade in use.
3. If tabs are fastened to the blades then the height of the bench should be lower than the bottom roller by the thickness of the tabs. See Fig.215. This is important to prevent dishing which would eventually occur if the bench top was level with the roller as for bandsaws.

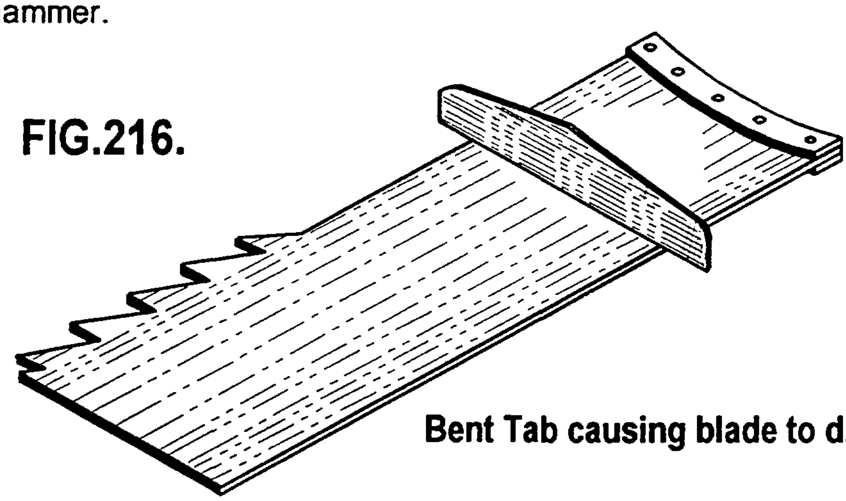
FIG.215.



4. The stretcher rolls should preferably be of the open ended type to facilitate the entrance of blades with tabs fastened to their ends and of course should be of very strong construction to cope with the gauge of blades used which are usually thicker than bandsaw blades.

Levelling:
Before any levelling of the actual blade is done, the tabs should be checked for being flat as bent tabs will hold the blade hollow as shown in Fig.216. During this checking of the tabs inspect the rivets and tighten any which may be loose using a ball pein hammer.

FIG.216.



Bent Tab causing blade to dish.

The actual levelling is carried out exactly as explained fully for wide bandsaw blades. Although lumps in the middle of the blade can be levelled with the roller, the stiffness of the thicker blades and the presence of tabs means that many of the lumps which would be rolled level on bandsaw blades may have to be hammered level. The teeth and the tabs if fitted should overhang the levelling plate when hammering making sure to keep the hammer square off the edge of the blade to avoid hammering a twist into the blade.

We have already stated that we should try to reduce saw kerfs to a minimum especially when running multiple blades, therefore it is important to make sure that the levelling process is carried out thoroughly so as to allow the minimum set to be used since a lumpy blade will overheat unless extra set is used to give clearance to the lumps.

Tensioning:
Before starting to tension the blade, put a chalk mark across the blade at each end about 150mm away from the end or tab. All tensioning is carried out in between these two lines as it is not practical and indeed necessary to tension right up to the ends of the blade.

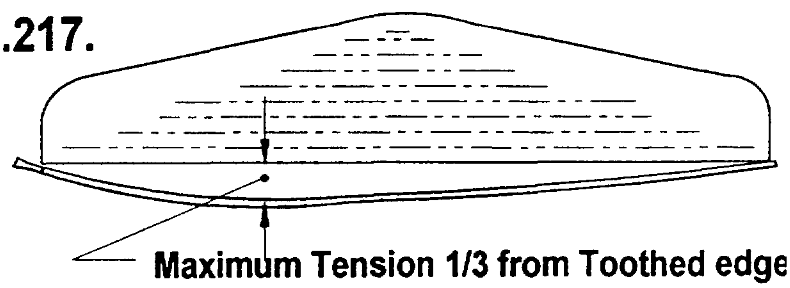
Be sure to work on both sides of the blade i.e. turn the blade over during tensioning, this is to prevent the possibility of the blade becoming dished because of any slight difference in the faces of the rollers or in bench top alignment.

Because framesaw blades are usually thicker than bandsaw blades for the same width, the amount of tension required is normally less, i.e. we will be able to use a *LARGER NUMBERED* tension gauge, but it will of course depend upon cutting speeds and the amount of heat generated within the blades. As with bandsaw blades we should use the minimum amount of tension that will work found by trials gradually using tension gauges with bigger numbers.

When tensioning framesaw blades the back edges are kept straight as there is no point in rolling in a crowned back as often used on bandsaw blades. The crowning of bandsaw blades is to make the front edge of the blade shorter than the back edge so that the toothed working edge can expand and still remain tight and so cut straight. With framesaw blades it is different, the toothed cutting edge will not be sharpened parallel to the back edge if it were crowned as with bandsaws but will be sharpened straight as it passes through the machine in a straight line controlled by the carriage not the back edge of the blade. Therefore a crowned back edge would achieve nothing. To overcome the front edge becoming loose as the teeth get hot the toothed edge on framesaw blades is usually strained up more at the front by positioning the straps off centre nearer to the front edge.

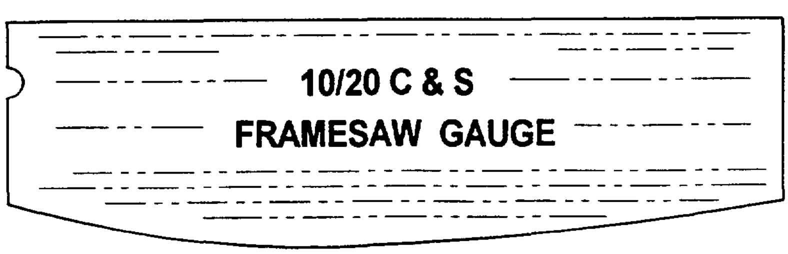
Because we are not able to use a crowned back edge to tighten up the front edge more than the back edge there may be a good argument for rolling in more tension into the front part of the blade near to the teeth which get hot and expand the toothed edge. For example the first third under the teeth could be fitted to a 10 metre gauge and the back two thirds to a 20 metre gauge. In this case the tension would look like Fig.217.

FIG.217.



If this system is adopted then a special gauge can be made to fit the blade after it has been tensioned to the two different gauges. To ensure that the gauge is used the correct way around, the toothed end should be clearly marked by grinding a notch into the end. See Fig.218.

FIG.218.



CHAPTER 16

Framesaw Blade Fitting.

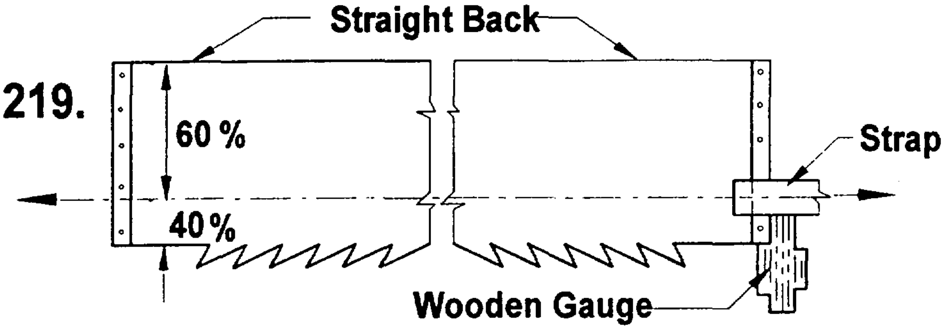
Introduction:
I believe that it is true to say that the *CORRECT & ACCURATE* fitting of framesaw blades, especially when fitted in multiples, is perhaps more skillful than fitting any other type of woodcutting blade. It may seem straightforward enough but with the popular use of wooden spacers and packings which can wear or even compress out of shape or just be cut inaccurately in the first place coupled with the possibility of inaccurately fitted straps can easily throw blades out of the true stroke of the machine which in turn can cause poor lumber and add vibration to the machine which, because of its reciprocating movement, tends to vibrate anyway and additional vibration is not noticed

All the work of the sawdoctor can be ruined if the blades are not fitted to the machine correctly. Therefore it is of the utmost importance that the sawdoctors understand thoroughly just how blades should be fitted otherwise he may waste a lot of time trying to find a fault in his maintenance, if blades are not cutting right, when all the time it may be a fault in the way the blades are fitted to the machine.

Horizontal Framesaw Blade Fitting:
The way the blade is attached to the frame will depend upon the make, design and age of the machine but only two possibilities exist, either the blade has straps attached to it permanently in a central position as on very old machines or the straps can be slid onto an end tab in any position as on modern vertical framesaw machines.

If the position of the straps can be adjustable then the straps should be placed at a point 40% from the front edge. This will ensure that the strain on the blade will keep the toothed edge tight even when it heats up from cutting. This is why we do not need to shorten the toothed edge by crowning the back edge when tensioning as often practiced on bandsaw blades. To make it easy and to ensure that the positioning is correct it is worth making wooden or steel gauges for the sawyer to use when setting the straps. You will see in Fig.219. how the gauge is used and how the 40%-60% excludes the teeth.

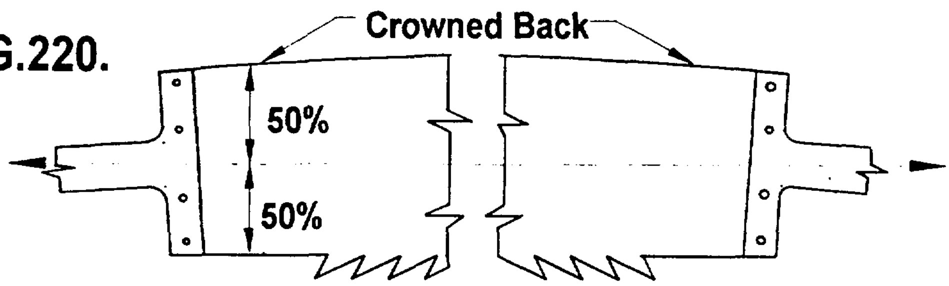
FIG.219.



Various sizes of gauge will be needed as the blades wear down in width as it is the remaining width of blade that counts. The 40% need not be too accurate so gauges based on widths for every 25mm or 1 inch of blade reduction i.e. by measuring the blade to the nearest 25mm will suffice.

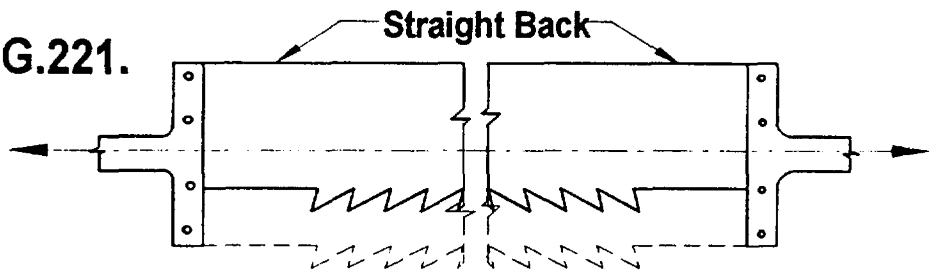
If the straps are riveted to the blade in a central position, this is one situation when the crowning of the back edge might be advantageous. The crowning during tensioning will throw the straps out as shown in Fig.220. and will tighten up the front edge slightly. You will see that, as the blade wears down in width, the position of the fixed strap improves and at some stage will arrive at the 40% measurement. At and near this point the back edge can be returned to straight. See Fig.221.

FIG.220.



Non-adjustable Tabs

FIG.221.



Non-adjustable Tabs

Whatever system is used to fit the straps there are *THREE* possible directions in which the blade can be out of line with the stroke of the machine.

First, and connected to this positioning of the straps, is that the cutting edge *MUST BE PARALLEL TO THE STROKE OR SLIDES OF THE MACHINE.* If this is not true the blade will not cut in both directions as it is designed to do and so seriously affect the efficiency of the sawing. See Fig.222. and Fig.223.

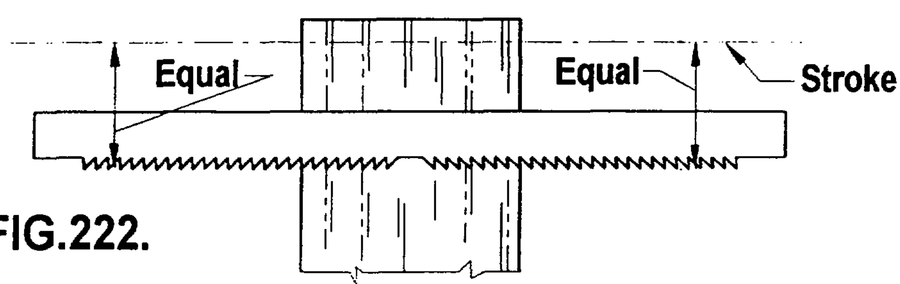
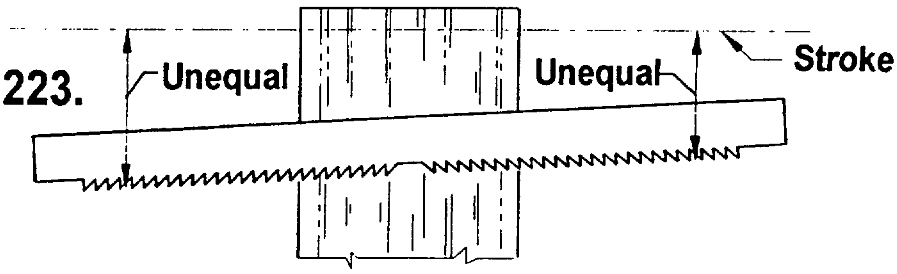


FIG.222.

Cutting edge Must be Parallel with the Machine's Stroke

FIG.223.



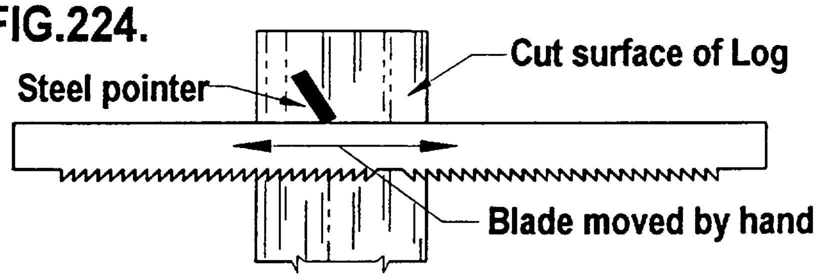
Cutting edge Not Parallel with Machine's Stroke

Suspect this fault if all or most of the sawdust spills out of one side of the log or timber being cut and of course the teeth on one half of the blade which is not cutting will not blunt.

Normally if the straps are positioned correctly i.e. both the same distance from the front edge of the blade. the blade should be parallel with the stroke but on these old machines wear and other things may be wrong to throw this out. If this alignment is suspected then a simple test can be conducted as follows:

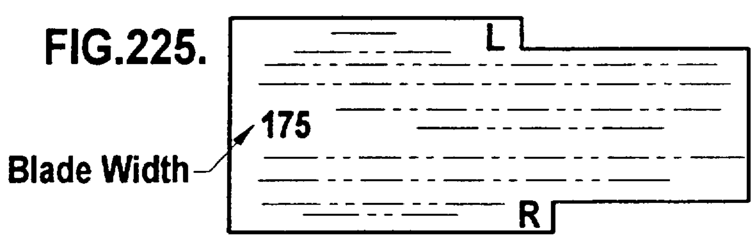
1. Place a piece of steel on the log carriage or better still on the cut surface of a log on the carriage as shown in Fig.224. just touching the back edge of the blade.
2. Disconnect the feed to the carriage and have an assistant rotate the flywheel by hand to move the blade the full width of its stroke across the log.
3. Watch the back edge to see if it touches the steel pointer at both ends of its stroke.

FIG.224.



If there is any error more than 1mm investigate to try to ascertain why there is a fault, there may be some parts worn or blades riveted on wrong or simply inaccurate fitting of the straps if they are of the movable type. Whatever is the cause it must be corrected if at all possible. It may be, if the straps can be adjusted, to correct the fault only needs a different gauge for each end of the blade. See Fig.225.

FIG.225.



Left & Right-Hand Gauge

Secondly the blade must also move parallel to its stroke in the other direction as shown in Fig.226. Normally this will be correct as the position is fixed. However if it is only slightly out for some reason then it will cause a lot of vibration as the blade tries to push the log sideways first one way then the other at every stroke. This will damage both the machine and the blade and must be corrected right away. The sawdoctor can suspect this fault if the blades become shiny on opposite sides at opposite ends.

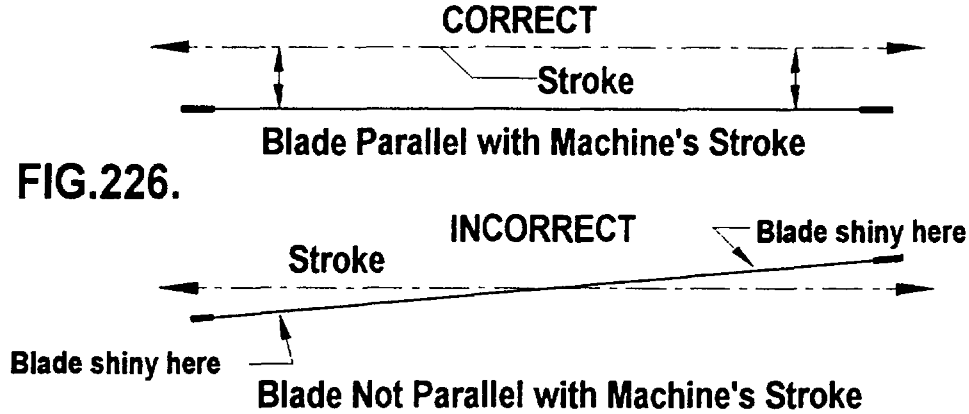


FIG.226.

To check this fault place a piece of steel on the cut surface of the log this time underneath the blade with the blade raised 1mm above the steel as shown in Fig. 227.

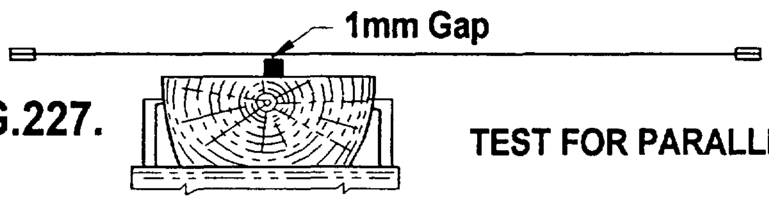


FIG.227. TEST FOR PARALLEL

With the feed disconnected have an assistant rotate the flywheel by hand so that the blade travels over the steel the full length of its stroke, at the same time watch the 1mm gap for any variation. If the gap looks different at each end of the travel, measure the gap using a set of feeler gauges. Note that any difference will be multiplied at the end of the blade by the number of times the blade is longer than its stroke. For example, let us say that the gap at one end is 1mm and at the other 1.6mm and the blade length is 2500mm with a stroke of 1000mm. The misalignment at one end would be:

$$(1.6 - 1.0) \times \frac{2500}{1000}$$

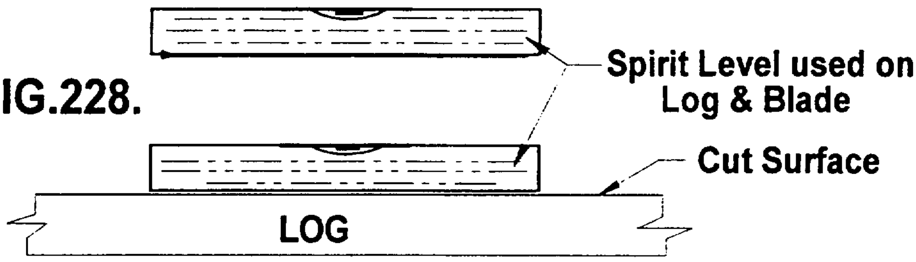
$$= 0.6 \times 2.5 = \underline{1.5\text{mm}}$$

This may seem a very small misalignment but it will certainly make a lot of difference to the cutting action of the blade and the vibration of the machine and should be corrected.

Third and finally the blade must be secured to the machine *PARALLEL* to the cut across the *WIDTH* of the blade as shown in Fig.228.

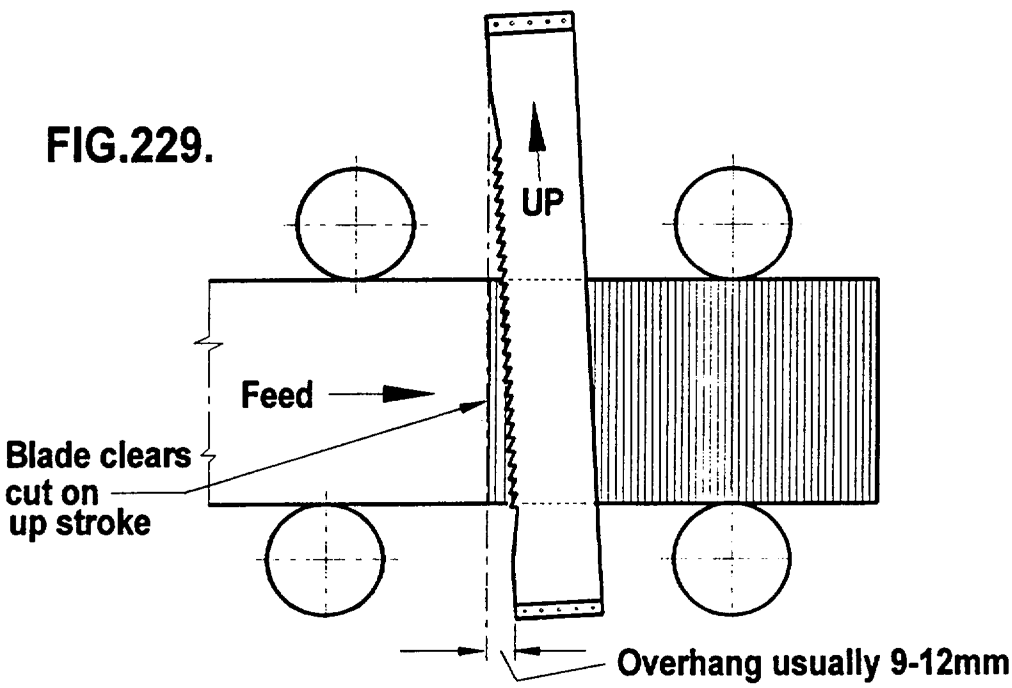
Note: any error in the level of the log carriage must be allowed for and can be overcome by putting new marks on the spirit level or adjusting the bubble it if it is of the adjustable type. If the spirit level is adjusted to allow for the log carriage being out of level then the spirit level must always be used it the same way around.

FIG.228.



Vertical Framesaw Blade Fitting:
There are some very sophisticated machines with special blade movements which need their blades fitted according to the manufacturer's instructions and others which tilt the frame automatically to suit the feed speed used so that the blades are set equally top and bottom. However most vertical machines whether they are single bladed or gang frames have to have their blades fitted with some amount of *OVERHANG* this is because the blade only cuts in one direction, the downward stroke, and needs to clear the bottom of the cut on the upward stroke. See Fig.229 . The amount of overhang depends upon the feed speed of the machine which may be continuous but is more often intermittent i.e. it jumps forward a set amount at every stroke of the blade. The feed speed is also usually variable and so the amount of overhang, in theory, needs to be more for higher feeds than for slow speeds but is often a set amount which will cope with the highest feed. If no information on the machine is available then an overhang of between 9mm and 12mm will usually prove satisfactory.

FIG.229.



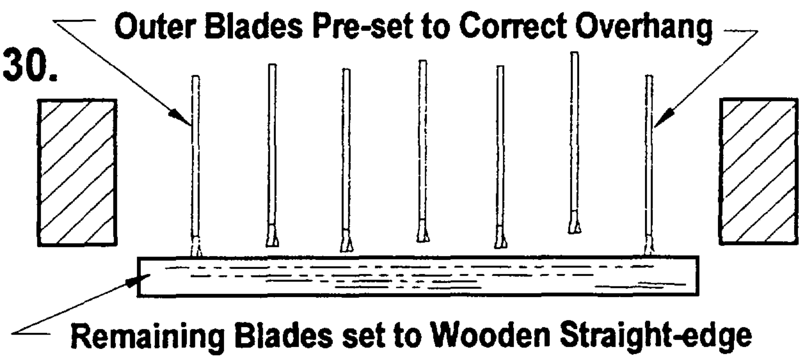
There are some single bladed vertical framesaw machines usually of the portable type to move around the forest but whether they are single or gang frames the principals of fitting and setting the overhang are the same.

The general rule of setting the straps at about 40% from the front as for horizontal blades to tighten up the tooth edge still applies although the top strap may have to be set more forward by the amount of overhang than the bottom strap.

Obviously when setting multiple blades in a frame which can often be 16 or 18 blades in a set, some quick way of setting the blades with their correct overhang is desirable. Several methods exist with many variations but let us consider three basic and different methods.

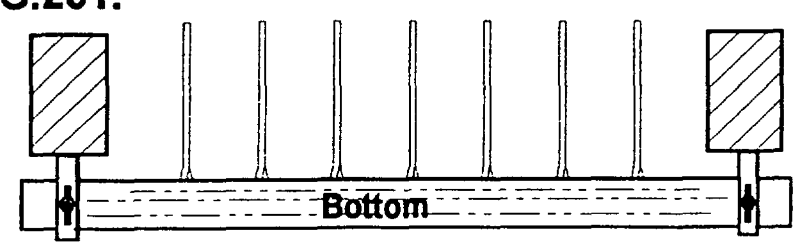
1. Some manufacturers supply a special overhang gauge incorporating a spirit level which can be adjusted to give the necessary overhang. The gauge is then used as a plumb rule by placing the gauge vertically on the teeth of the blade. The two outside blades can be 'plumbed up' with the gauge with the straps about 40% back from the front edge and the straps tightened but not strained up fully. The remaining blades can then be set in position quickly using a wooden straight-edge placed across the teeth near the top and bottom. See Fig.230.

FIG.230.



2. Special gauges can be made incorporating a straight-edge which will eliminate the need to use the spirit level. Two gauges are required, one for the top and one for the bottom so that they can be adjusted differently to give the correct overhang. The gauges need to be adjustable to allow for width of the blades ad they wear narrower and each should be marked clearly top or bottom. Fig.231. shows a gauge and how it is used.

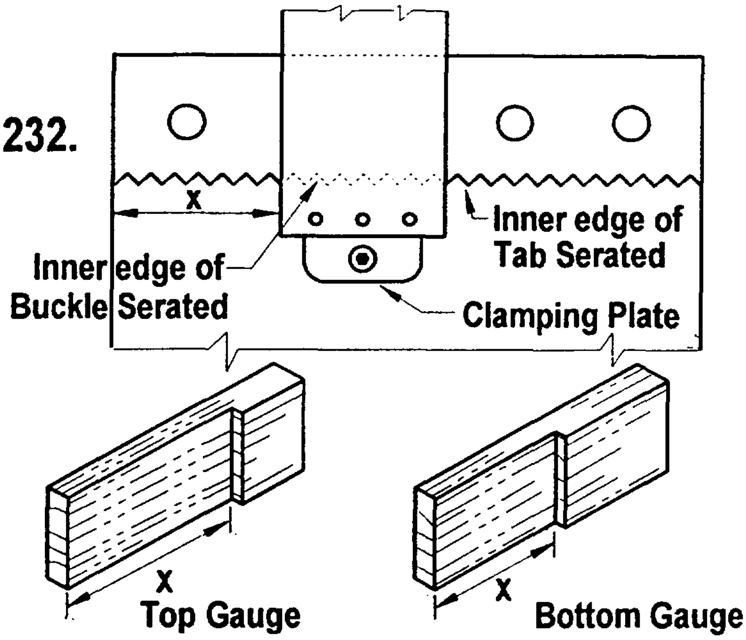
FIG.231.



Special Gauges (one top one bottom) to give Correct Overhang to All Blades

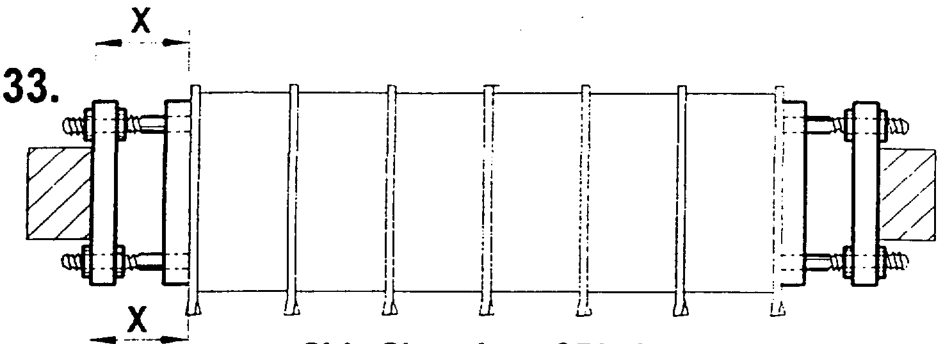
3. On some machines the straps or buckles are fixed to the blade by a small clamping plate so that the position the blades cannot be altered when the blades are in the machine. With this system the straps have to be fixed to give the correct overhang before the blades are put into the machine. Therefore two simple gauges, one for the top and one for the bottom, are used to set the position of the straps on each blade, the difference in length of the gauges giving the necessary overhang. See Fig.232.

FIG.232.



As with horizontal machines the sides of the blades must be parallel with the stroke and in line with the log carriage viewed in plan. Single blade machines should not give any trouble in this setting as the blade will normally be clamped to a fixed plate. With multiple blades the blades are not fixed so that they can be spaced to cut different thicknesses of lumber. Fig.233. shows a typical cross-section through a set of blades and associated parts of the machine. There are four clamping plates (two top and two bottom) and unless the overall width of the cutting pattern is changed considerably, one set of the plates top and bottom are never moved but are set very accurately to align the first blade. This first blade alignment is critical and must be done very accurately. Normally if the four distances marked "X" in Fig.233. are all made alike (two top and two bottom) on the same side the blade will be parallel to the stroke and carriage. This setting aligns the blade in *TWO DIRECTIONS* in plan view which if wrong will give the blades a tendency to cut tapered, and if viewed from the feed if wrong will make the blades lift and drop the logs being cut causing a lot of vibration.

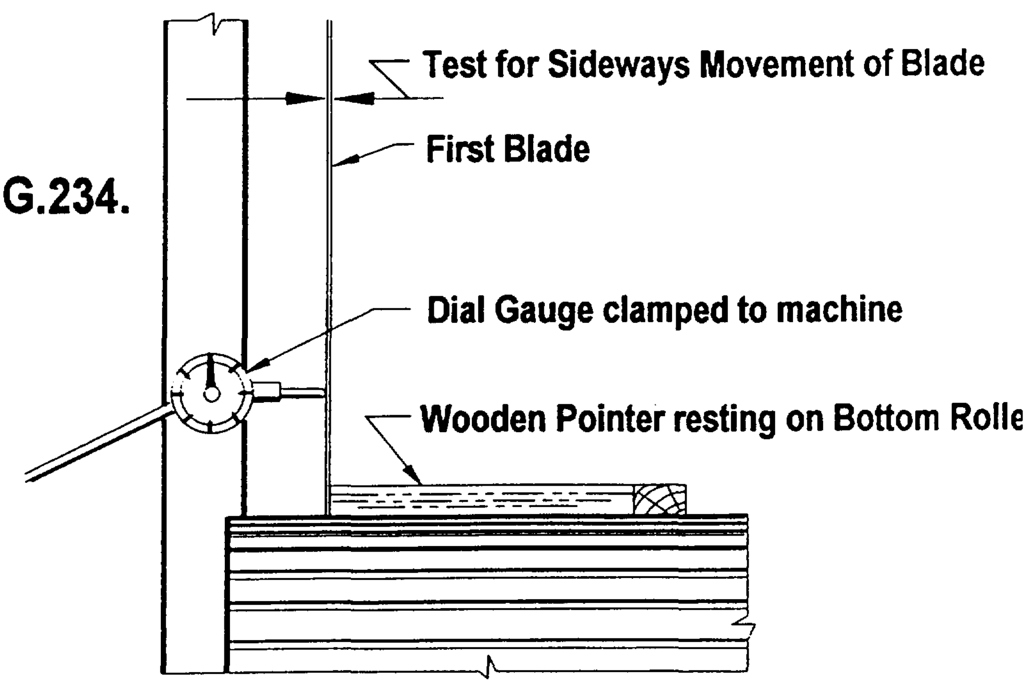
FIG.233.



Side Clamping of Blades

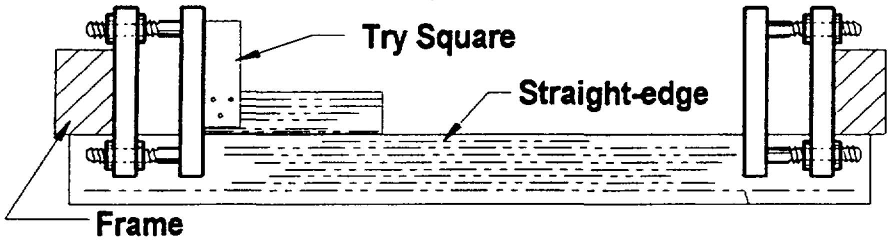
The sawdoctors are not always in the sawmill to see the machines working but it is a good plan to make time to have a walk around to see how the blades are cutting but if the vertical alignment is out the blades are likely to be shiny on one side at opposite ends and the sawdoctor should train himself to look for these signs even the sound of the machines will often tell you that something is wrong. If this additional vibration is noticed and the logs or timber being cut has a tendency to move up and down then the vertical alignment must be checked immediately otherwise the machine and blades will be damaged. To do this, stop the feed rollers then the machine and as the machine slows down hold the corner of a piece of wood against the outside blade resting the wood on some stationery part of the machine. If the alignment is out the blade will push the wood away and leave a gap at the top or at the bottom of the stroke. This rough test, if it shows that there is a fault, should be followed up with an accurate test using a dial gauge fixed to some stationery part of the machine as shown in Fig.234. this way you will be able to obtain an accurate measurement of the misalignment and so correct it in one operation. Do not forget that the amount of the adjustment will have to be multiplied by the length of the blade divided by the stroke as previously explained for horizontal blades.

FIG.234.



The misalignment in the width of the blade i.e. looking in plan view will normally be correct if the first top and bottom clamping plates are set to a try square as shown in Fig.235. or when both "X" measurements are the same as in Fig.233. But of course these settings could be wrong if the log carriage was out of line with the machine.

FIG.235.



Spacing Blocks:
Spacing blocks are sometimes supplied made of metal but more often they are made of wood in the sawmill. When this the case several things are important;

1. The blocks should be made of well seasoned hardwood, nŏt green wet timber.
2. The blocks need to be very accurate in size since any error will be multiplied by the number of blocks used. Because of this the thickness should be planed not just sawn to size with the exception of blocks for timber thicknesses of 50mm or over when these should be cut from end grain material i.e. as shown in Fig.236. when cut in this direction they should not suffer from shrinking or swelling as they would cut in any other direction. The blocks cut in this direction should be done on an accurate cross-cut or preferably on a dimension saw bench.

The shape and size of the blocks will differ with the type of machine and size of the blades but it is usual to shape the tops of the bottom blocks so that the sawdust will not pile up and bump on the underside of the log or timber being cut. See Fig.236.

It is usual to be able to raise or lower the position of the top blocks to suit the size of logs or depth of timber being cut. By keeping the distance between the top and bottom blocks to a minimum the blades will be held more stiffly and more accurate sawing should be possible.

FIG.236.