Cunningham & Holtrop

WOODSHOP TOOL MAINTENANCE

REVISED

Woodshop Tool Maintenance

A NOTE ABOUT THE AUTHORS

DR. CUNNINGHAM produced the basic manuscript covering both hand and machine tool maintenance, as a personal research project without equal in the field. Many of the illustrations were developed at his suggestion, and the thoroughgoing treatment of machine tools in Part Two is largely due to his pioneering efforts. Dr. Cunningham is dean emeritus, College of Applied Sciences, Bradley University, and was coordinator of the Bradley University ICA Iraq contract.

DR. HOLTROP headed the woodworking department at his college. Generally speaking, his work on this book dealt with the photographic and drafting requirements. However, he was producing a handbook on tool maintenance at the time the publishers brought the two men together, and contributed greatly toward the writing, editing, and preparation of copy. Dr. Holtrop is author of **Vocational Education in the Netherlands,** published by the University of California Press, and of regular contributions to school shop periodicals.

Both men have practical experience in building construction and in teaching high school woodworking and other subjects. Beryl Cunningham received advanced training at Union Christian College, Merom, Ind.; Ohio State University, Columbus; Illinois State Normal University; and Bradley University. William ("Bill") Holtrop was trained at State Teachers College, Kearney, Neb.; the University of Missouri; the University of California (Berkeley); and the University of California (Los Angeles).

Woodshop Tool Maintenance

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Foreword

THE MAINTENANCE of woodshop equipment covers a large variety of jobs. Maintenance includes the proper adjustment and care of tools and machines; periodical lubrication, reconditioning, and sharpening of cutting edges; the replacement of tools and parts; the repair of worn parts; and the installation of new equipment.

An important responsibility of a woodworker is to be able to put the equipment in good operating condition or, at least, to know how and when maintenance work needs to be done so that tools and machines operate efficiently. All equipment requires a reasonable amount of care to operate properly. Regardless of the quality of the equipment, good performance cannot be obtained unless the user becomes familiar with its construction and can make the necessary adjustments. Poorly conditioned equipment is frequently the cause of accidents.

Some users of woodshop equipment may feel that putting the tools and machines in good operating condition is the work of a specialist and is beyond the user's ability; this is not altogether true. Anyone who is capable of learning to perform the operations for which the equipment is built, can just as easily learn to maintain it. To be able to tell when a tool or machine is operating properly is an ability which all users have to some degree. This ability can be developed through experience in the care of tools and machines, together with a study of the principles on which they operate.

The beginner in woodwork may not always be able to appreciate some of the techniques and procedures that are given in this book because skill in the maintenance of a tool or machine and an understanding of the basic principles on which it works, in many cases, vary directly as the skill with which the tool is used. But it is believed that, with the development of more skill and a better understanding of the technology of materials and tools, these techniques will give results that are most satisfactory and will aid materially in securing longer and better service from woodshop equipment.

The importance of learning tool and machine processes has long been recognized but little emphasis has been placed on learning how to maintain the equipment. A search for an adequate textbook on the subject revealed that there is little material available to aid the teacher and the shop man in obtaining efficient service from shop equipment. This fact was brought to the writers' attention several years ago when they were asked to teach courses on the maintenance of woodshop equipment.

ILLUSTRATIONS

A great many of the illustrations were made especially for this book under the personal supervision of Dr. Holtrop. These include most of the drawings and all photographs not credited to a manufacturer.

Approximately 300 highly rated manufacturers of woodworking equipment and related products were selected from the *Thomas Register* as the chief source for the research material needed. These manufacturing concerns very generously supplied photographs, drawings, booklets, bulletins, catalogs, maintenance sheets, pamphlets and other data on the care and use of their particular products. The material was valuable for documenting a considerable amount of the instructions given in the study and to aid in making an analysis of the maintenance jobs that are necessary to keep shop equipment operating efficiently.

Suitable material was not available for guiding the woodworker in performing some of the maintenance jobs.

In these cases, the experimental technique was used to discover a maintenance procedure that would give satisfactory results for doing these jobs. For example, there seemed to be no procedure for gumming circular saws that would give a uniform spacing of the teeth. Therefore it was necessary to develop and illustrate a method for making a layout of the new teeth that would insure a uniform tooth spacing after a saw is gummed. The method given in this study gives satisfactory results.

The same is true for the detailed photographs of folding band saw blades.

The number of steps listed in the procedures were arbitrarily selected with the purpose of making the procedure easy to follow. The number of steps listed in a procedure is not very important if the complete procedure for the job is given. The total number of steps in a procedure for doing a job may vary, depending upon the analysis made by different writers.

The bibliographies given at the end of the chapters include only the material supplied by manufacturers and handbooks because the research reported by these sources would seem to be more valid than the information available from other sources.

The writers endeavored to produce a practical textbook which will enable those who use woodshop equipment to analyze and solve their maintenance problems. To this end, the principles of tool and machine care have been clearly explained and detailed procedures have been written for each job. The illustrations and tables have been carefully chosen for both class use and self-instruction.

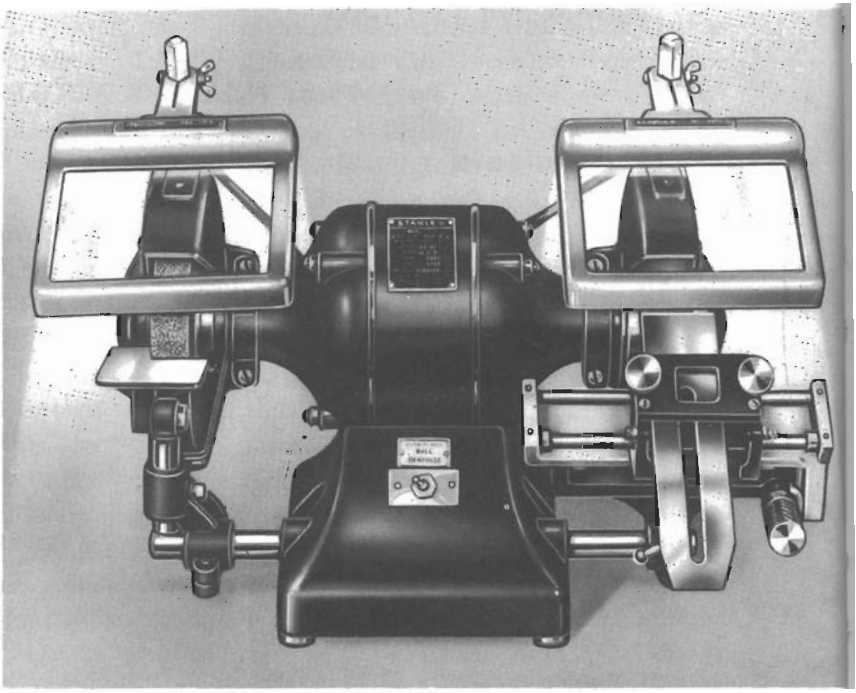
It is the sincere hope of the writers that this book will enable people interested in woodworking activities to become better craftsmen and more intelligent users of woodworking equipment so that they can obtain the full benefit of the service that is built into fine hand and machine tools.

BERYL M. CUNNINGHAM
WILLIAM F. HOLTROP

Contents

Fig. 1-A. Bench grinder with sharpening attachment.

COURTESY STANLEY ELECTRIC TOOL



PART ONE

CHAPTER I

Tools Used for Sharpening

SHARPENING operations usually are performed by the use of grinders, abrasive wheels, oilstones, and files, to re-shape the tool and to form a sharp cutting edge.

GRINDERS

The grinders used in the wood shop are usually of the *horizontal spindle* type with the arbor either on the motor shaft or on a shaft geared to the motor. They may be either *bench* or *pedestal* type.

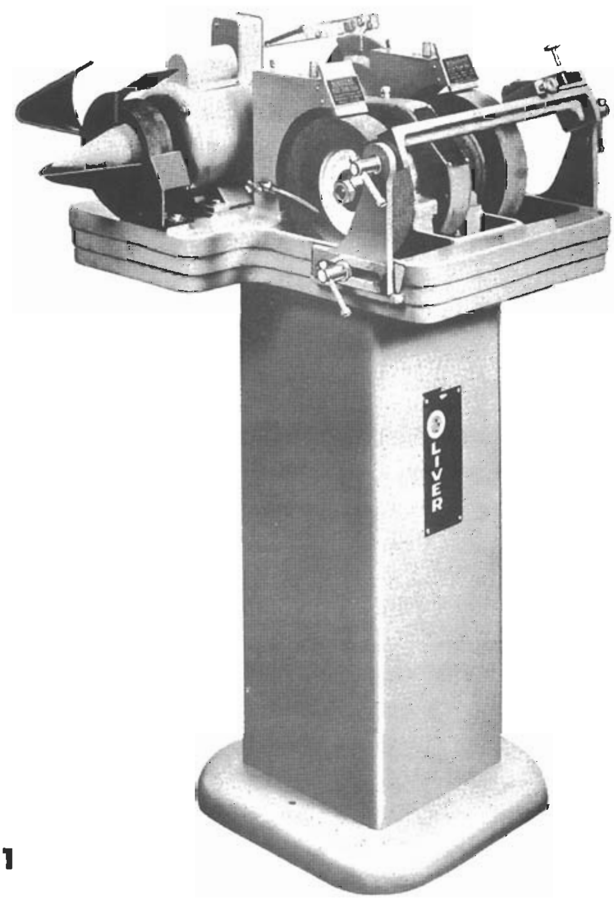
Some pedestal types have two straight cup wheels, fine and coarse, geared to a slower speed, with a straight wheel on one end of the motor shaft and a conical wheel on the other. Kerosene used to keep the wheel clean and serve as a coolant is fed to the inside of the cup wheel and is carried to the grinding surface by centrifugal force.

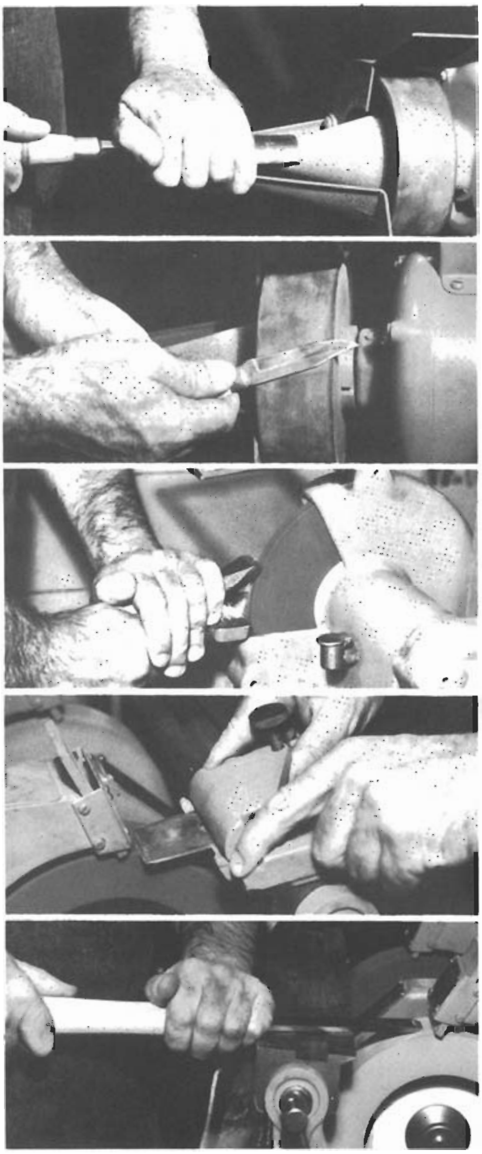
Some machines are equipped with special attachments for holding various kinds of tools during the grinding process. Others have only a tool rest to support work for flat grinding, making offhand grinding necessary for grinding bevels and sharpening many tools.

In Figs. 1-1, 2, 3, and 4, are a few examples of grinders that may be successfully used for most sharpening operations.

The *bearings* in the grinder should be kept tight and all the end play eliminated. This is especially important when grinding carbide tools. A grinding wheel cannot be expected

1-1. Variety oilstone tool grinder.
COURTESY OLIVER MACHINERY CO.





COURTESY OLIVER MACHINERY CO.

1-2. Some operations performed on the variety oilstone tool grinder.

to run true and grind efficiently when there is vibration and lateral movement in the arbor. In order to give the wheel sufficient support, the arbor flanges should be of equal size and not less than one-third of the diameter of the wheel. The side next to the wheel is recessed at least 1/16" (1, 27).[1]

If there are inadequate grinding facilities in the shop, one can use an arbor mounted on a wood turning lathe as shown in Fig. 1-5.

GRINDING WHEELS

A grinding wheel is composed of a *bond* and an *abrasive* used for removing particles from the material to be cut. As the sharp points of the abrasive grains gradually become dulled, they are broken loose from the wheel, bringing to the surface new sharp abrasive grains. These particles act as little tools, each actually chiseling out small portions of the material.

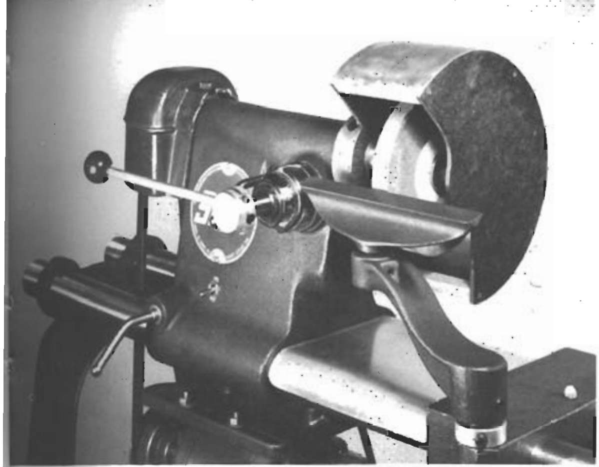
Making grinding wheels is not a simple process. It becomes rather complex when grinding conditions require wheels that will cut many types of materials, from the softest to the hardest, to extremely fine finishes and precision measurements.

The abrasives commonly used for making grinding wheels are aluminum oxide, silicon carbide, and diamond.

Abrasives

Abrasives may be classified as both natural and artificial. The natural abrasives generally used are flint, gar-

[1]NOTE: The numbers in parentheses indicate the source from which the quotation or suggestion was taken. The number to the left corresponds with the numbered references listed at the close of each chapter. The number, or numbers, to the right refers to the page(s) of the reference. This method of reference citation is used throughout this book.



COURTESY MC GRAW-HILL BOOK COMPANY

1-3. Grinding set-up on a multiple-use woodworking machine.

COURTESY ATLAS PRESS COMPANY

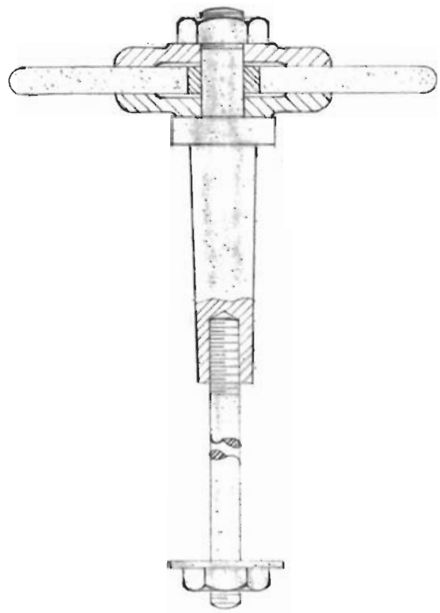
1-4. Grinding a cleaver on a utility grinder hone.

net, emery, and diamond. The artificial abrasives made in an electric furnace are aluminum oxide and silicon carbide. Each of these products has specific characteristics which make it useful for a particular type of work.

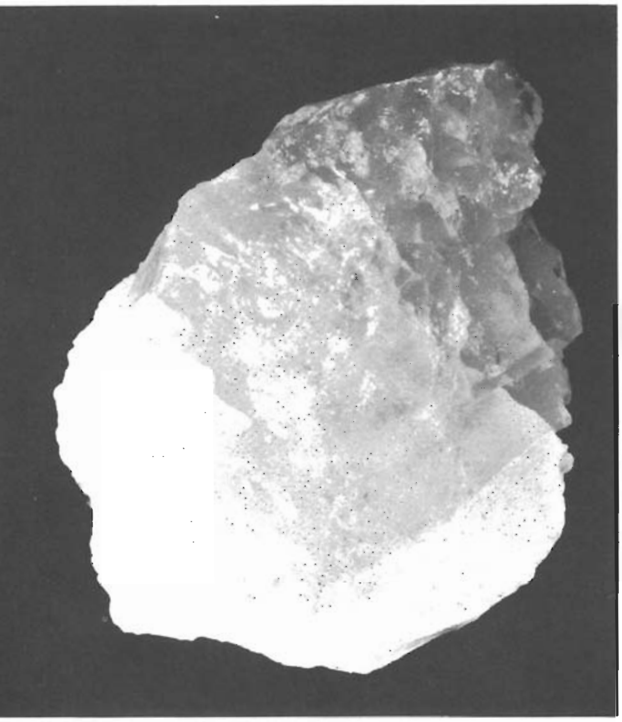
Flint abrasive is made of quartz crystals (Fig. 1-6) mined and crushed between large rollers. The graded grains used for making what is commonly known as flint sandpaper have a yellow cast. They are relatively sharp, but are too soft to last long. Flint paper may be used for finishing wood, but is best for cutting down old finishes, which will fill the paper by the time the grains become dull.

Garnet is a semi-precious, tawny red stone (Fig. 1-7) mined and crushed into very sharp crystals. These are somewhat softer than artificial abrasive grains, but much harder than quartz. Garnet fractures more easily than aluminum oxide, but is not so tough. Because it does fracture easily, it stays sharp as long as there are any of the grains on the backing. The woodworking industry uses garnet abrasive both for smoothing the surface of the wood and rubbing finishing coats.

Emery is a natural black abrasive and is composed of aluminum oxide embedded in iron oxide. The best quality comes from mines in Turkey and Greece. It is neither very sharp nor hard. The abrasive now used principally for polishing metals was

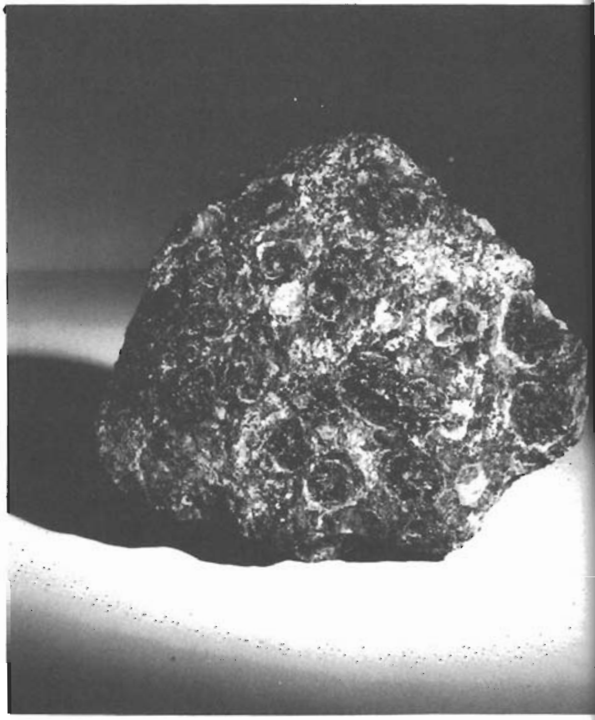


1-5. A grinding wheel can be mounted on the arbor of a woodturning lathe.



COURTESY BEHR-MANNING CORPORATION

1-6. Flint quartz used in the manufacture of flint paper.



COURTESY BEHR-MANNING CORPORATION

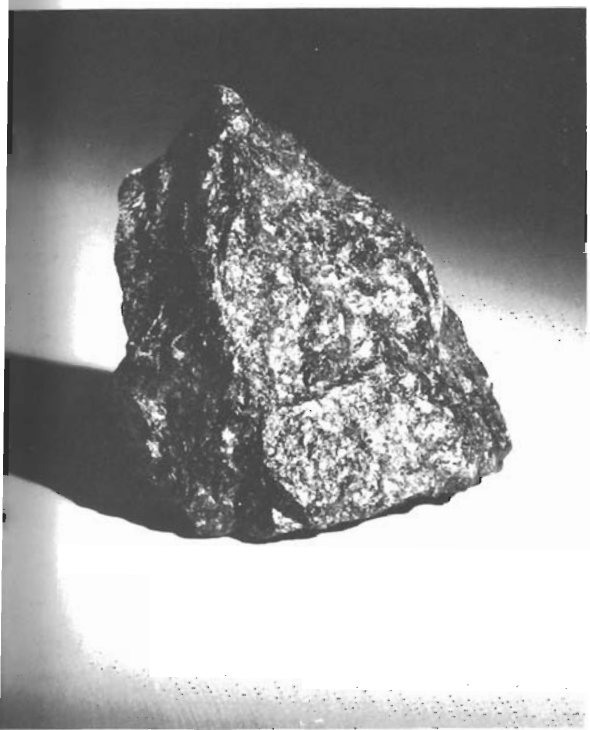
1-7. Garnet, a natural abrasive, is much harder than flint quartz.

once used for making grinding wheels. Emery is a conductor of electricity and should not be used on electrical equipment where there is a possibility of its causing a short circuit.

Commercial diamonds are by-products of the diamond mines of South Africa. They are carefully crushed and graded into suitable commercial sizes (10, 10). These grains are used to make wheel dressers, grinding wheels, and sharpening stones for grinding and lapping carbide tools.

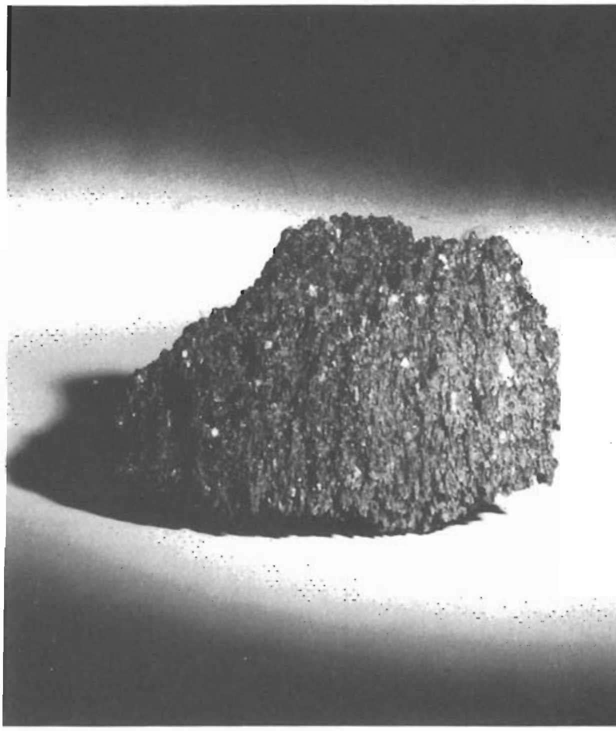
Aluminum oxide is obtained from a highly aluminous, claylike mineral known as bauxite (Fig. 1-8). When bauxite is fused in an electric furnace at temperatures in excess of 3700 degrees Fahrenheit and then cooled, brown aluminum-oxide crystals are formed (10, 5-6). The crystalline material is then crushed between large rollers and graded for size. These grains are not as sharp as either garnet or silicon-carbide grains, but are much tougher, and do not fracture as easily. Thus they last much longer under severe working conditions. Aluminum oxide is used for grinding and smoothing many kinds of steel. In more recent years it has become a production abrasive in the woodworking industry where sanding conditions are severe. It is non-magnetic.

Silicon carbide is composed of sili-



COURTESY BEHR-MANNING CORPORATION

1-8. Aluminum oxide, reddish brown in color, is made in electric furnaces by fusing the mineral bauxite at high temperatures.



COURTESY BEHR-MANNING CORPORATION

1-9. Silicon carbide is also produced electrically by fusing silica sand and coke.

ca and carbon in the form of coke which is produced from coal (Fig. 1-9). These materials are subjected to a temperature of 4000 degrees Fahrenheit, which would not only melt but would vaporize steel (15, 16). They are heated in an electric furnace by placing them around a carbon conductor through which is passed an electrical current. If the heat is accurately controlled, the materials react upon each other so as to produce very hard abrasive crystals when cooled (10, 6-7). They usually vary in color from steel gray to black. However, a green color is obtained by changing the production technique (5, 7). The grains are extremely hard and sharp. In hardness they are next to diamonds. Because they fracture easily, they remain sharp until worn out.

Silicon carbide is used for sanding wood in the white, for finishing, and for sharpening carbide-tipped tools. It is a conductor of electricity (15, 20). For this reason it should not be used for such jobs as cleaning and smoothing commutators, where it may cause a short circuit.

Abrasive materials are separated into uniform sizes by a screening process. The grain sizes are designated by the number of openings per

Table 1

CLASSIFICATION AND COMPARISON OF GRAIN SIZES

RELATIVE SIZE — *Abrasive Wheels* (11, 14)	*Screen Size*	*Symbol Size*	ARTIFICIAL ABRASIVES — *Aluminum Oxide and Silicon Carbide*	NATURAL ABRASIVES — *Garnet*	NATURAL ABRASIVES — *Flint*	NATURAL ABRASIVES — *Emery*	RELATIVE SIZE — *Coated Abrasives* (4, 30)
Flour Sizes	600	12/0	600				*Very Fine*
	500	11/0	500				
	400	10/0	400				
	360		360				
	320	9/0	320		7/0		
	280	8/0	280	280 (8/0)	6/0		
Very Fine	240	7/0	240	240 (7/0)	5/0		
	220	6/0	220	220 (6/0)	4/0		
					3/0		*Fine*
	180	5/0	180	180 (5/0)		3/0	
	150	4/0	150	150 (4/0)		2/0	
Fine					2/0		
	120	3/0	120	120 (3/0)			
					0	0	*Medium*
	100	2/0	100	100 (2/0)			
	90		90		1/2	1/2	
	80	0	80	80 (0)		1	
	70		70		1	1 1/2	
Medium	60	1/2	60	60 (1/2)			
	54		54			2	*Coarse*
	50	1	50	50 (1)	1 1/2		
	46		46		2	2 1/2	
	40	1 1/2	40	40 (1 1/2)			
					2 1/2		
	36	2	36	36 (2)			
						3	
	30	2 1/2	30	30 (2 1/2)	3		*Very Coarse*
Coarse	24	3	24	24 (3)			
	20	3 1/2	20	20 (3 1/2)			
	16	4	16				
	14		14				
	12	4 1/2	12				
Very Coarse	10		10				
	8		8				

linear inch in the screen. Grains that pass through a No. 16 screen, but are retained by a No. 20 screen, are graded as *No. 16 grain size.*

Another system is also used for designating grain size, especially for natural abrasive grains. These are specified by grade numbers such as 2/0, 1/0, ½, 1, and 1½. No. 1½ is coarser than No. ½ and No. 2/0 is finer than No. 1/0. The size of garnet grains may be designated by either system.

Table 1 gives a classification and comparison of the grain sizes for both artificial and natural abrasives.

Table 2

GRADES OF GRINDING WHEELS

Very Soft	Soft	Medium	Hard	Very Hard
ABCDEFG	HIJK	LMNO	PQRS	TUVWXYZ

Grade

Since the *bond* holds the abrasive grains in place, its strength largely determines the hardness of the wheel. *The more resistant the bond is to the cutting force* to which the abrasive grains are subjected, *the harder the grade.* Wheels that tend to release the grains with little grinding force are of a soft grade.

Letters designate the grade of a grinding wheel. The letters at the beginning of the alphabet indicate soft grades, the grades becoming proportionately harder as they reach the end of the alphabet.

The grades of grinding wheels are generally classified into groups (Table 2).

Structure

Structure is the manner in which the constituent particles, abrasive and bond, are arranged in a particular abrasive product to obtain definite characteristics (14, 65). It refers to the spacing of the grains throughout the wheel. A grinding wheel is not completely solid. The bond surrounds the grains and attaches them to adjacent particles, leaving pores, or open spaces, around the bonded abrasive cutting particles. Structure thus indicates the *relative spacing and separation* of the grains or *size of the individual pores* rather than the *total space occupied by pores* in the wheel. (Fig. 1-10). Two wheels may

1-10. Structure indicates the spacing and separation of the grains by the bond.

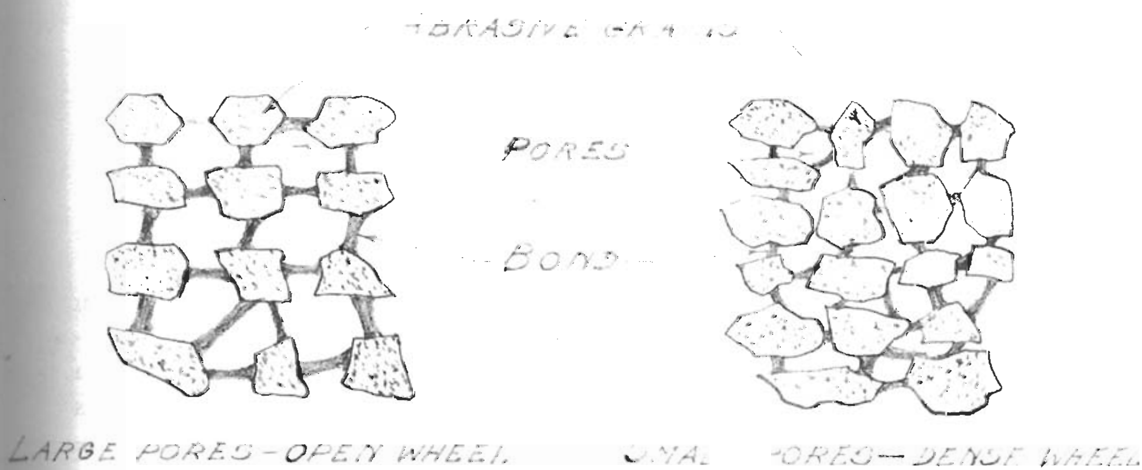


Table 3

STRUCTURE OF GRINDING WHEELS

Spacing	Close	Medium	Wide
Structure No.	0,1,2,3	4,5,6	7,8,9,10,11,12

have the same total *space allowance* for pores and yet have different *densities*. For example, the pores of one wheel are larger, but fewer in number, making this wheel more open than the other. The second wheel has more pores, but because they are smaller and allow for more grains, the wheel is more dense (11, 15-17).

Variations in the structure of wheels with the same grain size and hardness will cause them to cut differently. The wheel with the *wider grain spacing will cut faster,* whereas *the more dense wheel will cut more slowly* and yet appear to be harder. Selecting a wheel with the correct structure for a particular grinding job improves the rate of cutting, the wheel life, and the surface finish. *The recommendations of the manufacturer* should be followed unless experience has proved that another structure is more satisfactory.

The structure of grinding wheels is designated by a number. The higher numbers have wider spacing than the smaller numbers. The structure numbers and their classifications are given in Table 3 (11, 18).

Bonds

There are several different types of bonds used in holding the abrasive grains together to form a grinding wheel. The kinds used in wheels for general purpose grinding are *vitrified, silicate, resinoid, rubber,* and *metal,* each of which makes the best bond for certain kinds of work. (*Shellac* bond wheels are seldom used for grinding woodworking tools.)

Vitrified bond consists of carefully selected clays and other ceramic materials. These materials and the abrasive grains are fused or vitrified at high temperatures, forming a molten, glasslike mass. On cooling, this bond holds the abrasive grains together very rigidly. Because of its strength only a small amount of bond is required, thereby making a strong, porous wheel which has a free, cool cutting action. These wheels operate at speeds up to 6500 surface feet per minute. Vitrified bond is used for general-purpose grinding and is especially recommended for saw gumming wheels.

Silicate bond is composed primarily of silicate of soda mixed with a metallic oxide which becomes insoluble in water after being heated (2, 17). The bond is not very strong and is brittle. It does, however, have a milder cutting action, making it especially suitable for grinding fine-edged tools, knives, and cutlery, where the heat in grinding must be kept as low as possible to prevent burning the thin cutting edge (9, 9).

Resinoid bond is a synthetic resin combined with other compounds. Because it is strong and elastic, it can produce wheels with an open porous structure and a cool, fast cutting action. These wheels operate normally at 9500 surface feet per minute; when used for cut-off operations they are run at speeds up to 16,000 surface feet per minute (13, 12). Steel reinforcing rings are sometimes molded in the wheel, making operation at these high speeds entirely safe. These wheels are recommended especially for cut-off operations in steel, such as cutting stock for knives and shaper steel. They may be used for saw gumming and sharpening.

Rubber bond is a form of hard rubber which makes elastic, high-speed wheels. These wheels are good for cut-off work since they can be made thin enough to reduce the waste material to a minimum. They operate efficiently at both fast and slow speeds.

Metal bond is used for making diamond wheels. It forms a strong elastic bond, holding the diamond particles until they have been used (2, 17). These wheels are used for grinding and lapping tungsten-carbide-tipped tools.

Wheel Markings

Grinding wheel companies have generally accepted the *universal grade scale* for designating the characteristics of their wheels. The acceptance of a standard system has made the selection of wheels for the various grinding uses less confusing to the average consumer. Yet there is still some difference in wheel markings, since manufacturers occasionally add

Table 4

GRINDING WHEEL MARKING SYMBOLS

Positions	1	2	3	4	5	
Manufacturer's Special Abrasive Symbol	Abrasive Type	Grain Size	Grade	Structure	Bond Type	Manufacturer's Special Bond Symbol
Prefix	A	46	K	5	V	Suffix
Usually by letter or number if abrasive is special	Aluminum oxide- A Silicon carbide- C					Usually by letter or number if bond is special

Grain size:

Coarse	Medium	Fine	Very Fine
8	30	70	220
10	36	80	240
12	46	90	280
14	54	100	320
16	60	120	320
20		150	400
24		180	500
			600

Structure:

Close	Medium	Wide
0	4	7
1	5	8
2	6	9
3		10
		11
		12

Bond type:

V-Vitrified
S-Silicate
B-Resinoid
R-Rubber
E-Shellac

GRADES

Very soft	Soft	Medium	Hard	Very Hard
ABCDEFG	HIJK	LMNO	PQRS	TUVWXYZ

a prefix to the kind of abrasive to designate individual characteristics. They also add a suffix to the kind of bond to designate changes in the characteristics of wheels caused by bonds or other variations. If the prefix or suffix is omitted, the wheel is regular in those respects.

Table 4 shows the method commonly used for marking grinding wheels.

Grinding wheel selection

High resistance to point dulling and the ability to fracture under normal grinding conditions indicate the ideal abrasive (9, 7). Laboratory tests show that aluminum-oxide abrasive wheels are more suitable for grinding steel and high-tensile-strength materials, whereas silicon-carbide and diamond-abrasive wheels are more satisfactory for sharpening tungsten-carbide-tipped tools (9, 6 and 10).

When a finer finish is required, the structure of the wheel should be more dense; that is, have a closer grain spacing. It is apparent that a wheel with a close grain spacing will produce a finer finish than one of the same grain size spaced wider. A wheel with finer grains produces a finer finished surface.

Because a hard wheel naturally wears less rapidly than a softer one, there is a tendency for the user to select a harder grade for economy reasons. This is often a false assumption. If the wheel is so hard that the grains are not released by the time they become dulled, the surface will glaze over and generate excessive heat because of reduced cutting action. At the same time the operator may apply more pressure to make the wheel cut. This in turn generates still more heat, with the possibility that the combined heat and pressure will result in wheel breakage.

A softer wheel is required for grinding the harder steels so that the dulled grains will break out fast enough to keep the cutting surface sharp. If the cutting surface breaks down at a sufficient rate so that dressing is not necessary to keep it sharp, the grinding wheel is too soft for economical wheel life (12, 4).

Many times grinding jobs require the removal of a considerable amount of metal in order to obtain the correct bevel or clearance on the tool. In such cases, a coarse, free-cutting wheel will remove the excess metal with less possibility of burning the tool and drawing the temper.

The worker's knowledge about grinding wheels and his skill in using them are important factors in determining grinding results and wheel life. A skillful operator, using a softer wheel, can obtain wheel life that is equal to that of a harder wheel used by an inexperienced operator.

Vitrified wheels are preferable for general-purpose grinding where the speed does not exceed 6500 surface feet per minute. *Resinoid* and *rubber bonds* are required for cut-off wheels, because they will better stand the strain of bending and twisting.

Recommendations as to grain, grade, and structure are made by manufacturers on the assumption that the suggested wheel speed will be maintained (9, 22). The usual rec-

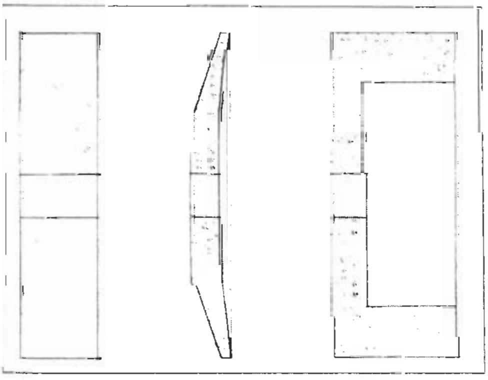
TABLE 5 — GRINDING WHEEL SPECIFICATIONS

Materials and Operations	Abrasive	Grain	Grade	Structure	Bond
Cemented Carbides					
Rough grinding	C	60	F	12	V
	D	100	L	100	V 1/16
Finish grinding	C	100	H	7	V
	D	200	P	100	V 1/16
Edge Tools—chisels, plane irons, etc.					
Light grinding	A	60	K	5	V
	A	60	M	8	V
Heavy grinding	A	36	O	5	V
Drill bits (under ½")	A	80	J	7	V
(over ½")	A	46	M	5	V
Knives (machine)					
Cut-off	A	46	N	6	B
Sharpening	A	46	J	5	V
	A	36	J	8	V
Saw, circular					
Gumming	A	46	M	5	V
Wheels less than ¼" thick	A	46	M	5	B
Tools, turning					
Light grinding	A	60	M	8	V
Heavy grinding	A	36	O	5	V

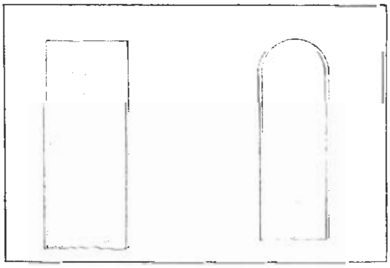
ommended speeds for tool grinding are from 4500 to 6000 surface feet per minute.

The selection of wheels in Table 5 should be considered as general, since so many factors affect the efficiency of a grinding wheel. No attempt has been made to add the prefixes and suffixes to the abrasive grains and bonds as recommended by the various companies, because these markings have not yet been standardized. Each manufacturer uses different symbols. If a grinding wheel is to be used largely for one type of grinding operation, it is advisable to get special recommendations from the manufacturer.

1-11. Cross sectional view of three types of grinding wheels.



1-12. Two types of grinding wheel faces.



Types of grinding wheels

Most of the maintenance work in the wood shop can be done on Type 1 straight; Type 6 straight cup; and Type 12 dish wheel (Fig. 1-11). Note that the cutting speed in surface feet per minute of the cup type wheel remains constant throughout its life, as the diameter is not reduced by use. However, *it will not fit on all machines*. The dish type with diamond-impregnated rim and the silicon-carbide cup-type wheels are recommended for both rough grinding and lapping carbide-tipped circular saws.

Face shape of grinding wheels

The face of grinding wheels can be obtained in a large number of shapes, depending upon the requirements of the job. The straight and round shapes shown in Fig. 1-12 are generally used in maintaining woodshop equipment. Special jobs such as making and sharpening shaper knives may require several other shapes. However, for grinding jobs that are seldom done, it may be more economical to dress a wheel to the desired shape instead of buying a special one. Frequency of use should be the determining factor in deciding which procedure is more desirable.

Information for ordering grinding wheels

1. Diameter of the wheel in inches.
2. Thickness of the wheel in inches.
3. Diameter of the arbor hole in inches.
4. Type of wheel—straight, dish, straight cup, etc.
5. Shape of face—straight, round, etc.
6. Type of abrasive—aluminum oxide, silicon carbide, diamond.
7. Grain size—8 to 600.
8. Grade or wheel hardness—A to Z.
9. Structure or grain spacing—0 to 12.
10. Bond—vitrified, silicate, resinoid, rubber, metal.

Grinding wheel speeds

The speed of a grinding wheel is designated by the surface speed, which is the distance in feet per minute traveled by any one point on the periphery of the wheel. Surface speed can be calculated by multiplying the diameter of the wheel in inches by 3.14 times the revolutions per minute and dividing the product by 12. If the diameter of the wheel in feet is used, the product should not be divided by 12. Either of the following formulas may be used for calculating the surface speed of a grinding wheel:

$$\text{S.F.P.M.} = (\text{wheel diameter in inches} \times 3.14 \times \text{R.P.M.}) \div 12 = (\text{wheel diameter in feet} \times 3.14 \times \text{R.P.M.})$$

Since 3.14 divided by 12 is approximately ¼, the surface feet per minute can be approximated for practical purposes by multiplying one-fourth the wheel diameter in inches by the revolutions of the arbor per minute.

Recommended speeds: In order to obtain long grinding-wheel life and efficient grinding service it is necessary for the wheel to run at approximately the recommended speed. If

Table 6

MINIMUM SPINDLE DIAMETERS

Diameter				Thickness of Wheel, Inches							
of Wheel	1/4	3/8	1/2	5/8	3/4	1	1 1/4	1 1/2	1 3/4	2	2 1/4
Inches				Diameter of Spindle in Inches							
2	1/8	3/16	3/16	1/4	1/4	3/8					
3	1/4	1/4	3/8	3/8	3/8	1/2					
4	5/16	3/8	3/8	3/3	3/8	1/2					
5	3/8	3/8	1/2	1/2	1/2	1/2					
6	1/2	1/2	1/2	1/2	1/2	1/2	5/8	5/8	5/8	5/8	3/4
7	1/2	1/2	1/2	1/2	5/8	5/8	5/8	3/4	3/4	3/4	3/4
8	5/8	5/8	5/8	5/8	5/8	5/8	3/4	3/4	3/4	1	1
9	5/8	5/8	5/8	5/8	3/4	3/4	3/4	3/4	1	1	1
10	3/4	3/4	3/4	3/4	3/4	3/4	3/4	3/4	1	1	1
12	3/4	3/4	3/4	3/4	3/4	1	1	1	1	1	1

the speed is too slow there will be excessive wear, resulting in wastage of the wheel and lack of efficiency. On the other hand, a wheel should not be run faster than the recommended speed. Increased speed will cause the wheel not only to generate excessive heat because of the increased grinding action, but also to be subjected to increased centrifugal force. Both of these conditions will result in poor grinding performance and wheel breakage. The possibility of injury to the operator and damage to the work is too great to risk operating wheels at an excessive speed.

The recommended speeds for vitrified and silicate bond wheels used for grinding tools range from 3500 to 6500 surface feet per minute.

Cut-off wheels which have resinoid or rubber bond may run as fast as 16,000 surface feet per minute, depending upon the condition of the grinder. Because there is not much cut-off work in the average wood shop and not many grinders that will operate at such speeds, the general-purpose grinder will suffice in most cases.

Minimum wheel spindle sizes

Grinding wheels should be adapted properly to the size of the machine. Larger wheels should not be used than those intended by the manufacturer. Arbor size and flanges are important factors in limiting the size of a grinding wheel that can be used.

Table 6 lists the minimum spindle diameters for wheels of various sizes commonly used in the wood shop. It is taken from the "Safety Code for the Use, Care and Protection of Abrasive Wheels." (1, 13).

Care of grinding wheels

Because all grinding wheels are fragile, considerable care should be used to avoid damaging them in handling and storage. It is easy to chip them by sudden blows to the edges, and they sometimes crack or break.

Chipped edges reduce the life of the wheel considerably, as it must be dressed sufficiently to remove all the chipped surfaces. A cracked wheel is a total loss. It should never be run because it may break at any time, thus causing serious injury to the operator and damage to the work.

Grinding wheels should be stored on suitable racks to prevent falling, or placed in special drawers where they will not be broken.

Before mounting a new grinding wheel, always inspect it carefully to see that it has not been damaged. If a grinding wheel rings clear when supported by a rod extended through the arbor hole and gently tapped on the side with a piece of wood, it is in good condition. If there is only a dull thud when it is tapped, it is probably cracked. *Wet wheels* will not ring when tested in the foregoing manner. The wheel should fit freely on the arbor. Forcing it may cause breakage.

When mounting a grinding wheel, place washers made of blotting paper on each side between the flanges and the wheel to equalize the pressure on the sides of the wheel. The arbor nut should be tightened only enough to hold the wheel. If too much pressure is applied, the wheel may break.

After a wheel is mounted, it should be run idle for a time before any grinding is done. It is well for the operator to stand at one side during the preliminary test in case the wheel should break. It should then be trued, if it is out of round. *If the wheel cannot be made to run true, do not use it.*

Work rests kept adjusted to within 1/8″ of the wheel will reduce the possibility of having material wedge between the rest and the wheel, stalling the motor and causing the wheel to break.

To mount a grinding wheel

1. Before mounting, carefully inspect the grinding wheel for chipped edges and cracks. A sound wheel, when supported by a rod placed through the arbor hole, should give a clear ring when lightly tapped on the side with wood.
2. Cut two washers made of blotting paper as large as the diameter of the flanges.
3. Remove the spindle nut and the outside flange. Also remove the wheel guard, safety shield, and work rest.
4. Clean the spindle with a clean cloth.
5. Place a paper washer against the inside flange, followed by the new wheel, second paper washer, and outside flange. The wheel must fit on the spindle freely. Do not force it.
6. Start the nut on the spindle and tighten it enough to hold the wheel. If too much pressure is applied, the wheel may break.
7. Replace the wheel guard and safety shield; set the work rest within 1/8″ of the grinding wheel.
8. Test-run the wheel for a short time. Stand to one side during this preliminary test in case the wheel should break.
9. True the wheel if it runs out of round.

Side grinding on straight wheels

Grinding on the flat sides of a straight wheel, if generally practiced, soon reduces the thickness to a point where the operation of the wheel becomes hazardous. Grinding on the sides is seldom advisable. There are occasions, however, when it seems advantageous to do a small amount of grinding on the side of the wheel. For example, if a suitable cup wheel is not available, the front of a wing-shaped cutter can easily be ground flat on the side of a straight wheel, but it would be very difficult to grind it properly on the edge. The operator must be careful to keep side grinding on straight wheels to a minimum. It definitely should not be a general practice.

Causes for wheel breakage

1. Wheel not correctly mounted on the arbor.
2. Insufficient wheel support because of ill-fitting flanges.
3. Wheel cracked by careless handling and improper storage.
4. Wheel running faster than the recommended speed.
5. Applying excessive pressure, forcing the wheel to cut faster than normal.
6. End play in the arbor, which at times, may cause extreme side pressure against the wheel on certain grinding jobs.
7. Excessive vibration due to the poor condition of the grinder.
8. Wheel running out of balance.
9. Material wedging between the guard or work rest.
10. Pressure and heat generated when grinding with a dull or glazed surface.
11. Drawing the arbor nut too tightly.
12. Forcing the wheel on the arbor when it fits too tightly.
13. General practice of grinding on the side of straight wheels.

Causes for poor grinding performance

1. Poor finish resulting from too fast a feed.
2. Heating and checking of the metal due to a hard or dulled wheel.
3. Burning the metal and drawing the temper by excessive grinding.
4. Improper selection of the wheel for the type of work being done, as to abrasive, grain size, grade, structure, and bond.
5. Wheel operation at too slow a speed.
6. Wheel vibration and chatter due to improper mounting and poor condition of the machine.

To change a grinding wheel

1. Pull the switch in the fuse box, and remove the wheel guard, safety shield, and work rest, if necessary.
2. Take off the spindle nut and remove the flange and grinding wheel. To loosen the nut, be sure to turn it in the same direction the wheel normally runs. *If it is turned in the opposite direction, the pressure may break the wheel.*
3. Before mounting, carefully inspect the wheel for chipped edges and cracks.
4. Clean the spindle with a clean

cloth and place blotting-paper washers as large as the diameter of the flanges on each side between the flanges and the wheel. The wheel must fit on the spindle freely. Do not force it.

5. Start the nut on the spindle and tighten it enough to hold the wheel. *If too much pressure is applied, the wheel may break.*
6. Replace the wheel guard and safety shield and set the work rest to within 1/8″ of the grinding wheel.
7. Close the switch in the fuse box and start the machine to test-run the wheel. Stand aside to be in the clear in case the wheel breaks.
8. True the wheel if it runs out of round.

Grinding wheel dressers

Grinding wheel dressers commonly used are the *mechanical*, the *abrasive stick*, and the *diamond*.

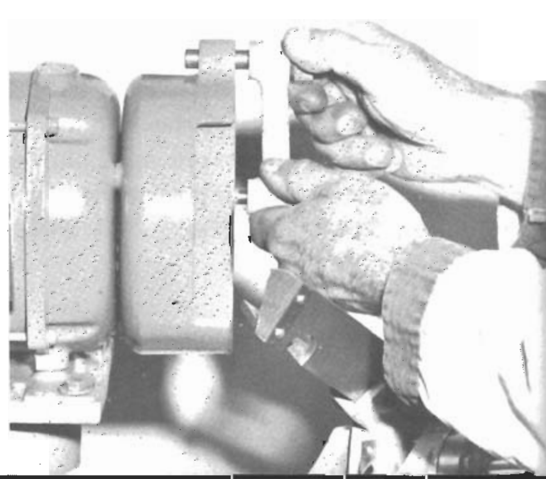
Mechanical dressers have a metal cutter which revolves against the grinding wheel, breaking out the grains. The cutters are mounted on a spindle at the end of the holder. They may be either star-shaped wheels or corrugated discs, and are made in various diameters for the different grinding wheel sizes. The 1¼″ to 1½″ diameter cutters are satisfactory for dressing grinding wheels generally available for woodshop maintenance. These dressers are inexpensive, yet are satisfactory for most jobs (Fig. 1-13).

Another inexpensive dresser is the *abrasive stick*. It is made of silicon carbide in either round or square forms and can be used in place of the more expensive diamond dresser. Its usual uses are for shaping and forming saw gumming wheels, as well as dressing wheels used for tool grinding. Some of these sticks approach the hardness of diamond, which makes them popular for dressing small tool-room wheels. They are usually applied by hand.

The *diamond* dresser may be used for general purpose dressing, but is used particularly for truing grinding wheels for precision work. Because of its extreme hardness, a wheel can be accurately surfaced (Fig. 1-14). Since a diamond is very brittle, it must not be subjected to sudden

1-13. Dressing a wheel with a 4-cutter wheel dresser. The metal cutters revolve against the wheel, breaking out the grains.
PHOTO BY CHARLES J. PEREZ

1-14. For precision grinding, wheels must have true faces and sides. Here, the side of a wheel is made true with a mounted diamond wheel dresser.
COURTESY MC DONOUGH MANUFACTURING CO.



shock which might fracture it. A ¾- to 1-carat diamond is a suitable size for the amount of wheel dressing and truing done in the average wood shop.

Dressing and truing grinding wheels

In order for a grinding wheel to operate efficiently, the cutting surface must be kept in good condition. This is accomplished by removing a portion of the abrasive on the cutting surface, either to true or dress the wheel.

A grinding wheel is *trued* to make it round and parallel and produce a smooth cut, or change the shape of the cutting surface (12, 3). To get a smooth surface, it is essential that the wheel cut evenly around the entire cutting surface.

Dressing a grinding wheel is done to renew the cutting surface in order to change its cutting action (12, 3). If the cutting surface becomes clogged with foreign material, or the abrasive grains become dull, the surface is dressed to remove the old surface and bring up new cutting edges.

Truing always dresses the wheel, but dressing a wheel does not necessarily make it true! A sharp, free-cutting surface may be restored satisfactorily to serve its cutting purpose and still be slightly out of round. When truing a wheel, take a number of light cuts rather than a few heavy cuts. It is much easier to hold the dressing tool steady when removing a small amount, thereby truing the surface quicker. Heavy cuts will true the wheel, but they shorten the life of both the grinding wheel and dressing tool.

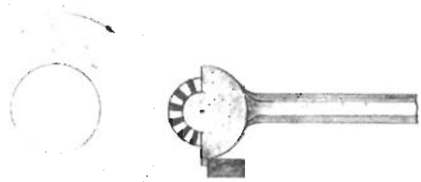
The speed at which the tool is moved across the face of the wheel is determined by the grain and grade of the wheel and the finish desired. A slow movement across the wheel gives a high finish, but may glaze the surface when diamond or abrasive dressers are used. Too fast a movement may leave grooves that will affect the ground surface. With some experience, the operator will be able to determine the correct rate of movement. The diamond dressing tool is held at a slight *angle* to the wheel, pointing in the same direction in which it rotates. To prevent the diamond from becoming dull and crushing or glazing the abrasive grains, turn the tool during the dressing process (9, 24).

To dress a grinding wheel with a mechanical dresser

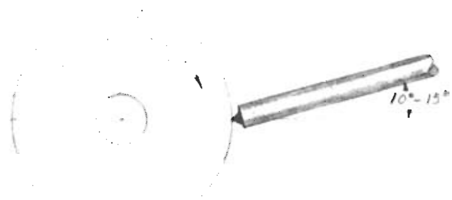
1. For offhand dressing, set the work support with the gap between it and the wheel just wide enough to permit the dresser heel to drop over the edge of the work support (Fig. 1-15).
2. With the grinder running, move the dresser across the surface of the wheel, holding the heel firmly against the work support. Be sure to hold the handle steady in order to insure a true wheel. If sparks come off the dresser wheels, apply more pressure against the grinding wheel.

To dress a grinding wheel with a diamond dresser

1. Mount the diamond dresser in the



1-15. Position of mechanical dresser against grinding wheel. Note lip on tool hooked over edge of tool rest.



1-16. Correct position of a diamond dresser against a grinding wheel. The diamond point is located on the horizontal center line.

tool holder at approximately a 10° to 15° angle, with a line extending from the point of contact through the center of the wheel (Fig. 1-16). Be careful not to grind the metal away from the diamond.

For offhand dressing, set the work support close to the wheel and hold the dresser at the angle suggested above.

2. With the motor running, move the dresser across the surface of the wheel, taking off about .001″ each time across. Turn the dresser occasionally to retain a sharp point.

OILSTONES

Oilstones are made of both natural stones and artificial materials. *The natural stones* include hard Arkansas, soft Arkansas, and Washita stones. They are fairly uniform in hardness and are used for producing fine to very fine cutting edges.

Artificial stones are made from aluminum-oxide and silicon-carbide abrasive grains formed into the desired shape. Since abrasive grains are made in different sizes, it is possible to make oilstones with various sizes of grains of uniform hardness that produce coarse to fine cutting surfaces. Except for the diamond, natural stones are much softer than artificial stones.

The hard Arkansas stone, in shades of white to gray, is very hard, with extremely fine cutting surfaces. It is so dense that the oil does not penetrate deeply and only a few drops are required to carry away the waste particles of steel (Fig. 1-17). For putting a keen edge on the finest tool, there is no substitute for this stone. It is used principally for stoning woodworking tools when finer cutting edges are desired. The comparatively high cost of the stone is offset somewhat by its extreme hardness, resulting in long life.

The soft Arkansas stone is softer than the hard Arkansas stone and is more porous and faster cutting. It is used for stoning woodworking tools and gives an adequate cutting edge (Fig. 1-18).

The Washita, a natural stone, is softer and faster cutting than the soft

Arkansas stone. It produces a moderately smooth, long-lasting edge on woodworking tools.

The aluminum-oxide stone is made of the same abrasive as is used for making grinding wheels. It is brownish and the structure is so porous that the oil penetrates deeply. Because of its cutting ability and its hardness, this stone is highly recommended for stoning a keen, fine cutting edge on woodworking tools (3, 10). It is made in coarse, medium, and fine grades. In some cases, aluminum-oxide stones are saturated with oil during the manufacturing process.

The silicon-carbide stone is gray and the abrasive grains are very hard and brittle. Because they fracture easily, the grains stay sharp and are fast cutting. The stone cuts freely by applying only light pressure. The manufacturer, to make it cut more easily and smoothly, usually impregnates the stone with oil. This stone is made in coarse, medium, and fine grades. See Figs. 1-19, and 20.

COURTESY BEHR-MANNING CORPORATION

1-17. Hard Arkansas bench stone. This stone will put a keen edge on the finest tool.

COURTESY BEHR-MANNING CORPORATION

1-18. Soft Arkansas bench stone, of sufficient hardness to stone woodworking tools.

COURTESY BEHR-MANNING CORPORATION

1-19. Silicon carbide factory impregnated bench stone.

Selection of oilstones

Before selecting an oilstone, one should understand the *sharpening process*. Sharpening means that steel is actually cut and removed from the tool to bring it to the appropriate cutting edge.

In order to serve satisfactorily for all stoning jobs, oilstones must be selected on the basis of grain size, hardness, brittleness, and toughness. With these characteristics in correct proportion, it will produce a suitable cutting edge on a particular type of tool.

If the tool requires a coarse edge, then a coarse, fast cutting stone is needed. For a finer cutting edge, a fine, slower cutting stone is required. As an extreme example, a stone used for sharpening a shovel would not be suitable for producing the fine cutting edge required for razors, engraving tools, and surgical instruments.

Since general woodworking tools require a medium cutting edge, it may

COURTESY BEHR-MANNING CORPORATION

1-20. Multi-oilstone includes three stones: coarse, medium, and fine. They revolve in the container as shown.

appear that a medium-grain oilstone would be most suitable for sharpening them. But this is not altoghether true. A keen edge can be more quickly obtained by first stoning the tool on a coarse surface and then finishing the edge to the desired fineness on a stone which has a fine surface (3, 7).

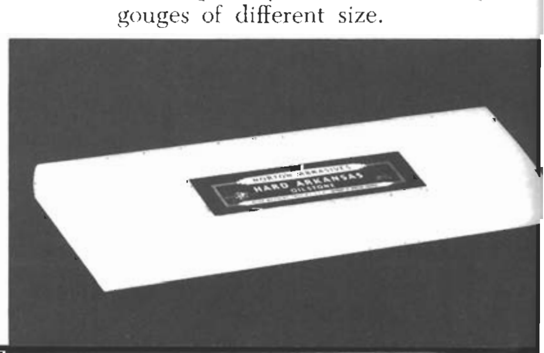
Oilstones are made in a large variety of shapes, sizes, and types to meet the requirements for all stoning jobs. The bench stone in sizes 6″ x 2″ x 1″ or 8″ x 2″ x 1″ is commonly used for general purpose sharpening. If artificial stones are used, the combination stone, coarse on one side and fine on the other, will prove to be very convenient. The coarse side can do the preliminary stoning, the fine surface the finishing (Fig. 1-21).

Other stones that are needed for special stoning jobs are the round edge slip, the special gouge slip, the carving tool slips, the auger bit stone, and the round and triangular shapes. See Fig. 1-22, 23, 24, 25, 26, 27 and 28.

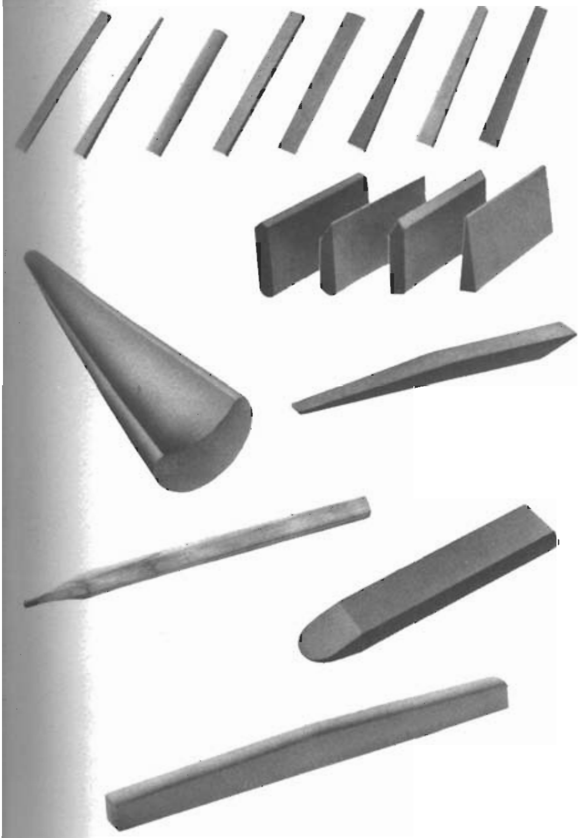
1-21. Silicon carbide bench stone with coarse and fine honing surfaces.

COURTESY BEHR-MANNING CORPORATION

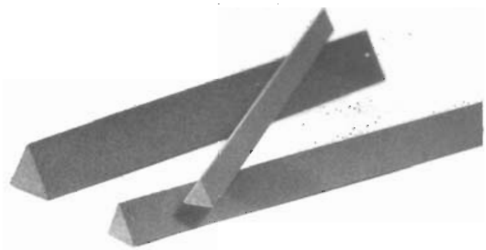
1-22. Hard Arkansas round edge slip. This stone is especially useful in stoning gouges of different size.



Oilstones used for stoning carbon and high-speed steel must be made soft enough to cut freely and yet sufficiently hard and tough to hold their shape. The aluminum-oxide stone meets these requirements very well.

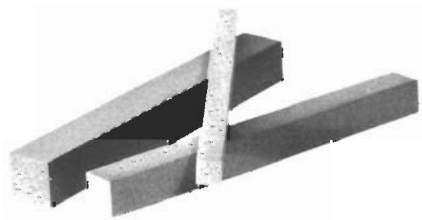


1-23. Selected stones for a variety of honing jobs.



FIGS. 1-22 TO 1-28
COURTESY BEHR-MANNING CORPORATION

1-26. India triangular files.



1-24. India square files.

1-27. India round files.

1-25. India half round files.

1-28. India auger bit stone.

Silicon-carbide stones are especially recommended for sharpening carbide-tipped tools, and are quite satisfactory for carbon and high-speed steel if not too much pressure is applied during the stoning process.

Care of oilstones

Plenty of thin oil should be used on the stone. It helps not only to produce a finer cutting edge, but also to make the stone cut faster. Then too, by carrying away the waste materials, it prevents the cutting surface from becoming clogged. A very light, free-flowing oil that will not dry and gum is best. Pike oil is recommended, but kerosene mixed with a lightweight machine oil may be used. Oilstones should never be used dry and should be cleaned and kept wet with oil when not in use. If the surface should become glazed or filled with gum, clean it with ammonia or gasoline. If it is still filled, renew the cutting surface by dressing.

When whetting a tool, use as much of the surface of the stone as possible to prevent it from wearing unevenly. When the surface becomes hollowed out in the middle, it should be dressed flat so that straight-edged tools can be properly stoned.

Fasten the bench-type oilstone in a container so that it can be kept in place while stoning the tool. The stone might be chipped or broken if it is clamped in a vise.

Truing oilstones

Occasionally it becomes necessary to true the surface of an oilstone. During the whetting process the portion of the stone which comes into contact with the tool is gradually worn down, forming a concave surface. Tools sharpened on such a surface will have rounded edges. True the surface by rubbing it on some kind of abrasive material which will remove the higher portions of the stone. Any one of the following methods may be used:

First Method: Place abrasive grains, aluminum oxide, or silicon carbide, and kerosene on a flat surface of either iron, glass, or hardwood. Rub the stone over the abrasive mixture until the surface is flat. Abrasive grains in sizes 24 to 36 give a satisfactory surface on most stones. Finer grains should be used for extra fine stones. (*This method cuts more slowly* than some other methods because the grains are free to move over the surface instead of being held in place against the stone.)

Second Method: Mount a plain silicon-carbide brick on the bench and rub the worn oilstone on the brick until it is flat, using water to carry away the waste materials. Occasionally rub the brick with a wire brush and water to keep the surface from becoming clogged. A brick 3″ x 3″ x 8″ with No. 24 grains and grade R is suitable for such jobs.

To remove any scratches in the surface of the oilstone, tack a sheet of 1/0 garnet paper on the flat surface of a board. Rub the stone over the abrasive, using kerosene to carry away the waste material.

Third Method: Select a patch of concrete sidewalk in which the surface stones are rather fine and rub the oilstone on the concrete until it is flat, using a generous supply of water. When the concrete loses its sharpness, shift to another surface. This is a rather "home-spun" procedure for truing an oilstone, but it is as effective as any other method.

The oilstone surface can be finished by rubbing it on garnet paper, following the procedure given in the second method.

Old grinding wheels and grindstones may be used as the abrasive for truing oilstones. Do not try to true an oilstone by holding it against a running abrasive wheel. Such practice will develop excessive friction and heat and cause the oilstone to break.

To repair broken stones

Broken stones can be restored to usefulness by the following method:

1. Heat the broken pieces over a hot plate or other heating unit. This will drive excess oil from the inside of the stone.
2. Scrub and clean the broken edges with gasoline or cleaning solvent.
3. Match the pieces together for trial fit.
4. When the fit is satisfactory, dust the broken edges thickly with finely ground stick shellac.
5. Match the edges carefully and reheat to melt the shellac.
6. Press the pieces tightly together, using a wooden clamp or vise.
7. Dress the flat surface if the joint is uneven.

FILES

Although there are many files to suit a variety of purposes, woodworking maintenance requires comparatively few.

Files are classified as to size, kind, and cut.

The size of a file is designated by its length in inches not including the tang. In general the thickness and width of files do not vary proportionately to the length, but they do increase somewhat in thickness and width as the length increases (8, 11). That is, a 12″ mill file is greater in thickness and width than one 6″ long, but it may not be twice as thick or twice as wide.

The kinds of files are designated by their shape. In cross section they are divided according to their geometric figure, such as quadrangular, triangular, and circular (8, 11). From these basic shapes many other classifications are made.

As to outline, files are either *tapered* or *blunt*. Tapered files are reduced in thickness and width from approximately the center to the point. Blunt files remain the same for their entire length.

Files are also classified as to use, but use is determined by shape. Examples of this classification are the *auger bit*, the *mill*, and the *taper saw files*.

The term "taper file" should not be confused with taper saw file. Files with cross sections of various shapes may taper toward the point. But the name "taper saw file" designates a particular taper file, triangular in cross sectional shape, used for sharpening saws that have 60° angle teeth.

The cut refers to both the kind of teeth and their spacing (8, 12). Files are made with two types of teeth, single and double. If parallel lines of teeth run diagonally across the surface of the file, it is *single cut*. These teeth have the cutting action of a series of chisels which shear off the metal.

Double-cut files have two series of diagonal teeth, crossing each other at an oblique angle, which form a series of cutting points that gouge out particles of metal. These teeth remove the metal much faster than single-cut teeth, but make a rather rough surface which is not suitable for the edge of cutting tools.

Single-cut files produce a smooth surface and require but little pressure to make them cut. For that reason files used for sharpening—such as the auger bit, the cant, the mill, and the taper file—are all single cut.

The spacing of the teeth determines the coarseness or fineness of a file. The finer one has more teeth per inch. These spacings are arbitrarily designated from coarse to fine in the following order: *coarse, bastard, second cut, smooth cut,* and *dead smooth.* Files of different sizes with the same cut do not have the same number of teeth per inch. A small file in a particular cut is finer than the larger one (7, 113). It is possible for a small file with bastard cut to be as fine as a large one with second cut. Therefore it is obvious that the tooth spacing should be considered when selecting file sizes. The files commonly used for *sharpening cutting tools* are *bastard* and *second cut.*

The question often arises as to why the name "bastard" has been applied to the cut of a file. At an earlier date, when files were made by hand, the name was supposedly given to a less typical cut that was between the coarse and finer cuts. This particular tooth spacing became so popular that it was later accepted as a standard spacing (6, 191).

Kinds of files

Mill files usually taper in thickness and width from near the center to the point, but some are blunt. Most of them are made with square edges, but they are obtainable with one or two round edges. These are desirable for filing circular saws, as they prevent cutting sharp corners in the gullets. The mill file is single cut with either bastard-cut, second-cut, or smooth-cut tooth spacings. The bastard cut is more generally used. It is used for filing mill saws, from which it gets its name, drawfiling and general filing where a smooth finish is required.

The *taper saw file* is a three-cornered file, usually single cut, with teeth on all surfaces and corners. These files are made with sides of various widths and are designated as "taper", "slim taper", "extra slim taper", and "double extra slim taper".

A file of a particular length will come in various tapers. However, as the length of a file with a particular taper changes, the width of the side also changes. It is possible to have a short, regular taper file with sides wider than those of a long, extra slim taper file. By reducing both the length and the slimness, the width of the sides can be considerably reduced.

These are important factors to consider when selecting files for saws with various tooth spacings.

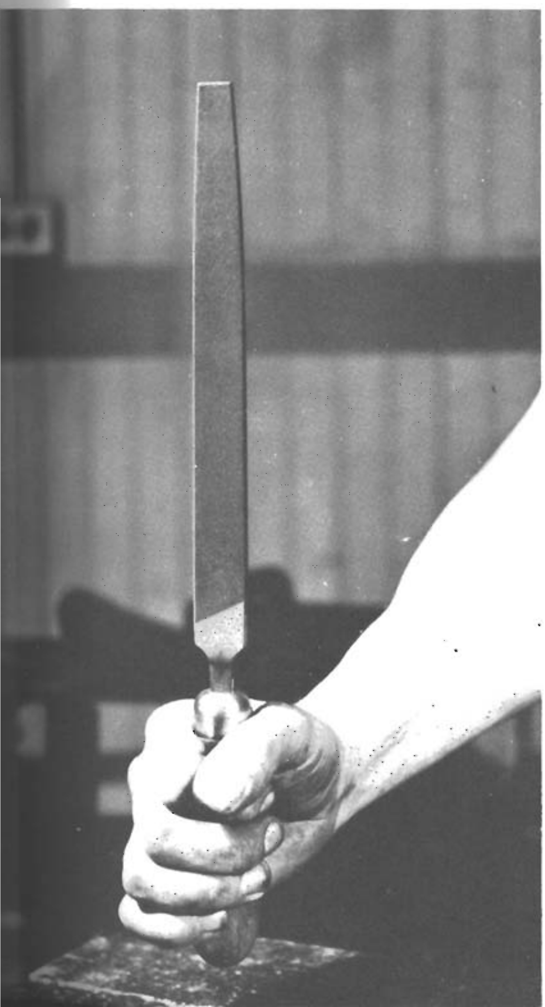
Taper saw files are single cut with second-cut tooth spacing. They are used for filing all types of saws that have teeth with a 60° angle at the bottom of the gullets.

The *cant file* is a second-cut, blunt file. It may be used in place of the mill file, but is made especially for filing saw teeth with an angle of less than 60°, since two of the sides have a low angle.

The *round file* with bastard cut is mostly for enlarging or finishing holes and filing gullets in saws. Single-cut teeth are preferable.

The *auger-bit file* is a second-cut file with safe edges on one end. On the other end the sides are safe and the edges are single cut. The safe surfaces make it possible to file an edge without damage to adjoining surfaces.

1-29. Adjusting a handle on a mill file by tapping the butt of the handle on the bench top.
COURTESY NICHOLSON FILE COMPANY



File handles

File handles are usually made of wood. Most of them have a hole in the end into which the tang of the file fits. The file is held in place by friction after being forced into the handle. A metal ferrule prevents the tang from splitting the end of the handle. The handle is attached by placing it on the tang and then forcing the file into it while holding the file in a vertical position. Tapping the butt of the handle on the bench top will fix the file in place. Do not hit the end of the file to drive it into the handle (Fig. 1-29).

Another type of handle has a spirally wound, hardened steel spring embedded in the wood and held in place by a metal ferrule. When the handle is put on the tang and twisted, the spring steel cuts threads on the tang, thereby holding the handle firmly on the file. Unscrew the handle to remove it.

No file should be used either without a handle or with a handle that does not fit the file. Filing is an art which requires accurate control of the file. The file can be skillfully manipulated only when equipped with a handle of the correct size firmly fitted on the tang. There is, also, a possibility of being injured by the tang when one uses a file without a handle.

Handles are usually made in four or five different sizes. The two smaller sizes will fit almost all files used for sharpening edge tools. The smallest size is suitable for files 3" to 6" long, and the next size will fit 6" to 10" files.

Care of files

Files are edge tools and must be handled as such if they are to give the service that is built into them. No file will last long when it is carelessly handled, but proper care will prolong its life.

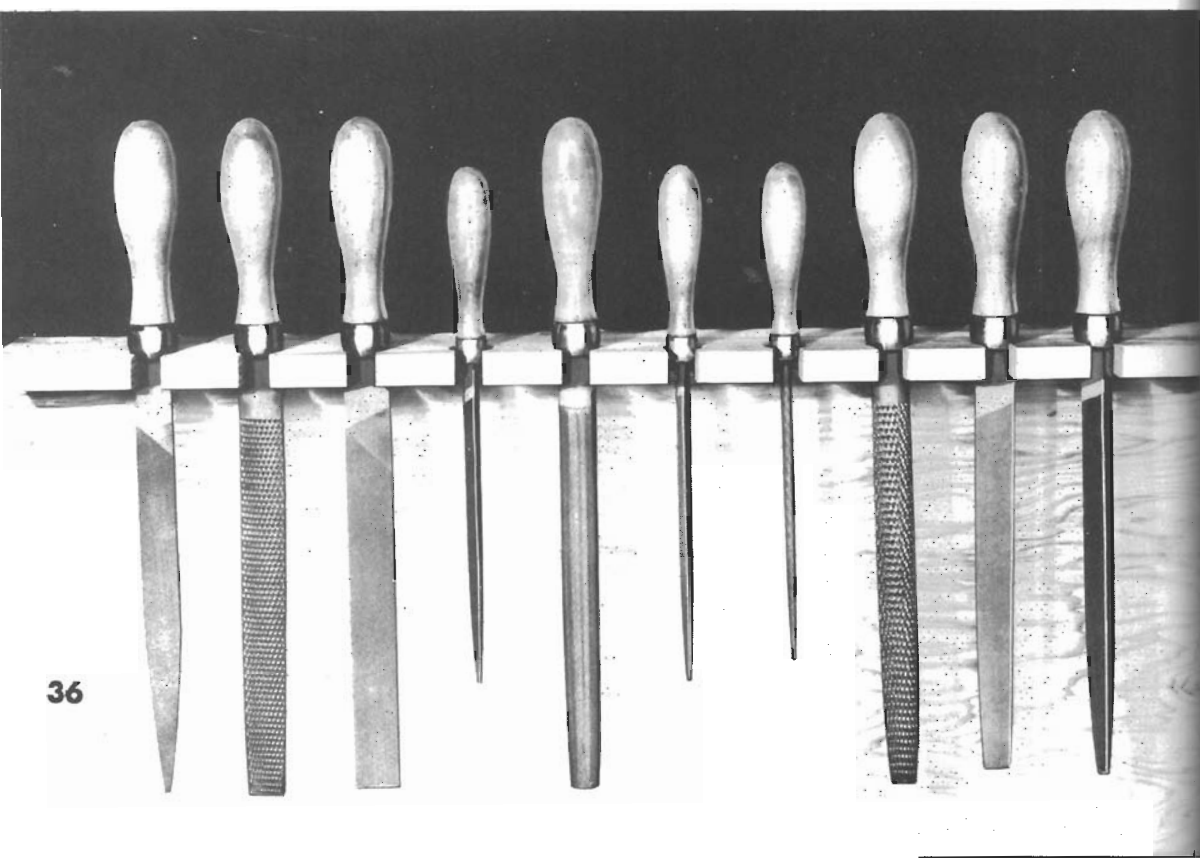
Keep files in individual compartments to prevent their coming into contact with other metal. The cutting teeth are extremely hard and brittle. Throwing files into a drawer may ruin them (Fig. 1-30). Do not use the file as a pry or a hammer, for the same reason.

Keep files clean at all times. When they are clogged, the cutting edges cannot get hold of the material. Chalk rubbed over the cutting surfaces helps to prevent clogging, as the metal shavings cannot be compressed into the serrations so tightly. The pieces of metal can then be easily removed with a file card (Fig. 1-31). Keep files in a dry place. Moisture will cause them to rust and eventually damage their sharp edges and clog the serrations.

Most files are made to cut on the

1-30. Files, when not in use, should be stored so that the cutting edges do not come in contact with each other.

COURTESY NICHOLSON FILE COMPANY



forward stroke. Dragging them back in contact with the stock dulls the teeth.

Apply sufficient pressure to make the file bite into the material. But *too much pressure* will not only cause it to become clogged, but will also tend to break the teeth. The teeth on the corners of a taper saw file may be broken in a few strokes if forced to cut excessive amounts.

Too little pressure will also cause excessive wear on the file. If the teeth do not cut into the material, they slide across the surface and dull the cutting edges. Be sure to hold the work firmly while filing. Any vibration which causes the file to chatter will quickly dull or break the teeth.

Brush both wood and metal files frequently with a file card or wire brush to keep them clean. *The ones that have been neglected* are cleaned by immersing them in turpentine for several hours to dissolve the resinous materials and then rubbed with a file card or a wire brush. Some craftsmen recommend dipping the file in alcohol and igniting the portion that remains on the file. This will burn the wood substance that fills the serrations. The file then can be cleaned with a wire brush. Such practice will not damage the file because the temperature will not be high enough to draw the temper.

Files are washed in gasoline or carbon tetrachloride to remove oil.

Information for ordering files

In selecting files, consider the following information:

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1-31. For longer lasting performance, clean a file frequently with a file card.

1. *Name*: based on cross-sectional shape and slimness of taper (in the case of the taper saw file), outline shape, and use.
2. *Cut*: a. kind of teeth, b. tooth spacing—if not included in the name.
3. *Length*: given in inches, not including the tang.

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PART ONE

CHAPTER 2

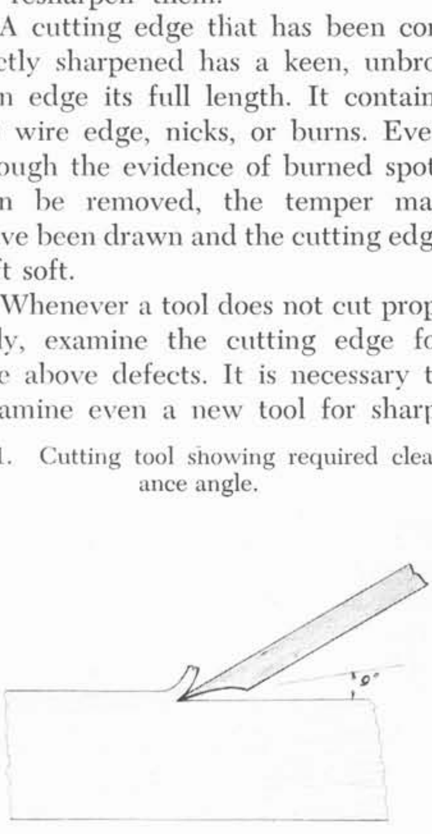
Maintaining The Cutting Edge Of Tools

THE GOOD craftsman keeps his tools sharp. They must be sharpened frequently if they are to cut efficiently. Also extremely dull cutting tools require more time and the removal of more material to restore the cutting edge. If cutting tools are sharpened when they are only slightly dull, very little stock needs to be ground off to resharpen them.

A cutting edge that has been correctly sharpened has a keen, unbroken edge its full length. It contains no wire edge, nicks, or burns. Even though the evidence of burned spots can be removed, the temper may have been drawn and the cutting edge left soft.

Whenever a tool does not cut properly, examine the cutting edge for the above defects. It is necessary to examine even a new tool for sharpness because the manufacturer does not always put a sharp edge on tools.

2-1. Cutting tool showing required clearance angle.



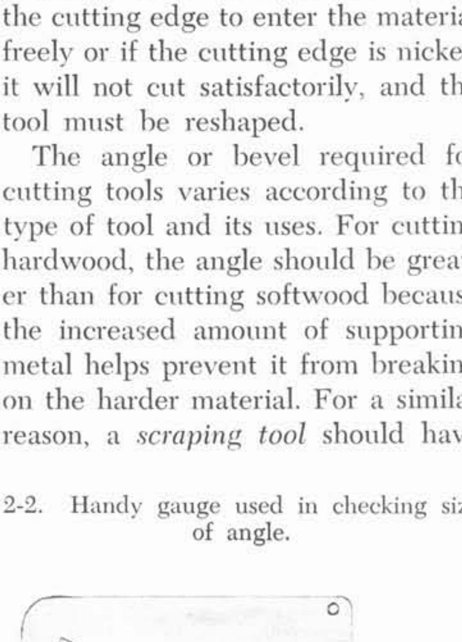
The various sharpening jobs involve *grinding*, *stoning*, or *filing*, or a combination of these operations.

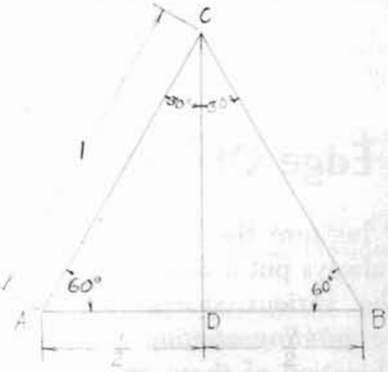
GRINDING

The purpose of grinding edge tools is to remove the excessive metal from the cutting edge to give the tool the correct form or shape. If the sharpened tool does not have the required *clearance angle* (Fig. 2-1) to allow the cutting edge to enter the material freely or if the cutting edge is nicked it will not cut satisfactorily, and the tool must be reshaped.

The angle or bevel required for cutting tools varies according to the type of tool and its uses. For cutting hardwood, the angle should be greater than for cutting softwood because the increased amount of supporting metal helps prevent it from breaking on the harder material. For a similar reason, a *scraping tool* should have

2-2. Handy gauge used in checking size of angle.



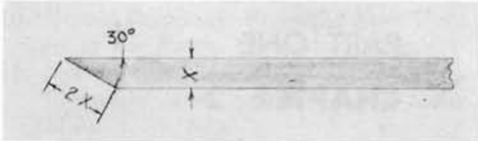


2-3. Geometrical layout of cutting angle. Use a 30° angle for most tools.

a larger angle than one that makes a shearing cut.

The angle made between the face of the tool and the bevel is commonly given in degrees. For example, a plane iron is usually ground at a 25° angle. But the size of an angle is rather difficult to determine without using a gauge (Fig. 2-2), or by comparing the *length of the bevel* with the thickness of the tool. Figure 2-3 illustrates the principle in geometry which states that "the hypotenuse of a 30°-60° right triangle is twice the length of the shorter side." In the equilateral triangle ABC, the line CD bisects both the angle at C and the line AB. Since the sides of the triangle ABC are equal, the length of line AC is twice that of AD.

In many cases, since most woodworking tools are beveled to nearly 30°, the comparison of the length of the bevel can be used for estimating the angle. In Fig. 2-4 the bevel length is twice the thickness of the material and the angle is 30°.

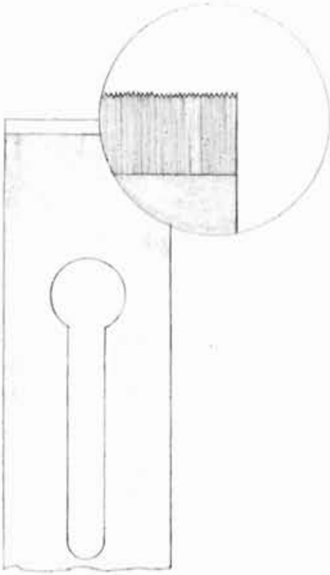


2-4. Bevel length equals twice the thickness of the tool. Depending upon the material, this proportion may vary somewhat.

For an angle of 25°, the length of the bevel is slightly less than 2½ times the thickness of the material, whereas for a 45° angle the length of the bevel is slightly less than 1½ times the thickness of the material. Except in those cases where the angle is very critical, this method is adequate for determining the angle for grinding most cutting tools.

A good grinding job is a prerequisite for a good edge. The best of stoning on a poorly ground tool will result in a mediocre cutting edge. Because offhand grinding is necessary on such tools as gouges and carving and turning chisels, which cannot be mounted in a tool holder, it is advisable to develop offhand grinding skills and techniques on straight-edged tools. It is much easier to learn to grind a uniform bevel on straight-edged tools than on curved-edges. Also, after learning the technique, it is easy to apply it to curved edged tools. Offhand grinding of cutting tools is done with more ease if the grinding wheel is at least 1¼″ thick.

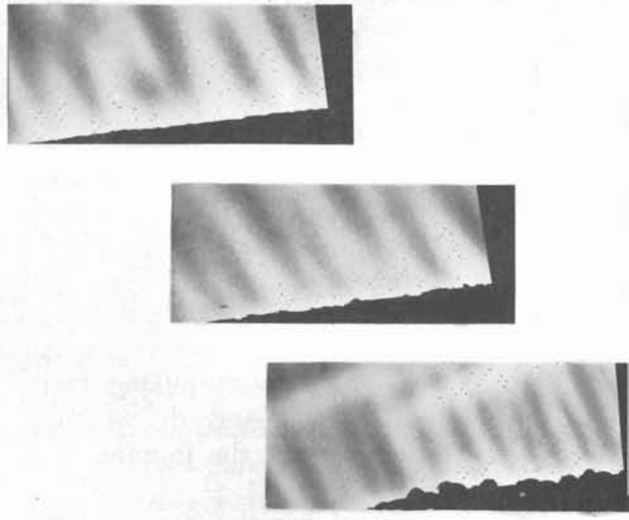
If properly ground, the bevel on the tool is slightly *concave*. The amount of concaveness is determined by the diameter of the grinding wheel, since the tool is moved hori-



2-5. A plane iron edge cuts by means of a series of small cutting teeth. Notice that the minute grooves are at right angles to the cutting edge.

zontally across the face of the wheel and at the same angle. When the bevel is either *flat* or is made up of a *series* of bevels, the tool has not been held at a constant angle to the wheel during the grinding process.

The grinding operation may be performed on either a dry or a wet grinding wheel. Aluminum-oxide wheels with No. 50 to 60 grit and medium bond are commonly used for grinding edge tools. They tend to grind faster without burning so easily and still make a relatively smooth surface. If the wheel is used dry, dip the tool in water frequently to keep it cool. If it is a wet wheel, use enough coolant to keep the wheel from becoming clogged and to keep the tool cool.



COURTESY BEHR-MANNING CORPORATION

2-6. Three successive views of a cutting edge, magnified 20 times.

Heating the tool until it turns blue draws the temper and makes the cutting edge soft.

STONING

Stoning, honing, or whetting is the process of cutting minute grooves on a surface at right angles to the cutting edge (Fig. 2-5, 6). These small scratches intersecting with the cutting edge form tiny cutting teeth which have the cutting action of little saw teeth shearing off the material.

Without these minute teeth, the edge loses its cutting efficiency because it slips over the fibers instead of severing them. When the teeth break or wear off, resulting in a dulled edge, restore them by stoning. Repeat the operation until the bevel has been altered to the point where the cutting edge no longer enters the material easily. The tool is dull and needs sharpening when a bright line forms on the cutting edge.

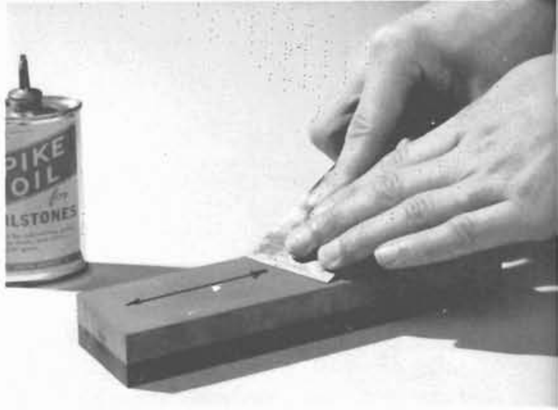
Stoning cutting tools after grinding has been known to increase the service of a cutting edge as much as 300 per cent before regrinding became necessary (1, 27). Stoning gives a smoother finish and can be done in a relatively short time. Whetting with straight strokes (Fig. 2-7) puts on an edge quicker than a rotary motion (3, 14). With a rotary motion, there is a tendency to change the whetting angle and prevent the forming of a true edge.

If the tool has the correct shape and a concave bevel, honing is all that is necessary to make a sharp cutting edge. It may be conveniently sharpened by whetting it first on the coarse side of a *combination stone* and finishing it on the finer side.

The clearance angle on a tool cannot be altered to any great extent without changing the performance of the tool. When the tool no longer cuts easily because of improper clearance angle, reshape it on the grinding wheel. If a grinder is not available, restore the proper angle by whetting the tool on a coarse oilstone. However, this method requires more work and is considerably slower.

REMOVING THE WIRE EDGE

After a tool has been ground or stoned on a coarse stone, it usually contains a "wire" or thin feather edge which must be removed if the cutting edge is to last. A wire edge may not be easily seen, but it can be readily felt. After some stoning from both surfaces to reduce the thickness of the wire edge, remove it by pulling it across the grain of a piece of hardwood (Fig. 3-13, page 50). This will break off the thin excess metal, leaving the cutting edge slightly blunt.



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2-7. Whet tool edge by moving in direction of arrows. Use correct oil for lubricant.

A minimum amount of stoning will then produce a keen cutting edge.

If the wire edge is not removed, it will break off with the first few strokes of the tool, leaving the edge blunt and rough.

FILING

Filing is an art which requires persistent practice. If the first attempt at filing proves unsuccessful, continue practicing to develop the necessary skill. Careful filing can be sufficiently accurate to do most maintenance jobs.

To file a surface

1. Clamp the work firmly at the proper height so it will not chatter. For general filing it should be slightly below the elbows to allow full motion of the arms. For light, fine filing, raise the work closer to the eyes.
2. Grasp the handle in the palm of the right hand with the forefinger resting either on top or at the side of the file. With the other hand, take hold of the end of the file, placing the first two fingers underneath and the thumb on top so that the file points toward the palm (Fig. 2-8).

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2-8. Good filing is an art. The correct method of holding the file is important.

COURTESY NICHOLSON FILE COMPANY

2-9. A surface can be made smooth by draw-filing as illustrated here.

For those who are left-handed, the file will be reversed in the hands, but held in the same manner.

3. While holding the right wrist rigid and the left wrist only slightly relaxed, and permitting free movement at the elbows and shoulders, push the file forward over the surface, applying only enough pressure to make the teeth cut into the material. Be sure to hold the file in the same plane during the entire stroke to obtain a flat surface. Each stroke should be almost the full length of the file.
4. Raise the file slightly on the return stroke so as not to drag the teeth over the surface and dull them.

Fig. 2-9 illustrates how to hold the file for draw filing. This practice produces a smooth surface.

SHARPENING CARBIDE TOOLS

Because the composition and physical properties of tungsten carbide are different from those of both carbon and high-speed steels, the sharpening of cutting tools must be done by special grinding techniques in order to obtain economical service. Because of their initial high cost and their brittleness, carbide tools require careful handling. But they will do from 75 to 250 times more work per sharpening than the ordinary tool, depending upon the material being cut.

Carbide tools should be resharpened as soon as they begin to show signs of dullness. If the tool is dull, the increased pressure required to make it cut causes excessive wear. It then requires more grinding to make a sharp edge. This results in a waste of tool life and loss of time.

Although carbide is very hard, it is also brittle. The cutting edge must be carefully protected from sudden shock to prevent chipping. The tools are generally made by brazing a piece of tungsten carbide to the tip so that the cutting edge is supported by the steel.

Carbide tools can be as easily sharpened as other tools, if the correct abrasives are used and the proper techniques are followed. Silicon-carbide and diamond-impregnated grinding wheels must be used for grinding the carbide, and aluminum-oxide wheels for grinding sufficient clearance on the steel that backs up the tips (6, 61).

The grinding wheel should cut against the cutting edge and not away from it. Very little pressure is exerted against the wheel. Too much pressure causes the wheel to glaze and the carbide to check because of the heating and cooling action (4, 16). Carbide tools are air-cooled after grinding. *Do not put them in water to cool,* as the metal is likely to check or crack.

First cut back the supporting steel with an aluminum-oxide wheel; then rough-grind the carbide with a silicon-carbide or diamond wheel. Use a finer grain of either of the latter abrasive wheels for finish grinding (5, 33). It is not necessary to relieve the metal behind the carbide tip each time the tool is sharpened. In fact, when the cutting edge is only slightly dull, it can be touched up by hand stoning, thereby prolonging the cutting life between sharpenings. Either a diamond hand hone or silicon-carbide stone can be used for this purpose (2, 11).

The jointing operation is not recommended because carbide fractures easily which may damage the cutting edge, therefore, the grinding operation should be done very accurately.

To sharpen carbide tools

1. Mount an aluminum oxide wheel of the correct markings on the grinder. See procedure, "To Mount a Grinding Wheel", on page 24. Then grind the portion of steel supporting the carbide tip to obtain proper clearance. Be careful not to cut on the carbide tip.
2. Mount a silicon carbide or diamond wheel of the correct markings on the grinder and rough grind the carbide tip to an edge.
3. Mount a silicon-carbide or diamond wheel of the correct markings on the grinder. Finish grinding the carbide tip to a fine edge.

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PART ONE

CHAPTER 3

Maintaining Hand Planes

THE JACK, smoothing, fore, and jointer planes are similar in construction. The principal difference among them is in the size. For this reason they are considered as one group.

Since most companies supply repair parts for all their planes, any broken parts can be readily replaced. Many times it is possible to recondition a damaged part without the added expense for new ones. To obtain the best service, use only the parts made for the particular plane in repairing it.

Frequently the bottom of the plane becomes nicked on the edges, forming projections which mar the surface of the stock that is being planed. These can be removed either by drawfiling or stoning them lightly.

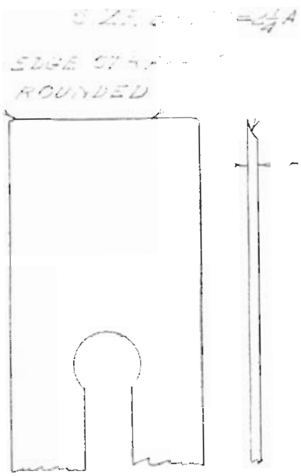
Handles and knobs are often broken by careless handling of the tool. They can be replaced either with wood or aluminum parts.

To the plane iron is attached a *plane iron cap* or *chip breaker* which breaks or curls the shaving immediately after it is severed by the cutting edge. Assembled, these two parts are called a *double plane iron;* the *cutter alone* is commonly referred to as a *single plane iron.*

The end of the plane iron cap near the cutting edge must fit closely against the side of the plane iron to prevent shavings of wood from wedging between the two parts. Frequently there is an opening between the end of the plane iron and the plane iron cap. This condition may be caused by the lack of a flat surface on either the plane iron or the plane iron cap or by a slight twist in the plane iron cap. The sides of the plane iron should be flat before the plane iron cap is fitted to it.

The plane iron cap is usually set about 1/16″ or more from the cutting edge for rough planing and is moved to within 1/32″ or less for planing cross-grained wood and for finished work where light cuts are made. If heavy cuts are taken with the plane iron cap set too close to the cutting edge, the shavings will be forced between the plane iron and the plan iron cap. If the plane iron cap is set too far from the cutting edge, it will not break or curl the shavings when making light cuts. Instead they will be curled by the angle of the plane iron before reaching the plane iron cap.

The *frog* of the plane holds the plane iron in place and is adjustable in the lengthwise direction of the plane. This permits changing the position of the plane iron in relation to the front of the throat opening in



3-1. A properly sharpened plane iron looks like this.

the bottom. When making heavy cuts, the plane iron must be set back from the front of the throat a sufficient distance to allow the shaving to pass through. The plane iron is set close to the front of the throat when planing cross-grained wood so that the wood will be held down by the plane bottom very close to where the fibers are being severed. Since the shavings are very thin, not much space is required to allow the shavings to pass between the front of the throat and the plane iron.

Cutting angle

Approximately a 25° angle is ground on the plane iron to form the cutting edge and to provide sufficient clearance for it to enter the wood freely. The variation of the angle will depend upon the hardness of the wood.

The shape of the cutting edge for finished planing is made straight, rounding slightly at the corners (Fig. 3-1). If the corners are not rounded, grooves will be cut in the wood. Rounded corners are obtained by whetting more toward the edges.

For general-purpose and rough planing, the cutting edge is curved slightly, depending upon the smoothness of surface required. If the cutting edge is curved to any great extent, the surface being planed will contain a series of "valleys."

The face of the plane iron (side opposite the bevel) must be flat before you attempt to grind the bevel. Since the cutting edge is formed by the intersection of the face and the bevel, it is obvious that the shape of the face will affect the shape of the cutting edge. If the face is curved, the cutting edge formed by it and a flat bevel will necessarily be curved also. *Any irregularities on the face will correspondingly affect the cutting edge.*

The cutting edge should be approximately square with the edges of the plane iron. The lateral adjustment on the plane will aid in compensating for slight variations in the angle of the cutting edge to the edges of the plane iron.

To flatten the face of a plane iron

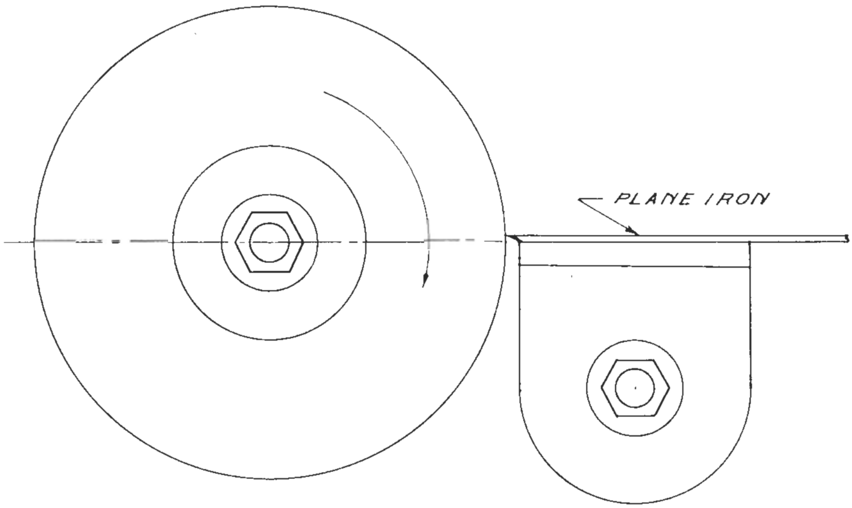
1. Select a piece of hardwood approximately 2″ x 4″ x 8″ and clamp it in the vise with the grain in a vertical position.
2. With the convex side up, place the plane iron on the end of the piece of hardwood and strike it

PHOTO BY CHARLES J. PEREZ

3-2. Flatten the face of a plane iron on the end grain of a piece of hardwood.

To fit a plane iron cap to a plane iron

1. If the plane iron cap is twisted so that it is considerably open toward one edge, place it in the vise and strike the high edge with a wooden mallet.
2. When the end of the plane iron cap approximately fits the plane iron, file the plane iron cap to fit the plane iron.
3. Place the filed surface on a fine oilstone and whet it smooth.



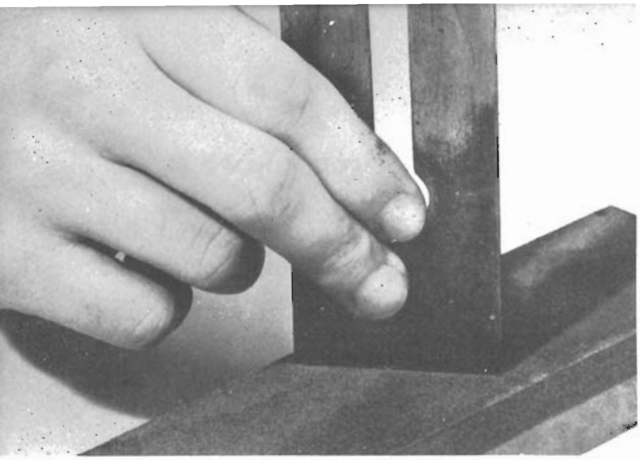
3-3. Position of tool rest when removing nicks and squaring the edge.

lightly with a hammer until the surface near the cutting edge is flat (Fig. 3-2). Test the surface with a square or straightedge. Do not place the plane iron on an anvil and strike it with a hammer because the metal might stretch.

3. Place the face of the plane iron flat on a bench-type oilstone and stone it true. Be sure the surface of the oilstone is flat and that the plane iron rests flat upon it.

To grind a plane iron

1. Remove the plane iron cap from the plane iron by loosening the cap screw.
2. Test the face of the plane iron (side opposite the bevel) to see that it is flat near the cutting edge. If it is not, make it flat following the procedure "To Flatten the Face of a Plane Iron," given on page 46.



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3-4. A slightly nicked edge may be squared on a coarse honing stone.

3. Start the grinder and regulate the valve for the proper flow of the coolant. If a dry grinding wheel is used, place a container of cold water close by for cooling the tool.
4. Holding the plane iron with the face up and in the same plane as the axial line of the grinding wheel (Fig. 3-3), grind the cutting edge straight, approximately at right angles to the edges of the plane iron.

   This may also be done by pulling the cutting edge across the oilstone, holding the plane iron so that the edges are at right angles to the surface of the stone (Fig. 3-4). Test the edge with a try square (Fig. 3-5).

3-6. First position of a plane iron on the tool rest. If the position is correct, move the index finger of the right hand up, until it serves as a guide along the edge of the tool rest.
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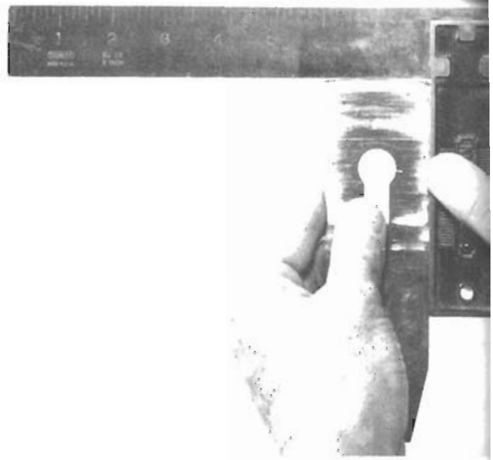

PHOTO BY CHARLES J. PEREZ

3-5. Test the cutting edge for straightness and squareness before proceeding to grind the bevel.

5. Grind the bevel on the plane iron, using one of the following procedures, *either* a, b, or c:

   a. To use tool holder:
      (1) Set the tool holder on the grinder at the appropriate angle to cut the required bevel.

3-7. Cool the cutting edge in water without changing position of index finger.

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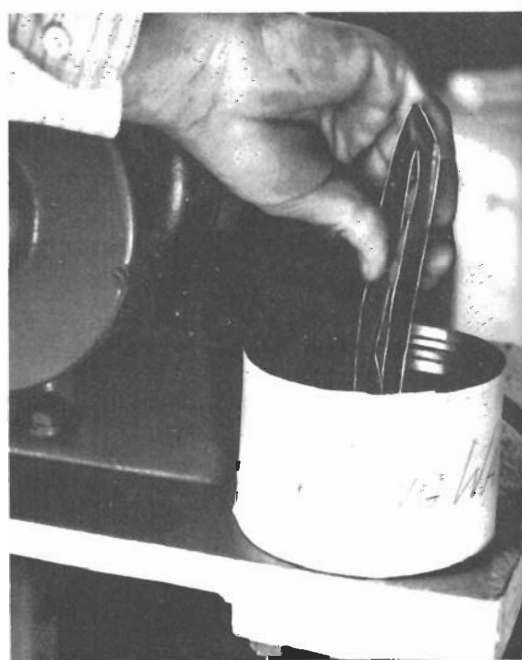


3-8. The plane iron cap can be used as a convenient guide in sharpening a plane iron. Be sure to fasten it at right angles to the plane iron.

3-9. Position of the right hand on the plane iron in offhand grinding method.

3-10. Position of both hands on the plane iron in offhand grinding method.

PHOTOS BY CHARLES J. PEREZ

3-11. Hold the plane iron like this when whetting the bevel.

Clamp the plane iron in it with the cutting edge lightly touching the face of the grinding wheel and parallel to its axial line.

(2) Move the plane iron back and forth across the face of the grinding wheel, adjusting it to the wheel to make the necessary contact for grinding the tool to an edge.

b. To use the tool rest:

(1) After all nicks have been removed, change the tool rest to the appropriate angle with the wheel.

(2) Hold the plane iron firmly between the thumb and index finger, giving support with the other hand. The index finger can serve as a guide along the edge of the tool rest (Fig. 3-6).

(3) Move the plane iron back and forth on the tool rest. Avoid overheating. Dip the plane iron into a container of water when it starts to get hot. When doing this, be sure not to move the position of the front index finger, since this may change the bevel (Fig. 3-7).

(4) Continue grinding until a cutting edge appears on the plane iron. Also check the size of the bevel. (For all-purpose planing it should be 2¼ times the thickness of the blade.)

(5) When the plane iron is

ground straight across, the corners may be rounded lightly (Fig. 3-1, page 46).

In Fig. 3-8 the plane iron cap is shown as a guide in grinding the bevel.

c. To grind off-hand:

(1) If you are right-handed, grasp the plane iron in the palm of your right hand between the thumb and the two last fingers, with the first two fingers placed on the face (side opposite the bevel) and extending toward the cutting edge (Fig. 3-9). Place the palm of the left hand on the first two fingers of the right hand and grasp them and the plane iron with all the fingers of the left hand extending around the plane iron from the right (Fig. 3-10). Be sure that the fingers of the left hand are back far enough to clear the grinding wheel. Reverse the procedure if you are left-handed.

(2) With the elbows fairly close to the body and the wrists held rigid, place the beveled side of the plane iron on the face of the grinding wheel with the cutting edge parallel to the axis of the wheel. Move it back and forth across the face of the grinding wheel, either by moving the arms at the shoulders or by shifting the body on your feet, or by both. Examine the bevel frequently, at first, to see if a uniform bevel of the proper angle is being formed. *Be sure to place the plane iron on the wheel in nearly the same place and at the same angle each time.*

(3) After a concave bevel has been formed, continue the grinding process until the tool is ground to an edge (Fig. 3-1, page 46).

To stone a plane iron

A. To stone a plane iron after grinding:

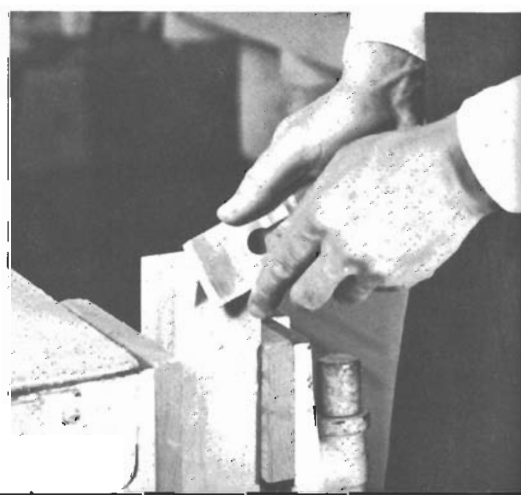
1. Select a fine, flat, bench-type oilstone. Wipe the surface with a clean cloth and apply a few drops of light oil.

3-12. Honing the flat side of plane iron.

PHOTO BY ELLENWOOD

3-13. Remove the wire edge on the end grain of hardwood.

PHOTO BY CHARLES J. PEREZ



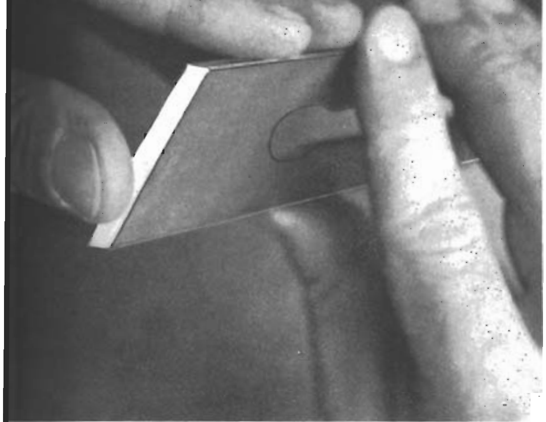
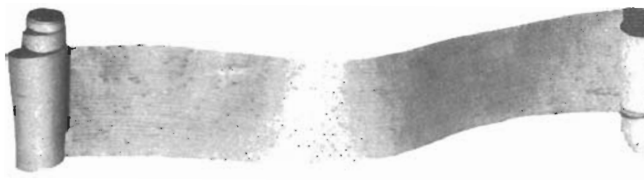


PHOTO BY GRIFFITH

3-14. Test the plane iron for sharpness like this.



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3-15. A sharp plane iron cuts a shaving like this.

2. Grasp the plane iron in the same way as instructed in step No. 5c (1) in the procedure "To Grind a Plane Iron", page 47.
3. Place the bevel on the flat surface of the oilstone and rock the plane iron to locate the position where the bevel rests flat on the surface.
4. With the cutting edge of the plane iron at approximately a right angle to the edges of the stone and holding the wrists rigid, make a few long forward and backward strokes on the stone, whetting the concave bevel at both the cutting edge and the heel simultaneously (Fig. 3-11). The corners may be whetted slightly round.
5. Lay the face (side opposite the bevel) flat on the stone and whet it against the edge (Fig. 3-12).
6. Continue Steps 3, 4, and 5 until the cutting edge is sharp. If a wire edge forms, pull the cutting edge across the edge or end grain of a piece of hardwood parallel to the cutting edge (Fig. 3-13).
7. After the wire edge has been removed, whet the cutting edge until it is sharp, following Steps 3, 4, and 5. Test the edge for sharpness (Fig. 3-14).

B. To stone a plane iron without grinding:

1. Select a bench-type oilstone, combination coarse and fine; or two stones, one coarse and the other fine. Wipe each surface with a clean cloth and apply a few drops of light oil.
2. Hold the plane iron in the same way as instructed in Step 5 c (1) in the procedure "To Grind a Plane Iron," on page 47.
3. Place the bevel on the flat surface of the coarse oilstone and rock the plane iron to locate the position where the bevel rests flat on the surface. If the bevel is no longer concave, the heel may be raised very slightly so that the cutting edge may be whetted without the necessity of removing metal on the whole bevel.
4. With the cutting edge of the plane iron at approximately a right angle to the edges of the stone, hold the wrists rigid and make a few long forward and backward strokes until a new cutting edge is formed on the tool. The corners may be whetted slightly round.
5. Following Steps 2, 3, and 4, whet

the bevel on the fine surface of the oilstone.

6. Lay the face (side opposite the bevel) on the stone and whet it against the cutting edge.
7. Continue Steps 5 and 6 until the cutting edge is sharp. If a wire edge forms, pull the cutting edge across the edge or end grain of a piece of hardwood (Fig. 3-13).
8. After removing the wire edge, whet the cutting edge until it is sharp, following Steps 4, 5, and 6. Test the edge for sharpness (Fig. 3-14).

A plane iron, properly sharpened, makes shavings as shown in Fig. 3-15.

PART ONE

CHAPTER 4

Chisels And Gouges

Chisels have two types of blades: *square edge* and *beveled edge*. The latter is preferable, as it clears itself from the cut easier and there is reduced friction at the edges.

Chisels are also made with three different lengths of blades. The *firmer chisel* is used for all kinds of general work and is usually the longer of the three styles. The *socket chisel* is similar to the firmer chisel, but the handle is thicker and shorter. The blade is also shorter. The *butt chisel* has a short blade which makes it handy for such jobs as cutting gains and setting hinges.

The handle is attached by three methods. Some chisels have a *tang* which fits into the handle. It is bound with a metal ferrule that aids in preventing the handle from splitting. It is suitable for light work. Another type, known for its durability has the *head, shank, and blade* forged into one piece. The blow struck on the head of the chisel is transmitted to the cutting edge without affecting the handle materially. The most common type of chisel has a *socket* into which the handle fits. The socket supports the end of the handle and prevents it from splitting when hit with a mallet. There is usually a leather washer attached to the top end of the handle to absorb the shock and prevent the blows of the mallet from splitting the handle.

The size of chisels is designated by the width of the cutting edge. The sizes vary from ⅛″ to 1″ by eighths and from 1″ to 2″ by quarters.

The construction of gouges is similar to that of chisels. They are made in three curvatures: *flat sweep, middle sweep*, and *regular sweep*. Those sharpened with the bevel on the convex side are *outside gouges* while those with the bevel on the concave side are *inside gouges*.

The cutting edges of both chisels and gouges are at right angles to the edges of the blade, and the bevel is approximately 20° to 30°, depending upon the hardness of the wood and the type of work. The bevel is commonly ground at 25° for general work. If the bevel is too long, the cutting edge will crumble, since there is not enough metal to support it.

The face of the chisel (side opposite the bevel) must be flat in order to make the cutting edge straight, since it is formed on the face surface. Because of careless stoning practice and the use of a stone that is worn concave, the surface sometimes becomes convex. If the condition of the surface is not too bad, it can be made flat by carefully stoning on a coarse oilstone, finishing with a fine stone. However, when the tool becomes too deformed, the face may be ground flat and then whetted to a smooth finish. If this operation is not performed with care, the tool can be ruined.

CHISELS

To fit the handle to a socket chisel

The handle is made to fit snugly into the gradual taper of the socket. If the taper on the handle is not the same as that of the socket, the handle will not stay in. Use the following procedure to fit the handle to the socket:

1. Clean the inside of the socket and apply a very light coat of Prussian blue to the surface.
2. Put the handle in the socket and twist it so that the blue will mark the portion of the handle that contacts the socket.
3. Carefully dress off the portion that is marked and test again, repeating the operations until the entire taper fits the socket.
4. After the taper has been shaped to fit the socket, drive the handle into it with a mallet.

To grind a chisel

1. Test the face of the chisel to see that it is flat at the cutting edge. If it is not, make it flat by carefully whetting it on a coarse, flat stone, finishing it on a fine stone. If it is in very poor condition, grind the face flat and finish it by whetting.
2. Start the grinder and regulate the valve for the proper flow of the coolant. If a dry grinding wheel is used, place a container of cold water close by for cooling the tool.
3. Holding the chisel with the face up and in the same plane as the axial line of the grinding wheel, grind the cutting edge straight and at right angles to the edges of the blade (Fig. 3-3, page 47). Test for squareness with a try square. The cutting edge may be shaped by pulling it across the oilstone, holding the edges of the chisel at a *right angle* to the surface of the stone.
4. Grind the bevel, using one of the following procedures, either a or b:

   a. To use tool holder:

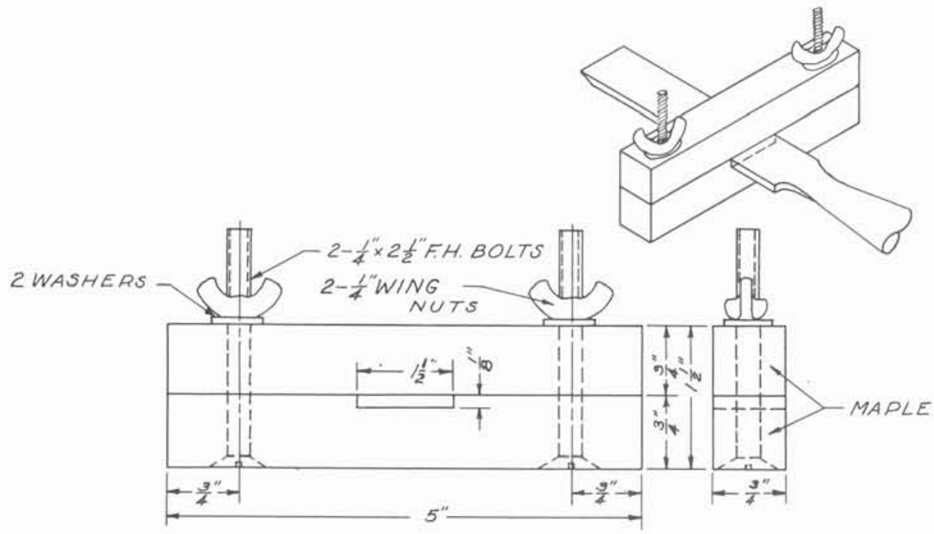
   (1) Set the tool holder on the grinder at the angle necessary to cut the required bevel and clamp the chisel in it with the cutting edge lightly touching the face of the grinding wheel and parallel to its axial line.

   (2) Move the chisel back and forth across the face of the grinding wheel, adjusting it to the wheel as is needed to make contact until the bevel is ground to the edge.

   A simple jig (Fig. 4-1, page 55) may serve as a guide in grinding a bevel of the proper size and shape when a tool rest is used.

   b. To grind offhand

   (1) If you are right-handed, grasp the handle of the chisel with your right hand and place



4-1. Simple jig used in sharpening wood chisels.

your left hand on the blade. Hold it with all the fingers extending around it from the right. Reverse the procedure if you are left-handed.

(2) With the elbows reasonably close to the body and the wrists held rigid, place the beveled side of the chisel on the face of the grinding wheel with the cutting edge parallel to the axis of the wheel (Fig. 4-2). Move it back and forth across the face. Examine the bevel frequently at first to see if a uniform bevel of the proper angle is being formed. Be sure to place the chisel on the wheel in as nearly the same place and at the same angle each time.

(3) After a concave bevel has been formed, continue the grinding process until there is a cutting edge.

To stone a chisel

A. To stone a chisel after grinding:

1. Select a fine, flat, bench-type oilstone. Wipe the surface with a clean cloth and apply a few drops of light oil.
2. Hold the chisel in the same way as instructed in Step No. 4b (1) in the procedure, "To Grind a Chisel", page 54.
3. Place the bevel on the flat surface of the oilstone and rock the chisel to locate the position where the bevel rests flat on the surface.
4. With the cutting edge of the chisel approximately at a right angle to the edges of the stone, and holding the wrists rigid, make a few long forward and backward strokes on the stone, whetting the concave bevel at both the cutting edge and the heel, simultaneously (Fig. 4-3).
5. Lay the face (side opposite the

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4-2. To grind a chisel offhand, hold the tool like this. After checking the bevel, replace it on the wheel in the same position.

PHOTO BY ELLENWOOD

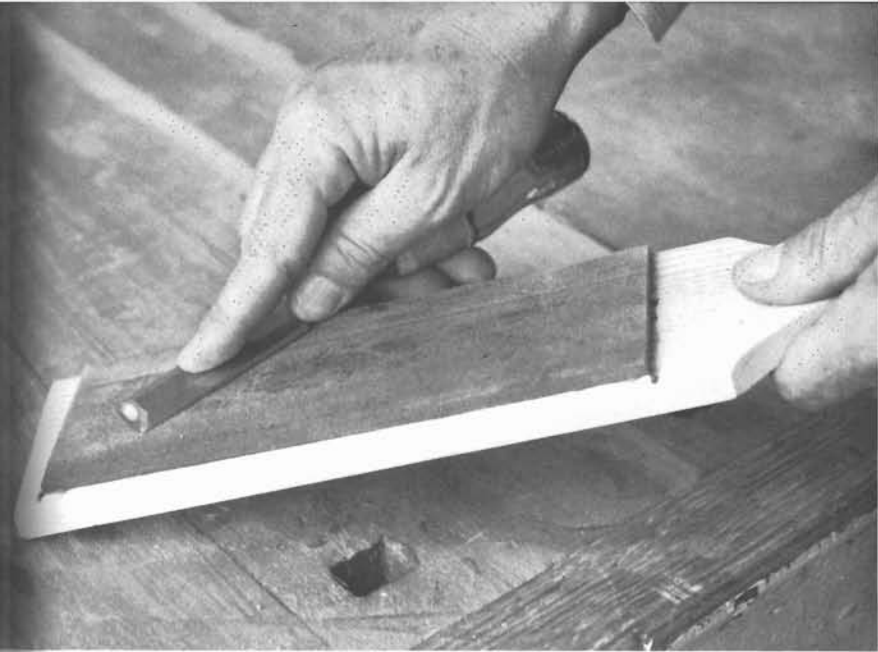
4-3. Whet the concave bevel at both the cutting edge and the heel simultaneously.

bevel) flat on the stone and whet it against the cutting edge.

6. Continue Steps 3, 4, and 5 until the cutting edge is sharp. If a wire edge is formed, pull the cutting edge across the edge or end grain of a piece of hardwood (Fig. 3-13).
7. After the wire edge has been removed, whet the cutting edge until it is sharp, following Steps 3, 4, and 5.

B. To stone a chisel without grinding:

1. Select a bench-type oilstone, combination coarse and fine; or two stones, one coarse and the other fine. Wipe each surface with a clean cloth and apply a few drops of light oil.
2. Place the bevel on the flat surface of the coarse oilstone and rock the chisel to locate the position where the bevel rests flat on the surface. If the bevel is no longer concave, the heel may be raised very slightly and the cutting edge whetted without the necessity of removing metal on the whole bevel.
3. With the cutting edge approximately at a right angle to the edges of the stone, and holding the wrists rigid, make a few long forward and backward strokes until a new cutting edge is formed.
4. Following Steps 2 and 3, whet the bevel on the fine surface of the oilstone.
5. Lay the face (side opposite the bevel) flat on the stone and whet it against the cutting edge.
6. Continue Steps 2, 3, and 4 until the cutting edge is sharp. If a wire edge is formed, pull the cutting edge across the edge or end grain of a piece of hardwood (Fig. 3-13, page 50).



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4-4. A keen edge can be produced on a leather strop. Prepare leather with tallow and fine graphite.

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4-5. Grind the bevel on an outside gouge like this. Roll the bevel carefully from right to left.

7. After the wire edge has been removed, whet the cutting edge until it is sharp.

   To produce a keen edge, place both the beveled and flat sides on a leather strop and pull the chisel toward you a few times (Fig. 4-4). It is easy to make a leather strop by gluing a piece of thick leather, such as a piece of used belting, on a flat piece of wood. Rub the leather with tallow. Next put some fine graphite on the leather. (Fine emery paste also works satisfactorily.)

GOUGES

To grind an outside gouge

1. Start the grinder and regulate the valve for the proper flow of coolant. If you use a dry grinding wheel, place a container of cold water close by for cooling the tool.
2. Holding the gouge with the bevel down and with the blade nearly in the same plane as the axial line of the grinding wheel, grind the cutting edge at right angles to the edges of the blade (Fig. 3-3, page 47).
3. If you are right-handed, grasp the handle of the gouge with your right hand and place your left hand on the blade with all the fingers extending around it from the right. Reverse the procedure if you are left-handed (Fig. 4-2, page 56).
4. With your elbows reasonably close to the body and the wrists held rigid, place the beveled side of the gouge on the face of the grinding wheel, with the edges of the blade at right angles to the axis of the wheel. Keeping the handle in practically the same position, roll the blade from one

side to the other so as to form a uniform bevel (Fig. 4-5).

5. Continue this movement until a cutting edge has been formed that is straight across and at right angles to the sides. Examine the bevel frequently at first to see that a uniform bevel of the proper angle is being formed. *Be sure to put the gouge on the wheel at nearly the same place and at the same angle each time.*

To stone an outside gouge

1. Select fine bench and slip oilstones that are in good condition. Wipe the surfaces with a clean cloth and apply a few drops of light oil.
2. Hold the gouge in the same way as instructed in Step 3 in the procedure, "To Grind an Outside Gouge", page 57.
3. Place the bevel on the flat surface of the bench stone and rock the gouge to locate the position where the bevel rests flat on the surface.
4. Whet the beveled surface by movements similar to those in Step 4 in the procedure "To Grind an Outside Gouge," page 57.
5. Place the round edge of the slip stone flat on the concave surface of the blade and whet against the cutting edge.
6. Continue Steps 3, 4, and 5 until the cutting edge is sharp. If a wire edge forms, pull the cutting edge across the edge or end grain of a piece of hardwood (Fig. 3-13, page 50).
7. After the wire edge has been removed, whet the cutting edge until it is sharp, following Steps 3, 4, and 5.

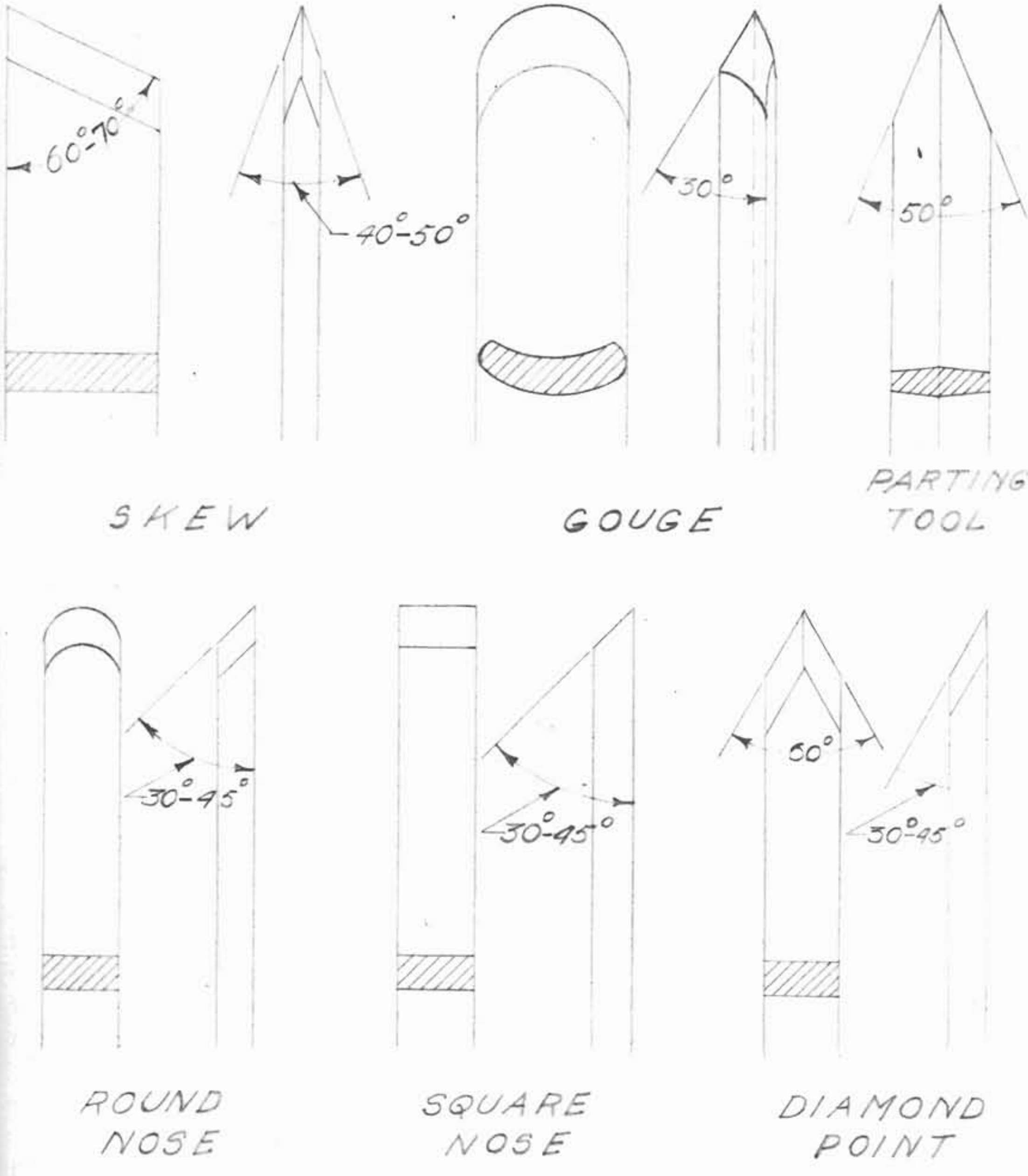
To grind an inside gouge

1. Follow Steps 1, 2, and 3 in the procedure, "To Grind an Outside Gouge," page 57.
2. With your elbow reasonably close to the body and the wrists held rigid, place the beveled side of the gouge on a cone grinding wheel, with the edge of the blade parallel to a vertical plane which passes through the center line of the wheel. Keeping the handle in practically the same position, roll the blade from one side to the other so as to form a uniform bevel.

   A straight wheel with a round face of the proper thickness may be used in place of the cone wheel.
3. Follow Step 5 in the procedure, "To Grind an Outside Gouge," page 57.

To stone an inside gouge

1. Select fine bench and slip oilstones that are in good condition. Wipe the surfaces with a clean cloth and apply a few drops of light oil.
2. Place the round edge of the slip stone flat on the beveled surface and whet it to an edge.
3. Place the convex surface of the gouge flat on the bench stone and whet against the cutting edge.
4. Continue Steps 2 and 3 until the cutting edge is sharp. If a wire edge is formed, pull the cutting



4-6. Proper cutting angles of major woodturning tools.

edge across the end grain of a piece of hardwood (Fig. 3-13, page 50).

5. After the wire edge has been removed, whet the cutting edge until it is sharp, following Steps 2 and 3.

Sharpening a set of woodturning tools. Woodturning can be one of the most interesting woodworking activities, particularly if one has learned to use the various tools properly. In order to do good work it is important to use sharp tools. Dull tools are likely to tear the wood, with poor workmanship as the result.

For good results, sharpen tools to the right shape and at proper cutting bevels. Fig. 4-6 shows the proper shape and design of the cutting edges of the common turning tools.

SQUARENOSE TURNING CHISELS

The squarenose turning chisel has a blade like the skew and roundnose, but the cutting edge is ground at a right angle to the edges of the blade and is beveled on one side only like the common chisel (Fig. 4-6). Since it is a scraping tool used for making surfaces flat, the cutting edge is made slightly convex to prevent the corners from digging into the surface. It is usually beveled at a 30° to 45° angle, depending upon the hardness of the material. For scraping softwood, a 30° angle will give sufficient support for the cutting edge. This tool usually varies in size from ¼″ to 1″, by eighths.

To grind and hone a squarenose turning chisel

Follow the procedure, "To Grind a Chisel," page 54.

SKEW TURNING CHISELS

The common skew chisel used in woodturning is beveled on both sides, with the cutting edge making an angle of 60° to 70° with one edge of the blade (Fig. 4-6). Because the tool makes shearing cuts, the bevel is reasonably long. The angle varies from 20° to 25°, depending upon the type of wood being turned. The tool cuts better if the bevels are slightly concave. It is difficult to use the skew when the bevels become convex. The lines formed by the bevels and the sides of the blade are parallel to the cutting edge and both bevels are the same length. Since the cutting edge is in the center of the blade, the angles must be equal.

In order to make the angle uniform and the cutting edge straight, it is very important to hold the chisel with the skewed cutting edge parallel, to the axis of the grinding wheel.

Right-hand and left-hand skew chisels are made by grinding the bevel on only one side. They are used for scraping, and are beveled at 30° to 45° to give the necessary support to the cutting edge. Skew chisels vary in size from ⅛″ to 1″, by eighths, and from 1″ to 2″, by quarters. The sizes used are ¼″, ½″, and 1″.

To grind a skew turning chisel

1. Start the grinder and regulate the valve for the proper flow of the coolant. If you are using a dry grinding wheel, place a container of cold water close by for cooling the tool.
2. Holding the side of the chisel in the same plane as the axial line of the grinding wheel, grind the cutting edge straight and at the proper angle to the edge of the blade (Fig. 4-7). Test the edge with a bevel.
3. If you are right-handed, grasp the handle of the chisel with your right hand and place your left

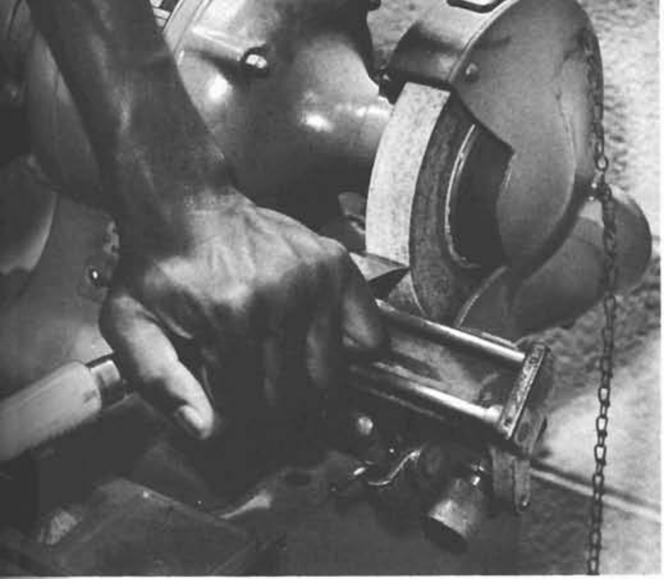


PHOTO BY BONTEMPS

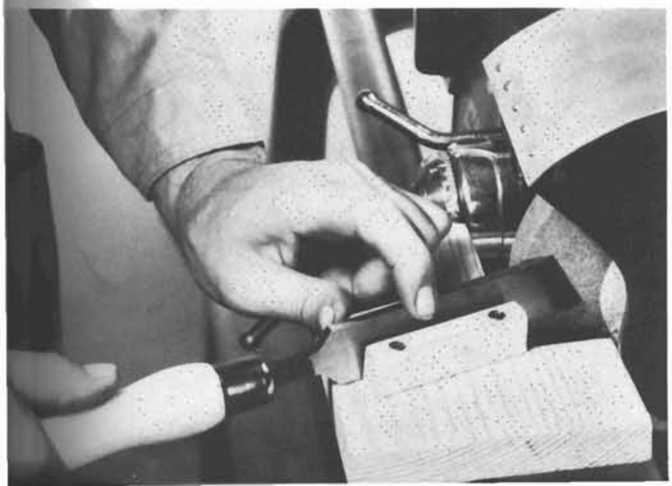
4-7. Grind the cutting edge of a skew turning chisel straight and at the proper angle to the edge of the blade. The included angle should measure 60°–70°

PHOTO BY ELLENWOOD

4-8. Grinding the bevels of a skew turning chisel. Notice offhand grinding method.

hand on the blade. Hold it with all the fingers extending around it from the right. Reverse the procedure if you are left-handed.

4. With the elbows reasonably close to the body and the wrist held rigid, place one of the bevels on the face of the grinding wheel with the cutting edge parallel to the axis of the wheel (Fig. 4-8). Move it back and forth across the wheel either by moving the arms from the shoulders or by shifting the body on your feet, or by both, until the bevel extends almost to the center of the thickness of the blade. Examine the bevel frequently at first to see if a uniform bevel of the proper angle is forming. Be sure to put the chisel on the wheel in nearly the same place and at the same angle each time.
5. Turn the chisel over and. grind the other bevel according to the preceding step. Check to see that the angles and bevels are right.



4-9. The bevel of a skew chisel can be ground on the flat side of a grinding wheel.

4-10. Sharpen the second bevel of the skew chisel also on the flat side of the grinding wheel. Avoid overheating the tool edge.

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6. Finish grinding whichever bevel necessary to shape the tool properly and to form a cutting edge. Be careful not to overheat the tool.

   Figs. 4-9 and 4-10 show the process of sharpening a skew chisel by means of a special jig.

To stone a skew turning chisel

1. Select a fine bench-type oilstone that is flat. Wipe the surface with a clean cloth and apply a few drops of light oil.
2. Hold the chisel in the same way as instructed in Step 3, in the procedure "To Grind a Skew Turning Chisel", page 60.
3. Place one of the bevels on the flat surface of the oilstone and rock the chisel to locate the position where the bevel rests flat on the surface.
4. With the cutting edge of the chisel approximately at a right angle to the edges of the stone, and holding the wrists rigid, make a few long forward and backward strokes on the stone, whetting the concave bevel at both the cutting edge and the heel simultaneously.
5. Turn the chisel over and whet the other bevel, following the two preceding steps.
6. Continue steps 3, 4, and 5 until the cutting edge is sharp. If a wire edge forms, pull the cutting edge across the end grain of a piece of hardwood (Fig. 3-13, page 50).
7. After removing the wire edge, whet the cutting edge until it is sharp, following Steps 3, 4, and 5.

To grind a right-hand or left-hand skew turning chisel

1. Test the face of the chisel to see that it is flat at the cutting edge. If the face is convex, carefully whet it on a coarse, flat stone, finishing it on a fine one. If the face is in very poor condition, grind it flat and finish by whetting.
2. Start the grinder and regulate the valve for the proper flow of coolant. If a dry grinding wheel is used, place a container of cold water close by for cooling the tool.
3. Holding the chisel with the face up and in the same plane as the axial line of the grinding wheel (Fig. 3-3, page 47), grind the cutting edge straight and at the proper angle to the edges of the blade. Check the angle with a sliding T bevel.
4. If you are right-handed, grasp the handle of the chisel with your right hand and place your left hand on the blade, holding it with all the fingers extended around it from the right. Reverse the procedure if you are left-handed.
5. With the elbows reasonably close to the body and the wrists held rigid, place the beveled side of the chisel on the face of the grinding wheel with the cutting edge parallel to the axis of the wheel (Fig. 4-8, page 61). Move the chisel back and forth across the

4-11. When sharpening a gouge offhand, move the handle of the gouge slightly to the left and at the same time gradually roll the blade to the left.

PHOTOS BY ELLENWOOD

4-12. Next move the gouge back and gradually roll the blade to the right. Handle moves to the right also.

face, either by moving the arms from the shoulders or by shifting the body on your feet, or by both. Examine the bevel frequently at first to see if it makes a uniform bevel of the proper angle. Be sure to put the chisel on the wheel *in nearly the same place and at the same angle each time.*

6. After a concave bevel forms, continue the grinding process until the bevel forms a cutting edge.

To stone a right-hand or left-hand skew turning chisel

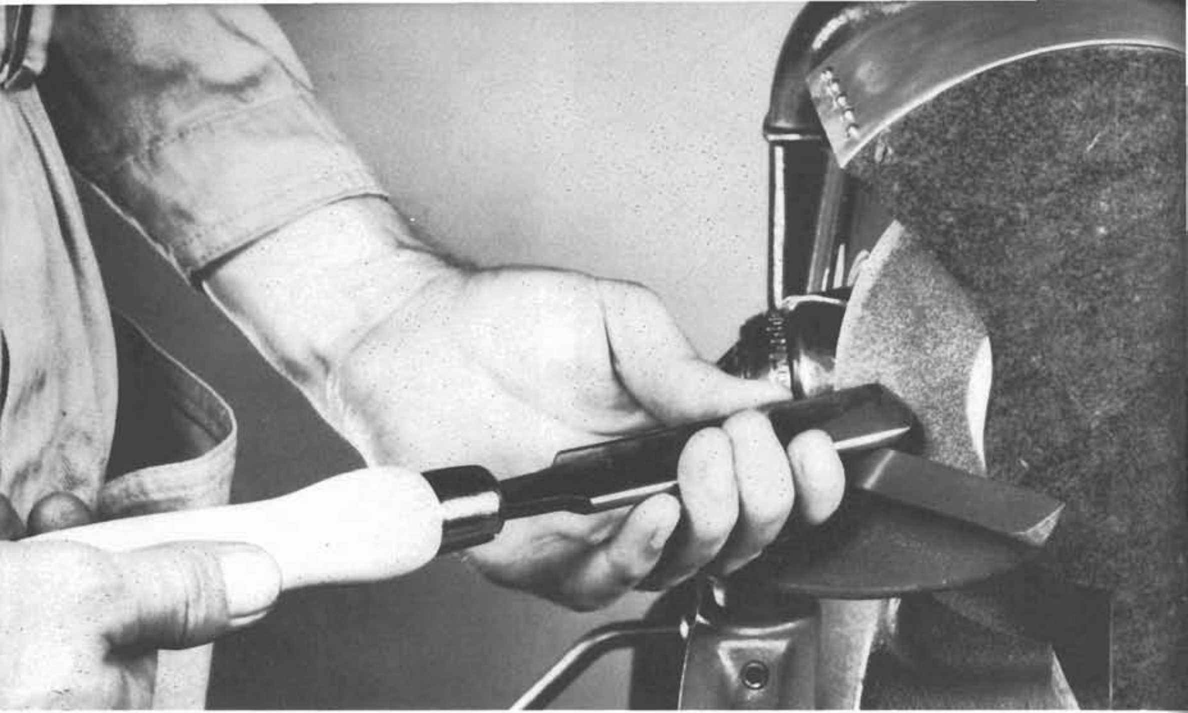
Stone the chisel to a sharp cutting edge. See procedure "To Stone a Chisel", page 55.

TURNING GOUGES

The large gouges have blades that are nearly uniform in thickness, but the smaller tools are much thicker at the center. Form the cutting edge by making a bevel on the outside or convex side. The cutting edge is semicircular in shape (Fig. 4-6, page 59). The bevel is commonly ground at a 30° angle on the outside or convex side of the chisel. Usually the gouge is held so as to make a shearing cut. It is made in sizes varying from ⅛″ to 1″, by eighths, and from 1″ to 2″, by quarters.

To grind a turning gouge

1. Start the grinder and regulate the valve for the proper flow of coolant. If the grinding wheel is dry, place a container of cold water close by for cooling the tool.
2. Holding the gouge with the bevel down and the blade almost in the same plane as the axial line of the grinding wheel, grind the cutting edge semicircular in shape (Fig. 3-3, page 47).
3. If you are right-handed, grasp the handle of the gouge with your right hand and place your left hand on the blade, holding it with all the fingers extended around



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4-13. A gouge can also be sharpened against the flat side of a grinding wheel.

it from the right. Reverse the procedure if you are left-handed.

4. With the elbows reasonably close to the body and the wrists held rigid, place the beveled side of the gouge on the face of the grinding wheel, with the edges of the blade at right angles to the axis of the wheel. Move the handle slightly to the left and at the same time gradually roll the blade to the left, similar to the position shown in Fig. 4-11. Then move the gouge back and gradually roll the blade toward the right simultaneously, as shown in Fig. 4-12.
5. Continue this movement until a semicircular cutting edge has formed. Examine the bevel frequently at first to see if a uniform bevel of the proper angle is being formed. Be sure to put the gouge on the wheel *in nearly the same place each time and at the same angle.*

In Fig. 4-13 the gouge is seen being sharpened against the flat side of the grinding wheel. Supported by the tool rest, the tool is rolled against the stone until the proper bevel is produced.

To stone a turning gouge

1. Select a fine bench stone and a slip oilstone, in good condition. Wipe the surfaces with a clean cloth and apply a few drops of light oil.
2. Hold the gouge in the same way as instructed in Step 3 in the procedure "To Grind a Turning Gouge", page 63.
3. Place the bevel on the flat surface

of the bench stone and rock the gouge to locate the position where the bevel rests flat on the surface (Fig. 4-14).

4. Whet the beveled surface by movements similar to those in Step 4, in the procedure "To Grind a Turning Gouge", page 63.
5. Place the appropriate round edge of the slip stone flat on the concave surface of the blade and whet against the cutting edge (Fig. 4-15).
6. Continue Steps 3, 4, and 5 until the cutting edge is sharp. If a wire edge forms, pull the cutting surface across the edge or end grain of a piece of hardwood.
7. After the wire edge has been removed, whet the cutting edge until it is sharp, following Steps 3, 4, and 5.

PARTING TOOLS

The blade of the parting tool is thicker in the center than at the edges. This provides clearance for the cutting edge which is formed by grinding two bevels in a wedge shape. They meet at the center with the cutting edge extending across the thickest part of the blade represented by the center line (Fig. 4-16). The parting tool is slightly tapered from the point to the handle. For this reason the sides should not be altered so as to lose that clearance for the cutting edge. The cutting edge must connect the two lines on each side in order to obtain the maximum cutting edge. Both bevels are ground at a 25° angle, making an angle of 50 degrees between the two bevels.

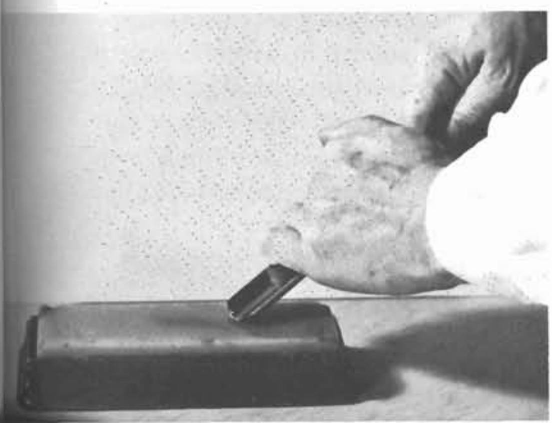
The size is designated by the width of the blade and usually varies from ½″ to ¾″, by eighths. The distance across the cutting edge ranges from ⅛″ to ¼″.

To grind a parting tool

1. Start the grinder and regulate the valve for the proper flow of the coolant. If the grinding wheel is dry, place a container of cold water close by for cooling the tool.
2. Holding the chisel on edge and with the center line of the blade in the same plane as the axial line of the grinding wheel, grind the cutting edge straight and at right angles to the center lines on

4-14. Stoning the bevel of a turning gouge is done by carefully rolling the edge back and forth on the stone.

PHOTO BY CHARLES J. PEREZ



4-15. Hone the inside of a gouge with a slip stone.
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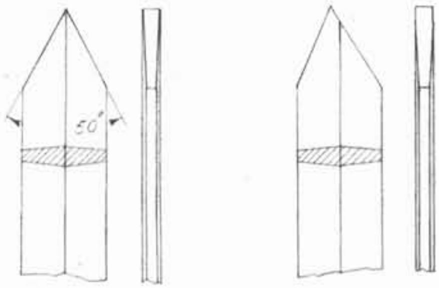


4-16. For maximum clearance the cutting edge forms in the center of the tool.
Cutting edge in center; maximum clearance
Edge off center; clearance lost

the sides (Fig. 3-3, page 47).

3. If you are right-handed, grasp the handle of the chisel with your right hand and place your left hand on the blade, holding it with all the fingers extended around it from the right. Reverse the procedure if you are left-handed.
4. With the elbows reasonably close to the body and the wrists held rigid, place one of the bevels on the face of the grinding wheel with the cutting edge parallel to the axis of the wheel (Fig. 4-17). Move it back and forth across the wheel until the bevel extends almost to the center line of the blade. Examine the bevel frequently at first to see if a uniform bevel of the proper angle is forming. Be sure to put the chisel on the wheel in nearly the same place and at the same angle each time.
5. Turn the chisel over and grind the other bevel according to the preceding step. Check to see that the angles and bevels are right.
6. Finish grinding the bevels so that they connect at the thickest portion of the blade. If both bevels are not even, tilt the blade slightly toward one side so that the cutting edge can be formed properly.

To stone a parting tool

Whet the bevels until they form a sharp edge, using the procedure "To Stone a Skew Turning Chisel", page 62.

ROUNDNOSE TURNING CHISELS

The blade of the roundnose chisel is like those of the squarenose and skew chisels. The cutting edge is formed by beveling only one side and is semicircular in shape as shown in Fig. 4-6, page 59. The roundnose chisel is a scraping tool used for shaping concave surfaces. It is usually beveled at a 30° to 45° angle with the face. These chisels usually vary in size from ¼" to 1", by eighths.

To grind a roundnose turning chisel

1. Follow steps No. 1 and 2 in the procedure "To Grind a Right or Left Hand Skew Turning Chisel", page 62.
2. Holding the chisel with the face up and in the same plane as the axial line of the grinding wheel, grind the cutting edge semicircular (Fig. 3-3, page 47).
3. If you are right-handed, grasp the handle of the chisel with your right hand and place your left hand on the blade, holding it with all the fingers extended around

PHOTO BY CHARLES J. PEREZ

4-17. When sharpening a parting tool offhand on the face of a grinding wheel, hold the tool as shown here.

PHOTO BY ELLENWOOD

4-18. Grind the bevel on a round-nose turning chisel by moving the handle to the left. At the same time, roll the blade to the left.

it from the right. Reverse the procedure if you are left-handed.

4. With the elbows reasonably close to the body and the wrists held rigid, place the beveled side of the chisel on the face of the grinding wheel with the blade at right angles to the axis of the wheel. Move the handle to the left and at the same time gradually roll the blade to the left (Fig. 4-18). Then move the chisel back through the first position and gradually roll the blade toward the right, with the handle moving simultaneously toward the right (Fig. 4-19).
5. Continue this movement until a semicircular cutting edge forms. Examine the bevel frequently at first to see if a uniform bevel of the proper angle is forming. Be sure to put the chisel on the wheel in *nearly the same place and at the same angle* each time.

To stone a roundnose turning chisel

1. Select a fine, flat bench-type oilstone. Wipe the surface with a clean cloth and apply a few drops of light oil.
2. Hold the chisel in the same way as instructed in Step 3 in the procedure "To Grind a Roundnose Turning Chisel", page 66.
3. Place the bevel on the flat surface of the oilstone and rock the chisel

PHOTO BY ELLENWOOD

4-19. Move the chisel back and gradually roll the blade toward the right. Handle moves to the right.

to locate the position where the bevel rests flat on the surface.

4. Whet the beveled surface by movements similar to those in Step 4 in the procedure, "To Grind A Roundnose Turning Chisel", page 66.
5. Lay the face flat on the stone and whet it.
6. Continue Steps 3, 4, and 5 until the cutting edge is sharp. If a wire edge forms, pull the cutting edge across the edge or end grain of a piece of hardwood (Fig. 3-13, page 50).
7. After the wire edge has been removed, whet the cutting edge until it is sharp, following Steps 3, 4, and 5.

SPEARPOINT TURNING CHISELS

The spearpoint or diamond-point chisel has a blade like the squarenose, but it is ground with two bevels on one side. This forms two cutting edges which come to a point in the center (Fig. 4-6, page 59). This chisel is a scraping tool used for such jobs as making surfaces flat and the corners of recesses equal. It is commonly shaped with a 60° angle between the cutting edges. The bevels are ground at a 30° to 45° angle with the point being formed in the center of the face. They should be uniform as to size and angle. These chisels usually vary in size from ¼″ to 1″, by eighths.

To grind a spearpoint turning chisel

1. Follow Steps 1 and 2 in the procedure "To Grind a Right-hand or Left-hand Skew Turning Chisel", page 62.
2. Holding the chisel with the face up and in the same plane as the axial line of the grinding wheel, grind the cutting edges straight and at the proper angle. Check angles with a sliding T bevel.
3. Grind the two bevels following Steps 4 and 5 in the procedure "To Grind a Right-hand or Left-hand Skew Turning Chisel".
4. After concave bevels have been formed, continue the grinding process until proper cutting edges are formed.

To stone a spearpoint turning chisel

Stone the chisel until both cutting edges are sharp, using the procedure "To Stone a Chisel," page 55.

PART ONE

CHAPTER 5

Wood Scrapers

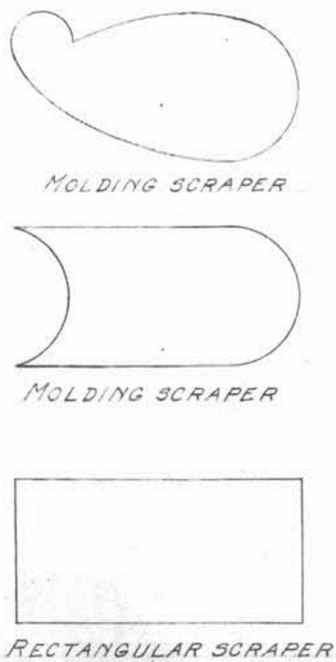
THE BEST wood scrapers are made of a high-grade flat steel, specially tempered. It is similar to good saw steel. In fact, old handsaw blades cut into pieces make good scrapers.

Scrapers are usually rectangular. However, they may be curved for scraping curved surfaces, such as those on cove moldings (Fig. 5-1).

THE SCRAPER BURNISHER

A scraper burnisher is a tool for turning the cutting edges of a scraper. Use it for no other purpose. The blade, either oval or round, is made of fine tool steel mounted in a handle. It has an exceptionally smooth surface and is tempered very hard. The tool will give years of service and still maintain a smooth surface, if properly used.

When a burnisher is not available, the hardened end of a nail set or punch can be used satisfactorily, if the surface is properly polished. Although not finished to the same degree of smoothness as a burnisher, it is hard and smooth enough to serve the purpose. The disadvantage of using either a punch or nail set in place of a burnisher is the shortness of the portion used as the blade and the smallness of the diameter.



5-1. Wood scrapers of different shapes.

SHARPENING A WOOD SCRAPER

The edge of the scraper may be formed at right angles to the sides so as to make two cutting edges, or it may be beveled to form one sturdy cutting edge which can be turned sufficiently to make heavy cuts. In the latter case, it is usually filed at a

PHOTO BY ELLENWOOD

5-2. Hone the scraper with the side flat on the oilstone.

60° to 70° angle with the sides. The edge is made straight, with the corners rounding slightly to prevent their digging into the wood.

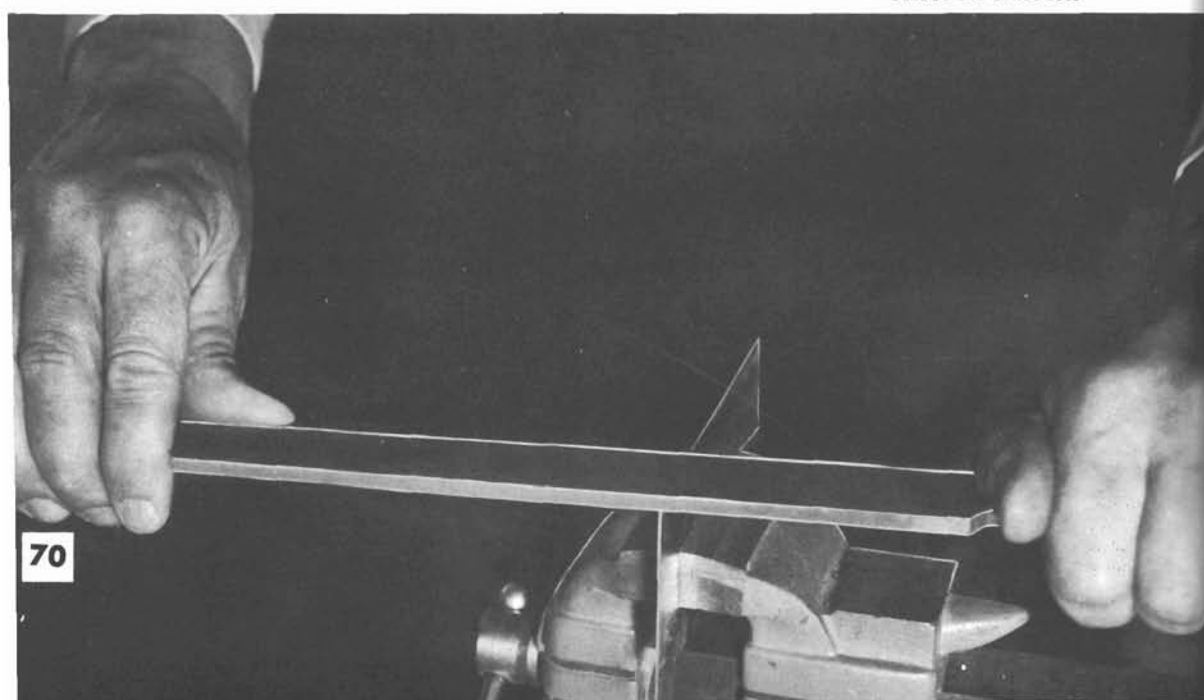
The sides of the scraper must be kept smooth and free from scratches. Side scratches extending to the cutting edge form a series of nicks which leave ridges on the scraped surface. For this reason the sides of the scraper are never filed, not even to remove the old turned edge during the sharpening process.

Burnishing is done by holding the handle of the burnisher with either one or two hands and firmly pulling the blade across the edge of the scraper with a slicing motion, using practically the full length of the blade. When this motion is used, the blade will not become nicked or grooved, but will remain smooth. *Never hold the handle of the burnisher in one hand and the point of the blade in the other* and saw back and forth on the edge of the scraper. Such abuse will soon cut grooves and nicks in the blade so that the edges of the scraper cannot be properly turned. Although the blade may be refinished by grinding, stoning, and polishing, it is difficult to equal the original glass-smooth, hard surface.

A drop or two of lubricating oil on the burnisher will help keep both

5-3. After cross-filing the edge straight and perpendicular to the sides, smooth the edge by draw-filing as illustrated here.

PHOTO BY GRIFFITH



the surface of the burnisher and the edge of the scraper smooth.

The cutting action and process are the same whether the scraper is manipulated by hand or in a variety of holders. When properly sharpened, it will cut a continuous shaving similar to that of the plane. When it begins to remove the wood in the form of dust instead of shavings, it is dull.

To sharpen a wood scraper

1. To remove the old cutting edge, hone the scraper with the side placed flat on a fine oilstone (Fig. 5-2). Perform the operation on both sides of the scraper if the edge is filed at right angles to the sides. Do not file the sides of the scraper because filing scratches the surface and causes breaks in the cutting edge.
2. Place the scraper in a vise, preferably a machinist's vise, with the edge to be sharpened projecting approximately ½″ above the jaws. Be careful not to damage the sides.
3. With a mill bastard file, cross-file the edge straight and perpendicular to the sides, rounding the corners slightly.
4. Drawfile the edge until it is smooth. Keep the surface flat to turn a good cutting edge (Fig. 5-3).
5. On a fine oilstone, whet the edge and sides of the scraper, using long, steady strokes until the edge is smooth and the wire edge has been removed. When whetting the edge, grasp the scraper firmly with both hands, being careful to keep the sides perpendicular to the top surface of the stone (Fig. 5-4). Next whet the sides. Be sure to keep the sides of the scraper flat on the oilstone when they are being whetted (Fig. 5-2).
6. With the scraper lying on the bench close to the edge, burnish each flat side, keeping the burnisher flat on the side of the scraper so as to draw the cutting edge slightly (Fig. 5-5). This step is often omitted, but should be done carefully to obtain a better cutting edge. Put a drop of oil on the burnisher.
7. Place the scraper in the vise with

5-4. Whet the edges first. Hold the scraper firmly with both hands.
PHOTO BY BONTEMPS

5-5. Draw the edge with the burnisher, using a drop of oil for better performance.
PHOTO BY GRIFFITH

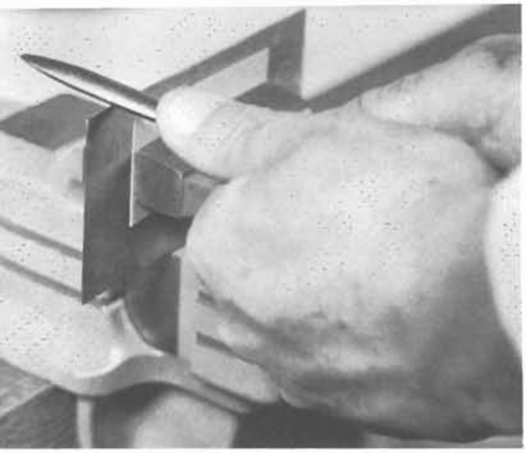
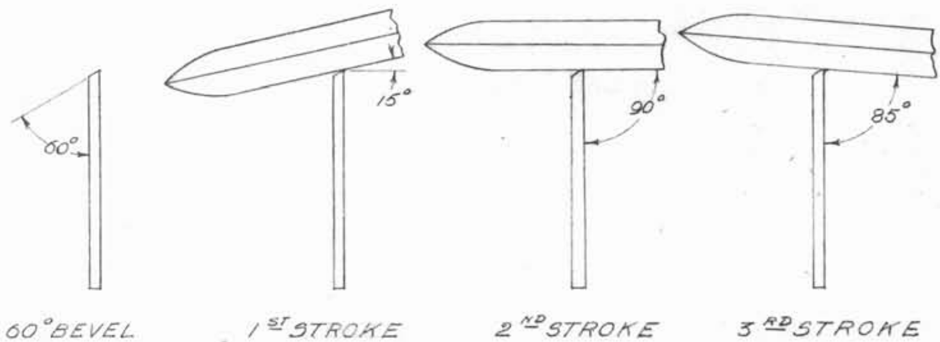


PHOTO BY CHARLES J. PEREZ

5-6. Produce the scraping edge with the burnisher like this.



5-7. Steps in burnishing the edge of a beveled scraper blade.

the whetted edge projecting approximately 1 inch.

8. Put a drop or two of oil on the burnisher. Then place the burnisher flat on the edge of the scraper and firmly stroke the surface, each time lowering the handle slightly until the burnisher makes an angle of 85° with the side of the scraper (Fig. 5-6). To keep the surface smooth, hold the burnisher firmly by the handle and make slicing strokes, using a large portion of the length of the blade. If the edge is beveled, start burnishing at a slightly less angle than that of the bevel and gradually drop the hand of the burnisher until an angle of approximately 85° is formed by the burnisher and the scraper side (Fig. 5-7).

PART ONE

CHAPTER 6

Handsaws

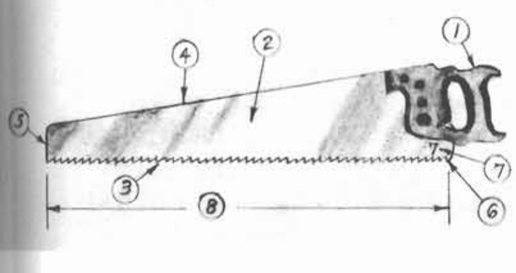
THE HANDSAW is a reciprocating saw made of a tough, thin, flat piece of steel with cutting teeth on one nearly straight edge. The other edge is cut on an angle, making the blade narrower at one end. The handle is attached to the wider end (Fig. 6-1). The sides of the blade are highly polished so that there is very little friction when they rub against the stock.

Care and selection

Handsaws are generally classified according to the style and shape of the teeth, either *crosscut* or *rip*. Those with crosscut teeth less than 26″ in length are commonly known as *panel saws*.

Other special-purpose saws similar to handsaws in cutting action and maintenance are *back, miter-box, dovetail, compass,* and *keyhole saws.*

6-1. Parts of a hand saw: 1. Handle. 2. Blade. 3. Teeth. 4. Back. 5. Point. 6. Heel. 7. Points per inch. 8. Length.

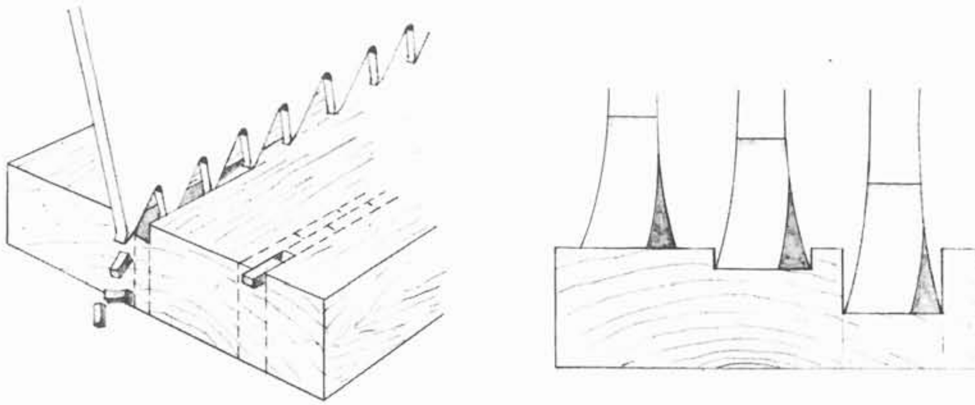


TEETH

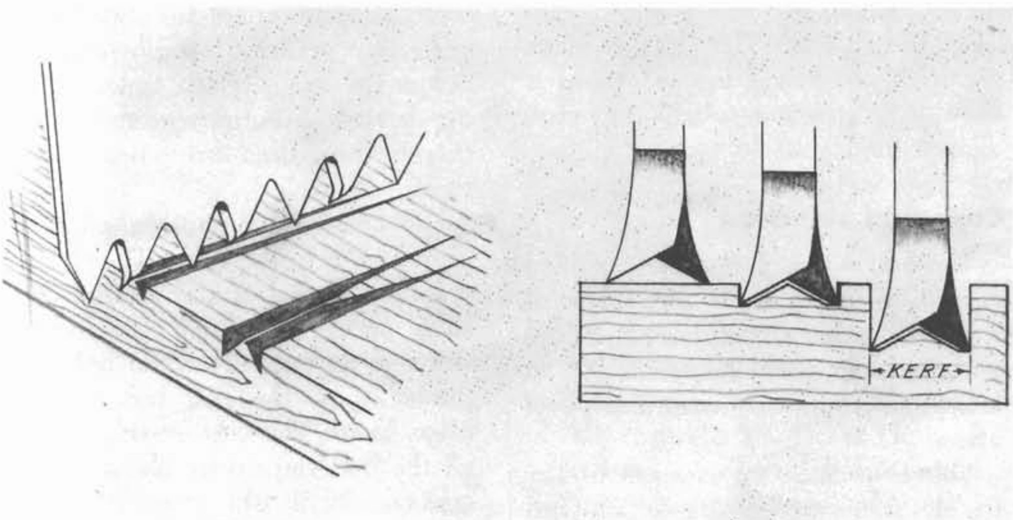
Handsaws, as just stated, are available with two kinds of teeth. *Rip teeth* are designed to cut parallel with the grain. *Crosscut teeth* cut across the grain. Each type of sawing action is entirely different and therefore requires a different shaped tooth.

Rip teeth have cutting edges at right angles to the sides. Their action is similar to that of a series of chisels, each paring off small shavings of wood (Fig. 6-2). They do not score the sides of the cut, but tear the fibers loose. The cutting edges shave off the material in the bottom of the saw cut. These shavings occupy the gullet space between the teeth and are carried out of the cut. Because the set makes a wider kerf than the thickness of the teeth, each tooth removes only a portion of the width of the cut.

Crosscut teeth have two rows of points on either side and a skewed cutting edge extending from the point to the other side of the blade. The points may be compared to knife points which sever the fibers on either



6-2. Rip teeth cut like a series of small chisels.



DRAWINGS COURTESY HENRY DISSTON AND SONS

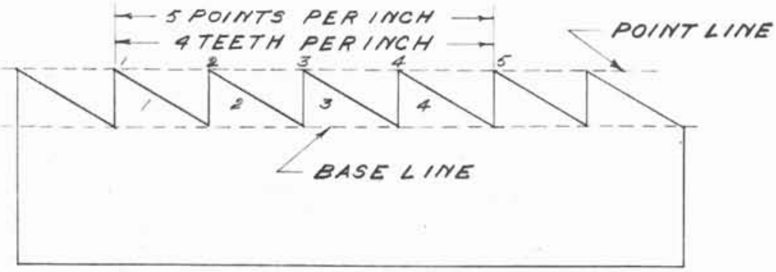
6-3. Cross cut teeth cut like a series of sharp pointed knives.

side of the kerf while the skewed edges serve as chisels, paring the fibers left between the two scored lines (Fig. 6-3).

Tooth spacing

The size of the teeth in a handsaw is designated by the number of points per inch. There is always one more point per inch than there are teeth (Fig. 6-4).

A saw with coarse teeth will cut faster than one with fine teeth, but the cut will be rough. A coarse saw is better for green or wet wood, since the gullets will not clog so easily and



6-4. Points and teeth per inch compared. Notice that there is always *one* more point than teeth per inch.

a rough cut is all right for wood in this condition. A fine saw is advantageous in cutting dry lumber. Some rip saws are made one point finer toward the point than at the heel to aid in starting the stroke. The number of points per inch is generally stamped on the side of the blade at the heel.

Crosscut saw teeth vary in size from 5 to 12 points. For general work, an 8- or 9-point saw is the most satisfactory. Rip-saw teeth usually are larger than crosscut teeth for the same type of work. The sizes of teeth range from about 3½ to 7 points per inch. A 5- or 6-point saw is commonly used for ripping.

Most special-purpose saws are standardized as to tooth spacing and change only slightly, depending upon the manufacturer. The number of points per inch usually made on special saws are as follows: *back,* 13 to 14; *miter-box,* 11; *dovetail,* 15 to 17; *compass* and *keyhole,* 8 to 10.

Length

The length of a saw is specified by the length of the cutting edge in inches. A 24″ saw means that the cutting edge is 24″ long.

Handsaws are made in length varying from 16″ to 28″. Popular sizes in these saws are 22″ or 24″ for crosscutting and 24″ or 26″ for ripping.

Back saws range in size from 8″ to 18″ in length. In most cases the 12″ or 14″ lengths are recommended.

Popular lengths are 8″ or 10″ for dovetail saws and 12″ for compass and keyhole saws.

Type of back

Saw blades are made with two types of backs, *straight* and *curved.* Each of these shapes has some advantages, and the selection of either one is a matter of personal preference. The straight back makes the saw slightly heavier, but adds stiffness to the blade which may be desirable for heavy sawing. The back may also be used as a straightedge for layout purposes. The curved-back saw is slightly lighter and the blade has more flexibility. To some people this type of back gives the saw a better balance. This may be because of the increased flexibility of the blade.

BLADES, HANDLES

Blade pattern

Handsaws may be obtained in either the *regular* or the *ship-pattern* blade. The only difference between the two is that the ship-pattern is not as wide at the point. The narrow point is necessary for sawing in close quarters. It makes the blade lighter and more flexible. For general-purpose sawing, if there is sufficient room, the regular-pattern is probably more serviceable, since the wide point gives the blade increased stiffness and weight.

Blade grinding

Saw blades are ground either *flat* or *tapered*. The better handsaws are taper ground. Though the cutting edge remains the same thickness, the remainder of the blade gradually tapers from the handle to the point and from the cutting edge to the back. This causes the blade to run more freely in the kerf and reduces the possibility of binding or buckling.

Some special saws are ground thinner from the teeth to the back in order to provide sufficient clearance for the saw to cut without setting the teeth. Special crosscut saws and some back saws are ground for clearance and should not be set. These saws make a very smooth cut.

Quality of steel

All saws are not made of the same quality of steel. Not only does quality vary between manufacturers, but each manufacturer may make saws of different grades to meet competition and various sawing requirements. A saw made of high-quality steel will give years of efficient service if properly maintained. It will hold the set and stay sharp much longer than one made of inferior steel, thereby appreciably reducing the maintenance cost. A saw made of high-quality steel should be selected if the saw is used much. If it is used only occasionally, one made from steel of a lower quality may be satisfactory.

Type of handle

There are several available designs and shapes of handles. They are made of wood or synthetic material and are mounted on the blade at different angles. The type and mount of the handle change the force of the saw on the cutting stroke, giving different saws a different feel or balance. To some extent the selection of a particular type of handle is a matter of personal preferance. However, some inexpensive saws are not well balanced because the handles are either poorly shaped or mounted at an improper angle.

SELECTING AND MAINTAINING A HANDSAW

Factors To Consider In Selecting A Hand Saw

1. *Kind of teeth*—crosscut or rip.
2. *Length*—of cutting edge in inches.
3. *Tooth spacing*—number of points per inch.
4. *Type of back*—straight or curved.
5. *Blade pattern*—regular or ship pattern.
6. *Blade grinding*—flat or taper ground.

7. Type of handle.
8. Quality of steel.

Care of a hand saw

1. Put the saw in a rack or hang it up when it is not in use.
2. Provide sufficient clearance so that in sawing the point of the saw will not strike any object.
3. Do not twist the saw in the cut to split off waste material.
4. Do not lay anything on the saw which will bend the blade or damage the teeth.
5. Avoid cutting any foreign material in the wood that would dull the saw.
6. Take long strokes to use nearly all the cutting edge of the saw.
7. Apply light pressure when starting each stroke and be careful that the point does not cause the blade to buckle and become kinked by binding.
8. After the cutting stroke is over, avoid pulling the saw back at a speed that will cause the point to vibrate excessively.
9. Do not bend the blade.
10. Avoid rusting of the blade. After using a saw, wipe the blade with an oily rag.

Handsaw maintenance tools

Some of the tools necessary for sharpening the handsaw are the handsaw *filing clamp*, the *jointer*, and the handsaw *set*.

Handsaw filing clamp

The hand saw must be held firmly in a clamp when filing it. If it chatters the teeth will be broken from the edges of the file and the surfaces on the saw teeth will not be flat. A poor filing job will result.

Manufactured clamps are easily fastened to the bench top at a convenient height for filing the saw. They consist of two long jaws which clamp the blade close to the teeth. One is stationary, but the other is movable and controlled by a lever. When the jaws are opened, the saw is placed between them with the body of the blade extending into the deep throat, the teeth projecting. The lever is then pushed down, pressing the jaws against the sides of the blade to hold it firmly for filing.

If a good vise is available, it may be used in place of the saw clamp. Considerable care should be exercised so that the blade will not be damaged by the jaws. If the jaws are rough, place strips of soft metal or pieces of hardwood between them and the saw to protect the blade.

Jointer

The jointer serves to produce uniformity of tooth height. It is also used to produce a small amount of crown in the tooth line (Fig. 6-11, page 81). When a jointer is not available, a saw may be jointed with a flat mill file.

Handsaw set

Since uniform set in the teeth is so important for a smooth running saw, always use a good saw set. The *lever set* is the most common. The best kinds have two plungers which are operated by the handles. Pressure applied to the handle, which has a lever action, causes the plunger to clamp the body of the saw tightly against the central portion of the anvil. The other plunger then makes contact with the top portion of the tooth and bends it against the beveled surface of the anvil (Fig. 6-16, page 84).

Sharpening handsaws

There is no economy of time or material in using dull tools. The handsaw is no exception to this rule. It must be kept in proper condition if it is to run freely and cut efficiently.

Handsaws are more difficult to sharpen than any other edge tools. An understanding of the proper form and shape of the teeth and a fair degree of skill in filing are necessary. As in acquiring any skill, the ability to file accurately is obtained by diligent practice. Almost everyone who is willing to apply himself to the task can soon attain sufficient proficiency with the file to put a saw in good cutting condition.

To gain proficiency in sharpening, practice on discarded saws or practice strips. Most saw manufacturers can supply these strips at a nominal cost. They are made from saw steel with crosscut teeth on one edge and rip teeth on the other.

LAYING OUT NEW TEETH ON A HANDSAW: Sometimes a saw that needs sharpening is in such poor condition that it is necessary to replace all the old teeth with new ones. Before new teeth can be laid out, the old ones are first removed with a flat mill bastard file. What previously was a row of teeth now becomes a straight or slightly convex edge. (Old teeth should not be removed by a grinding wheel. The excessive heat created at the tooth line may harden the blade to a point where any attempt at filing in new teeth may prove difficult if not altogether impossible.)

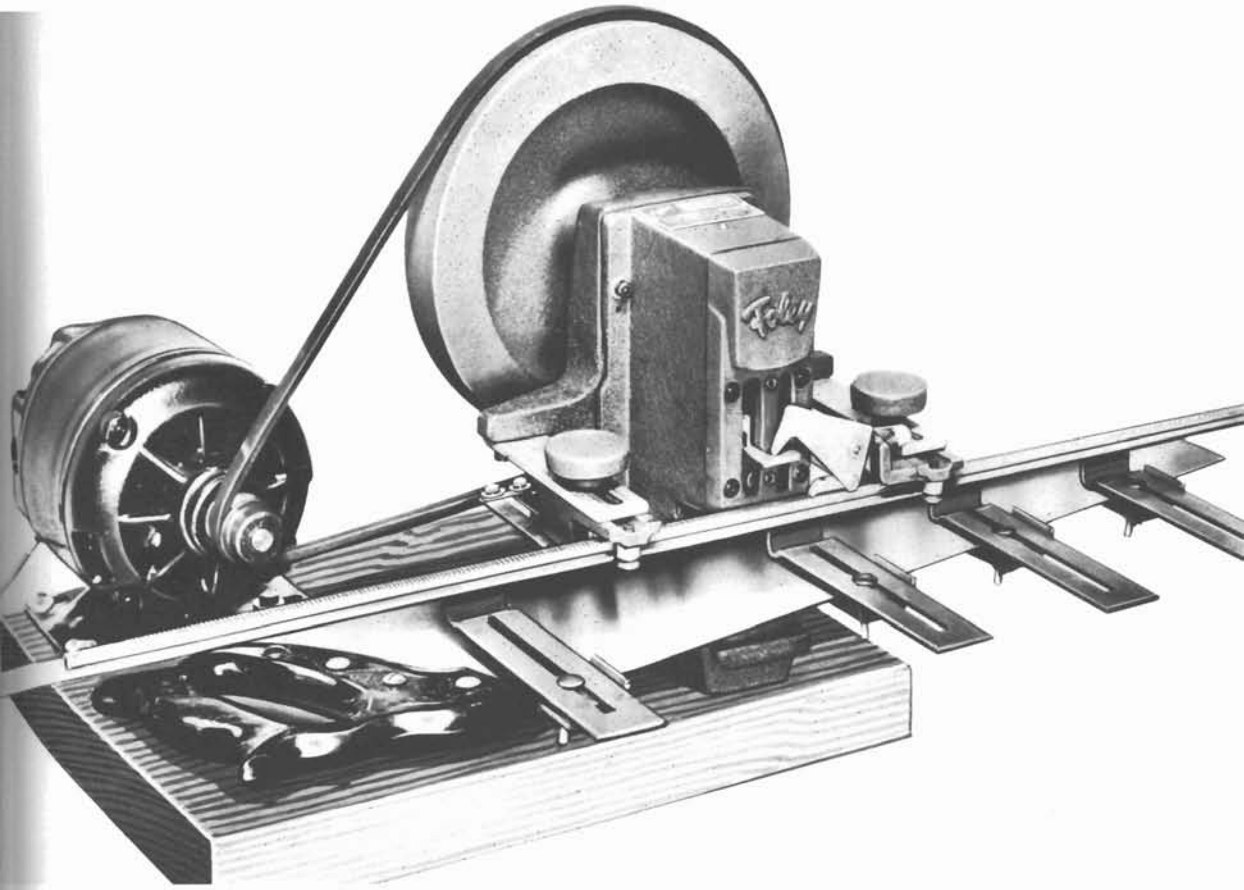
The teeth of a saw are sometimes removed and new ones laid out in order to change the size of the teeth. For example, it may be desirable to change a 6-point saw to a 10-point saw for smoother cutting performance.

The layout of rip-saw teeth naturally differs from that of crosscut teeth. In a rip-saw tooth the front usually makes an angle of 90° with the tooth line, whereas the front of a crosscut tooth forms an angle of 75° with the tooth line.

When many saws need retoothing, it will save time and effort to use a mechanical retoother (Fig. 6-5).

To lay out new teeth on a hand rip saw

1. Select a rip saw with teeth in such condition that they need to be replaced by new ones.
2. Place the saw in a saw filing clamp with the teeth about 3/8″ above the clamp.
3. With a flat mill bastard file remove the old teeth. The completed filed edge may be straight or slightly convex.
4. Take the saw out of the filing clamp.
5. Apply a coat of marking dye to both sides of the saw where the new teeth are to be laid out.

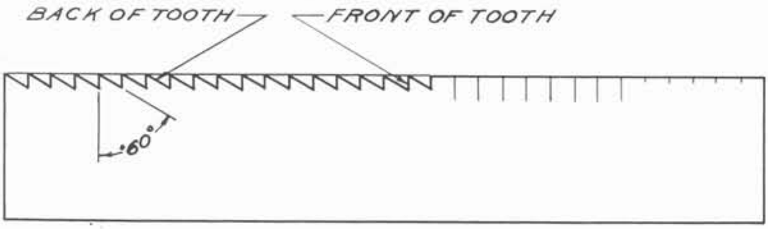


COURTESY FOLEY MANUFACTURING COMPANY

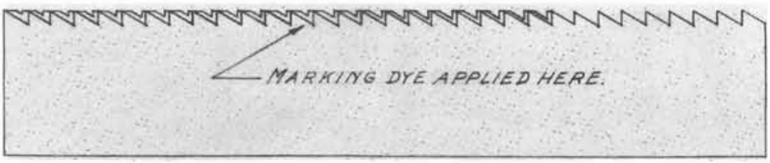
6-5. Retoothing a hand saw on the Foley automatic hand saw retoother.

Marking dye causes the layout lines to show up more distinctly.

6. Decide on the number of points wanted per inch.
7. With the use of a steel rule and a sharp scratch awl, lay off a series of uniform marks representing the desired tooth spacing (Fig. 6-6).
8. Using a try square, extend these marks, forming lines at right angles with the saw edge. Each of these lines forms the front of the teeth.
9. With the sliding T bevel set at 30°, lay off the slanting lines which form the backs of the teeth. (Fig. 6-6).
10. Place the saw in the saw filing clamp with the edge of the saw within 3/8" of the top of the clamp.
11. Select a taper file of the proper size and proceed to remove the metal between the lines. The file may be slightly dropped from a horizontal position, but should make an angle of 90° with the saw edge. This slight drop avoids screeching. The file is made to cut on the forward stroke only.
12. In successive strokes remove all the metal from every gullet, bringing all teeth to a sharp point. Do not file beyond the original layout lines of the teeth. Completed teeth appear in Fig. 6-7.



6-6. Layout of rip saw teeth.



6-7. Steps in filing rip saw teeth.

FITTING A HANDSAW

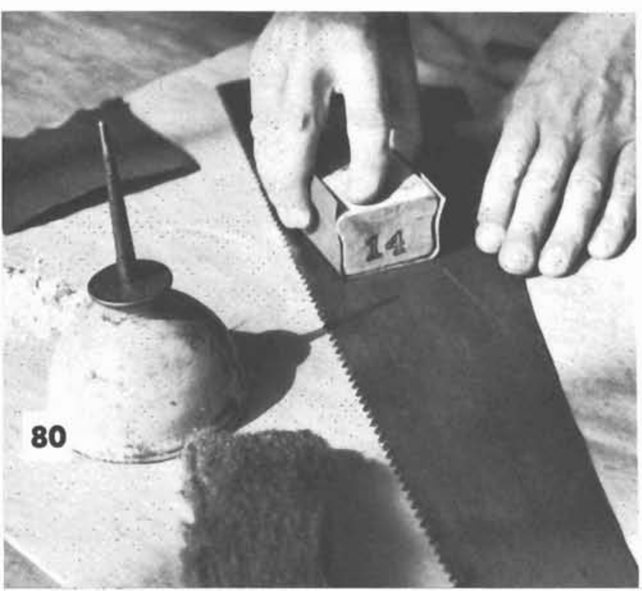
There are six operations required in fitting a saw that is in poor condition. They are *inspection, jointing, shaping, setting, filing,* and *sidejointing.* It is not necessary to perform all of these operations each time a saw is sharpened. A good saw with proper set may be jointed and filed several times before it will begin to bind in the cut.

Inspection

An old, rusty saw first needs a thorough cleaning. For best results, the handle should be removed temporarily, and the blade polished with a fine grade of abrasive cloth or steel wool (Fig. 6-8). For a high polish, rub with abrasive grains and oil. Close inspection may also reveal the following factors: (1) The teeth are uneven and need shaping. (2) The

6-8. Cleaning and polishing a rusty saw, using abrasive cloth, steel wool, pumice stone, and oil.

PHOTOS BY GRIFFITH



6-9. Check points of teeth for flat spots of reflected light which indicate dull teeth.

tooth edge is concave. The teeth of such a saw do not perform to their maximum capacity. The point line should be straight or slightly convex. (3) Teeth have insufficient set and would bind even if they were sharp; the saw kerf made should be approximately 1½″ times the thickness of the blade. (4) The teeth are dull. Whenever the teeth develop flat or shiny spots on the edges or points, the saw is dull. You may see these spots easily by holding the saw in the light and looking down on the teeth at a slight angle (Fig. 6-9). (5) The blade shows so-called "kinks." Whereas a correctly shaped blade is flat, a kinked blade is twisted and irregular. Kinks may be removed by placing the saw blade on an anvil or a flat, heavy piece of hardwood. Strike the raised section of the blade lightly with a hammer. The hammerhead should be smooth and lightly rounded to avoid hammer marks. Strike the blade in a circular motion, gradually increasing the striking radius of the area (Fig. 6-10).

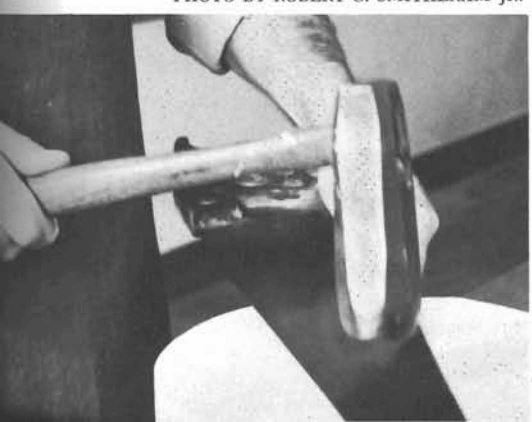
JOINTING A HANDSAW: The teeth of a handsaw become uneven through normal wear as some sections cut more than others. Also they quickly dull when they strike a hard, foreign material in the wood. Such teeth must be jointed or filed on the tops to make them even or to form a uniform cutting line. Jointing also serves as a gauge for determining when the teeth have been filed sufficiently. It is an essential operation in sharpening saws and should always be performed before filing. If not, there is no assurance that the cutting edges of the teeth form a uniform line, with each tooth doing its share of the cutting.

A handsaw is jointed so that the tops of the teeth form either a straight or a convex line. The line may be as much as ⅛″ high in the center for a 26″ saw. Through normal wear, the cutting line has a tendency to become concave. To remedy this, the teeth at each end must be jointed more than at the center. Jointing may be done with either a mill bastard file or a handsaw jointer (Fig. 6-11). An 8″ file is commonly used.

To joint a handsaw

1. Place the saw in a saw clamp and lay the flat side of the file lengthwise on the edge of the teeth. Take a few strokes the full length of the saw until the top of every tooth has been touched. Be sure to *keep the file at right angles to*

6-10. Remove kinks by striking the blade lightly with a special hammer.
PHOTO BY ROBERT C. SMITHERAM JR.



6-11. For better sawing performance a small amount of crown is put in the saw. Use a handsaw jointer or a flat mill file.
PHOTO BY CROW

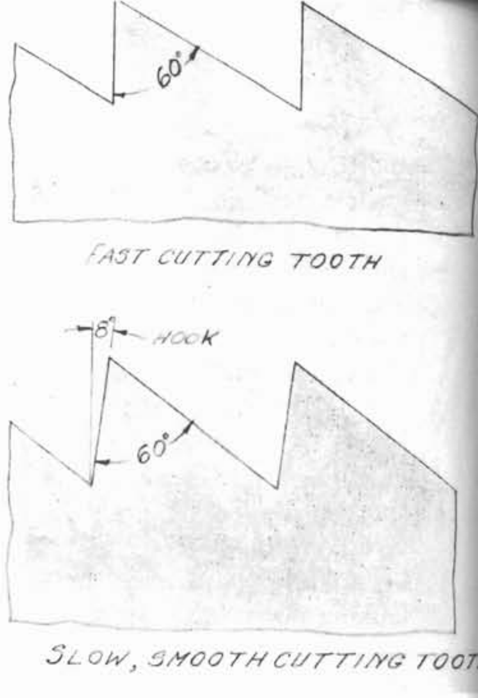
the sides of the saw to prevent rounding the jointed surface.

In case the teeth are very uneven, joint the longer teeth and shape them, repeating the two operations until all the teeth are uniform in size and shape. Otherwise, if the teeth are too uneven, a heavy jointing may cut to the bottom of some of them, making them difficult to reshape.

SHAPING HANDSAW TEETH: When the teeth of a handsaw are very uneven, they should be shaped after they are jointed. The purpose of shaping is to make them uniform in shape, size, and angle. It is very important for the teeth to be uniform in size. If they are not, the set will be irregular. The set can be uniform only when the teeth are uniform.

The shape of the teeth on handsaws is fairly well standardized. On the rip saw, the back of the tooth makes a 60° angle with the front. The front of the tooth is usually perpendicular to the line passing through the cutting edges of the teeth (5, 32). But on some rip saws, the front of each tooth is hooked 8° back of the perpendicular to the line passing through the cutting edges of the teeth (2, 1). The latter tooth shape will run easier, but will not cut as fast as the former. It is the better shape for cutting hardwood. Both of these tooth shapes are illustrated in Fig. 6-12. The teeth may be shaped with the same sized file that is used for sharpening.

The front of the teeth of crosscut saws is commonly hooked 15° back of the line that is perpendicular to a line through the cutting edge of the saw (Fig. 6-13). The teeth are shaped with a file one size smaller, either in taper or length, than is used for sharpening the saw, because the space increases in size when the teeth are set and filed at an angle to bring them to points. See informational unit, "Selection of a Handsaw File with the Proper Size Taper," page 86.



6-12. Rip teeth of different shapes. Difference in shape accounts for change in performance.

Because the angle at the bottom of the gullet is 60°, the file cuts on the back of one tooth and the front of the adjacent tooth at the same time. A metal filing gauge (Fig. 6-14) will aid in keeping the angle on the front of the tooth uniform. It is made with the top edge parallel to the cutting line of the teeth when that particular angle is being filed on the fronts.

To shape handsaw teeth

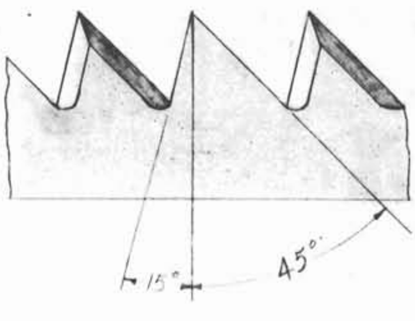
1. After the saw has been properly

jointed, using the procedure "To Joint a Hand Saw", page 81, place the handle end of the saw in the saw clamp with the gullets projecting ⅛" above the clamp. The handle may be either to the right or to the left. Since the shape of the tooth can be estimated more easily by the angle being filed on the front of the tooth, it seems that a right-handed person would prefer to have the handle to the left so that the front of the tooth would be more visible from the filing position. The left-handed person then would want the handle to the right.

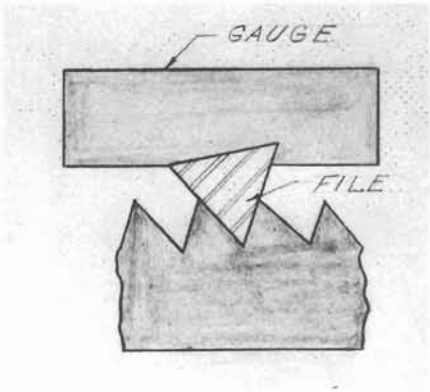
2. Hold the file as instructed in Step 2 of the procedure "To File a Surface", page 42. Place it in the gullet at the heel of the saw, at the proper angle for the front of the tooth, and file straight across until approximately ½ the flat surface has been removed. Apply sufficient pressure to make the file cut on the forward stroke, but lift it slightly on the return stroke. Be sure to keep the file at right angles to the sides of the saw and hold it steady so that the filed surfaces will be flat. Check the angle with the filing gauge.
3. File in each succeeding gullet until the jointed surface approaches an edge. Examine each tooth to determine on which surface to apply the most pressure in order to make the teeth uniform. It is necessary to watch the gullet depth as well as the edges being formed on the teeth, since the edges do not necessarily form in the center of the flat surface (Fig. 6-15).
4. File all the teeth again, bringing each tooth to an edge. Then stop, for any more filing only shortens the tooth and makes the cutting edge uneven.
5. Examine the teeth for evenness by holding the saw up to the light and looking down the row of teeth at a slight angle to the side of the saw.

SETTING HANDSAW TEETH: All saws require clearance to keep the blade

6-13. Shape of common crosscut teeth.



6-14. A metal filing gauge aids in keeping teeth uniform.



6-15. Shape of teeth after jointing.

from binding in the cut. Clearance is obtained in most saws by spring set—that is, by bending a portion of every other tooth toward one side and alternate teeth toward the opposite side. (It is possible to make provision for clearance in some saws used for fine work by grinding the blade several gauges thinner from the teeth to the back. Some back saws and special crosscut saws have this type of blade and require little or no set.)

The amount of set required depends upon the condition of the wood to be cut. Wet wood requires more set than dry, and softwood requires more set than hardwood of the same moisture content. Some manufacturers recommend setting the teeth .003″ to .005″ (1, 19). As a general rule the cut should not be more than 1½ times the thickness of the blade—that is, each tooth should be bent or set slightly less than ¼ the thickness of the blade.

Not more than ½ the body of the tooth should be set—usually ⅓ or less. However, the construction of the hand set and the amount of set required will determine how much of the tooth to set. If the teeth are set too much or too deep, there is a possibility of breaking some of them or cracking the blade.

Setting the teeth is a very important operation in sharpening a saw.

6-16. Setting rip teeth, using a handsaw set.
PHOTO BY CROW

6-17. Setting a handsaw on the Foley automatic power setter.
COURTESY FOLEY MANUFACTURING COMPANY

The set must be uniform in order to have a smooth running saw. If some teeth are set more than others, the cut will be very rough. More set in one side of the saw than in the other will cause the saw to run out of line.

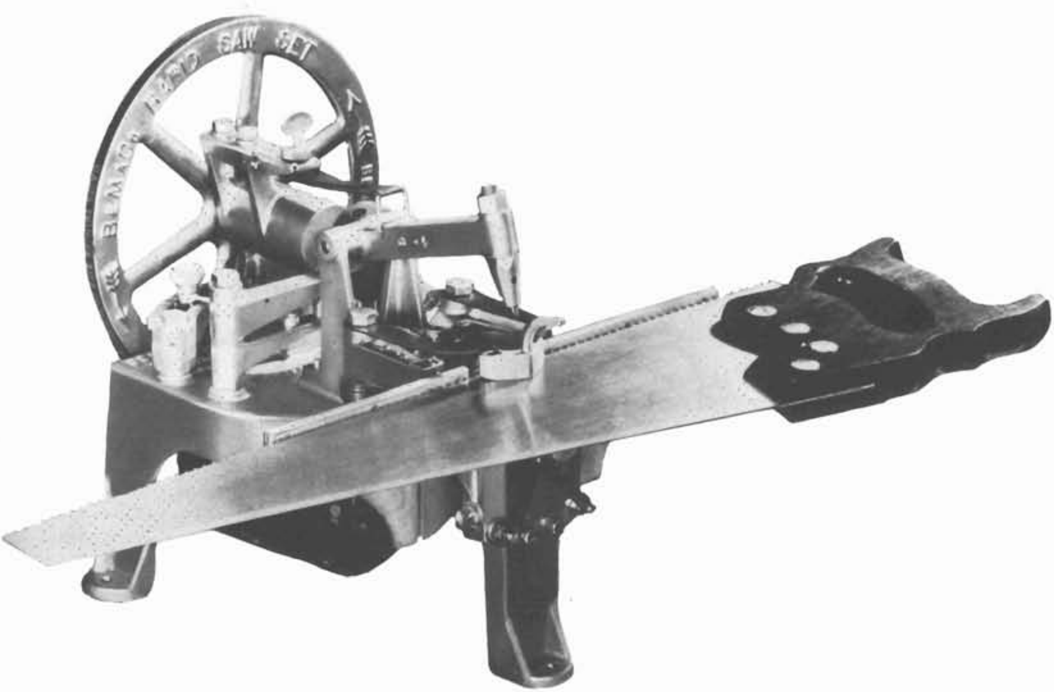
To set handsaw teeth

1. Place the saw in a clamp with the teeth projecting high enough for the saw set to be fitted on them. With a little experience, the operator may hold the saw in one hand while operating the saw set with the other (Fig. 6-16).
2. Adjust the saw set so it will clamp the blade and bend the tooth properly.
3. Beginning at the heel of the saw, set *the first six teeth toward both sides* and examine them to see that the proper portion of each tooth is bent and that there is sufficient set. *Do not lift or twist the saw set when setting the teeth.* Let it take its natural position. The plungers clamping the blade and tooth against the anvil will do the setting.
4. When the saw set is properly adjusted, set *alternate teeth toward one side* and then turn the saw around in the saw clamp and set the *remainder of the teeth toward the other side*. Be sure to grip the handles sufficiently tight to bend all the teeth uniformly against the anvil.

Mechanical saw sets (Figs. 6-17, 18) can be used for this operation.

SIDE-JOINTING HANDSAWS: Side-joint-

6-18. Setting a handsaw on the Bemaco rapid saw set.
COURTESY BEAVER MANUFACTURING COMPANY



ing is the process of dressing the sides of the teeth to make the set uniform so that all the teeth on the same side of the saw will cut in one plane. This operation is necessary after the teeth have been set because they always spring back slightly in varying amounts during the setting process. It needs to be done only once between settings and usually follows the first sharpening.

Some filers, however, prefer to side-joint immediately after setting the teeth. The saw is side-jointed very lightly with a fine oilstone. If the teeth are side-jointed too heavily, the large flat spots that are cut on the sides of the teeth will cause the saw to bind in the kerf. *Do not attempt to remove excessive set by side-jointing.*

To side-joint a handsaw

1. After the saw has been properly set and sharpened, lay the blade flat on the bench top or on a true board.
2. Lay a fine oilstone lengthwise on the blade, so it covers the teeth, and push it along the cutting edge so as to joint the teeth lightly.
3. Turn the saw blade over and dress the other side in the same manner.

Selection of the proper-size taper handsaw file

The *tooth spacing,* or *number of points per inch,* determines the size of file needed for sharpening handsaw teeth. If the file is too large, the teeth will be shortened because the radii on the corners increase in size as the sides of the file become wider. There is no advantage in using a file which has sides that are more than twice the length of the teeth, because a center portion of the sides cannot be used. A large file also costs more than a small one.

If the file is too small, the gullets become deep, forming long slender teeth that spring easily when cutting. It is possible for the file to be so small that the width of the sides would be less than the length of the front or back of the teeth, in which case the saw could not be properly filed.

Table 7 indicates the sizes of taper saw files that are commonly used for filing handsaws with the various tooth spacings.

Table 7

FILE SIZES FOR SHARPENING HANDSAWS

Points Per Inch	Size of File
4½ 5 5½	6″ regular taper or 7″ slim taper
6 7 8	6″ or 7″ slim taper
9	5½″ slim taper or 6″ extra slim taper
10 11	5″ extra slim taper
12 13	4″ extra slim taper
14 and above	4″ double extra slim taper
To joint teeth	8″ mill bastard

Since the width of the sides of a taper saw file is determined by either the length or the taper, it is readily apparent that the sizes of files given in the foregoing table are not the only ones that could be used.

The most important factor to consider in the selection of a file is the width of the side required to file a saw with a particular tooth spacing (Fig. 6-19). It is then a matter of personal preference in choosing between a long, slim file and a short, thick one. The long file has a longer cutting surface and will obviously last longer if a full length stroke is used. It may be controlled with greater ease when filing, but it will cost more.

6-19. File must be of proper size; if the file is too small, the side will not cover the entire length of the back of the tooth.

Table 8

COMPARISON OF THE SIZES OF TAPER SAW FILES

Length in Inches	Taper	Width in Inches
7	regular slim extra slim double extra slim	17/32 13/32 11/32 1/4
6	regular slim extra slim double extra slim	15/32 11/32 9/32 7/32
5½	slim extra slim double extra slim	9/32 1/4 3/16
5	regular slim extra slim double extra slim	13/32 9/32 7/32 3/16
4½	slim extra slim double extra slim	1/4 7/32 11/64
4	regular slim extra slim double extra slim	11/32 7/32 3/16 5/32

Table 8 gives the widths of the sides of the different length files in the various tapers (4, 108). Although the different brands of files do not have exactly the same width sides in a particular length and taper, they are sufficiently close that the table is helpful in selecting a file of the proper size. For example, a 4″ regular taper file can be used in the place of a 6″ slim taper file for filing a saw with 6, 7, or 8 points per inch, since both files have sides that are 11/32″ wide. However, the 4″ file would be a little short for easy filing.

FILING HAND RIP SAWS: Rip saws are usually filed straight across—that is, the file is held at right angles to the sides of the saw both horizontally and vertically. This forms a cutting edge on the tooth that is square with the sides of the saw. If the file is carefully held in this position, all of the teeth can be filed from the same side. The filing operation, in this case, is the same as the shaping operation done before the saw was set. If special care is not given to the angle of the file, all the teeth may be low on one side and have the edges skewed the same direction. This method does have one advantage, in that the size of the individual teeth can be judged more easily as they are being filed.

Some saw filers prefer to file half the teeth from one side, filing the front of the teeth that are set toward them and the back of the teeth that point toward the opposite side. Then they turn the saw around in the clamp and file the rest of the teeth.

If the cutting edge of the teeth is to be skewed slightly, to give the teeth a slight crosscutting action for sawing tough wood, it must be filed from both sides. The teeth can be skewed either by dropping the handle of the file or by moving it horizontally. In either case, the angle should not be more than 5°.

To file a hand rip saw

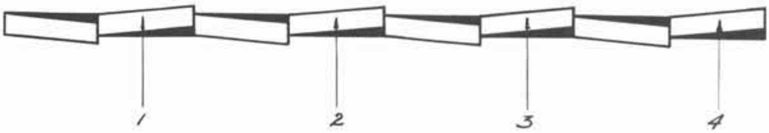
1. Joint the teeth lightly. Use procedure "To Joint a Hand Saw", page 81. A light jointing not only evens the teeth, but serves as a guide for filing.
2. Place the saw in the saw clamp according to Step 1 in the procedure "To Shape Hand Saw Teeth," page 82. Select the proper file. See informational unit, "Selection of the Proper Size Taper Hand Saw File", page 86.
3. Select the method below that is to be used for filing the saw (either a or b):

   a. Filing from one side only:

   (1) Take hold of the file as instructed in Step 2 in the procedure, "To File a Surface", page 42. Place it in the first gullet at the heel of the saw. Holding it at right angles both vertically and horizontally to the sides of the saw and in the proper relation to the angle on the front of the tooth, file in the gullet until almost half of the jointed surface has been removed from the two adjoining teeth. Check the angle of the tooth with the filing gauge.

   (2) Move the file to the next adjoining gullet and file until the previously filed tooth is almost to an edge and nearly half of the jointed surface of the next has been removed.

   (3) Continue filing the remainder of the teeth in the same manner.



6-20. Numbered teeth are filed in direction of arrows.

(4) Repeat the filing operation and bring each tooth to an edge, keeping the teeth uniform in shape and size. Do not file on a tooth after it has come to an edge, because the removal of any more metal will make the tooth too short. Carefully examine each tooth for flat spots. They are clearly visible if you hold the saw in the light and look down on the teeth at a slight angle.

b. Filing from both sides

(1) Take hold of the file as instructed in Step 2 in the procedure, "To File a Surface", page 42. Place it in the gullet in front of the first tooth that is set toward you at the heel of the saw. Holding it at the desired angle to the sides of the saw and in the proper relation to the front of the tooth, file the gullet until almost half of the jointed surface has been removed from two adjoining teeth. Check the angle of the tooth with the filing gauge.

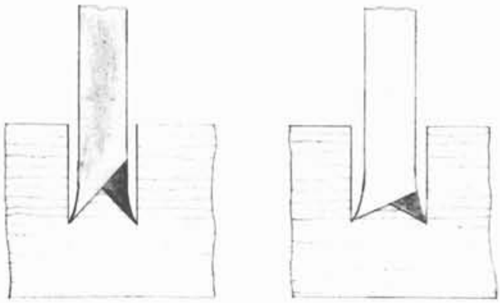
(2) In the same manner, file the remainder of the teeth that are set toward you (Fig. 6-20).

(3) Turn the saw around in the saw clamp and, beginning at the handle end, file the rest of the teeth until they come nearly to an edge.

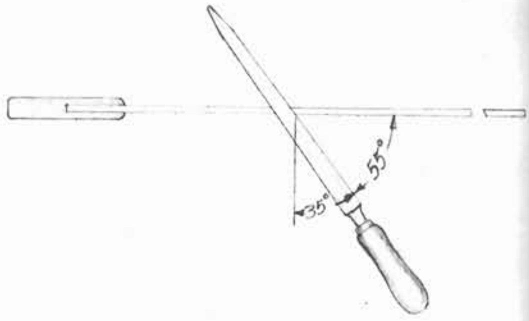
(4) Repeat Steps (2) and (3) and bring each tooth to a sharp edge, keeping the teeth uniform in size and shape. Do not file a tooth after it has come to an edge because any more filing will make it too short. Carefully examine each tooth for flat spots. These are visible when you hold the saw in the light and look down on the teeth at a slight angle.

Filing crosscut handsaws: Crosscut saws are filed with a bevel on the front and back of the teeth so that they come to points on the side toward which they are set. Since half of the teeth are set toward each side, alternately, a central angular groove is formed between the two rows of points. The teeth must be filed so uniformly that *a needle will slide freely down the groove* for the entire length of the saw. The groove must be in the center of the two rows of points, if the saw is to run properly.

The amount of bevel on the teeth is an important factor in determining the ease with which a saw will perform in a particular situation. If the teeth are beveled excessively, the points will be long and slender and break easily when they cut hardwood



6-21. Cutting action of crosscut teeth of different bevel size. Tooth to the left is weaker than tooth to the right.



6-22. Position of file in relation to handle and saw blade. Notice that file points toward the handle.

and knots. They will also score the fibers so deeply that the skewed edge of the tooth cannot easily break out the material between the two scored lines. With less bevel, the skewed edge can readily shave these fibers (Fig. 6-21).

The fibers in softwood are relatively easy to break out, in which case more bevel on the teeth is desirable.

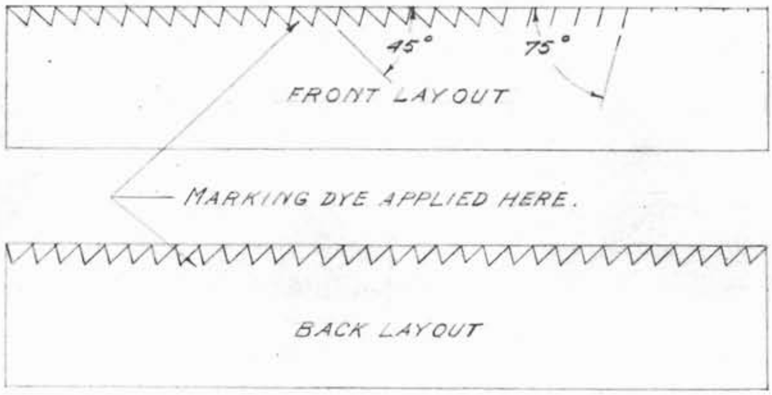
Obtain the bevel by holding the file so that the vertical angle with the sides of the saw is 90° and the horizontal angle is less than 90°. For rapid cutting in softwood a 45° bevel is sometimes used (3, 158). When sawing in hardwood, the bevel may be as little as 25° (5, 32). For general use, a 35° bevel is commonly filed on the teeth. The file would make a 55° angle with the saw when making a 35° bevel on the teeth because the complementary angle is 55° for a 35° angle (Fig. 6-22). (When filing 45° and 25° bevels, the file makes angles of 45° and 65°, respectively, with the saw.)

It is better to file the front of the tooth against the cutting edge—that is, to file the front of the tooth that is set toward you with the end of the file pointed toward the saw handle.

For a right-handed person, the saw should be in the saw clamp with the handle to the right. (This is the most difficult angle to file with the left hand stretched across the saw and ahead of the right hand.) It is evident that the filing should start at the heel and progress toward the point. The saw can then be turned around in the saw clamp and the remainder of the teeth filed in a more natural position, with the file pointed toward the left so the points are more visible. A left-handed person probably would want to reverse the order of filing. It is all a matter of personal preference, since some filers have equally good results when following other procedures.

To lay out new teeth on a crosscut saw

1. Select a crosscut saw with teeth in such condition that they need to be replaced by new ones.
2. Place the saw in a saw-filing clamp with the teeth about $\frac{3}{8}''$ above the clamp.
3. With a flat mill bastard file, re-



6-23. Layout of crosscut teeth.

move the old teeth. The completed filed edge should be straight or slightly convex.

4. Take the saw out of the filing clamp.
5. Apply a coat of marking dye to both sides of the saw blade where the new teeth are to be laid out.
6. Select the number of points per inch.
7. With the use of a steel rule and a sharp scratch awl, lay off a series of uniform marks representing the desired tooth spacing (Fig. 6-23).
8. With the sliding T bevel set at 75°, lay out a series of lines, passing through the marks at the edge.
9. Repeat this layout on the other side of the blade. Each of these lines forms the front of the crosscut teeth.
10. Change the angle on the sliding T bevel to 45° and lay out the second series of slanting lines.
11. Repeat this layout on the other side of the blade. These lines form the backs of the crosscut teeth. The completed layout appears in Fig. 6-23.
12. Select the proper size, regular taper file with handle and remove the metal within 1/16 inch of the layout lines. The file makes an angle of 90° with the blade and may be slightly dropped from its horizontal position to avoid screeching. The file is made to cut on the forward stroke only.
13. Complete filing the teeth to a sharp point. Follow the procedure, "To File a Crosscut Handsaw," below.

To file a crosscut handsaw

1. Joint the teeth lightly. Use procedure, "To Joint a Handsaw," page 81. A light jointing not only evens the teeth but serves as a guide for filing.
2. Place the saw in the clamp, with

the handle preferably to the right, according to Step 1 in the procedure, "To Shape Hand Saw Teeth", page 82. Select the proper file. See informational unit, "Selection of a Handsaw File with the Proper-Size Taper", page 86.

3. Take hold of the file as instructed in Step 2 in the procedure, "To File a Surface", page 42, and place it in the gullet in front of the first tooth that is set toward you at the heel of the saw. Holding it with the point toward the handle at the desired angle, usually at 55° horizontally with the sides, and in the proper relation to the front of the tooth, file the gullet until almost half of the jointed surface has been removed from the two adjoining teeth. Check the angle of the tooth with the filing gauge. Remember the top side of the file must slope to the left in order to keep the proper angle or hook on the front of the teeth (Fig. 6-24).
4. In the same manner, file the remainder of the teeth that are set toward you.
5. Turn the saw around in the saw clamp. Holding the file in the same relationship to the saw as before and beginning at the heel, file the teeth that are set toward you until they come nearly to points. The top side slopes to the right in order to keep the proper angle or hook on the front of the teeth.
6. Repeat Steps 4 and 5 and file each tooth to a sharp point, keeping the teeth uniform in size and shape. Do not file a tooth after it has come to a point, because any more filing will make it too short. Carefully examine each tooth for flat spots. They are easily visible when you hold the saw in the light and look down on the teeth at a slight angle.

FILING COMBINATION HANDSAWS: The saws that are included in this group are the *back saw, compass saw, dovetail saw, keyhole saw,* and *miter box saw.* These saws are often referred to as crosscut saws, but they are really combination saws. They are all used for ripping as well as crosscutting. For example, when the back saw is used for cutting tenons, there is considerably more ripping done than crosscutting. According to one manufacturer (18, 162), the angle on the teeth of the compass saw should be between that of the crosscut saw and the rip saw, since the nature of the work includes both types of sawing.

It is apparent that these saws should not have as much bevel on the teeth as is ordinarily put on crosscut saws. Probably a 20° to 25° bevel would skew its edge from the point to the other side sufficiently to pare the wood between the sides of the cut. When cutting bevels of 20° and 25° on the teeth, the file would make angles of 70° and 65°, respectively, with the sides of the saw.

The teeth on keyhole and compass saws have an angle or hook on the front similar to the rip-saw teeth shown in Fig. 6-12, page 82, which makes them cut very fast. They are especially designed for cutting curves

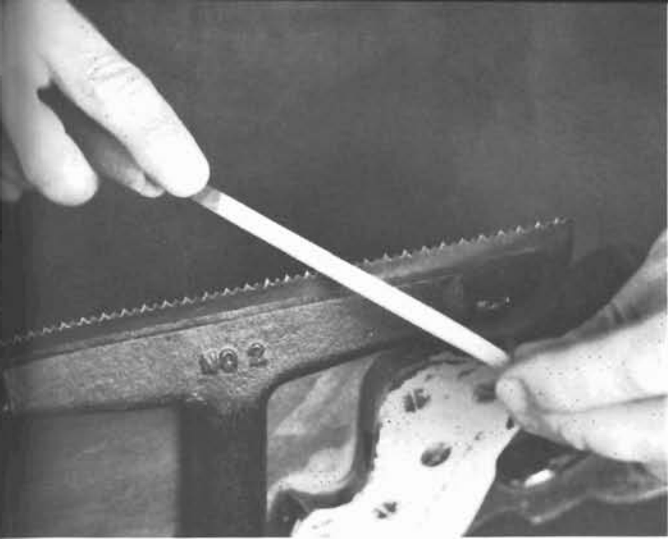


PHOTO BY GRIFFITH

6-24. Position of file when filing a crosscut saw. Notice chalk on file edges for easier removal of steel particles.

PHOTO BY CROW

6-25. Filing a compass saw. The teeth are beveled from 20–25°.

and circles. This requires a tooth that will efficiently do both crosscutting and ripping (Fig. 6-25). The only difference between a keyhole saw and a compass saw is that the blade of the keyhold saw is smaller and thinner.

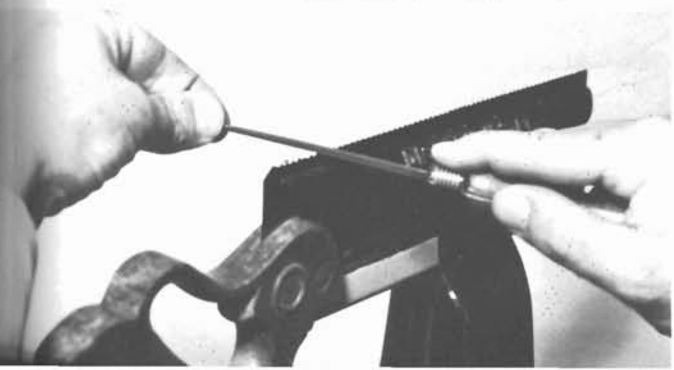
The teeth on the back saw, miterbox saw, and dovetail saw have an angle or hook on the front similar to that of the crosscut teeth shown in Fig. 6-13, page 83. They can be beveled from 20° to 45°, depending upon the type of work. If the saws are used for cutting at an angle to the grain, the teeth should have less bevel (Fig. 6-26, 27, 28). For example, the miter cut made with a miterbox saw which has the teeth beveled at 45° will be wide and irregular because the long slender teeth have a tendency to follow the grain on each stroke, pulling toward one side on the forward stroke and toward the other on the backward stroke. The saw will make a much truer miter cut if the bevel does not exceed 25° —that is, if the file does not make less than a 65° angle with the side of the blade.

To file a combination handsaw

Follow the procedure, "To File a Crosscut Handsaw," page 91, but make a bevel on the teeth that will be suitable for the specific kind of sawing.

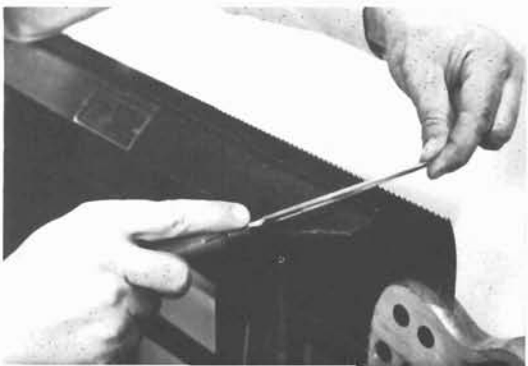
6-26. Filing the teeth of a back saw. They are beveled from 20–45°, depending upon the type of work to be done.

PHOTO BY CHARLES J. PEREZ



6-27. Filing a miterbox saw. The bevel on the teeth should not exceed 25°.

PHOTO BY CHARLES J. PEREZ



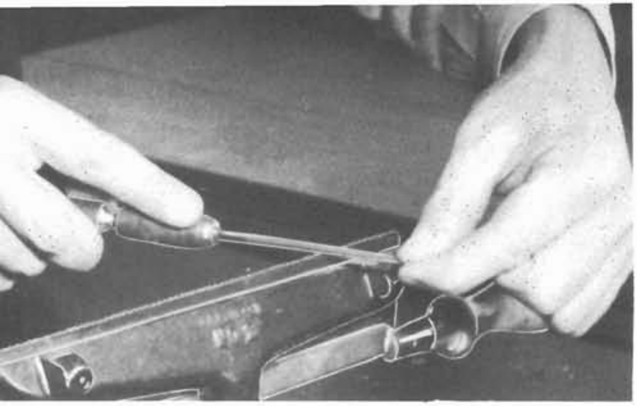


PHOTO BY CROW

6-28. Filing a dovetail saw. The file used here is a 4" double extra slim taper.

To sharpen a handsaw

The steps listed below are those required to sharpen a saw that has poorly shaped teeth and no set. If a saw has uniform teeth and sufficient set, it can be sharpened by following Steps 4 and 5.

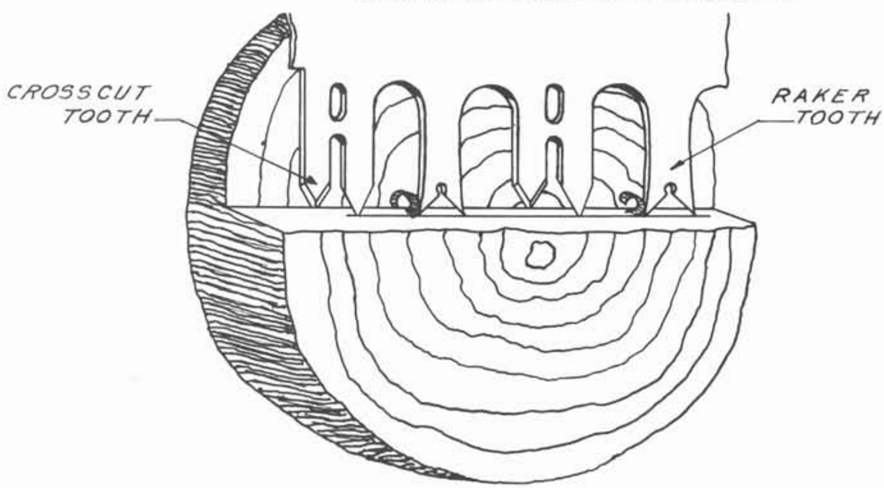
1. Joint the teeth to a uniform height. Use procedure, "To Joint a Handsaw," page 81.
2. Shape the teeth to a uniform size and angle. See procedure "To Shape Handsaw Teeth," page 82.
3. Set the teeth. See procedure, "To Set Hand Saw Teeth," page 85.
4. Joint the teeth lightly. Follow procedure, "To Joint a Hand Saw," page 81.
5. File the teeth. Follow the procedure which is appropriate for the kind of saw, "To File a Hand Rip Saw," page 88, "To File a Crosscut Handsaw," page 91, or, "To File a Combination Handsaw," page 93.
6. Side-joint the saw. Use procedure, "To Side Joint a Handsaw," page 86.

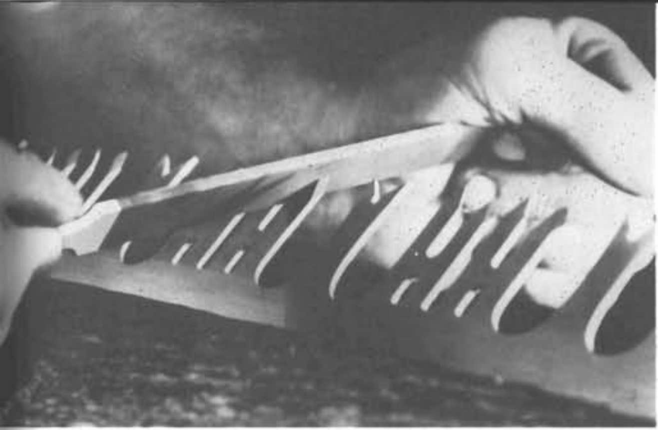
Mechanical saw filers

A number of mechanical saw filers

6-29. Cutting action of teeth of a one-man crosscut saw.

COURTESY SIMONDS SAW AND STEEL COMPANY





COURTESY SIMONDS SAW AND STEEL COMPANY

6-30. Filing the crosscut teeth of a crosscut saw as seen from the front.

COURTESY NICHOLSON FILE COMPANY

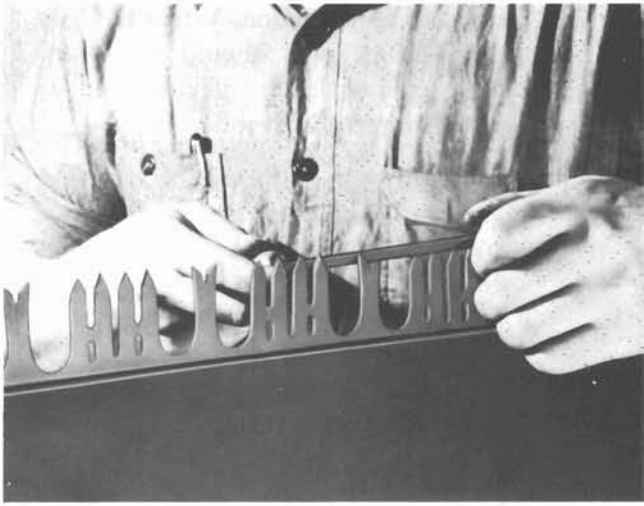
6-31. Filing the crosscut teeth of a crosscut saw, as seen from the rear.

are now on the market. A skilled operator can do highly satisfactory work on these machines, cutting labor cost as well as eliminating much of the severe eye strain that accompanies hand filing.

Filing a one-man crosscut saw

These saws are useful for cutting logs and small trees. The teeth consist of a number of crosscut teeth, followed by a pair of raker teeth. When filing this saw, it is important to file the raker teeth just a little shorter than the crosscut teeth. They cut on the principle of a series of little chisels, and serve primarily to clear away wood particles from the saw kerf. It is best to file the crosscut teeth with a flat mill file and the raker teeth with a regular taper or cant file. For accurate work, use a special jointer, a setting hammer, and a steel setting block.

Fig. 6-29 shows the cutting action of this type of saw. The position of the file is illustrated in Fig. 6-30 and 31. Fig. 6-32 shows how to file the raker teeth.



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6-32. Filing the raker teeth of a crosscut saw with a taper or cant file.

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PART ONE

CHAPTER 7

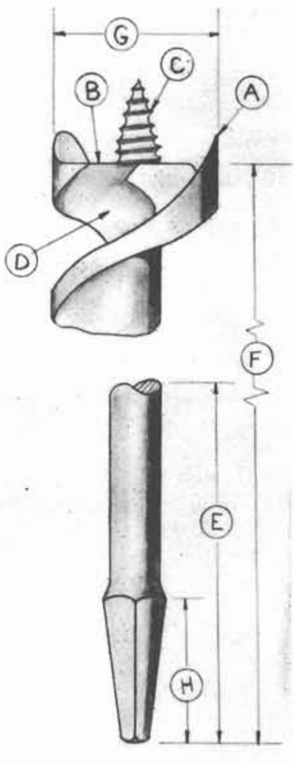
Wood Bits

Every woodworker or cabinet maker needs to bore holes for various types of construction. When he does, the boring tools should be sharp. Dull tools cut with difficulty and often damage the wood.

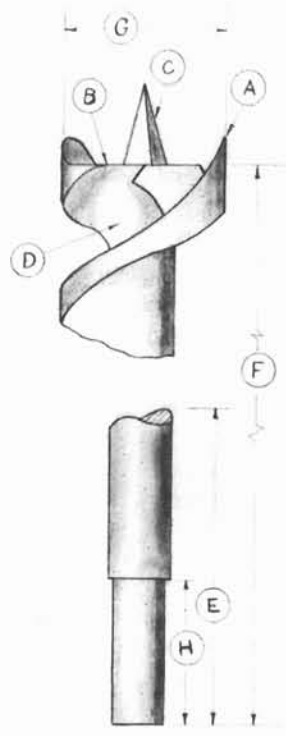
AUGER BITS

Auger bits are made in a number of designs and styles, depending upon their use, but the general cutting principle is similar. They are composed of the shank, the twist, and the

7-1. Principal parts of a square-tang auger bit: A. Spurs. B. Cutters. C. Screw point. D. Throat, E. Shank. F. Length. G. Size. H. Tang.



7-2. Principal parts of a round-tang auger bit: A. Spurs. B. Cutters. C. Square point. D. Throat, E. Shank. F. Length. G. Size. H. Tang.



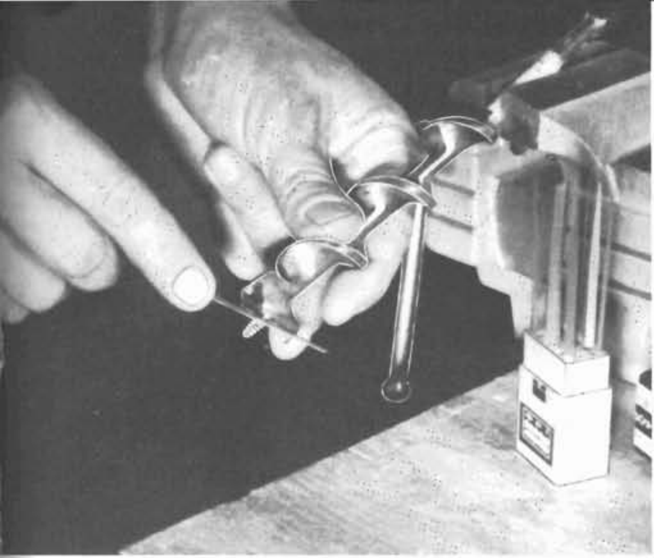


PHOTO BY CROW

7-3. Recondition threads of the screw point with a small three-cornered file.

PHOTO BY CROW

7-4. Remove dirt and resin from the screw point of an auger bit with file card.

head (Figs. 7-1, 2). The end of the shank is usually square on bits that are held with a brace, and round on those which fit into a chuck on a boring machine. The *head* is made up of the *spurs, cutters, screw* or *square point*, and *throat.*

The purpose of the *screw point* is to pull the bit into the stock. The depth of cut for each revolution of the bit is determined by the pitch of the thread. Screws have three different threads or pitches. The one with the *fine thread* or *low pitch* pulls the bit into the stock very slowly and makes a smooth cut. The *coarse thread* has a *steep pitch* and cuts deeper per revolution, but makes a rough cut. The *medium thread* has a pitch between the two extremes and is used for general purpose boring.

If the thread or feed screw is not well formed, the bit will not bore properly. Sometimes a slightly damaged thread can be reconditioned with a 4″ double-extra-slim taper file (Fig. 7-3, 4) but badly damaged threads are often beyond repair.

The square point is used on machine bits where a screw is not needed to feed them into the stock. Its purpose is to guide the bit. The sharp edges formed by the intersection of the sides compress the wood as the bit is forced into the stock.

A bit with a screw point should not be used on a machine because the thread will continue to feed the bit even after the pressure has been released. This causes the stock to be raised off the table. Sometimes a damaged screw point bit can be reshaped for limited machine boring by filing the point to the shape of a square pyramid.

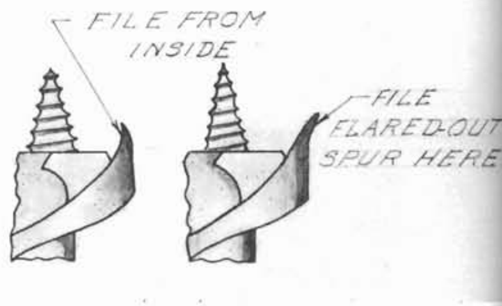
The spurs score the fibers at the outside edge of the cut in advance of the cutters, making a hole sufficiently large for the twist to enter without binding. They should be long enough to score the fibers entirely ahead of the cutters before they lift the chips. They must be slender enough not to bind in the cut, yet have sufficient strength to support the cutting edges. When they are worn so short that the fibers are not scored ahead of the cutters, they will not bore efficiently and will make a rough cut.

If the spurs become damaged by cutting into a foreign material while boring (Fig. 7-5), it is necessary to reshape them so the cutting edges are the same length and in the same plane as the sides of the head. They may be damaged to the extent that reshaping is impractical. It is apparent that the spurs should be sharpened on the inside surface rather than on the outside. Sharpening on the outside would reduce their cutting diameter, causing the bit to bind in the stock.

The cutters shear off the material that has been scored by the spurs and start lifting it from the hole. They should be sharp, with the cutting edges in the same plane so each will do its share of the cutting. If one cutter is short, it will remove only a thin shaving, if any at all.

Cutters are designed to provide a clearance angle between the bottom of the hole and the cutter back of the cutting edge. This angle should not be altered during the life of the bit, if the bit is to cut properly. The cutters are sharpened on the top side and are beveled at approximately 45° to give sufficient support to the cutting edge. The heel of the bevel is gradually rounded into the throat surface. An auger bit file should be used for these sharpening operations.

Auger bits should be handled and stored carefully so that they will not be bent or damaged. Light hammer blows will straighten a bent bit if it is not too badly damaged (6, 12)



7-5. Spurs when damaged on either the inside or outside must be reshaped in order that the bit cuts properly.

Keep bits bright by wiping them with an oily cloth before putting them away, because the acid in the wood and moisture from the hands will rust them. A *rusty bit* will not enter the wood easily, nor will the twist keep the shavings moving freely to the surface. *If the tool should become rusty,* dip the screw first into oil and then into a fine abrasive grit and bore into a piece of softwood (3, 3). *To remove rust from the twist,* coil a heavy cord around the twist and pull it back and forth after dipping it first in oil and then in a fine abrasive grit. The bit may also be rubbed with a piece of fine abrasive cloth dipped in oil.

Auger bits vary in size from 3/16″ to 2″, by sixteenths. They are commonly made in standard sets, varying from 1/4″ to 1″, by sixteenths. Special sets vary by thirty-seconds. The size of a bit is designated by a number on the tang, giving the diameter of the bit in 16ths unless otherwise noted.

PHOTO BY CHARLES J. PEREZ

7-6. Clean outside of twist with a piece of abrasive cloth.

To clean a rusty bit

1. Wrap a piece of emery cloth, size 4" x 6", around the twist of the bit.
2. Pull the emery cloth up and down along the twist several times. Finish with a fine grade of crocus cloth (Fig. 7-6).
3. To remove rust from the shank and inside the twist, loop a strip of abrasive cloth, size ½" x 12", around the twist.
4. Pull the strip of abrasive cloth back and forth along the entire length of the bit (Fig. 7-7).

7-7. Clean inside of twist with a narrow strip of abrasive cloth dipped in thin oil.

PHOTO BY CROW

PHOTO BY CROW

7-8. Finish cleaning with a piece of rope, saturated in kerosene and pumice stone.

5. Repeat this operation with a heavy piece of manilla rope, well saturated in a mixture of kerosene and fine abrasive grit (Fig. 7-8).
6. Clean the entire bit with an oily rag.

If a buffer with a steel wire brush and a buffing wheel is available, you can do the cleaning satisfactorily on this machine (Fig. 7-9). Some experience is highly desirable. Extreme caution must be exercised to prevent the wire brush from grabbing the auger bit.

7-9. A rusty auger bit can also be cleaned on a buffing machine mounted with a wire brush and buffing wheel.

PHOTO BY CROW

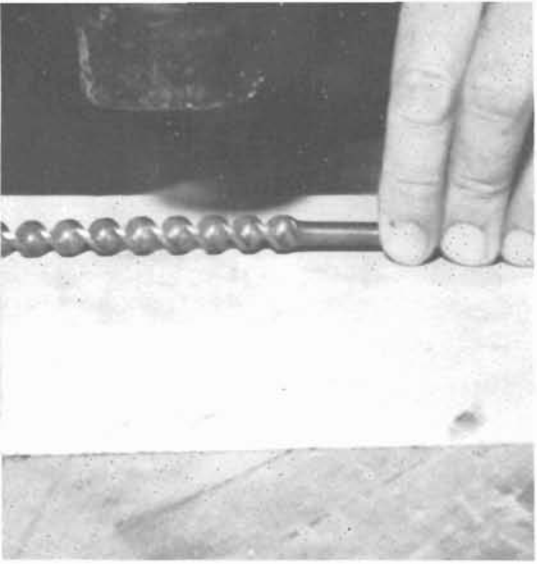


PHOTO BY CROW

7-10. When straightening a bent auger bit, strike the bend lightly with a rubber or rawhide mallet. Use a block of hardwood for support.

To straighten an auger bit

1. Lay the bit on a flat surface and roll it to locate the bend.
2. Place it on a hard piece of wood with the convex surface up and strike it light blows with a mallet (Fig. 7-10).
3. Repeat the two foregoing operations until the bit rolls straight on a flat surface.

7-11. Sharpen the spurs from the inside with an auger bit file.
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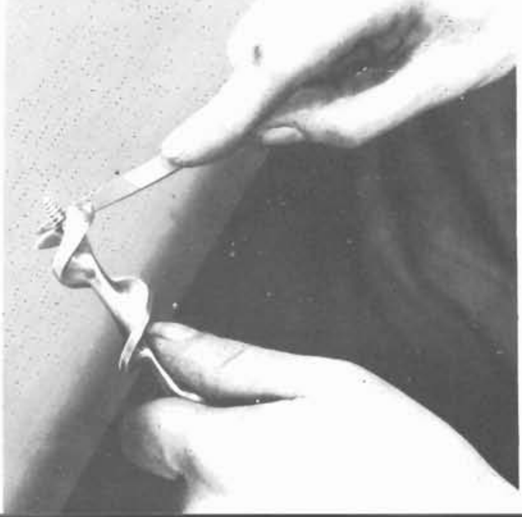

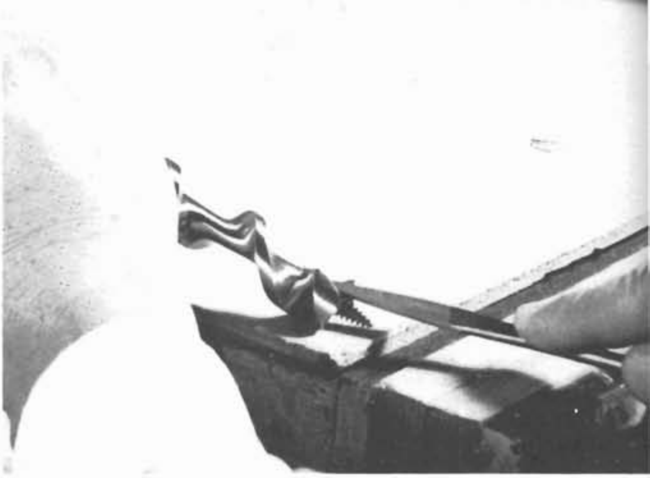

PHOTO BY CHARLES J. PEREZ

7-12. File the top side of the cutters with an auger bit file.

To sharpen an auger bit

1. Place the twist of the bit against the top arris of the bench top with the head projecting slightly above the top.
2. File the inside of each spur with an auger bit file until the edges become sharp, removing only a minimum amount of material at the base. Do not file the spurs on the outside (Fig. 7-11).
3. Holding the bit with the screw resting on the bench top near the edge, file the top side of the cutters (Fig. 7-12). Do not file the under side of the cutter.

7-13. Finish sharpening the cutters and spurs with an auger bit oilstone.
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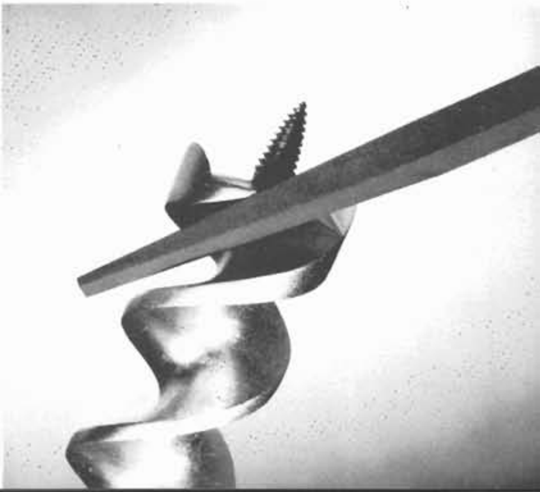

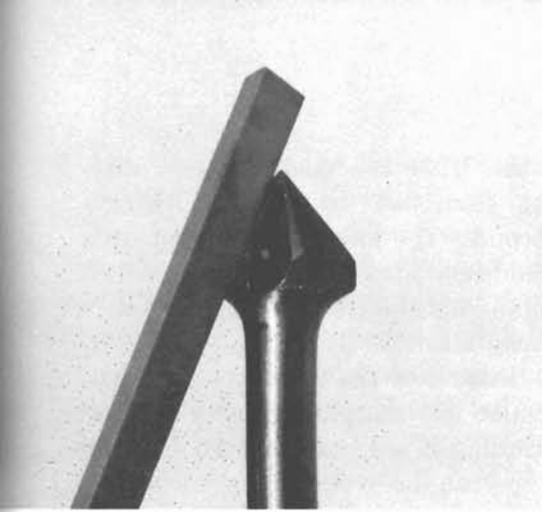

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7-14. Sharpen the flutes of a countersink with a triangular oilstone.

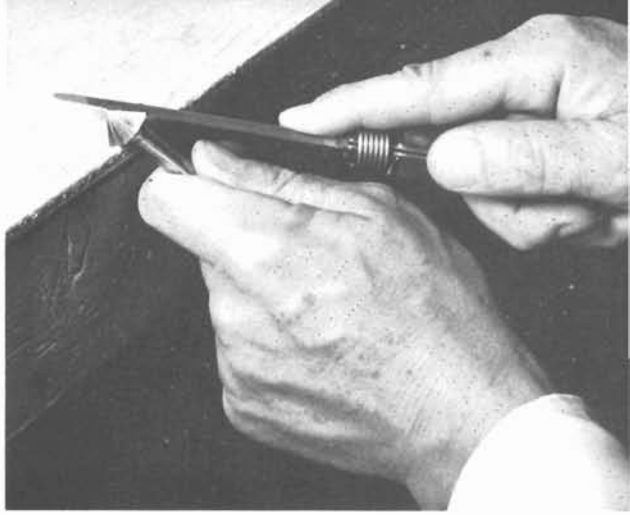


PHOTO BY CHARLES J. PEREZ

7-15. Badly damaged flutes can be restored by careful filing.

4. Whet the cutting edges with an auger bit oilstone. The outside of the spurs and the under side of the cutters may be whetted lightly to remove the burr (Fig. 7-13).

COUNTERSINK

To sharpen a countersink

1. Select a fine-grain, triangular oilstone and wipe it with a clean cloth. Then apply a drop or two of light oil to the surface.
2. Place the surface of the oilstone against the *face of the cutting edges* and stone them until they are sharp. It is not advisable to stone backs, as it might make the cutting edges uneven (Fig. 7-14).
3. If a burr forms on the back of the cutting edge, remove it by rubbing the stone lightly over the back with the surface flat on the bevel.

   When the tool is extremely dull, a small amount of filing with a taper file is advised. (Fig. 7-15).

FOERSTNER BITS

The Foerstner bit is used for boring flat bottom holes in stock where the hole made by the screw of the auger

7-16. Foerstner bit. This type of bit is used when boring flat bottom holes.

bit would be objectionable. It has a small point which aids in locating the position for making the hole. The lips shear off the chips after they have been scored by the outside rim projecting below the lips (Fig. 7-16). These bits are made in sizes varying from 1/4" to 1 1/2", by sixteenths, and from 1 1/2" to 3", by eighths. They are sharpened by filing the lips on the face and on the inside surface of the scoring rim. The outside surface of the scoring rim and the clearance angle of the lips should not be altered. If they are changed, the bit either will not cut or will bind in the hole.

To sharpen a Foerstner bit

1. Holding the shank of the Foerstner bit inclined from a vertical position, place the rim on the bench close to the edge.
2. Place the auger bit file on the face of the lip and file against the cutting edge until it is sharp. Sharpen the other lip in the same way.
3. Holding the head of the bit against the top edge on the bench top with the shank extending down, place the end of the auger bit file on the beveled side of the rim and move it in a side motion to form a sharp edge. The motion of the file is somewhat similar to that of draw filing.

GIMLET BITS

Gimlet bits are used for boring smaller holes in wood, such as those required for fastening stock with screws. They have a tang like the auger bit and fit into the common brace. They are made in sizes varying from 1/16" to 3/8", by thirty-seconds. The size is designated by a number stamped on the tang which represents the diameter of the bit in thirty-seconds.

Because of the construction of the gimlet bit, sharpening by filing and grinding is not practical. The cutting edge can be restored by turning it in a hole made by the bit, which is then filled with a flour-sized abrasive and oil (1, 22).

To sharpen a gimlet bit

1. Place a piece of hardwood 1 1/4" to 1 1/2" thick in a vise with a side facing up. Mount the gimlet to be sharpened in a brace.
2. With the gimlet, make a hole in the side of the piece of wood approximately 3/4" deep and fill it with flour-sized abrasive and oil.
3. Place the gimlet in the hole and slowly bore down into the wood until the point reaches the opposite side. Repeat the operation several times.
4. Place a piece of softwood approximately the same thickness as the one used above in the vise and repeat the process without using oil.

TWIST DRILLS

Twist drills are made chiefly for drilling holes in iron and other harder materials. In the wood shop they are used for drilling small holes in wood and in other materials in the case of maintenance jobs.

A considerable amount of information concerning the construction and cutting action is necessary to obtain the best drilling performance in all kinds of material. But since twist drills are primarily netalworking tools, only the operations and information pertaining directly to their use in the wood shop will be considered here.

The principal parts of a twist drill are the *cutting lip, dead center, body, body clearance, margin, flute,* and *shank* (Fig. 7-17).

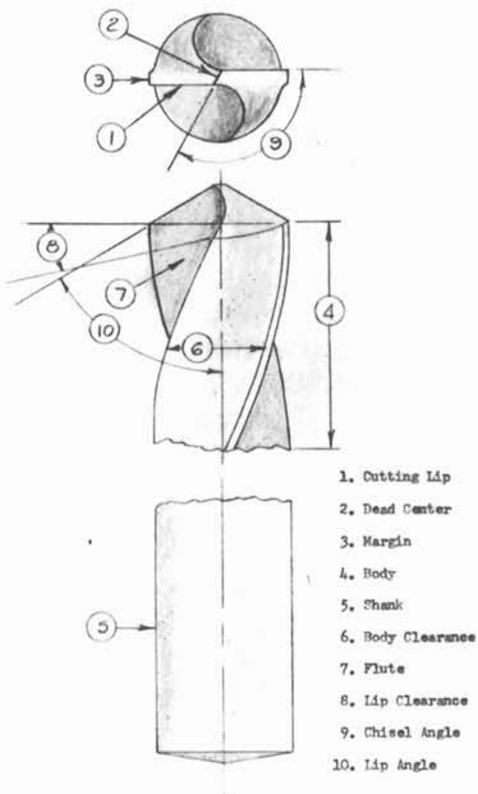
Twist drills may be obtained in high-speed steel, carbon steel for metal or wood, and carbon steel for wood. Because drills for metal can also be used for wood, it seems advisable to select them. If twist drills for wood only are used in the shop, they may be damaged by drilling in metal.

Drill sizes are commonly designated numerically from No. 80 to No. 1 (.0135″ to .228″), alphabetically from A to Z (.234″ to .413″), and fractionally from 1/64″ to 4″, and over by 64th (4, 8).

Drills for the wood shop are usually the straight shank type that can be used in a hand drill or in the drill press. Bits with a tang similar to the auger bit can be used in a brace. The straight shank drill is most common.

Twist drills are very hard and brittle. Therefore they should be carefully handled to avoid chipping or breaking. They commonly break for the following reasons:

1. Lack of rigidity of drill press or hand drill as well as lack of rigidity of the work being drilled.



7-17. Principal parts of a twist drill.

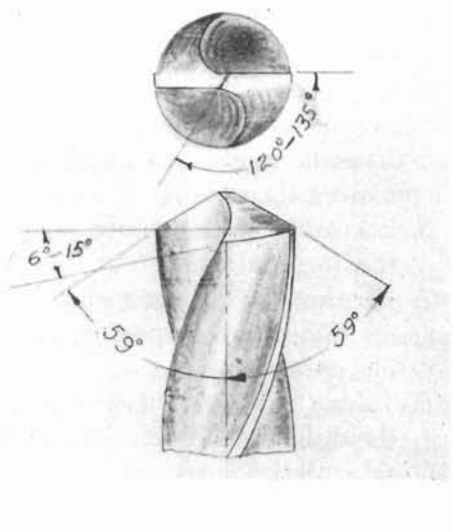
2. Attempted use of drills that are dull.
3. Improper clearance angle, too little or too much.
4. Improper feed in proportion to the speed.
5. Unequal angle and length of the cutting lips.
6. Excessive angle on the lips for the material being cut.
7. Heating the drill excessively during either the sharpening or drilling operation.
8. Taking a heavy cut at the time the drill cuts through the opposite side of the stock.

9. Clogging of the flutes, especially when drilling in wood or other soft material.
10. Running the drill at too high a speed.

Twist drills should be kept sharp to obtain longer drilling service and to prevent their breaking from the excessive pressure required to make them cut. Proper sharpening affects the life of drill bits more than any other factor. It is therefore important to understand the principles and procedure for reconditioning.

The drills first begin to dull at the outer portion of the cutting lip. At the same time the chisel edge tends to wear away, requiring an increased pressure to make the drill cut. This in turn causes it to dull faster. Using a drill in this condition is false economy, as all the worn part must be removed to sharpen the tool properly (5, 40).

7-18. Proper twist drill angles for general drilling.

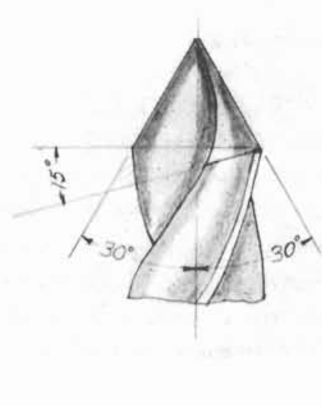


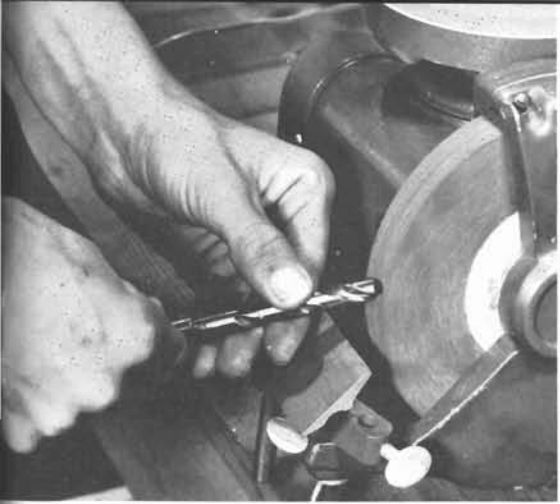
During the sharpening process, three parts of the point must be properly shaped, namely, the *lip clearance*, the *length and angle of the lips,* and the *position of the point and the dead center* in relation to the axial line of the drill (4, 9).

Lip clearance is the amount of material removed from the surface back of the cutting edges to permit them to enter the material freely. It has been found that this angle may vary from 6° for hard metal to 15° for soft metal, measured at the circumference of the drill. The clearance angle is increased toward the center to obtain a chisel-edge angle of 120° to 135° (5, 47). The chisel edge angle increases with the clearance angle. Too much clearance will make the cutting edge weak; too little clearance will keep it from entering the material.

The cutting edges or lips should be the same length and at exactly the same angle with the axial line of the drill in order to make a hole true to size. If they are not the same distance from dead center, they will

7-19. Reduced point angle is preferred for drilling holes in wood.





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7-20. Sharpening a twist drill offhand on the face of a grinding wheel.

not cut concentric circles—that is, one lip will take a heavier cut than the other and the hole may be larger than the diameter of the drill. Uneven lips will shorten the life of a drill considerably because of uneven strain set up in the tool. An angle of 59° (Fig. 7-18) between the cutting edges and the axis of the drill is satisfactory for general drilling (7, 208). However, if the drill is used only for making holes in wood, an angle of 30° (Fig. 7-19) is recommended (7, 208).

This angle should be gradually increased toward the center so that the angle at the chisel point is from 120° to 135° (4, 11). Drill points may be checked for size with a gauge.

Because an accurately sharpened drill point is essential for satisfactory performance of the drill, a grinding machine is recommended. However, a skilled person can do a satisfactory job of sharpening twist drills by the offhand grinding method.

To sharpen a twist drill by offhand grinding

1. Select the proper grinding wheel. See the chart on, "Grinding Wheel Specifications," page 21.
2. Mount the grinding wheel on the grinder. Use the procedure, "To Mount a Grinding Wheel," page 24.
3. Start the grinder and, holding the drill with both hands, place one of the cutting lips on the face of the grinding wheel with the cutting edge parallel to its axial line (Fig. 7-20).
4. Slowly roll the drill from the cutting edge toward the heel, forming a slightly convex surface. Continue this operation on each cutting lip until the lip and clear-

7-21. Sharpening a bit offhand on the flat side of a grinding wheel.
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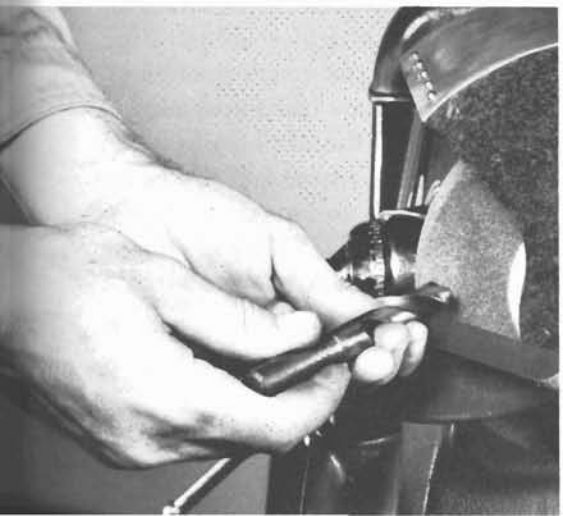


7-22. Grinding a twist drill on a homemade grinding attachment.
PHOTO BY CHARLES J. PEREZ

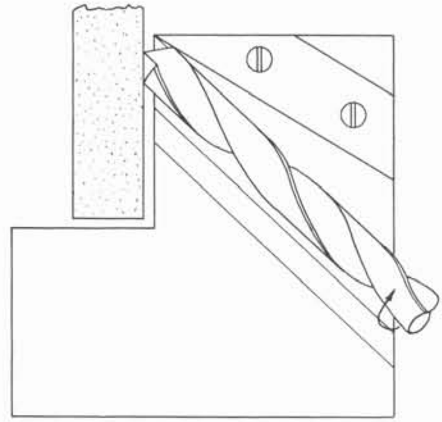
ance angles on both lips are properly formed. For a smooth cutting edge, the line should be stoned on a fine oilstone.

Drill bits can be successfully sharpened on the flat side of a grinding wheel (Fig. 7-21).

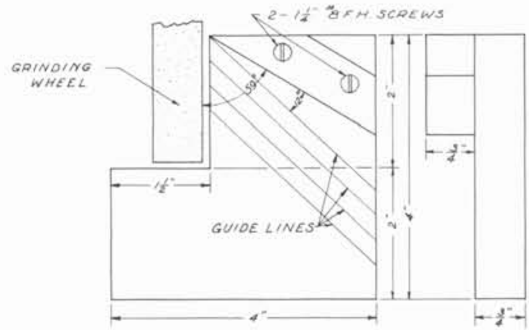
To sharpen a twist drill using a jig

1. With screws, mount the attachment on the tool rest.
2. Place the cutting lip of the bit against the side of the grinding wheel with the body of the drill against the guide block (Fig. 7-22, 23).
3. Rotate the drill about ⅙ of a complete turn, moving it at the same time to a position parallel to the guide lines (Fig. 7-24).
4. Sharpen the second lip in a similar way.
5. Check for proper point and clearance angle with drill gauge. Fig. 7-25 shows a working drawing of this inexpensive but useful jig.

Large bits used for precision boring in steel and other metals usually make it necessary to sharpen drills on specially-built drill grinders. Figs. 7-26, 27 show two such machines. Figs. 7-28, 29 show close-up views of the position of the drill in relation to the grinding wheel.

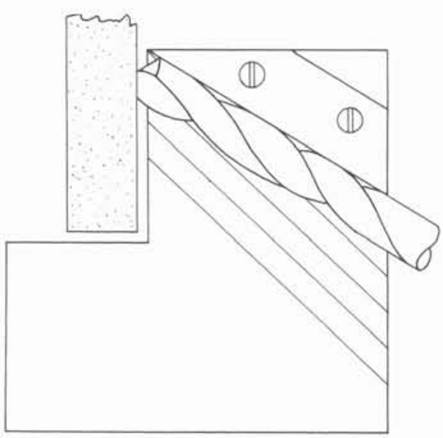


7-24. Position of drill after sharpening.



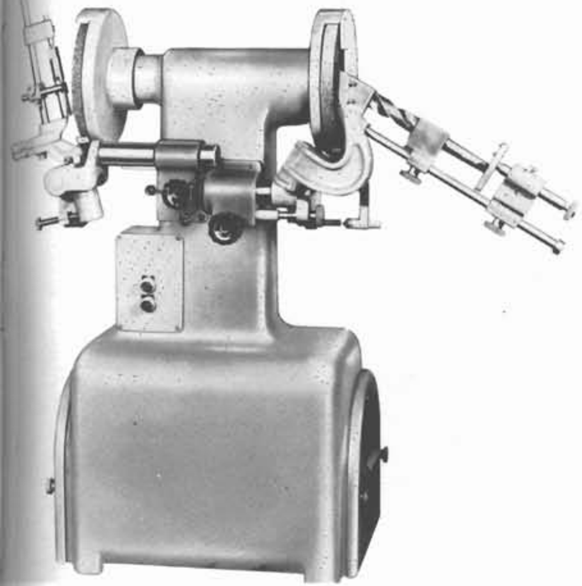
7-25. Homemade grinding attachment.

7-23. First position of drill on attachment.



PLUG CUTTERS

The plug cutter is composed of a



COURTESY GALLMEYER AND LIVINGSTONE CO.

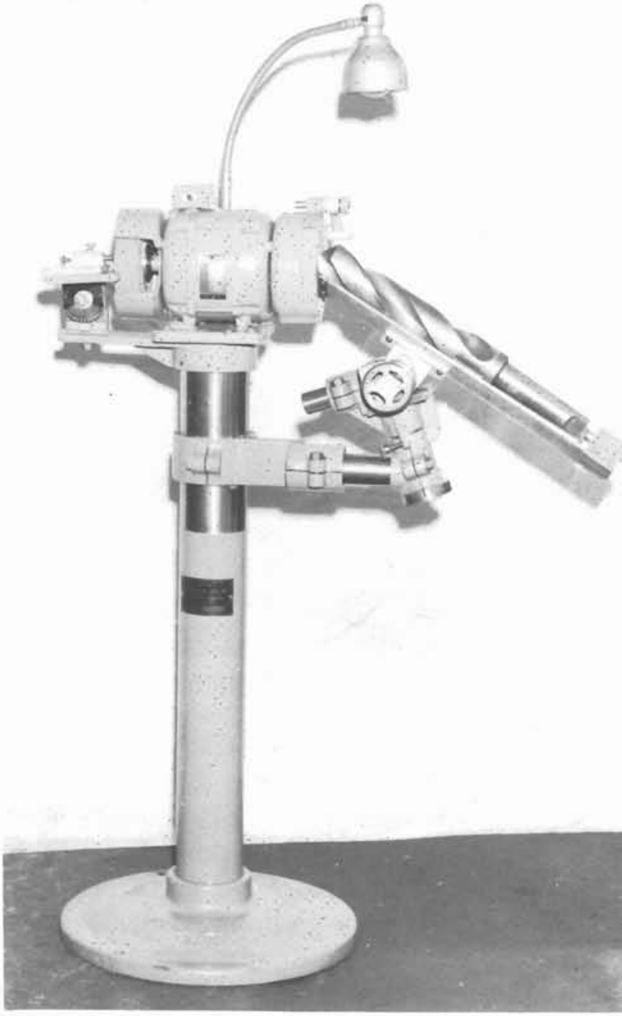
7-26. Sharpening large drills on the CD2 combination drill and tap grinder.

barrel and a shank. The end of the barrel is shaped to form a knife-edged rim which scores the fibers, and a cutter that removes the chips (Fig. 7-30). The body of the barrel is ground both internally and externally to provide sufficient clearance.

The knife-edged rim cuts the outline of the plug and is beveled from the outside at an angle of approximately 25° to allow it to enter the wood freely. It may be sharpened by whetting the bevel on an oilstone and occasionally reshaping the bevel with a file or fine grinding wheel (2, 1).

The back of the cutter is beveled slightly to form a skewed cutting edge with the longer portion on the inside. The longest point on the cutter should be 1/32″ below the cutting edge of the rim, so that the fibers will be sufficiently scored for making a smooth cut before the cutter begins to lift the chips.

Plug cutters are commonly made



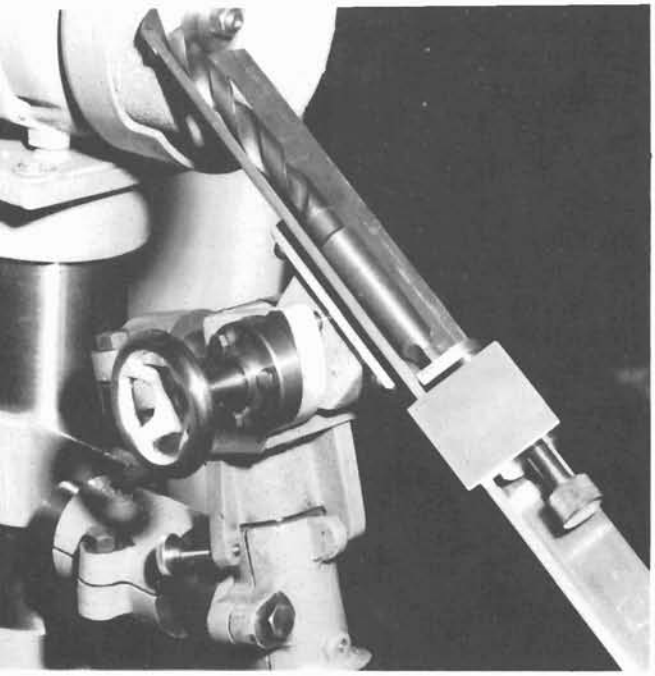
COURTESY MC DONOUGH MANUFACURING CO.

7-27. Model "DA" drill and carbide tool grinder.

in sizes from ⅜″ to 1″, by eighths; the smaller sizes sometimes vary by sixteenths.

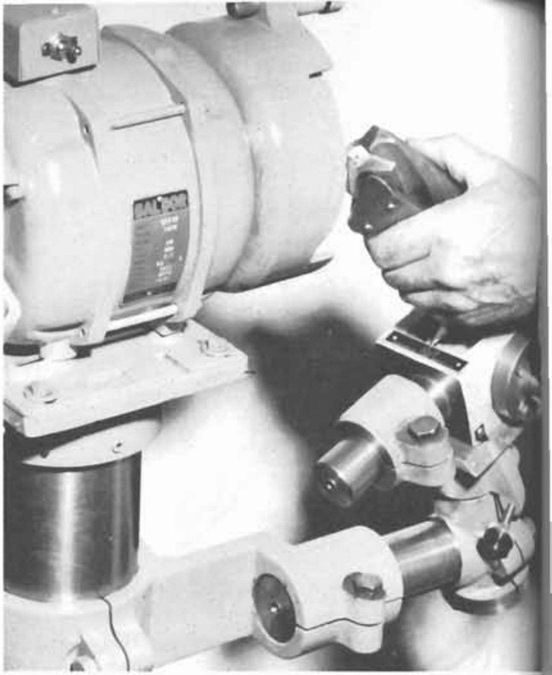
To grind a plug cutter

1. Select the proper grinding wheel. See the chart on, "Grinding Wheel Specifications," page 21.
2. Mount the grinding wheel on the grinder. Use the procedure, "To Mount a Grinding Wheel," page 24.
3. Start the grinder and regulate the valve for the proper flow of the



COURTESY MC DONOUGH MANUFACURING CO.

7-28. Position of drill when grinding on the "DA" drill and carbide tool grinder.



COURTESY MC DONOUGH MANUFACURING CO.

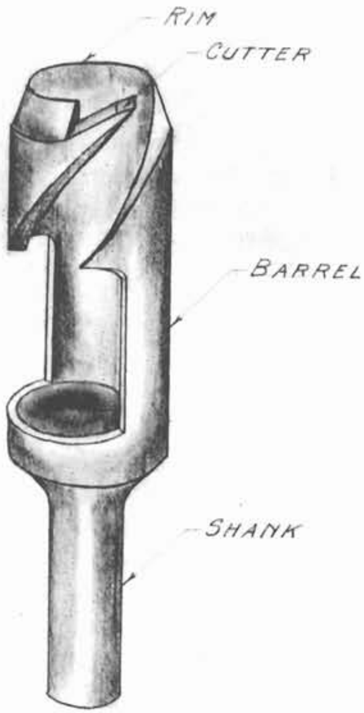
7-29. Grinding a 4-lip drill on the "DA" drill and carbide tool grinder.

coolant. If the grinding wheel is dry, place a container of cold water close by for cooling the tool.

4. Holding the tool with both hands, place the beveled surface on the face of the grinding wheel, and carefully grind a uniform bevel on the rim until a cutting edge forms.
5. Grind the back of the cutter until it is 1/32" shorter than the rim, skewing the cutting edge slightly.

To stone a plug cutter

1. Select fine bench, slip, and round oilstones. Wipe them with a clean cloth and apply a few drops of light oil to the surfaces.
2. Whet the beveled surface of the rim on the bench stone. Remove the burr on the inside of the barrel by whetting against the cutting edge with a round stone,



7-30. Typical plug cutter. As the rim cuts the outline, the cutter removes the chips.

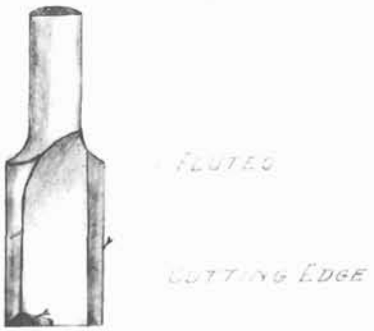
keeping the stone parallel to the side. Continue whetting these surfaces until a sharp cutting edge is obtained.

3. Whet the back of the cutter on the bench stone. Remove the burr on the face by whetting it with a slip stone. Continue whetting until the cutting edge is sharp.

ROUTER BITS

The router bit is a machine tool used for cutting recesses and elongated holes. Most of the cutting is done on the side of the bit by first using it to bore to the required depth and then feeding the stock against the side. The cutting edges are obtained by machining one or two flutes on the body extending to the end. By providing sufficient clearance, cutting edges are formed on the sides and end (Fig. 7-31). Because they operate at a relatively fast speed and are subjected to considerable strain, it is advisable to use bits that are made of high-speed steel. These commonly vary in sizes from ⅛" to ⅝", by sixteenths, and from ⅝" to 1¼", by eighths. The smaller sizes sometimes vary by thirty-seconds.

Router bits should be kept sharp if they are to give satisfactory service. The high speed at which they run causes them to burn easily when dull. If they are allowed to become extremely dull, too much metal must be removed to form a new cutting edge. They can be sharpened by honing the face on a suitable oilstone, bench, or slip type, depending upon the shape of the faces. If they have been run dull, it may be necessary to grind the face to obtain a sharp cutting edge. Grind or whet only the face.



7-31. Typical router bit.

Router bits cannot be jointed, but they can be kept uniform in length by stoning each edge only enough to make it sharp. Since the cutting edge that projects the farthest takes a heavier cut, it tends to dull more than the shorter cutting edge. Careful stoning will help keep the cutting edges uniform.

To sharpen a router bit

1. Select a suitable oilstone. Wipe it with a clean cloth and apply a few drops of light oil.
2. Place the face of the cutting edge on the oilstone and carefully stone it until a sharp edge forms, maintaining the original shape of the surface. Stop stoning as soon as the edge is sharp. Check the cutting edge on the end as well as those on the side.

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2. Rockwell Manufacturing Co., Delta Division, *Dowel Cutter Sharpening Instructions,* PM-1703. Milwaukee, Wisconsin.

PART ONE

CHAPTER 8

Miscellaneous Tools

THE CLAW hammer is the hammer most commonly used by woodworkers. It is composed of the head and the handle. The parts of the head (Fig. 8-1) are the *face, poll, neck, cheek, adze eye,* and *claw*. The shape of the face may be either flat or rounded. The rounded face, being more convex, is used to drive nails even with or slightly below the surface without leaving hammer marks in the wood. The claw is made with a uniform split and a beveled grip so that it cuts into the body of the nail to aid in drawing it. Good hammers are heat-treated to give the poll and face extra hardness. The claw is softer to prevent breakage.

The cross-section of the eye is rectangular, with the opening becoming smaller at the middle than it is at each end. The handle is held tight by spreading the end with wedges to make it fit the eye.

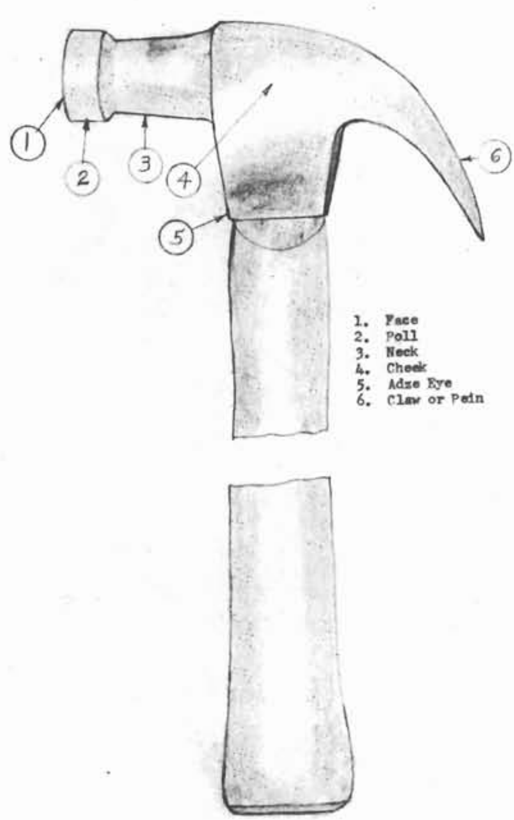
The *size* of a claw hammer is designated by the weight of the head in ounces. Heads commonly vary from 5 to 28 ounces with 10, 13, and 16 ounces in more general use.

The best adze-eye handles are made of selected second-growth, straight-grained hickory that is thoroughly dry and well-shaped. The handle should be examined carefully for straightness, because a straight handle is essential for a properly balanced hammer. Some handles warp and twist after manufacture.

Hammer handles

To replace a broken handle, select one with the end large enough so

8-1. Parts of a claw hammer.



that it will just start into the eye. If it is too small, it cannot be tightened in the head. If it is much larger than the eye, the handle will be too large in comparison to the weight of the head, thus causing improper balance. Handles are made in 12″, 13″, 14″, and 15″ lengths. The 13″ length is generally used in 10-, 13-, and 16-ounce heads.

Handles are tightened in the head by a wooden wedge to expand the thickness of the handle, and a sufficient number of metal wedges to expand the width to fit the eye. Metal wedges are made in sizes appropriate for the various sizes of handles. Numbers 2, 3, and 4 are suitable for the common sizes of hammers used in the wood shop.

If the head is not too loose, drive it on the handle and tighten the wooden and metal wedges. Drive the metal wedges deeper even though it may not be possible to drive the wooden wedge farther.

A hammer handle may also be tightened to some extent and protected from moisture by placing it in a container filled with a sufficient amount of linseed oil to immerse the head, allowing the handle to soak for about 24 hours. Then remove it from the oil and wipe it dry with a clean cloth. Keeping the oil hot will increase the penetration.

The face of the hammer gradually wears uneven after continued use. To reshape it, grind the face at right angles to the center line of the poll. Some workers rough the face on a grinding wheel to keep it from slipping when it is driving large nails.

A good hammer will give many years of service if properly used. Following is a list of suggestions for the maintenance of hammers:

1. Always use the face when striking an object. Do not use the cheek, as it is the weakest part of the hammer.
2. Keep the head tight on the handle by setting the wedges deeper. Striking the end of the handle to tighten the head only tightens it temporarily and eventually causes the handle to split.
3. Do not strike an object that is as hard as or harder than the face of the hammer. Avoid hitting faces of two hammers together.
4. Use only the back of the claw when pulling to gain increased leverage and reduced strain on the handle. Place a piece of wood under the head to keep the leverage on the claw.
5. Do not strike the poll of the hammer to drive the claw behind the head of a nail, or to cut the claw into the body of the object to be pulled.
6. Do not damage the claw by attempting to pull hardened steel objects, such as nail sets fastened into the wood.
7. Do not strike the handle when pulling nails. This practice will eventually break the handle.

To replace a hammer handle

1. Remove the old handle from the

eye of the head. It may be necessary to cut out a portion of the wood by drilling some holes before driving the remainder of the material out with a punch or a piece of hardwood.

2. Select a straight-grained handle that will just start into the eye of the head. Carefully examine the handle to see that it is not warped or twisted.
3. Estimate the location of the head on the handle and with a back saw make a kerf across the width of the handle and approximately half the distance through the eye (Fig. 8-3).
4. Make a hard wooden wedge the width of the end of the handle, about ¼″ longer than the depth of the saw cut and approximately ⅛″ to 3/16″ thick. Taper the wedge to a feather edge at one end.
5. Start the handle into the eye. Holding the handle in mid-air with the head down, strike the other end of the handle a few blows with a mallet so that the momentum of the handle will force it into the head a short distance.
6. With a flat wood file, remove only the wood that has started to curl up around the entrance to the eye.
7. Repeat Steps 3 and 4 until the handle projects through the head and the head is located in the proper position on the handle.
8. Place the end of the handle on the bench and tightly drive the wooden wedge into the saw kerf. File the end of the handle flush with the head.

8-3. Hammer handle prepared with saw kerf to hold thin wooden wedge.

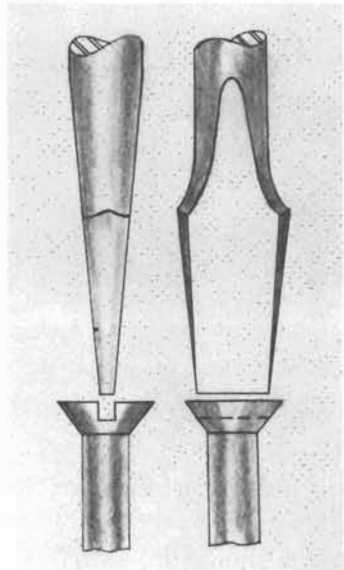
9. Select iron wedges that are almost as wide as the handle is thick at the eye and estimate the number required to spread the handle sufficiently to fit the eye. No more than two of the proper size are usually required.
10. Placing the other end of the handle on the bench, drive a sufficient number of wedges at right angles to the wooden wedge to compress the handle tightly in the eye. File the end of the handle flush with the head.

SCREW DRIVERS

Screw drivers are composed of a blade, a handle, and a ferrule. There are many methods for fastening the blade to the handle. Good screw drivers have a pin which passes through the ferrule, handle, and blade, securely fastening the blade to the handle.

Sometimes the shank passes through the handle and at other times a portion of it is swaged and forced into the handle. The tip is usually tempered so it will hold its shape.

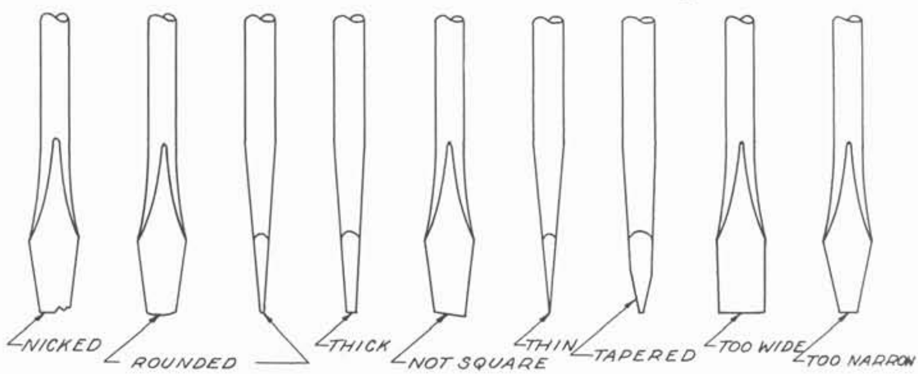
The size of screw drivers is designated by the length of the blade, measuring from the tip to the ferrule. Screw drivers range in length from 1½" to 30", with common sizes of 4", 6", and 8". The shank of regular screw drivers increases in diameter as the size increases. The tapered tip also increases in size. Some special screw drivers are made to follow screws in counterbored holes. The tip has parallel sides and is the same width as the diameter of the shank.

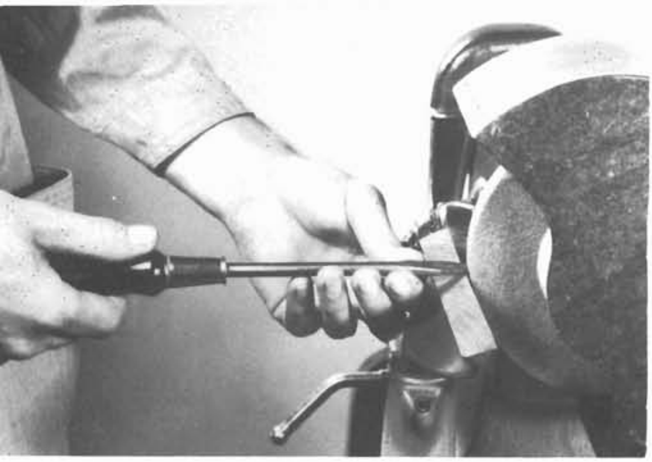


8-4. A properly shaped screw driver tip looks like this.

Screw drivers should be carefully selected as to size and style for each specific job. The tool with the large handle and the long blade produces more torque than the one with the smaller handle and the shorter blade. It is obvious that the larger handle provides more leverage than a smaller one, but it may not be so clear why the tool with the longer shank is more powerful. Although it is generally accepted that the center lines of the screw driver and the screw should be kept as nearly congruent as possible for driving screws, it does seem that some variation from this position is the determining factor in obtaining the increased torque. Because the angle of deviation can be only very slight so as not to affect the position of the tip on the screw slot, a long

8-5. Some common faults of screw driver tips.





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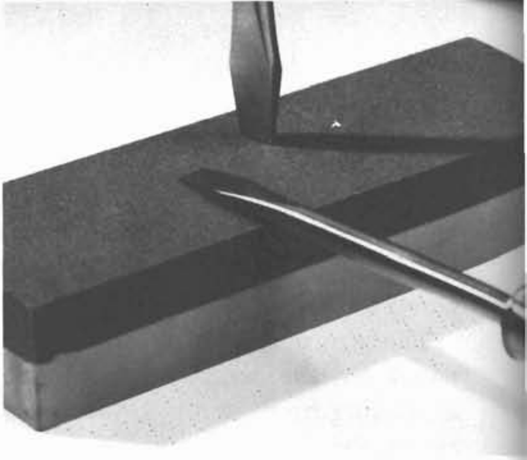
8-6. Grind the tip square on the face of the grinding wheel.



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8-8. Finish the tip on a flat honing stone.

blade is necessary to secure the additional leverage.

The tip should be nearly as large as the length and width of the screw slot (Fig. 8-4). If it is too small, it will twist out of the screw slot and damage it or the tip. The faces should be flat and taper gradually into the shank. If they become poorly shaped, or are formed with a sharp angle, it will be difficult to keep the tip in the screw slot (Fig. 8-5).

To shape a screw driver tip

1. Grind or file the end of the tip so that it is straight and at right angles to the shank (Fig. 8-6).
2. Grind or file the faces of the tip so they are flat and the end of the tip has been reduced to the proper thickness for the size of the screw (Fig. 8-7). If the end is made too thin, it will not be strong enough to stand the strain applied to the screw driver and will break or twist.
3. Remove wire edges on a flat honing stone, (Fig. 8-8).

Screw driver tips can also be shaped on the side of a wheel (Fig. 8-9).

DRAW KNIVES

To grind a draw knife

1. Start the grinder and regulate the

8-7. Grind the tip to the proper shape on the face of the wheel, using offhand method.

PHOTO BY ELLENWOOD

8-9. Faces of a screw driver can also be shaped on the side of a grinding wheel.

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valve for the proper flow of coolant. If the grinding wheel is dry, place a container of cold water close by for cooling the tool.

2. With the handles pointing away from you, grasp them with both hands and place the beveled side of the draw knife on the face of the grinding wheel with the cutting edge parallel to the axial line of the wheel. Next move the blade back and forth across the face. Examine the surface frequently, at first, to see if a uniform bevel at a 30° to 40° angle is being formed. Be sure to put the blade on the wheel in almost the same place and at the same angle each time (Fig. 8-10).
3. After a concave bevel has been formed, continue the grinding process until the bevel is ground to the edge.

To stone a draw knife

1. Select a fine bench-type oilstone that is flat. Wipe the surface with a clean cloth and apply a few drops of light oil.
2. With the handles pointing toward you, grasp them with both hands, place the bevel on the flat surface of the oilstone, and rock the blade to locate the position where the bevel rests flat on the surface (Fig. 8-11).
3. With the cutting edge diagonally to the edges of the stone, draw the blade across the stone to whet the entire length of the cutting edge. Whet the concave bevel at both the cutting edge and the heel simultaneously.
4. Lay the face flat on the stone and whet it against the cutting edge.
5. Continue Steps 2, 3, and 4 until the cutting edge is sharp. If a wire edge forms, pull the cutting edge across the edge or end grain of a piece of hardwood.
6. After removing the wire edge, whet the cutting edge until it is sharp, following Steps 2, 3, and 4.

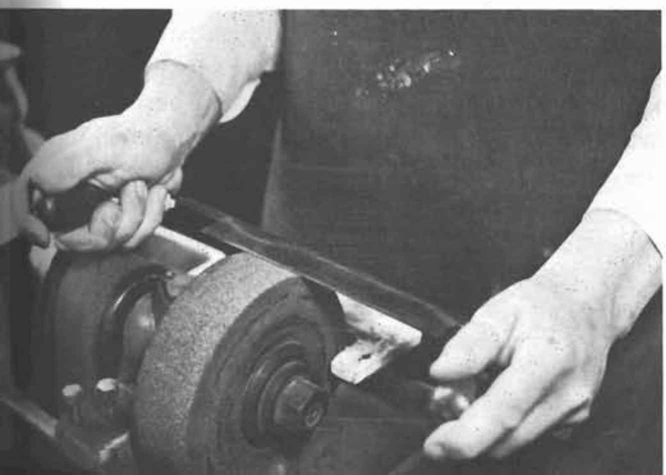
SPOKESHAVE CUTTERS

To grind a spokeshave cutter

Grind the cutter as you would a plane iron, using the procedure, "To Grind a Plane Iron," page 47.

Figs. 8-12, 13 show two other methods of sharpening a spokeshave cut-

8-10. Sharpen a draw knife on the face of a grinding wheel.
PHOTO BY CHARLES J. PEREZ



8-11. Hone the bevel on the flat surface of an oilstone.
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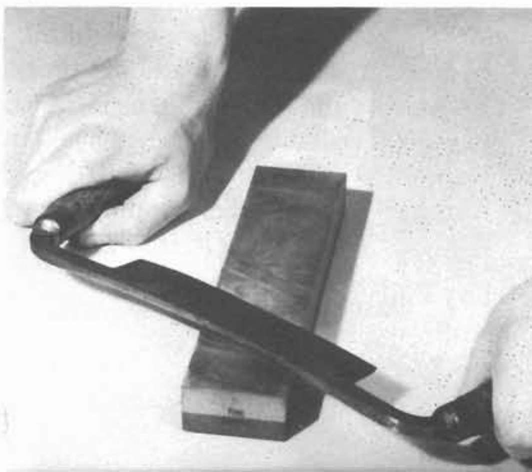

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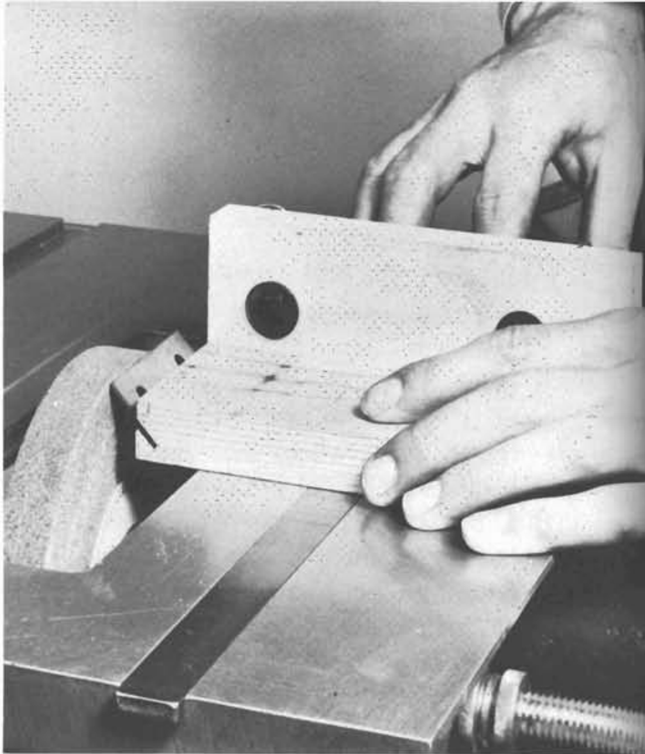
8-12. With the aid of a slotted jig a spokeshave cutter is sharpened here on the face of a grinding wheel.



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8-13. Illustrated here is a method by which a spokeshave cutter is sharpened on the side of a grinding wheel.

ter. A simple wooden jig is used to hold the cutter in place.

To whet a spokeshave cutter

Whet the cutter as you would a plane iron.

POCKET AND SLOYD KNIFE

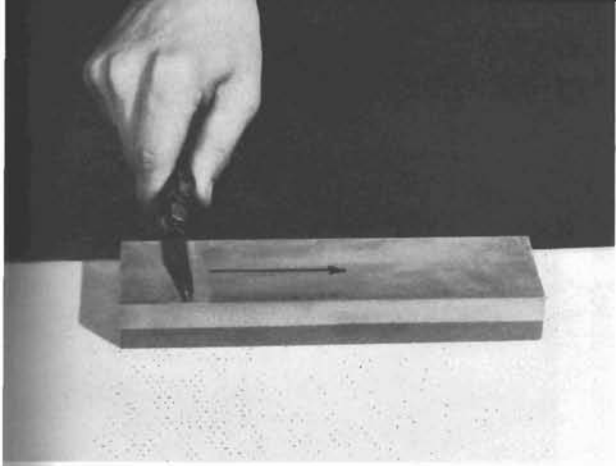
To sharpen a pocket and sloyd knife

1. Select medium and fine bench-type oilstones and wipe the surfaces with a clean cloth. Apply a drop or two of light oil.
2. Place the blade flat on the medium stone; then raise the back slightly and whet back and forth on each side until the edge becomes sharp, applying moderate pressure (Figs. 8-14, 15).
3. Place the blade flat on the fine stone and raise the back slightly. Whet each side against the cutting edge. To remove the wire edge, pull the edge across a piece of hardwood.
4. Continue whetting against the cutting edge until it is sharp.

When the knife edge is nicked, remove the nicks first on a fine wheel (Fig. 8-16).

SCISSORS AND SHEARS

Scissors and shears should be kept sharp if they are to give satisfactory service. Frequently these tools are used long after they have become dull. This causes them to develop corrugations on the inside surface of each blade. To remedy this condition the blades may be whetted on the



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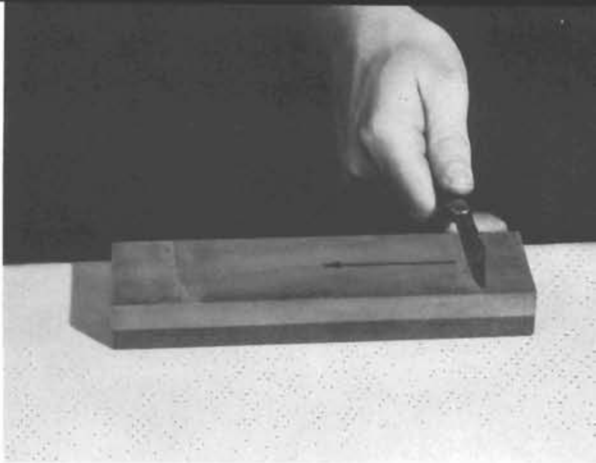
8-14. Sharpen a knife by pushing the edge across the stone in direction of arrow.



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8-15. Reverse the blade and push it in direction of arrow.

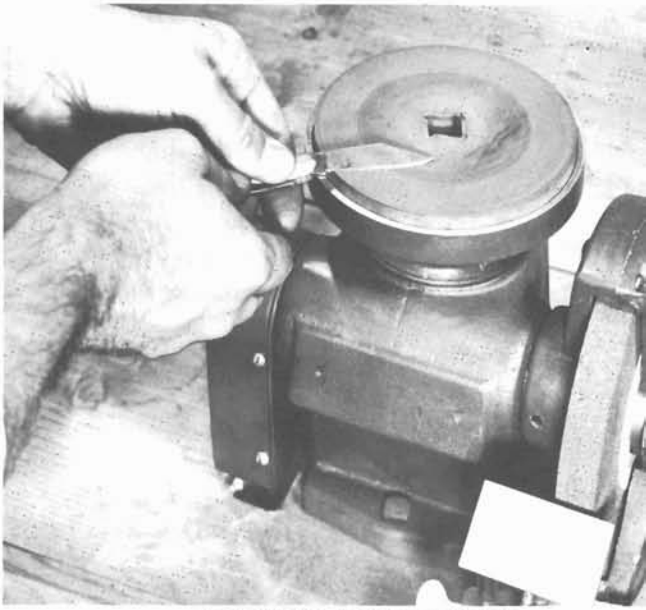
inside if the surface is concave; but this practice will soon cause the blades to make poor contact at the cutting edge. *The only way to secure long service from these tools is to keep them sharp.*

Proper bevel angles for scissors and shears are illustrated in Fig. 8-17.

A drop of light oil applied occasionally to the joint will keep it from gumming and make the tool cut more easily.

To sharpen scissors or shears

1. Select coarse and fine bench-type oilstones and wipe them with a clean cloth. Apply a few drops of light oil to both stones.



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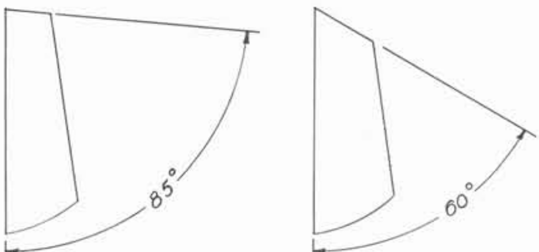
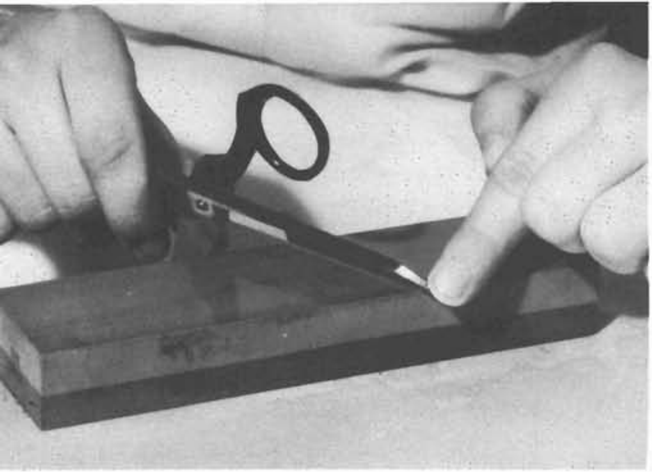
8-16. Remove small nicks on a fine grinding wheel.



8-17. Proper bevel angles for shears and scissors.



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8-18. Sharpen the edge on a flat oilstone.

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8-19. Sharpen very dull scissor edges on a fine grinding wheel.

2. Place the coarse oilstone near the edge of the bench so that one blade can hang free. Take hold of the blade at the handle and the point and place the edge on the stone with the flat side of the blade inclined at about 5° from a vertical plane (Fig. 8-18).
3. Draw the blade diagonally across the stone and against the cutting edge, starting at the heel of the blade and ending with the point.
4. After both blades have been cut to an edge on the coarse stone, repeat Steps 2 and 3, using a fine oilstone. Continue the operation until a fine, sharp edge has been obtained on each blade.

Extremely dull edges can be restored by careful grinding on a slow-moving stone (Fig. 8-19).

SQUARES

The two squares commonly used in the wood shop are the framing square and the try square. The *framing square* has essentially two parts, the body and the tongue. The body is 2″ wide and 24″ long. The tongue is 1½″ wide; either 16″ or 18″ long.

The *try square* has a handle and a blade. The blade is attached to the end of the handle with rivets. The size is designated by the length of the blade from the end to the handle. The common range of sizes is from 2″ to 12″, varying by 2″.

Squares are of little value unless they form a perfect right angle. They cannot be used with any degree of accuracy if the body or tongue of the framing square or the blade of the try square is bent or nicked. The blade of the try square must also be kept tight in the handle.

To recondition a framing square

1. Check the body and the tongue for straightness. If either part is bent, lay the bent portion on a block of hardwood and tap it gently with a mallet until it is straight.
2. With a precision square, check both the inside and outside angles of the framing square for squareness.
3. If the body and tongue are out of square, place the framing square in a vise and draw-file the

edges of the blade and tongue until they fit the precision square.

If the body and tongue are out of square to any great extent, it may be necessary to clamp one part in a vise near the angle and spring the other part until they are approximately at right angles to each other, before draw-filing the edges.

To recondition a try square

1. Check the joint to see that the blade is tight in the handle. If the blade is loose, tighten the rivets by laying the square on an anvil and spreading the rivets with a punch.
2. Straighten the blade so that it is parallel with the broad surfaces of the handle.
3. With a precision square, check both the inside and the outside angles of the try square for squareness.
4. If the handle and the blade are out of square, place the blade in a vise and draw file the edges of the blade until they are at right angles to the edges of the handle. Frequently check them with a precision square.

CLAMPS

The clamps commonly used in the wood shop are *bar clamps, C clamps,* and *hand screws.* All of these clamps have screw spindles which tighten the jaws against the stock. The threads and the movable parts of the clamp should be lubricated occasionally with a lightweight oil to make them work freely.

The bar clamp usually has a spring in the movable jaw to hold it in place after it has been adjusted. Sometimes the spring loses its tension and must be replaced. In such a case, the jaw must be removed so that a new spring can be installed. It can be removed by taking out the rivet at the end of the bar. After the new spring has been inserted and the jaw mounted on the bar, replace the rivet to keep the jaw from coming off.

To remove any glue that may adhere to the surface, clean the wooden jaws of hand screws frequently. Glue on the clamping surface may make indentations on the surface of the stock when it is clamped. Apply a coat of boiled linseed oil to the jaws after they have been cleaned. Linseed oil prevents the penetration of glue into the clamp jaws. Do not use lubricating oil, because it will not dry and will soak into the stock that is clamped, causing a discoloration.

Occasionally it is necessary to replace a jaw on a hand screw. The hand screw can be disassembled by driving the pin out of the handles and unscrewing them. The spindles will then screw out of the jaws. In assembling the hand screw, be careful to start the spindles into the jaws at the proper time so that the jaws can be closed and will not come off the spindles when they are opened. If it does not work properly, the hand screw should be taken apart and reassembled.

WOODWORKERS VISES

The two types of woodworkers vises commonly used are the *continuous screw* and the *rapid-action screw.*

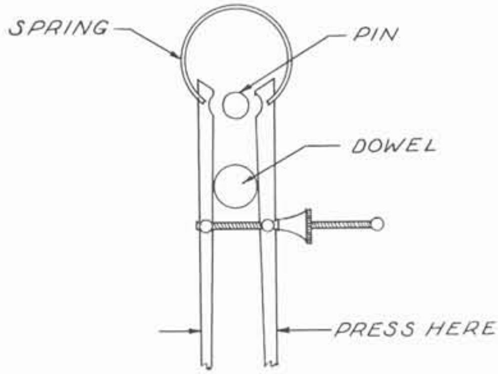
There is a large variety of rapid-action vises, but all of them have a mechanism which engages and disengages the nut from the screw. The nut, usually made of brass, wears much faster than the screw and must be replaced occasionally. Although vises differ in their construction, the vise can be disassembled in most instances by removing the cotter pins from the end of the guide rods and pulling the movable jaw and screw out of the part attached to the bench. The old nut can be removed from the engaging and disengaging mechanism and the new nut inserted.

Lubricate the working parts of the vise frequently with a lightweight oil.

The vise should be securely fastened to the bench. If the screw holes in the bench have become enlarged so that the screws cannot be tightened, plug the holes with hardwood and reset the screws.

DIVIDERS

Dividers usually come in two types: *spring dividers* and *wing dividers*.



8-20. Replace pivot pin by spreading divider legs.

With the first kind, it often happens that the pivot pin will slip out of place or be lost. Pivot pins can be replaced by placing a piece of dowel under the pin and spreading the spring lightly (Fig. 8-20).

In wing dividers the little set screw that tightens down on the wing often becomes lost. In that case it must be replaced by one that fits the threaded hole correctly.

The points of divider legs should be sharp in order to strike a circle. Dull points can be sharpened on an oilstone.

PART TWO

CHAPTER 9

Band Saws

A BAND saw consists of a metal *frame* supporting *two wheels mounted in a vertical position*. The wheels carry the blade. The lower wheel drives the saw blade and the upper one acts as an idler. A *slotted table* through which the blade passes is mounted on the right-hand side between the wheels. The blade is held in line by *two guides*, one below and one above the table. The guide above the table is supported by a *guide post and is adjustable* for the various thicknesses of stock (Fig. 9-1).

BAND SAW WHEELS

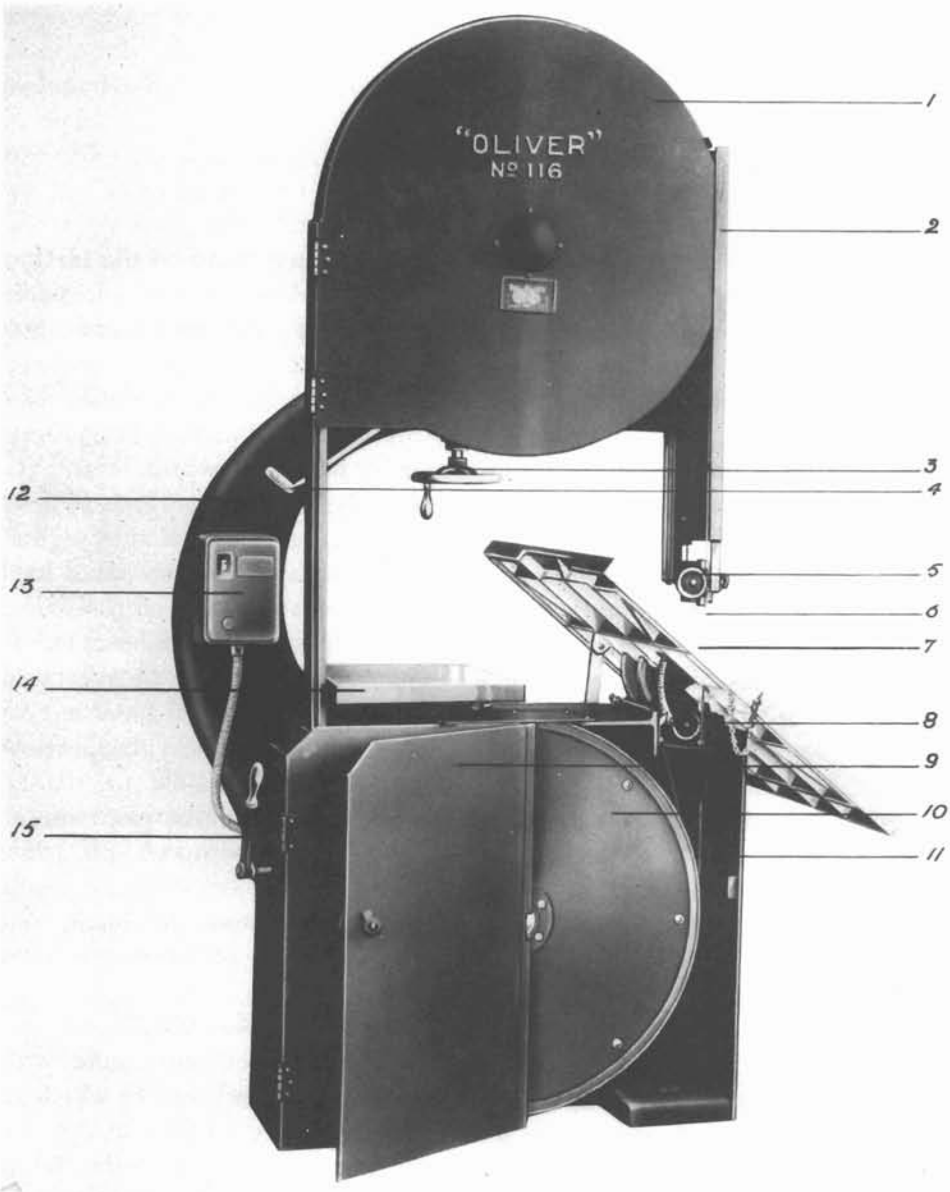
Lightweight band-saw wheels are more desirable than heavy wheels, as they do not place so much strain on the blade when the machine starts and stops.

Band-saw wheels are fitted with rubber tires to protect the set in the teeth and to cushion the blade and prevent its slipping. Soft, pliable rubber gives the needed protection and cushioning effect (Fig. 9-2). The life of the blade is shortened when the tires become hard, thin, cracked, grooved, or loose from the wheels, and no longer cushion the teeth (Figs. 9-3, 4). This condition places unnecessary strain on the teeth, causing the blade to crack. Inspect tires periodically for cracks, cuts, grooves, loose spots, and excessive wear.

There are several methods of attaching tires to the rim (Fig. 9-5). On small machines with a relatively slow rim speed, the tire is held in place by a flange on each side of the rim. The tire is sufficiently small in diameter to make it stay on the wheel. On large, high-speed machines it is necessary to fasten the tires securely to the rim. Centrifugal force is extremely great when the rim speed of the wheel reaches 8,000 to 10,000 and possibly 15,000 feet per minute. If a tire should be thrown off while the machine is in operation, it would undoubtedly break the blade, damage the machine, or injure the operator.

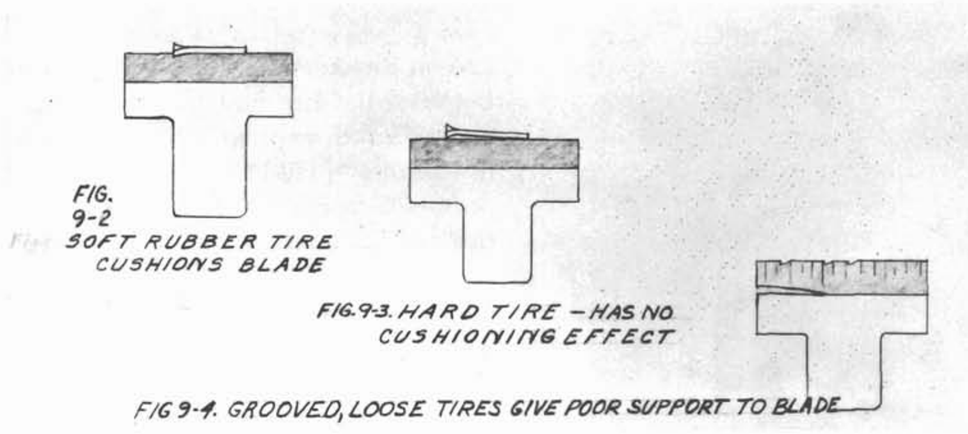
Demountable rims

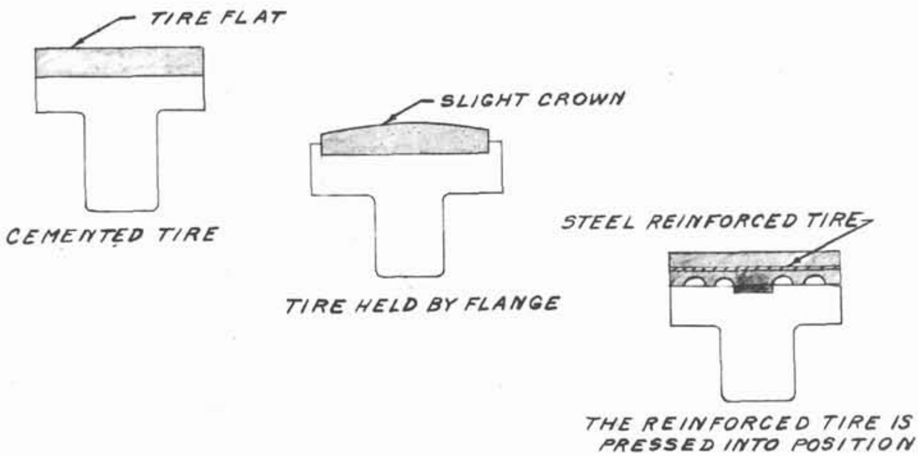
Some wheels are made with demountable steel rims to which rubber tires are vulcanized and dressed true at the factory (Fig. 9-6). When the tire becomes worn, the flanged band which holds the rim on the wheel may be removed and the old rim driven off or cut in two with a hack saw. The new tire, when mounted on



COURTESY OLIVER MACHINERY COMPANY

9-1. Production band saw, showing principal parts: 1. Upper wheel guard. 2. Blade guard. 3. Tension wheel. 4. Tension scale. 5. Upper guide. 6. Blade. 7. Tilting work table. 8. Lower guide. 9. Lower wheel guard. 10. Lower wheel. 11. Rubber tire. 12. Arm. 13. Switch box. 14. Stationary table. 15. Brake.





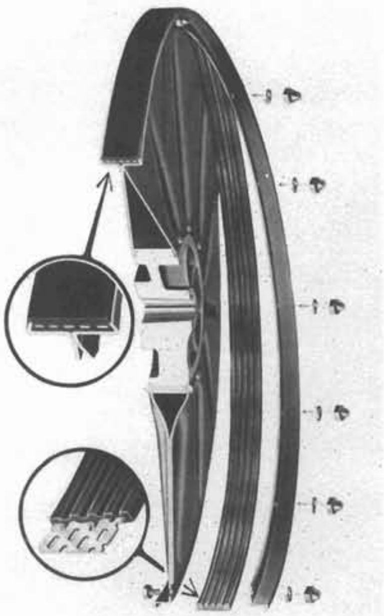
9-5. Different types of tires and rims.

the accurately balanced and centered wheel, is ready to operate.

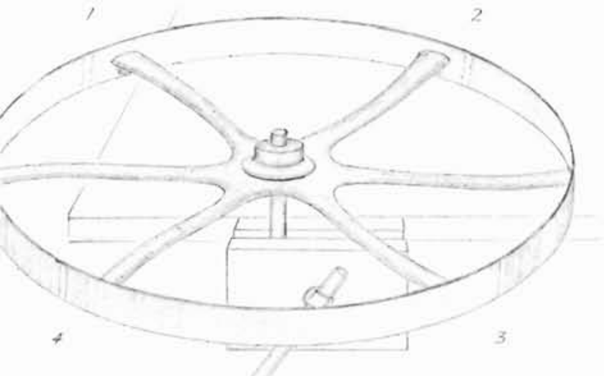
Cemented tires

Some tires are cemented to the rim. The type of cement required is largely determined by the rim speed of the wheel. On high speed machines a good, elastic, rubber cement made for this purpose is recommended (13, 10). When properly applied, a good cement should hold the tire on the rim until the tire is worn out. A new cement should be tested before being used to mount new tires. If the rim speed is slow, shellac, a little thicker than is used on wood, may be used as a substitute for elastic rubber cement.

Mounting tires with cement: There are two different procedures for mounting tires on metal rims. Each can be used successfully. One



COURTESY CARTER PRODUCTS CO., INC.
9-6. Band saw wheel with demountable rim.



9-7. Band saw wheel in horizontal position showing rim divided into four equal parts.

is to apply the cement to the rim and the tire, allowing it to dry slightly before mounting the tire on the rim (13, 10). The other is to place the tire on the rim and apply the cement between the tire and the rim by inserting a rod, approximately one inch in diameter (17, 13). The latter procedure seems more desirable as the tire can be applied without working with glued surfaces. It also allows the tire to be stretched uniformly on the wheel. However, to insure strong adhesion, some cements may need to set partially before the glued surfaces come into contact. If such is the case, the tire will be very uneven in thickness and require excessive dressing to make it run true. The tire is difficult to shift once the glued surfaces come together.

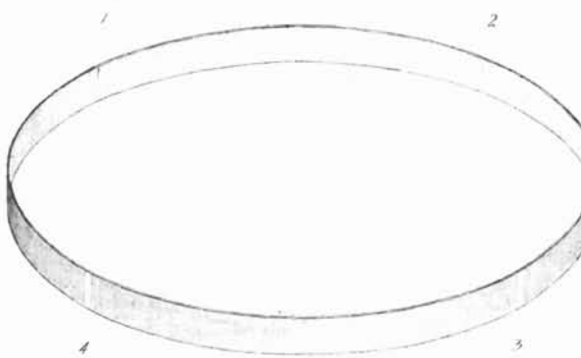
To mount band saw tires with cement

1. Remove the band saw wheels from the machine. If the wheels fit on a tapered shaft you may need a wheel puller.
2. Remove the old tire and clean the surface of the rim. Take off dirt, grease, and cement by washing it with benzine or gasoline. A wire brush will aid in cleaning the bottom of the grooves in the rim.
3. Wash the rough or inside surface of the new tire to remove powder and other foreign material.
4. Clamp a large dowel vertically in the bench vise with the end projecting approximately 6″ above the vise. Lay the wheel on the bench in a horizontal position with the dowel projecting through the hub (Fig. 9-7).

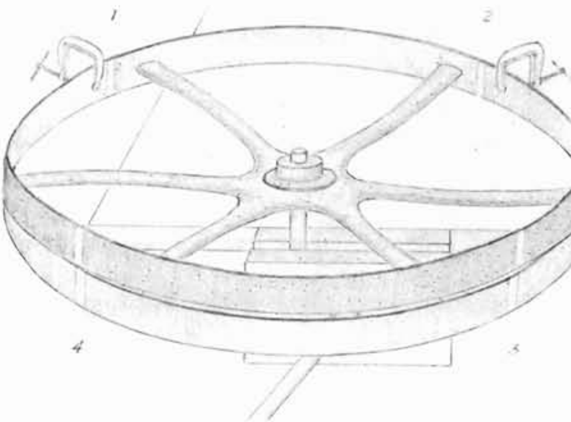
5. Divide the rim of the wheel into four equal parts and mark the points on the edge of the rim with chalk.
6. In a like manner divide the tire into four equal parts, marking the points on the edge of the tire with chalk. (Fig. 9-8)
7. Clamp the tire to the rim with a point on the tire even with a point on the rim.
8. Stretch the tire and clamp it to the rim so that the second points approximately meet. (Fig. 9-9).
9. Continue stretching and clamping the tire to the rim until it is mounted. Be careful not to damage it.
10. Remove the clamps and place a rod approximately one inch in diameter between tire and rim. (Fig. 9-10).
11. Roll the rod around the rim, at the same time applying a liberal coat of cement to both the tire and the rim behind the rod. Be sure there is sufficient cement to squeeze out at the edges of the tire and the rim.
12. Remove the rod and adjust the tire until the marks on the edges of the tire and the rim correspond. The tire should project over both edges of the rim.
13. After the glue has dried almost 40 hours trim off the cement and rubber flush with the edges of the rim.

Shaping band saw tires

A new tire is not likely to be uniform in thickness when mounted on

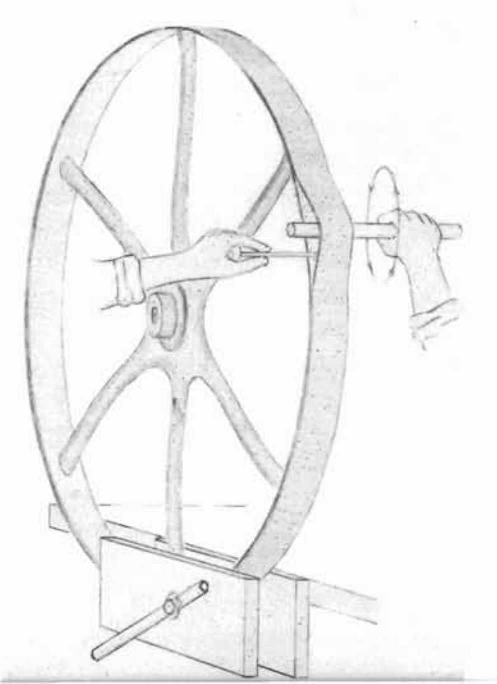


9-8. Band saw tire divided into four equal parts.



9-9. Tire clamped to the rim with points 1 on each coinciding and points 2 meeting.

9-10. Rod used to hold tire away from rim while applying cement.



the rim. Uneven thickness may cause the wheels to run out of balance and place varying tensions on the blade. This condition necessitates *truing* and *shaping* the tire after the wheel has been mounted on the machine.

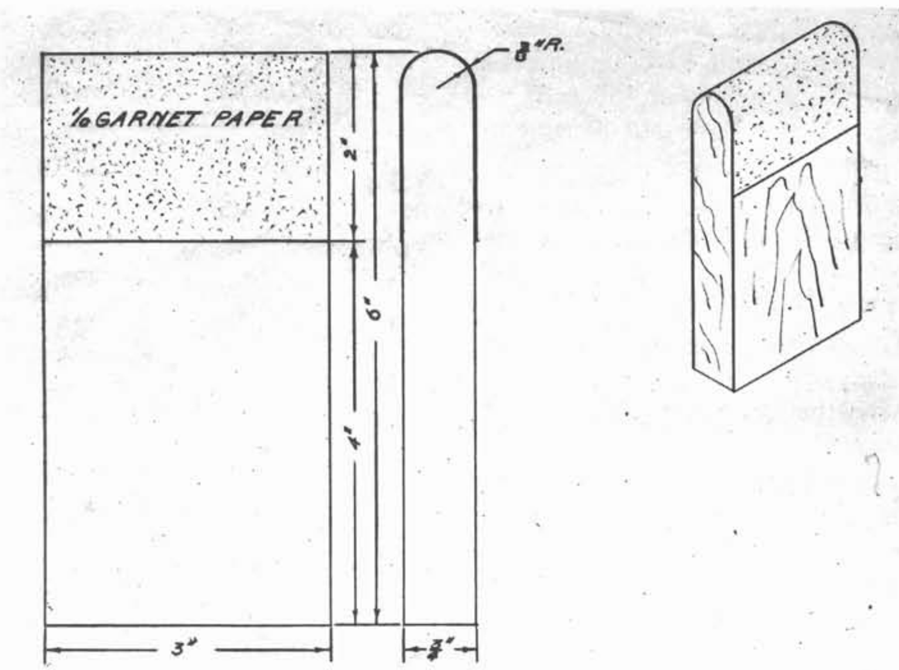
There is no common agreement among band saw manufacturers as to the most desirable shape of the surface of tires. For example, one company (16, 4) recommends making both the upper and the lower tires flat, while another (10, 3) advocates a slight crown on the upper wheel, but a straight lower wheel. Other companies (1, 4, and 14, 7) suggest crowning the surface of both tires slightly to aid in "tracking" the blade.

Practical experience seems to indicate that a slightly convex surface on both tires is desirable because the blade will have a tendency to run to the highest part of the tire and will be more likely to remain on the wheels while in motion. The set in the teeth gradually cuts grooves in the tire, developing a concave surface which makes "tracking" difficult. The convex surface would increase the time before shaping is needed.

Too much crown must be avoided. Extremely convexed surfaces cause uneven tension on the wide blades because only a portion of the blade comes into contact with the tire. Narrow blades, 3/16" and under, are difficult to "track" because there is not enough width to cause the blade to run to the high portion of the tire.

Some band saws have wheels that

9-11. Block for shaping tire.



are *interchangeable;* others are *non-interchangeable.*

To dress a tire on an interchangeable wheel, mount it on the lower shaft and use the motor for turning it.

If the wheels are not interchangeable, mount them on their respective shafts. The lower wheel can then be shaped with the aid of its motor.

Since the blade is running on a tire with an uneven surface, the worker must be especially careful to guard the machine completely for his own protection in case the blade breaks.

A suitable tool for dressing tires can be made by gluing or tacking a piece of 1/0 garnet or aluminum oxide abrasive paper over the rounded end of a wooden block (Fig. 9-11).

To shape tires on interchangable wheels

1. Mount a wheel on the lower shaft. Be sure the wheel is tight on the shaft.
2. Securely clamp a 2″ x 4″ piece of wood of suitable length close to the surface of the tire to serve as a tool rest for the dressing tool.
3. Start the motor and place the dressing tool on the rest and lightly press the abrasive against the surface of the tire. Be sure to hold the dressing tool steady to true the tire.
4. Continue dressing until the tire runs true and the surface is straight or convex, whichever is preferred.
5. Remove the wheel and mount it on the upper shaft.
6. Mount the other wheel on the lower shaft and dress the tire, following the same procedure as before.

To shape tires on wheels not interchangeable

1. Mount the wheels on their respective shafts.
2. Dress the tire on the lower wheel, following the foregoing procedure.
3. Mount a wide blade on the band saw. Use procedure, "To Mount a Band Saw Blade," page 138.
4. Close the doors which cover the wheels and set the guide and guard down upon the table to guard the blade as much as possible.
5. Make a U-shaped guard which will fit around the guide and vertical adjustment bracket, long enough to reach from the table to the upper wheel guard. (Fig. 9-12).
6. Clamp the temporary guard to the vertical guide adjustment bracket so that the blade is fully enclosed from the front and both sides.
7. Start the machine and hold the shaping tool against the tire on the under side of the wheel. (Fig. 9-13).
8. Continue shaping until the tire is properly shaped.

Care of band saw tires

When the band saw is in operation, *saw dust, gum, and pitch,* falling from the gullets, catch between the blade and tires. This waste accumulates on the tires, especially the lower one. Continual accumulation of dirt eventually causes uneven blade tension, vibration, and blade slippage. For this reason, surfaces of the tires should be cleaned periodically. If a cloth dampened with benzine or gasoline does not remove the dirt, the tires should be rubbed with a stiff fiber or

PHOTO BY ROBERT C. SMITHERAM JR.
9-12. Guard placed over blade while tire is being shaped.

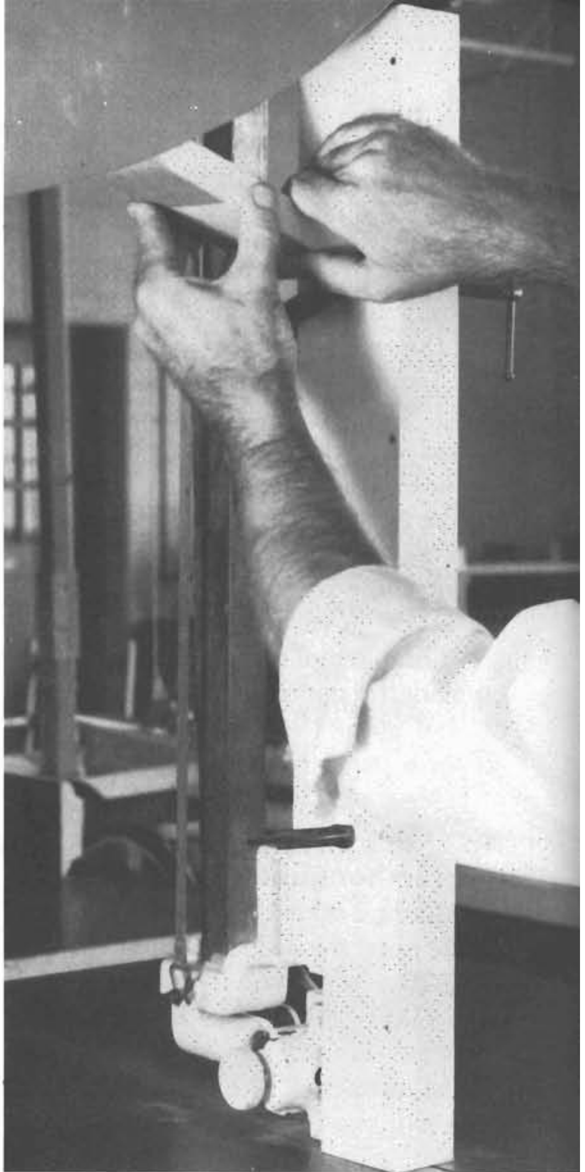


PHOTO BY ROBERT C. SMITHERAM JR.
9-13. Shaping tire on upper wheel with shaping tool.

wire brush and sanded lightly with 1/0 abrasive paper.

Keeping the tires free of grease and oil which cause rubber to deteriorate will also extend the life of the tire.

Set causes the teeth to wear grooves in the tires eventually, making it difficult for the blade to "track." (See page 126). The surface must then be renewed by reshaping the tire, following the procedure for dressing new tires. The tires will operate longer between shapings if the blade is tracked to run at different places, sometimes toward the front and sometimes to the back.

When the machine is to stand idle for any considerable length of time, always release the blade tension. The continued pressure of the blade on the tires causes them to become uneven and need frequent reshaping.

Inspect tires from time to time for loose spots where the tire has separated from the rim. *Cement worked between the tire and the rim* with a thin applicator will repair these spots.

Tension adjustments

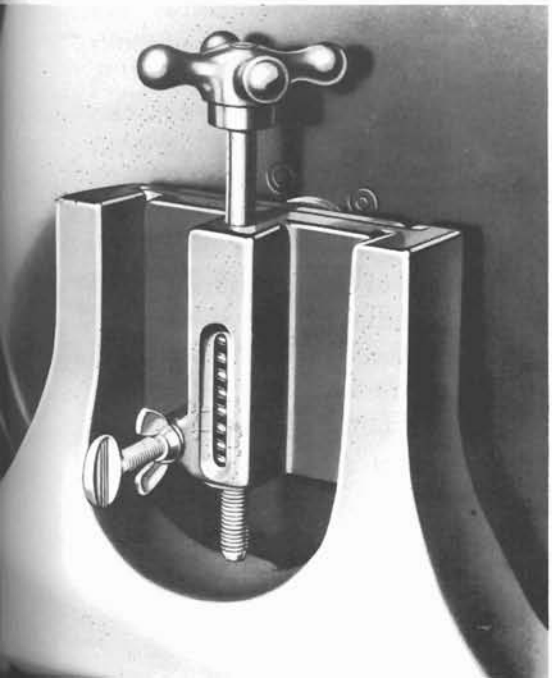
The upper wheel assembly is mounted on a bracket which can be raised or lowered by turning a hand wheel. This vertical adjustment allows for some variation in the length of the blade. It also puts the blade under tension.

A tensioning device commonly used is mounted on the upper wheel assembly by means of a coil spring supported by a screw (Figs. 9-1, 14). Turning the screw to the right raises the upper wheel assembly. When the blade becomes tight on the wheels, further turning of the screw compresses the coil spring to obtain the required tension. The coil spring cushions any shock to the blade when the machine is running.

Another method of obtaining blade tension, is to place a lever on a fulcrum so that the upper wheel assembly is supported on one end and counterbalanced by a weight placed on the other. Placing the weight at different distances from the fulcrum regulates the amount of strain. As the weight moves from the fulcrum, the tension increases. A graduated scale indicates the tension required for blades of various width. Because the upper wheel has considerable vertical travel and the tension does not begin to operate until the blade has become snug on the wheels, the tension scale will indicate the blade tension accurately regardless of the length of the blade.

A blade should never be so tight that the tensioning device no longer functions to cushion and protect the blade from sudden shock. Maximum tension places tremendous strain on the whole machine – bearings, blade, frame, tires, and wheels (15, 42). Such practice, if continued, will eventually damage these parts.

The correct amount of tension is necessary for efficient sawing and long blade life. Yet there is no definite rule to follow for determining it. Consideration must be given to such factors as blade length, type of steel, thickness, width, tooth space, and set when calculating the correct tension for a particular blade (1, 2). Thick blades require more tension than thin



9-14. Compressing coil spring places tension on blade.
COURTESY DELTA POWER TOOL DIVISION, ROCKWELL MFG. CO.

ones; wide blades require more tension than narrow, and long blades require more tension than short ones.

If a blade is too loose, it will whip; if too tight it will produce a low moaning sound. The correct tension is usually between these two extremes. There is no need to put more tension on a blade than is necessary to keep it on the wheels and make it cut straight. It is better to have too little tension than too much.

The tension scale on machines indicates the recommended tension for standard blades for general work. Its use by the inexperienced operator will often reduce much of the blade breakage caused by improper tension. Experienced operators can usually estimate the amount of tension required by pulling the blade out of the guide and testing side movement.

Blade tracking adjustments

"Tracking" is the term used for tilting the upper wheel to a position that will cause the blade to run on a particular place on the tires. One end of the upper wheel shaft housing usually pivots on the vertical adjustment bracket and the other end rises or lowers by means of a screw equipped with a hand knob or a lever. With this arrangement the upper wheel may be tilted to either side of a vertical line to make the blade "track". Each blade has a tendency to run in a different place on the wheels, especially after it has been repaired. It is, therefore, necessary to adjust the "tracking" device each time another blade is mounted.

Alignment of band saw wheels: Align band saw wheels so that the sides are in the same plane. If they are out of line, tracking is difficult and the blade is under excessive strain from running in a twisted condition. There is usually provision for sufficient adjustment on the machines to allow for proper alignment. On some machines the lower wheel can be tilted by raising or lowering one end of the shaft housing. Also, the shaft housing bracket can be shifted horizontally. On other machines the lower wheel is brought into alignment with the upper wheel by shifting its location on the shaft where a key and set screws hold it securely in place. Sometimes the upper wheel has a sidewise or cross-line adjustment with the lower wheel. In such cases all the necessary adjustments can be made on the upper wheel.

With these provisions for adjusting either the lower or upper shafts with reference to each other, the two wheels can be properly aligned.

To align band saw wheels

1. Place a straightedge across the rims at the extreme left of both wheels (Fig. 9-15).
2. Check the relationship of the straight edge to a plumb line with a level.
3. Follow the same procedure at the extreme right side.

If the back of the straightedge is in the same relationship to the plumb line when placed in both positions, the wheels are in proper alignment.

Band saw guides: Band saws are

usually equipped with two guides, a stationary one below the table and an adjustable one above the table. The function of these guides is to hold the traveling blade in place. Guide blocks, located on each side of the blade, prevent it from leading away from the line when it makes a straight cut. They prevent the blade from twisting when it cuts curves. A thrust wheel located back of the blade keeps it from being pushed off the back edge of the wheel by the pressure of the stock against the teeth (Fig. 9-15).

In the place of guide blocks to support the sides of the blade, some band saws have guide wheels. These roll with the blade, eliminating most of the friction and heat which develop when a blade runs between guide blocks. Consequently, guide wheels can be set closer to the blade than guide blocks. For accurate work and maximum blade life the guides should be accurately adjusted.

Guide blocks are placed just back of the gullets. The set will be removed from the teeth if they run between the guide blocks. If too much of the body of the saw projects beyond the guide blocks, the blade will not be sufficiently controlled.

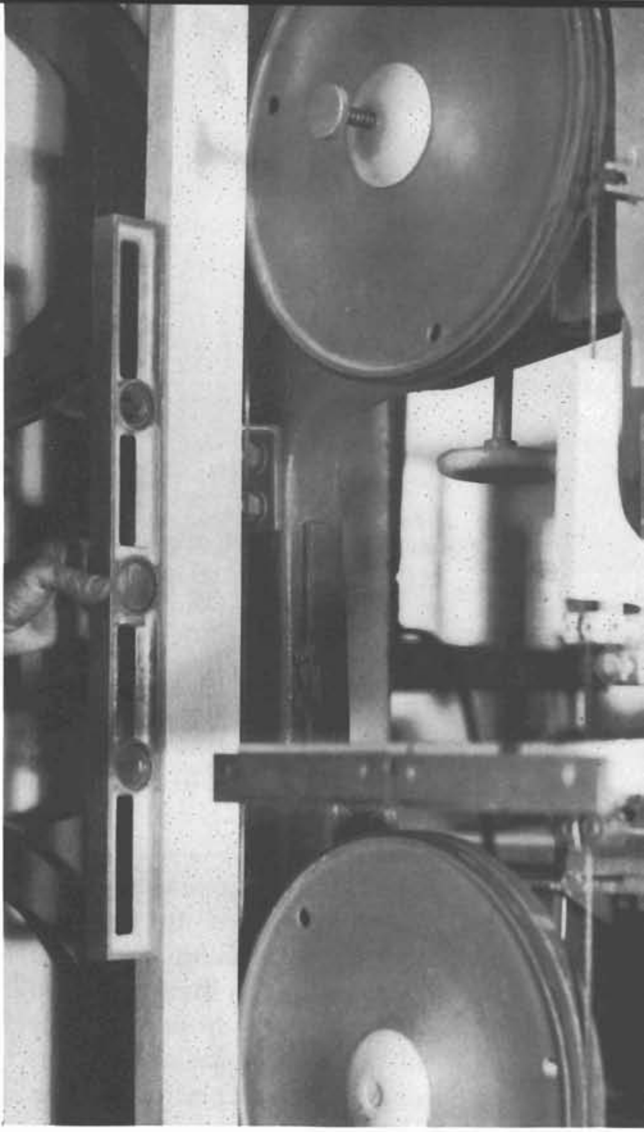
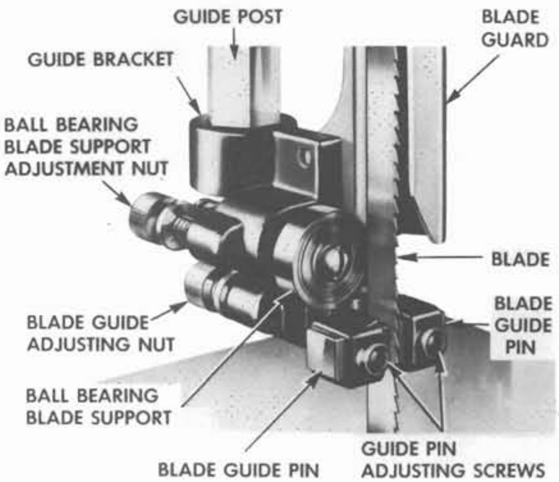


PHOTO BY CHARLES J. PEREZ

9-15. Checking wheel alignment with straightedge and level.

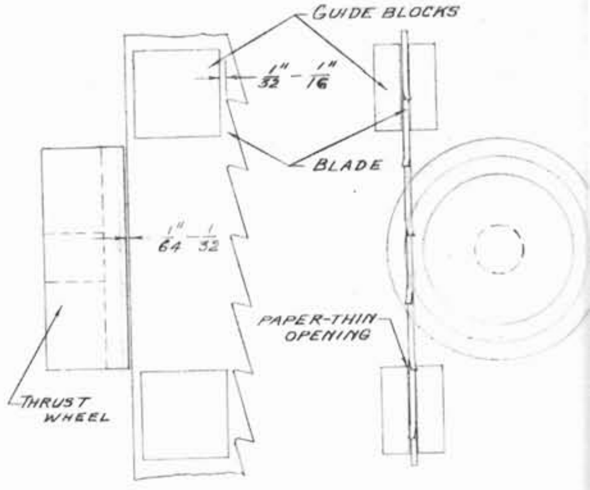
The correct amount of blade clearance is also important for satisfactory sawing performance. If the guides are set with excessive blade clearance, the blade will twist and not make a true cut. With insufficient clearance, it will bind in the guides, causing the blade to fatigue and develop planished spots.

With proper clearance, a thin piece of typewriter paper can be slipped between the blade and each guide block without crowding the blade out of place. No guide block should force the blade from its normal vertical position. Though the total blade clearance may be sufficient, the rubbing of the blade against the one guide block will cause too much friction for proper performance.



COURTESY DELTA POWER TOOL DIVISION, ROCKWELL MFG. CO.

9-16. Band saw guide showing function of principal parts.



9-17. Position of saw blade in relation to guide blocks and thrust wheel.

If guide wheels support the blade, they can be adjusted to touch it lightly, since the rolling movement will not create much friction. However, excessive pressure on the sides of the blade should be avoided, as it will have a drawing effect on the blade, causing the metal to harden and be more subject to fatigue.

The thrust wheel is set $\frac{1}{64}$″ to $\frac{1}{32}$″ back of the blade (Fig. 9-17). It should not turn when the machine is running idle, if so, only very slowly. Too much pressure against the thrust wheel heats the back of the blade, causing planished or hardened spots. As a result, the guide surfaces are quickly worn and blade life shortened.

After the guides have been adjusted, the wheels are slowly turned to see that the full length of the blade passes through the guides without binding. Joints that have not been worked down to the thickness of the blade may bind. If so, they are dressed to the thickness of the blade before they are used. Since there will naturally be a temperature rise in the guides and blade because of friction, check the blade clearance after the machine has been in operation a short time. Adjustment of the guides is necessary whenever a blade of different thickness and width is used. The blade or guides should never be lubricated to reduce blade friction because of dust collection and impaction. After lubricating the bearings be sure to wipe the exterior surfaces of the guide free of oil with a clean cloth.

When cutting curves the blade exerts considerable pressure against the guide blocks. Because of the twisting effect the front edge of the guide blocks wear faster than the back edge. Such blocks do not give the blade proper support at the front or at the back. To remedy this situation, they may be reversed in the holders by using the opposite end.

The ends should be ground flat when they are worn out of square. They should be kept cool during the grinding operation because over heating the metal will draw the temper and leave the surface too soft. It requires care and patience to make the surface flat and square with the sides. When the guide blocks become too short, new ones should be installed.

The upper guide is mounted on a guide post which may be raised or lowered depending on the thickness of the stock to be cut. It is obvious that the guide should remain in the same relationship to the blade to support the blade properly regardless of its height above the table. The adjustment of the guide should be checked at the two extreme positions of the guide post. On some machines an adjustment can be made in the guide post bracket for correcting errors in the alignment of the guide.

To adjust band saw guides

1. After the band saw blade has been tracked, move the upper guide forward until the front edge of the guide blocks or wheels are just back of the gullets of the teeth.
2. Set the guide blocks with .003″ clearance between each guide block and the blade. A thin piece of typewriter paper slipped between the blade and each guide block without crowding the blade out of place provides the necessary clearance.
3. Set the thrust wheel about 1/64″ to 1/32″ from the back of the blade.
4. Set the lower guide following the foregoing procedure.
5. Adjust the upper guide post so the guide is 1/4″ above the stock.

BAND SAW TABLES

The band saw has two tables, a work table and an auxiliary table. The work table is mounted on trunnions so it can be tilted 5° to the left and 45° to the right (Fig. 9-1, page 122). Some tables can also be adjusted horizontally to align them with the "run out" of the blade so that the rip and cut-off fences can be used for straight line sawing.

Most machines have a leveling stop to aid in setting the work table at right angles to the blade. To adjust the leveling stop loosen the lock nut and adjust the threaded stop until the top of the work table is square with the blade. With the blade under tension check the table for squareness with the blade by using a try square. When the table is square with the blade, tighten the lock nut. Next set the pointer to zero on the scale.

The work table is slotted from one edge to the throat so that the blade can be inserted. In the edge of the table there is a hole in the slot into which a taper pin fits to keep the top of the table flush and to give added support (Fig. 9-1, page 122). The pin should be replaced immediately after changing the blade to prevent the table from springing and possible breakage.

There is a throat opening in the work table where the blade runs through. A throat plate with a narrow slot opening for the blade fits into the throat to keep pieces of wood from falling between the blade and the lower wheel. It is made of soft metal or hard wood which does little damage to the teeth in case the blade is pushed against it. When the slot becomes enlarged so that pieces of wood other than sawdust can fall through, the worn throat plate needs replacing.

The auxiliary table is located at the rear of the work table and is bolted to the main frame.

BRAKES

Some band saws are equipped with a braking mechanism which brakes the lower wheel; others have one which works on both wheels simultaneously. Both types may be either mechanical or hydraulic. Brakes operating on both wheels permit the machine to be stopped quickly without putting much strain on the blade. When the operator applies the brake to the lower wheel, the blade stops the upper wheel. He must be careful in applying the brake to prevent breaking or throwing the blade off the wheels, especially when using narrow blades. Sometimes the electrical circuit is automatically broken when the brake is applied; at other times the stop button must be pushed before the brake is applied. On some machines the braking mechanism is connected with the tension device so that, when the blade breaks suddenly, releasing the tension, the brakes are automatically set.

Since there are so many types of braking mechanisms, it is advisable to follow the manufacturer's instructions when any adjustments are needed.

BAND SAW BLADES

The band saw blade is subjected to considerable strain during the cutting process. The twisting action when the blade is cutting curves; the flexing from a straight line to a half circle and vice versa as the blade travels over the wheel; the tension developed from the cutting action; and the blade tension required to keep it on the wheels — all cause one to wonder how a small band of steel can be made to stand the strain even with the best of care. Yet, there are few woodworking tools more abused. The life of a blade depends upon the way it is used. Its life can be extended only by selecting the correct blade for the work, by giving it proper care, and by carefully adjusting the machine.

The regular wood cutting blade is made both flat and beveled. Because the beveled blade is thinner toward the back, it will cut smaller curves than a straight blade of the same size and many users prefer it. The teeth can be set, jointed, and filed by hand or machine.

Since the development of the metal cutting band saw, a new type of blade is being used on wood cutting band saws for certain kinds of materials and jobs. The body of the blade is softer and more flexible than the ordinary blade. The cutting edge is hardened to prolong its cutting life between sharpenings. The teeth are so hard that they cannot be filed by hand; neither can they be set. However, they can be sharpened one or two times by grinding and still have sufficient set. The cost of grinding is approximately one-half the cost of a new blade. Some operators find it more economical to discard the blade when it gets dull.

The buttress tooth pattern, a hard edge, flexible back blade, commonly called a skip tooth blade, is recommended for sawing hard, thick stock where extra large gullets are required to carry away the saw dust.

Selection of band saw blades

Narrow band saw blades should be selected with care and judgment, considering both the work to be done and the size of the wheels upon which they are used.

Width of blades

In woodworking, blades under ¾″ are designated as narrow blades. Those under ¼″ vary in widths by sixteenths of an inch, and those above ¼″ vary by eighths of an inch. The sizes more commonly used in the shop for scroll sawing range from ⅛″ to 1″. The capacity of the machine is the deciding factor in selecting the wide blades.

The size of radius that can be cut is determined by the ratio of the width of the saw cut to the width of the blade. A smaller radius can be cut by increasing the amount of set or reducing the blade width, as either increases the cutting angle of the blade. Since the principles of tooth design limit the amount of set that is practical, the minimum radius that can be cut is determined almost entirely by the width of the blade. Because wide blades usually last longer, it is best to use the widest blade that will make the cut without twisting. As a general rule the width of the blade should be approximately one-third the radius of the circle being cut.

Table 9 gives the minimum radius that can be satisfactorily cut with the various widths of blades with average set (11, 5).

TABLE 9

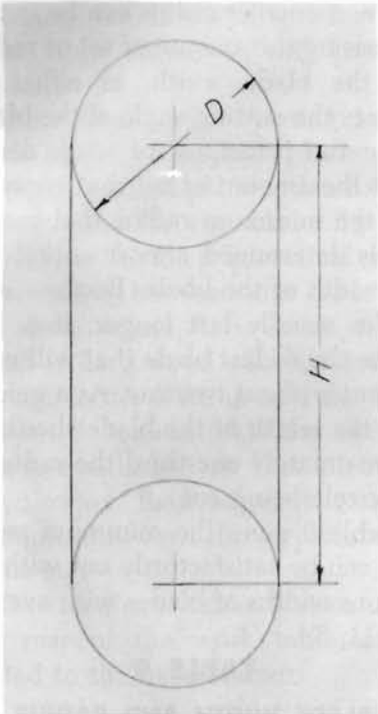
BLADE WIDTH AND RADIUS CUT EQUIVALANTS

Width of Blade (any gauge)	Minimum Radius Cut Without Twisting Blade
⅛ ″	¼ ″
3⁄16″	½″
¼ ″	¾ ″
⅜ ″	1 ″
½ ″	1¼ ″
⅝ ″	1¾ ″
¾ ″	2½ ″
1 ″	4½ ″

Blades used on high speed band saws should be narrower than those normally used on slow-speed machines. They reduce burning caused by the increased friction of wide blades. Because of better balance, narrower blades can be used on the high speed machines with equal blade life.

Length of blades

The diameter of the wheels and the



9-18. To calculate the length of a band saw blade, take twice the distance between wheel centers (2H) and add 3.14 times the diameter of the wheel (3.14D).

maximum and minimum distances between the hub centers must be known to calculate the length of the blade that can be used on the machine. In Fig. 9-18, if D is the diameter of the wheel in inches and H is the distance between the hub centers in inches, by letting L equal the length of the blade, the following formula can be used to calculate the length of the blade: $L = 2H + 3.14D$. When calculating the length for new blades, take the measurement between the hub centers with the upper wheel raised to its maximum height. The blade should be cut slightly shorter than the maximum length so that the upper wheel will not reach its extreme height when the tension is applied. This will give the blade sufficient length to be joined several times in case of breakage.

Thickness of blades

Considerable care should be given to the selection of the proper thickness of a blade. Possibly as much as 75% of the blade strain comes from bending over the wheels and straightening out again (11, 5). This continual flexing of the blade causes metal fatigue and failure. Fatigue is the tendency for a metal to break under continued flexing considerably below the maximum tensile strength (12, 6). It is a false belief that crystallization is the cause of metal failure. The crystalline structure does not change if the fracture is due to repeated abnormal stress alone (12, 4).

The gauge of the blade required depends upon the diameter of the wheels and the work to be done. Thick blades will stand more strain from cutting than thin blades, but will break more easily from the bending action, especially when run on small wheels. Each revolution flexes the blade near the elastic limit of the steel, which causes the metal to tire and break quickly. Thinner blades are preferable to heavy blades when the work is light.

A general rule for determining the thickness of a blade is to allow .001″ in thickness for each inch in the diameter of the wheels (3, 5). The gauge of the blade can be determined by referring to a table of wire and metal gauges and their decimal equivalents. Saw manufacturers generally use the Birmingham or Stubbs gauge for listing the thicknesses of saws.

A study of factors which affect blade life shows that there is a direct relationship between the length and the thickness of the blade and the diameter of the wheels. Table 10 gives the size combinations that are recommended for satisfactory performance (11, 6).

TABLE 10

RECOMMENDED THICKNESS FOR BAND SAW BLADES

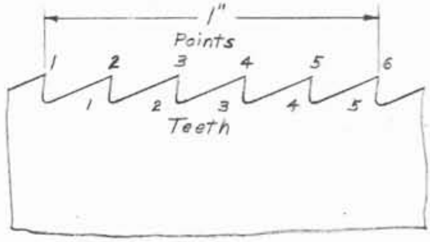
Length of Blade	Diameter of Wheels	Recommended Thickness (Gauge)
6′ to 10′	10″ to 20″	25 gauge
10′ to 15′	21″ to 30″	22 gauge
15′ to 21′	31″ to 40″	21 gauge
*Over 21′	41″ and over	20 gauge

*Blades ¾″ and under can be 21 gauge.

Tooth spacing

The cutting speed and smoothness of cut depend upon the spacing of the teeth. A coarse saw cuts faster, but not as smoothly. The wide tooth spacing provides a large area between the teeth for the accumulation of sawdust. Such spacing cleans out the cut faster and with less friction and heat. This is an important factor for obtaining efficient sawing performance, especially when cutting thick stock. With thin stock the tooth spacing is not so important.

Fine-toothed saws have more teeth in contact with the stock at a given time, each removing a small portion



9-19. Points and band saw teeth compared. Note that there is always one more point than there are teeth per inch.

of material, making smoother cuts. But more teeth rubbing the saw cut create more heat and increase the possibility of clogging when cutting thick stock.

Tooth spacing is also affected by the speed of the machine. As the speed is increased the tooth space is increased; therefore high speed machines can be operated efficiently with coarser saw blades than would normally be used.

Tooth spacing is designated by giving either the number of points per inch or the number of teeth per inch. The former method has been used for many years, but some manufacturers have adopted the latter. The only difference is that there is always one more point than tooth per inch (Fig. 9-19).

For general purpose sawing the coarse saw blade is desirable. Four or five points per inch will give a satisfactory cut, but where a very smooth cut is required six or seven points are better. (8, 17).

Narrow blades have shallow gullets and thus a greater number of points per inch. More points give added width and strength to the body of the blade. Wide tooth spacing on a narrow blade, 1/8" for example, would require almost the full width of the blade to form the teeth. The depth of the tooth is approximately 0.3 to 0.4 of the tooth spacing (7, 62).

Information for purchasing blades

Band saw blades are sold either in single blade length or in rolls of 100, 250, and 500 feet. They may be purchased as follows: set, filed, and joined; neither set nor filed; filed but not set; set but not filed, and not joined.

If the shop is equipped with a brazer or welder, band saw set, and a filer, it is more economical to purchase blades by the coil, neither set nor filed. The whole coil should be set before saw lengths are cut off. The set will aid in cutting lengths which contain an even number of teeth. If the teeth at the two ends are set toward opposite sides, there is an even number of teeth in the piece cut off. If a blade does not have an even number of teeth, setting is difficult, especially with a machine. Unless the setting is started at the odd tooth, some of the teeth will be bent toward the opposite side each time this operation is performed.

When selecting a blade consider the following points:

1. Length
2. Width
3. Thickness (gauge)
4. Type of teeth – regular, hard edge, buttress, etc.
5. Type of back – plain, beveled
6. Coarseness – teeth or points per inch
7. Condition – set and filed, filed but not set, set but not filed, joined or not joined

Changing band saw blades: Band saw blades are changed when a different width blade is required, the blade has broken, or the teeth have become dull. Successful saw performance largely depends on the proper installation of the blade.

To remove a band saw blade

1. Pull the switch in the fuse box and open the doors which guard the two wheels.
2. Pull the alignment pin in the edge of the table and remove the throat plate, if necessary.
3. Release the tension on the blade by lowering the upper wheel.
4. Grasp both sides of the blade and lift it off the wheel.
5. Coil the blade. Use procedure, "To Coil a Band Saw Blade," page 139.

To mount a band saw blade

1. Pull the switch in the fuse box and open the doors which guard the two wheels.
2. Pull the alignment pin in the edge of the table and remove the throat plate, if necessary.
3. If possible, loosen the guide holders and push the guides out of line with the wheels. Some guide holders have no horizontal adjustment so the guides cannot

be moved back from the blade.

4. Uncoil the blade. Use the procedure, "To Uncoil a Band Saw Blade," page 140 and following.
5. With the teeth edge toward you and the hands grasping the blade approximately in the middle, work the blade through the slot in the table, and set it on the upper wheel. Be sure that the teeth passing through the table point down. If not, the blade must be removed and turned inside out.
6. Place the blade on the lower wheel. It may be necessary to change the height of the upper wheel slightly in case there is a variation in blade length.
7. Apply the correct amount of tension to the blade. A blade cannot be properly tracked unless it has approximately the correct tension.
8. Replace the throat plate and alignment pin, tapping it lightly. Avoid driving it too tight as excessive strain may crack the table.
9. Slowly turn the wheels by hand in the direction of normal operation. At the same time, adjust the tracking device until the blade runs in the desired position. The blade has a tendency to run toward the tight or high edge of the rim. If the guides have no horizontal adjustment or have not been moved back from the blade, the thrust wheel must be adjusted to prevent the teeth from running between the guide blocks or wheels while the blade is made to track.
10. Adjust the guides. Use procedure, "To Adjust Saw Guides", page 133.
11. Turn the band saw wheels by hand and recheck all the adjustments, making any necessary changes. The power is never turned on until the blade tracks satisfactorily. The blade can be thrown off by changing the tilt of the wheel when it is running at full speed.
12. Close the doors which cover the band saw wheels and close the switch in the fuse box.
13. Adjust the guide post until the top guide is about 1/4″ above the stock to be cut.
14. Start the machine. Make minor adjustments while the machine is in operation.

To coil and uncoil a band saw blade

Band saw blades are conveniently stored if they are coiled. Usually they are coiled in three loops. For packaging purposes, however, long blades are usually coiled in five loops.

A. To coil a blade in three loops.

1. Hold the blade vertically with both hands as when putting it on the saw, with the teeth pointing toward you (Fig. 9-20).
2. Let the bottom of the blade slip under the toe of one foot. While holding the blade at about the middle between the thumb and fore finger, extend your arms from each side of your body and at the same time turn the teeth in, thus permitting the top half of the blade

PHOTO BY R. A. MC COY

9-20. Hold the blade with teeth pointing toward you and with bottom of blade held under toe of one foot.

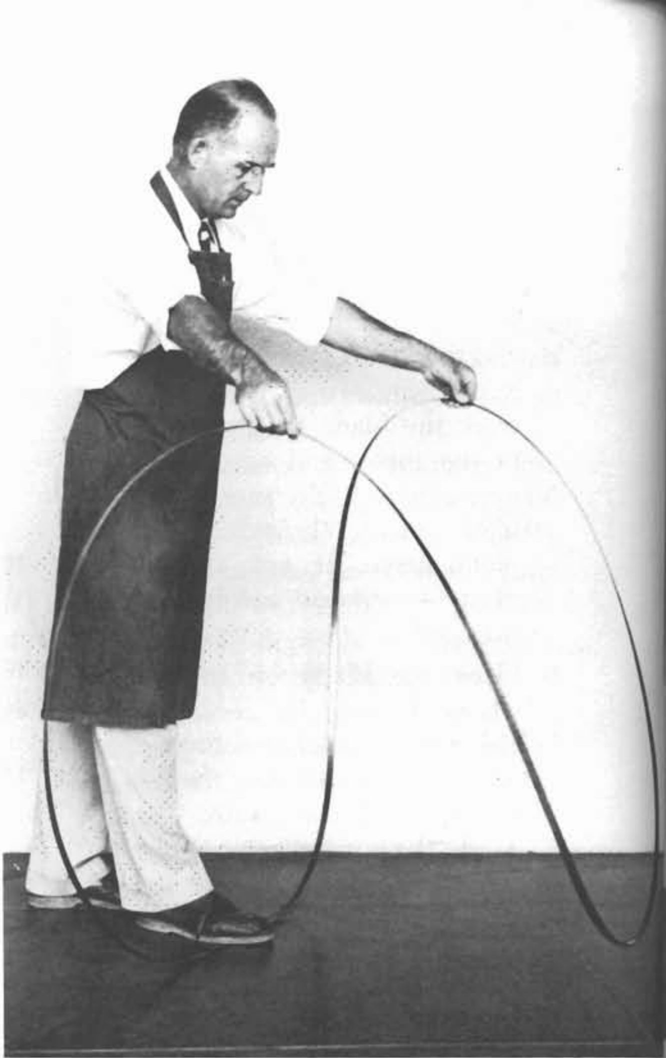


PHOTO BY R. A. MC COY

9-21. Extend your arms, turn the teeth in, permitting top half of the blade to bend away from you.

to fall away from you (Fig. 9-21).

3. Bring your hands together and swing the loop until it comes to rest on your instep (Fig. 9-22).
4. After letting the portion of the blade held in your hands cross (Fig. 9-23), pick up the loop resting on your instep (Fig. 9-24), and raise it to the position of the top loop (Fig. 9-25).
5. The blade is now ready for storage.

B. To Uncoil a Blade with Three Loops.

1. Hold all three loops in your right hand with the teeth pointing to the left (Fig. 9-27).
2. With the left hand select a loop at random until one is above the two crossed loops below.

PHOTO BY R. A. MC COY

9-22. Bring your hands together and swing the loop until it rests on your instep.

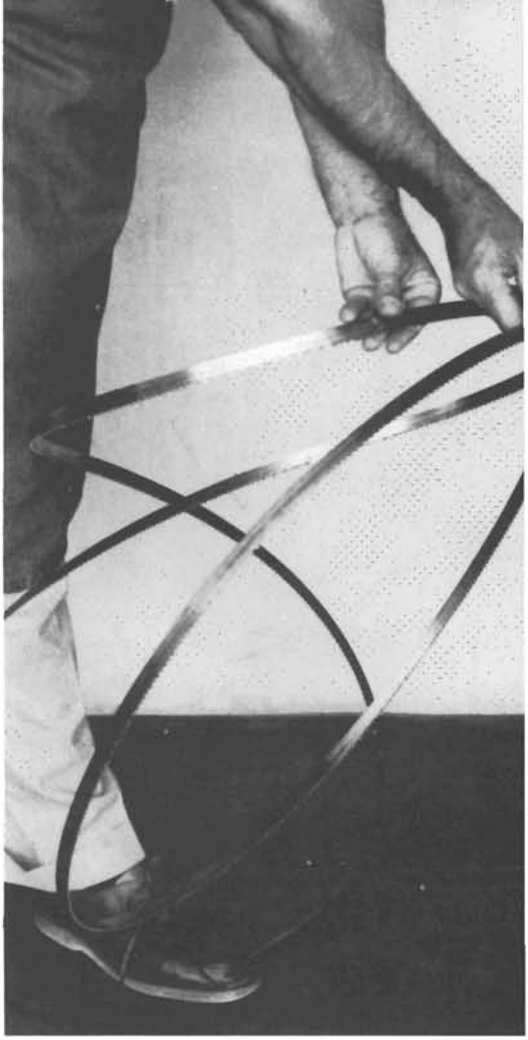


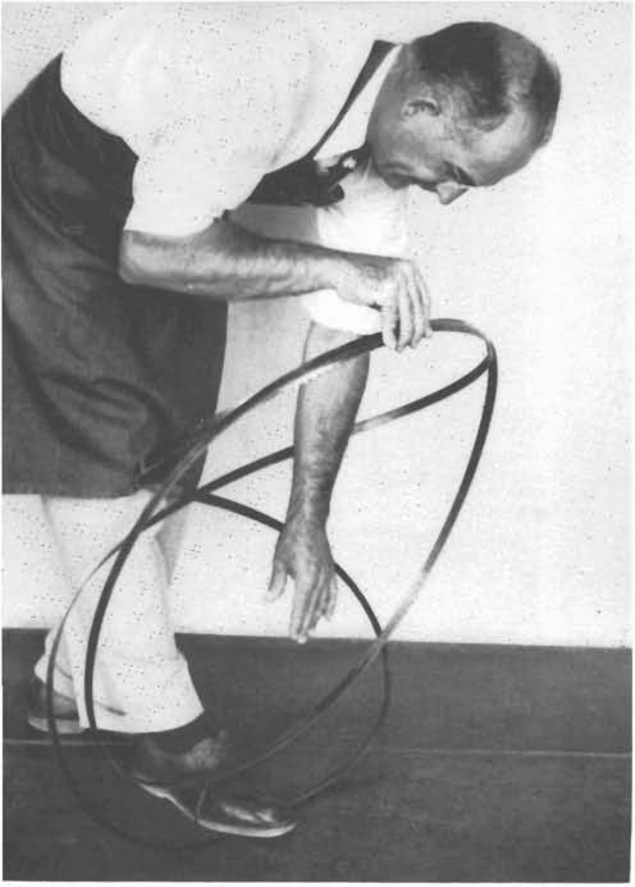
PHOTO BY R. A. MC COY

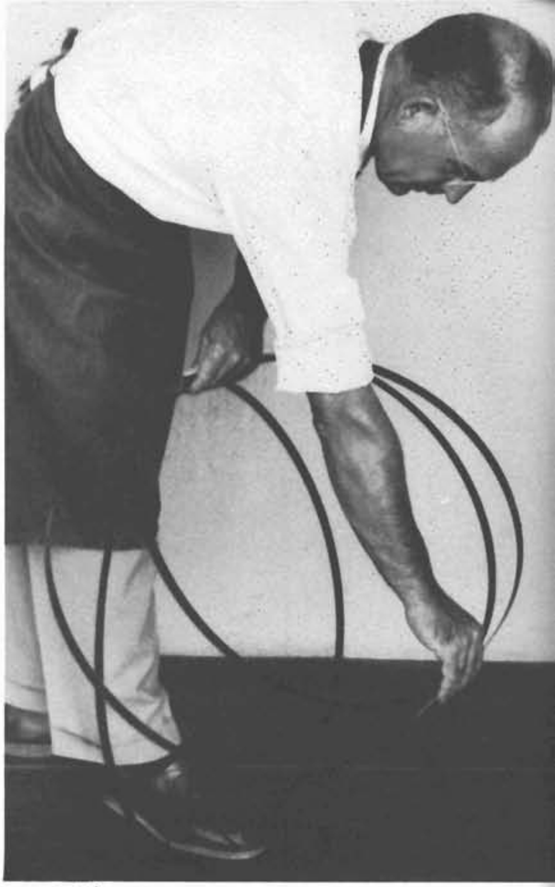
9-23. Let the portion of the blade held in your hands cross.

3. With the left hand still holding one loop, reach down and grasp the loose loop (Fig. 9-28).
4. While holding the two loops firmly in the left hand, let go of the loops held in the right hand.
5. The blade is now held in the middle by the left hand and is full length (Fig. 9-29).
6. Hold on to one loop in the left hand, and grasp the other with the right hand.
7. The blade is now unfolded and ready for installation.

C. To Coil a Blade in Five Loops.

1. Repeat the steps given for coiling a blade in three loops.
2. When three loops are formed, pull two of them together making them small and leaving one large loop (Fig. 9-30).
3. Hold the two small loops in your left hand and grasp the large loop


9-24.


9-25.

9-26.


9-27


PHOTOS BY R. A. MC COY

9-24. Holding the top of the loops with your right hand, reach down with the left hand and pick up the loop resting on your instep.

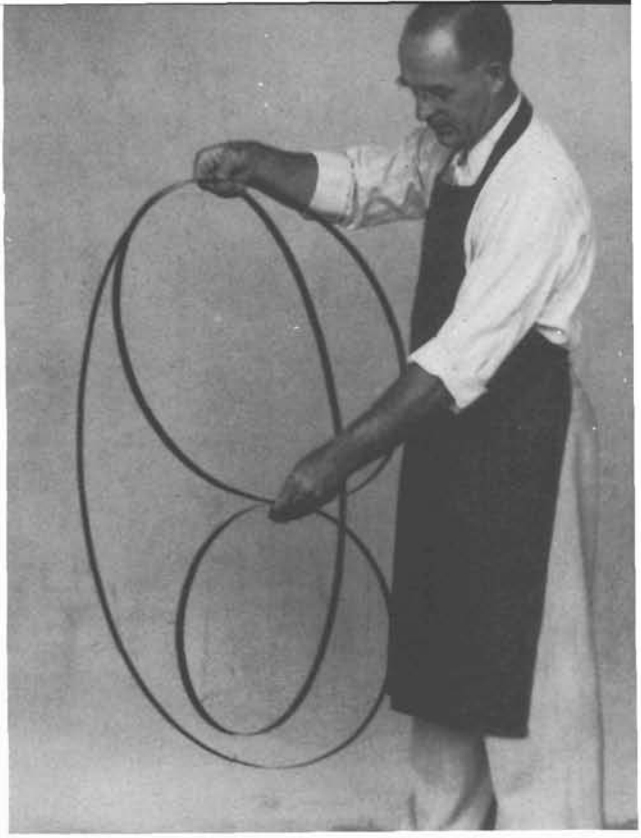
9-25. Raise this loop and release the ones held in your right hand.

9-26. The blade is now folded, ready for storage.

9-27. Uncoiling blade with three loops showing two loops in right hand and one loop above the two crossed loops at the bottom.

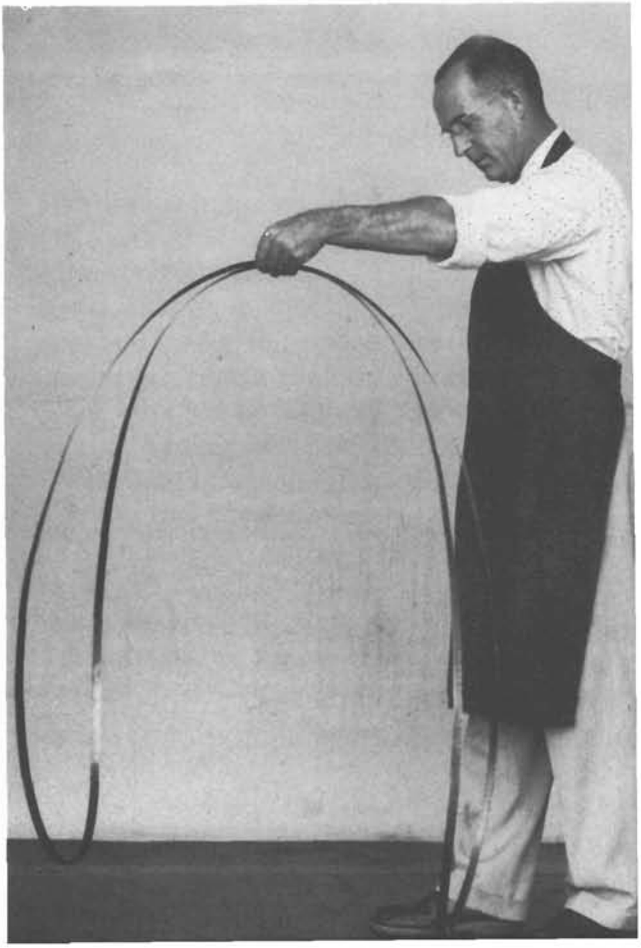
9-28. Reach down and pick up loose loop with left hand.

9-29. Uncoiled blade held in left hand after loops in right hand have been dropped.



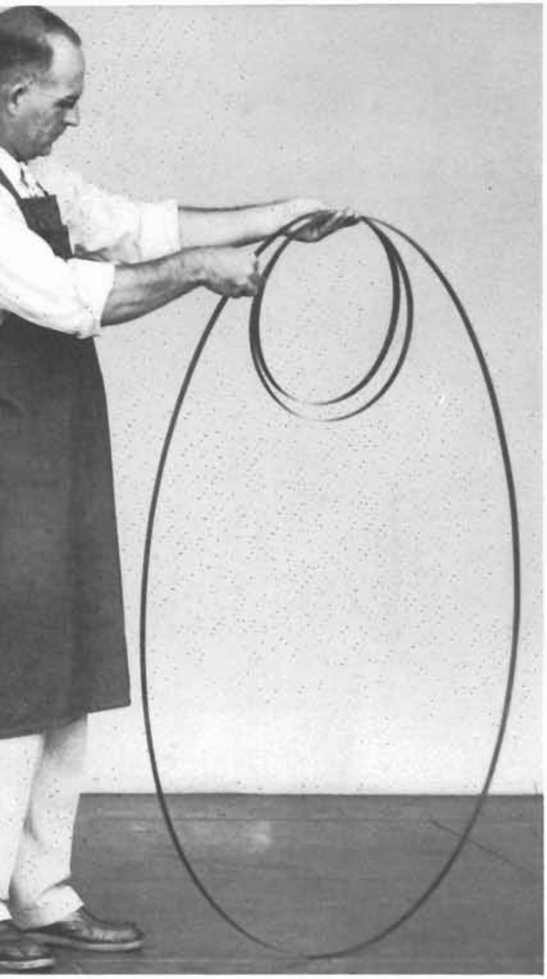
9-28

9-29

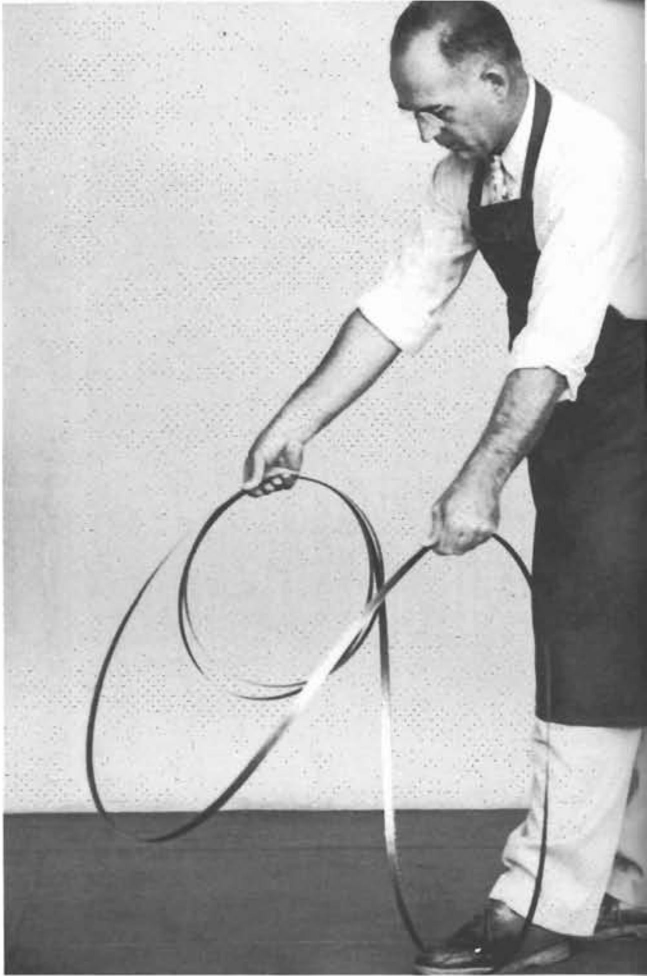


in the middle with your right hand, with the teeth pointing toward you.

4. Place the bottom of the large loop under the toe of one foot.
5. With the thumb and forefinger, turn the teeth in and let the top half of the large loop fall away from you (Fig. 9-31).
6. Bring your hands together and let



9-30. Blade coiled in three loops showing one large loop.



9-31. Holding two loops in left hand and middle of large loop in right hand permits top of large loop to fall away from you.

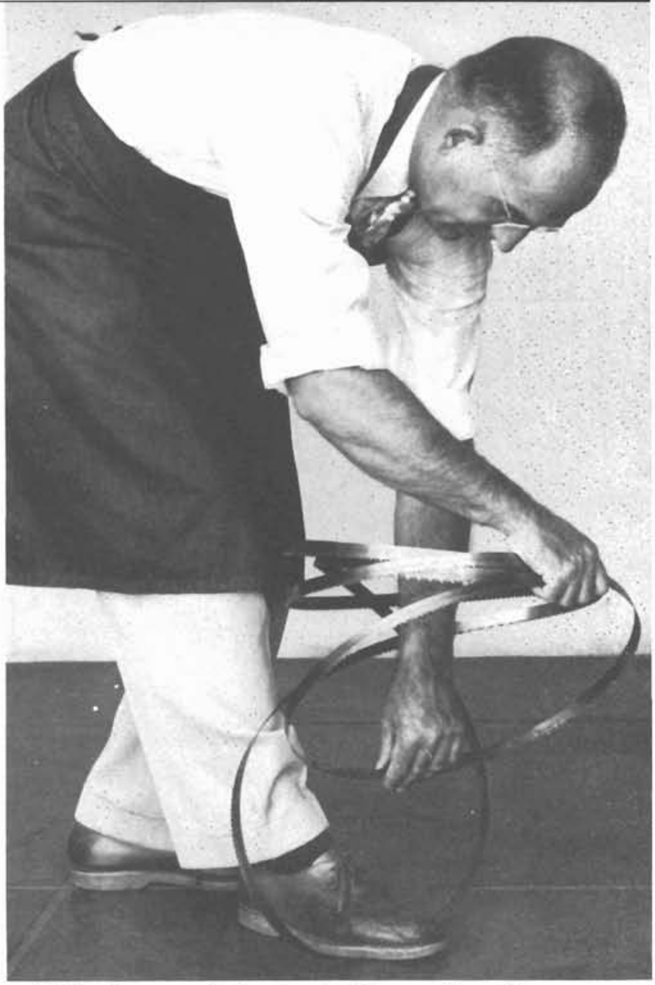
this loop rest on top of your instep.

7. Cross the blade held in the right and left hands, the right over the left (Fig. 9-32).
8. Reach down and grasp the loop resting on your instep and raise it to the position of the top loops (Fig. 9-33). The blade is now coiled in five loops (Fig. 9-34).

D. To Uncoil a Blade with Five Loops

1. Hold all five loops in the right hand with the teeth pointing toward the left (Fig. 9-35).
2. With the left hand select the loop the ends of which combine in forming the two loops held in the right hand (Fig. 9-36).
3. With the left hand still holding one loop, reach down and grasp all three loose loops and drop the loops held in the right hand.
4. You are now holding two small loops and a large loop held in the middle (Fig. 9-38).
5. With your right hand grasp the two small loops and one side of the large loop (Fig. 9-39) and drop the loop held in your left hand.

9-32. Top of large loop comes to rest on top of your instep and right-hand loops are crossed over left-hand loops.



9-33. Loop on instep is raised to position of top loops.

6. As the blade is now in three loops, follow the procedure for uncoiling a three loop blade.

Sharpening band saw blades

Sawing efficiency depends upon the use of sharp blades. Dull blades cut slower even with excessive pressure of the stock against the cutting edge. The heat created by the pressure against the teeth and the thrust wheel and the extra power required to pull the blade places a tremendous strain on such a delicate piece of steel. With such abuse, blade life is very short. A large percentage of blade breakage is due to cutting with dull saw blades.

The sharpening process includes setting, jointing, and filing.

Setting the teeth

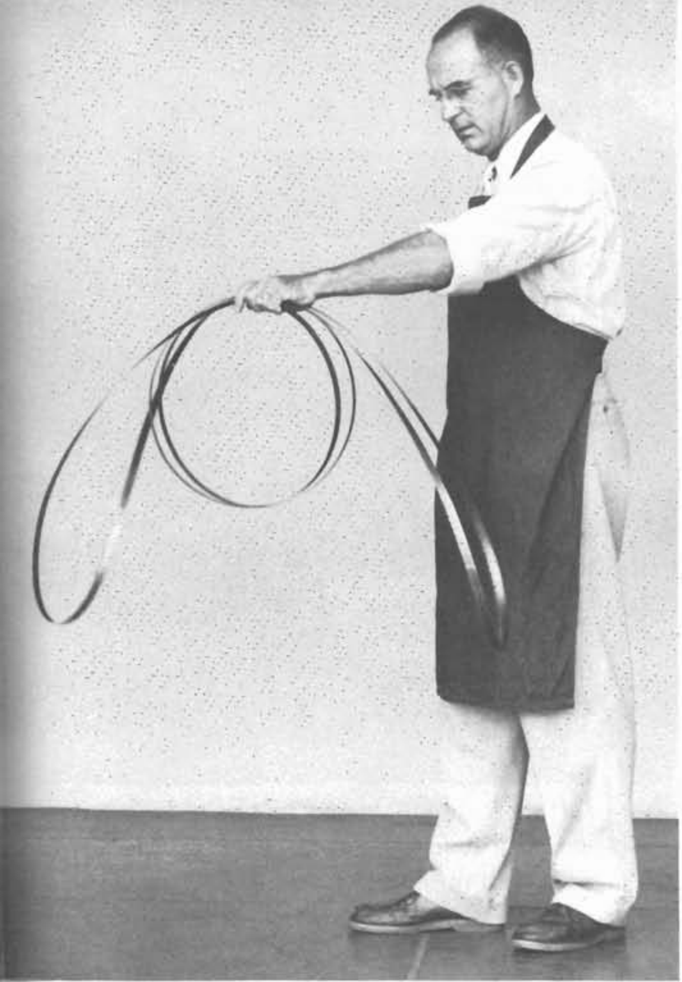
Clearance for narrow band saw blades is nearly always provided for by spring set. The amount of set is in proportion to the gauge and tooth spacing. There are several rules for

9-34. Blade coiled in five loops.

9-35. Blade held in right hand with teeth toward the left.

9-36. Notice three loops above two crossed loops below. The continuation of the loop in the left hand forms the two loops held in the right hand.

9-37. Hold the one loop and three lower loops with left hand and release loops in right hand.



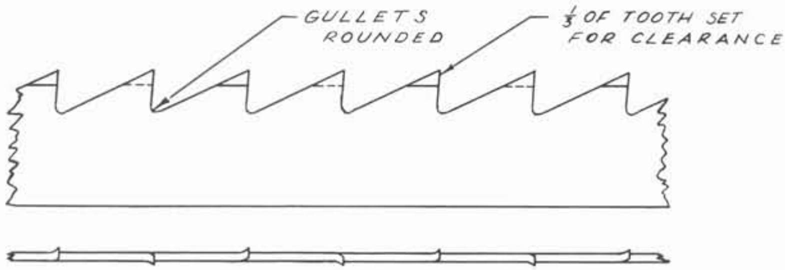
9-38. Holding two small loops and a large loop in the left hand.

9-39. Right hand holds two small loops and one side of the large loop and the left hand holds one side of large loop.

determining the amount of set required for sufficient clearance. One manufacturer (7, 65) recommends that the cut be two or three gauges more than the thickness of the blade for general work. A rule sometimes used for judging the amount of clearance is to set the teeth to make a cut approximately 1½ times the thickness of the blade.

Another manufacturer (11, 12) suggests that each tooth in blades ¼″ wide and under be set .005″ and that each tooth in blades 1″ wide be set .010″. Blades between ¼″ and 1″ wide are set proportionately. This rule is better in one respect. Determining the amount of set by the width of the blade does consider tooth spacing since the narrow saws usually have more teeth per inch and therefore are shorter. It is reasonable to assume that the small teeth on narrow blades should not be set as much as large teeth on wide blades.

The set should be even and uniform. Too much set or uneven set places the blade under extra strain.



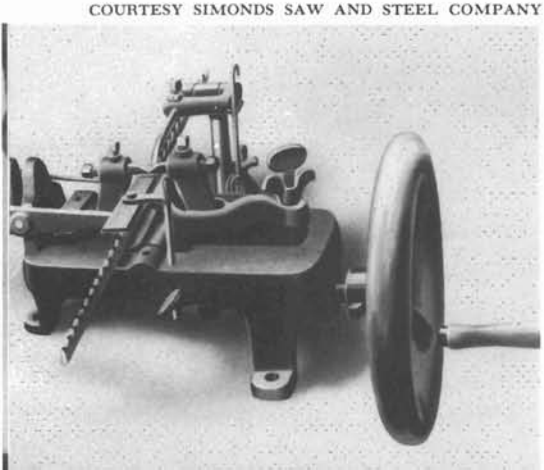
9-40. Properly set band saw teeth.

If there is more set in one side of the blade than the other, the blade will have a tendency to lead toward the side with the most set. Not more than one half the depth of the tooth should be set. If the whole tooth is set, the body of the blade may be distorted, causing the blade to run "snaky," vibrate, and make a rough cut. The line of set should be kept parallel to the back of the blade (Fig. 9-40), (4, 35). This helps to keep the saw dust in front of the teeth and remove it readily from the cut.

BAND SAW SETTING MACHINES

A band saw setting machine is composed of a clamp to hold the blade, a pawl which feeds the blade through the clamp, and pins mounted on each side of the blade which set the teeth. By means of cams, the various parts work in order. The pawl pushes each tooth in line with the pins and at the time the plunger contacts the tooth a cam tightens the clamp on the blade to prevent it from twisting (Fig. 9-41).

9-41. Hand-operated band saw setting machine.
COURTESY SIMONDS SAW AND STEEL COMPANY



Setting machines may be operated by hand or motor. With a band saw setting machine, blades can be quickly set. If a machine set is not available, the teeth in blades ⅜" wide and more can be set by hand with a spring set such as that used for setting hand saws. The hand set will not keep the body of narrow blades from twisting and at the same time set the teeth.

To set band saw teeth with a setting machine

1. Place the blade in the clamp so that the feed pawl makes contact with the face of the tooth when pushing it in line with the setting pins. It may be necessary to turn the saw inside out for the feed pawl to contact the face of the tooth.
2. Adjust the depth gauge to set the correct portion of the tooth. Do not set more than one-half the depth of each tooth.
3. Adjust the clamping device so that

PHOTO BY CHARLES J. PEREZ
9-42. Adjusting hand set to set not more than one-half the depth of the tooth.

the blade is clamped when the tooth is being set.

4. Adjust the pawl to push each succeeding tooth in line with the setting pins.
5. Adjust the setting pins to set the teeth the required amount.
6. Mark the starting place on the blade and set all the teeth. If the blade does not have an even number of teeth, find the odd tooth and start the setting on the next tooth. The odd tooth is not set.

HAND SETTING AND JOINTING

To set band saw teeth with a handsaw set

1. Place the blade on a bench with the teeth up.
2. Adjust the hand set to set the correct portion of the tooth (Fig. 9-42). Do not set more than one-half the depth of each tooth.
3. Adjust the setting anvil to the correct bevel for the amount of set required.
4. Mark the starting place on the blade and set every other tooth toward one side (Fig. 9-43).
5. Set the remainder of the teeth toward the opposite side.

PHOTOS BY CHARLES J. PEREZ
9-43. Mark starting place on blade and set every other tooth toward one side.

Jointing band saw blades

Hand-filed band saw blades are lightly jointed before they are filed. This tends to keep the teeth the same length and serves as a guide for filing.

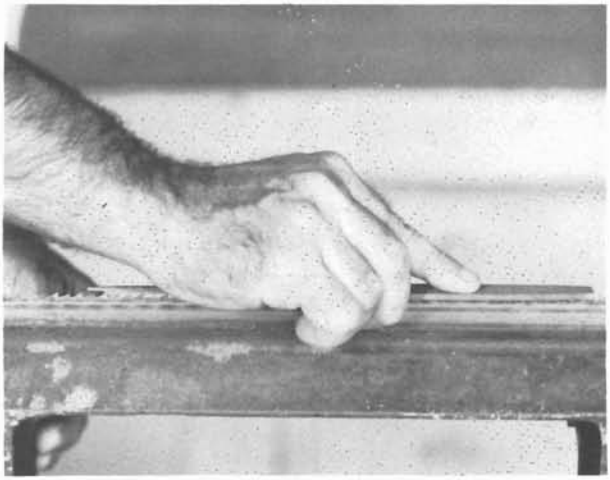


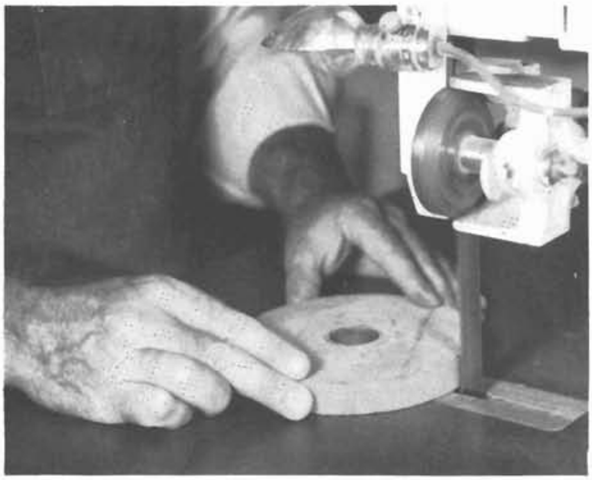
PHOTO BY CHARLES J. PEREZ

9-44. Jointing band saw teeth by hand with a mill file.

When the teeth are jointed by hand, successive sections of the blade are placed in a saw clamp and the teeth in the clamped portion are jointed (Fig. 9-44). Since only a portion of the teeth can be jointed at one time, the teeth in any one section may be the same length, but the teeth in the various sections may vary considerably. The teeth can be jointed while the band saw is running, provided the blade does not weave back and forth across the face of the wheel. Weaving can be overcome by tracking the blade to make steady contact against the guide thrust wheel.

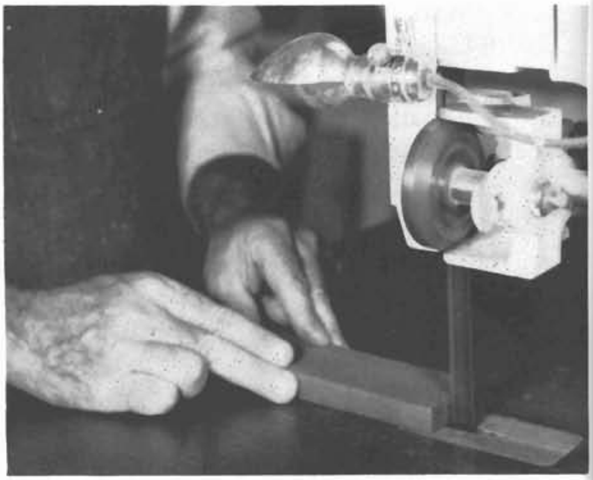
9-45. Jointing band saw teeth with hard grinding wheel.

PHOTO BY CHARLES J. PEREZ



9-46. Jointing teeth of band saw with oilstone.

PHOTO BY CHARLES J. PEREZ



To joint a blade on the band saw

1. Mount the blade on the band saw. Use procedure, "To Mount a Band Saw Blade," page 138.
2. Track the blade to make sufficient contact with the guide thrust wheel to keep the blade from weaving back and forth on the wheel.
3. With the machine running, place a jointing stone, hard abrasive wheel (Fig. 9-45), or oil stone (Fig. 9-46) on the table and lightly press it against the cutting edge of the teeth. Hold the stone at right angles to the sides of the blade until the teeth are the same length.

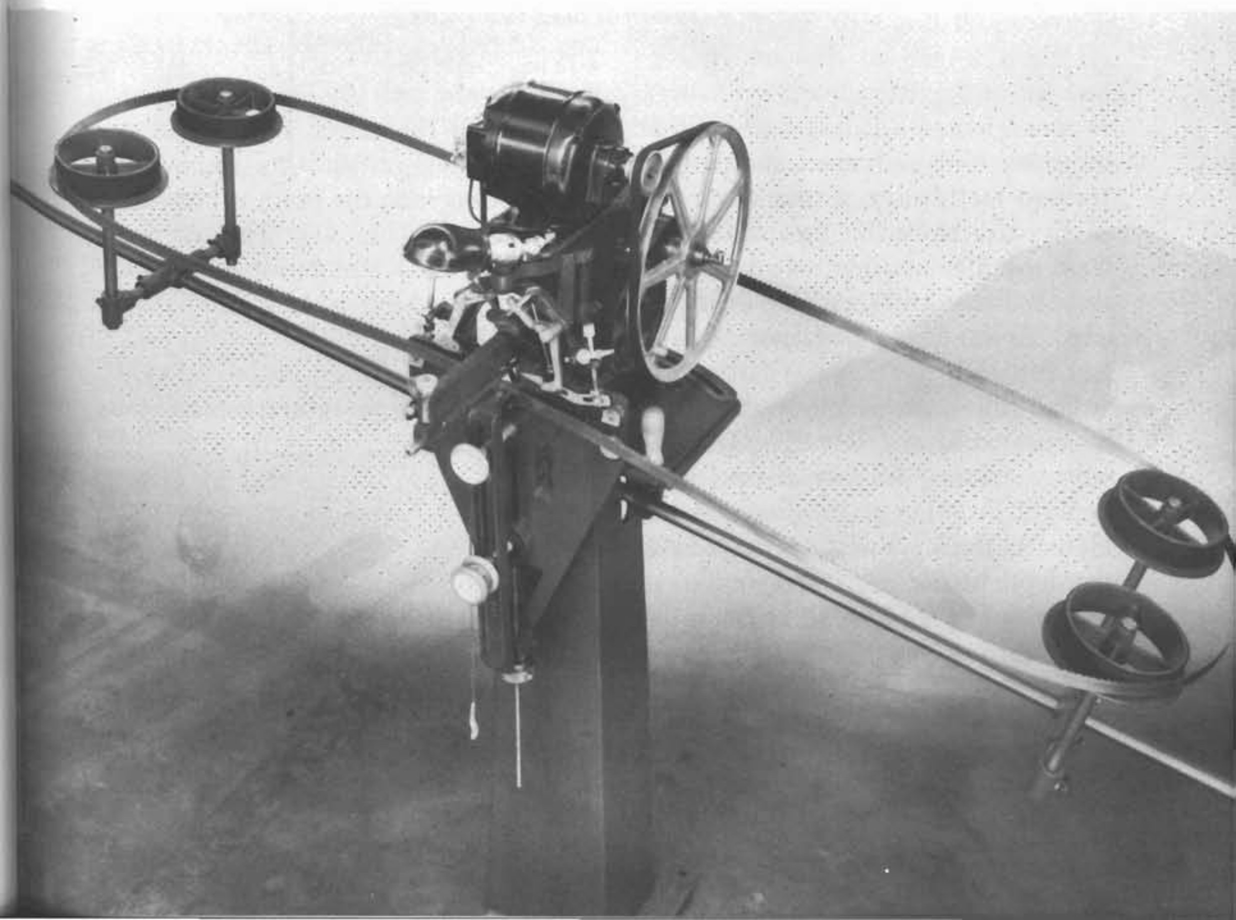
BAND SAW FILING MACHINES

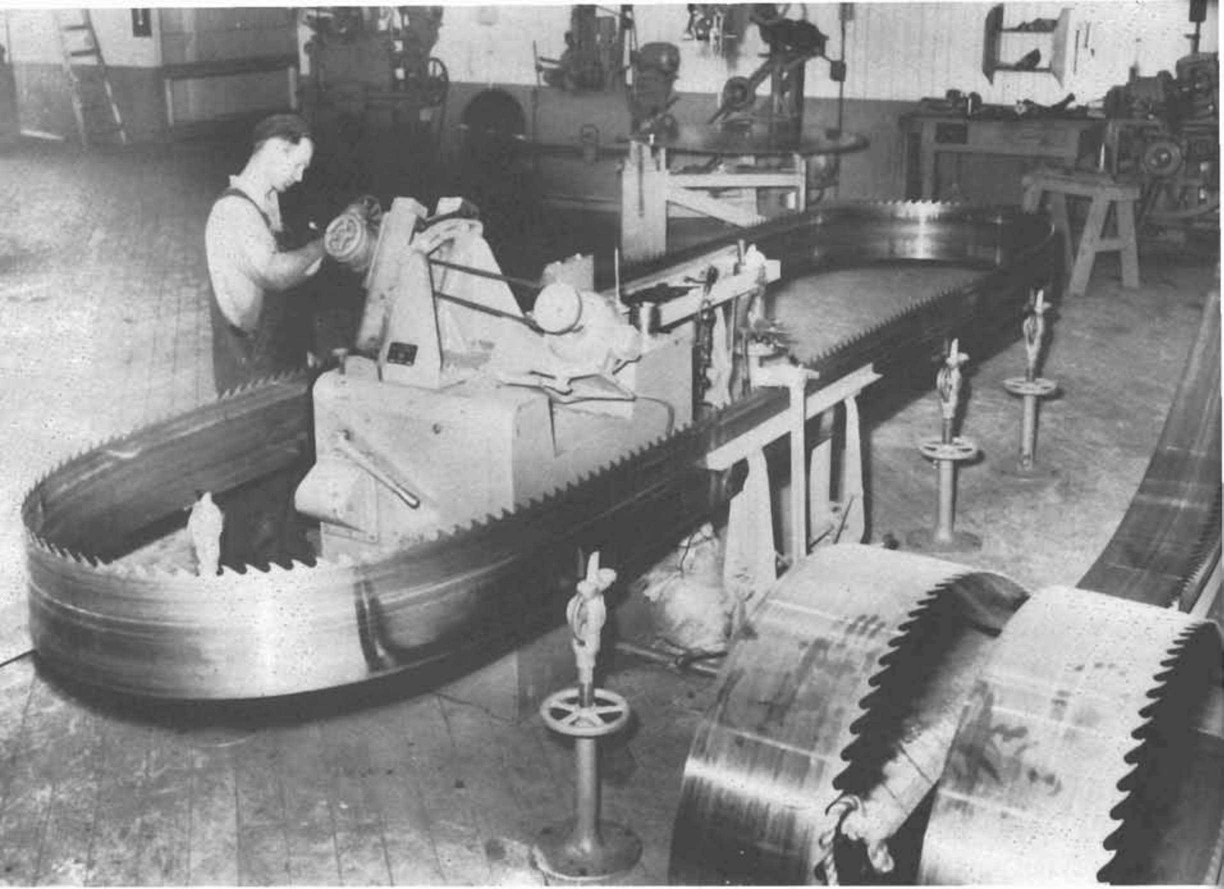
Band saw filing machines for narrow band saws operate by means of a filing arm and a feed pawl. The filing arm holds the file and operates with a reciprocating action, while the feed pawl moves the blade through the vise to the next gullet after each stroke of the file. The filing arm is positive in its action and makes each cut the same depth, automatically jointing and filing the teeth in the same operation. The machine, which makes the same motion as that of a person filing by hand, files about 55 to 60 teeth per minute. Fig. 9-47 shows a mechanical saw filer for narrow blades. Figs. 9-48, 49 show how some of the wide blades are sharpened.

Filing band saw teeth

Band saw teeth should be kept sharp and uniform in shape and size. Whenever it takes excessive pressure

9-47. Sharpening a narrow band saw blade on an automatic saw filer.
COURTESY FOLEY MANUFACTURING COMPANY



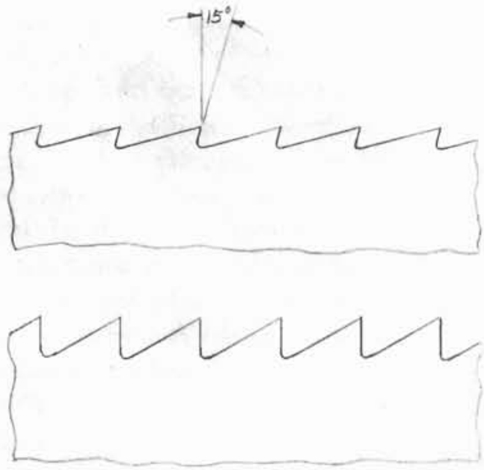


COURTESY HANDCHETT MANUFACTURING COMPANY
9-48. Sharpening of a large band saw blade in a commercial filing room.

to make the teeth cut, it is a sign that they are dull and need sharpening. Uneven teeth make a rough cut and place extra strain on the blade. The teeth are filed straight across; that is, the file is held at right angles to the edge of the blade both horizontally and vertically.

The gullets are shallow, especially on narrow blades. Tooth spacing is only one factor in determining their depth. The other is the hook of the tooth. As the hook angle is decreased, the depth of the gullet is increased as shown in Fig. 9-50. With no hook the body of the blade is too narrow in relation to the depth of the gullet, making it less resistant to strain. The angle or hook on the tooth is between 8° and 15° (11, 11). The correct amount of hook is determined by the

9-49. Close-up view of the process of sharpening a large band saw blade.
COURTESY HANDCHETT MANUFACTURING COMPANY



9-50. When the hook angle on the teeth is increased the gullet depth is decreased. The gullet depth is approximately .3 to .4 of the tooth spacing.

TABLE 11

RECOMMENDED FILES FOR DIFFERENT SIZES OF TEETH

Tooth space Points per inch	Length	File Taper
3	10″	reg. taper band saw
3½-4	8″	reg. taper band saw
4½	8″	slim taper
5 -5½	7″	slim taper
6 -7	7″	extra slim taper
8	6″	extra slim taper

depth of the gullet. It is approximately .3 to .4 of the tooth spacing. The bottom of the gullets should be kept round in order to distribute the strain over a large surface rather than to center it in one point as in the case of sharp gullets.

The kind of file used largely determines the shape and size of the teeth. If the file is short and slim, the teeth will be deep with sharp gullets. A file with a large cross section forms short teeth which have a large radius at the root of the gullets. The file must be large enough to cover the back of the tooth.

One saw manufacturer (3, 5) recommends the following sizes of files for the different sizes of teeth, as shown in Table 11.

To file a blade on a filing machine

1. Set the teeth if there is not sufficient clearance. Use procedure, "To Set Band Saw Teeth with a Setting Machine", page 148, or "To Set Band Saw Teeth With a Hand Saw Set", page 149. It is not necessary to joint the teeth.
2. Mount the blade in the carrier rack so that the feed pawl makes contact with the face of the tooth when pushing it in filing position.
3. Adjust the blade support with the bottom of the gullets projecting only enough to permit filing the teeth without cutting into the vise. The body of the blade needs all possible support in the vise to prevent twisting when the tooth is filed.
4. Adjust the vise to hold the blade sufficiently for filing and yet allow the pawl to feed it to the next tooth.
5. Select and mount the proper file in the filing arm holders. Be careful to set the file for the correct tooth angle.
6. Adjust the file depth to take the proper cut. There is a tendency to take too heavy cuts, breaking the corners off the file. The dull cor-

ners draw the metal in the gullets toward one side, leaving a heavy burr. This hardened, planished surface may cause the blade to crack.

7. Adjust the feed pawl to push the tooth to a position where the file cuts lightly on both the front and the back of the teeth. To keep the tooth spacing uniform, the feed pawl should push against the front of the tooth that has just been filed. Mark the starting point.
8. Start the machine and make any necessary minor adjustments. Continue filing until all the teeth are sharp.

Since the adjustments vary so much on the different filing machines, read carefully the special instructions for the care and operation of each machine before attempting to file a blade.

Band saw blades can be hand filed by laying the blade in a horizontal position and holding it in a band saw clamp. An ordinary hand saw clamp may be used, but the blade must be shifted more often because of the shortness of the clamp jaws.

HAND FILING AND JOINING

To file a band saw blade and housing

1. Set the teeth if there is not sufficient clearance. Use procedure, "To Set Band Saw Teeth with a Setting Machine," page 148 or "To Set Band Saw Teeth with a Hand Saw Set," page 149.

2. Joint the teeth. See procedure, "To Joint a Blade on the Band Saw", page 151.
3. With the blade in a horizontal position, place a portion of it in the saw clamp with the bottom of the gullets projecting only enough to permit filing the teeth without cutting into the vise. The body of the blade needs all possible support in the vise to prevent its twisting when the tooth is filed. The teeth may point either to the right or to the left, whichever is preferable. The filing progresses around the blade in the same direction as the teeth point. The cutting edge is then formed by filing the front of the teeth last. Thus more of the tooth that is being brought to an edge is visible than if it were filed on the back last.
4. Select the proper size file for the width of the blade and spacing of the teeth (Table 11, page 153).
5. Holding the file at right angles to the blade both horizontally and vertically and with sufficient roll to give the required tooth angle or pitch, take steady, even strokes in each gullet until the teeth are sharp. Use only enough pressure for the file to take a normal cut, lifting it from the surface on each return stroke. Too much pressure on the file on the cutting stroke will break the corners off the teeth. Dragging the file on the return stroke dulls the cutting edges. It may help in keeping the teeth uniform to file a section partially and finish it on the second filing. This will not remove too much material

from any one gullet. The shape of the gullet should conform to the shape of file. Both the front of one tooth and the back of the other is filed at each stroke, but the pressure toward one or the other may be varied.

6. File each successive section until all the teeth have been filed.

Joining band saw blades

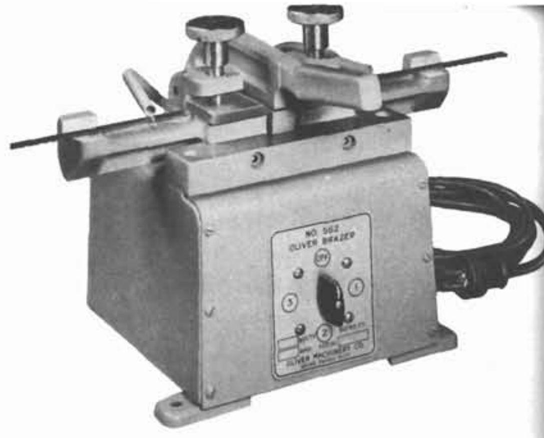
It is necessary to join band saw blades to make new blades from coil stock or to repair broken ones. Blades with spring set are joined with an even number of teeth so that half of the teeth are set toward either side. If the blade has an odd number of teeth, the odd tooth is not set. If the teeth are set by a machine, the odd tooth creates a problem. The setting needs to start at the next tooth and end with the tooth preceding the odd one. If the odd tooth is overlooked, some of the teeth may be set toward the opposite side, with the possibility of their breaking.

Broken blades are joined so the same side will run on the wheels. They are not turned over, since flexing the blade both ways shortens its life. NOTE: Blades that have been broken several times may also be weak in other places and not worth joining. When you are joining a blade it is important to keep the back of the blade straight, the tooth spacing equal on blades with spring set, and the blade of uniform thickness at the joint.

Band saw blades are joined either by brazing or butt welding. Brazing is the process of joining metals by fusion of non-ferrous alloys that flow at a temperature above 800° Fahrenheit. This is lower than the temperature of the metals to be joined (12, 3).

Band saw blades are brazed by placing the brazing material between the two scarfed ends and applying heat with a torch, a hot clamp, or an electric brazer. The ends are cut so that the teeth will match evenly when the lap is made. The lap will vary from ¼″ for narrow blades to ½″ on wide blades. It is long enough only to give the required strength to the joint. *Long bevels* are more difficult to file flat and still be sufficiently thin at the ends. The joint should cover all the beveled surface; otherwise, the blade will be too thin at the uncovered portion of the bevel.

To obtain a strong braze, the joint and the soldering material must be clean and free from grease or finger prints. Foreign substances prevent free flow of the solder, leaving portions of the beveled surfaces that are not joined. A brazing compound or borax applied to the joint before heating will prevent oxidation or absorb any oxides that may form during the heating process. The oxide formed when metals are heated prevents the soldering material from flowing in the joint. Borax may be used in either stick or pulverized form. When the stick is used, it is rubbed on the joint as the blade is heated. This causes it to melt and flow over the joint, protecting the joined surfaces. If pulverized borax is used, it is made into a paste and spread between the joint.



COURTESY OLIVER MACHINERY COMPANY
9-51. Electric brazer for band saw blades.

The paste may be made by mixing pulverized borax with water. However, one band saw blade manufacturer (5, 113) recommends that the pulverized borax be burned in a pan over a slow fire and frequently stirred to permit the gases to escape. Next the burned borax is pulverized as finely as possible and mixed with water into a paste.

Silver solder is in common use for joining band saw blades. It is composed of silver, copper, and zinc. By using different proportions of the metals, the characteristics of the alloy are changed. Generally it contains 40 to 50% silver and varying amounts of copper and zinc. It flows at approximately 1350° Fahrenheit (2, 211). By increasing the amount of zinc to equal the amount of the copper the melting point is lowered. To make a good joint the temperature is raised to approximately 1500° to 1600°. The joint should show a light red color. At this temperature silver solder flows readily.

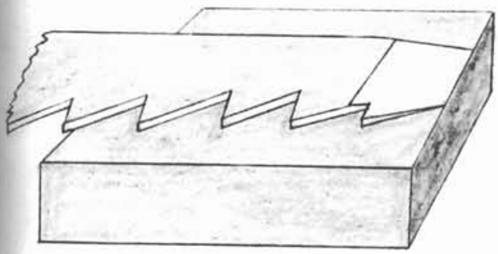
Sometimes thin sheet brass is used to braze band saw blades. It is cheaper than silver solder, and makes fully as good a joint, but requires more heat to make it flow (13, 10). Brass is composed of copper and zinc. Brazing brass which is 75% copper and 25% zinc has a melting point of approximately 1775° Fahrenheit. As the zinc content increases, the melting point lowers. Brass that is 63% copper and 37% zinc flows at 1660° Fahrenheit (9, 1622).

ELECTRIC BRAZERS: An electric brazer operates on the principle of a step-down transformer. It is composed of a primary coil, a secondary coil which incorporates the blade in the circuit, a blade aligning clamp, and a hand-operated pressure device. The current is controlled by a three-heat reciprocating switch. The hand-operated pressure device clamps the scarfed ends together when the soldering material has melted and the current is turned off (Fig. 9-51).

For brazing blades up to ½″ wide, the number one position usually supplies sufficient heat. For 1″ blades, turn the switch to number one for a few seconds and then to number two until the soldering material has melted. Turn the switch off by passing through the number one position. On blades of heavier gauge and up to 1½″ wide, turn the switch to number one for a few seconds, then to number two for a few more seconds, before turning to number three until the blade has reached the required heat. If there is too much heat, the blade will melt at the point of brazing.

To braze a band saw blade

1. Cut the ends of the blade square.



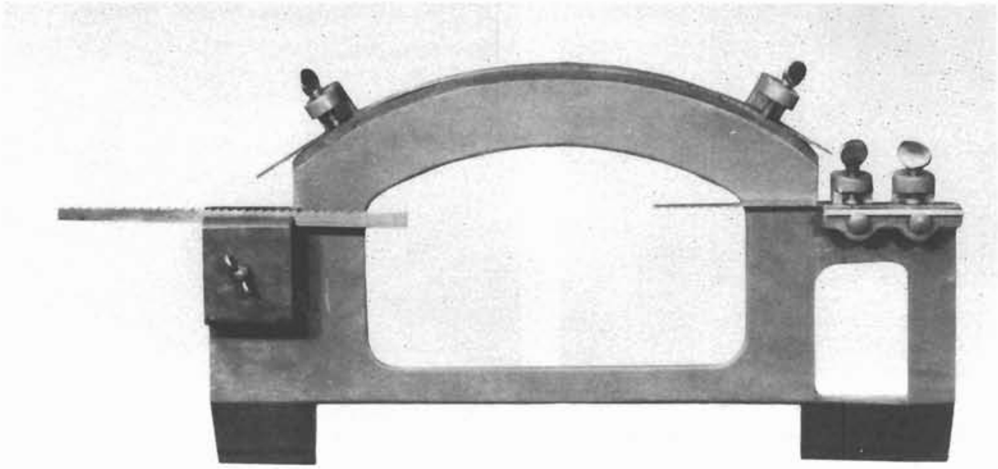
9-52. One end of a broken blade squared and scarfed.

blade can be held for filing by clamping it to a piece of metal (Fig. 9-52) and fastening the metal block in a vise. A special dressing and scarfing vise may be used (Fig. 9-53).

3. Braze the blade. Select the method that is most convenient.

   A. Using the Electric Brazer.

   (1) Clean the blade with fine



COURTESY OLIVER MACHINERY COMPANY

9-53. Band saw braze dressing and scarfing vise. The clamps to the right hold the blade so that the ends can be properly scarfed. To the left is a vise which is readily used to file any irregular teeth. The curved clamp on top is used to file the joint to the correct thickness of the blade.

Be sure there is an even number of teeth and a ¼″ to ½″ lap, depending upon the width of the blade. There is an even number of teeth when the teeth that coincide in the joint are set toward the same side.

2. Scarf each end of the blade and on opposite sides, extending back from the end the distance of the lap. Make the surfaces flat, keeping the ends thin and square. The

emery cloth where the clamp plates fit to insure good electrical contact.

(2) Clean the surfaces to be joined and place the blade in the brazer with the beveled ends overlapping. Clamp them with the joint in the center of the pressure device. Be sure the joint fits

PHOTO BY CHARLES J. PEREZ
9-54. The band saw blade is clamped with the joint in the middle of the clamp throat.

PHOTO BY CHARLES J. PEREZ
9-55. The flux is applied to the joint.

together closely and that the back edge is against the clamp.

(3) Apply paste or liquid flux between the joint.

(4) Cut a strip of soldering material a little larger than the beveled surfaces. Clean the sides of the solder and place it between the beveled surfaces. A fine wire may be wrapped around the joint to hold it together.

(5) If a stick form of flux is used, apply it immediately after turning on the current.

(6) Turn the switch to the proper position or positions to secure sufficient heat, turning the current off when the blade reaches a light red color and the soldering material has melted. Read information unit under "Electric brazer", page 156, on how to operate the switch to secure sufficient

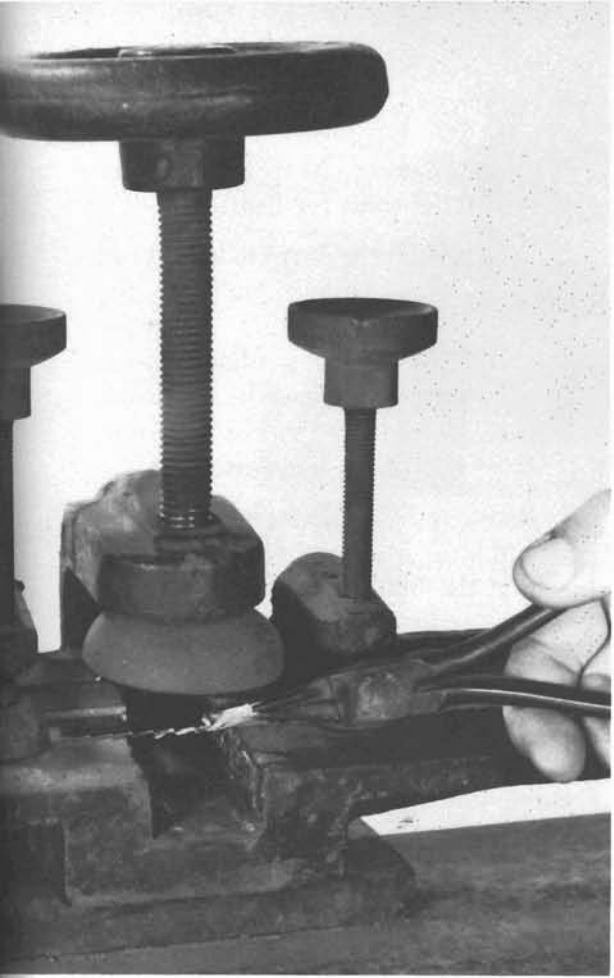


PHOTO BY CHARLES J. PEREZ
9-56. A piece of silver is placed between the joint.

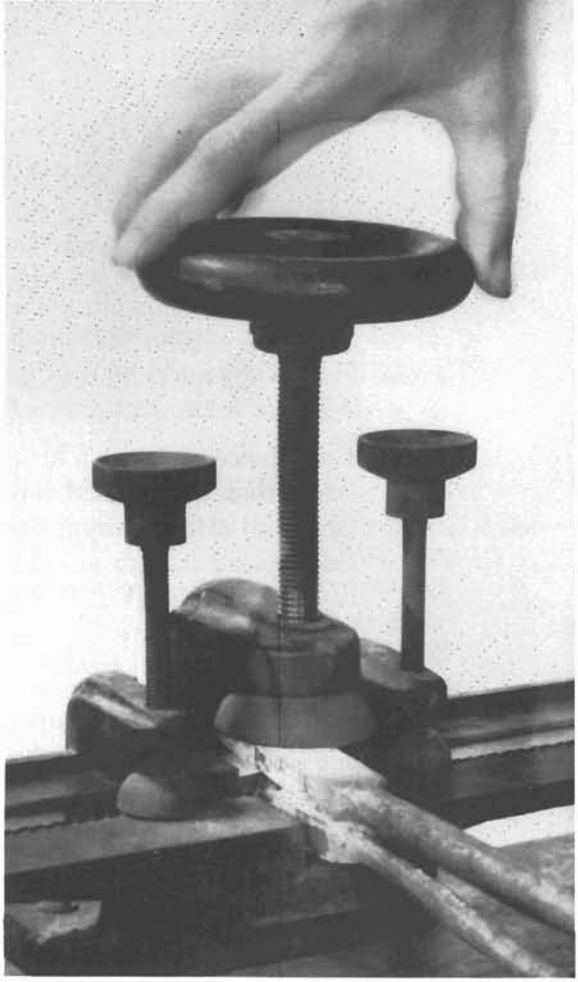


PHOTO BY CHARLES J. PEREZ
9-57. . The tongs are heated to a light red and clamped over the joint.

heat for the various widths of blades.

(7) Immediately after turning off the current, apply pressure to the joint with the hand-operated clamping device.

(8) Anneal the joint by turning the switch to number one until the blade becomes a very dull red.

(9) With a file, test the blade for hardness. If the blade is too hard, turn on the current and draw the temper. If the blade is too soft, turn on the current a short time; on turning it off, apply the pressure device to the heated joint to cool it faster.

B. Brazing Clamp and Torch.

(1) Place the blade in the brazing clamp with the back

against the clamp and the joint in the middle of the throat. Be sure the joint fits closely together (Fig. 9-54).

(2) Apply a paste or liquid flux between the joint (Fig. 9-55).

(3) Cut a piece of solder a little larger than the beveled surfaces and after cleaning the sides, place it between the beveled surfaces (Fig. 9-56). Wrap a fine wire around the joint to hold it together.

(4) If stick flux is used, apply it immediately after applying the heat.

(5) Apply heat to the joint with either an oxy-acetylene or blow torch, playing the flame over the joint slowly to bring it to an even temperature.

(6) When the joint has reached a light red shade and the solder has melted, clamp the joint with a pair of tongs or a large pair of pliers.

(7) Test the joint with a file and draw the temper, if necessary, by heating the joint to a dull red and letting it cool.

C. *Brazing Clamp and Heated Tongs.*

(1) Follow the steps numbered (1), (2), and (3) under "b" for mounting the blade in the brazing clamp and prepare the joint for heat.

(2) Heat the tongs to a light red and clamp them over the joint (Fig. 9-57). After the red color has disappeared, the tongs may be removed. The blade will be the right hardness when it cools.

4. Remove the blade from the clamp, and straighten and file the joint so that the blade is uniform in thickness and smooth on the back edge. Test it for thickness with a gauge.

BUTT WELDER

The butt welder is an electrical machine which operates by passing sufficient current through the blade to fuse the ends instantaneously (Fig. 9-58). The blade is held in place by two clamps with the ends butted together. Pressing the welding lever closes the circuit. As the metal melts, the ends are pushed closer together by tension on a movable jaw. After the weld is completed, the circuit automatically opens. The machine has an annealing position where the blade is heated to a dull cherry red and allowed to cool slowly. Some welders are equipped with a grinder for grinding the ends square in preparation for welding and to finish the joint smooth after the weld is made.

BUTT WELDING BAND SAW BLADES: When a blade is butt welded, it carries an electric current which creates enough heat to melt and fuse the ends. Because of the difference in the characteristics of the metal some

COURTESY GROB BROTHERS, INC.
9-58. Butt welder used for joining narrow band saw blades.

blades of the same size require more pressure than others. Sometimes the movable jaw places too much pressure on the butted ends during the welding and as a result the ends overlap. To overcome this difficulty, it may be necessary to change the tension on the movable jaw, in which case the instructions for the particular machine are followed. Another way to reduce the pressure on narrow blades is to leave approximately 1/64" space between the ends when clamping the blade in the welding jig.

If welding a narrow blade seems difficult, it is helpful to clamp it in the annealing position with the ends butted together and anneal the metal before attempting to make the weld (15, 259). It is important that the ends be parallel and make contact the full width of the blade when it is clamped in the welding position. If the entire width does not make contact simultaneously, the heat concentrated on a small area will melt away some of the metal.

In order to adjust the welder properly for a particular blade, it is wise to make some practice joints on some of the same sized pieces before attempting to weld the blade.

To cut a hardened tooth blade, start at the back and cut nearly to the teeth; then bend the brittle metal back and forth until it breaks. A hardened blade will damage the cutting edge of most snips and shears.

To maintain the proper tooth spacing, about 1/16" must be allowed at the joint to make the weld.

To butt weld a band saw blade

1. Cut the ends of the blade so that there is an even number of teeth. If the two adjoining teeth point toward opposite sides, the number is even. If equal tooth spacing is needed, add 1/16" for the weld.
2. Hold the blade with the ends even

and extended in the same direction. Place the two sides of the blade together with the teeth edge of one end toward the back edge of the other. Grind the ends flat and approximately square (Fig. 9-59). By grinding the two ends simultaneously in the position described, the angles ground on the ends will form complementary angles and will make a straight line when butted together (Fig. 9-60). Use as much of the surface on the side of the grinding wheel as possible to prevent grooving it.

3. With the back of the blade against the guides, clamp it in the welding jig with the joint midway between the jaws. Be sure that the ends are parallel and in contact or possibly with a 1/64" gap for narrow blades.
4. If there is a heat control, set it for the amount of heat required, considering the thickness and width of the blade.
5. Set the tension control to the graduation which corresponds to the width of the blade.
6. Press the welding lever and hold it momentarily, loosening one jaw clamp before releasing the lever (Fig. 9-61). The circuit automatically breaks when the weld is completed. A good weld will have a small bead around the joint.
7. Clamp the blade in the annealing position and close the annealing circuit until the joint reaches a dull red. Pushing the annealing switch intermittently will cool the blade gradually and make it softer.
8. Grind the bead or welding flash from both the sides and the back of the blade (Fig. 9-62). Test the weld for thickness with a gauge. Extra thickness may cause it to bind in the guides.

9-59. To grind ends flat and square, place teeth edge of one end toward the back edge of the other end.

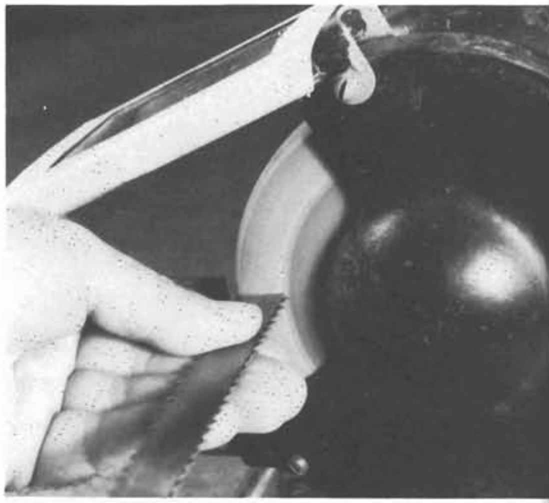
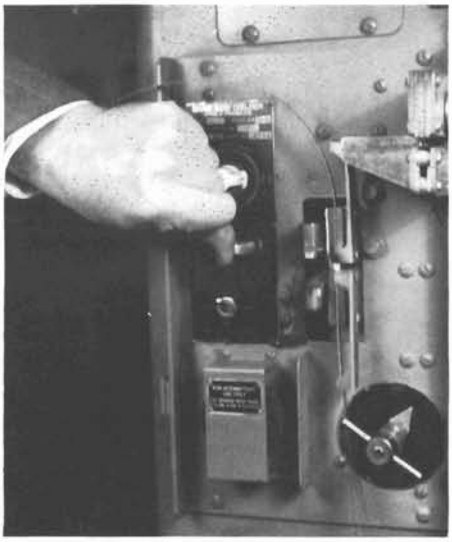


PHOTO BY ROBERT C. SMITHERAM JR.
9-60. Grinding the two ends simultaneously as shown forms complimentary angles and the blade will be in a straight line when the ends are butted together.

CAUSES OF BAND SAW BLADE BREAKAGE

The following factors are responsible for much blade breakage:

1. Use of defective blades caused from improper punching, filing, or welding.
2. Vibration of the upper wheel and



PHOTOS BY CHARLES J. PEREZ

9-61. Welding a band saw blade on an electric butt welder.

9-62. The bead or welding flash is carefully removed on the build-in grinding wheel.

uneven tension caused by too light a "goose neck" or frame.

3. Tires and wheels out of balance. This causes uneven blade tension.
4. Too light a blade for the work.
5. Blade too thick for the size of the wheels.
6. Twisting blade in the guides.
7. Sawing with a dull blade.
8. Improper amount of set – either too much or too little.
9. Improper tooth spacing for the work.
10. Sharp gullets at the root of the teeth.
11. Loose or worn tires.
12. Collection of dirt, rosin, and saw dust on the face of the tires, causing uneven blade tension.
13. Pieces of material falling between blade and lower tire because of worn out throat plate.
14. Wheels out of alignment.
15. Blade running through worn guides.
16. Too much blade pressure on the guide thrust wheel.
17. Stopping the heavy wheels too fast, especially when braking only the lower wheel.
18. Blade too tight in the guides.
19. Uneven blade thickness.
20. Leaving the blade under tension for long periods of time.
21. Wrong angle or hook on the teeth.
22. Poor type of tension device that does not reduce the shock on the blade.
23. Blade under excessive tension.
24. Throwing the blade off the wheels.
25. Poor joint – too thick, too thin, improper temper, or back of blade not forming a straight line.
26. Teeth not uniform in length.
27. Blade weaving or running back

and forth across the face of the wheel.

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PART TWO

CHAPTER 10

Circular Saws

CIRCULAR SAWS are made with double and single arbors. The double arbor is usually equipped with both crosscut and rip saws. When the operator turns a crank, the revolving mechanism lowers one blade below the table and at the same time raises the other blade into cutting position above the table (Fig. 10-1).

The variety saw has one blade which can be varied in height above the table. The blade is changed either for crosscutting or for ripping. A combination blade is used for all types of sawing.

The size of the machine is determined by the diameter of the blade it will take. For example, a machine that takes a blade 10″ in diameter is called a 10″ saw.

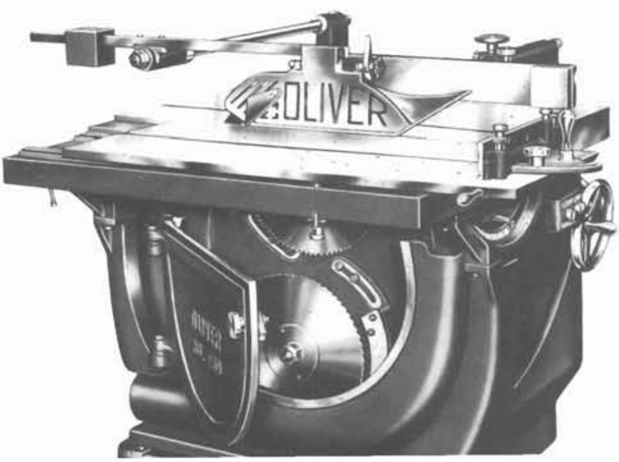
TABLE

The table fastens to the frame of the machine with bolts. It is either solid or it has a movable section on the left side of the saw blade. The movable section helps in crosscutting heavy or wide stock which would be difficult to slide on a solid top. Both types of tables have grooves cut in the top on either side of the blade. They are parallel to the blade and guide the cut-off gauge during crosscutting or mitering.

A variety of mechanisms carry the movable section. Some are mounted on ball bearing ways which have a vertical adjustment for alignment and wear. Others are mounted on rollers which run on an adjustable track. The track may have either flat or beveled surfaces and may be attached to the frame or to the lower side of the table. *Flat tracks* mounted on the frame have a tendency to *become loaded with sawdust and dirt* if some device is not used to keep the track clean. An accumulation of dirt on both the track and rollers causes the table to run bumpy and become tight in the ways.

The movable section must be kept level with the remainder of the table; therefore all the bearings should give equal support. Since there are many mechanisms for mounting the section,

10-1. Double arbor tilting saw.
COURTESY OLIVER MACHINERY COMPANY



it is advisable to follow the instruction book of the company for making the necessary adjustments.

Tilting table

Universal and variety saws change the angle of the table and blade by tilting either the table or the arbor as much as 45°. Clean and lubricate the tilting mechanism occasionally with light oil so that the horizontal table can be moved easily to an angular position.

To adjust a tilting table

1. Set the table at right angles to the saw and, using the cut-off gauge set at 90°, cut a trial piece of stock.
2. Test the cut with a square to see if it is at right angles with the side of the stock that was against the table.
3. When a square cut has been made, adjust the pointer on the gauge to zero and tighten it firmly.
4. Set the stop screw against the table and tighten the lock nut. The stop screw automatically brings the table to a right angle position after it has been tilted. When returning the table to a right angle position, be sure to stop when it lightly touches the stop screw. Forcing the table against the stop will twist it out of alignment, with the possibility of breaking some part.

Table inserts

Saws with solid tables and some with movable sections have inserts which fit into the throat through which the blade projects. Inserts are made of soft metal or wood. The metal ones are usually adjustable to make them level with the table. The wooden inserts should be replaced when the blade slot becomes too large.

To make a wooden insert

1. Select a hard, close-grained piece of wood. Joint one side and plane it to the required thickness and width.
2. Lay out the proper shape and length on the ends of the stock to fit the throat. Some throats are semicircular at the ends, whereas others are square.
3. Accurately cut the outline and fit the new piece into the throat.
4. Clamp a piece of stock lengthwise over a portion of the insert, leaving a space for the blade to cut through.
5. With a blade mounted on the arbor and set below the table top, start the machine, raise the blade slowly to its full height, and cut the slot for the saw. It may be necessary to make the cut slightly wider to provide sufficient clearance for the blade. By shifting the insert slightly to either side and raising the saw blade as before, you can increase the width of the slot.

To level a metal insert

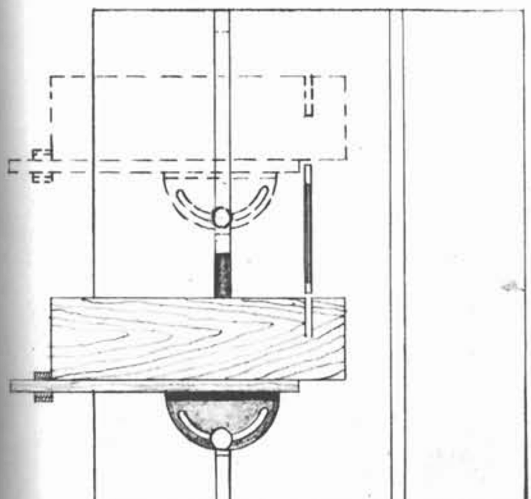
Level the metal insert either by adjusting the brackets attached to the table on which the insert rests, or by adjusting the leveling screws which support the insert.

ALIGNMENT OF THE SAW BLADE

The saw blade must be parallel to the grooves in the top of the table so that the back of the blade will follow in the cut. If it is not parallel to the grooves, the back teeth will cut against one side of the stock with the possibility of forcing the saw off the line and heating the rim.

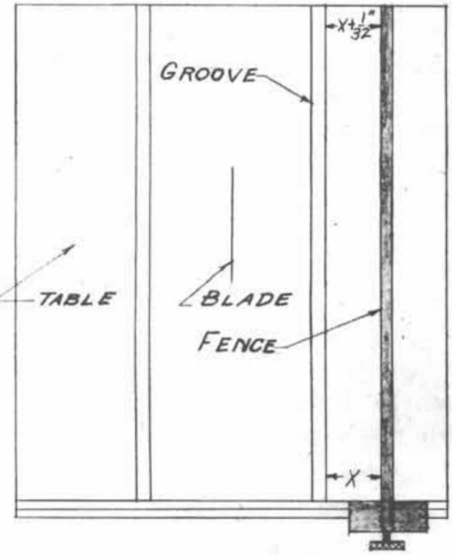
On some bench saws the table is attached to the base with machine screws. The holes are usually large enough to allow the table to be shifted sufficiently to align the grooves with the saw blade. The saw arbor is held in place by bearings rigidly attached to the base. On other machines the motor and arbor are mounted on the base by bolts or machine screws, thus permitting sufficient movement to align the saw blade with the grooves in the table.

10-2. Checking a circular saw blade for proper alignment. After cutting the wood halfway through from the front, the other half is cut by carefully feeding the wood into the back of the saw.



To test a circular saw blade for alignment (12, 8-9)

1. Place the cut-off gauge in the left hand groove, approximately at right angles to the blade.
2. Set a stop on the cut-off gauge about 15″ from the blade.
3. With the saw blade raised to its full height, place a squared piece of softwood approximately ¾″ thick, 5″ wide, and 16″ long on the table with an edge against the cut-off gauge and an end against the stop.
4. Start the machine and saw about halfway across the piece. Pull the stock back from the blade and turn the machine off (Fig. 10-2).
5. After the machine has stopped, push the cut-off gauge to the rear of the table in the same groove and place the piece of wood in its original position against the cut-off and the stop gauge.
6. Start the machine and, holding the piece of wood firmly against both the cut-off gauge and the stop, slowly pull the piece of wood toward the saw until the two saw cuts meet. Be sure to hold the piece of wood down on the back of the table when it makes contact with the back of the saw blade, as the cutting action will try to lift it. If there is any play in the cut-off gauge, take up the slack by holding



10-3. Method of checking fence alignment. The distance between the fence and the groove is 1/32" more at the rear than it is at the front of the table.

it toward the same direction. WARNING: *Be extremely careful* when performing this operation.

7. Examine the two cuts closely. When they meet accurately, the saw blade is parallel to the grooves in the table.

FENCE ALIGNMENT

Because of the variety of fences, the adjustment for aligning the fence may be in a number of places. Some fences are aligned by loosening the bolts which hold them to the bracket and shifting them to their correct position. Other fences are held in place by two tapered pins which fit into holes in the table. One of these pins may fit in an eccentric bushing, which can be turned to change the fence in relation to the hole in the table.

Since the saw blade is set parallel to the grooves in the table, the fence can also be aligned with these grooves. It may be set parallel to the grooves, but, in so doing, the saw teeth at the back will contact the edge of the stock the same as at the front. This condition may cause the back teeth to throw the binding stock between them and the fence. For this reason, set the rear end of the fence a fraction farther from the blade.

To align the fence on a bench saw

1. Examine the fence assembly and determine how to make the adjustment.
2. Loosen the fasteners slightly to a point where they are still quite snug but loose enough so that the position of the fence can still be changed. It may be necessary to remove the fence from the table in order to reach the fasteners.
3. With the fence to the right of the

10-4. Radial saw.
COURTESY DE WALT, INC.

right-hand groove, fasten it in its natural ripping position.

4. Shift the fence so that the extreme rear end is 1/32" farther from the edge of the groove than the front end (Fig. 10-3). If the fence is to be used on both sides of the saw blade, it may be set parallel to the groove.
5. Tighten the fasteners and carefully recheck the alignment.

RADIAL SAWS

A radial saw is a movable saw supported by a column mounted vertically on the back of a work table. To the column is attached a long arm that projects across the table forming a track for the motor and saw assembly. The motor is attached to the arm in a way that enables it to move back and forth over the work table (Fig. 10-4).

Basically, radial saws are of three types, depending upon the method used to allow the saw to travel across the table. On one type a stationary arm, fastened to the column and extending across the table, forms a track on which the motor assembly travels. On the second type, a movable arm to which the motor is attached slides back and forth on bearings mounted at the top of the column. The third type has two arms. One is connected to the column and extends across the table. The other arm, which forms a track for the motor, is attached to the lower side of the arm connected to the column.

Adjusting the saw blade parallel to the arm travel

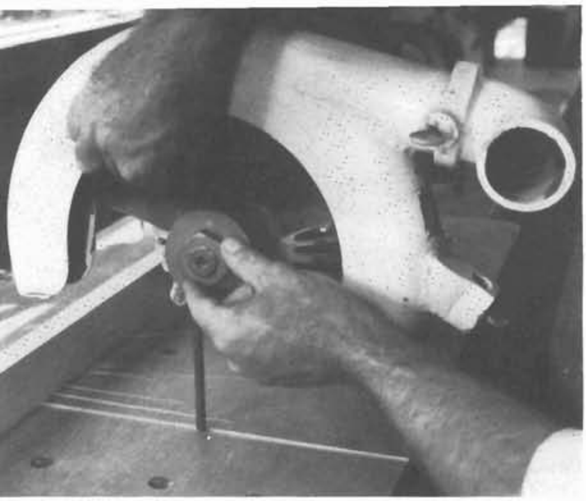
For efficient sawing performance and avoiding damage to the blade, keep the side of the blade parallel to the track. If the blade is not parallel to the arm travel, it will be pulled across the stock at an angle that is slightly sideways. It will not coincide with the line of movement, so the back of the blade will not follow exactly in the saw cut. The saw blade should be parallel to the arm when the saw is in both a vertical and angular position. Follow the manufacturer's instructions for checking and making the necessary adjustments.

Adjusting the saw travel square with the fence

The travel of the saw must be at right angles to the fence to make square cuts. It can easily be checked by placing the jointed edge of a board against the fence and making a cut across the end. If the end is not cut at right angles to the jointed edge when checked with a square, reset the blade travel. Since the mechanism of each machine is different, follow the directions supplied by the manufacturer closely.

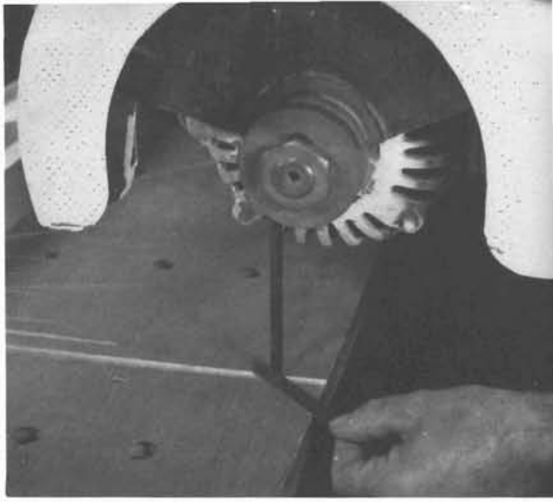
Adjusting carriage bearing

The carriage bearing must be properly adjusted for accurate work. If the gearing is too loose, the saw will not always follow the same line. A small amount of tolerance at the track is multiplied many times at the saw cut. The saw will be hard to pull if the bearing is too tight. The adjust-



PHOTOS BY CHARLES J. PEREZ

10-5. The end of the rod clamped between the saw collars lightly touches the table.



10-6. Checking the table setting with the arm in the crosscutting position.

ment can be made by following the manufacturer's instructions.

Leveling the table

Adjust the table top parallel to the saw arm to perform satisfactorily all the operations possible on the radial saw. When it is parallel, the depth of cut will always be uniform. Many of the machines have leveling screws for paralleling the table, but some are paralleled by shims placed between the table and the frame.

To set the table parallel to the arm of a radial saw

1. Set the motor shaft approximately parallel to the table and lock the motor in position.
2. Insert an iron rod about 5/16″ in diameter and about 10″ long between the saw arbor collars in place of the blade and adjust the machine until the end barely touches the table when the motor arbor is turned back and forth (Fig. 10-5).
3. With the arm set in crosscutting, mitering, and ripping positions, pull the motor the full length of travel, and at the same time check the distance between the iron rod and the table (Figs. 10-6, 7, 8).
4. If the table is not parallel to the motor arm, loosen the nuts on the leveling screws and adjust the screws until all points on the table are equidistant from the end of the iron rod.

   If there are no leveling screws, loosen the table fasteners and insert sufficient shims to make all points on the table equidistant from the end of the iron rod.
5. Tighten the screws that fasten the top to the frame and recheck the table. On some machines it may be necessary to plane the top of the table slightly to make it parallel to the arm.

CIRCULAR SAW BLADES

A circular saw blade is a circular steel plate with teeth cut on the rim. The size of the blade is designated by

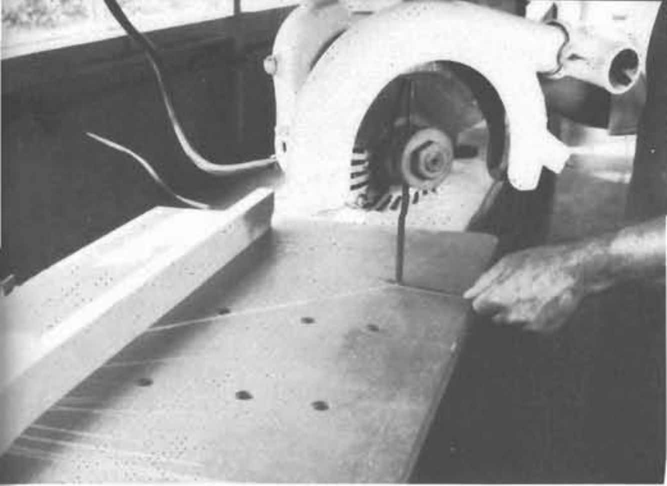


PHOTO BY CHARLES J. PEREZ
10-7. The arm is set in the mitering position.

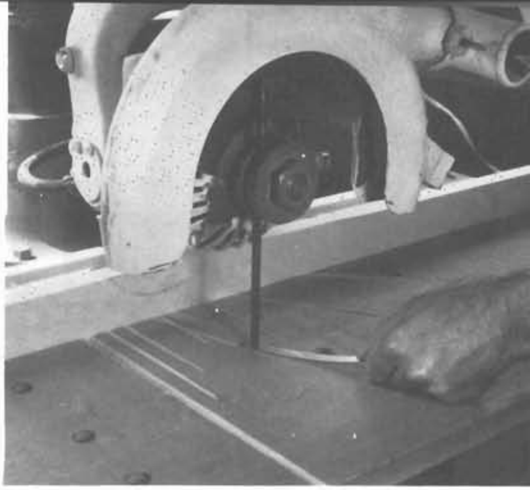


PHOTO BY CHARLES J. PEREZ
10-8. The table setting is also checked with the arm in the ripping position.

the outside diameter and the thickness.

There are many types of saws and cutter heads used for special kinds of work. They are made for crosscutting, ripping, and combination sawing. Table 12 gives a classification of the various kinds of circular saw blades. A typical selection of circular saws is shown in Figure 10-9.

Blade tension

Tensioning is the process of hammering the body of the blade to counteract the effects of centrifugal

10-9. A typical selection of circular saws as used in many shops.
COURTESY SIMONDS SAW AND STEEL COMPANY

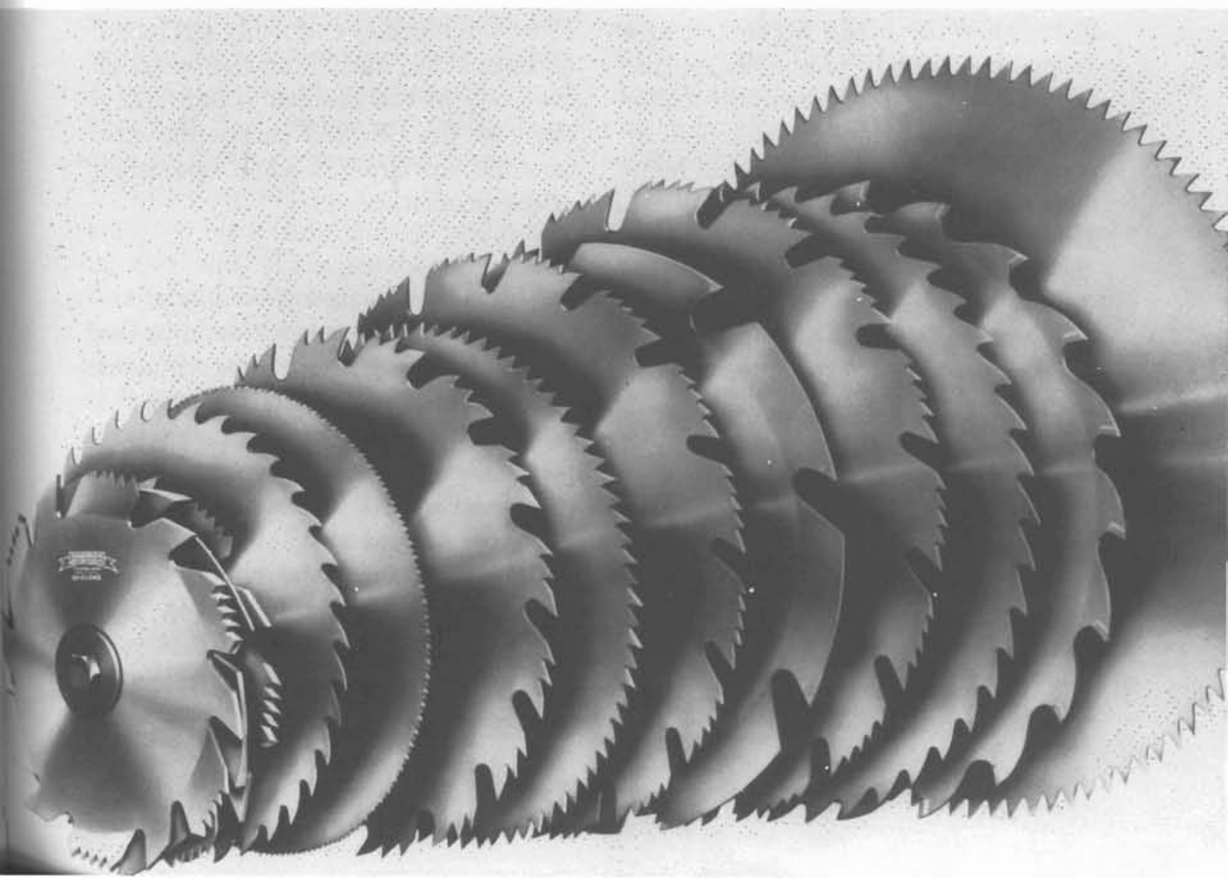
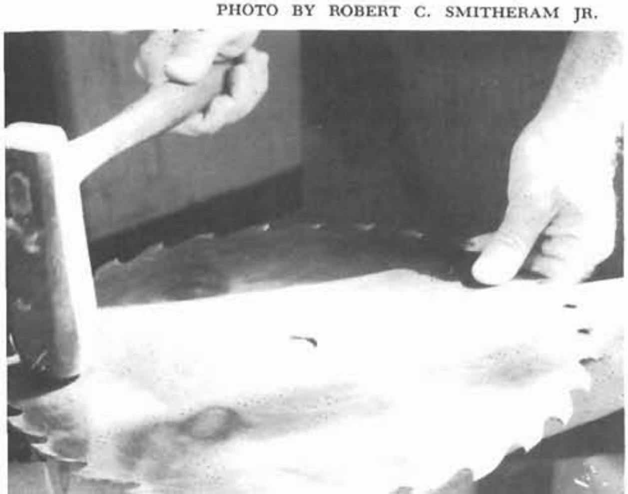


Table 12
CLASSIFICATION OF CIRCULAR SAWS

DIRECTION OF CUT	TYPE OF SAW	TYPE OF CLEARANCE	USES
Across the grain	Cut-off	Spring set, flat ground	General purpose cross-cutting
	Trimmer	Hollow ground	Smooth surface crosscutting
	Mitre		Smooth surface crosscutting and mitering
With the grain		Spring set, flat ground	General purpose ripping
	Rip	Swaged	Production ripping
		Hollow ground	Only smooth surface ripping
All directions	Combination—uniform teeth		General purpose, fast cutting feed
	Combination—two scoring teeth—one raker per section	Spring set, flat ground	General purpose, medium cutting feed
	Combination—four scoring teeth and one raker per section		General purpose, slow cutting feed
		Hollow ground	Only when a smooth surface is required, very slow cutting feed

force when the blade is running at a designated speed. The body of the saw, the portion between the collar space and the rim, is stretched by placing the saw on an anvil and hammering the sides evenly (Fig. 10-10). This prevents the saw from dishing, because the metal is uniformly stretched on both sides. Stretching the metal in the body of the saw has a tightening effect at the rim and causes the saw to stand up straight when operating at the proper speed.

10-10. Blade tension is restored by hammering the body of the saw carefully.
PHOTO BY ROBERT C. SMITHERAM JR.



Although tensioning a blade requires skill and is seldom done in the average shop, it is very important to understand the principle to obtain the best service from the circular saw blade. Saws must be hammered for the speed at which they are run. Unless saws have enough tension, they will not stand up straight and will run "snaky" and vibrate (7, 14). The increased diameter of the blade, high speeds, increased power, fast feed, and decreased thickness of the blade are all conditions that require a blade with more tension.

Saws used for cutting hardwood require more tension than those used for cutting softwood.

There are several causes for saw blades to lose their tension. Heating and cooling and strain from cutting will permanently expand the blade at the rim, making the body too stiff. Gumming (the enlarging of spaces between teeth) causes a blade to lose its tension. See page 198, "Gumming Circular Saws." The removal of metal at the rim sets up new strains that disturb the tension. After a saw has been gummed several times, or severely one time, it often needs rehammering.

Saw blades that are run for any length of time with insufficient tension will crack at the bottom of the gullets. They seldom lose their tension evenly because of uneven temper of the plate and unevenness of the tension in the manufacturing process.

With insufficient and uneven tension, the blade runs "snaky" and heats at the rim. This condition causes lumps to develop on one side of the body and depressions on the opposite side. These lumps naturally bind in the cut and create extreme heat at these places, leaving black spots in the depressions and brightly polished spots on the raised portions. When a blade has developed burned spots or runs snaky, it must be hammered to make it run true.

Hammering saw blades is an art that requires considerable skill. When a saw needs hammering, unless you are an expert, send it to the manufacturer, giving information as to speed and working conditions under which it is to be operated. The expert can then correctly tension the blade so that it will run like new.

Thickness of circular saw blades

The thickness of a saw blade is usually designated by a gauge number. Saw manufacturers generally use the Birmingham or Stubbs gauge for indicating the thickness.

Several factors must be considered when one selects a blade of the proper thickness. As the diameter of the blade increases, the thickness also increases. The blade thickness required also increases as the sawing rate and stock thickness increase. The body needs to be stiff enough to support the rim and prevent it from whipping or vibrating. Added pressure against the teeth or against the side of the blade will cause it to lead away from a straight line.

A thick blade makes a wide cut and wastes more material in the form of sawdust. It also requires more power. This may seem to suggest a preference for a thin blade. However, the evenness of cut, the life of the cutting edge or point, and the ability to take abuse are sacrificed when a thin blade is used. A thin blade cannot be expected to stand up under all sawing conditions as well as a thick one.

Thin blades require only a little less set than thick blades, so that the sav-

Table 13

A COMPARISON OF BLADE SIZE AND NUMBER OF TEETH

Size in inches	Rip	Number of Teeth Crosscut	Combination, non-raker type	Number Sections Combination, flat. Two cutting teeth and one raker	Combination, flat. Four cutting teeth and one raker	Gauge
6"- 8"	36, 40	100	44	16	14	18
9"-10"	30, 36	100	44	16-18	16	16
12"	30, 36	72, 100	44	20	18	14, 15
14"-16"	30, 36	60, 100	44	22-24	20-22	14

ing of material by the reduced width of cut is almost negligible. The cutting strain on the teeth due to the set required almost equals that of the thick blade. However, a thicker blade should not be selected than is needed to do the work satisfactorily. Tables 13 and 14 list the sizes of blades and the gauge commonly used.

Tooth spacing

The total number of teeth in the saw indicates the coarseness of circular saws. Saws are *always* made with an even number of teeth. If there were an odd number of teeth, *one tooth either could not be set or two adjoining teeth would be set toward the same side.*

Tooth spacing is a factor in determining the cutting speed and smoothness of a cut of a saw blade. The greater the number of teeth, the smoother the cut, all other factors being equal, but the rate of feed is also reduced. Fewer teeth make a rougher cut, but the speed of feed can be increased. Therefore the speed at which a saw will cut under a given condition is determined largely by the number of teeth. One should not select a fine toothed saw for smooth cutting and expect to force it through stock at the same rate of feed as a coarse saw. The gullets are too small to handle the sawdust at fast feeds.

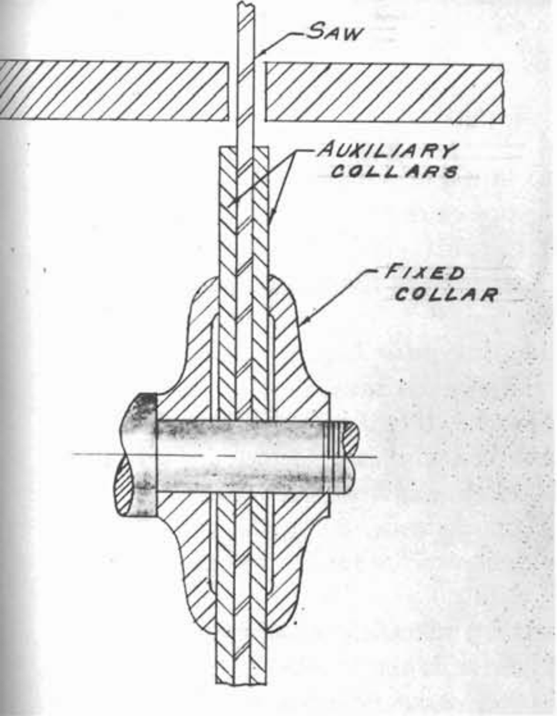
Table 14

GAUGE COMBINATIONS OF HOLLOW GROUND SAWS

Size in in.	Gauge at hole	Gauge at edge of collar	Gauge at rim
6	16	19	16
8	15	18	15
10	14	17	14
12	13	16	13
14, 16	12	15	12

Thin saws require more teeth than thick ones doing the same work. The greater number of teeth distributes the cutting strain over the blade more evenly and reduces the tendency for the thinner teeth to spring sideways, setting up a vibration in the blade (4, 31).

For general-purpose sawing Table 13 lists the diameter of the blade and the number of teeth commonly used.



10-11. Auxiliary collars have a stiffening effect upon the saw blade.

Flanged collars

Properly fitted, true-running collars are essential for efficient sawing performance. Large collars give more support to the saw, thereby reducing vibration, which is one of the causes of metal fatigue and cracks developing at the bottom of the gullets. It is best to use as large set of collars as possible. Collars that are recessed to allow for good contact near their outside diameter give better support to the saw.

Auxiliary collars are sometimes used to give additional support to the saw (8, 13). These are placed on each side of the saw and between the regular collars. They are made ⅛" to 3/16" thick and as much larger in diameter as possible. Fig. 10-11 illustrates their stiffening effect. With an auxiliary collar between the fixed collar and the saw, it may be necessary to make some adjustment to align the saw with the slot in the throat insert. The motor arbor may have to be moved back the thickness of the auxiliary collar. A new insert may be required.

To change a circular saw

1. Pull the switch in the fuse box, or remove the fuses. Lay the guard back; remove it, if necessary.
2. Remove the throat insert, or pull the movable table away from the saw to provide for working space. Double arbor saws may be reached easily when they are at the bottom position.
3. Place a wrench on the arbor nut and turn it in the direction the saw normally runs while holding the saw with a piece of wood wedged between the edge of the teeth and the frame of the machine.
4. Remove the nut, collar, and saw, placing the saw on a piece of wood so that the cutting portion of the teeth will not be damaged. Do not lay the blade on a metal table.
5. If the arbor has not been marked, make a center punch mark on the outside of the tight collar. The punch mark is placed in the same position each time the saw is mounted.
6. Check the collars and the saw to see that they fit the arbor, removing any rosin or foreign material from the face surfaces. The collars and threads must be clean. Collars

and saw should fit the arbor to prevent vibration.

7. With the punch mark on the tight collar turned to the top, place the saw on the arbor with the teeth pointing toward the front and the manufacturer's name at the top. This is a practice generally followed. If the saw is mounted in this position for jointing, it will run true only when mounted in the same position, since the arbor hole is slightly larger than the arbor.
8. Place the retaining collar on the arbor with the recessed side against the saw and screw the nut on the arbor by turning it in the direction opposite to which the machine normally rotates. Add a sufficient number of collars to cover the unthreaded portion of the arbor.
9. Tighten the nut by holding the saw with one hand and giving the wrench a quick jerk with the other hand.
10. Replace the throat insert, or adjust the movable table and reset the guard.
11. Close the switch in the fuse box or replace the fuses.

Circular saw blade clearance

All circular saws should run in the saw cut without binding. Unless there is sufficient clearance on each side, the blade will heat. Provide clearance by setting or swaging the teeth and by hollow grinding.

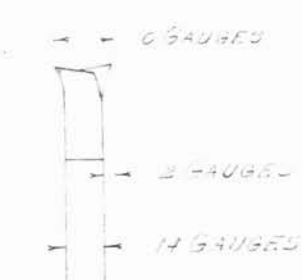
Setting circular saw teeth

Setting is the process of bending a portion of every other tooth toward one side and the remainder toward the opposite side so that the teeth will make sufficient kerf to allow the blade to run freely.

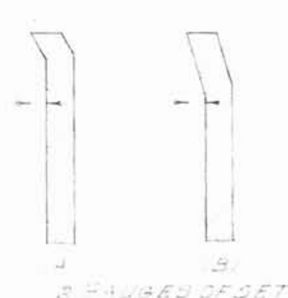
The smoothness of the cut is partly determined by the uniformity and evenness of the set. If the set is uneven, the teeth that have the most set cut deeper into the stock. The increased strain placed on that portion of the blade may cause it to crack. Saws should be set only enough to

10-12. Amount of set for a 14-gauge saw. 10-13. Tooth A with short set causes less friction than tooth B. 10-14. Set showing relationship of breakline to front and back of teeth.

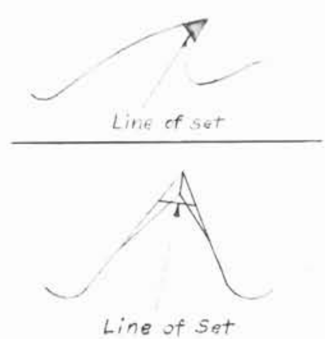
10-12



10-13



10-14



allow them to run freely. In no case should the teeth be set to make a cut more than twice the thickness of the blade as there would be nothing to remove the material left between them. Excessive set causes a rough cut because of vibration, eventually leading to metal fatigue and cracks at the bottom of the gullets. Insufficient set causes the blade to crack with expansion of the heated rim.

The amount of set varies according to the kind of machine on which the blade is used and the kind of stock that is cut. Softwood requires slightly more set than hardwood; portable saws require more than bench saws. Generally, for the blade to cut freely requires 2 gauges of set on each side of the saw for blades used on bench saws and 2½ gauges on each side for portable saws. (8, 23). That is, a 14 gauge saw with 4 gauges of set would make a cut the thickness of a 10 gauge saw (Fig. 10-12). A saw with 4 gauges of set makes a cut that is approximately 1½ times the thickness of the saw. A saw with 5 gauges of set will make a kerf about 1¾ times its thickness.

When the saw is placed on the saw set, each tooth should project over the beveled surface of the anvil only a short distance, so that it can be bent sharply without putting too much set in the saw. This reduces the portion of the tooth which can rub the sides of the cut. If a large portion of the tooth is set, the angle is so gradual that too much of the tooth is in contact with the kerf, thus causing increased friction (Fig. 10-13).

The portion of set for each tooth is determined largely by the size of the teeth and the thickness of the saw. In general, ⅛″ to ¼″ of the tooth is set (1, 4). On fine toothed saws a larger portion of the tooth must be set in order to provide sufficient clearance without bending it to the breaking point. On the other hand if the tooth set is too deep, the blade may be twisted, with the possibility of starting a crack at the gullet. Each tooth should be set at such an angle as to give maximum clearance for the body of the tooth and carry the sawdust out of the cut instead of letting it crowd past the tooth and bind the saw. Fig. 10-14 shows the relationship of the break line to the front and back of the tooth of both crosscut and rip saws. It intersects the front and back of the tooth at approximately the same distance from the point (11, 9).

The setting operation twists the teeth slightly and throws the front out of square with the sides of the saw. The front may be squared either by grinding it lightly on a rounded gumming wheel or by filing with a round edged file. If a file is used, be careful not to cut sharp corners in the gullets.

A smoother cut can be obtained by setting a larger portion of the tooth but at a lesser angle, so that the kerf will still remain the same width. The gradual angle gives the sides of the teeth more support in the kerf. In this case the set must be uniform and the teeth kept sharp (2, 28).

A saw with spring set performing within its capacity, will cut *easier* than a saw with the same number of swaged teeth, since a set tooth only removes a portion of the width of the cut. (See "Swaging," page 179.) However, teeth with spring set will not cut as *fast* as swaged teeth. Usually a circular saw set is used to set the teeth. However, heavy hand sets are made that will successfully set saws as thick as 14 gauge.

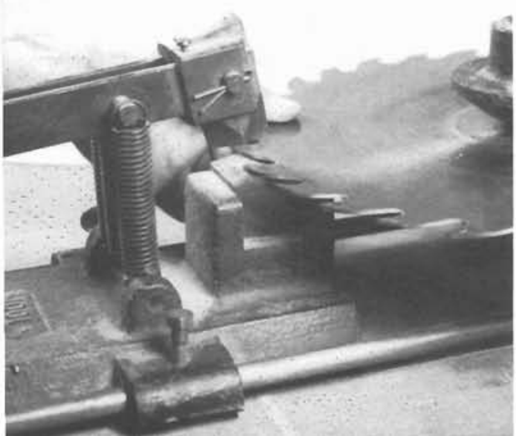
Circular saw sets or stakes

Circular saw stakes consist of a frame upon which is mounted an arbor and an anvil. The arbor may be located at various distances from the anvil. It is furnished with cones to fit various sized arbor holes to center the saw. The anvil is beveled on the outer edge and regulates the angle at which the tooth can be set. Some sets have a trip hammer which is lifted by a lever to a predetermined point at which time it is released. The force exerted by the springs drives the hammer against the beveled portion of the anvil (Fig. 10-15). Another type has a plunger mounted above the anvil. The plunger, when hit with a hammer, drives the tooth against the anvil. A coil raises the plunger to its original position. The teeth in another type of set are bent by means of a punch placed at right angles to the beveled portion of the anvil. The punch is then hit with a hammer. The teeth of coarse saws are struck directly with the hammer.

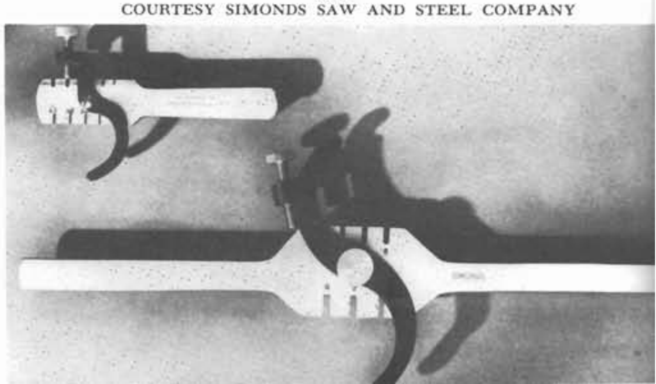
Some hand sets are heavy enough to set saws up to 14 gauges satisfactorily. The most common is the lever set. It has an anvil that can be adjusted to set varying portions of the tooth. As pressure is applied to the lever, the plunger is pushed against the tooth, bending it against the beveled portion of the anvil. Fig. 10-16 shows two sizes of adjustable saw sets.

To set a circular saw with a stake

1. Mount the saw on the stake and adjust its position and the beveled surface of the anvil to give the required amount of set. Bend the correct portion of the tooth.
2. With the tooth located in the proper position on the anvil, set it with the setting tool. If this tool is a punch, place it on the tooth at right angles to the bevel on the anvil and strike it a sufficiently firm blow with a hammer to bend the tooth. Too hard a blow will crush the tooth. If the hand set is used, adjust it to fit on the tooth correctly.
3. Set two or three teeth on each side



10-15. Setting a circular saw with a trip hammer stake.
PHOTO BY CHARLES J. PEREZ



10-16. Two sizes of adjustable circular saw sets.
COURTESY SIMONDS SAW AND STEEL COMPANY

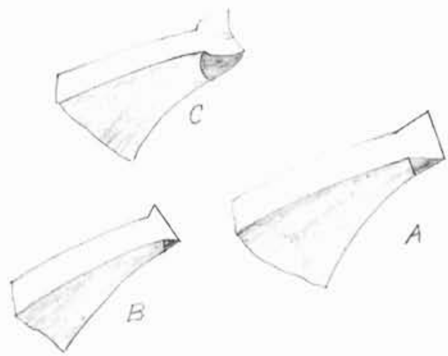
of the saw and check them to see that they are spread enough to make a kerf approximately 1½ times the thickness of the blade.

4. If the test teeth are properly set, set each alternate tooth toward one side and the remaining ones toward the other side.
5. Square the front of rip teeth on a gumming wheel, or with a round edge file. Keep the gullets well shaped and grind the face of each tooth only enough to make it square with the sides of the blade. If a gumming wheel is not available, file the face of the teeth square with a round edge 8″ flat mill bastard file. Be careful to maintain the proper hook on the teeth and avoid cutting into the gullets.

   It is not necessary to grind the teeth on crosscut saws. They are easily shaped when the bevels are filed on the front and back.

SWAGING

Swaging is a process of upsetting the ends of the teeth with a special tool to make the cutting edge wider than the thickness of the blade. Swaged teeth are actually chisels, each cutting the full width of the kerf, whereas spring set teeth are like narrow chisels, each removing only a part of the total width. A swaged saw will cut faster, but requires more power than saws with other types of clearance, because every tooth makes a cut the full width of the kerf. Swaged teeth on a rip saw are preferable for production work.



10-17. The effects of swaging on different shapes and sizes of teeth. A shows a properly formed tooth, B illustrates the effects of swaging a slender tooth, and C the effects of swaging a tooth with a thick body.

For swaging, all of the teeth must be uniform and of the correct size and shape. Exceedingly thin teeth spread too much at the points without upsetting the body of the tooth sufficiently to support the cutting edge. This causes them to dull quickly and break off when cutting hard material. If the teeth are too thick, they will upset deep into the body and very little at the cutting edge, placing extra strain on the edge (Fig. 10-17). This may cause them to split (9, 17). They should be swaged on the front rather than the back to prevent raising the edge. A drop of oil placed on the die will aid in spreading the teeth.

To understand swaging and other work on a saw, study the actual tools. Only a knowledge of how they look "in person" will make it possible to read about them intelligently.

Saw swages

Both the *lever* and the *upset swage*

are used for swaging saws. The lever swage clamps to the side of the saw with the tooth between the die and the anvil. When the operator applies pressure with the lever, the die presses the tooth against the anvil sufficiently to spread the cutting edge. These swages are used in production plants where a considerable amount of swaging is necessary.

For the small shop where such equipment as grooving cutters, dado heads, or rip saws needs infrequent swaging, the upset swage is satisfactory. It is composed of two dies. The upper opening has a convex surface on the bottom which places pressure on the center of the tooth, spreading and shaping it. The lower die is flat on both surfaces and is used for squaring the edge. The tooth is spread by placing the swage against the edge and striking it with a hammer.

To swage a groover or a rip saw

1. Joint the teeth to a uniform length. Use procedure, "To Joint a Circular Saw", page 182.
2. File the teeth sharp and to a uniform shape. It is advisable to use a gauge for checking the shape of the teeth.
3. Place the convex surfaces of the swage against each tooth, holding them at such an angle that the shape of the back of the tooth will not be changed. Strike them light blows with a hammer until the tooth is spread to the required width. Be sure to swage all teeth at the same angle to keep them the same length. Put a drop of oil on the swage frequently.
4. Place the flat surfaces of the swage against each tooth and strike it a sufficient number of light blows to square the tooth.
5. Joint the saw or groover only enough to make it round.

To complete the sharpening process follow the procedure "To Sharpen a Groover or a Rip Saw," page 195.

Hollow grinding

In some saws provision is made for clearance by grinding them several gauges thinner between the rim and

10-18. Two methods of hollow grinding saw blades.

the collar area. Two methods of hollow grinding are used. One is to grind a gradual taper from the rim to the collar area (A, Fig. 10-18). The other is to grind part of the sides parallel and several gauges thinner than the rim and collar area (B, Fig. 10-18). This latter method shortens the life of the saw to some extent. After many filings the rim becomes so narrow that the gullets extend into the thinner portion of the saw. However, because of the increased clearance obtained by grinding the sides parallel, it will run freer in the kerf than the taper ground saw and cut much faster.

The purpose for using hollow ground saws is to obtain a smooth cut. The smoothness of a cut depends largely on the evenness of set and true rim travel of the saw. Because the hollow ground saw has uniform clearance and a rim that is supported in a minimum kerf, it is an extra smooth cutting saw (Fig. 10-19).

No other saw is abused as much as the hollow ground saw. It was never made for general purpose sawing. If used for such work the slow cutting teeth running in such a narrow kerf soon heat and burn at the points. The burned points then become dull and rounded and no longer cut a full width kerf. As a result, the teeth start binding just back of the points, causing the rim to heat and the saw to run "snaky." Whenever a saw gets so hot it smokes, it sustains serious damage. The corners cannot be allowed to round off the least bit or show other signs of dullness.

The hollow ground saw should be used only when smooth finished cuts are desired without jointing.

In order to take advantage of the clearance obtained by hollow grinding, the operator should run the saw approximately at full height above the table so that the smallest possible amount of rim thickness will be in the kerf. If the saw barely projects through the stock, a large portion of the rim runs in the kerf and very little advantage is gained from the reduced thickness of the saw. Most of the clearance is beneath the table (8, 51). From a safety point of view the saw should project through the stock only a small amount. But the benefits of hollow grinding are lost if it is not operated at full height. If the saw has a guard and the operator uses good judgment, it may be as safe to operate the saw raised to its full height with the added clearance as to have it just projecting through the stock and binding in the kerf. Of course, binding may throw the stock back.

Hollow ground saws are commonly three gauges thinner in the body than at the rim and collar area. It is necessary, therefore, to use blades with thicker rims than would ordinarily be required for flat ground, spring set blades. The additional body thickness makes these saws withstand the strain to which they are subjected.

The common gauge combinations of hollow ground saws are shown in Table 14 (6, 38).

Jointing circular saws: It is important that the saw be jointed before it is filed. Jointing serves as a guide

COURTESY SIMONDS SAW AND STEEL COMPANY
10-19. Hollow ground saw. Clearance is provided by grinding a gradual taper from the rim to the collar area.

for filing as well as making the saw round. The operation must be carefully performed because no saw will cut properly unless it is perfectly round. Only then is it possible for each tooth to do its share of the cutting.

The saw is made round by first mounting it on the machine and jointing the teeth with a jointing stone or piece of hard grinding wheel while the machine is running. Raise the saw to a point so that the teeth project slightly above the table. Check the height by pushing a piece of wood over the saw with the aid of the cut-off gauge. If there is a possibility of scratching the table or throat insert with the jointing stone, tape a piece of drawing paper over that portion of the top.

Overhead saws, such as swing cut-off saws and radial saws, can be jointed by clamping a stop on the machine to regulate the travel of the saw. The blade should slightly touch the jointing stone when it is placed against the cut-off fence. It is advisable to test the set-up with a piece of wood before jointing the saw.

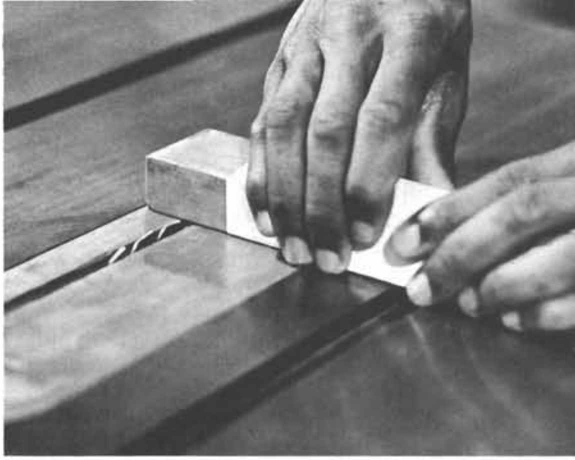
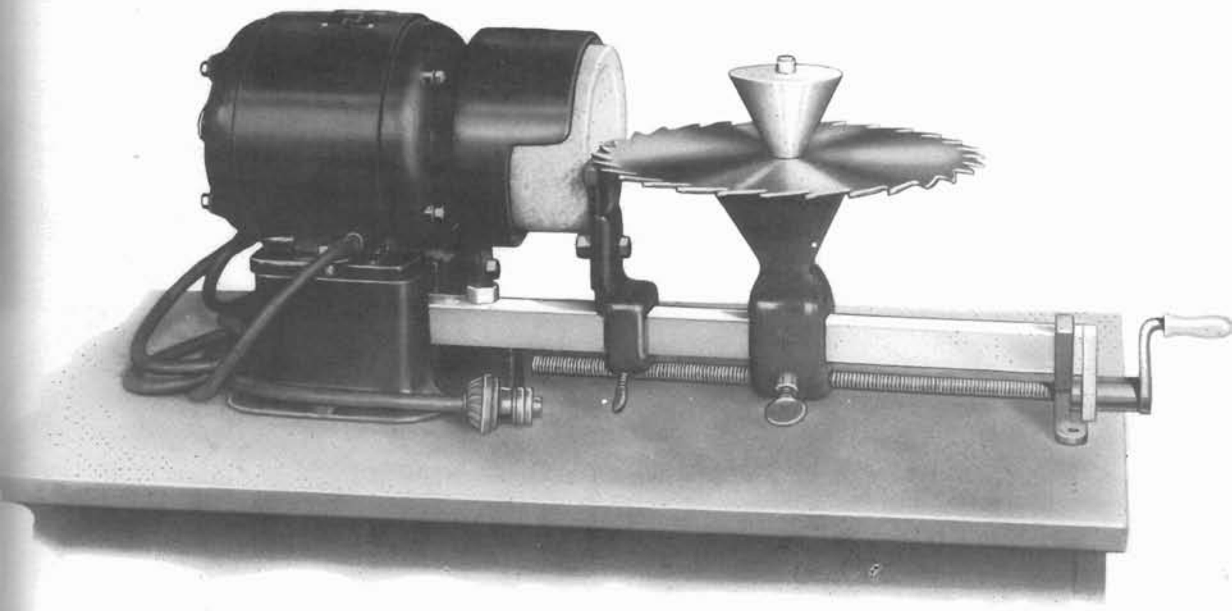


PHOTO BY BONTEMPS
10-20. Jointing the teeth of a circular saw. Notice paper wrapped around stone to prevent scratching of the table top.

There does not seem to be much agreement among manufacturers as to how to mount the saw for jointing. Some joint the teeth with the saw mounted in its normal running position, whereas others suggest that it be turned around so that the teeth point in the opposite direction, but with the manufacturer's name placed in its proper relationship to the mark on the arbor. Experiments indicate that there is little preference. Either method gets the job done satisfactorily.

To joint a circular saw

1. Mount the saw on the arbor. Use procedure to mount a circular saw, page 176. The saw may be mounted with the teeth pointing in either direction.
2. Adjust the saw so that the teeth



COURTESY HUTHER BROS. SAW MFG. CO.
10-21. Combination circular saw jointer and cutter grinder.

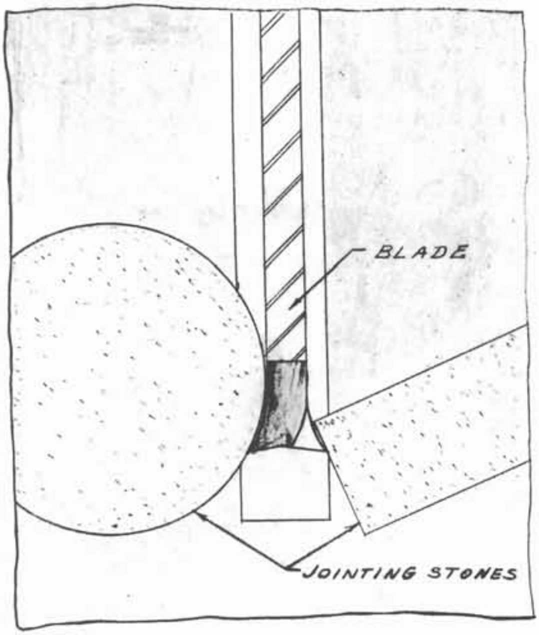
are slightly higher than the table. Test the height by pushing a piece of wood over the saw with the aid of the cut-off gauge. Score the wood very lightly.

3. With the saw running, joint the teeth by pushing a jointing stone over the saw (Fig. 10-20). A piece of hard grinding wheel is excellent for this purpose. Never use a soft stone or wheel because the groove cut in the stone will round the corners of the teeth.
4. Stop the saw and examine the teeth. If any have been missed, it will be necessary to repeat the process. Circular saws can also be jointed in specially built motor-driven jointers (Fig. 10-21).

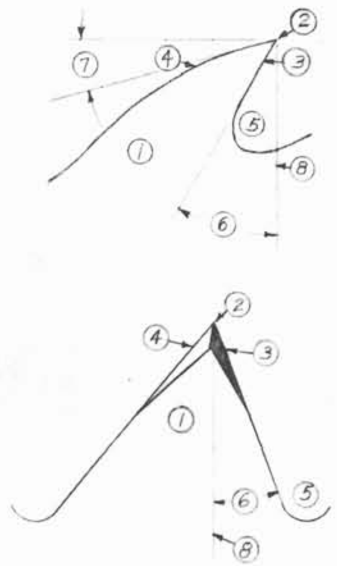
Side jointing circular saws: After a saw has been set or swaged, it should be side jointed lightly so that all the teeth are even on either side of the saw. This process requires extreme care, for the teeth damage easily. If the corners are slightly rounded, or if the jointed surface is parallel to the sides of the saw and becomes too large, the saw will have a tendency to bind in the kerf. It is advisable to side joint the teeth with a slight taper from the cutting edge toward the body of the saw. Side jointing may be done with either a flat or a round stone.

To side joint a circular saw

1. Mount the saw on the machine. Use the procedure, "To Change a Circular Saw," page 175.



10-22. Side jointing the teeth of a circular saw.



10-23. The terms listed above are typical of rip and crosscut teeth. 1. Body. 2. Edge or point. 3. Face or front. 4. Back. 5. Gullet. 6. Pitch or hook. 7. Clearance angle. 8. Center line.

2. Adjust the machine so that the saw extends the full height above the table.
3. With the machine running at full speed, lay the jointing stone on the table and carefully move it against the sides of the teeth, making a slight taper from the ends toward the body of the saw (Fig. 10-22). Do not side joint more than is necessary.

Shape of circular saw teeth

The pitch or hook of the teeth and the size, shape, and depth of the gullets are very important factors in determining the service and sawing performance. If the tooth has too much pitch, the body will be weak. With exceedingly large gullets this weakness will occur at the base of the tooth, causing it to chatter, vibrate, and eventually crack. A tooth that has a small amount of pitch has a scraping or tearing action. It requires more power, places greater strain on the rim, and dulls quickly.

The tooth should have as much pitch as possible and still give sufficient support to the body to make it strong and to provide large, well rounded gullets to carry away the sawdust. It should also have plenty of back clearance so that the portion of the tooth just back of the cutting edge will not bind in the bottom of the cut. The faster the feed, the lower the back of the tooth should be, giving more clearance and space for sawdust. (2, 9).

The elements of a saw tooth are shown in Fig. 10-23.

Care of circular saws

Circular saws should cut easily and not require an undue amount of pressure to feed the wood into the saw. They should always be kept smooth, bright, and clean. Scratches, patches of gum, or rust will cause the saw to bind and collect more pitch and gum.

Pitch and rosin may be removed from a saw by covering the surface with a solvent, such as kerosene or turpentine, and rubbing it with a stiff brush after the pitch has softened. One of the best ways to remove hardwood gum (8, 16) is to soak the saw in hot water for a short time and then wipe it dry with a cloth. A coat of light oil is applied immediately to prevent rusting. Commercially made pitch removers can also be used to remove pitch and rosin. Never clean a saw by scraping it with a sharp tool since this may scratch the surface and cause recesses which collect gum.

It is essential that saws be kept sharp. As they become dull, the points or corners become slightly rounded. This causes the teeth to bind in the kerf, create heat, run "snaky," and form cracks in the gullets. To remedy this condition file new points or edges on the teeth. Saw blades will last considerably longer if they are kept sharp. Waiting to sharpen a saw until it is very dull actually removes more metal than if it were sharpened more frequently. The length of time the teeth stay sharp depends upon the hardness of the wood and the speed of the feed. Either too fast or too slow a feed will dull the teeth quicker than a normal cutting speed.

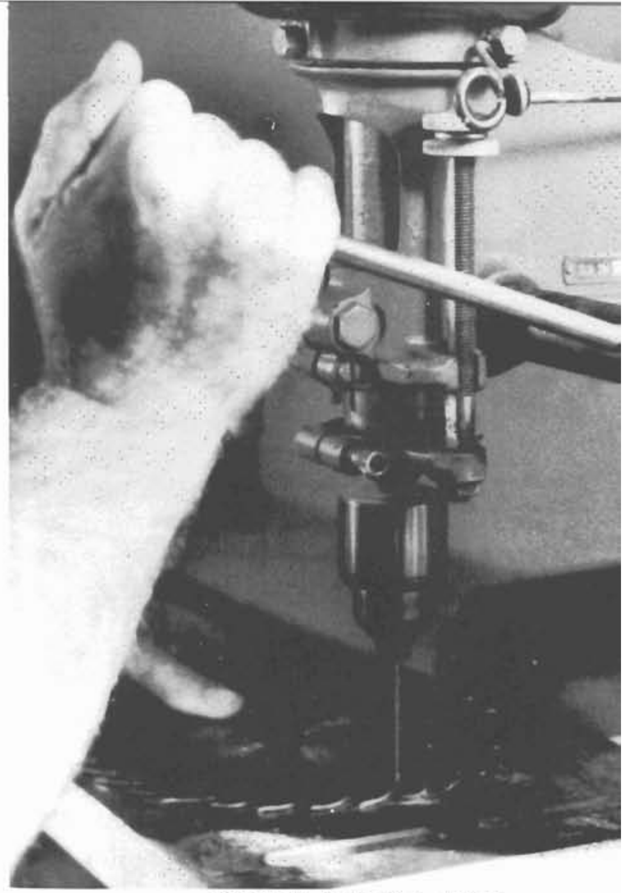


PHOTO BY CHARLES J. PEREZ

10-24. Drilling a hole at the bottom of a crack will prevent further cracking.

The gullets must be kept round. Square corners do not provide free movement of sawdust and are likely to cause the saw to crack because of the concentration of strain at one point (4, 36). If a crack does develop at the bottom of the gullet, it can often be stopped by drilling a hole approximately 1/8″ in diameter at the end of the crack (Fig. 10-24), or by center punching both sides at the same point (Fig. 10-25), (5, 79). If the end of the crack is not carefully located and extends below the hole or

PHOTO BY CHARLES J. PEREZ

10-25. To stop small cracks, center punch both sides of the saw at the end of the crack.

punch marks, it may continue to crack. A saw with teeth that have cracked too deeply should not be used, since the strain from sawing may cause a piece to break out while it is running.

Circular saw filing clamps

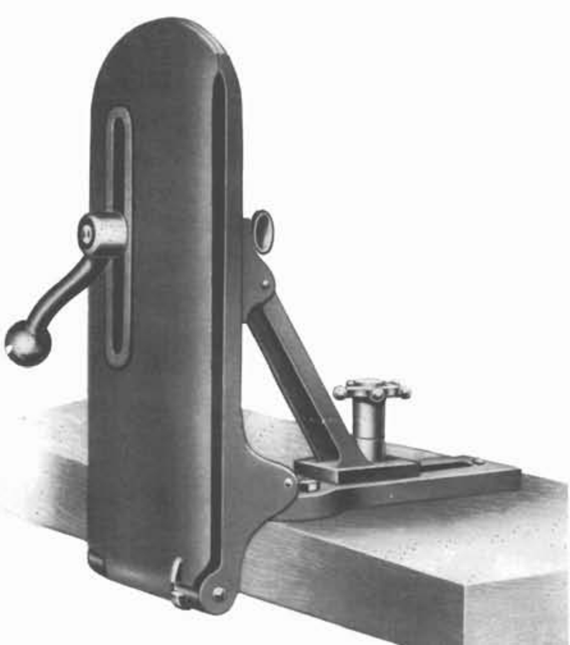
Place circular saws in a circular saw vise for filing. It will hold the saw firmly near the teeth to prevent chatter and vibration. It is adjustable for a range of sizes of saws and constructed to allow the teeth to be conveniently rotated into filing position (Fig. 10-26 and 27). Clamps of this type may be purchased, but a good clamp can be made that serves the purpose. The clamp shown in Fig. 10-28 is satisfactory.

Sharpening circular saws: The rip saw cuts with the grain, the teeth serving as a series of chisels which cut out succeeding particles of wood (Fig. 10-29). The teeth of a rip saw are made in several different shapes as to pitch, body width, back clearance, and tooth bevel, depending upon the type of work to be done.

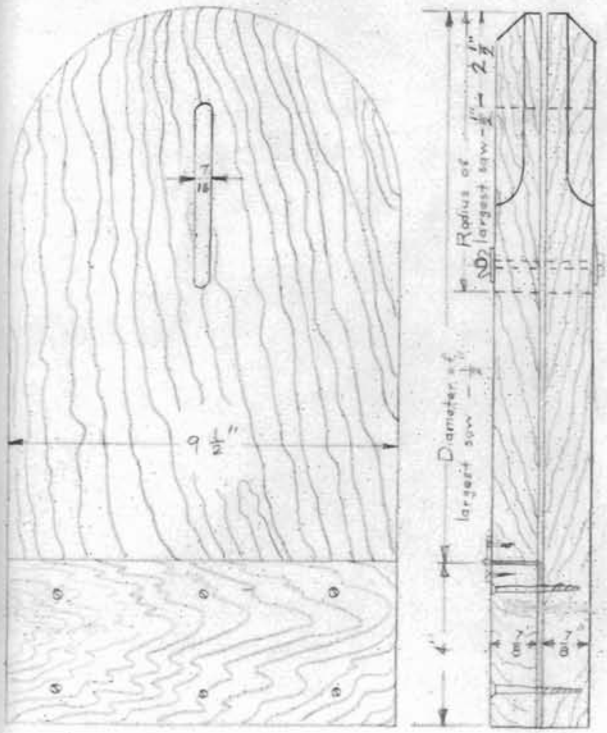
For general purpose sawing a tooth with 30° hook back of the center of the saw and a back clearance of 10°

10-26. Adjustable circular saw vise, vertical position.

COURTESY HUTHER BROS. MFG. CO.



10-27. The same vise in a tilting position. When sharpening dado blades this position is preferred.



10-28. Home-made circular saw clamp.

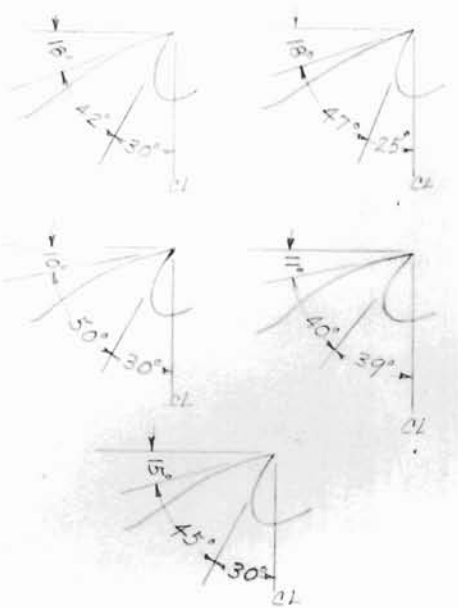
COURTESY SIMONDS SAW AND STEEL COMPANY

10-29. Rip saw blade.

to 15° has long been recognized as the correct shape (5, 80). In more recent years new saw steels have made it possible to increase the hook of the teeth without sacrificing sawing efficiency or weakening the saw. The hook should be 30° or more, but never less (9, 12). However, one saw manufacturer (2, 28-29) recommends tooth patterns wth 30° hook, 45° body, and 18° back clearance. Still another company (7, 14) suggests a rip tooth pattern with 39° hook, 40° body and 11° back clearance. Layout of tooth patterns that may be used for reshaping rip saw teeth is in Fig. 10-30.

The gullet space should be kept sufficiently large to discharge the sawdust properly, but not so deep that the teeth become weak. If the gullets are too deep in proportion to the strength at the base, the tooth will chatter and vibrate, resulting in metal fatigue.

Tooth spacing determines for the most part the depth of the gullet. The greater the distance between teeth, the greater the gullet area required to carry away the sawdust, since each tooth must take a deeper cut at a given feed. Generally, the gullet depth is two-fifths of the distance between the points of the teeth (1, 4). If the distance between the points of the teeth is 1¼", the gullet depth equals ⅖ of 5/4" or ½".

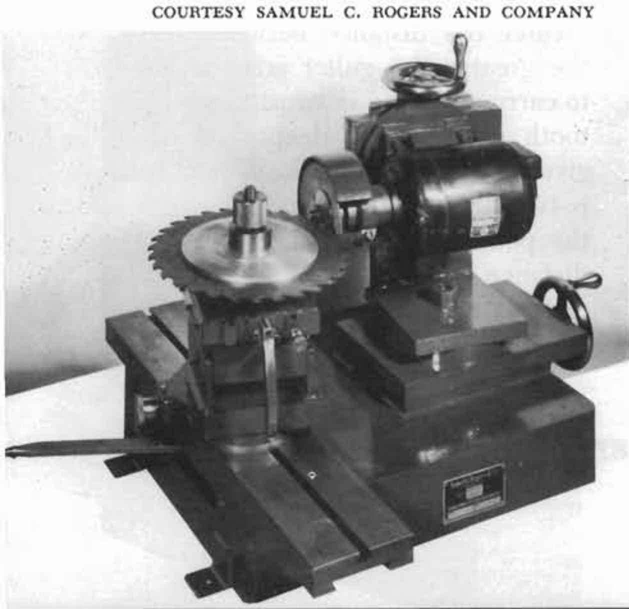


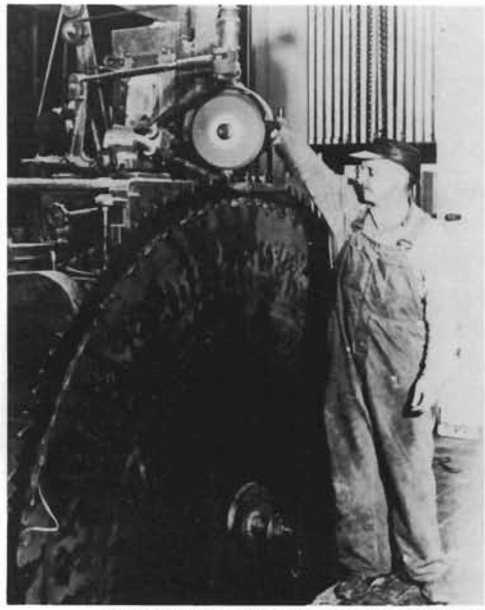
10-30. Various layouts of rip saw teeth showing different amounts of hook, body and back clearance.

The front of the teeth is filed straight across. The back of the teeth may also be filed straight across for some types of work, but for general ripping they may be beveled 5° to 10° (8, 39). This gives the teeth a slight crosscutting action, permitting them to cut faster and easier. Too much bevel creates a splitting rather than a cutting action, and may cause the saw to vibrate, make a rough cut and result in metal fatigue. An 8″ mill bastard file with two rounded edges is recommended for filing rip saws.

10-31. Sharpening a rip saw on a mechanical blade sharpener. The back of each tooth is sharpening on the flat side of the grinding wheel.

COURTESY SAMUEL C. ROGERS AND COMPANY





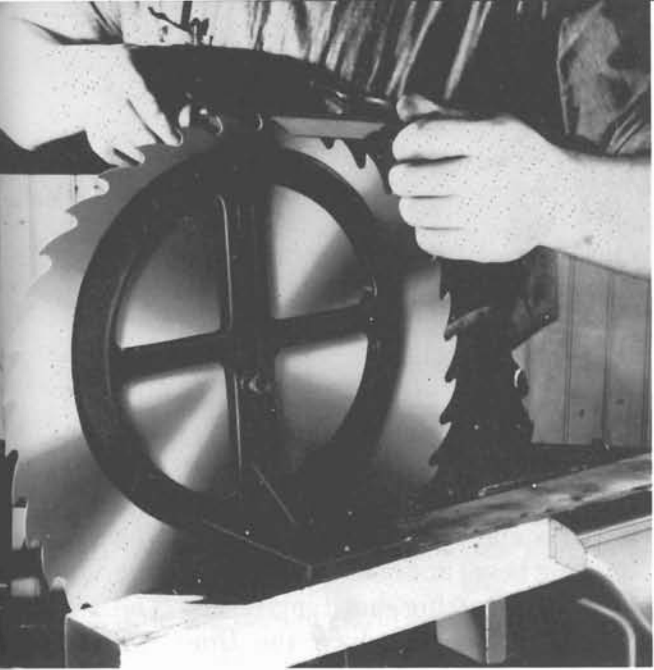
COURTESY HANCHETT MANUFACTURING COMPANY

10-32. Sharpening a 108″ diameter saw with a specially-shaped grinding wheel.

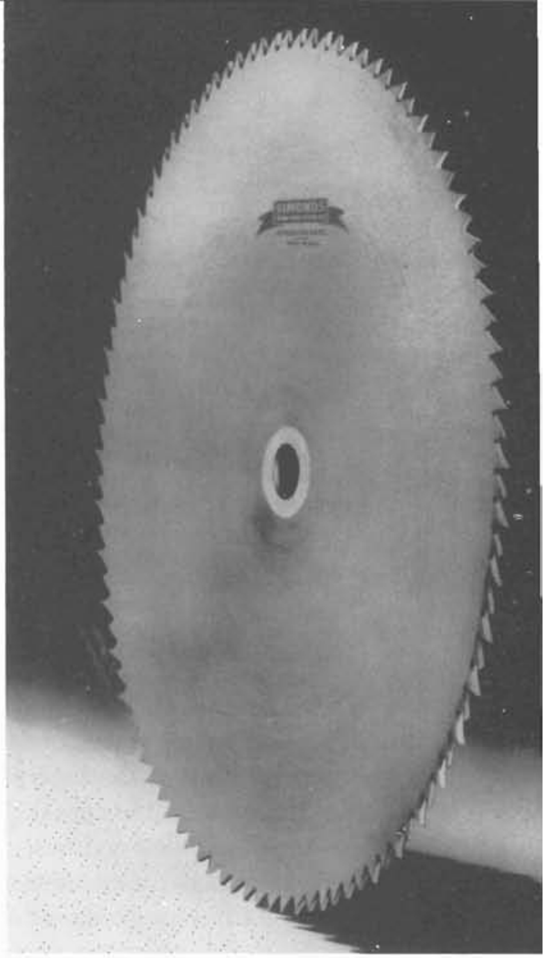
Several mechanical sharpeners have been perfected to do a highly satisfactory job. Figs. 10-31, 32 show how heavy gauge and large diameter saws may be sharpened on special grinders.

To sharpen a circular rip saw

1. Set the saw. Use procedure, "To Set a Circular Saw with a Stake," page 178.
2. Joint the saw. Use procedures, "To



COURTESY NICHOLSON FILE COMPANY
10-33. Sharpening the teeth of a rip saw. Note that the file is held in a horizontal position at right angles with the blade. The handle may also be dropped 5° to 10°.



COURTESY SIMONDS SAW AND STEEL COMPANY
10-34. Circular crosscut saw.

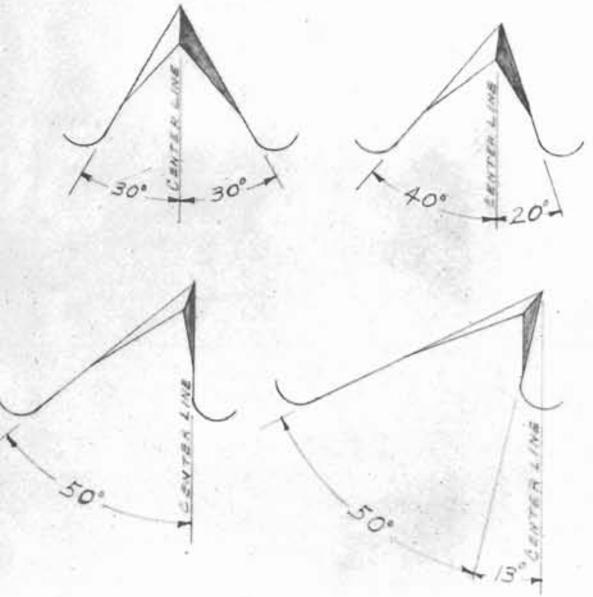
Change a Circular Saw," page 175, and, "To Joint a Circular Saw."

3. Place the saw in the circular saw filing clamp and file the back of the tooth which points away from you until it comes to a sharp edge. The file may be held at right angles to the sides, or the handle may be dropped 5° to 10°, skewing the edge slightly, whichever is preferred. Be sure to keep the filed surface flat (Fig. 10-33).

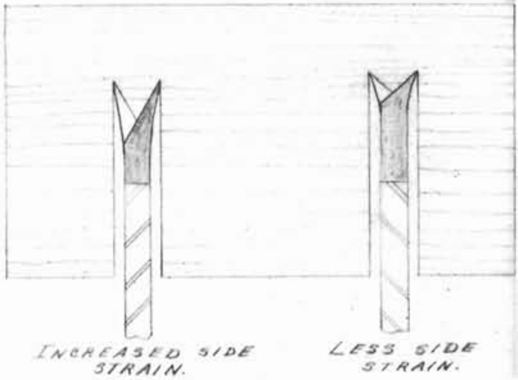
   If the saw was not set at this sharpening, the teeth should be filed lightly on the front.
4. Turn the saw around in the clamp and file the remaining teeth at the same angle.
5. Mount the saw on the machine and side joint it. Use procedures, "To Change a Circular Saw," page 175, and, "To Side Joint a Circular Saw", page 183.

   If the saw does not require more set, it may be sharpened by jointing it round and filing each tooth to a sharp edge.

SHARPENING CIRCULAR CROSSCUT SAWS: Crosscut saws cut across the grain, the teeth serving as two rows of knife points scoring the fibers on each side of the cut. The edge formed by the intersection of the beveled surfaces on the front and back of the teeth break out the fibers that have been severed (Fig. 10-34).



10-35. Crosscut teeth showing different amounts of hook.



10-36. Length of bevel is directly related to side strain of blade.

Fig. 10-35 shows the types of teeth that are used on the various types of crosscut saws. Saws with the front of the teeth in line with the center of the saw are recommended in most cases (1, 10). A coarse saw, used on a swing cut-off and radial saw, should have teeth hooked 20° or more ahead of the center of the saw. Smooth trimmer saws have teeth hooked as much as 13° back of the center of the saw (8, 56).

The front and back of the teeth are beveled, usually with more bevel on the front than on the back. Crosscut saws used for general work are filed with a 15° angle on the front and a 10° angle on the back. When smooth, fine work is required, a 25° to 30° angle is filed on the front and a 10° to 15° angle on the back (2, 26).

The bevel should extend down about one third to one half the length of the tooth. The distance is greater for smooth cuts and for softwood than for hardwood; but it should never extend down into the gullet to change its shape or make sharp corners. The long bevel does not stay sharp as long when cutting hard material. The greater the bevel on the front and back of the tooth and the farther it extends down the tooth, the greater the side strain and the more pointed it becomes. One can see in Fig. 10-36 that the long, pointed tooth has more tendency to pull out into the side of the cut. Because of the increased lateral strain on the teeth, a crosscut saw is more susceptible to cracking than any other type of saw.

The proper file is selected according to the tooth spacing. Saws with coarse teeth may be filed with 8″ mill bastard round edge files. Crosscut saws with a tooth spacing under ⅜″ may be filed with 8″ cant saw files or 6″, 7″, and 8″ slim taper files (8, 45). If the tooth spacing permits, a round file may be used to clean and deepen the gullets.

To sharpen a circular crosscut saw

1. Set the saw. Use procedure, "To Set a Circular Saw with a Stake," page 178.
2. Joint the saw. Use procedures, "To Change a Circular Saw," page 175

and, "To Joint a Circular Saw," page 182.

3. Place the saw in a circular saw filing clamp. If the teeth have a 60° gullet angle, file them to the proper shape and gullet depth. Hold the file at right angles to the sides of the saw, both horizontally and vertically.

   The teeth on saws with wide tooth spacings may be shaped on the gumming wheel.
4. File the correct bevel on the front and back of the teeth pointing away from you. Stop filing when they come to a sharp point.
5. Turn the saw around in the clamp and file the remainder of the teeth at the same angles.
6. Mount the saw on the machine. Use procedure, "To Change a Circular Saw," page 175.
7. Side joint the saw. Use procedure, "To Side Joint a Circular Saw," page 183.

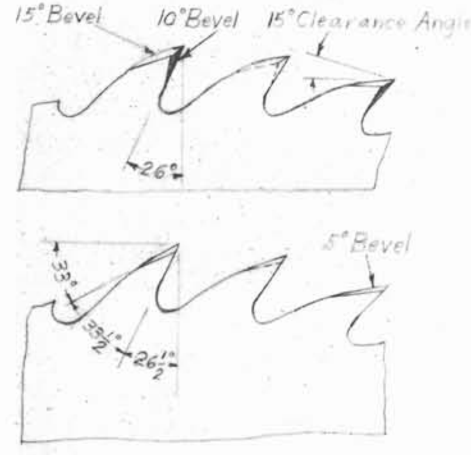
If the saw does not require more set, it may be sharpened by jointing it round and filing each tooth to a sharp point.

SHARPENING THE COMBINATION CIRCULAR SAW: A combination saw is used wherever it is necessary to alternate frequently between crosscutting, ripping, or mitering, especially when these operations are performed on one machine. The performance of this saw is not equal to that of the other saws but it does satisfactory work and saves the worker considerable time.

Combination saws follow two different principles of design. In one case, the style of the teeth resembles that of a rip saw. These saws usually contain more teeth and are beveled on both the front and the back, making it possible to score the fibers when crosscutting. The saw is flat ground and obtains clearance by spring set. The ease with which it can be sharpened and its fast cutting speed make it a popular saw even though it does not make as smooth a cut as other combination saws. It can be used on all types of machines, but is especially recommended for portable electric saws.

The teeth on some of these saws are hooked approximately 26° back of the center of the saw and have a back clearance of 15° to 20°, forming a strong tooth body. The front of the tooth is beveled 10° and the back 15° (8, 53). One company equips its bench saw (10, 8) with a blade that has the teeth hooked 26½° back of the center

10-37. Shape of combination circular saw with uniform teeth.



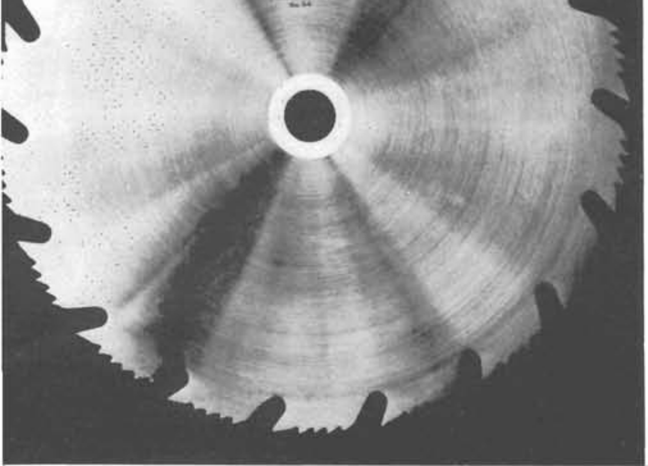
of the saw and a $33\frac{1}{2}°$ body and $30°$ back clearance. The front of the tooth is filed straight across and the back is beveled $5°$. The layouts of these two designs are given in Fig. 10-37.

The gullet depth of these saws is approximately two thirds of the distance between the points of the teeth. The reduced hook on the teeth makes it necessary to have deeper gullets than those on the rip saw in order to remove sawdust.

The amount of set required is determined mostly by the type of machine on which the saw is used. Generally, the teeth are set two gauges toward each side, making a kerf about $1\frac{1}{2}$ times the thickness of the saw. When the saw is used on a portable electric saw, the teeth require $2\frac{1}{2}$ gauges toward each side to cut a kerf about $1\frac{3}{4}$ times the thickness of the saw.

The teeth can be filed with either an 8″ cant or a mill bastard file.

10-38. Flat-ground combination saw. The teeth of this saw require spring set.
COURTESY SIMONDS SAW AND STEEL COMPANY

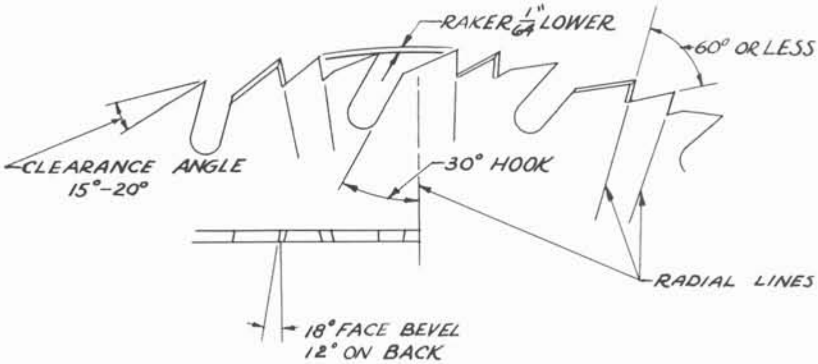


The other style of combination saw has two kinds of teeth, crosscutting and raker. The groups of crosscutting teeth score the fibers on either side of the cut and the rakers remove the material left between the two scored lines, allowing the scoring teeth to cut faster with less friction. These saws are made either flat or hollow ground, depending upon the smoothness of cut required.

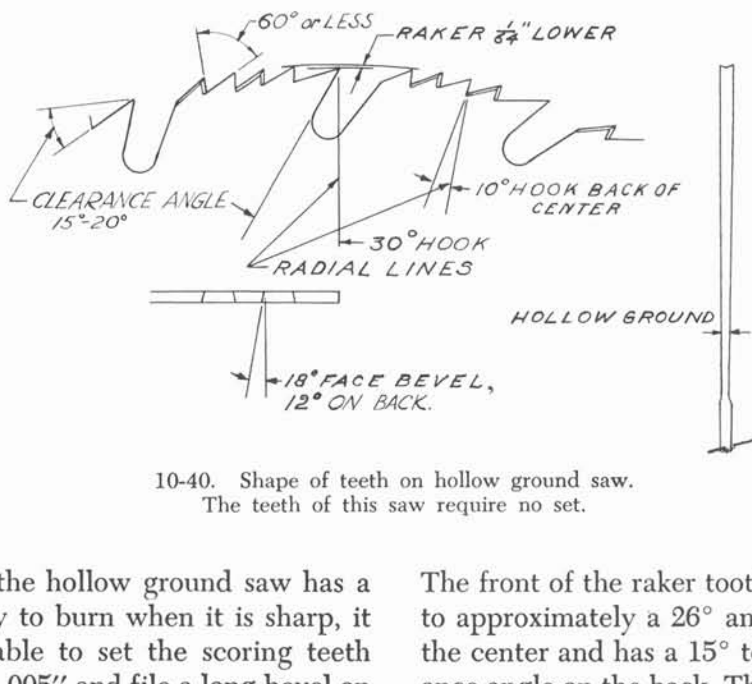
The flat ground saws are made in sections containing either two or four scoring teeth and one raker tooth per section. The saw with two scoring teeth and one raker tooth per section is faster cutting and is especially adaptable for use on overhead machines, such as radial and swing cut-off saws. The one with four scoring teeth and one raker tooth per section cuts slower, but makes a smoother cut (Fig. 10-38).

Hollow ground saws are made in sections containing four scoring teeth and one raker tooth per section. They make exceptionally smooth cuts, but require more power to operate and cut slower than other saws. They should be used only when a smooth surface is required without further work. These saws must not be crowded nor used for general purpose sawing. They must be kept sharp. A limited amount of clearance, a little dullness, and a slight rounding of the points of the teeth cause the saw to bind in the kerf (Fig. 10-19, page 182).

Spring set is not required, as hollow grinding provides sufficient clearance for light work. Spring set would cause the saw to make a rougher cut. How-



10-39. Shape of teeth of a flat ground combination saw. Scoring teeth require spring set.



10-40. Shape of teeth on hollow ground saw. The teeth of this saw require no set.

ever, if the hollow ground saw has a tendency to burn when it is sharp, it is advisable to set the scoring teeth .003″ to .005″ and file a long bevel on the front of the teeth at 15° to 30°.

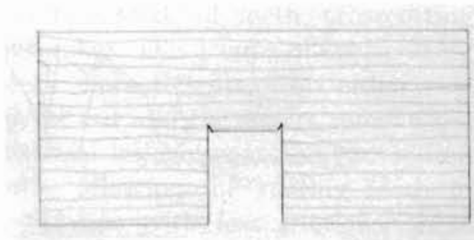
The shape of the teeth on both the flat and hollow ground saws is almost the same. On some saws the front of the scoring teeth is hooked to the center of the saw with 60° gullet openings. The front of the teeth has an 18° bevel and the back a 12° bevel. The front of the raker tooth is hooked to approximately a 26° angle back of the center and has a 15° to 20° clearance angle on the back. The front and back are filed straight across (10, 7). Teeth with 60° gullets are cut to depth when they are filed straight across with a regular or slim taper file. Then the front and back of the teeth can be beveled (Figs. 10-39 and 10-40).

On other saws the front of the scoring teeth is hooked 10° back of the center of the saw with approximately 50° gullet openings. The front of the teeth has a 10° bevel and the back approximately the same. The front of the raker tooth is hooked 30° back of the center of the saw and has a 15° to 20° clearance angle on the back. The front and back are filed straight across (8, 50).

A cant saw file must be used for filing the scoring teeth when the gullet angle is less than 60°. If a taper file is used, either the back hook on the teeth will be removed, or the length of the teeth be decreased. Neither one should be altered. The 10° hook causes the saw to cut faster, and the large gullet depth is necessary to remove the sawdust at the faster cutting speed.

The raker teeth are filed 1/64″ to 1/32″ shorter than the scoring teeth. If they are the same length or longer, the scoring teeth do not have a chance to score the fibers before they are removed by the rakers. This results in a rough cut. If the raker teeth are too short, they will not remove the scored fibers near enough to the scored depth. This causes excessive friction at the points of the scoring teeth. Fig. 10-41 shows the shape of the cut if the teeth are correctly sharpened. The scoring teeth in each section are beveled alternately to the right and the left, whereas the raker teeth are filed straight across.

If the scoring teeth gullets have a 60° angle, 6″, 7″, or 8″ taper or slim taper files may be used, depending upon the tooth spacing. If the angle is less than 60°, an 8″ cant saw file should be used. Either an 8″ cant saw or mill bastard file may be used for filing the rakers.



10-41. Enlarged view of cut made by correctly-sharpened combination blade.

Study all illustrations carefully and plan your job well before you try saw filing. This is one of the most exacting kinds of maintenance in the shop.

To sharpen a combination saw with scoring and raker teeth

1. Set the saw. Use procedure, "To Set a Circular Saw with a Stake," page 178. *Do not set hollow ground saws.*
2. Joint the saw. Use procedures, "To Change a Circular Saw," page 175 and, "To Joint a Circular Saw," page 182.
3. Place the saw in the circular saw filing clamp and file the scoring teeth to the proper hook and gullet depth. Hold the file at right angles to the side of the saw both horizontally and vertically (Fig. 10-42).
4. File the correct bevel on the front and back of the scoring teeth pointing away from you, stopping when the teeth come to a sharp point.
5. Turn the saw around in the clamp

COURTESY SIMONDS SAW AND STEEL COMPANY
10-42. Position of file when filing a combination saw. Use a cant file when the gullet angle is less than 60°.

and file the remaining scoring teeth at the same angle.

6. File the back of the raker teeth straight across until they are 1/64″ to 1/32″ shorter than the scoring teeth. File the front only enough to remove the burr.
7. Side joint the saw. Use procedure, "To Change a Circular Saw," page 175, and, "To Side Joint a Circular Saw," page 183. Do not side joint a hollow ground saw.

If the saw does not require more set, sharpen it by jointing it round and filing the teeth sharp and to the correct angles.

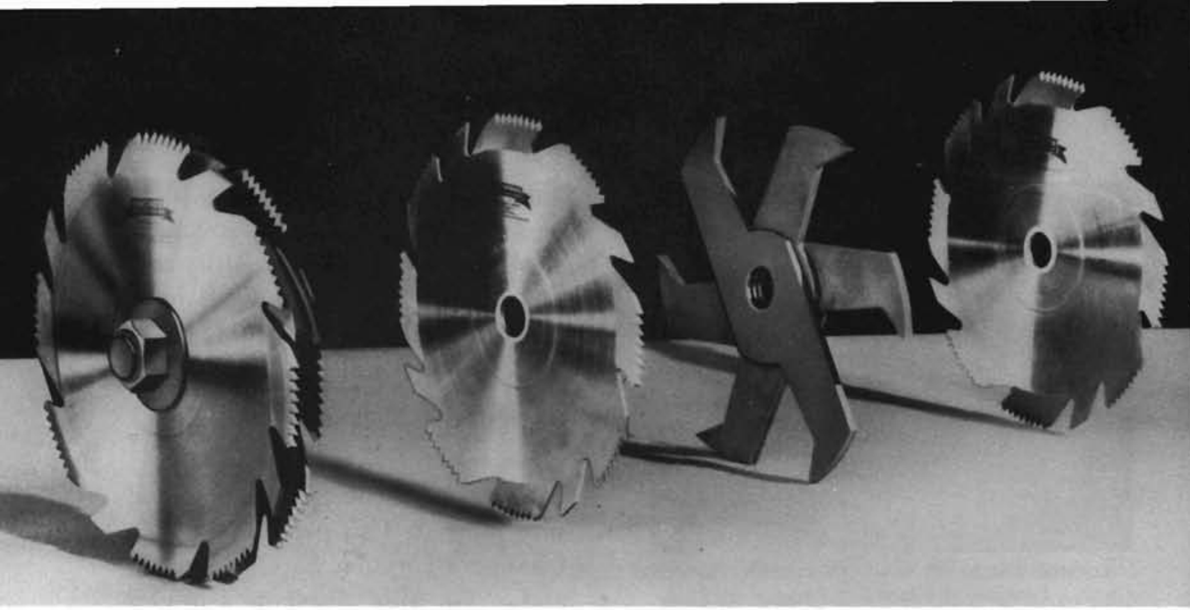
To sharpen a combination saw with uniform teeth

1. Set the saw. Use procedure, "To Set a Circular Saw with a Stake," page 178.
2. Joint the saw. Use procedures, "To Change a Circular Saw," page 175 and, "To Joint a Circular Saw," page 182.
3. Place the saw in the circular saw filing clamp and file each tooth which points away from you until it comes to an edge. Keep the correct angles on the front and back of the teeth.
4. Turn the saw around in the clamp and file the remaining teeth at the same angle.
5. Mount the saw on the machine and side joint it. Use procedures, "To Change a Circular Saw," page 175 and, "To Side Joint a Circular Saw," page 183.

If the saw does not require more set, sharpen it by jointing it round and filing each tooth to a sharp edge at the correct angle.

To sharpen a swaged groover or rip saw

1. Joint the teeth to a uniform length. Use procedure, "To Joint a Circular Saw," page 182.
2. Swage the teeth. Use procedure, "To Swage a Groover or Rip Saw," page 180. If the teeth cut the required width and the corners are not too round, it may not be necessary to swage the teeth.
3. File the teeth straight across to a keen edge. Always hold the file at right angles to the sides of the saw to prevent skewing the cutting edge. Do not round the corners.
4. Side joint the teeth either even or to cut a required width. Use procedure, "To Side Joint a Circular Saw," page 183. In the case of a groover saw the teeth may be side jointed with a side jointing file. Be careful not to make flat surfaces



COURTESY SIMONDS SAW AND STEEL COMPANY

10-43. Assembled dado head and its component parts of outside combination saws and inside cutters.

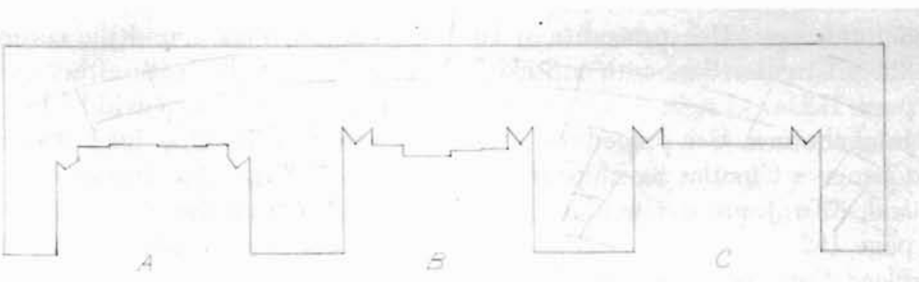
on the sides of the teeth which will cause them to bind in the kerf.

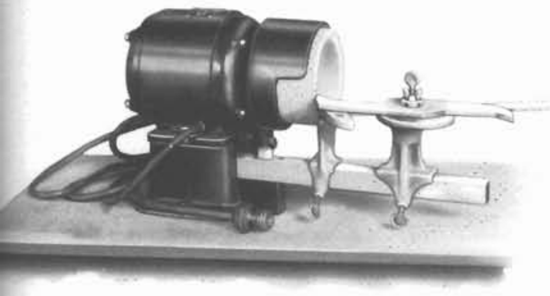
Dado heads for mounting on bench saw

The dado head is composed of two hollow ground, outside combination saws and inside cutters 1/16″, 1/8″, and 1/4″ wide. The outside saws have a series of scoring and raker teeth. All the scoring teeth in each section have the points on the same side with the opposite side ground to obtain additional clearance. The points and ground surfaces are reversed in each succeeding section. The two cutting edges are swaged on the 1/8″ and 1/4″ cutters (Fig. 10-43).

It requires considerable skill to sharpen the dado head. It should not be operated when it is dull. The binding effect will cause it not only to

10-44. Enlarged diagram showing cuts made by dado head sharpened properly and improperly. (A) Inside cutters long, leaving irregular corners; (B) Inside cutters short, causing uneven surface; (C) Saws and cutters proper length.





COURTESY HUTHER BROS. SAW MFG. CO.
10-45. Sharpening a cutter on a cupped wheel.

burn but to throw stock out of the machine. The outside saws are filed similar to the hollow ground combination saw. The scoring teeth are filed to sharp points, whereas the raker teeth and inside cutters are filed straight across. They are 1/64″ to 1/32″ shorter than the scoring teeth. Fig. 10-44 shows the cuts made by a dado head that is properly and improperly sharpened. The inside cutters and raker teeth are not filed on the front except to remove the burr. An 8″ cant saw file is suitable for filing the dado head.

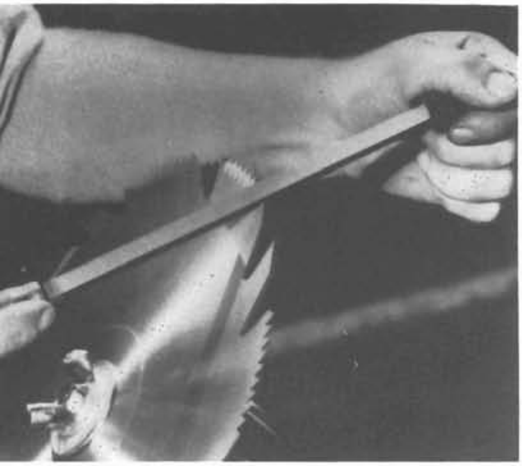
The cutters may be sharpened to uniform length on a special grinder (Fig. 10-45).

To mount a dado head on a bench saw

1. Pull the switch in the fuse box, or remove the fuses. Lay the guard back, or remove it.
2. Remove the throat insert, or pull the movable table away from the saw.
3. Place one of the saws on the arbor with the front of the tooth toward the front of the saw.
4. Place an inside cutter against the saw with the swaged points in the gullet opening between the raker and the scoring section. Distribute the remaining cutters with the edges evenly spaced.
5. Place the outside saw on the arbor and arrange the saws with the raker tooth of one across from the scoring teeth of the other. Adjust the inside cutter with the swaged points between the raker and scoring sections.
6. Place the outside flanged collar on the arbor. If necessary, add sufficient space collars to cover all but the threaded portion of the arbor so that the nut can be pulled tight against the collars.
7. Place the proper insert into the throat opening, or adjust the movable table.
8. Close the switch or replace the fuses.

To sharpen a dado head

1. Joint the dado head round. Use procedures, "To Mount a Dado Head on a Bench Saw," page 197, and, "To Joint a Circular Saw," page 182.
2. Remove the dado head and file the outside saws similar to a hollow ground combination saw, keeping the angle on the scoring teeth at approximately their original angle. Stop filing the teeth when they come to a sharp point (Fig. 10-46).
3. File the raker teeth and inside cutters on the back until they come to an edge, then file the same number of strokes on each tooth or cutter to make it 1/64″ to 1/32″



COURTESY SIMONDS SAW AND STEEL COMPANY
10-46. Position of file when sharpening a dado blade. Notice the protective tip on the end of the file as a precaution against possible injury.

shorter than the scoring teeth. Be sure to keep the file at right angles to the sides of the saws or cutters.

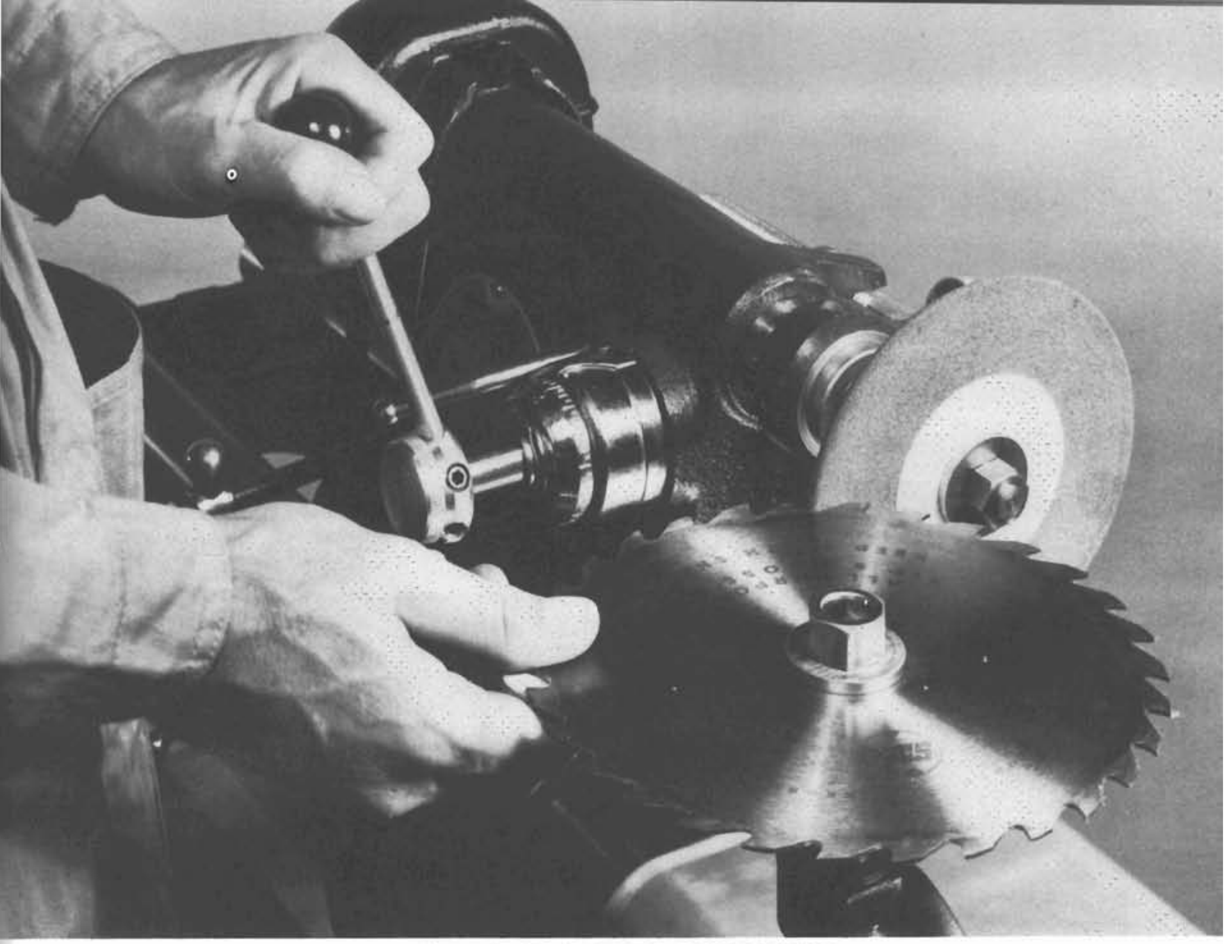
GUMMING CIRCULAR SAWS: Gumming is the process of enlarging the gullets to provide sufficient space between the teeth for the easy removal of sawdust. Jointing and filing the saw shorten the teeth and in turn make shallow, poorly shaped gullets.

There are two methods of reshaping the gullets — filing and grinding. In either case, the gullets must be kept uniform in shape and size. Small saws of thin gauge can be gummed with an 8″ or 10″ round second cut file (Fig. 10-47). The file should be turned in an axial motion as it is pushed through the gullet to draw file the surface slightly. Gumming with an abrasive wheel may be more satisfactory, especially for heavy gauge saws (Fig. 10-48).

Unless one is careful when gumming with an abrasive wheel, the teeth may be heated and cooled rapidly enough to develop hardened spots or be burned. This will make the steel brittle and subject to cracking. It is better to go around the saw several times and grind a small amount from each gullet. This prevents the heat from expanding the rim or burning the teeth. If the rim expands too much, the saw must be hammered to restore the proper tension. If the points are badly burned, they are likely to crumble and dull easily. If hardened surfaces should form, remove them with an abrasive wheel. It would ruin a file to use it for this purpose.

The method used for making the layout for gumming a saw must take into account tooth spacing as well as gullet depth and shape. Jointing and filing will not only reduce the length of the teeth and the gullet area, but at the same time may change the tooth

10-47. Deepening the gullets of a rip saw with a round file.
COURTESY SIMONDS SAW AND STEEL COMPANY



COURTESY MC GRAW-HILL BOOK COMPANY
10-48. Gumming a circular saw with a gumming wheel.

spacing because the edge or point may develop at a different position on the jointed surface each time the tooth is filed. This must be considered when making the layout of the saw to be gummed. Any method that uses the old edges or points only perpetuates the error that creeps into the filing process. *The method given here insures both uniform gullets and tooth spacing*:

To gum a circular saw

1. Make a layout of the new tooth.

   a. Draw a circle on a sheet of drawing paper 1/16" less than the diameter of the saw. With the dividers, locate the same number of equally spaced points on the circumference as there are teeth in the saw.

   b. Very accurately draw a gullet between the points of two teeth (Fig. 10-49).

   c. Secure a thin piece of hardwood, preferably 1/8" thick hard maple, to be used in making a template of the gullet (Fig. 10 50).

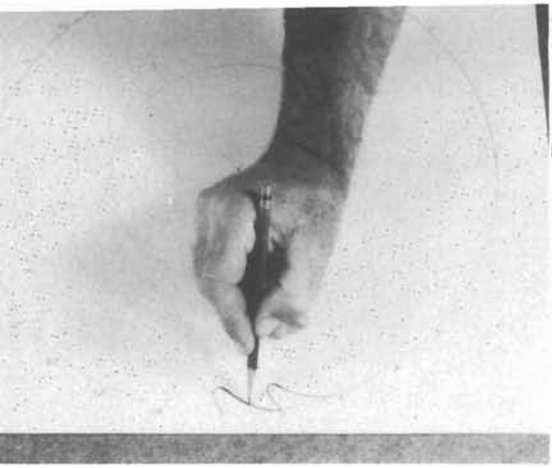


PHOTO BY ROBERT C. SMITHERAM JR.
10-49. Circumference of circle is divided into same number of equally spaced points as there are teeth in saw. Note how tooth shape is carefully designed.

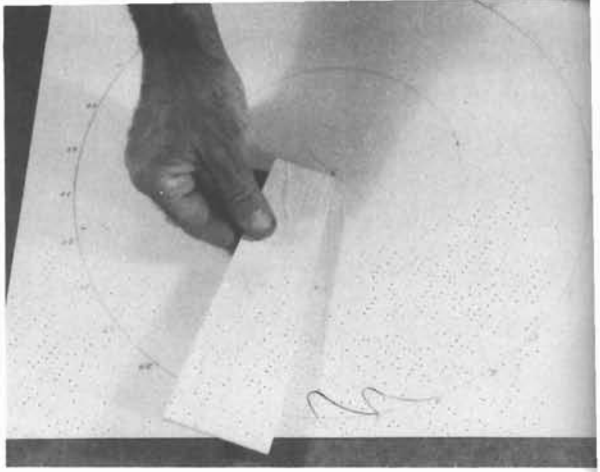


PHOTO BY ROBERT C. SMITHERAM JR.
10-50. The tooth template is made of hardwood.

d. Place the stock and a sheet of carbon paper under the layout of the gullet and trace the outline on the stock with a sharp pencil. Be sure to locate the center of the circle on the template stock (Fig. 10-51).

e. Cut the tooth laid out on the template on the jig saw.

2. Make the layout of the new teeth on the saw.

a. Turn a piece of softwood to fit the arbor hole in the saw, using the dead center end (Fig. 10-52).

b. Place the saw on the grinder in the position best for easy gumming. Mark the top side of the saw and apply marking dye to it, covering approximately 1½″ around the rim. Perhaps the saw can be gummed on the grinder more easily from one side than from the other.

c. Put the turned piece in the arbor hole with the dead center end on the dyed side of the saw and draw a circle approximately ¼″ below the bottom of the gullets by placing one leg of the dividers in the dead center hole (Fig. 10-53).

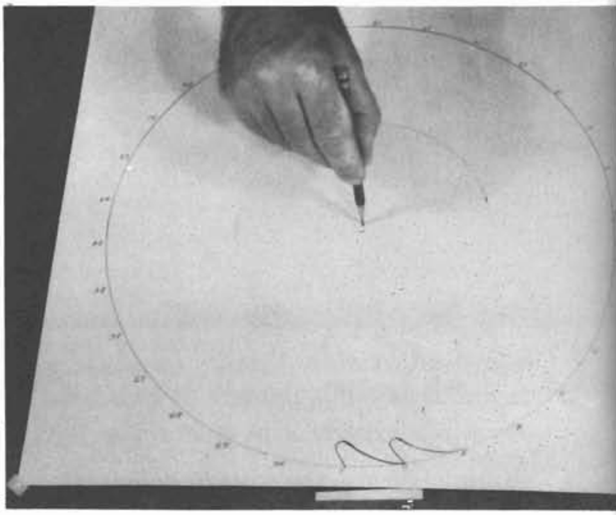


PHOTO BY ROBERT C. SMITHERAM JR.
10-51. The tooth outline is transferred to the template stock. Accurately locate saw center on the template.

d. Draw a line from the point of one tooth to the center of the saw (Fig. 10-54). Starting with the point where the line inter-

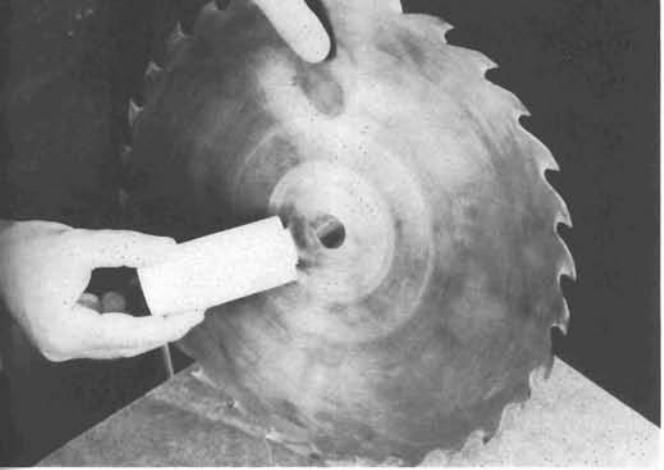


PHOTO BY ROBERT C. SMITHERAM JR.
10-52. The dead center end of a piece of turned stock fits the arbor hole tightly.

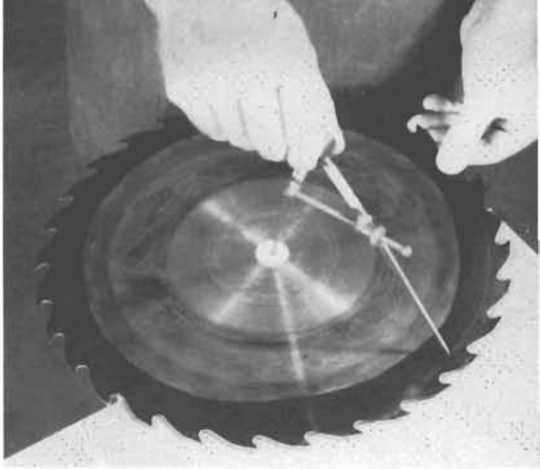


PHOTO BY ROBERT C. SMITHERAM JR.
10-53. Circle is drawn on dyed side of saw, using dead center end in arbor hole piece for the center.

PHOTO BY ROBERT C. SMITHERAM JR.
10-54. Line from point of tooth to center of saw intersects circumference of circle.

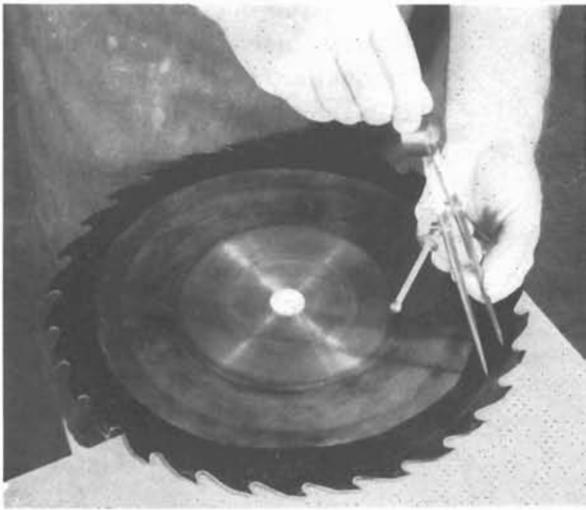


PHOTO BY ROBERT C. SMITHERAM JR.
10-55. Equal spaces are located on circumference of circle.

10-56. Lines are drawn across dyed portion.

PHOTOS BY ROBERT C. SMITHERAM JR.

10-57. Gullet template is attached to arbor stock so the centers on the template and arbor stock coincide.

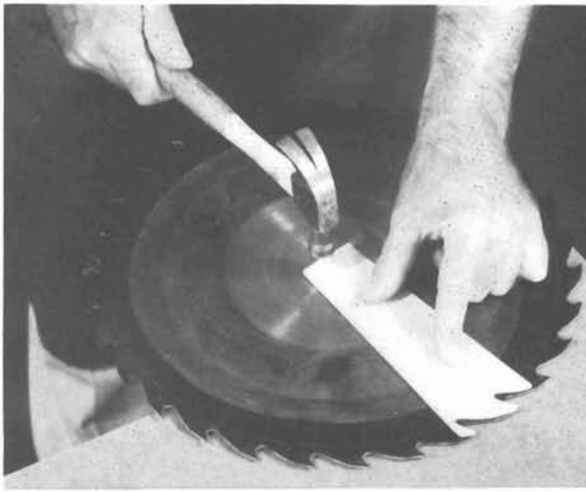


PHOTO BY ROBERT C. SMITHERAM JR.
10-58. Locating a common point on edge of template.

PHOTO BY ROBERT C. SMITHERAM JR.
10-59. Outlines of the new teeth are scribed on the saw. The common point on the template is placed on the lines extending through the circumference of the circle.

sects the circumference of the circle, carefully step off as many equal spaces as there are teeth in the saw (Fig. 10-55).

e. Lay a straightedge on each of the points and the center and draw lines across the dyed portion (Fig. 10-56).

f. Place the gullet template on the saw and drive a brad through the template at the center point and into the dead center hole in the arbor stock (Fig. 10-57).

g. Locate a common point on the edge of the template so that when it is placed on any of the lines extending through the circumference of the circle, the outline of the new gullet can be drawn on the saw (Fig. 10-58).

h. Place the common point on each of the lines extending through the circumference of the circle and lay out the new gullets with a scriber (Fig. 10-59).

3. Form the new gullets.

a. Mount the proper abrasive wheel on the grinder or lathe. See procedure, "To Mount an Grinding Wheel," page 24.

b. Set the tool support close to the abrasive wheel and to the height of its center.

c. Put on an eye shield and wear it while performing the gumming operation.

d. Dress the abrasive wheel to the required shape. See procedure, "To Dress a Grinding Wheel," page 27.

e. Lay the saw flat on the support and grind off a small portion of

10-60. New teeth are formed by removing the surplus metal with a grinding wheel.
PHOTO BY ROBERT C. SMITHERAM JR.

the metal; then move to the next tooth (Fig. 10-60). Continue the grinding operation until all the surplus metal has been removed. Be careful not to burn the teeth by excessive grinding.

f. Remove the burr on the lower side of the saw.

Cut-control saws

The cut-control saw is a rip saw with teeth which prevent "kick-backs." The rim is a perfect circle with the teeth protruding above the rim, providing a definite clearance. The depth of cut is controlled by this clearance of .02″ on the back of each tooth, limiting the cut of each tooth to that depth. The eight teeth permit the saw to cut .16″ each revolution (Fig. 10-61, 62).

The saw is sharpened by filing the front of the tooth and lightly filing the back to remove the burr. If the back is filed, the clearance is readily removed. The saw cannot be jointed for this reason. It must be kept round by filing the front of the teeth that show dullness. Each time the saw is filed, part of the clearance is re-

COURTESY SIMONDS SAW AND STEEL COMPANY
10-61. Cut control saw. Notice the small number of teeth as compared with conventional circular saws.

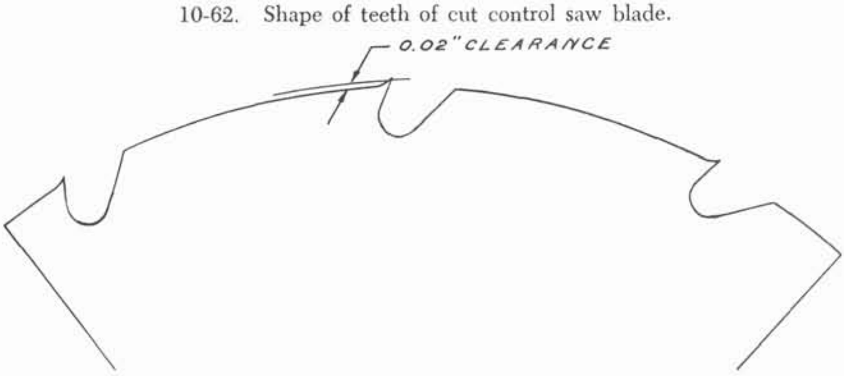
moved, reducing the feed of the saw.

When the clearance becomes too short, allowing the wood to rub on the back of the rim, the rim must be reshaped to restore the tooth clearance. Manufacturers provide this service at a nominal charge. Special attachments for bench grinders are also available for reshaping the rim.

Information for ordering circular saws

The following information should

10-62. Shape of teeth of cut control saw blade.



be given for ordering a circular saw:

1. Kind of saw – crosscut, rip, and so forth
2. Size of saw – diameter in inches
3. Thickness of saw – gauge
4. Size of arbor hole
5. Speed of arbor – rpm.
6. Style of tooth
7. Number of teeth in saw
8. Type of clearance – spring set, hollow ground, swage

Reasons for the cracking of saws

1. Square or sharp corners filed in the gullets. Sawdust, packing into sharp corners, increases the strain already concentrated at these points.
2. Too much set in the teeth. This will increase the strain on the teeth because of the extra width of the cut, as well as increase side strain which sets up vibration.
3. Too much and too long a bevel on the front of the teeth causes side strain and vibration.
4. Long and short teeth and uneven set concentrate the strain at the points where the teeth are long and the set excessive.
5. Feeding the saw too fast or too slowly causes the rim to heat and lose its tension.
6. The continued operation of a dull saw causes heat, friction, and vibration.
7. Uneven tension as well as too little or too much tension puts the saw under excessive strain and results in metal fatigue.
8. Insufficient gullet area to permit free, easy movement of the sawdust causes the teeth to load up and bind in the kerf.
9. Improperly designed teeth that are too long and slender are weak at the base and vibrate in the kerf.
10. Operating the saw with insufficient clearance causes it to heat in the kerf and expand the rim.
11. Insufficient clearance on the back of the teeth causes the rim to heat.

Reasons for poor sawing performance

1. Excessive vibration of the machine and improper speed cause the saw to wobble and veer from a straight line.
2. Too much set reduces the capacity of the saw and wastes power.
3. Feeding the saw too fast or too slowly causes the rim to heat.
4. Unequal set on each side of the saw makes it lead toward the side with the most set.
5. Insufficient clearance on the back of the teeth reduces the cutting speed and burns the cutting edges.
6. Gullets too small to permit free easy movement of the sawdust reduce the speed of feed.
7. An accumulation of pitch and gum on the teeth require extra power and cause the rim to heat.
8. Heating of the arbor bearing next to the saw causes the saw to heat and wobble.
9. Too much bevel on the front of

the teeth causes vibration and a rough cut.

10. Ill-fitting collars and arbor out of true makes the saw vibrate and run snaky.
11. Too much hook on the teeth causes the saw to feed too fast and lead away from a straight line.
12. Lumps, ridges, bends, or twists in the saw cause it to bind in the kerf and run snaky.
13. Teeth are not correctly shaped for the type of work.
14. Insufficient set damages the saw and wastes power.
15. Improper tension makes the saw heat and run crooked.
16. Saw is too thin for the type of work.
17. Saw is too thick for the work and wastes both material and power.
18. Saw is out of round and puts excessive strain on a portion of the teeth.

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PART TWO

CHAPTER 11

Jig Saws

THE JIG SAW cuts by means of a short blade held in a vertical position by chucks at either end. The lower chuck is attached to a shaft driven in a vertical reciprocating movement by an eccentric which is an integral part of the drive shaft. A U-shaped arm or gooseneck fastens to one end of the base and extends over the two blade chucks. A tension device containing the upper blade chuck is located at the end of the arm. An assembly including a hold down and a blade guide is also fastened to it. The table may be tilted to the right or to the left, and is supported above the lower blade chuck by the base (Fig. 11-1).

The flexibility of speed of the jig saw may be obtained either by an adjustable motor pulley or by placing matched four step cone pulleys on both the jig saw and the motor shaft. Since the jig saw has a speed range of 600 to 1750 rpm., the operator can adjust the speed to suit a specific job.

Guide adjustment

The function of the guide is to hold the blade straight against the cut so that it cannot be pushed to one side. Set the thrust roller or support so that it touches the back of the blade very lightly. Adjusting a slot in the guide makes the blade run steadily without binding. Adjust the guide to support the whole body of the blade with only the teeth protruding. If it projects over the sides of the teeth, the set will be taken out of the saw blade.

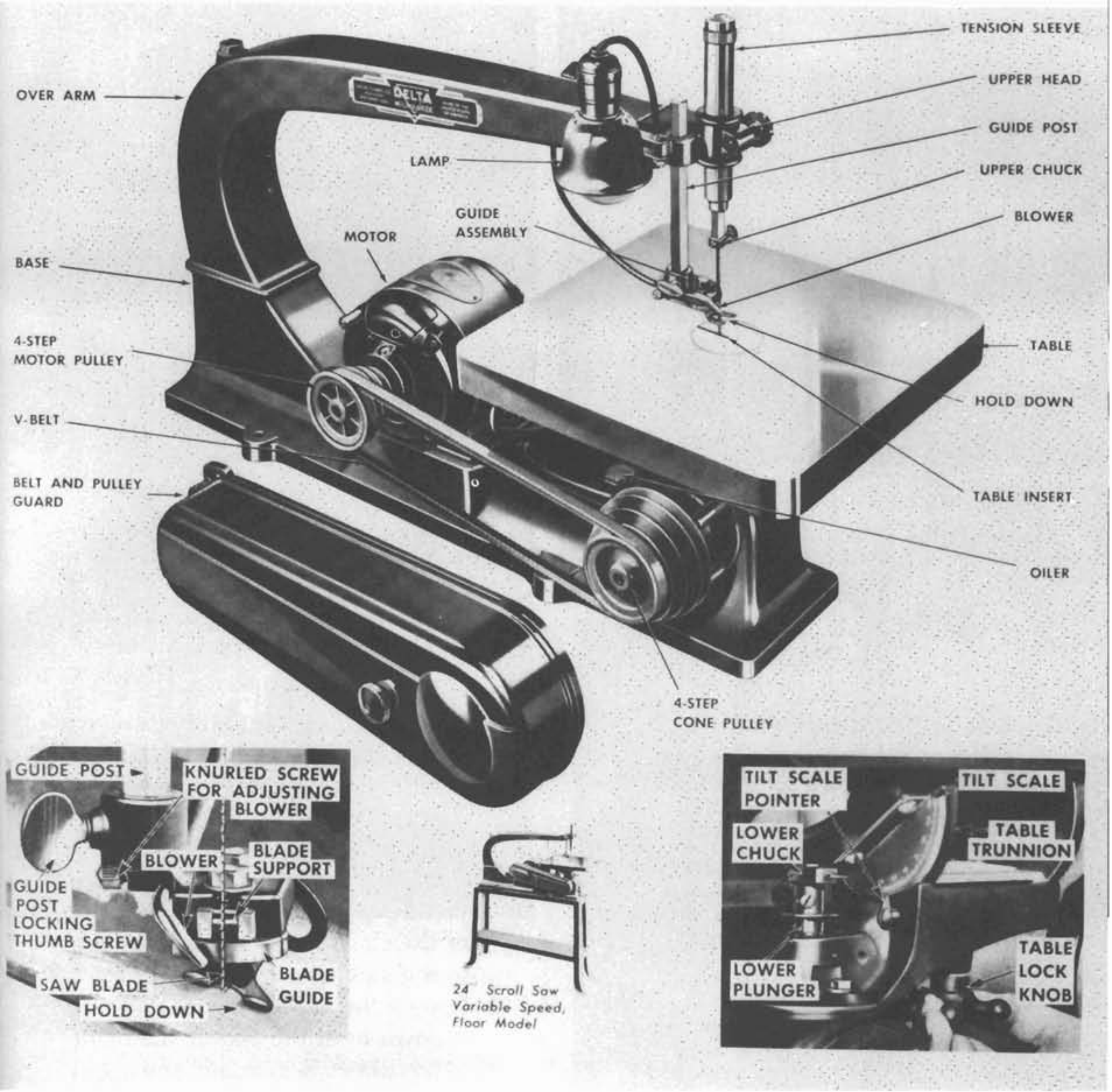
JIG SAW BLADES

The blades adaptable for use in a jig saw vary from tiny jeweler's or fret blades to heavy saber blades. Sometimes coping saw blades are used if the pins are pulled and inserted in the same manner as jeweler's blades.

The width of the blade and the coarseness of the teeth are important factors in determining the proper blade to use for a particular job. The blade should be as wide as possible to permit cutting the smallest curves and as coarse as possible, without making a cut too rough for the purpose.

Blade tension

It is difficult to specify the correct tension for a blade. Factors which determine to some extent the proper



COURTESY DELTA POWER TOOL DIVISION,
ROCKWELL MFG. CO.

11-1. Jig or scroll saw showing the component parts.

tension are (1) the nature of the work, (2) the material being cut, (3) the thickness of the material, and (4) the length of the blade between the chucks. The blade should have sufficient tension to hold it straight against the cut, but not enough to cause the blade to break easily (4, 2). Raising or lowering the tension device changes the tension on the blade.

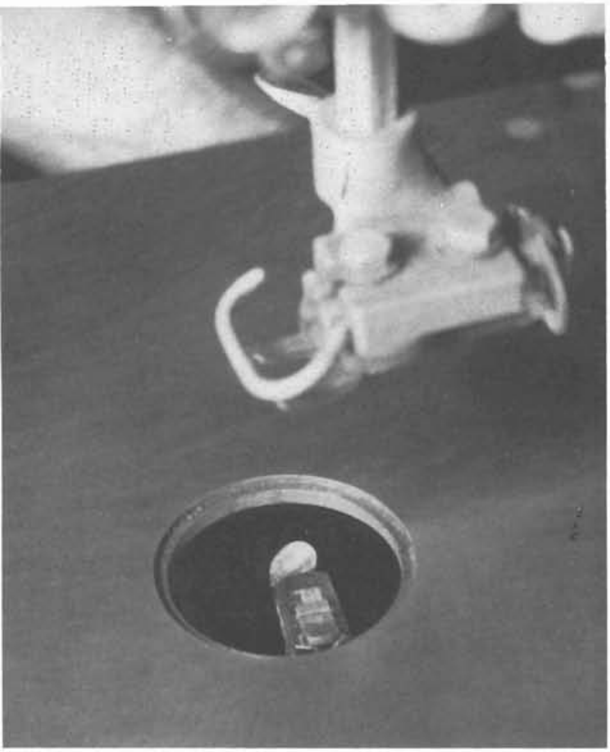


PHOTO BY CHARLES J. PEREZ

11-2. The blade is released by loosening top and bottom chuck screws.

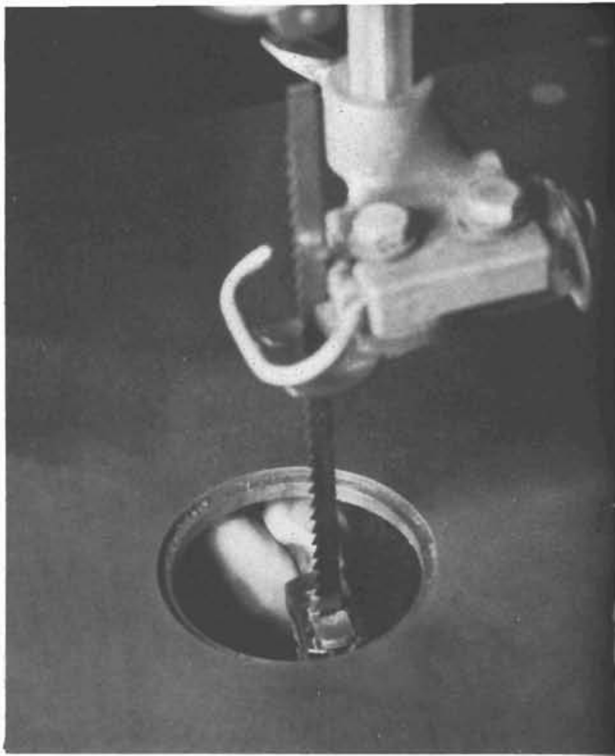


PHOTO BY CHARLES J. PEREZ

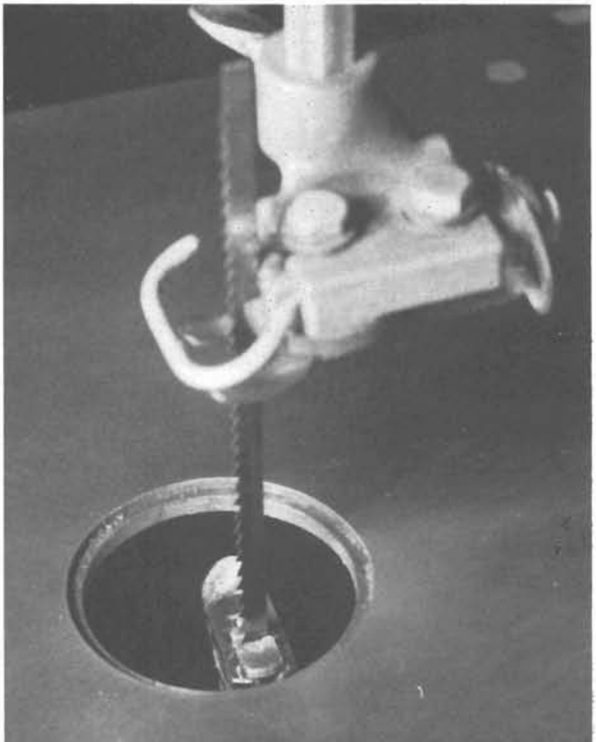
11-4. The blade is tightened in bottom chuck first.

To insert a jig saw blade

1. Remove the table insert and turn the pulley until the lower chuck is at the top of the stroke. Then loosen the top and bottom chuck screws (Fig. 11-2).

11-3. Blade is inserted in the chucks with the teeth pointing down.

PHOTO BY CHARLES J. PEREZ



2. With the teeth pointing down, insert the end of the blade between the bottom chuck jaw about ½ inch (Fig. 11-3). Holding the blade in a vertical position and in the center of the chuck jaws, tighten the bottom chuck screw (Fig. 11-4).
3. Loosen the tension device and pull it down until the end of the blade enters about ½ inch into the upper chuck (Fig. 11-5).
4. Center the blade between the chuck jaws and tighten the screw (Fig. 11-6). Adjust the tension device until the proper tension is applied to the blade (Fig. 11-7).
5. Place a thin piece of wood or metal on the table against the back edge of the saw blade to check the path

11-5. Top chuck is lowered by loosening tension device.

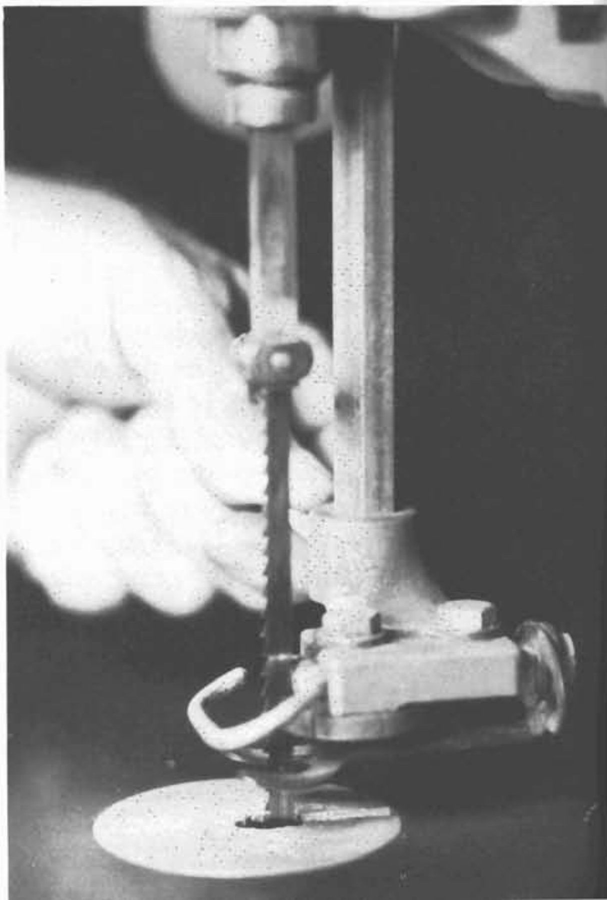
PHOTOS BY CHARLES J. PEREZ

11-6. Tighten blade in center of top chuck.

of the blade travel. Slowly turn the pulley by hand and note the relationship of the back of the blade to the piece of material (Fig. 11-8). If the blade moves the piece of material, or moves away from it, the pressure of the blade against the guide thrust will not remain constant. This will cause an uneven strain on the blade.

6. If the back of the blade does not travel in a straight line, make the necessary adjustments, following Steps 3, 4, and 5.
7. Replace the table insert and set the hold down slightly above the top of the table. Adjust the slotted guide and thrust piece to give the proper support to the blade (Fig. 11-9).

11-8 11-9



PHOTOS BY CHARLES J. PEREZ

11-7. Apply proper tension to the blade.

11-8. Checking travel of blade.

11-9. Hold down guide should be properly adjusted.

8. Turn the pulley by hand to make sure that there are no obstructions to prevent the machine from operating freely.

Saber blades are mounted in the same way except that the top end is not connected to the upper chuck.

LUBRICATION

The crankcase is filled to the proper level with a good grade of oil of the weight recommended by the manufacturer. One manufacturer (3, 3) recommends SAE 10, whereas others (2, 1) (1, 1) recommend SAE 30.

Lubricate the working parts of the tension device by occasionally applying a few drops of light oil to the moving parts.

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PART TWO

CHAPTER 12

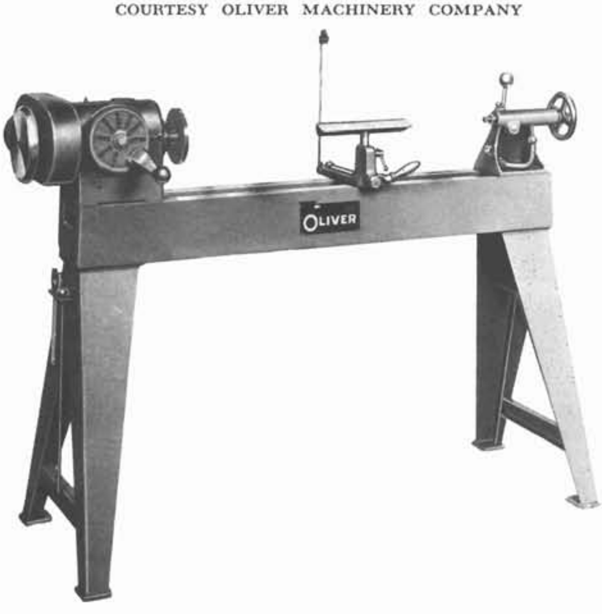
Speed Lathes

THE LATHE is composed of the following major parts: a bed, headstock, tailstock, tool rest, and motor. A new machine usually comes with several faceplates, a live center, a push rod, and a wrench (Fig. 12-1).

The headstock is attached securely to the left side of the lathe bed. It contains a hollow spindle which turns on ball bearings or sleeve bushings. The inside end of the spindle has a right-hand thread for faceplates and is taper-bored to hold the live center. The outside end of the spindle has a left-hand thread and generally carries a combination hand wheel and faceplate.

Faceplates should be tightened securely on the spindle when they are mounted. If they are loose when the machine starts, the inertia will cause them to become so tight that they will be difficult to loosen. They can be tightened properly with a wrench by locking the spindle to keep it from turning. The faceplate on either end can be loosened by holding the spindle and turning the faceplate with a wrench in the same direction as that in which the lathe normally runs. For easy removal of the faceplate, some operators place a paper shim between the faceplate and the spindle collar.

12-1. Woodturning lathe.
COURTESY OLIVER MACHINERY COMPANY



The live center has the same taper as the spindle so that it will fit snugly. When the spindle and the center do not have the same taper, they may make contact on such a small area that the live center pivots at the point of contact, permitting the center to run out of true. This condition could damage the taper on the spindle in a relatively short time, making it necessary to cut a new taper. This would require the services of a skilled machinist.

Use a mallet to drive the live center into the stock when mounting work between centers. Too often a hammer is used for this purpose. As a result, the end becomes upset to such an extent that the live center will not fit into the spindle. This condition can be corrected by grinding the upset end until it is smaller than the taper.

It is also poor practice to mount stock by placing the end of it against the live center in the lathe and striking the other end with a mallet or hammer. There is much danger of breaking the headstock housing or chipping a bearing, especially if the spindle is mounted on ball bearings.

TAILSTOCK

The tailstock is mounted on the right side of the lathe bed. It is attached to the bed with a positive lever clamp mechanism and can be readily set at any location along the length of the bed. Some tailstocks are mounted on a sub-base with a lateral adjusting device for aligning or offsetting the tailstock in relation to the headstock. The tailstock can be aligned by setting it so the points of the two centers almost touch and adjusting the device on the sub-base until the points are in line. The amount of offset can also be checked by measuring the difference between the points of the two centers.

The tailstock spindle, which receives the dead center, is bored to the same taper as the headstock spindle. It moves in and out of the tailstock by the turning of a crank. The crank operates an adjusting screw which feeds into an adjustment screw nut that is attached to the spindle. The spindle can be removed by turning the crank until the adjustment screw nut is run off the end of the adjusting screw. When putting the spindle in the tailstock, be careful not to damage the threads on the adjustment screw nut when it engages the adjusting screw. The dead center is removed by drawing the spindle in until the end of the adjusting screw pushes the dead center out of its seat.

TOOL REST

The tool rest may be easily adjusted for the desired height by loosening a lock bolt mechanism and raising the tool rest to its proper position. It can also be adjusted to any position along the ways of the bed and held in place by a quick acting clamping device. The clamping device must be adjusted to hold the tool rest firmly and prevent it from touching the wood.

The surface of this rest on which tools are held must be kept smooth to control accurately the position of the cutting edge of the tool on the stock. Contact made by the sharp corners of tools gradually wears grooves in the tool rest. These grooves can be removed by draw filing the surface with a mill file while the rest is mounted on the lathe.

The sharpening of wood-turning tools is discussed in Chapter 4, "Chisels and Gouges," pages 53-68.

PART TWO

CHAPTER 13

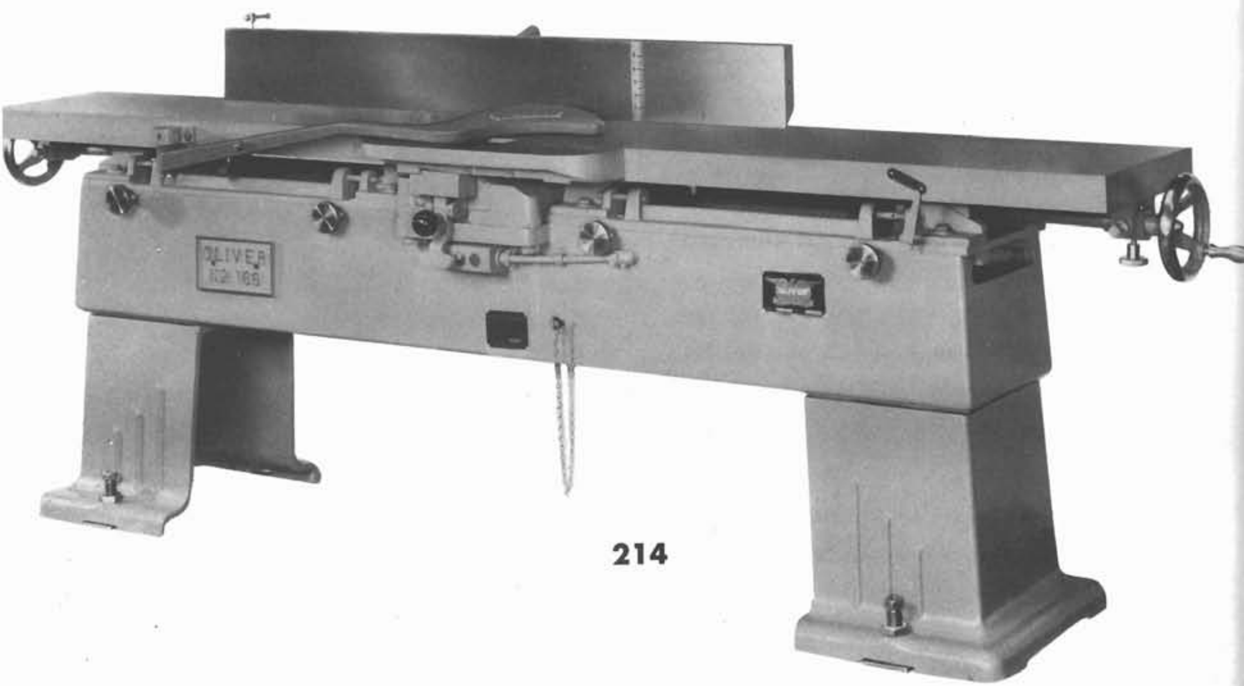
Jointers

THE JOINTER is composed of a cutter head, base, and two tables. The table nearest the operator is the front or infeed table; the other one is the rear or outfeed table. Each of these has vertical adjustments that regulate their height with reference to the cutter head. A fence and a guard are also mounted on the machine (Fig. 13-1).

It is obvious that the top surfaces of the tables must be in alignment if the jointer is to operate properly. Although they are machined true at the factory, they still should be checked carefully when received. Castings sometimes warp or twist after the machining process, especially if they are not properly cured.

ALIGNMENT OF TABLES: The tables of the jointer should be aligned so that their top surfaces are in parallel planes or in the same plane when at the same height. They should also be parallel, or nearly so, to the center line of the cutter head. A slight vari-

13-1. Hand planer and jointer.
COURTESY OLIVER MACHINERY COMPANY



ation in relation to the center line of the cutter head can be corrected when the knives are set (1, 1).

Aligning the tables of a jointer is a rather difficult job that must be done accurately if the jointer is to cut properly. It should not be attempted except by a competent workman who has the necessary equipment.

To align jointer tables

1. Check the jointer to see that it is level and not twisted. If the machine has a three-point bearing base, it reduces somewhat this possibility.
2. Check the tables with a good straightedge for flatness.
3. Set the outfeed table parallel to the cutter head and level it lengthwise. Do this by adjusting the ways or shoes upon which the table rests. Check the position of the table with relation to the cutter head using a dial indicator or a straightedge and feeler gauge. You can use a level to check the table lengthwise.
4. Adjust the infeed table to nearly the same height as the outfeed table. Put four pieces of thin paper on the tables, one at each end of each table. Place a straightedge that is the length of the machine on the four pieces of paper (Fig. 13-2).
5. Adjust the ways or shoes on the infeed table so that all four pieces of paper are held tight by the straightedge. Make several tests across the width of the tables. Also check them diagonally.

Adjusting jointer tables

A jointer will not operate satisfactorily unless the tables are properly adjusted, even though the knives are correctly set in the cutter head. Both tables have adjusting screws for changing their vertical position. The infeed table is always set lower than the top of the cutting circle of the knives and it needs frequent adjusting because it regulates the depth of cut.

The adjustment of the outfeed is more critical than that of the infeed table and is changed only when it needs adjusting for a particular operation.

To set the pointer of the depth scale

1. After resetting the knives in the cutter head, adjust the infeed table so that the top is in a plane that is tangent to the cutting circle. Use a straightedge in the same way that is given in the procedure, "To Change Jointer Knives," page 221.
2. Loosen the screws that hold the pointer on the depth gauge and set it at the zero mark. Then tighten the screws that hold the pointer. All the readings on the gauge will coincide with the actual cuts being made.

GRINDING AND STONING JOINTER KNIVES

Grinding is necessary to restore the proper bevel and cutting edge after jointer knives have been whetted and the bevel no longer provides the proper clearance. Such knives contact

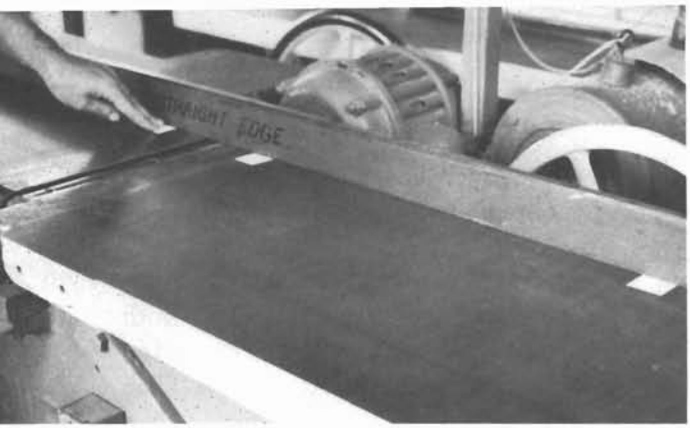
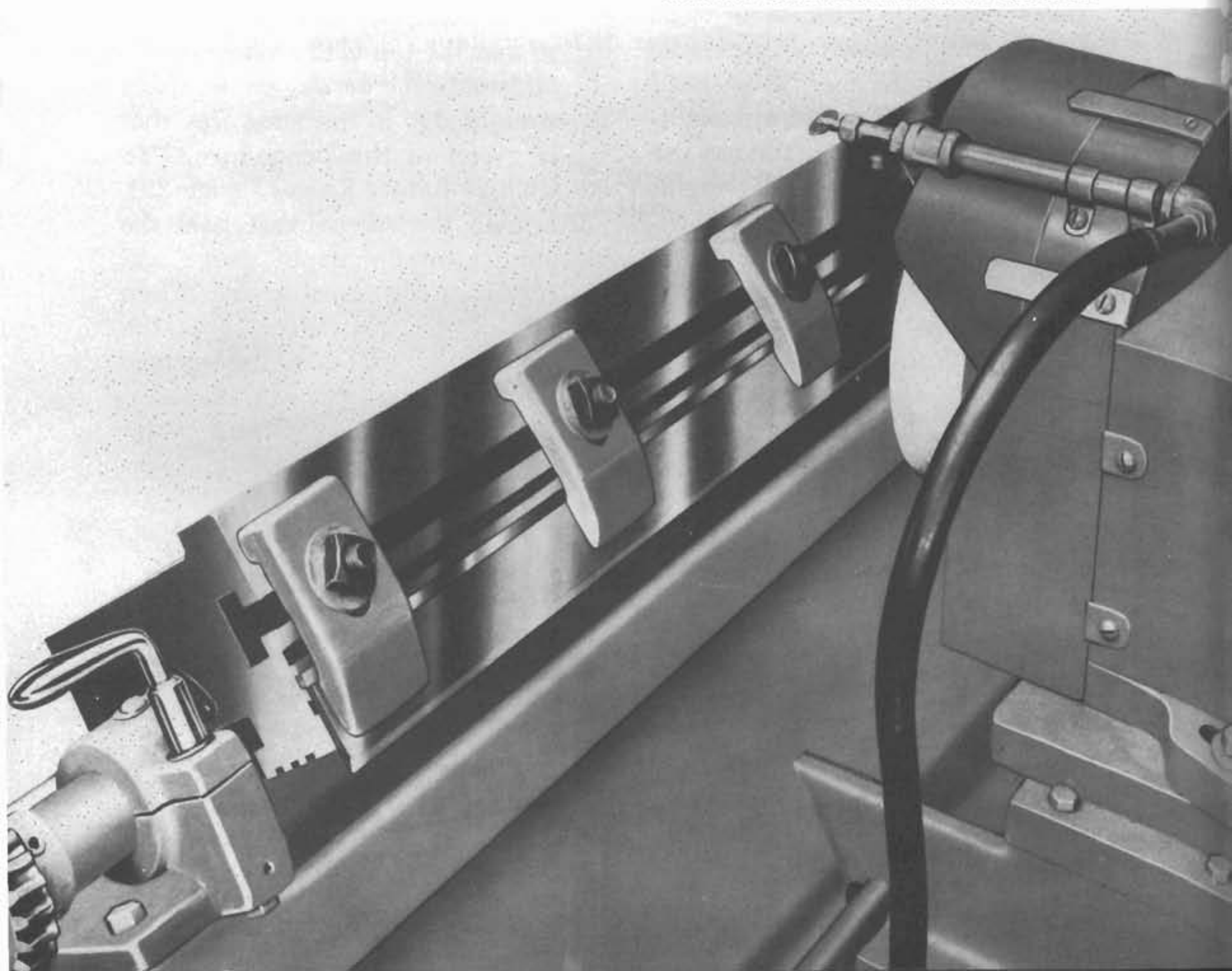


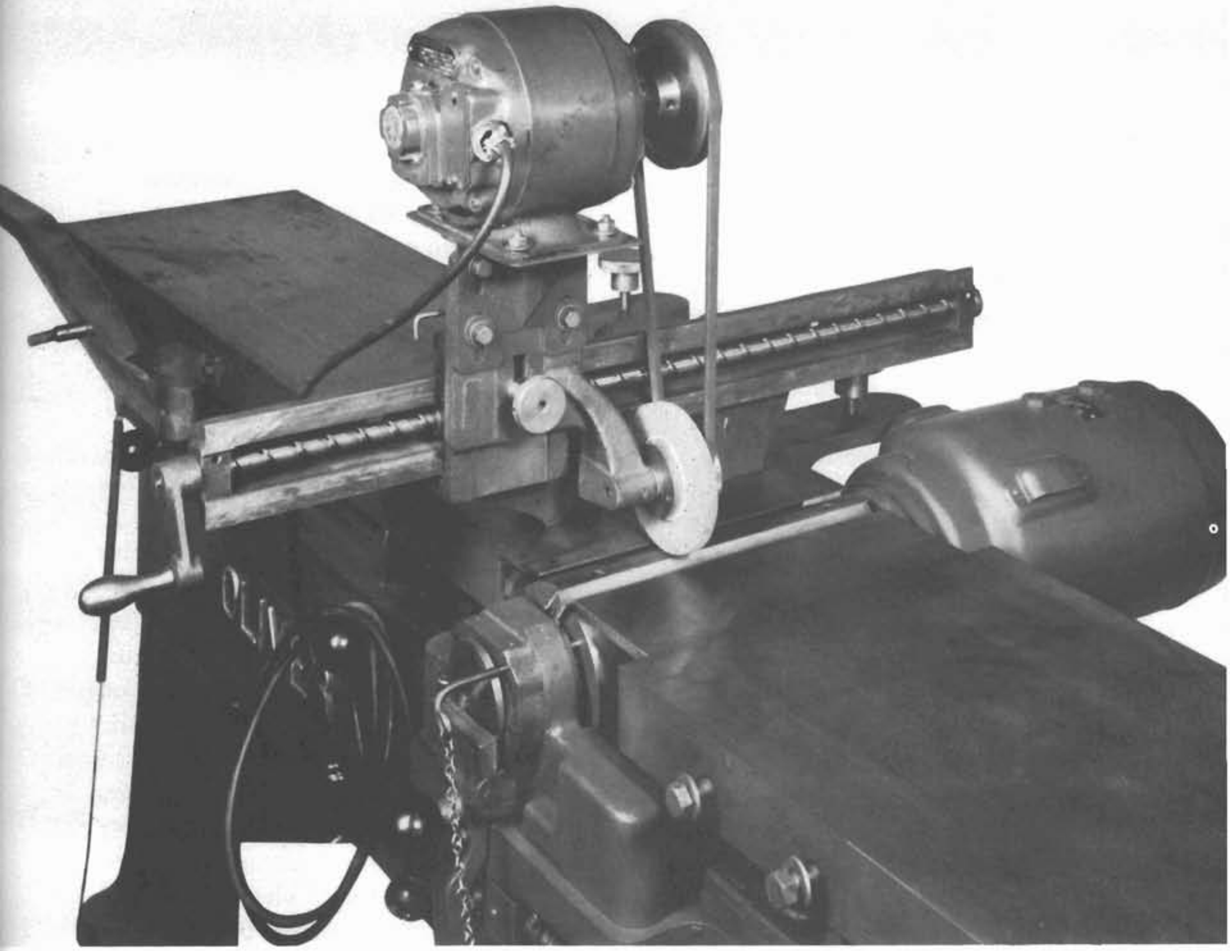
PHOTO BY CHARLES J. PEREZ
13-2. Aligning jointer tables with straightedge and paper shims.

COURTESY DEPENDABLE MACHINE COMPANY
13-3. Knives must be ground on a special grinder to obtain a straight cutting edge.

the stock back of the cutting edge, and cause a pounding effect. They also need grinding when they are badly nicked. Grinding of jointer knives is a precision operation which requires a knife grinder to make a straight cutting edge. This is especially true for grinding long knives (Figs. 13-3, 4). If a knife grinder is not available, the better commercial con-

13-4. Close-up view of a knife grinder. Knife, clamped in place, is sharpened on the flat side of the grinding wheel.
COURTESY DEPENDABLE MACHINE COMPANY





COURTESY OLIVER MACHINERY COMPANY

13-5. Knife grinder directly mounted on the outfeed table of the jointer. The grinding unit is moved along the knife edge by means of the hand-operated crank to the left.

cerns will do the job at a nominal charge. An extra set of knives will keep the jointer in service while the dull ones are being sharpened.

It is very important to keep the knives uniform in weight when they are ground; otherwise the cutter head will be out of balance and will vibrate.

The knives are beveled at an angle of 30° to 35° to form the cutting edge (3, 38). If the length of the bevel is more than twice the thickness of the knives, the cutting edge is likely to break down. This is especially true when cutting hard stock, because the metal is too thin to support the cutting edge.

Knife grinding and jointing attachments which fit on the outfeed table are available for grinding the knives in the machine. This method is highly desirable as the projection is kept uniform so that the knives have a common cutting circle. If the shop is equipped with a planer and a jointer of the same make, the grinding attachment can be used for grinding the knives in both machines, and thereby reduce maintenance cost (Fig. 13-5).

Dull knives not only make the operation of a jointer hazardous but also reduce their own length of service and cause greater strain and wear on the machine. When knives become so dull they cause the stock to vibrate, they should be sharpened. Dull knives that are not nicked may be stoned several times before regrinding.

To sharpen knives on a knife grinder

1. Fasten the knife securely on the carriage with clamps and bolts (Fig 13-4, page 216).
2. Bring the knife into its approximate position without touching the stone.
3. Set the stops so that the knife starts on the return stroke after reaching the middle of the stone.
4. Start the motor and coolant.
5. Make needed adjustments until an even light cut is made.
6. Continue grinding until an edge is produced. Bevel should measure from 30° to 35°.
7. Stop the motor and coolant.
8. Move the knife edge away from the stone.
9. Remove the wire edge with a hard slip stone.
10. Remove the knife from the carriage and proceed to sharpen the next knife.

To sharpen knives with a knife grinder mounted on the outfeed table

1. Open the switch in the switch box.
2. Remove the guard and the fence temporarily.
3. Place knife grinder in position.
4. Bring one knife into position and lock it in place with pin (Fig. 13-5, page 217).
5. Lower grinding wheel over knife edge.
6. Make a light cut across the full length of the knife edge.
7. Release the lock pin and grind the next knife.
8. Continue grinding until a wire edge is produced on all knives. Use slip stone to remove it. It is better to take a number of light cuts, instead of a few heavy ones. Too heavy a cut is likely to burn the edge and draw the temper.

In addition to the knife grinders illustrated above, there are a number of others that do a satisfactory job.

Figs. 13-6, 7 show where a cupped wheel is used to perform the grinding operation.

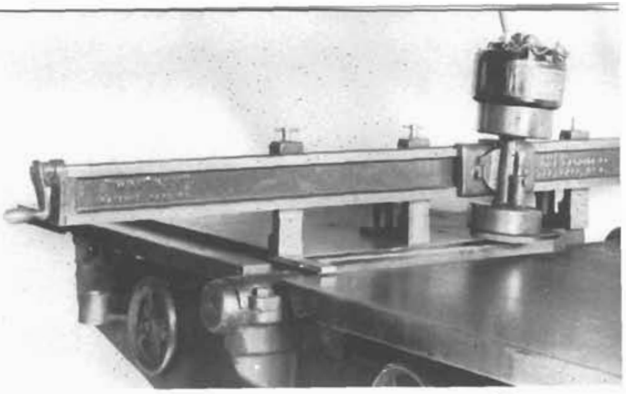
The sharpener illustrated in Fig. 13-8 can be used for a number of purposes, one of which is to sharpen jointer knives.

To stone the jointer knives

1. Select a flat combination or one medium and one fine bench type oilstone and a small slip stone. Wipe the surfaces of each with a clean cloth and apply a few drops of oil to the surfaces.
2. Lower either the infeed or outfeed table about 1/16" below the cutting edge of the blade when it is at the highest point in the cutting circle.
3. Wrap a piece of paper around the

oilstone with one third of its length projecting at one end. Lay it on the table with the exposed end extending over the cutter head.

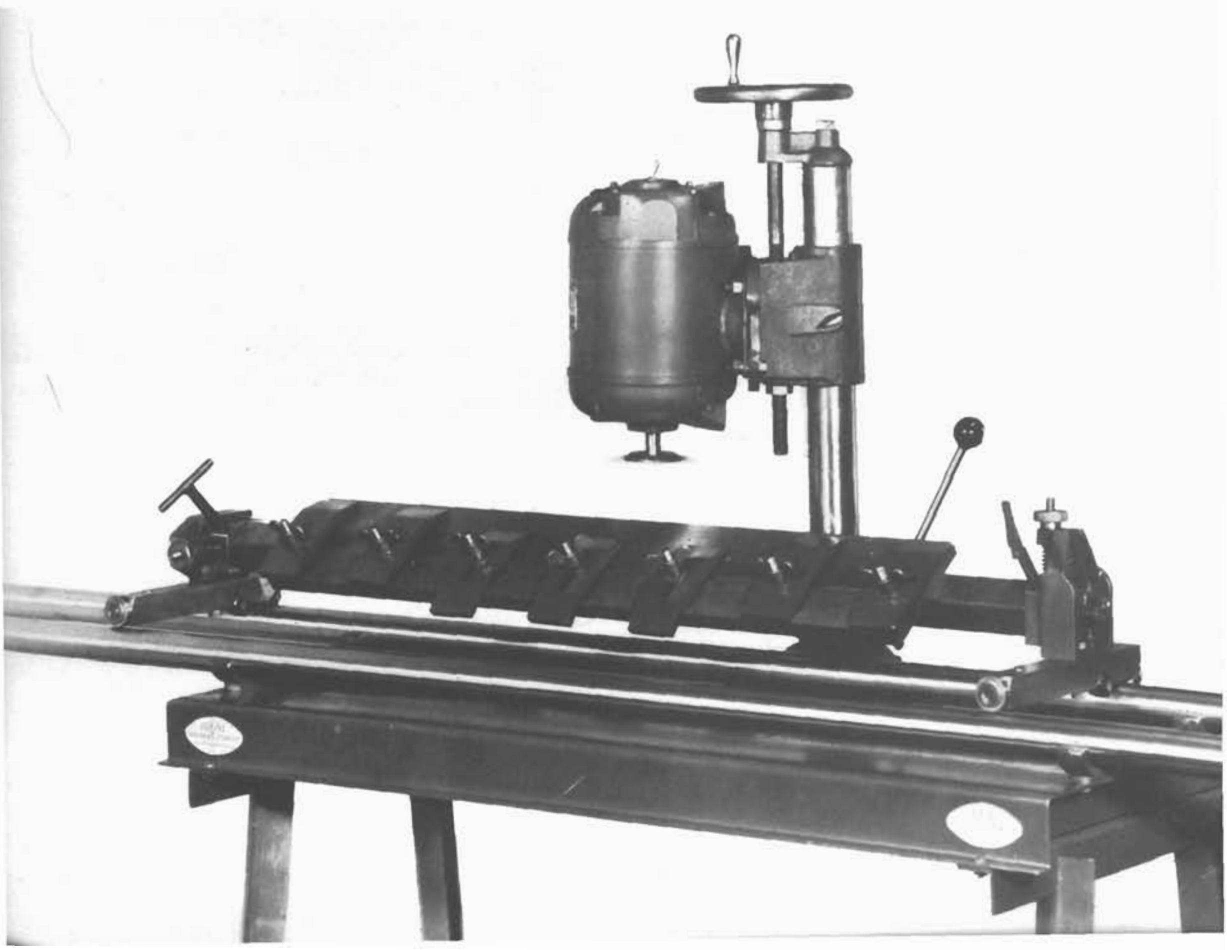
4. Turn the cutter head until the stone lies almost flat on the bevel, touching slightly more at the cutting edge. Fix the cutter head in position by wedging a piece of wood between it and the frame.
5. Whet the knife its full length until the edge is sharp, using a circular motion (Fig. 13-9).
6. Repeat the operation with the fine oilstone and remove the burr from the face with the slip stone (Fig. 13-10).

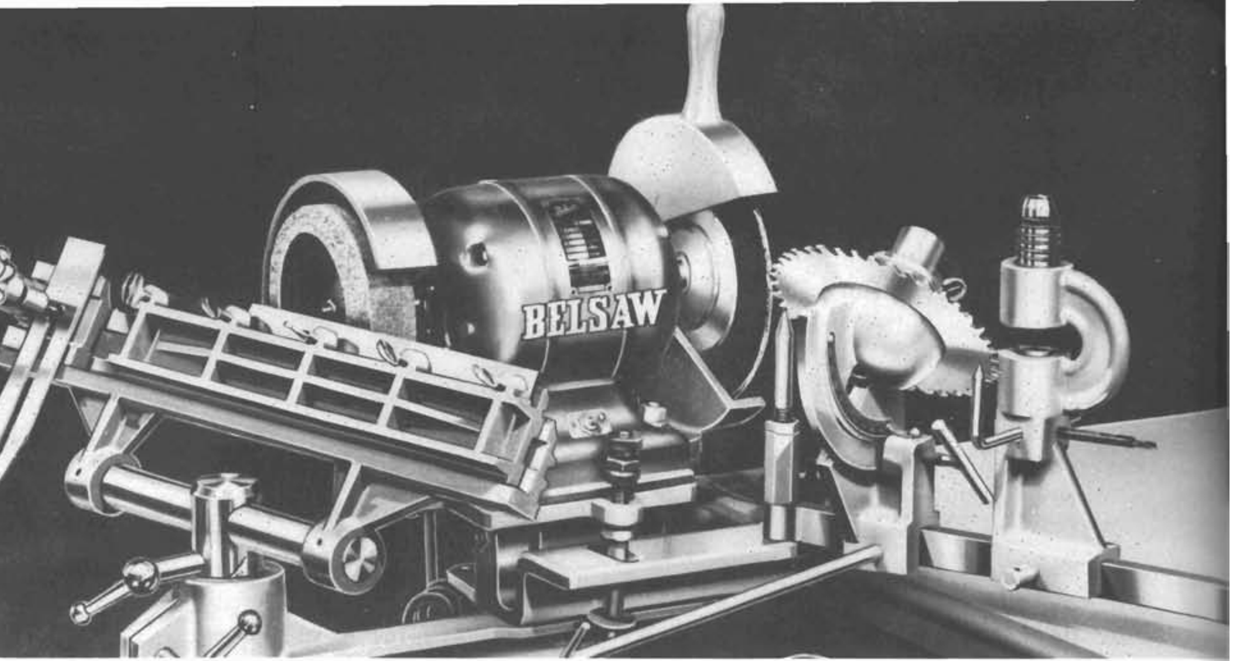


COURTESY BAXTER D. WHITNEY AND SON
13-6. Sharpening jointer knives with an attachment mounted on the outfeed table.

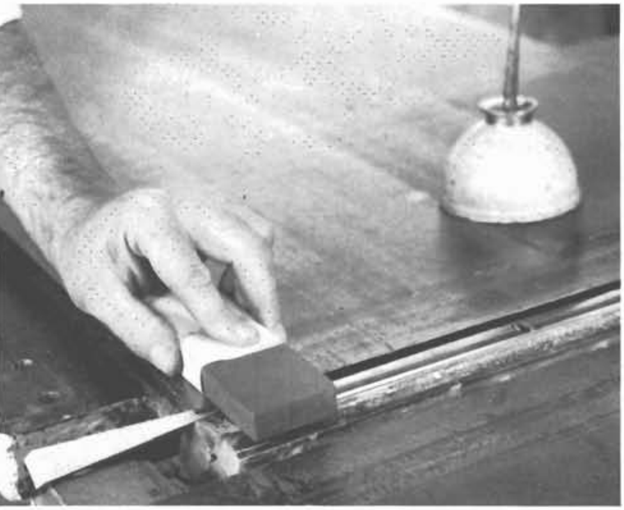
7. Stone the remaining knives, following Steps 4, 5, and 6.
8. Reset the table to its proper height. Whetting each knife just enough to make it sharp will make all the knives run in the same cutting circle. If one is longer, it will dull faster and therefore require more whetting.

13-7. Bed knife grinder. Note small wheels on carrier for easy movement.
COURTESY THE FATE-ROOT-HEATH COMPANY

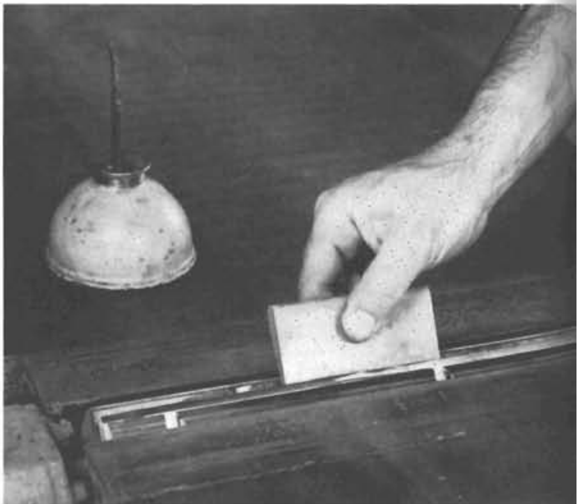




COURTESY BELSAW MACHINERY COMPANY
13-8. Combination knife and saw sharpener.



13-9. Stoning a jointer knife with a flat oilstone. Paper is wrapped around stone to protect table top.



PHOTOS BY CHARLES J. PEREZ
13-10. After stoning the bevel remove burr from the face of the knife with a slip stone.

A specially made circular knife stone may be used to stone the knives (Fig. 13-11). Lift back of stone lightly to avoid cutting the top of the table.

CHANGING JOINTER KNIVES

Each knife is held between a machine slot in the cutter head and the throat piece by devices which apply pressure either to the throat piece or

PHOTO BY CHARLES J. PEREZ

13-11. Stoning a jointer knife with a special knife stone. Lift back of stone lightly to prevent cutting into table top.

a part of the cutter head. There are a number of pressure devices used on the various cutter heads, but they all work on the same principle. By loosening the threaded part of the devices with special tools furnished for the purpose, the pressure is released from the sides of the knife, to make removal from the cutter head possible.

In order to secure more room for removing the knives, the infeed table should be lowered as far as possible. Some tables can be moved horizontally on the bed to provide more room for working on the cutter head.

Pitch and gum collect on various parts of the cutter head, especially in the throat area. It is therefore necessary to clean all of these parts and the slots in the cutter head before resetting the knives. This makes good bearing surfaces that will hold them firmly. A cloth dampened with turpentine or kerosene is usually adequate for cleaning. In the more extreme cases it may be necessary to rub the parts with steel wool dipped in kerosene to remove the pitch.

The knives should not project out of the cutter head more than 1/16″ beyond the heel of the bevel. If they project too far, the cutting edges may hit the tables when the machine is running.

If the jointer is to be used for rabbeting, the knives should project 1/32″ beyond the rabbeting edge of the outfeed table.

Setting the knives in the cutter head requires considerable care and accuracy. If they are not set to run in the same cutting circle they will not make uniform cuts. It is possible to set them so unevenly that one knife does almost all the cutting and leaves heavy machine marks on the planed surface. The cutting efficiency of the jointer is increased so much when the knives are uniformly set that the extra time required to do the job correctly is well spent. In order for the jointer to cut accurately, the knives must be set parallel to the outfeed table. They can be adjusted lower in the cutter head by tapping them lightly with a wooden mallet. If the manufacturer has not furnished a special tool, for moving knives out of the cutter head, you may use a punch for that purpose. Insert it at the back edge of the knife at the end of the slot in the cutter head and tap it lightly with a small hammer to bring the knife out.

To change the jointer knives

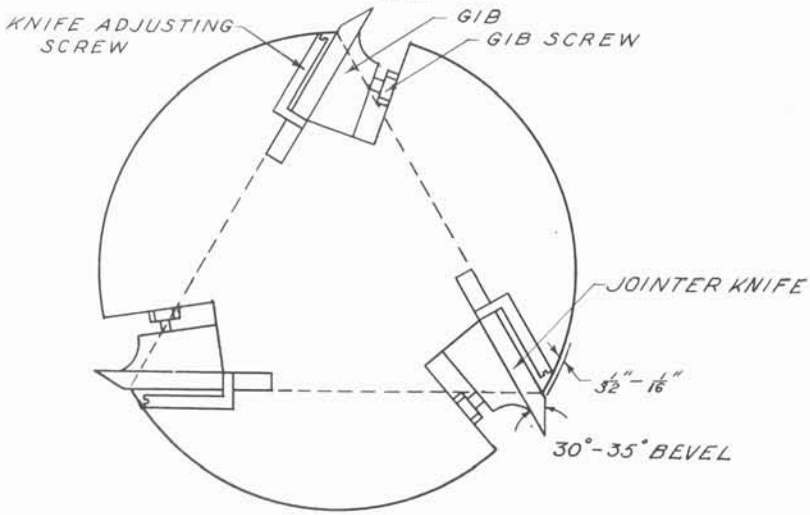
1. Provide room for working on the cutter head either by lowering the infeed table or by pulling the tables horizontally away from the cutter head.

PHOTO BY CHARLES J. PEREZ

13-12. Removing dull jointer knives from the cutter head. Use a wrench that fits the gib screws properly.

2. Fasten the cutter head in a convenient position to reach the holding screws and loosen them with the proper tools (Fig. 13-12). Pull the knife and the gibs from the cutter head. Remove the other knives in the same way.
3. Remove pitch and gum from all the parts and the slots to provide good bearing surfaces for holding the knives.
4. Replace the gibs in the cutter head for one new knife and put it in the slot. Tighten the gib screws sufficiently to hold the knife in place while adjusting it.
5. Shift the knife horizontally so that the left end of the cutting edge extends past the outfeed table nearly $\frac{1}{32}''$ for proper rabbeting. Depending upon the length of the bevel, adjust the knife so it projects from $\frac{1}{32}''$ to $\frac{1}{16}''$ beyond the heel of the bevel (Fig. 13-13).
6. Place the outfeed table in its normal operating position. Then place a straightedge on the outfeed table at one edge, letting a portion project over the cutter head. A jack plane with the plane iron retracted, makes a suitable straightedge for this purpose. A wooden straightedge may also be used.
7. Adjust the outfeed table until the edge of the knife touches the straightedge. Check this adjust-

13-13. Position of knives in relation to cutter head.



ment accurately by a slow backward hand rotation of the cutter head and carefully listen for the sound of the knife lightly touching the straightedge (Fig. 13-14).

8. Move the straightedge to the other end of the cutter head and adjust the projection of the knife. The knife should barely touch the straightedge when the cutter head is rotated as in Step 7.
9. Continue adjusting the knife in the cutter head and test it with the straightedge until it is parallel to the top of the table. Fasten the knife securely in the cutter head by carefully tightening the gib screws. Recheck the knife adjustment to see that it is properly set.
10. Without changing the height of the outfeed table, set the remainder of the knives in the same manner.
11. Recheck all the gib screws in the pressure devices to see that they are tight. Make a final test with the straightedge to see that the knife edges have a common cutting circle.

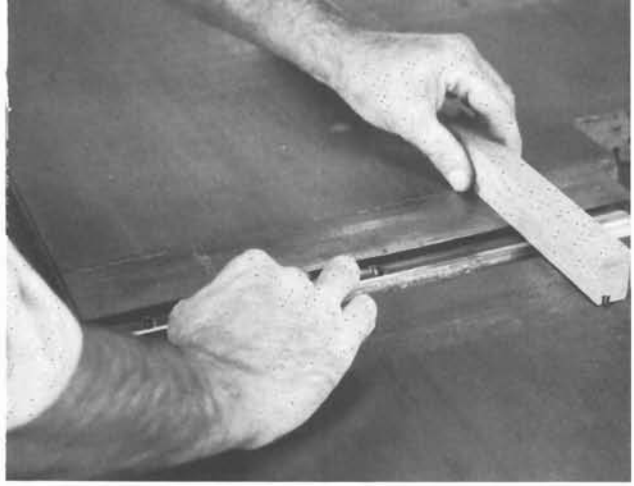


PHOTO BY CHARLES J. PEREZ
13-14. Adjust each knife to proper height, using a straightedge.

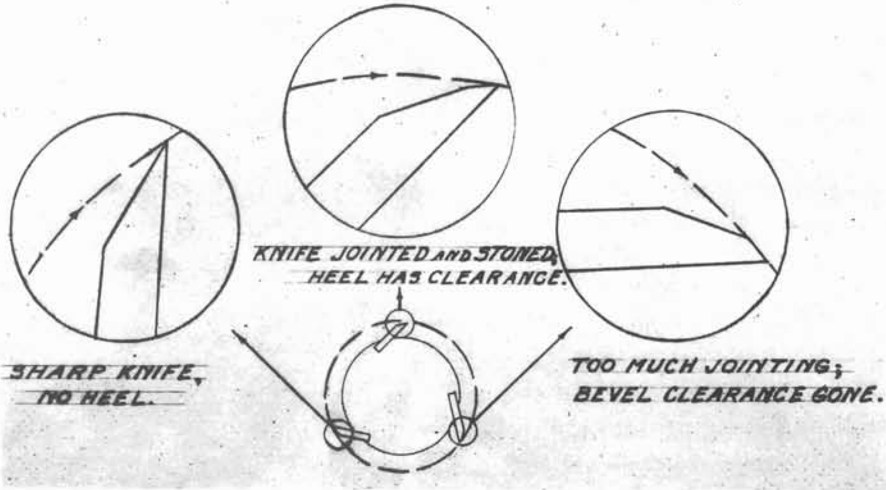
USING NICKED JOINTER KNIVES

Occasionally jointer knives will become nicked a short time after they have been ground. Because they can be whetted in the machine a number of times before regrinding is necessary, it is sometimes advisable to continue using them nicked. The ridges made on stock by the nicks can be avoided by shifting one or more of the knives horizontally in the cutter head so that the nicked portions of the knives do not coincide. The nicks will not materially affect the efficiency of the jointer except when it operates at production speed.

JOINTING JOINTER KNIVES

Sometimes it is desirable to joint the knives in order to make the cutting edge run in a common cutting circle, especially if they were not set carefully. They may also be jointed if the bevel is too long, or if they are to be used for cutting hard material when more metal is required to support the cutting edge (2, 1).

A very small amount of material should be removed by jointing because the surfaces so formed run in the same circle as the cutting edges. This condition causes the surface of the knives just back of the cutting edges to pound against the stock when the cutting edge begins to dull (Fig. 13-15). The duller the knives the greater the tendency for them to pound against the stock and cause vibration. (Some operators joint the knives to sharpen them, but this method of sharpening is only of temporary value.)



13-15. Knives with correct and incorrect bevel clearance.

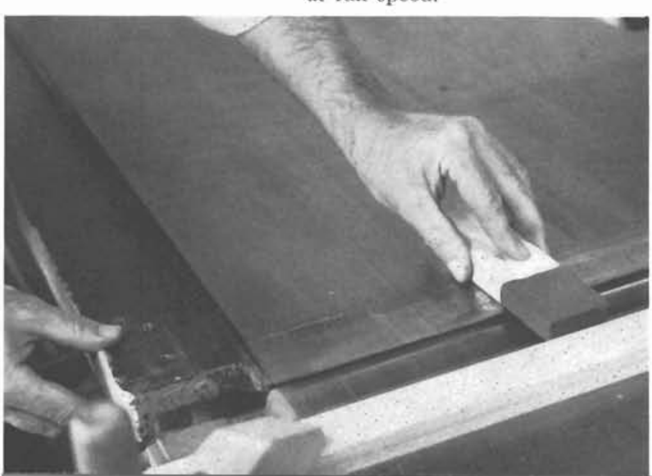
The surfaces formed on the jointed knives can be partly removed by stoning them immediately afterward.

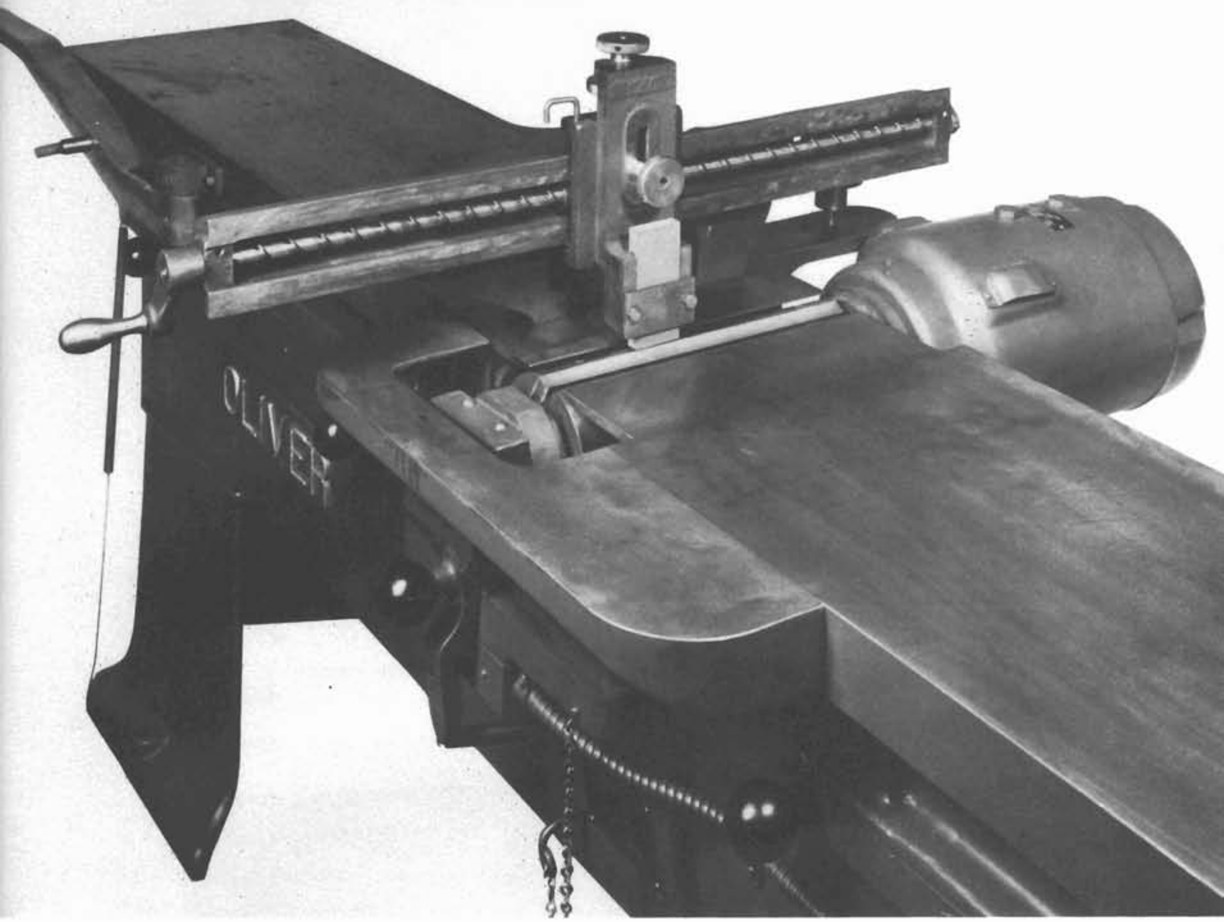
To joint jointer knives

1. Set the infeed table slightly lower than the top of the cutting circle of the knives and clamp a piece of wood across it near the cutter head.
2. Wrap a piece of paper around an oilstone with one third of its length projecting at one end. Lay it on the outfeed table with the exposed end extending over the cutter head, touching the piece of wood clamped on the infeed table.
3. Lower the outfeed table so that the knives touch the oilstone very lightly when the cutter head is rotated by hand. Then remove the oilstone.
4. Start the jointer and when it has reached full speed lay the oilstone on the outfeed table with the exposed end toward the cutter head. Slowly move the oilstone back and forth over the cutter head and at the same time gradually work from one end of the cutter head to the other. Be sure to keep it flat on the table (Fig. 13-16).
5. Stop the jointer and examine the knives. If they are not properly jointed, lower the outfeed table .001 or .002 inch and repeat Step 4.
6. Stone the knives lightly following the procedure, "To Stone the Jointer Knives," page 218.

PHOTO BY CHARLES J. PEREZ

13-16. Jointing knives with machine running at full speed.





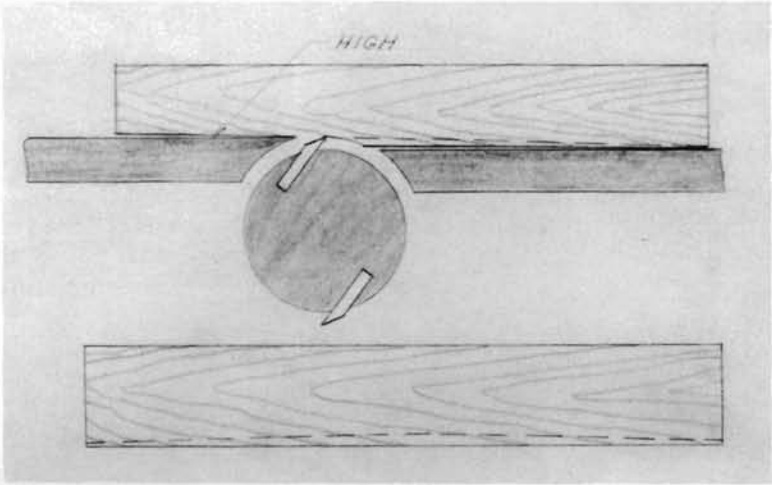
COURTESY OLIVER MACHINERY COMPANY

13-17. Jointing knives with the jointing attachment. In this operation the machine runs at full speed.

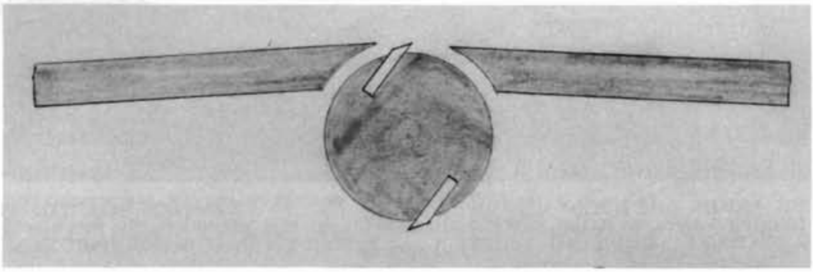
When the machine is equipped with a special jointing attachment, this operation can be performed as shown in Fig. 13-17. With the jointing stone set to barely touch the knives, move it slowly over the top of the knives. During this operation the machine runs at full speed.

CAUSES OF POOR JOINTER PERFORMANCE

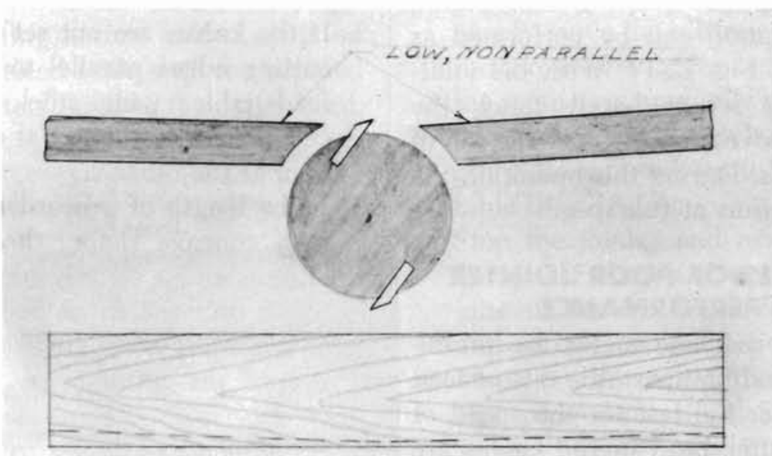
1. If the machine marks are prominent and far apart, the rate of feed is either too fast for the speed of the cutter head or the knives are not properly set to make uniform cuts.
2. If the knives are not set with the cutting edges parallel to the outfeed table, wide stock will be cut noticeably thinner at one edge than at the other.
3. If the length of a board is planed to a concave shape, the outfeed table is either slightly higher than the cutting circle, or one or both of the tables are higher at the end nearest the cutter head (Figs. 13-18, 19).
4. If the length of the board is planed



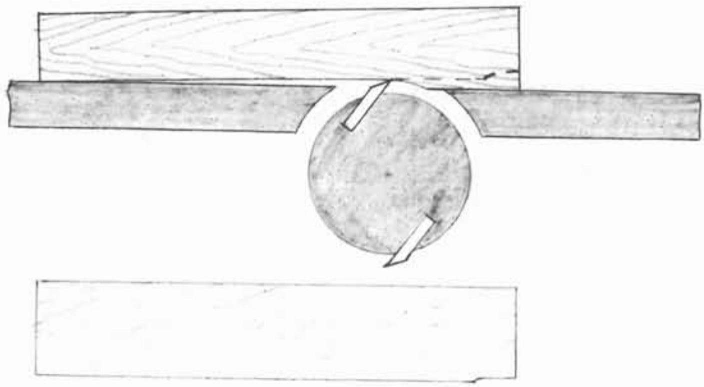
13-18. Outfeed table too high results in concave surface.



13-19. Tables high and nonparallel result in concave surface.



13-20. Tables low and nonparallel result in convex surface.



13-21. Low but parallel outfeed table results in heavy cut at rear end.

to a convex shape, one or both of the tables are low at the end nearest the cutter head (Fig. 13-20).

5. If the board is planed almost straight for its full length but an additional cut is made at the rear end of the stock, the outfeed table is lower than the top of the cutting circle (Fig. 13-21).
6. If the jointer does not make the same cut at any position across the width of the cutter head when the tables and knives have been properly set, one or both tables may be warped. They should be carefully checked at the time a new machine is installed.
7. If ridges are left on the surface, there may be nicks in the knives.
8. If the knives make the stock vibrate instead of cutting it, they are dull.
9. If the cutter head slows down considerably while jointing stock, either the power is insufficient to pull the machine or the belt may be slipping.

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PART TWO

CHAPTER 14

Hollow Chisel Mortisers

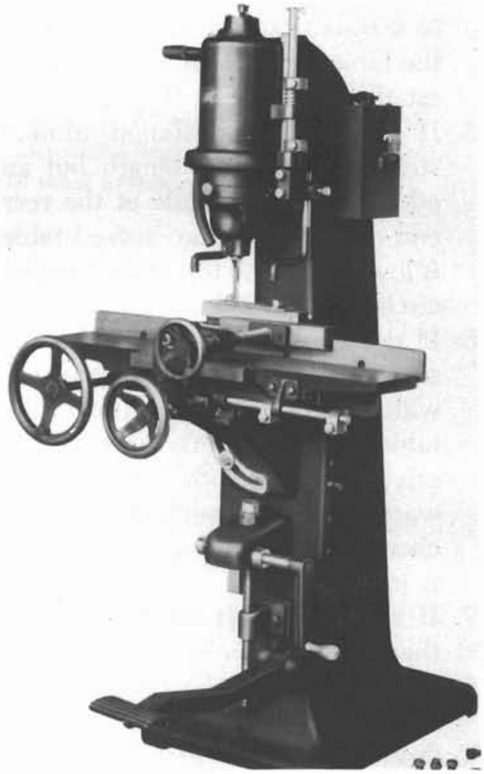
THE MORTISER consists of a frame, mortising head, table, and mortising tool. The frame is a one-piece vertical casting with a heavy base. The mortising head is attached to the top of the frame and moves vertically in gibbed ways. A table is mounted on the side of the frame under the mortising head (Fig. 14-1).

The table assembly can be adjusted vertically by turning a crank attached to a screw shaft. Some table assemblies may be tilted to a 45° angle either to the right or the left. The table is moved in a horizontal direction by a rack and pinion attached to a hand wheel.

The ways on which both the table and the mortising head move must be properly adjusted to insure correct alignment and consistent accuracy. If the ways are too loose, the pressure applied when mortising will cause the mortising head and the table to assume one position when the cut is being made and another position when the chisel is removed from the stock. This change in relationship of the chisel to the stock causes the chisel to bind in the cut, making it difficult to pull it out of the wood.

The mortising head shaft should be free from end play. End play in the shaft allows the bit to be raised when the mortising tool is forced into the stock. This condition may change the clearance between the head of the bit

14-1. Hollow chisel mortiser.
COURTESY OLIVER MACHINERY COMPANY



and the chisel enough to allow them to make contact. If there is not sufficient clearance between the bit head and the chisel, there may be enough heat generated to damage them.

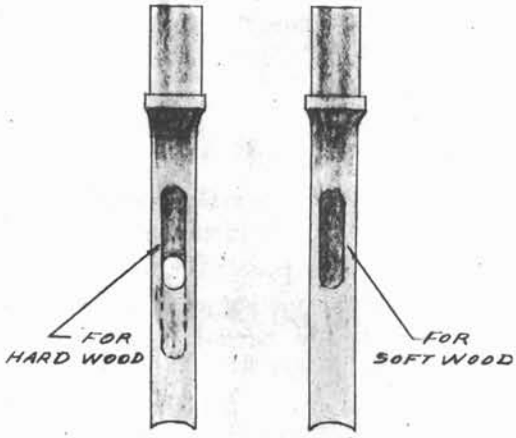
MORTISING TOOLS

The mortising tools are composed of a hollow chisel and a bit that turns inside the chisel. The bit cuts and removes a large portion of the stock by a boring operation. The cutting edges of the chisel immediately follow the cutting edges of the bit and make a square hole by shearing out the remaining wood and forcing it into the twist of the bit.

The hollow chisel is held in place by a bracket that is fastened to the mortising head housing (Fig. 14-3). The bit is attached to the mortising head spindle. It is essential for the chisel bracket and the spindle chuck to be accurately machined so that the chisel and the bit will be in alignment. If not, the bit will tend to run against the inner walls of the chisel, and cause excessive heat and wear.

Bushings adapt the various sizes of mortising tools to the machine. They must accurately fit the bit and the chisel. Improper size or badly worn bushings on either cause poor alignment.

Chisels have one or two openings in the blade for the clearance of shavings (Fig. 14-2). The chisel with one opening is used for ordinary mortising jobs. The one with two openings is recommended for mortising in hard wood (1, 6). One opening is located close to the cutting edge and the second is on the opposite side, toward the shank. The two openings overlap slightly which helps to prevent the chisel from clogging and heating.



14-2. Two types of mortising chisels.

The chisel and the bit must be kept sharp if they are to give satisfactory service. Both the bit and the chisel cut the wood. There is no excuse for burning the stock. If enough heat is created to make the shavings smoke, the mortising tool should either be changed or sharpened. When either the bit or the chisel is dull, excessive strain is placed upon both of them.

The performance of the mortiser is determined by the condition of the machine and the mortising tool.

INSTALLING THE MORTISING TOOL: Installing the mortising tool in the mortiser requires considerable care. Improper installation is one of the most common causes of damage to the tool. Bits up to 3/4″ in size are set in the spindle so that there is a minimum clearance of 1/32″ between the bit head and the cutting bevel of the chisel. Bits that are larger than 3/4″

have a 1/16" clearance. If the bit head is in contact with the chisel, sufficient heat is created to burn the contacting parts when the machine is in operation (Fig. 14-3).

To install a mortising tool

1. Pull the switch in the fuse box or remove the fuses. Loosen the set screws in the spindle and chisel bracket. Place a piece of wood under the chisel bracket to protect the bit in case it drops on the steel table.
2. Place the proper bushing on the chisel with the flanged end down. Insert the bit in the chisel and place the proper bushing on the top end of the bit.
3. Insert the mortising tool with the flat side of the chisel bushing facing the set screw and with the flange in contact with the chisel bracket (Fig. 14-3). Tighten the screw enough to hold the bushing in place.
4. Set the chisel square with the back fence and tighten the set screw enough to hold the chisel securely.
5. Turn the bit bushing so that the flat surface faces the set screw in the spindle. Set the bit with 1/32" clearance between the bit head and the beveled edges of the chisel. Tighten the spindle set screw to hold the bit firmly. If there is an adjusting nut on the bit bushing, tighten it against the end of the spindle.
6. Recheck the clearance between the bit head and the chisel to be sure of accuracy.

THE HOLLOW CHISEL BIT

The hollow chisel bit does most of the work in mortising. Keep in good condition so that it will produce a fine broken shaving that can be easily cleared through the chisel.

The head of the bit overcuts the chisel to some extent. When it becomes worn, it reduces in size until it does not remove enough material. This condition places an excessive strain on the chisel that eventually causes it to split. Replace worn bits before the chisel is damaged because they are considerably less expensive than chisels.

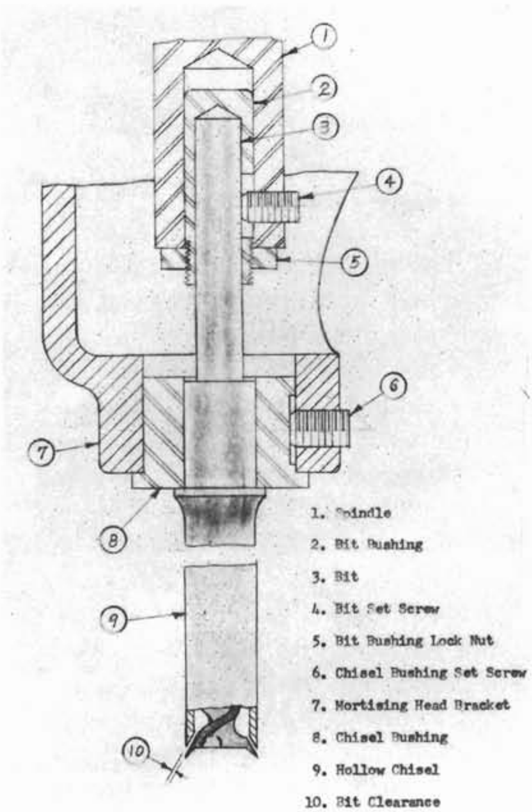
To sharpen a hollow chisel bit

Follow the procedure, "To Sharpen an Auger Bit," Chapter 7, page 100.

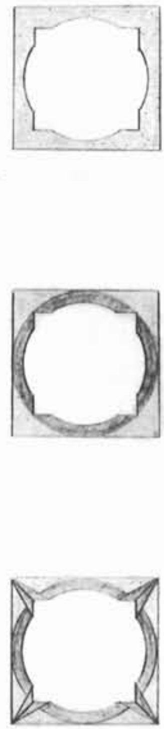
THE HOLLOW CHISEL

The chisel is generally square. It has a hole through the center for the bit, reamed at the bottom end and filed in the corners to form cutting edges (Fig. 14-4). The corners are longer than the sides and form curved edges that make a shearing cut when the chisel is forced into the stock (Fig. 14-2, page 229).

The cutting edges are usually sharpened by hand-filing them with small half round and square files (2, 2). However, the bevel may be reshaped by grinding it with a mounted, cone-shaped grinding wheel (4, 1). If the grinding wheel is used, take special care to form uniform bevels of the proper angle. The angle of the bevel is made at 25° to 30° with the side of the chisel.



14-3. Major parts of a mortising chuck.



14-4. Steps in manufacturing the hollow chisel point.

If hollow chisel mortisers are operated to any great extent, use a machine for sharpening the chisels. The machine has a cutter with a pilot that fits the bore of the chisel. It accurately cuts uniform bevels on all the cutting edges (Fig. 14-5).

To sharpen a hollow chisel

1. Clamp the chisel in a vise so that the cutting edges are easily accessible. File the inside of the curved edges at a 25° to 30° angle with the sides, using a 4″ half round second cut file. Be sure the corners are the same length.
2. File the inner double angles at a 25° to 30° angle with the sides, and groove the four corners with a 4″ square second cut file. Do not file the outside of the chisel (Fig. 14-6).
3. If small round and square oilstones are available, whet the cutting edges of the chisel. The burr may be removed by whetting the outside of the chisel lightly on a flat oilstone.

CAUSES OF POOR MORTISING PERFORMANCE

1. Too much tolerance in the gibbed

COURTESY GREENLEE BROTHERS
14-5. Specially-built hollow chisel sharpener.

ways, allowing the table mortising head to change position during the mortising operation.

2. Gibbed ways so tight that the machine is difficult to operate.
3. Lack of rigidity in the frame, allowing the relationship of the chisel and the stock to change during the mortising operation.
4. Too fast a feed, throwing excessive strain on the chisel and the bit.
5. Too slow a feed, creating excessive friction between the head of the bit and the stock.
6. The bit improperly set with reference to the chisel.
7. The use of poor fitting bushings which throw the bit and the chisel out of alignment.
8. Excessive end play in the spindle, resulting in insufficient clearance between the head of the bit and the chisel during the mortising operation.
9. The bit not securely held in the spindle. This allows it to slow down or stop when cutting.
10. Mortising with dull or improperly sharpened tools.
11. The use of lubricating oil on the mortising tool, causing the bit and the inside of the chisel to become coated with dirt and gum.
12. Mortising damp or green wood, causing the bit and the inside of the chisel to become rough.

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COURTESY MC GRAW-HILL BOOK COMPANY
14-6. Filing the inside corners of a hollow mortising chisel.

PART TWO

CHAPTER 15

Single Planers Or Surfacers

THERE seems to be a general belief that once a planer is set up at the factory it will satisfactorily do all planing jobs. Too many operators do not recognize the fact that it must be adjusted according to the moisture conditions and the nature of the lumber. A machine adjusted as a finishing planer will not do satisfactory work as a roughing planer because the lower feed rolls do not project above the bed enough to allow for the unevenness of the stock. Thus it permits too much frictional contact between the stock and the bed.

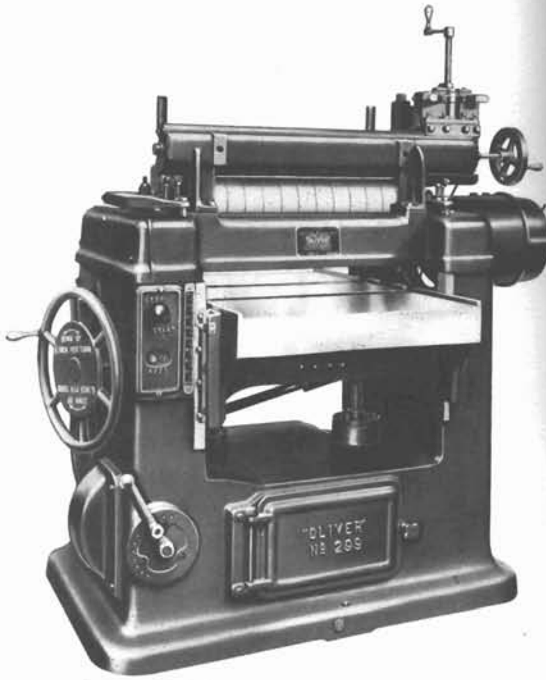
Some planers are designed specifically to do rough surfacing. Others do finish work. It is largely a matter of making the proper adjustments for whatever type of work is required. The function and relationship of such parts as the feed rolls, chipbreaker, bed, cutter head, and pressure bar should be fully understood in order to make the proper adjustments (Figs. 15-1, 2).

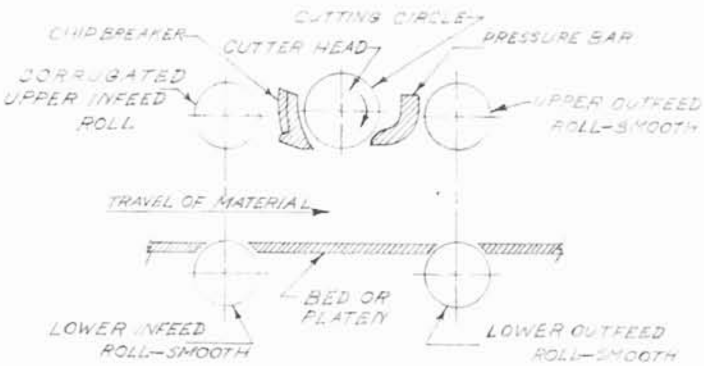
CUTTER HEAD

The cutter head turns in bearings mounted on the frame of the machine. Because the position of the cutter head remains constant with relation to the frame of the planer, the parts of the machine that come in contact with the stock are set with reference to the cutter head.

Large-diameter cutter heads cut easier and smoother than those with a small diameter because they cut more nearly parallel to the grain. The small-diameter cutter head does more cutting across the grain, thereby increasing the tendency to pick up the grain and break it below the planed surface. However, there is a disad-

15-1. Single planer or surfacer.
COURTESY OLIVER MACHINERY COMPANY





15-2. Fundamental parts of a typical planer.

vantage in using a cutter head that is too large. The stock must be held in front of the cutter head by the chipbreaker and at the back of the pressure bar. It is obvious that the larger the cutter head, the greater is the distance between these two holding points. This increases the minimum length of stock that the machine will plane (Fig. 15-2).

BED OR PLATEN

The bed is guided in its vertical movement by carefully machined ways which are provided with gibs. These gibs may be adjusted to take up any wear and prevent the table from tilting or moving horizontally. The vertical position of the bed is changed by turning a hand wheel geared to two screws on either side so that they turn simultaneously. Each revolution of the hand wheel changes the position of the bed 1/16″.

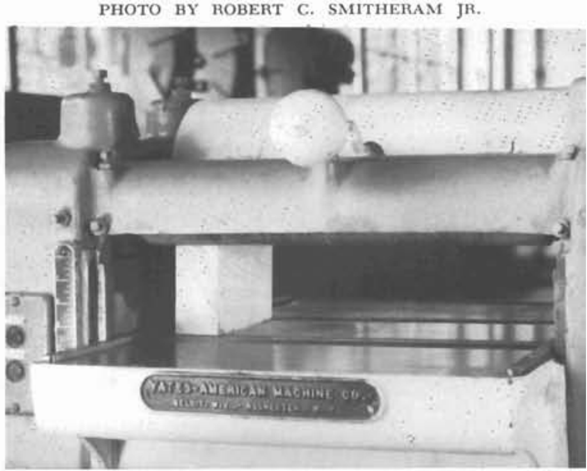
For satisfactory planing, the bed must be set parallel to the cutter head; otherwise, the stock will be planed thinner at one edge than it will be at the other. This adjustment is seldom necessary (5, 11).

To adjust the bed parallel to the cutter head

1. Adjust the gibs to hold the bed firmly in position. Do not make the gibs so tight on the ways that the bed binds in the frame and moves with difficulty.
2. Turn the cutter head until a knife reaches the lowest point of the cutting circle.
3. Place a gauge made of hardwood, about 2″ x 4″ x 5″, on the platen under the cutter head near one end

15-3A. Piece of hardwood placed at one end between bed and cutter head to test adjustment of bed.

PHOTO BY ROBERT C. SMITHERAM JR.



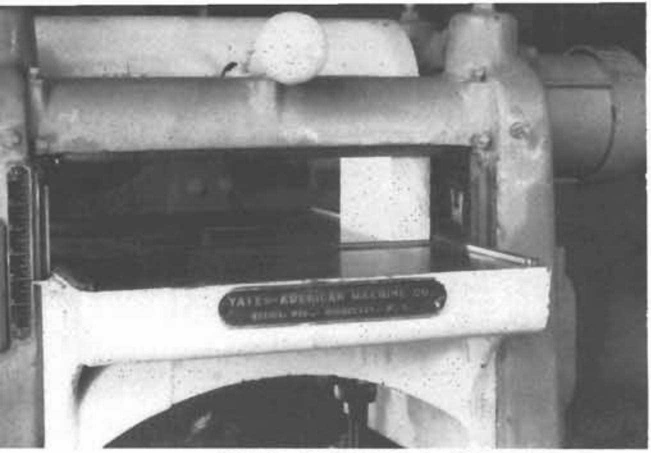


PHOTO BY ROBERT C. SMITHERAM JR.
15-3B. Wooden gauge block is placed at other end to determine if bed is parallel with cutter head.

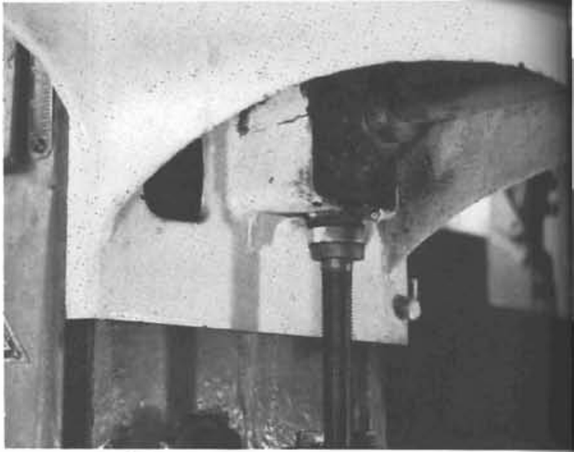


PHOTO BY ROBERT C. SMITHERAM JR.
15-4. The bed is made parallel with the cutter head by loosening one of the bevel gears and turning the hand wheel.

(Fig. 15-3A). Raise the bed until the gauge block just touches the cutter head. Then try the gauge at the other end (Fig. 15-3B). A dial indicator mounted on a surface gauge may be used instead of the wooden block.

4. If the bed is not parallel to the cutter head, loosen one of the bevel gears that turns the screw on the high side and turn the hand wheel until the platen is parallel to the cutter head. Tighten the bevel gear (Fig. 15-4).

Sometimes other means are provided for paralleling the bed, but in all cases the general procedure is the same.

FEED ROLLS

The *lower feed rolls* carry the stock slightly above the surface of the bed. They reduce much of the friction between the stock and the bed. Without them, the stock would be difficult to feed through the machine (Fig. 15-2, page 235).

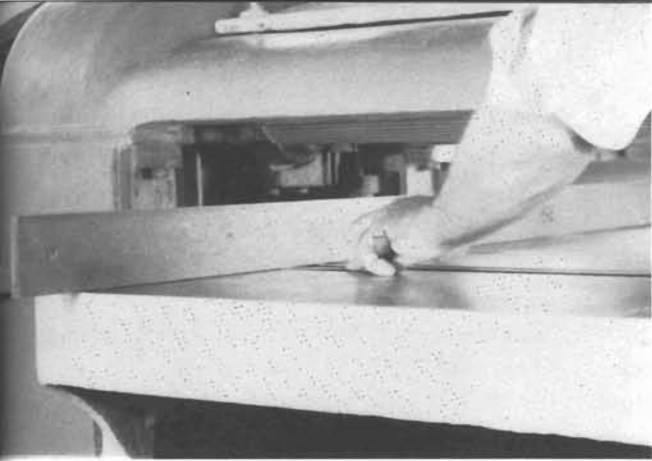
Many factors must be considered in determining a satisfactory height for these feed rolls. If the stock is surfaced in the rough they must be higher than if it has been planed because the unevenness of the rough surface allows large areas of the stock to make contact with the bed. Set the feed rolls higher when planing softwood or lumber that is not well seasoned because the rolls have a tendency to impress themselves into such wood and reduce the clearance between the stock and the bed.

If the lower rolls are set too high the stock will be suspended above the platen, which permits it to vibrate under the cutter head. This results in a rippled surface. For good finish planing, set them comparatively close to the level of the bed.

Because so many conditions determine the most satisfactory height of the feed rolls, only some general locations can be given. For finish work most manufacturers suggest a roll elevation of .025″, but one (3, 10) recommends .0156″ for its planer. Others recommend setting the rolls at .004″ for general purpose planing and .006″ to .010″ for rough planing (2, 21).

To adjust the lower rolls

1. Lower the bed as far as it will go to obtain sufficient room in which



15-5. Use a feeler gauge to check space between straightedge and lower feed rolls.

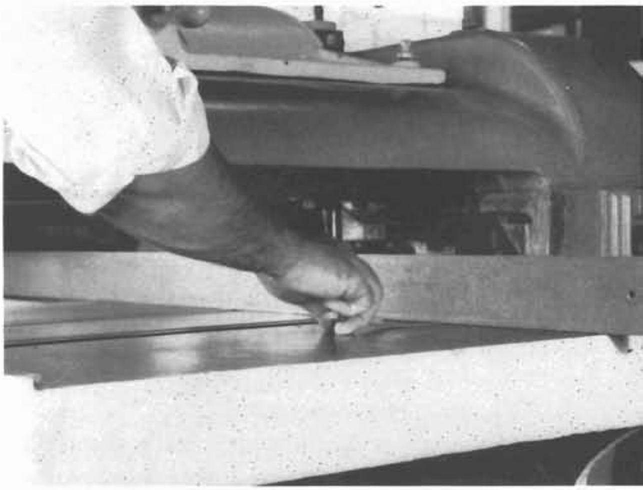
PHOTOS BY ROBERT C. SMITHERAM JR.

15-6. Position of feed rolls is changed by turning adjusting screws.

to work. Clean the rolls and bed with kerosene and fine steel wool. Wipe them dry with a clean cloth.

2. Across one end of the feed rolls, place a straightedge (preferably metal) that is as long as the bed. Check the space between the straightedge and the bed with a feeler gauge at all points along the straightedge (Fig 15-5).
3. If the straightedge is not parallel to the bed, or the space between it and the bed is not correct, turn the adjusting screws which change the position of the feed rolls until the space is correct and uniform for the full length of the straightedge (Fig. 15-6).
4. Move the straightedge to the other end of the feed rolls and set the rolls, following Steps 2 and 3 (Fig. 15-7).
5. Recheck the space between the bed and the straightedge at both ends of the feed rolls and tighten the lock nuts.

The *upper infeed roll* has a corrugated surface which helps in feeding the stock into the machine (Fig. 15-2, page 235). The impressions made on the surface of the stock are not objectionable because the thickness of the cut removes them.



15-7. Adjustment of other end of feed rolls checked with straightedge and feeler gauge.

Planers have either solid or sectional feed rolls. The sectional roll is desirable, as stock with some variation in thickness can be fed into the machine simultaneously without danger of kickback.

The upper infeed roll has a vertical movement to allow for a variation in the thickness of the cut. It is commonly set 1/32″ below the cutting circle of the knives, but may be set 1/16″ to 3/32″ below for planing rough stock.

Most planers have a mechanism to regulate the pressure of the infeed roll against the stock. If there is not sufficient pressure to feed the stock into the machine, the tension on the spring is increased. Too much pressure, however, causes the corrugations to make deep impressions on the surface and break the fibers below the cut, especially in softwood.

The *upper outfeed roll* is made smooth because it comes in contact with the planed surface. It is commonly set 1/32″ below the cutting circle of the knives.

To adjust the upper feed rolls

1. Lower the bed as far as it will go to obtain sufficient room in which to work. Clean the upper and lower feed rolls with kerosene and fine steel wool. Wipe them dry with a clean cloth.
2. Place a straightedge with parallel edges across the lower feed rolls at one end. Raise the bed until the space between the straightedge and the cutting circle of the knives is equal to the distance the feed rolls are to be set below the cutting circle. Check the distance with the thickness gauge.
3. Turn the adjusting screws at the same end until the feed rolls are even with the straightedge.
4. Move the straightedge to the other end of the feed rolls and adjust them in the same manner. Recheck the adjustment at the opposite end.

SETTING PLANER KNIVES

The knives are held between the machined surface of the cutter head and the throat piece by devices which apply pressure either to the throat piece or a part of the cutter head. There are a number of pressure devices used by the various manufacturers, but they all work on a similar principle. If the threaded part of the devices is loosened with special tools furnished for this purpose, the pressure is released from the sides of the knives so that they can be removed from the cutter head.

Pitch and gum collect on various parts of the cutter head, especially in the throat area. Therefore clean all parts and the slots in the cutter head before resetting the knives. This insures good bearing surfaces that will hold the knives securely. Clean by wiping the parts with a cloth dampened with turpentine or kerosene. In the more extreme cases remove pitch by rubbing the parts with steel wool dipped in kerosene.

Since the bed and lower feed rolls are set parallel to the cutter head, it is important for the knives to be set in the cutter head with their cutting edges parallel to the bed and rolls. They should not project more than 1/8″ beyond the circumference of the cutter head. If they project too far, the cutting edges will be damaged by making contact with some part of the machine when the cutter head revolves.

Setting the knives in the cutter head requires considerable care and skill, especially, when it is necessary to grind them out of the cutter head. If they are not set to run in the same

COURTESY BELSAW MACHINERY COMPANY
15-8. Knife setting gauge for planer knives.

15-9. Position of gauge on cutter-head.

cutting circle, they do not make uniform cuts. Also, when they all project farther at one end than at the other, the stock is cut thinner at one edge than on the other.

While the knives can be ground in the cutter head, it is still necessary to set them with a uniform projection. Otherwise, after they have been reset unevenly a few times, they vary in width and cause the cutter head to run out of balance and vibrate when it reaches operating speed.

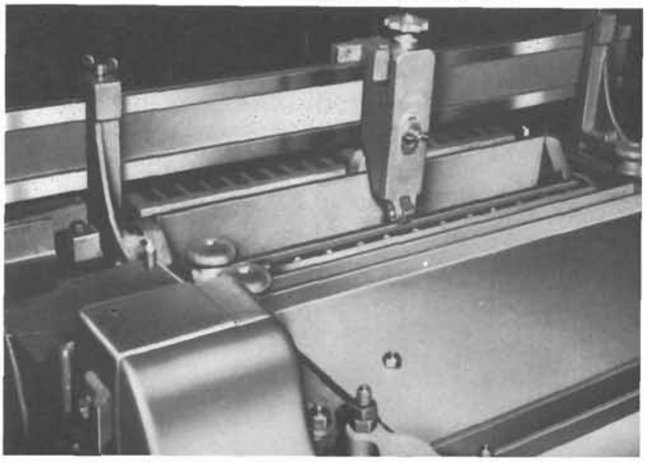
The knives can be lowered in the cutter head by tapping them lightly with a wooden mallet. If a special tool is not furnished by the manufacturer for moving the knives out of the cutter head, a punch is used for this purpose. Set it at the back edge of the knife at the end of the slot in the cutter head and tap it lightly.

Many manufacturers furnish gauges with their machines to check the position of the cutting edge with reference to the circumference of the cutter head (Figs. 15-8, 9, 10). If gauges for setting the knives are not available, the knives may be checked by placing a straightedge that has parallel edges across the lower feed rolls or on the platen between the feed rolls. "Sounding out" the projection of the knives is done by turning the cutter head so that the cutting edge lightly touches the straightedge.

To set planer knives

1. Pull the switch in the fuse box or remove the fuses. If an exhaust system is used, remove the shav-

15-10. Knife setting device mounted on grinder bar.
COURTESY BAXTER D. WHITNEY AND SON, INC.



ings hood. Turn the chipbreaker back to have access to the cutter head.

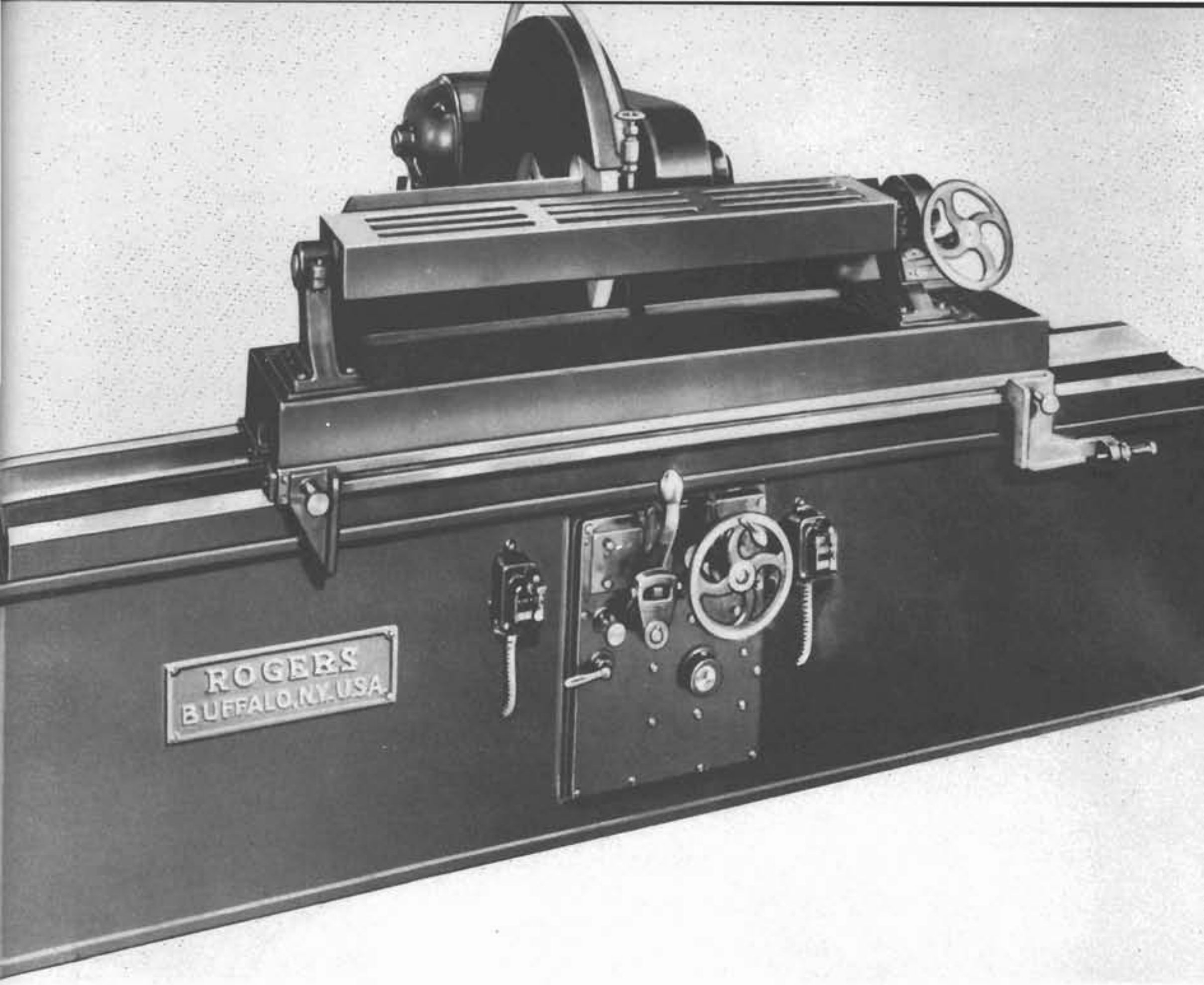
2. Fasten the cutter head in a convenient position to reach the screws holding one of the knives and loosen them with the proper tools. Pull the knife and other parts from the cutter head. Remove the other knives in the same way.
3. Clean the pitch and gum from all the parts and the slots to provide good bearing surfaces for holding the knives.
4. Replace the parts in the cutter head, placing a knife in the slot. Tighten the screws lightly to hold the knife in its approximate place.
5. Shift the knife horizontally so that it has the same relationship to the cutter head at each end. Adjust the knife so the cutting edge projects approximately 3/32″ beyond the circumference of the cutter head.
6. If a special knife setting gauge is not available, place a piece of hard wood with parallel edges on the platen under one end of the cutter head. Adjust the bed so that there is a 3/32″ space between the piece of hard wood and the cutter head.
7. Adjust the knife so that it touches the piece of wood very lightly. Check the adjustment by slowly rotating the cutter head backward and carefully listening for the knife to touch the piece of wood very lightly.
8. Move the piece of wood to the other end of the cutter head and set the knife in the same manner as in Step 7. Securely fasten the knife in the cutter head by carefully tightening all the screws. Recheck it to see that it is properly set.
9. Set the remainder of the knives, following Steps 4, 5, 6, 7, and 8.
10. Recheck all the screws in the pressure devices to see that they are tight. Make a final test of the knife settings.

GRINDING PLANER KNIVES

The planer knives must be kept sharp if they are to cut efficiently. Just because the machine is power fed is no reason to expect satisfactory work from dull knives. Knives in such condition mash the wood fibers and leave a raised grain on the planed surface instead of shearing the fibers to form a smooth surface.

If the machine has no provision for grinding the knives in the cutter head, they must be removed and ground on a knife grinding machine (Figs. 15-11, 12). Special care must be taken to keep the knives the same weight. Knives of uneven weight will cause the cutter head to run out of balance and vibrate when it is running at operating speed.

Planers may be purchased with grinders and jointers fitted on the machine. It is highly desirable for the planer to be so equipped because the knives can be ground in the cutter head without removing them. The bar on which the grinder travels must be set parallel to the cutter head so that

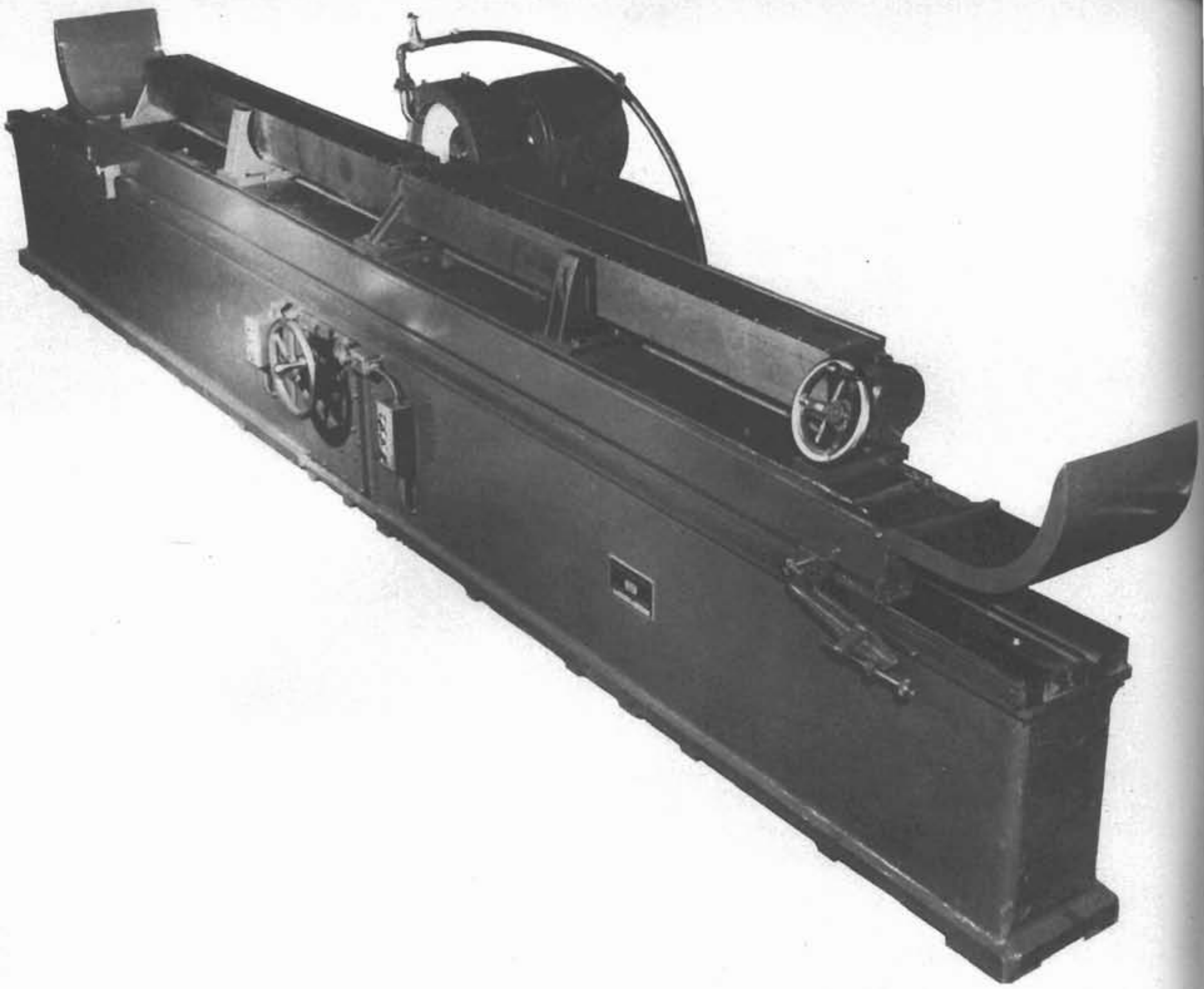


COURTESY SAMUEL C. ROGERS AND COMPANY
15-11. Specially built knife grinder.

the projection of the cutting edges of the knives will be equal (Fig. 15-13). Some manufacturers have made provisions whereby the grinder bar may be mounted on either their planer or jointer so that the knives on both machines can be sharpened with the same grinding equipment. If the grinder is used for both purposes, the bar must be carefully mounted so that it is parallel to the cutter head. All of the parts should be firmly attached and the gib screws adjusted so that there is no vibration to produce irregular cutting edges.

The grinding wheel must be of the proper specifications so that the knives will not be damaged in the grinding process. It must be kept true and in a free cutting condition. If the grinding surface is allowed to become clogged or dull, the cutting edge of the knife is likely to be burned. See the informational unit on "Grinding Wheel Selection," Chapter 1.

Grinding the knives reduces the amount they project beyond the cutter head. This makes it necessary to reset them to maintain the proper projection. After they have been reset



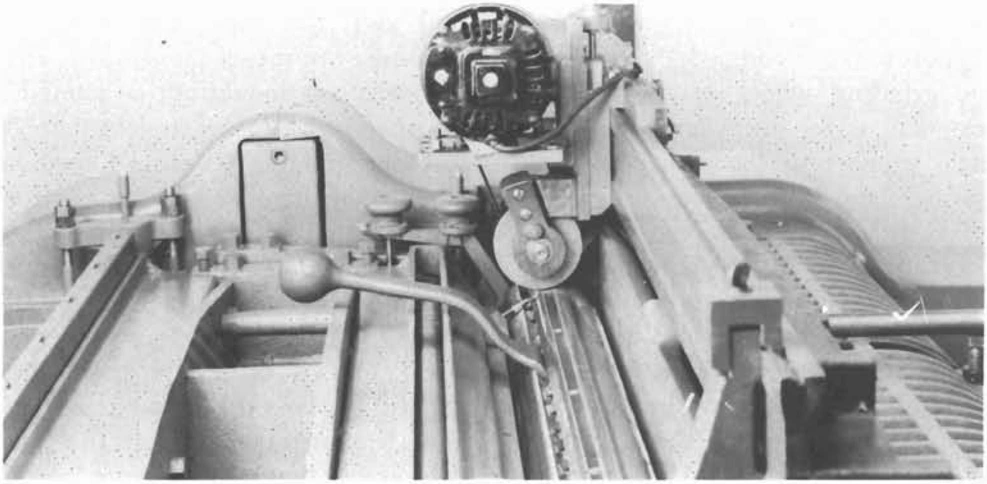
COURTESY SAMUEL C. ROGERS AND COMPANY
15-12. Knife grinder with capacity for large knives.

several times, take them out of the cutter head and balance them. If a knife grinder is not available, send knives to a commercial concern that is equipped to do such work.

It is recommended that the planer be covered with a cloth during the grinding operation so that loose abrasive grains will not enter the bearings.

To grind planer knives

1. Pull the switch in the fuse box or remove the fuses. If an exhaust system is used, remove the shavings hood. Raise the chipbreaker to have access to the cutter head.
2. Mount the grinder on the grinder bracket. Wipe the ways of the bar with a clean cloth and apply light machine oil to the ways and moving parts of the mechanism.
3. Lock the cutter head in its grinding position. With the grinder running, slowly adjust it until the grinding wheel lightly touches the knife.



COURTESY BAXTER D. WHITNEY AND SON, INC.

15-13. Close-up view of sharpening knives directly on the machine.

4. Take a very light cut back and forth across the knife without changing the adjustment of the grinder.
5. Turn the cutter head to the next knife and follow the procedure in Step 4. Repeat this procedure on the remainder of the knives.

Grinding back and forth on each knife causes the knives to be sharpened alike as the grinder grinds slightly different when moving in the opposite direction.

Lower the grinder and repeat Steps 4 and 5 until the knives are ground to a sharp cutting edge.

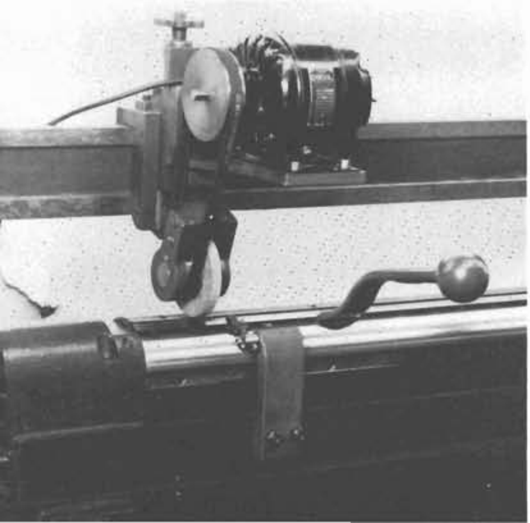
Figs. 15-14 and 15 show additional machines and methods used to sharpen planer knives.

JOINTING PLANER KNIVES

In some instances knives that are sharpened by grinding alone may not give satisfactory service. The cutting edge may break down either because

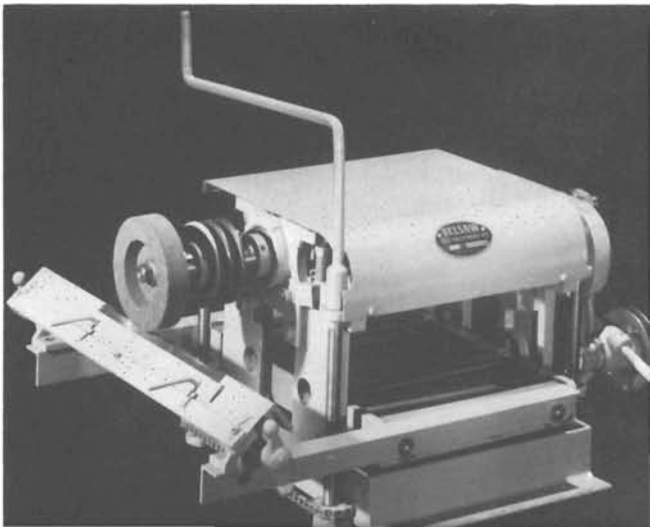
15-14. Grinding knives by placing cylinder head in a supporting cradle.

COURTESY BAXTER D. WHITNEY AND SON, INC.



15-15. Knife sharpener attached to the side of the surfacer.

COURTESY BELSAW MACHINERY COMPANY



the bevel is too long to give proper support to the cutting edge or because the grinding wheel grains form an irregular edge. Such an edge gives little support to the projections, allowing them to break off easily. This difficulty can be overcome to a considerable extent by whetting the knives with a fine oilstone after they are ground. Whetting not only forms a finer continuous cutting edge which is much stronger than the irregular projections made by the grinding wheel, but also reduces the bevel to some extent at the cutting edge, giving it more support.

Planers with jointed knives operate at greater efficiency than those with knives that are not jointed, because of the accuracy of the method used. They are jointed by attaching a special stone to the bracket that holds the grinder. The jointing stone moves along the cutting edges, while the cutter head is turning at normal speed. Because all machines vibrate slightly and run out of true to some extent, jointing the knives with the machine running would make them turn more nearly in a common cutting circle than grinding them with the cutter head stationary, where vibration is not taken into account (5, 7).

It is possible (3, 11) to joint the knives four or five times before they need regrinding. However, with each jointing, the width of the jointed surface is increased and more heat is generated because of increased friction. Whenever the planed surface appears fuzzy and has a raised grain, it is an indication that the knives are dull and, therefore, need grinding.

Some operators maintain that planer knives should not be jointed if the speed of the feed is less than 60 feet per minute. A reduced feed increases the number of cuts per foot if the normal speed of the cutter head is maintained. The increased number of knife contacts per foot causes the cutting edges of jointed knives to burn. This is especially true when planing hardwood because they have more frictional contact with the stock than knives that are not jointed. Since the jointed surface turns in the same cutting circle as the cutting edges, a larger portion of the knives rubs against the stock than is the case when using knives that are not jointed, and more heat is therefore created.

If the knives are not jointed, the planer may be operated with a slow feed without damage to the cutting edges. The output of the planer under such operating conditions is reduced to a minimum, so that a relatively small exhaust system can easily remove the shavings. If jointed knives were used on the same machine, the speed of the feed would have to be increased. The exhaust system would be inadequate to handle the large volume of shavings, especially when planing wide stock (5, 7).

In some instances, jointed knives do not give as much planing service between sharpenings as those that are sharpened without jointing. As soon as the cutting edge begins to dull slightly, it allows the jointed surface immediately back of the cutting edge to rub heavily against the stock. This condition cannot continue long before the knives require resharpening.

To joint planer knives

1. If an exhaust system is used, remove the shavings hood. Turn the chipbreaker back to have access to the cutter head.
2. Mount the jointing stone on the grinder bracket. Wipe the ways of the bar with a clean cloth and apply light machine oil to the ways and moving parts of the mechanism.
3. Adjust the jointing stone on the knives until it lightly touches each knife. Move it to one end until it clears the cutter head.
4. Start the cutter head motor, and run the jointing stone across the full length of the knives.
5. Stop the cutter head motor and check the knives to see that all the cutting edges have been lightly touched. If they are properly jointed, a fine bright line will be visible the full length of each knife. If it is not visible, repeat the jointing operation.

CHIPBREAKER

The chipbreaker is located between the corrugated feed roll and the cutter head (Fig. 15-2, page 235). It conforms to the type of upper infeed roll used on the machine, either solid or corrugated. Its function is to hold the stock firmly on the platen and to prevent the knives from chipping stock.

15-16. Check the space between the straightedge and the cutting circle with a thickness gauge.

PHOTO BY ROBERT C. SMITHERAM JR.

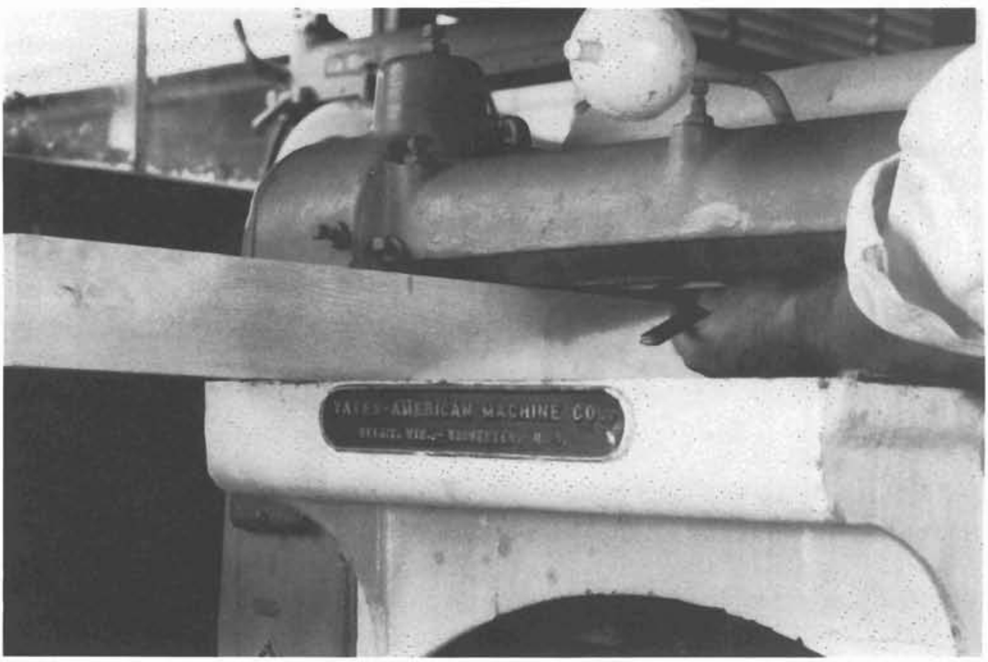


PHOTO BY ROBERT C. SMITHERAM JR.

15-17. The chip breaker is set in the correct position by turning the adjusting screws. planer with the side on the bed.

Manufacturers vary slightly in their recommendations as to the height of the chipbreaker in relation to the cutting circle of the knives. One manufacturer (2, 20) says the chipbreaker on his machine should be set even with the cutting circle of the knives. Another company (3, 10) sets it 1/16″ below the cutting circle of the knives. Still a third manufacturer (6, 2) recommends setting the chipbreaker 3/32″ below the cutting circle. The difference in the adjustment of the chipbreaker for proper performance depends upon the design of the machine. On some machines the upper infeed roll automatically raises the chipbreaker as the stock enters between the feed rolls. On others the upper infeed roll must be raised a specified amount before it raises the chipbreaker. Such a chipbreaker would exert more pressure on the stock because it does not begin to rise until the upper infeed roll has been raised a predetermined amount. The chipbreaker, therefore, would need to be set nearer to the level of the cutting circle of the knives than in the former case. If the chipbreaker moves simultaneously with the upper infeed roll, it may be set 1/32″ to 1/16″ below this feed roll to insure proper contact with the stock.

To adjust the chipbreaker

1. Lower the bed as far as it will go to obtain sufficient room in which to work. Clean the lower feed rolls

with kerosene and fine steel wool. Wipe them dry with a clean cloth.

2. Place a straightedge which has parallel edges across the feed rolls at one end of the chipbreaker.
3. Raise the bed until the space between the straightedge and the cutting circle of the knives is equal to the distance the chipbreaker is to be set below the cutting circle. Check the distance with a thickness gauge (Fig. 15-16).
4. Turn the adjusting screws until the chipbreaker is even with the top of the straightedge (Fig. 15-17).
5. Check the adjustment of the chipbreaker at both ends.

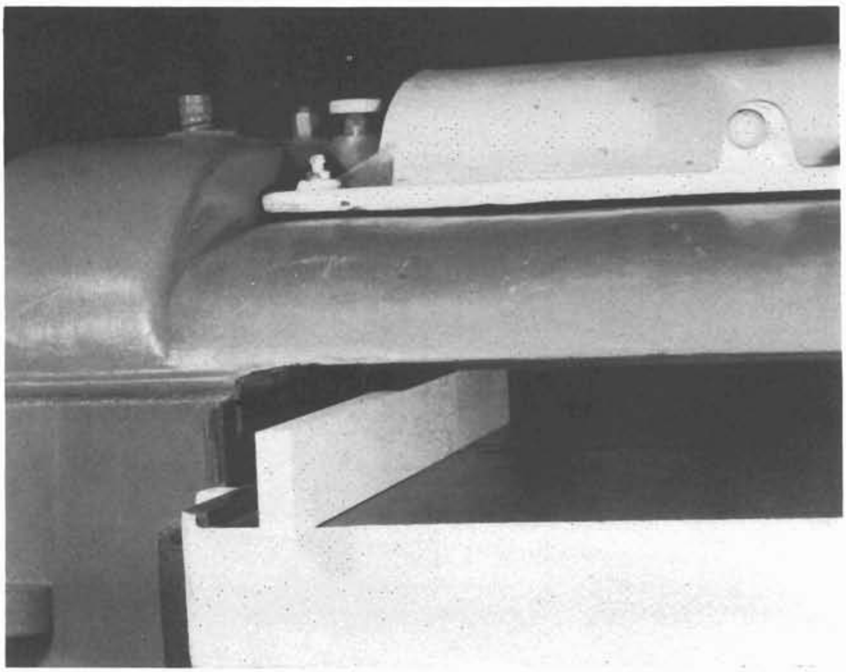
PRESSURE BAR

The pressure bar is located back of the cutter head (Fig. 15-2, page 235). Its function is to hold the stock firmly on the platen after it has passed the cutter head. When the last end of the stock has left the infeed rolls and chipbreaker, the pressure bar prevents the overhanging end that has been planed from raising the last end up into the knives. It is good planing practice to lift the end of a long board.

Set the pressure bar so that it exerts sufficient pressure to hold the stock on the platen and still permits it to feed through the machine. This requires that the adjustment be made to within a few thousandths of an inch. The pressure bar will need to be adjusted each time the knives are sharpened.

15-18. Piece of stock used to test the position of the pressure bar. It may be run through the planer with the side on the bed.

PHOTO BY ROBERT C. SMITHERAM JR.



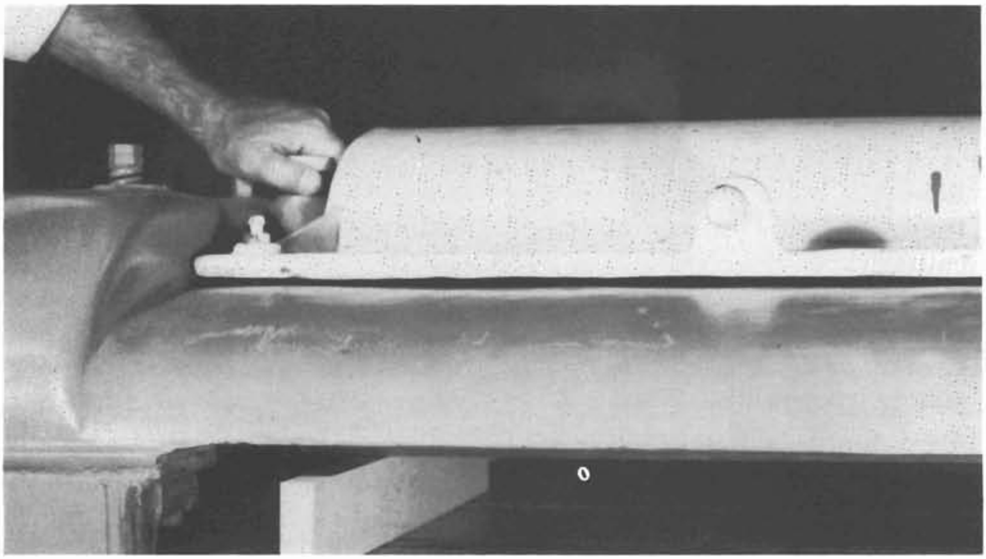
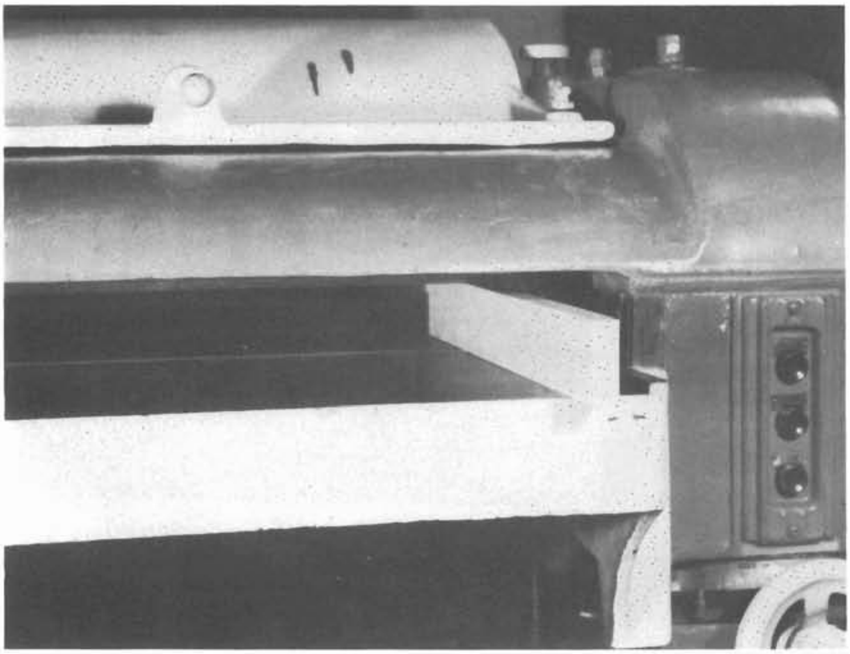


PHOTO BY ROBERT C. SMITHERAM JR.

15-19. Slowly raise the pressure bar until the piece of stock feeds through.

15-20. Using the second piece of stock, test the other end of the pressure bar for adjustment.

PHOTO BY ROBERT C. SMITHERAM JR.



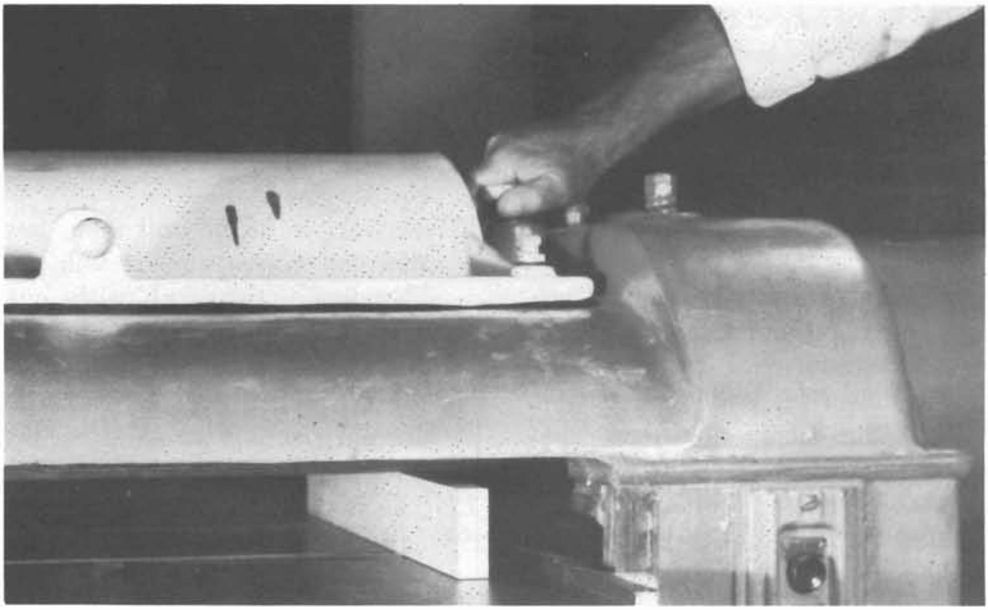


PHOTO BY ROBERT C. SMITHERAM JR.

15-21. Slowly adjust the second end of the pressure bar until the piece of stock feeds through.

To adjust the pressure bar

1. Turn the adjusting screws at each end of the pressure bar until it is slightly lower than the cutting circle.
2. Select two pieces of soft wood, preferably white pine, approximately ¾″ x 2″ x 24″ and start one piece through the planer close to one side of the bed, taking about a 1/16″ cut (Fig. 15-18).
3. When the end of the piece of wood makes contact with the pressure bar and stops, slowly raise the bar until the piece feeds through (Fig. 15-19).
4. Make the same adjustment at the other end, using the second piece of stock (Figs. 15-20, 21).
5. Lower the adjusting screws one turn at both ends and carefully repeat Steps 2, 3, and 4. Tighten the lock nuts to keep the adjustment.

REASONS FOR POOR PLANING PERFORMANCE

1. A pressure bar is too high, causes a deeper cut at the back end of the stock after it leaves the chipbreaker. Overhanging stock raises the back end of the stock off the bed.
2. An insufficient shavings disposal unit allows the shavings to pass between the planed surface and the upper out feed roll. Impressions are made on the top surface of the stock.
3. Pitch and gum deposits on the smooth feed rolls make impressions on the finished surfaces.

4. Pieces of wood or knots lodged between the bed and the lower feed rolls and projected above them prevent the stock from feeding through the machine or making grooves in the surface.
5. Nicked knives form ridges on the planed surface.
6. Dull knives cause the planed surface to appear fuzzy and have a raised grain.
7. The lower feed rolls are so low that the increased friction between the stock and the bed hinders the movement of the stock through the machine.
8. The lower feed rolls are so high that the stock is held above the platen under the cutter head. This permits the stock to vibrate and form a rippled surface.
9. The lower infeed roll is so high that the rear end of the stock drops on the platen when it leaves the infeed roll. This causes the knives to make a lighter cut on the stock at the time the end drops on the platen.
10. The lower outfeed roll is so high that the front end of the stock must be raised off the platen to enter between the outfeed rolls. This causes the knives to make a heavier cut at the time the stock enters the outfeed rolls.
11. The chipbreaker is set too low to apply sufficient pressure to retard the movement of the stock.
12. The pressure bar is so low that it retards or stops the movement of the stock.
13. The upper infeed roll is so low that the corrugations break the fibers below the depth of the cut.
14. The stock is planed thinner at one edge than at the other because the bed and the lower feed rolls are not parallel with the cutting circle.
15. The stock has a tendency to twist as it feeds through the machine because the lower feed rolls, pressure bar, or chipbreaker are out of parallel with the cutting circle.

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PART TWO

CHAPTER 16

Sanding Machines

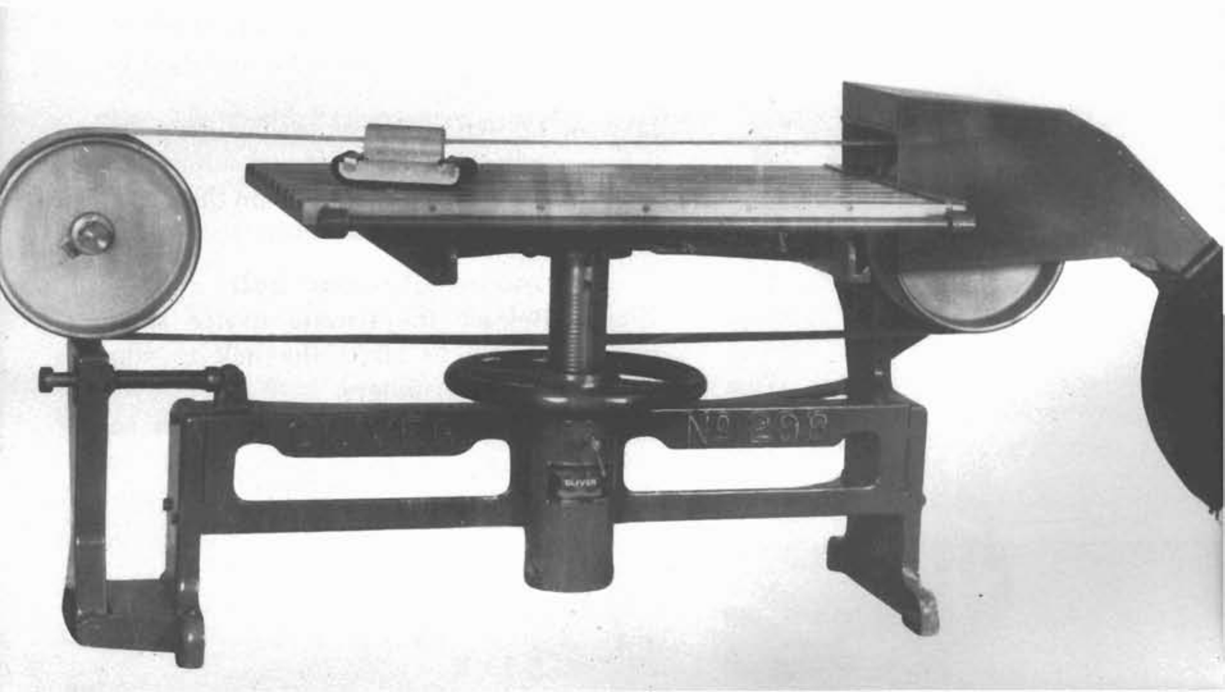
THE COMMON types of sanding machines used in the wood shop are the belt and disk sanders. Each of these types are made in a variety of styles and sizes, but the operation and maintenance of each type are similar regardless of style or size.

BELT SANDERS

The belt sander consists of an endless abrasive belt that runs over two or more pulleys. The pulleys are mounted on two vertical columns which may or may not be connected. The pulley mounts commonly have a vertical adjustment so that the belt can be adjusted to various heights. The machine is driven by a motor connected to one of the pulleys. The other pulley which serves as an idler has an adjustment for tracking the belt. It can also be moved horizontally to tighten the belt. Both pulleys are usually faced with rubber to prevent the belt from slipping (Figs. 16-1, 2).

The table which supports the stock is between the two bases. It may be either separate from or connected to the bases to form an integral part of the machine. The top or carriage moves horizontally on rollers which

16-1. Belt sander with attached dust catcher.
COURTESY OLIVER MACHINERY COMPANY



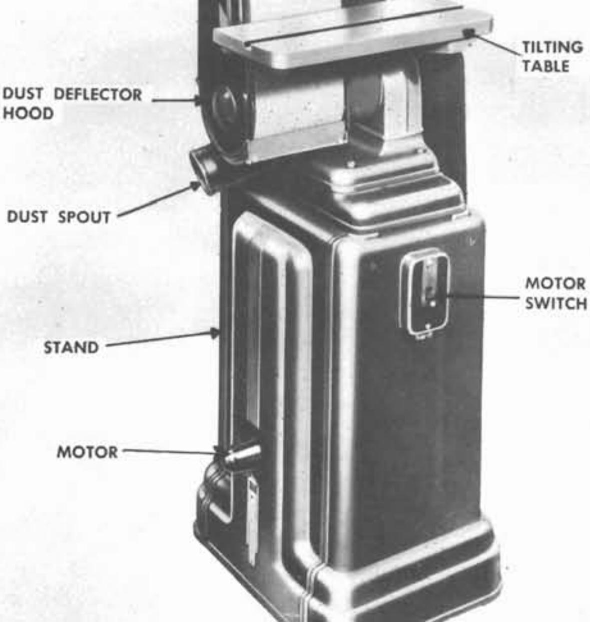
run on a track. The brackets that form the track should be parallel and the bearing surface for the rollers kept clean. The carriage has a vertical adjustment so that the work may be brought to the proper height in relation to the abrasive belt.

A sanding pad is held on the back of the belt to bring the abrasive side into contact with the surface of the stock to be sanded. The pad generally used is a flat piece of wood rounded at the ends on one side with a handle on the other. The side with the rounded ends is covered with a piece of felt or several thicknesses of cloth to form a cushion. A thick piece of canvas is fastened over the cushion. A piece of old sanding belt may be used in place of the canvas. Place the abrasive side next to the cushion.

A pneumatic pad is sometimes used for sanding flat and irregular surfaces. The cushion for this type of pad is made of a rubber inner tube, inflated to the proper pressure to give the casing the necessary flexibility.

The principal differences between the large belt sanders and the small ones, particularly the portable type, is that, instead of having a table between the pulleys to carry the stock, the small ones have a platen back of the belt to give it support when the stock is pressed against the abrasive side.

16-2. A small belt sander showing component parts. A platen supports the belt under the area where the sanding is done.
COURTESY DELTA POWER TOOL DIVISION, ROCKWELL MFG. CO.



To adjust the table track and carriage of a belt sander

1. Loosen the nuts at one end of the spacing stud between the track arms.
2. Adjust them until the track arms are equally spaced at both ends. Tighten the nuts firmly.

   If the track arms are attached to the two vertical sander columns, make the adjustment either where the track arms are attached or where the columns are fastened to the bases.
3. Loosen the set screws fastening the rollers to the shaft and adjust the rollers to run properly on the track.
4. Tighten the set screws.

To mount abrasive belts

1. Release the tension device sufficiently to allow the belt to slip over the pulleys.
2. Place the belt on the pulleys so

that the spliced end runs away from the stock (Fig. 16-3). Apply tension to the belt.

3. Turn the machine by hand and adjust the tracking hand wheel until the belt tracks properly. Do not turn on the power until the belt tracks.
4. Start the motor and make any minor adjustments in either the tension or the tracking. Do not apply more tension than is necessary to keep the belt from slipping and whipping. Too much tension shortens the life of both the bearings and the belt.

DISK SANDERS

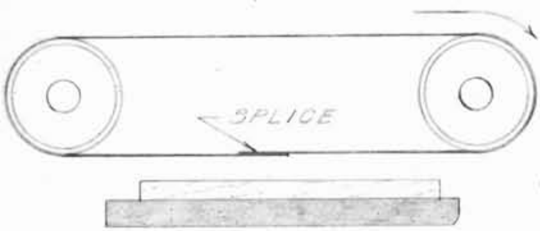
The disk sander is basically a plate attached to a shaft that is turned by a motor. These parts are mounted on a base. A table is attached to the pedestal and is located near the center of the disk. It may be set at a right angle to the disk or adjusted to as much as a 45° angle. Slots are commonly milled in the table so that a miter gauge may be used for holding the stock in the desired relationship to the plate (Fig. 16-4).

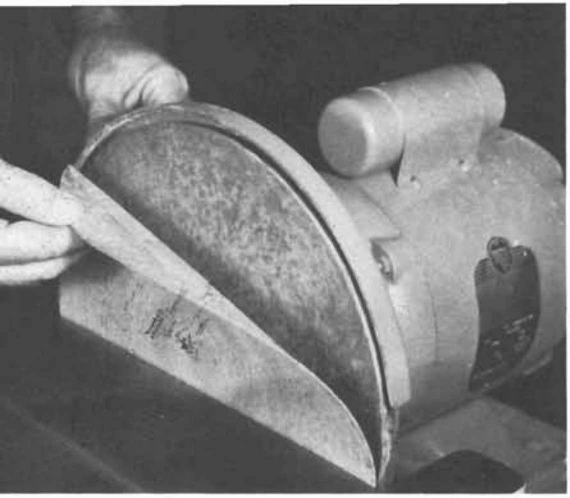
COURTESY OLIVER MACHINERY COMPANY

16-4. Disk sander.

Abrasive disks are sometimes attached to the plate with screws near the center, but generally they are cemented to the plate. The ease with which the old cemented disk can be removed depends upon the cement used. The large abrasive disks require a strong cement to hold them in place because of the rim speed at which they operate. The small disks can be held in place with a mastic cement. Because no one cement is satisfactory for fastening coated abrasives to the

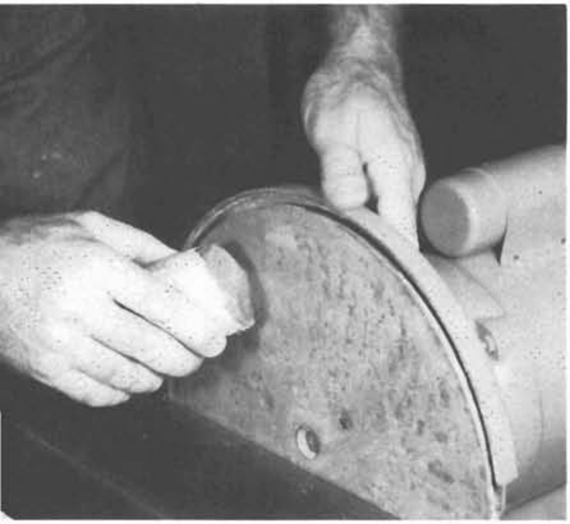
16-3. Relation of belt splice to travel direction.





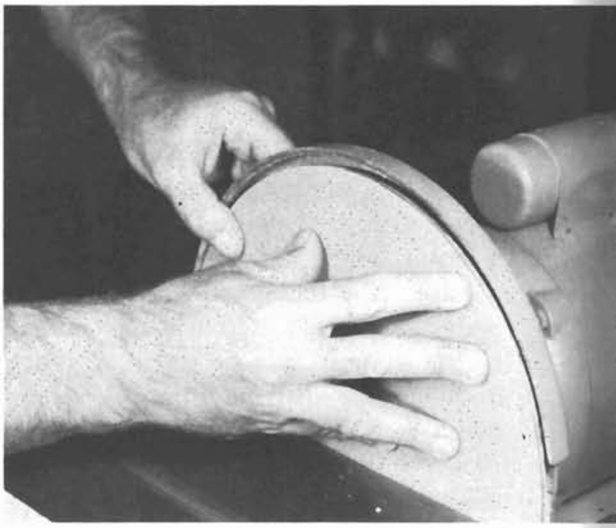
16-5. A worn abrasive disk attached with mastic cement is easily peeled off the metal plate.

16-7. An even coat of mastic cement is also applied to the abrasive disk.



PHOTOS BY CHARLES J. PEREZ

16-6. Mastic cement is applied to the metal plate.

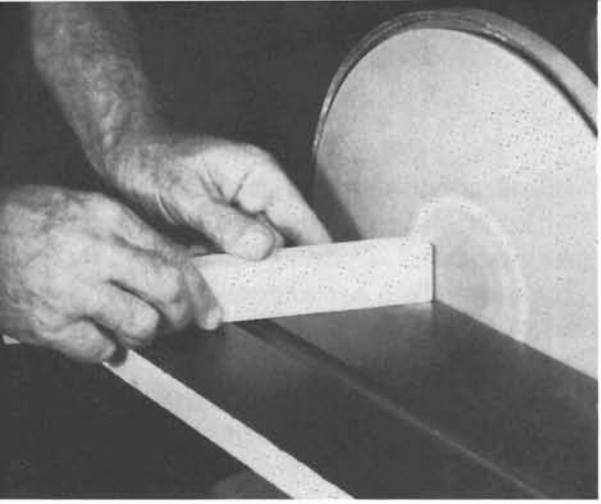


16-8. The abrasive disk is pressed firmly against the plate.

plate under all conditions, several methods are used so that the operator can select the one most satisfactory for his particular need.

To mount an abrasive disk with mastic cement

1. Peel off the old abrasive disk (Fig. 16-5). Apply a coat of mastic cement to both the metal plate and the new abrasive disk by rubbing the end of the mastic stick over them (Figs. 16-6, 7).
2. Press the new abrasive disk firmly against the plate with the hands (Fig. 16-8). Start the machine and, using the table as a support, sand the end of a narrow piece of stock and press the disk tightly against



16-9. Press the abrasive disk tightly against the plate by sanding the end of a piece of wood. Start at the center and work toward the edge of the disk.

PHOTOS BY CHARLES J. PEREZ

16-10. An old mill file is used to trim the projecting edges of the abrasive disk.

the plate. Start at the center of the disk and work toward the edge (Fig. 16-9).

3. Trim the projecting edge of the abrasive disk by placing an old mill file on the table and moving it against the edge of the disk while it is running (Fig. 16-10).

To mount an abrasive disk with hard setting cement

1. Remove the old disk by working a knife or old plane iron between the abrasive disk and the plate. Then thoroughly clean the surface of the plate.
2. Using a good cement that will stick to metal, apply an even coat to both the plate and the abrasive disk. Then place the abrasive disk against the plate.
3. Clamp a piece of ¾″ thick 5 ply stock over the abrasive disk and leave it clamped until the cement sets. Be sure the piece of stock covers the entire surface of the disk.
4. Start the machine and trim off the projecting edge of the abrasive disk by placing an old mill file on the table and moving it against the edge of the disk.

To mount an abrasive disk with rosin

1. Remove the disk plate from the sander and place it in a horizontal position with the abrasive side up. Then lay a cloth over the old abrasive disk.
2. Iron the surface of the disk with a flat iron that is warm enough to melt the rosin. Then pull the abrasive disk off when the rosin has softened and clean the surface of the metal disk.
3. Sprinkle an even coat of powdered rosin on the surface of the metal disk and place the new abrasive disk on it. Cover the abrasive disk with a cloth and iron it with a flat iron warm enough to melt the rosin.
4. When the plate has cooled, mount it on the machine and trim the projecting edge of the abrasive

disk by placing an old mill file on the table and moving it against the edge of the disk while it is running.

COATED ABRASIVES USED ON SANDING MACHINES

Abrasives

The abrasives in common use on sanding machines are garnet and aluminum oxide. Aluminum oxide is harder and more durable than garnet, and is considered to be more economical, although the initial cost is higher (5, 2). It is obtainable in grain sizes ranging from No. 12 (4½) to No. 400 (10/0). Garnet is available in grain sizes No. 20 (3½) to No. 280 (8/0).

Backings

The principal backings used for machine sanding are paper and cloth. Paper backing is made in four different weights (Table 15). Only heavy-weight paper is satisfactory for making belts, disks, rolls, and sleeves.

The cloth backings are made of cotton cloth woven according to the specifications of the coated abrasive industry. They possess greater strength and flexibility than paper backings. Cloth backings are made in two weights, designated as drills and jeans (4, 14).

Drills are the heaviest, strongest, and the most stretch resistant of the cloth backings. The increased strength is achieved by weaving more threads lengthwise than in the width (1, 15). This quality of backing is known as "X" backing. It is used primarily for making belts, disks, and rolls.

Jeans are a lightweight cotton cloth that have considerable flexibility They are known to the trade as "J" backings. Jeans are used wherever coated abrasives with great flexibility are more necessary than long production life.

Table 15

WEIGHTS OF PAPER BACKING

PRODUCT	TECHNICAL WEIGHT (4, 14)	POUNDS PER 480 SHEETS 24" x 36" (3, 14)
Finishing	"A" (very light)	40
Cabinet	"C" (light)	70
Cabinet	"D" (medium)	100
Rolls, Belts Disks, Sleeves	"E" (heavy)	130

Coatings

Coating is the application of the abrasive grains to the backing. Through modern manufacturing methods the grain spacing is accurately controlled for the purpose of obtaining chip clearance between the grains (5, 1). The two kinds of coating (Fig. 16-11) commonly used are the "closed coat" and the "open coat."

In the "closed coat," the backing is covered as densely as possible with the abrasive grains. It is used for coated abrasives that are subjected to more pressure and are required to remove a great amount of material. A "closed coat" will do more work than an "open coat" when used on materials that are not likely to clog the cutting surface.

The "open coat" may cover up to 70 per cent of the backing surface, leaving open spaces between the grains. It is used for working materials that would normally clog the more densely coated abrasive. Under such conditions an "open coat" will do considerably more work than a "closed coat."

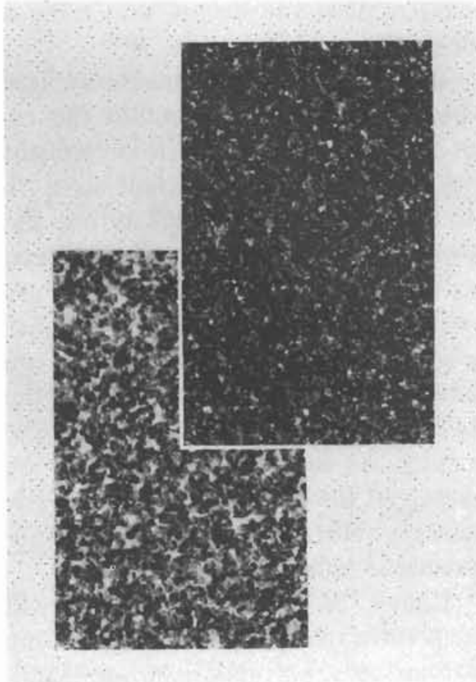
Flexing

Flexing is the breaking of the bond bed of the coated abrasive by pulling the coated material over the edge of a flat surface, making a right angle break. The purpose of flexing is to make it more adaptable to the machine and the work (4, 16). There are three types of flexing: regular, standard, and special. The regular flexing breaks the bond at a 90° angle to the edges of the stock. Standard and special flexing is the process of breaking the bond at 45° angles after it has been regular flexed. Standard flexing is only slightly flexed at 45° angles, whereas special flexing severely flexes the material at 45° angles. Special flexed material is very pliable (1, 22).

This breaking of the glue bond reduces the life of coated abrasives considerably, since many abrasive particles are removed from the backing. A certain amount of work performed must be sacrificed at times to obtain the necessary flexibility. Therefore coated abrasives which have the minimum flexibility necessary to meet the work requirements will give longer service and are recommended.

Forms of coated abrasives

Coated abrasives are made in



16-11. Close-coat and open-coat abrasive paper compared.
COURTESY BEHR-MANNING CORPORATION

sheets, rolls, disks, sleeves, and belts.

Sheets 9″ x 11″ are made in either cloth or paper and are used on power reciprocating machines or cut into disks. They are packaged in units of 100 sheets, but may be bought in single sheets.

Disks and sleeves are made in either heavyweight paper or cloth. They are available with garnet and aluminum oxide abrasives.

Rolls are obtainable up to 48 inches x 50 yards in size. They are available in garnet and aluminum oxide with either paper or cloth backing. Their principal use is to make belts for belt sanders, and for drums that have a device to hold the ends.

Belts for sanding machines are made from roll stock cut to the required lengths. The heavyweight paper backing has sufficient strength and is satisfactory for sanding flat work when used by an experienced operator. It is not advisable to use paper belts in the school shop because students with little experience are likely to place too much strain on the belt while learning to operate the sander. As a result, the belt may be damaged beyond use long before the abrasive surface has shown any appreciable wear.

Heavy "X" weight cloth belts will give satisfactory service for sanding flat surfaces, particularly where sanding conditions place the belt under excessive strain. The increased expense, however, may not warrant the use of cloth belts in the place of paper belts on normal sanding jobs.

The light "J" weight cloth is used for sanding irregular surfaces such as moldings, where an extremely flexible belt is required, one that will conform to the shape of the surface of the stock. Lightweight belts are used only when the sanding job requires a flexible belt, because the abrasive does not last as long on a light, flexible belt as it does on a firm, heavy one.

Factory-made belts can be purchased, but it is more economical to buy roll stock and make the belts.

Care of coated abrasive products

Coated abrasive products require considerable care in their handling and storage. Atmospheric conditions affect them more than any other conditions. The humidity of the storage room should be neither too high nor too low. As the *humidity rises* the work value of the abrasive products lessens because the glue begins to soften and release the abrasive grains. Whenever the humidity again reaches 50 per cent the glue is restored to its maximum strength and maximum work value can be expected (1, 35).

Low humidity may reduce the work value even more than high humidity. When the humidity is lower than 50 per cent the glue tends to become too hard and lose its flexibility. This causes the coating to peel off. If the humidity goes below 25 per cent, the moisture content of the glue is reduced to a point where it will not reabsorb sufficient moisture to reach its maximum strength. As a result, the abrasive product is ruined (1, 34). Especially during the winter months, when buildings may go considerably below 25 per cent humidity, coated abrasive products can be completely ruined in a few days' time.

Temperature, also, affects the work service of coated abrasives. Their maximum work value is received when the storage room is kept at a temperature from 65° to 70° Fahrenheit.

SPLICING ABRASIVE BELTS WITH A LAP JOINT

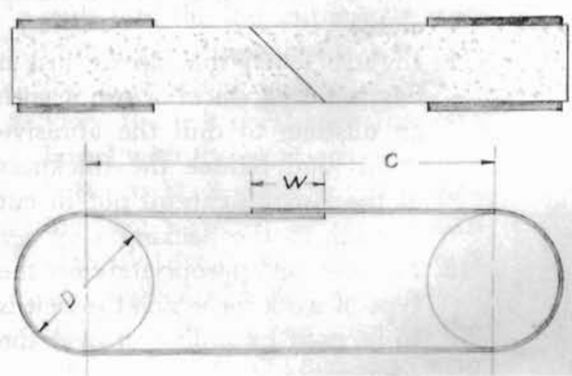
Splicing abrasive belts is a comparatively easy operation. Splices can be made without any special equipment, although belt splicing dies are available. The splice in a belt should not be thicker than any other part or it will cause an uneven pressure against the stock when the splice passes under the sanding pad. Unless the pressure against the stock is kept uniform, the sanded surface will not be flat. Keep the edges of the belt straight when the joint is glued; otherwise, the belt will run "snaky."

The length of the sanding belt can be readily determined by setting the idler midway between the extreme positions of travel of the tension adjustment and reading the measurement on a tape that has been placed on the pulleys as a belt. If the sander has only two pulleys, the length of the belt can also be calculated by setting the idler pulley at its midway position and figuring twice the distance between the centers of the pulleys plus the circumference of one pulley. When the belt is spliced at a 45° angle, the width will need to be added to the length to obtain the total length of the roll material needed for a belt. In Fig. 16-12, "C" is the distance between centers of the pulleys, "D" is the diameter of the pulleys, and "W" is the width of the belt. If "L" equals the total length of material required to make a belt use the following formula to calculate the length: $L = 3.14D + 2C + W$.

To splice an abrasive belt with a lap joint

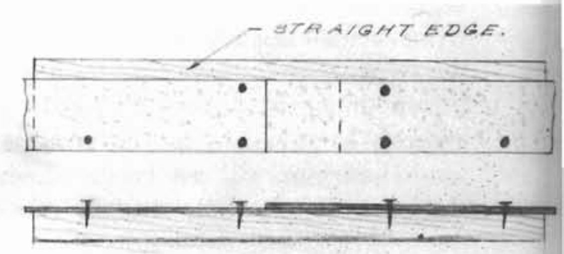
1. Calculate the length of the material needed to make the belt and cut it from the roll.
2. Select a ¾" board that is somewhat wider than the width of the belt and from 4 feet to 6 feet long. Joint one side flat and straighten one edge.
3. With the abrasive surface of the belt facing up and the ends overlapping the distance of its width, place the belt on the board so that the edge is even with the straight edge of the board. The lap is approximately in the middle. Next, "slip tack" each end back from the lap with three or four tacks (Fig. 16-13).
4. Select a straight piece of stock that is approximately ¾" x 2" and long enough to reach across the belt (Fig. 16-14). Clamp it across the lap at a 45° angle.
5. Using the edge of the board as a straightedge, cut through both thicknesses of the belt. An old mill file that is rounded toward the end and ground sharp makes a good tool with which to cut the belt. Do not use a good edge tool because cutting the abrasive will damage it.
6. Remove the tacks from one end

16-12. Calculating the length of a belt.

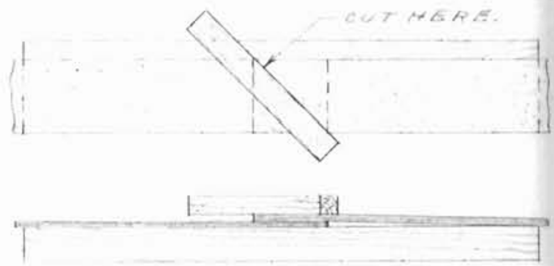


of the belt and lap it over the other end approximately ¾". Replace the tacks. Be sure the edge of the belt is even with the jointed edge of the board to which it is fastened (Fig. 16-15).

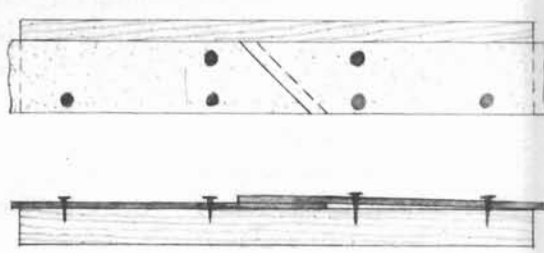
7. Remove the abrasive at the end of the belt covered by the lap. Apply water to remove the abrasive grains. After the glue has softened, the abrasive can be readily scraped off. If it is not easily removed, give it another application of water.
8. Next place a piece of heavy paper between the board and the belt at the lap. Apply a good wood glue to the scraped surfaces of the belt. Do not use an excessive amount of glue.
9. Press the lap together and lay a piece of heavy paper over it. Place the jointed side of the piece of stock used for cutting the angle on the belt across the lap and clamp it to the board to which the belt is fastened.
10. After the glue has dried, remove any paper that may stick to the belt by rubbing it with a damp cloth.
11. Lightly touch the lap against a fine grinding wheel or rub it with an oilstone to dull the abrasive grains and reduce the thickness of the lap. Be careful not to cut through to the backing.
12. Flex the lap appropriately for the type of work for which the belt is to be used by pulling it over the edge of the work bench until the desired flexibility is gained.



16-13. Belt slip tacked in position.



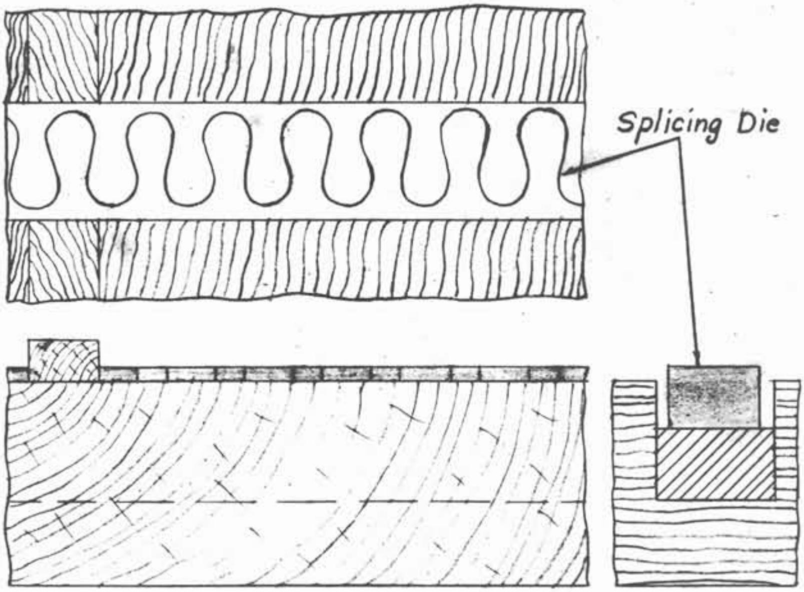
16-14. Cut splice along straight edge, placed diagonally over splice.



16-15. Splice cut, ready for gluing. Ends of belt overlap ¾".

SPLICING ABRASIVE BELTS WITH A SPLICING DIE

Abrasive coated belts, either paper or cloth, can be satisfactorily spliced with an interlocking joint cut on the ends. A thin piece of cloth glued to the backing prevents the dovetail



16-16. Splicing die mounted in a jig holds it in the proper relationship to the belt when the splice is made.

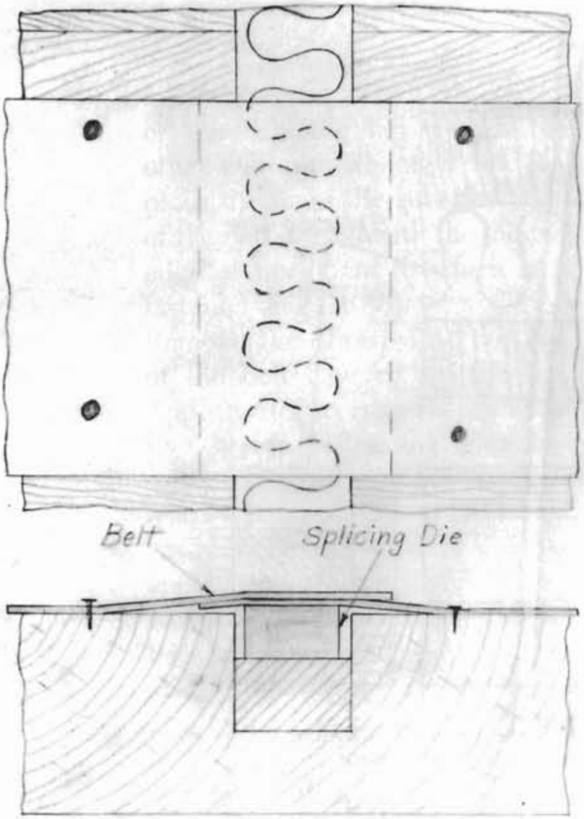
joint from coming apart. The belt is spliced straight across or diagonally.

The splicing die used for cutting the joint is made of an iron base on which is mounted a spring steel cutter. The spring steel is woven around iron pegs, forming a dovetail design.

A splice can be more easily made if the die is mounted in a jig similar to the one shown in Fig. 16-16.

To splice abrasive belts with a splicing die

1. Calculate the length of the material needed to make the belt and cut it from the roll goods. See informational unit, "Splicing an Abrasive Belt with a Lap Joint." Add slightly more than the lap to the actual length of the belt.
2. With the abrasive surface of the belt up and its edge against the straightedge, "slip tack" the belt to the jig so that the ends lap over the cutting edge of the splicing die enough to make the joint (Fig. 16-17).
3. By using the end of a block of wood or a mallet, drive the lapped ends into the die, cutting through both thicknesses of the belt to form the interlocking joint.
4. Place the belt on the flat side of a board with the backing side of the belt up. Then press the interlocking joint together and slip a piece of heavy paper between the belt and the board at the joint.
5. Apply a good wood glue to the backing at the joint and lay a strip



16-17. The belt is lapped over the splicing die and "slip tacked" to the jig.

of thin cloth approximately 3″ wide over the joint. "Sign-writer's" cloth is recommended, as it is thin and is coated on one side to prevent the glue from soaking through. Aeroplane linen is also satisfactory (2, 1). Do not use an excessive amount of glue.

6. Lay a piece of heavy paper over the cloth and place the joined side of a board on the joint. Now clamp the two boards together.
7. After the glue has dried, remove any paper that may be glued to the belt by rubbing it with a damp cloth.
8. Flex the lap appropriately for the type of work for which the belt is to be used by pulling it over the edge of the work bench. See informational unit, "Flexing," in this chapter.

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PART TWO

CHAPTER 17

Shapers

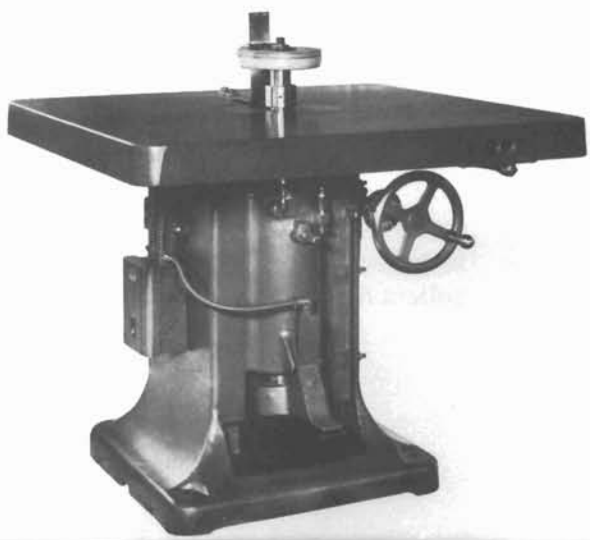
THE SHAPER consists basically of a vertical spindle which projects through a table supported by a heavy base. Many shapers are constructed with the table mounted stationary on the base and with provisions to adjust the spindle vertically. Others have the spindle housing attached firmly to the base with the table adjustable for height. Some small shapers have the motor and spindle assembly unit mounted in such a way that the spindle can be adjusted at an angle to the table (Figs. 17-1, 2).

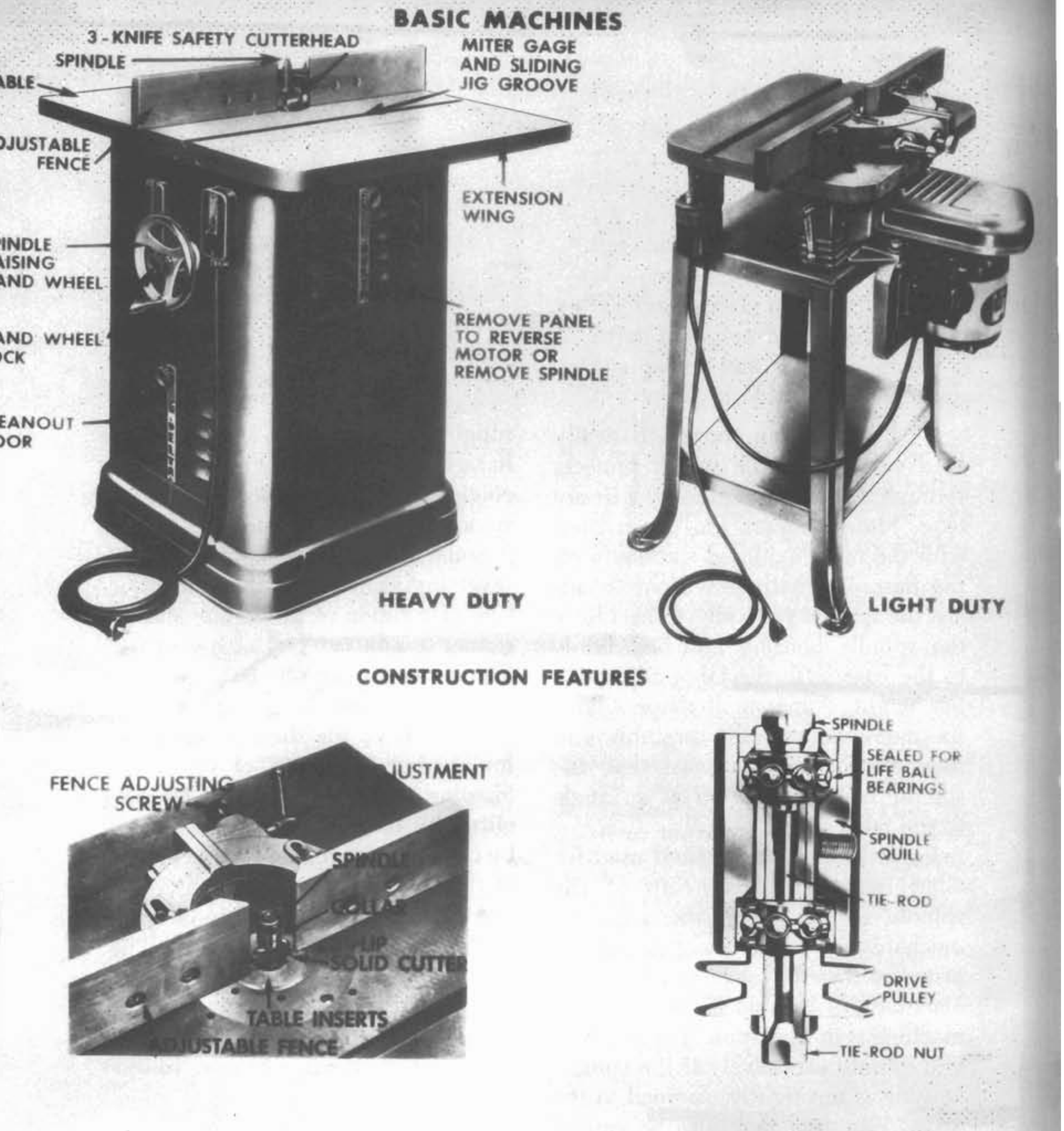
Regardless of the method used for changing the relationship of the spindle to the table, the adjusting mechanism must be designed and adjusted so that the movable part of the machine can be held firmly when the machine is in operation. The machine will vibrate excessively if the spindle housing is not tightly clamped in the ways. Vibration may also be caused by worn spindle bearings, loose vertical spindle adjustment ways, spindle pulled out of line by the spindle nut, and improperly balanced knives. It is essential that vibration be kept to a minimum; otherwise, it may place undue strain on the machine, make a rough cut on the stock, and may prove hazardous to the operator. Shaper efficiency is also reduced when the spindle is out of balance.

Some shapers are equipped with reversing switches so that the direction of rotation of the motor and the shaper spindle can be changed at will. The reversing switch is a desirable feature because it permits running the cutters in the direction required for cutting the grain of the wood. Shaping with the grain can be done either by turning the cutters over or by using cutters that are made in pairs of right and left.

A comparatively high spindle speed is required to do smooth shaping. Shaper spindles commonly run 8,000 to 15,000 rpm. Small diameter cutters

17-1. Heavy shaper.
COURTESY OLIVER MACHINERY COMPANY





COURTESY DELTA POWER TOOL DIVISION,
ROCKWELL MFG. CO.

17-2. Shaper and component parts.

need to run at higher speeds than large ones to maintain the normal cutting speed. This speed is designated by the surface feet per minute the cutting edge travels.

FENCE

An adjustable shaper fence is highly desirable. Even though there are numerous shaping jobs for which it cannot be used, it makes many of the straight line jobs easy to perform. Generally the fence is fastened to the top of the table with clamp studs which make it easy to adjust with relation to the spindle. Either half of the fence may be adjusted whenever necessary. If a line is scribed across the two fence brackets at the joint when the faces of the fence are in the same plane, it can be used for resetting the fence. Wooden pieces are usually fastened to the face of the fence with bolts. The heads of the bolts are set below the surface by counterboring the holes. The wooden pieces may be made adjustable horizontally so that the distance across the opening between them can be kept to a minimum.

The faces of the two sections of the fence must be in parallel planes if the cut is to be uniform in depth throughout the entire length of the stock. In case the two faces are not in parallel planes, they can be reconditioned by setting the index lines on the brackets together and jointing the face of the fence flat on the jointer. Be sure the heads of the bolts in the fence are far enough below the surface to allow for sufficient jointing.

When the entire surface of the stock is cut by a shaper cutter, the outfeed section of the fence must be even with the shaped surface in order for the shaped surface to be in a straight line. The infeed and outfeed sections of the adjustable fence function in the same way as the infeed and outfeed tables on the jointer. See the informational units, "To Adjust Jointer Tables" and "Causes of Poor Jointer Performance," in Chapter XIII, pages 215 and 225.

AUXILIARY SPINDLES

Auxiliary spindles are attached to the end of the main spindle. On small shapers they are sometimes attached by setting the shank into a socket in the main spindle. It is keyed to prevent it from turning within the socket and is held in place by a tie rod.

Large shapers commonly have splines cut on the upper end of the main spindle and the lower end of the auxiliary spindle. If a collar is fastened over the joint between the two spindles, the spindles are joined together firmly so they will not come loose, regardless of the direction of rotation.

Shapers which use auxiliary spindles have more operational flexibility than those designed with one spindle. Different sizes of spindles may be used, or a permanent set up of several patterns may be made and the entire spindle changed when another pattern is needed (6, 5).

When mounting the auxiliary spindle, clean all the contacting surfaces thoroughly. A small amount of dirt will keep the spindle from seating properly and throw it enough out of line to cause excessive vibration. A little oil placed on the threads will keep them from sticking and make it easier to tighten the nut.

Tighten the nut which holds the spindle joint together with a smooth wrench, applying even pressure. Do not strike the wrench with a hammer to tighten the nut.

SPINDLE COLLARS

The knife collars and spacing collars should be accurately ground to uniform thickness. If they are not uniform in thickness, the spindle will be pulled out of line when the nut is tightened against the collars. This condition will cause the machine to vibrate when running the spindle at operating speed. Wipe the collars with a clean cloth and inspect them for burrs before they are put on the spindle. Keep extra collars in good condition by hanging them on wooden pegs or by storing them in a box which is divided into individual compartments. Do not keep them loose in a box with the other shaper accessories. (A film of light oil will prevent rust).

Plain knife collars are slotted to fit against the 60° beveled edges of flat shaper knives. Keep the surfaces of these slots flat so that they will provide sufficient friction to hold the knives in place when the machine is running. NOTE: When the slots become damaged, discard the collars. The danger of throwing a knife and causing a serious accident is very great.

Safety knife collars have locking screws in the upper collar. The threaded portions of the locking screws project into the machined slots. They engage the serrated edges of the knives and hold them in position. The projection of the knife can be accurately regulated by turning the locking screw.

Spacing collars are made in varying thicknesses and diameters, and in either plain or ball bearing types. Stock can be run in contact with ball bearing collars without burning the contacting surface of the stock.

SHAPER CUTTERS

There are two types of cutters generally used on the shaper. One is the solid wing cutter and the other is the flat shaper knife.

Solid wing cutters

Solid wing cutters are milled from solid bars of tool steel, and ground to a specified shape. They are available in a variety of sizes and shapes. Special shapes may be made to order. Solid cutters are the *safest and most practical for use on small shapers.*

Mounting solid cutters is a rather easy job. The cutter is merely slipped over the spindle with the face of the cutter toward the side from which the stock is fed. It is locked to the spindle by means of a lipped washer and a nut which tightens against the cutter at the top end of the spindle (Fig. 17-3). A sufficient number of loose collars can be placed on the spindle to hold the cutter in the proper position with relation to the top of the table.

FLAT SHAPER KNIVES: Flat shaper knives are clamped between two slotted knife collars (Fig. 17-4). They are used in a number of ways. Usually two knives are ground to the same contour and set to make long, uniform cuts. For short runs, one knife is frequently used to do the shaping and a blank or odd knife is used in the other slot as a filler. The filler must be the same width as the knife so that the spindle will not be pulled out of line when the nut is tightened against the collar. Also, it should be approximately the same weight as the cutting knife so that the spindle is properly balanced. With a little practice a spindle can be made to run in balance even though the knives are not exactly the same weight. Proper balance is achieved by distributing the mass so that the centrifugal force of both knives is equal. If the spindle runs out of balance, the centrifugal force of a knife can be equalized by changing its position in the slot in relation to the axis of the spindle.

Flat shaper knives must be securely clamped by the spindle nut. There is very little possibility of their coming out if they are properly mounted. They should never be mounted without using a lipped washer under the spindle nut. The function of the washer is to keep the spindle nut tight regardless of direction of rotation.

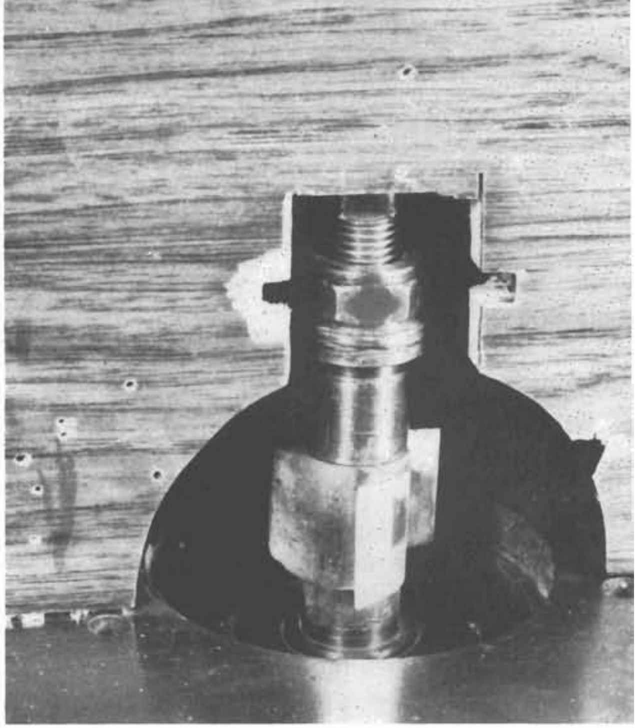


PHOTO BY CHARLES J. PEREZ
17-3. Solid wing cutter is held in place by a lipped washer and a nut.

To mount flat shaper knives

1. Lock the spindle with the locking device and remove the spindle nut, washer, and top knife collar. Clean all the parts. Be sure the knife slots are clean and in good condition.
2. Select the knives to be mounted and place them in the slots of the lower knife collar. Next, place the top knife collar in position so the knives fit in the slots.
3. Place the washer and the nut on the spindle and tighten the nut very lightly by hand.

PHOTO BY CHARLES J. PEREZ
17-4. Flat shaper knives are clamped between two slotted knife collars.

4. Test the knives to determine if there is an equal pressure on them, by grasping the end of each knife between the thumb and fingers and slipping it endways in the slots. If one knife pulls more easily than the other, the knives are not the same width. Unless knives of equal width are used, the spindle may be pulled out of line when the nut is tightened or one knife may be thrown when the machine is running.
5. Clamp a piece of wood on the table top with the distance between the end and the knife collar equal to the knife projection required. Set the end of each knife against the end of the wood.
6. Tighten the spindle nut securely with the spindle nut wrench. Do not strike the wrench or put an extension on the handle. Such practice may damage the threads or cause wide knives to buckle and break.
7. Release the spindle locking device.

MAKING FLAT SHAPER KNIVES: Flat shaper knives are made from 60°, beveled-edge shaper steel with one edge either plain or serrated. The bars are made in 24″ standard lengths, but most companies will furnish them in 12″ lengths. The following thicknesses of steel are recommended as safe for knives of the various widths: 3/16″ thickness for knives up to 2″ wide, 1/4″ thickness for 2″ to 2½″ widths, 5/16″ thickness for 2½″ to 3½″ widths, 3/8″ thickness for 3½″ to 4″ widths, and ½″ thickness for 4″ to 5″ widths (5, 36).

Shaper steel is available in both carbon and high speed steel. The latter is generally used for making knives where a large quantity of stock is run on one set-up, because they stay sharp considerably longer than carbon steel knives. They give from five to ten times the service of carbon steel knives (3, 23). But they are more difficult to make because high speed steel is too hard to cut with a file. As a result the knife design must be formed by grinding, and some of the shapes are difficult to make on a grinding wheel. The initial cost of carbon steel stock is considerably less than that of high speed steel.

Carbon steel knives, tempered "hard to file," are good for small jobs and occasional use. Most of the knife design can be formed by grinding, finishing the sharp corners with a file.

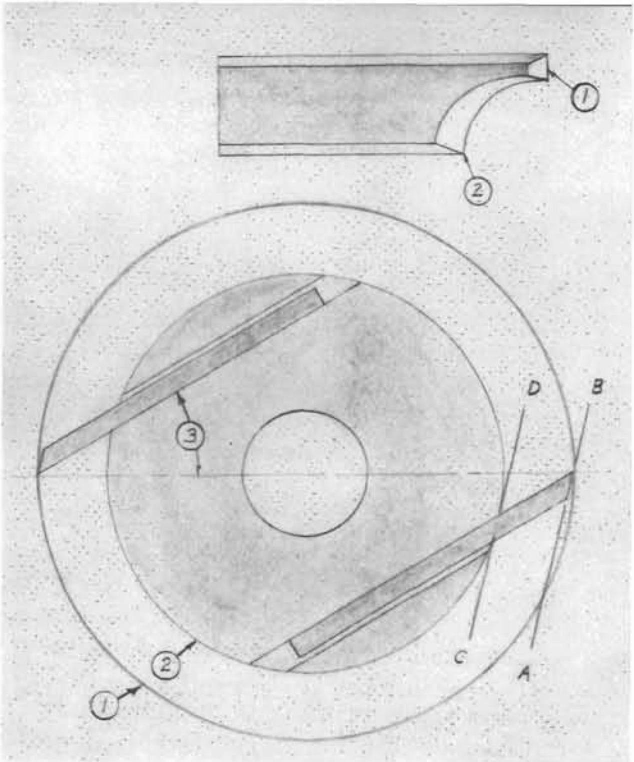
Shaper steel may be cut into knife lengths with an abrasive cutoff wheel. If one is not available, the bar of steel may be notched square across on the *back side* with the corner of an ordinary straight face grinder. (If you notch the bar of steel on the face side, too much stock must be ground off the end to form the cutting edge at the face side.) It can then be broken by placing the bar vertically in the vise with the notch even with the top and striking the projecting end a sharp blow with a mallet. The piece that is broken off can be caught and held by covering it with a heavy cloth. Some people prefer to hold a push broom back of the piece of steel and catch it in the bristles.

A different contour is commonly

ground on each end of the knife to obtain a variety of shapes with a minimum number of knives.

The *rake angle,* or the angle at which the knife is set with reference to a line drawn from the cutting edge of the knife through the center of the spindle, determines the shape of the cutting edge and the length of the bevel (Fig. 17-5). If the knife were located on the center line it would cut a contour the same size and shape as the shape ground on the knife. But when the knife is set to one side of the center line it cuts a contour that is somewhat shorter than the length of the shape ground on the knife. (2, 33). The difference between the shape of the knife and the contour it cuts increases as the rake angle increases.

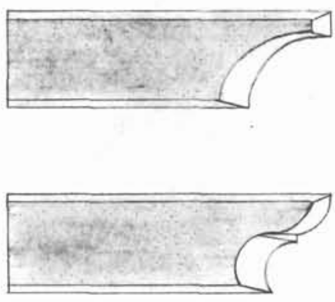
The amount of bevel required on the cutting edge of the knife increases as it approaches the inner cutting circle. In Fig. 17-5, lines AB and CD are parallel. It is evident that there is clearance between the bevel of the knife on the line AB and the outer cutting circle, but practically no clearance between the same bevel of the knife on the line DC and the inner cutting circle. The knife patterns in Fig. 17-6 show how the bevel is increased at the inner cutting edges of the knife so that the required amount of clearance is maintained. The bevel required on shaper knives varies from 30° to 45°, depending upon the rake angle of the knife. The bevel on the portions of the knife that travel parallel to the line of cut does not need to be more than 10° to 15° to provide sufficient clearance.

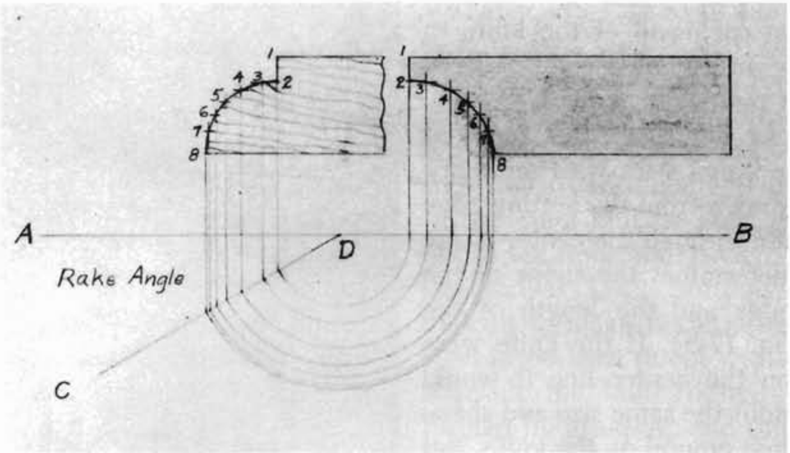


17-5. Determining rake angle for flat shaper knives. 1. Outer cutting circle. 2. Inner cutting circle. 3. Rake angle.

After the pattern has been laid out on the knife stock, the shape on the outline is cut on the knife and is then ground to the approximate bevel. It is very difficult to grind the right bevel and to form the proper outline for the cutting edge simultaneously. There is

17-6. Knife pattern showing increased bevel.





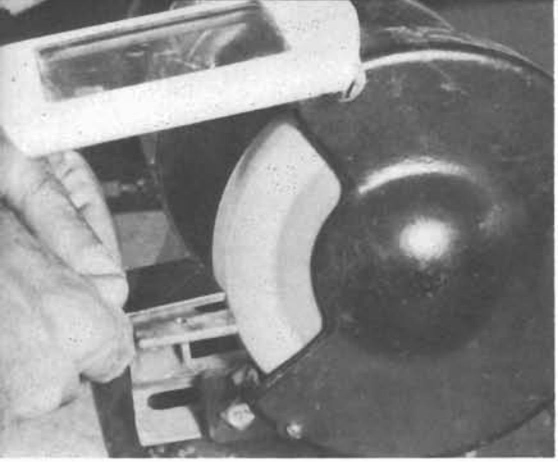
17-7. Knife layout for a given contour.

also a greater risk of burning the knife because too much grinding is done after a thin edge has been formed. A poorly made knife will be the result if both operations are performed at the same time.

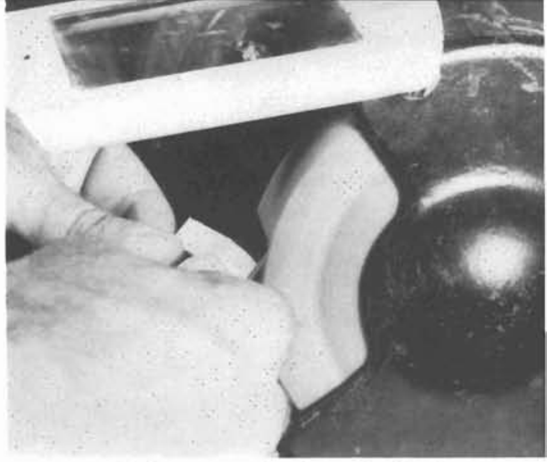
Several shapes of grinding wheels may be required for making a large variety of knife shapes. However, many of the more common shapes can be made on the straight and the round-faced grinding wheels. Dress the face of the wheel to the proper shape, if a wheel of the required shape is not available.

To make a flat shaper knife to cut a given contour

1. Make a full-sized drawing of the contour to be duplicated (Fig. 17-7), (2, 33).
2. Locate D at a convenient point on the line AB and draw the line CD, forming an angle ADC equal to the rake angle of the knife.
3. Locate a number of points (1, 2, 3, 4, 5, 6, 7, 8) on the portion of the contour to be made, and draw vertical lines from the points to the line CD.
4. Using point D as a center, draw arcs from the points on line DC to line AB on the opposite side. From the points located by the arcs on AB, extend the lines vertically above line AB.
5. Horizontally, from the point selected on the contour, locate the points of intersection on the corresponding vertical lines on the right hand side of point D.
6. Connect the points that have been established to obtain the shape of the knife required to cut the original contour. Draw the body of the knife. Be sure it is long enough to be held securely between the knife collars.
7. Cut a piece of shaper steel of the same size as the pattern and cover a sufficient portion of the face (side opposite the bevel) with marking dye to make the layout of the knife design.



PHOTOS BY ROBERT C. SMITHERAM JR.
17-8. Grind the outline of the design on the knife stock.



17-9. Grind the proper bevel on the knife to form sharp cutting edges and to provide the necessary clearance.

8. Fold the paper along the edge of the outline of the knife. Place the paper on the knife so that the folded edge fits against the corresponding part of the knife, with the paper extending over the edge of the knife stock.
9. Hold the pattern securely on the knife stock and lay out the knife design by pricking the paper at selected points on the design with a sharp pointed instrument to aid in transferring the outline of the knife to the dyed surface of the knife stock.
10. Draw the knife design on the knife by carefully connecting the points.
11. Mount the proper grinding wheel on the grinder. See Procedure, "To Mount a Grinding Wheel," in Chapter 1, page 24.
12. Holding the knife with the face in the same plane as the axial line of the grinding wheel, accurately grind the outline on the knife stock (Fig. 17-8). Be careful not to burn the knife. It may be necessary to use several different grinding wheels to make the outline. If the steel is not too hard, form the corners with a single cut file.
13. Grind the appropriate bevel on the knife to form sharp cutting edges and to provide the necessary clearance (Fig. 17-9). The corners may be finished with a single cut file.
14. Stone the cutting edges until they are sharp, using oilstones of the proper shape.

SHARPENING SHAPER CUTTERS: Shaper cutters are often abused and frequently ruined because they are used when dull. The high speed at which they operate causes a dull cutter to burn easily. Also, dull cutters overload the motor and give a poorly finished surface. The condition of the cutters determines largely the difference between good and poor work.

Shaper cutters last considerably longer and require less time for maintenance if they are sharpened as soon as they begin to dull.

Solid shaper cutters and some

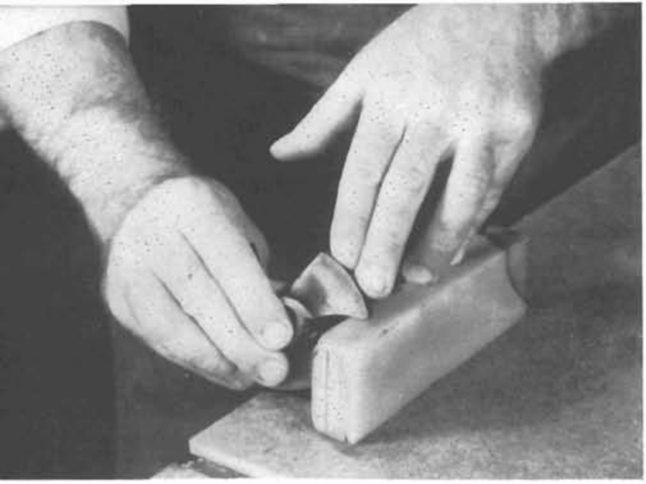


PHOTO BY ROBERT C. SMITHERAM JR.
17-10. Solid wing cutters are sharpened by grinding and honing on the face only.

PHOTO BY ROBERT C. SMITHERAM JR.
17-11. Honing the face of a wing cutter with a slip stone.

knives held in cutter heads are ground so that the proper clearance is maintained throughout their life. The bevel must not be altered when the cutters are resharpened. They should always be sharpened on the face only.

Flat shaper knives must be sharpened on the bevel by grinding or whetting and whetting lightly on the flat side. They may be sharpened by whetting until the bevel becomes round, at which time they will need regrinding. Use a template for checking the contour of the knife. Otherwise, the shape may be altered considerably. A number of special oilstones is necessary for sharpening the various shapes of flat knives.

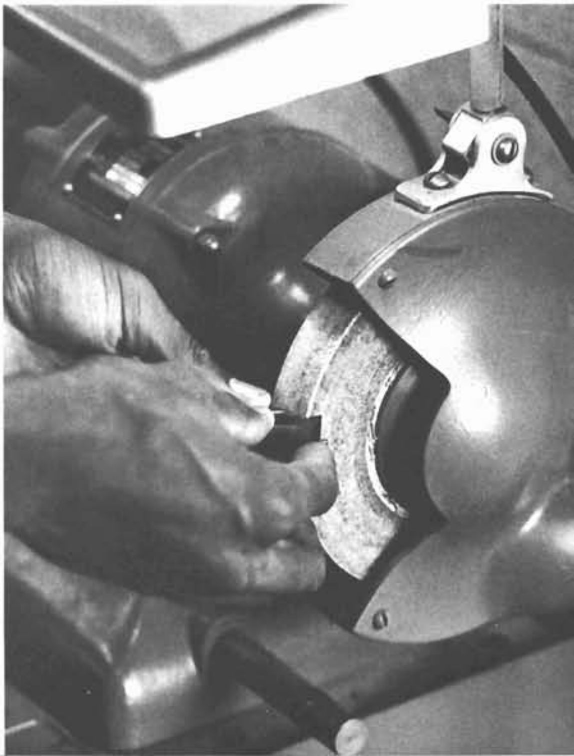
To sharpen a solid wing cutter

1. Select a suitable bench-type oilstone that is in good condition. Wipe the surface with a clean cloth and apply a few drops of light oil.
2. Place the face of one wing of the cutter flat on the oilstone and whet it until the edge is sharp (Fig. 17-10). Repeat the operation on the remainder of the wings. A slip stone can also be used to hone the wing faces (Fig. 17-11).

If the wings are accurately whetted just until the cutting edge becomes sharp, they will make reasonably uniform cuts throughout the life of the cutter.

17-12. Sharpening a three-wing shaper cutter by offhand grinding on the side of a grinding wheel.

PHOTO BY BONTEMPS



COURTESY MC GRAW-HILL BOOK COMPANY
17-13. Sharpening a three-wing shaper cutter on the side of a grinding wheel with the aid of a special holder. Sharpening is usually done by offhand grinding.

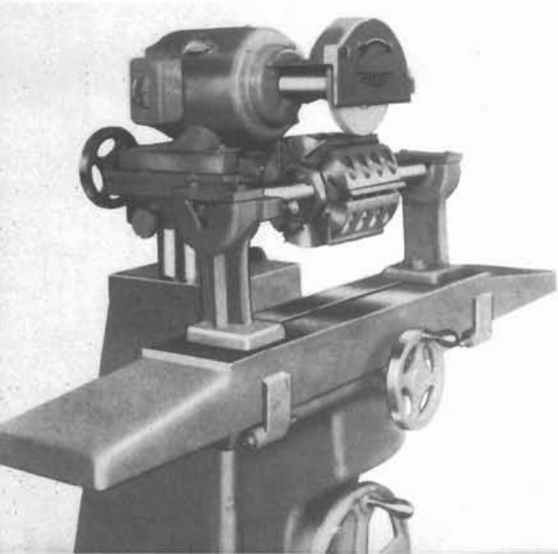
Cutters that are exceedingly dull may need to be ground on the face before they are whetted. They can be ground by holding the face flat against the side of a straight grinding wheel in offhand grinding or by using a special jig (Fig. 17-12, 13).

To sharpen a flat shaper knife

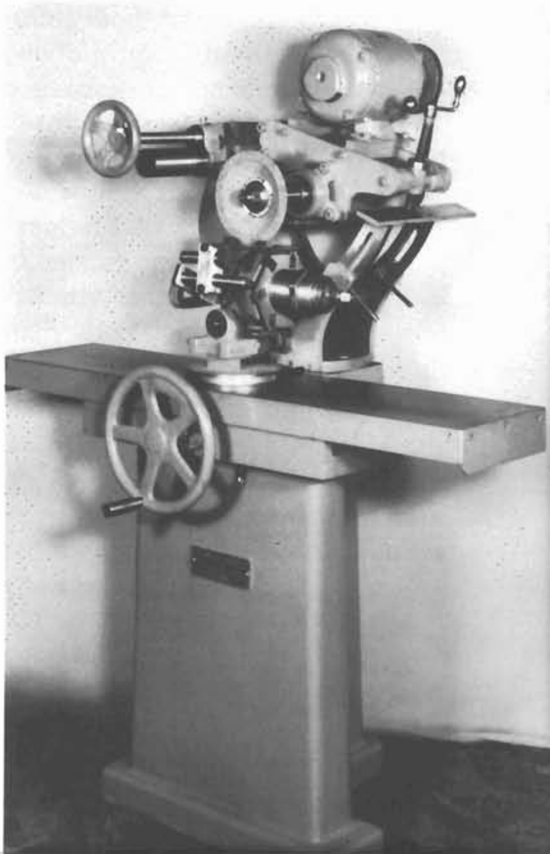
1. Mount the proper grinding wheels on the grinder. See procedure, "To Mount a Grinding Wheel," Chapter 1, page 24.
2. Grind the bevel at the proper angle, keeping the original shape of the knife. Check the shape of the knife with a template.
3. Select suitable oilstones that are in good condition. Wipe them with a clean cloth and apply a few drops of light oil.
4. Whet the beveled edges of the knife. Next, whet the flat side very lightly by placing it on a flat oilstone. Continue the process until the edges are sharp.

A knife can be sharpened by whetting until the bevel becomes round. Grinding is necessary only when

17-14. Sharpening straight knives on a cutter head grinder.
COURTESY DEPENDABLE MACHINE COMPANY



17-15. Sharpening the knives in a cutter head with the flat side of a cup grinding wheel.
COURTESY JONES-ORTH CUTTER HEAD COMPANY



the bevel does not provide the proper clearance.

CUTTER HEADS

Cutter heads are used on heavy-duty shapers and molding machines. Their general shape resembles the cutter heads of planers and jointers but they are shorter. Straight or irregularly shaped knives can be fastened into these units. To sharpen them properly usually requires special machines. Fig. 17-14 shows a cutter-head grinder sharpening straight knives.

The grinder in Fig. 17-15 shows how knives can be sharpened on the flat side of a cup grinding wheel.

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PART TWO

CHAPTER 18

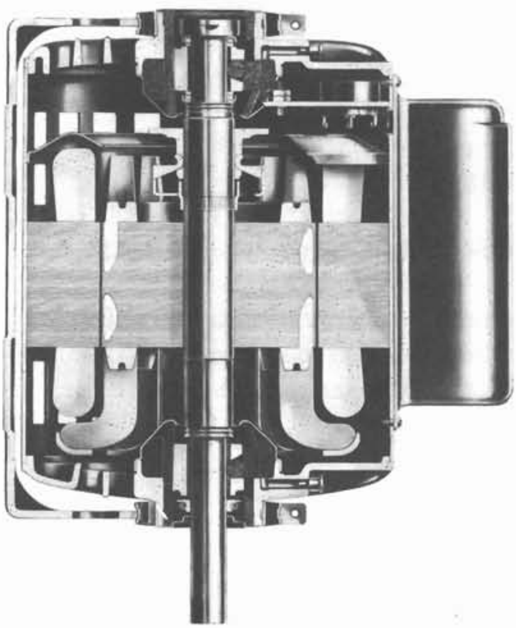
Electric Motors

THE MAINTENANCE of electric motors (Fig 18-1) in the wood shop is often neglected. Because they are so reliable, it is too often assumed that they will continue to run without attention. But periodic maintenance aids considerably in extending the life of electric motors and reducing costly repairs.

VENTILATION

Open motors are air cooled and depend upon a constant, abundant circulation of air through the ventilating ducts for efficient, cool operation. Ventilating fans are commonly mounted on the motor shaft. They are designed to draw an ample supply of air through the motor and dissipate the heat naturally created in the windings by inherent power losses.

18-1. Cut-away view of a capacitator start motor.
COURTESY GENERAL ELECTRIC COMPANY



Clogged ducts and dirty motor windings frequently cause a motor to operate at excessively high temperatures. This results in deterioration of the insulation due to carbonization (1, 153). When it deteriorates to such an extent that a short circuit occurs, the motor windings burn out.

Some motors in the wood shop need cleaning more frequently than others, depending upon the amount of dust and shavings in the air supply to the motor. They must be cleaned as frequently as necessary to permit an ample supply of air to flow through the motor. Clean the ventilating ducts of all motors once a week. Clean more frequently motors that are in exceptionally dirty locations and those on portable machines operated at high speeds and relatively high temperatures. The life of a motor depends upon keeping the ventilating ducts open to prevent the temperature from rising higher than the limit given on the nameplate.

These ducts can be cleaned easily with dry compressed air, a portable electric blower, or hand bellows. If compressed air is used, the pressure should not exceed more than 35 to 40 pounds. There is danger of damaging the windings and connections if the air pressure is high enough to force the wires out of their natural position. *Excessive moisture* in the compressed air is also injurious to the motor as it will tend to short out the windings. Dry air can be maintained with a compressor by installing a filter in the line to remove the water.

After a time, sticky or gummy dirt, that cannot be removed by blowing air through the ventilating openings, may accumulate in a motor. The motor must then be taken apart and cleaned. In some instances, it may be advisable to have the job done by an electrician.

To clean an electric motor

1. Disconnect the motor from the circuit and the machine.
2. Remove the end plates on the motor and carefully observe the relationship and position of all the parts so that the motor can be properly reassembled.
3. Brush the windings with a clean, dry brush. Wipe them with a clean, dry cloth. If they are coated with dirty grease or oil, clean them with gasoline or naptha. These liquids evaporate quickly and, if applied sparingly, will not damage the insulation.
4. Wash the metal parts with gasoline and wipe them dry with a clean cloth. Be sure all the dirt is removed and that the ventilating ducts are open.
5. Carefully reassemble the motor and tighten the end plates. Be sure that the shaft turns freely.
6. Lubricate the bearings with the proper kind of lubricant. See informational units, "Selection of Lubricants" and "Application of Lubricants," in Chapter 20, pages 288 and 291.
7. Mount the motor on the machine and make the electrical connections. Start the motor and check its performance.

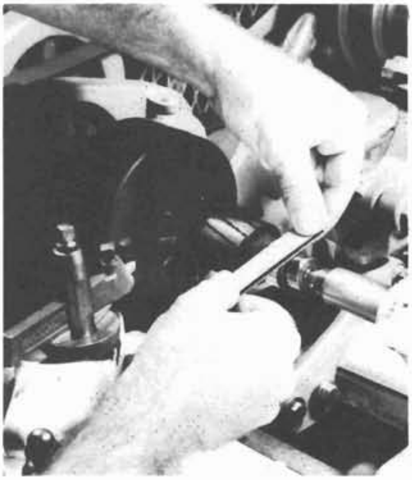
LUBRICATION

The bearings, unless they are sealed, need lubrication at regular intervals. The type of bearing, design of the bearing housing, and the operating conditions are some factors that determine how frequently the motor should be lubricated. Regardless of the lubrication requirements of the motor, do not apply too much lubricant at one time. If any leaks out of the bearing and comes into contact with the windings, it will cause the insulation to deteriorate as well as to accumulate dust and dirt.

The lubrication of bearings is discussed more fully in Chapter 20, "Lubrication of Machines," pages 285 and 302.

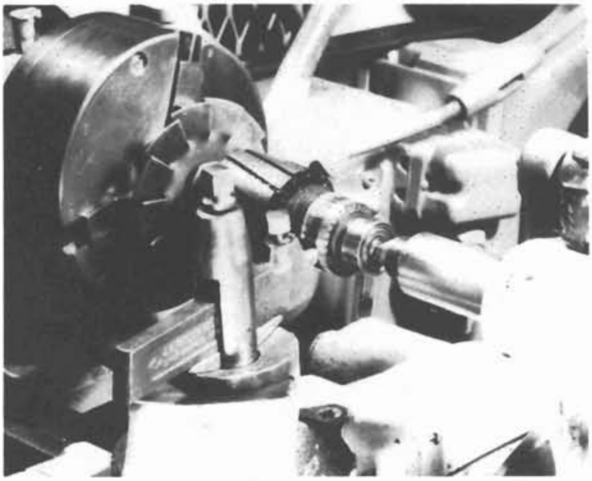
COMMUTATOR AND BRUSH CARE

Some types of motors have a commutator and carbon brushes. The brushes fit into holders so that they



PHOTOS BY CHARLES J. PEREZ

18-2. Dirty commutators can be cleaned with a piece of fine garnet paper.



18-3. Recondition a worn commutator by truing it on an engine lathe and polishing the surface.

ride on the commutator under spring pressure. Most of the friction wear between the brushes and the commutator is on the brushes, but gradually the brushes cut grooves in the commutator.

Keep the commutator clean at all times. Do not put oil on it or on the brushes. If the commutator becomes dirty or rough, carefully clean and smooth it with a piece of 4/0 or 6/0 garnet paper (Fig. 18-2). Emery cloth should not be used because it is a conductor of electricity and may cause a short circuit in the commutator. If grooves have been cut by the brushes or the segments have been worn so that the mica projects beyond them, turn the commutator down in a lathe and polish until smooth (Fig. 18-3). *This operation requires the services of a skilled machinist.*

In the opinion of one manufacturer (3, 16) 75 per cent of portable electric tool failures is due to the lack of attention given to carbon brushes. Keep the brushes clean so that they will slide freely in their guides and be held firmly against the commutator. Check springs and brushes so that weak springs and worn brushes can be replaced immediately. The use of worn brushes may cause excessive wear to the commutator, and inefficient motor performance. New ones should be of the same type as those originally furnished with the machine.

GROUNDING MOTORS

Electrical machines should be grounded to eliminate the possibility of getting a shock if the motor develops a short circuit. This precaution should be taken at all times, but it is especially important wherever there is dampness. All electrical installations above the 115 volt circuits are permanent and must be grounded by an electrician.

Machines that are not grounded through their foundation require a ground wire. The ground wire may be run from the machine to the outlet box if the box is connected to a metallic conduit. If the wiring system is nonmetallic, the ground wire will need to run to some grounded system such as a water pipe or a rod driven into the ground. Many portable machines are equipped with an electrical cord containing a third wire (ground wire) which can be connected to the metal outlet box. Some receptacles are made to receive three-pronged polarized plugs. In this case the third wire is connected to the third prong, which automatically grounds the machine when the plug is inserted in the receptacle.

FUSE BOXES AND SWITCH BOXES

Fuse boxes and switch boxes should be cleaned out at regular intervals with compressed air or hand bellows. The fine dust that accumulates within the boxes is frequently the cause of improper functioning of the switch. The dust particles prevent the contact points from making the correct connection. This causes them to arc across the points and burn, especially when magnetic switches are used. Since fine dust is combustible, there is a possibility that the arcing across the contacts may ignite and cause the dust to burn violently.

If knockout plugs have been removed unnecessarily, close the holes to prevent dust from entering the fuse box.

MOTOR PROTECTION

Electric motors naturally create some heat in the windings as a result of inherent losses. The windings burn out if the temperature cannot be kept within safe limits.

The ambient temperature for class A insulation should not be higher than 40° Centigrade (104° Fahrenheit) and the motor temperature rise should not be higher than the value given on the nameplate for safe operation of a motor (5, 11). For example, the temperature of a motor which has a temperature rise of 40° Centigrade (104° Fahrenheit) should be below 80° Centigrade (176° Fahrenheit) for safe operation. Usually, the life of the best grade of insulation is cut in half for each 10° Centigrade (50° Fahrenheit) above 90° Centigrade (194° Fahrenheit) (5, 11). If the expected life of a motor operating under normal conditions is 10 years, it might operate for less than 5 years if it were placed under a continuous load that would cause a temperature rise of 10° Centigrade (50° Fahrenheit) above the maximum given on the nameplate.

Protect a motor from excessive *instantaneous loads* which cause it to draw an exceptionally high current. For example, if for some reason a heavy load stalls or reduces the speed of the motor appreciably, it draws sufficient current to burn it out in a relatively short time. The device that protects the motor against instantaneous loads must carry a higher amperage than the running current given on the nameplate, because the

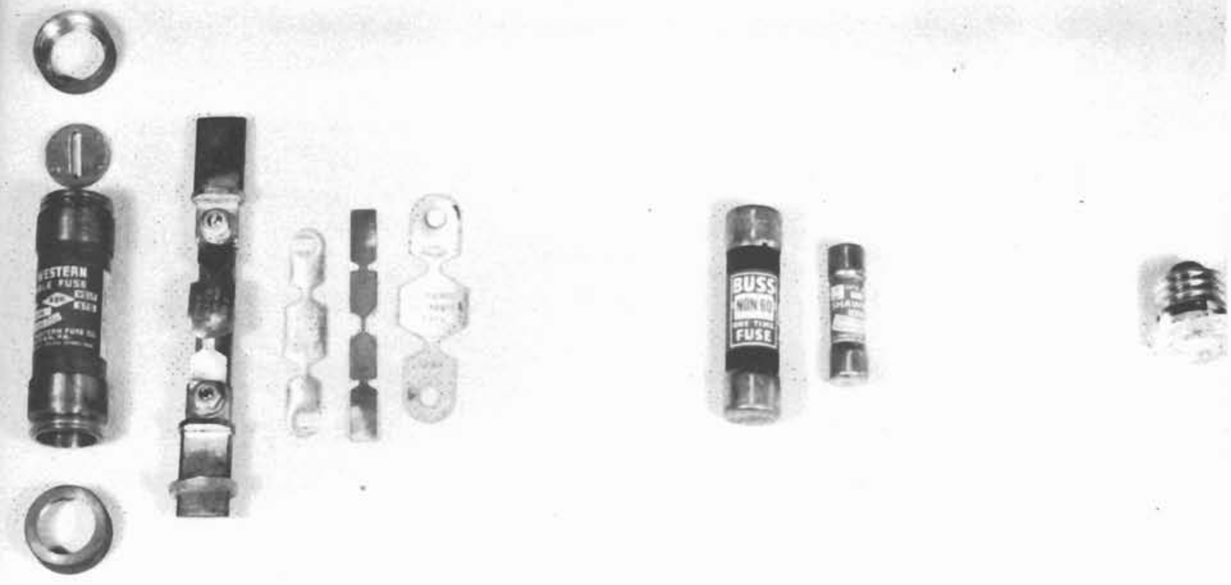


PHOTO BY CHARLES J. PEREZ

18-4. Different type fuses used as protective devices for circuits. From left to right: 1. Enclosed cartridge fuse with links. 2. Enclosed fuses—non renewable. 3. Screw in type plug fuse.

current required for starting many motors is several times that of the free running current, unless the load is great. These devices will not protect the motor against an overload.

A low voltage will have the same effect on a motor as an overload because the low voltage does not supply a sufficient starting current for the motor to reach its normal running speed. The *current drawn* may be enough higher than the running current to damage the windings if the condition is allowed to exist for long.

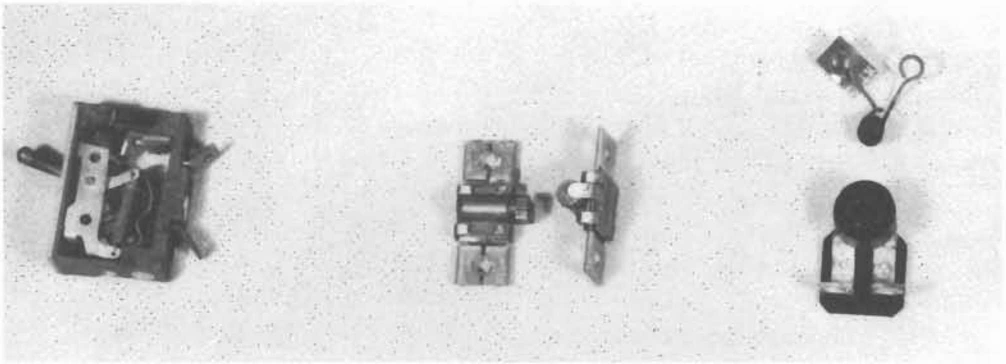
Also, the motor needs protection from an excessive temperature rise due either to mechanical failure, such as an overheated bearing, or to a high ambient temperature. Either of these conditions can make it impossible to dissipate the heat fast enough to keep the motor below a safe operating limit.

PROTECTIVE DEVICES

Circuit breakers or fuses will protect the motor from excessive instantaneous loads. Circuit breakers usually are built into the switch panel and are reset by pushing the switch handle past the off position. Then when the switch is closed the circuit is complete, if the current demand has been reduced sufficiently.

Fuses used for 115 volt circuits are sometimes the ordinary plug fuse which must be replaced with a new one each time it blows. However, circuits to which motors are connected should be fused with the cartridge type fuse. Circuits of 220 volts and above must use this type. Some are one-time fuses and others have renewable fuse links (Fig. 18-4).

Circuits should be fused as near to the starting current as is practical without burning out an excessive



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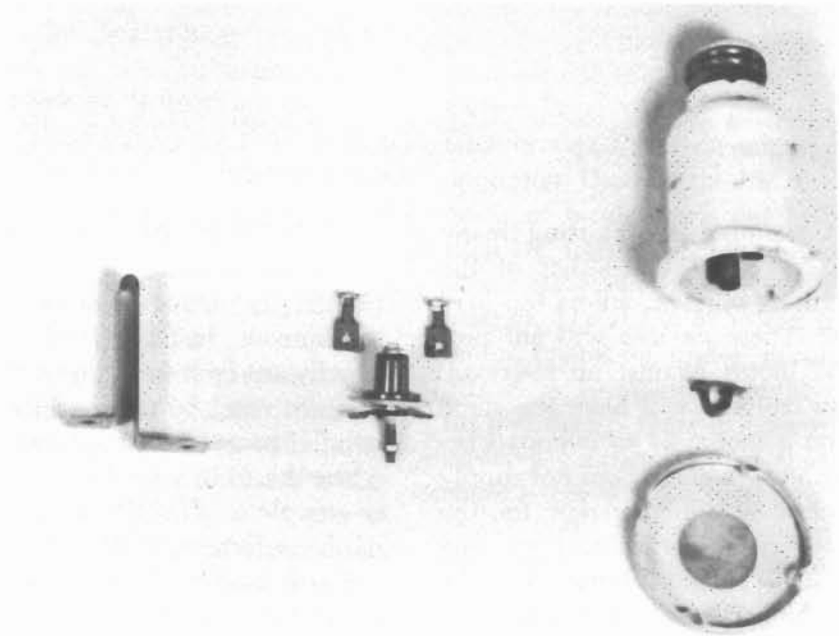

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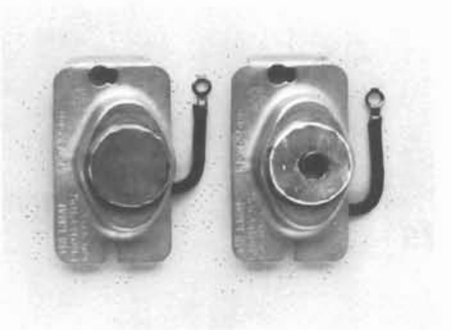
PHOTO BY CHARLES J. PEREZ

18-5. Circuit and motor overload protective devices. From left to right: 1. Circuit breaker, thermal type. 2. Thermal melting alloy overload. 3. Heater coils—thermal melting alloy overload. 4. Heater element for bi-metallic thermal overload. 5. Thermostatic disk. 6. Time protective plug with renewable link.

number of fuses. If the fuses are close to the source, but are too heavy, the motor will not be adequately protected.

Thermally operated circuit breakers are required to protect the motor against an excessive temperature rise (Figs. 18-5, 6). When the thermal unit reaches a designated temperature, the circuit breaks. After the motor has cooled to a safe operating temperature the thermal unit is reset either manually or automatically. When the unit is mounted on the motor frame



COURTESY GENERAL ELECTRIC COMPANY
18-6. Automatic and manually operated thermal protectors. When the motor has cooled to a safe operating temperature the circuit is automatically closed. The circuit is closed by pushing the reset button on manual protectors.

the motor is protected from overload as well as a temperature rise in the frame because of such causes as a heated bearing. It is very important that the proper size of thermal unit be used to prevent the motor from becoming overheated.

Dual element and delayed-action fuses are now available to serve the purpose of both the ordinary fuse and the thermal unit. They are highly recommended for use in circuits where the motor is not otherwise protected against excessive instantaneous load or continuous overload. The size of the dual element fuse must be the size that is recommended for the amperage rating of the motor.

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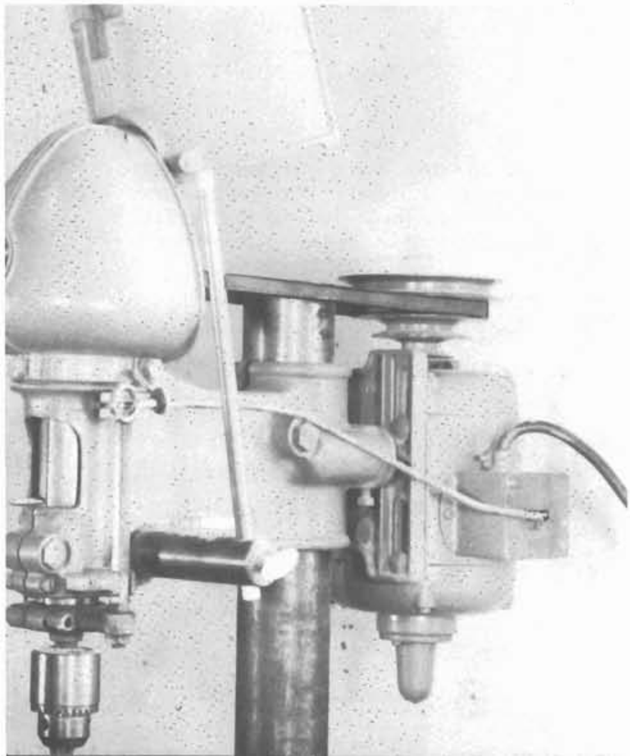
PART TWO

CHAPTER 19

V Belts

At the present time, a few of the individually driven machines are equipped with V belts. V belts operate efficiently on short center distances without slipping and with a minimum amount of noise and vibration (Fig. 19-1). Those generally used in the wood shop are composed of rubber and cotton, and are trapezoidal in cross-section. The bending of the belt around the sheave forms a neutral area across the center of the belt with a compression section on the inside and a tension section on the outside. The cotton power cords are in the neutral section. They give the belt strength—actually carry the load. They must be bonded firmly to the other sections of the belt. The compression section serves as a cushion and absorbs the shock and vibration, whereas the outside section adds to the stiffness of the belt. A protective covering made of a closely woven, wear-resistant material encloses the belt. A good protective cover is an important part of a belt (Fig. 19-2).

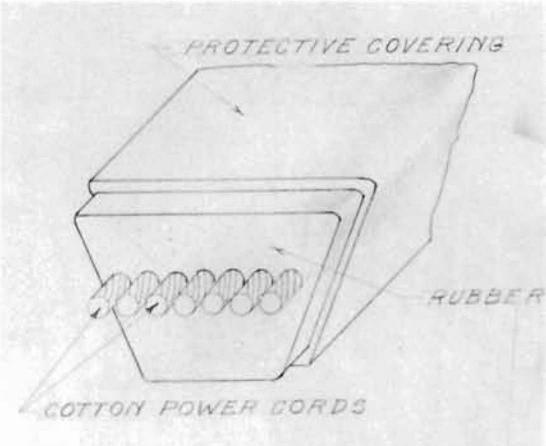
19-1. V-belts operate efficiently on short center distances.
PHOTO BY ROBERT C. SMITHERAM JR.



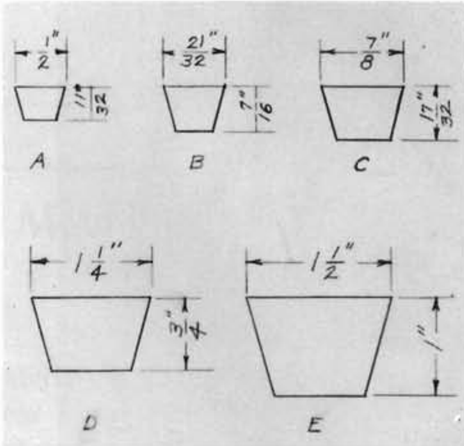
SELECTION OF V BELTS

Probably the best method to use in selecting the proper belt is to determine the amount of pull that will be placed upon the belt, the size of the sheaves, and the arc of contact. Study the manufacturer's specifications of the different belts before selecting the proper one. If there is still any doubt, consult the belt manufacturer.

V belts are made to fit different-sized grooves in the sheaves. A belt that is too large for the groove rides so high that the sides of the belt make only partial contact with the groove. Too small a belt rides the bottom of



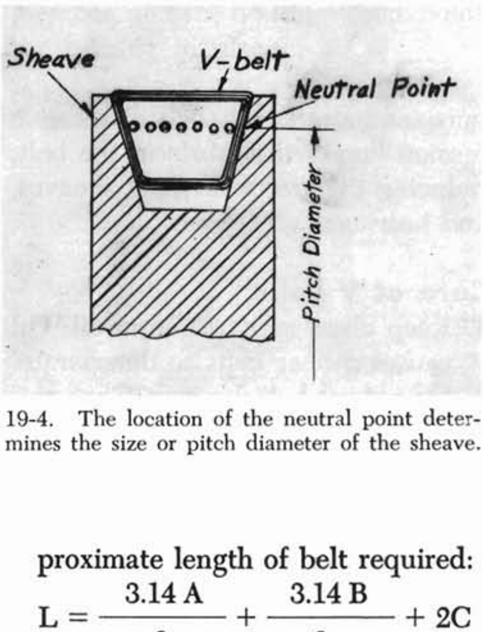
19-2. Cross section of a V-belt.



19-3. Five standard cross sectional belt sizes are designated by letters, A, B, C, D, and E.

the groove and makes little or no contact with the sides. Five standard cross-sectional belt sizes are designated by letters A, B, C, D, and E (2, 21). The measurements are shown in Fig. 19-3.

Belts are also made in different lengths. The length is determined by the circumference measured at the neutral point (Fig. 19-4). The neutral point is located at approximately one third the distance through the thickness of the belt, measured from the outside. The place where the neutral point makes contact with the sides of the groove determines the size or pitch diameter of the sheave. The length of belt required for a particular situation is determined by the size of the sheaves and the distance between their centers. When L equals the length of the belt measured at the neutral point, A and B equal the diameters of the two sheaves, and C equals the distance between centers, the following formula gives the approximate length of belt required:

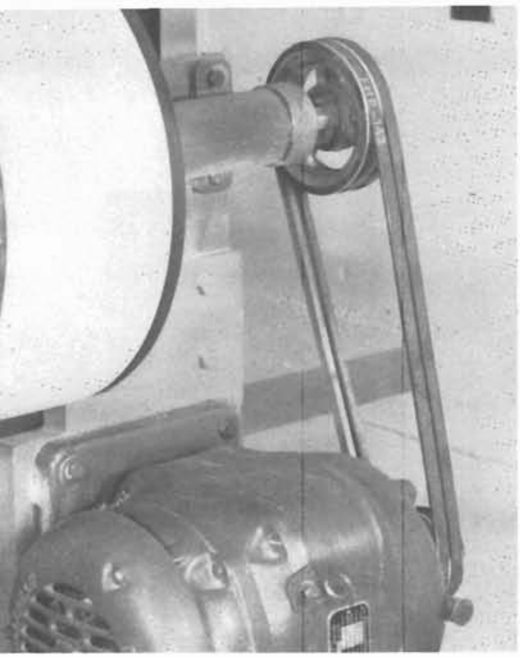


19-4. The location of the neutral point determines the size or pitch diameter of the sheave.

$$L = \frac{3.14\,A}{2} + \frac{3.14\,B}{2} + 2C$$

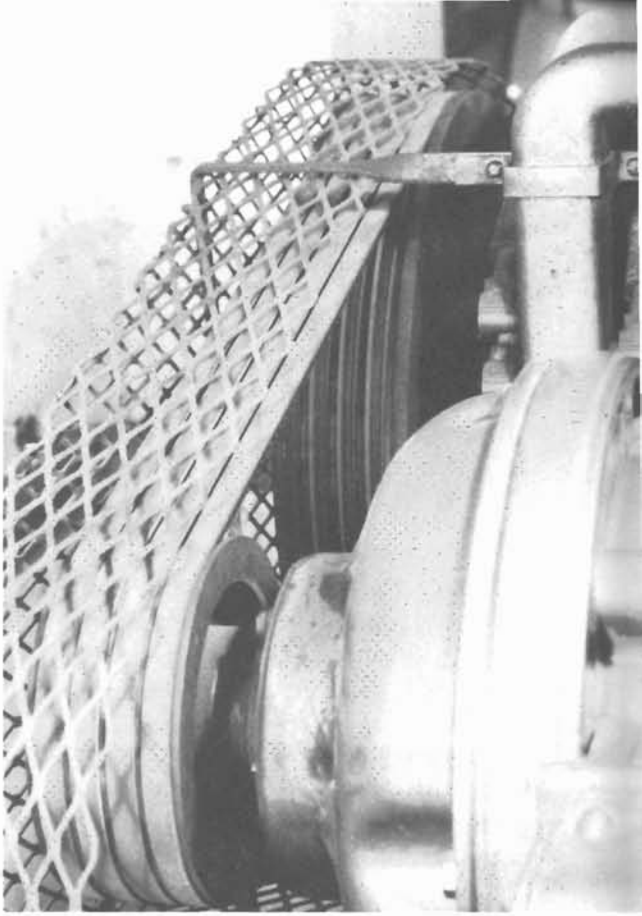
Belt tension

V belts require relatively little tension. They should be operated with only sufficient tension to prevent slipping. If they are run too loosely, the slippage will damage the sheave grooves and create frictional heat to



PHOTOS BY ROBERT C. SMITHERAM JR.

19-5. A pair of matched belts are required to transmit the power required to operate this belt sander.



19-6. Belts on a multiple drive are replaced in matched sets to equalize the tension.

burn and crack the belt. Excessive tension breaks the fabric in the belt, reducing the life of the belt, sheaves, and bearings.

Care of V belts

1. Keep clean and free from oil. Oil causes rubber belts to deteriorate.
2. Do not use belt dressing. The gripping action of the belt is sufficient to prevent slipping.
3. Do not pry or use force of any kind to try to mount the belt in the grooves of the sheaves, because the strain may break the fabric.
4. When belts on a multiple drive become worn or broken, replace them with a matched set (Figs. 19-5, 6). Used belts may be saved to make up a matched set for temporary use. (A new belt should never be put on a drive with old belts because it will carry more than its share of the load until it stretches.)
5. Use belts that match the grooves. If the grooves become worn and do not fit new belts, replace the sheave.
6. Keep sheaves in alignment. The sides of the belt and the grooves wear excessively when the sheaves are not properly aligned. Be sure the shafts are parallel.
7. The speed of ordinary V belts should not exceed 5,000 feet per minute. Special belts are more satisfactory for higher speed.
8. Do not subject rubber belts to a temperature higher than 130° F.

PART TWO

CHAPTER 20

Lubrication of Machines

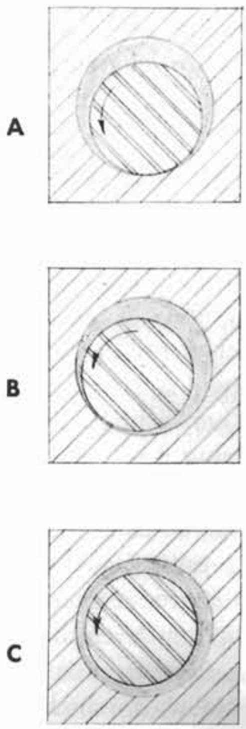
Lubrication is a subject which must be given serious consideration by those who are responsible for the efficient maintenance of machines. Insufficient lubrication results in excessive heat, unnecessary wear and short bearing life, excessive power consumption, waste of machine service, and unsafe working conditions.

BEARINGS

A bearing is a component of a machine which permits a force to be transmitted between two proportionately moving elements. The purpose of the bearing is to hold moving parts in the proper position and to transfer the force with the greatest degree of efficiency and with a minimum amount of friction. Bearings may be classified under two general headings, plain and antifriction.

Plain bearings are those in which the transfer of load between two moving surfaces is produced by sliding contact. One of these parts is a material selected because of its structural properties, usually steel. The other member is composed of a material which operates effectively against the structural part. These materials have a high resistance to wear and can withstand the stresses imposed upon them. The components of the bearing assembly consist of the bearing, the shaft or other moving member, and the housing which holds the bearing in place.

20-1. Action of lubricant in a plain bearing. Clearance is exaggerated to illustrate the formation of the oil film.



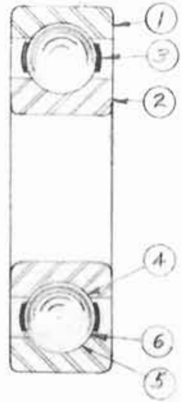
Failure of plain bearings to operate properly is due either to incorrect lubrication or mechanical problems.

The chief causes of damage are:

1. Insufficient lubrication.
2. Use of improper lubricant.
3. Entrance of foreign matter.
4. Decomposition of lubricant by chemical action.
5. Deterioration of metal caused by corrosion.
6. Cavity formation caused by erosion.
7. Pitted surface caused by electrical discharge across bearing surface space.
8. Vibration of shaft caused by unbalanced load.
9. Misalignment of either bearing or shaft.
10. Lack of proper clearance.
11. Overloading along with lack of provision for adequate dissipation of heat.

The *ball bearing* is a type of *antifriction bearing* in which the transfer of load between two moving parts is produced by rolling contact. In general, a ball bearing consists of an outer ring (race), an inner ring (race), a set of rolling elements, and a retainer, which separates the balls and keeps them equally spaced, making the bearing a self-contained unit.

The assembled bearing component consists of the housing, the shaft, and the bearing unit. Usually the inner ring, which is grooved on the outside diameter to form a circular raceway for the balls, is pressed onto the shaft, and the outer ring, which has a circular groove on the inside diameter to form a matching raceway, has a push fit in the housing. In some instances, however, the outer ring is pressed into the housing and the inner ring has a push fit on the shaft.



20-2. Cross-sectional view of ball bearing: 1. Outer ring. 2. Inner ring. 3. Ball cage. 4. Inner ring ball race. 5. Outer ring ball race. 6. Steel ball.

Ball bearings are adaptable to many situations, as they produce little friction and may be run at high speeds.

Failure of ball bearings to operate properly is caused by either inadequate lubrication or mechanical problems. Some of the typical causes of failure are:

1. Insufficient lubrication.
2. Entrance of dirt and other foreign particles.
3. Rust, corrosion, or erosion caused by chemical action of contaminated lubricant.
4. Use of wrong kind of lubricant.
5. Excessive use of lubricant.
6. Decomposition of lubricant, causing the formation of varnishes, resins, and lumpy matter.

7. A loose race turning either on the shaft or in the housing.
8. Mechanism out of balance, causing excessive wear and fatigue of the bearing.
9. Misalignment of bearing.
10. Fractured ball, faulty cage, or marred surface of a ball on raceway.

Ball bearings are precision components which require careful handling, critical inspection, skillful assembly, and regular maintenance to extend their useful service.

BEARING LUBRICATION

Probably the most important single factor in determining the life and service of a machine is the attention given to correct and adequate lubrication of the bearings.

Since the mechanical design of a plain bearing is different from that of a ball bearing, there must be some difference in the principles of lubrication. The plain bearing is dependent upon the maintenance of a film of oil between the contact surfaces for proper lubrication, but this is not as important for the satisfactory performance of ball bearings.

The ideal lubrication for a plain bearing is one in which it is possible to maintain a state of fluid friction between the contact surfaces of the metals (2, 1). Such a condition can exist only with high speeds and light loads. The action of a lubricant in a plain bearing is shown in Fig. 20-1. At "A," the machine is assumed to be at rest, with the shaft making contact directly below the center. As the shaft begins to rotate, the frictional resistance is so high that it tends to climb or roll up on the bearing surface as illustrated in "B" until a point is reached where slippage occurs. At this point of action, the two surfaces are but partially separated, providing only limited lubrication. As the shaft increases in speed, as in "C," the adhesive quality of the lubricant and the rotation of the shaft cause the lubricant to be pulled between the contact surfaces in sufficient quantities to build up a film between them. As long as the shaft and the bearing are separated, there is no mechanical friction between them—only a state of fluid friction exists. If some condition causes the oil film to break down, mechanical friction exists, resulting in increased heat and faster wear on the bearing.

With ball bearings, the load is supported by the direct metal-to-metal, rolling contact between the balls and the ball races (Fig. 20-2). The existence of high unit pressures between the balls and the ball races under load makes the formation of an oil film between the contacting points very difficult (1, 23).

It may seem that ball bearings could operate efficiently without lubrication, but this is not the case. A true rolling motion does not always exist under all conditions, even in the most perfect bearings, because some slippage of the balls cannot be prevented. This results in a sliding friction. Additional friction is created by deformation developed in the balls and the ball races and by the rubbing contact of the balls against the ball cage. If sufficient lubrication is not present, the sliding action will cause increased friction and abnormal temperature rise, resulting in damaged bearing surfaces, heated balls, loss of clearance, internal overloading, and eventually the destruction of the bearing.

Proper lubrication performs a number of important functions. The principal ones (3, 25) are to:

1. Reduce frictional resistance to a negligible degree by replacing mechanical friction with fluid friction.
2. Dissipate much of the heat generated.
3. Protect highly polished surfaces of the bearing from rust, erosion, and corrosion.
4. Remove contaminants from the bearing.
5. Reduce the rate of bearing wear and maintenance costs.
6. Form a partial seal to prevent foreign substances from entering the bearing.

SELECTION OF LUBRICANTS

The ideal lubricant for bearings is a neutral mineral oil or grease. Such a lubricant does not contain free acids or alkali and will not deteriorate due to atmospheric action. It is very important that the lubricant not be injurious to the bearing surfaces either in its original form or through deterioration. The use of lubricants which contain free acids, alkali, or sulphur will cause pitting, etching, and corrosion, thereby seriously damaging the highly polished surfaces of the bearing. For this reason, vegetable and animal greases and oils are not suitable for bearing lubrication. They have a tendency to gum, become rancid, and develop free acid. Lubricants that contain talc, pumice, graphite, resin or other solidifying matter should not be used because they accumulate on the bearing surfaces, prevent a free rolling action, and act as a lapping compound, causing accelerated wear of the bearing. One should be especially careful that the lubricant does not contain any of these elements.

Oils and greases are the two major lubricants used for bearings. Manufacturing processes make both of these lubricants suitable for use over the range of temperatures and speeds generally encountered. The proper type of lubricant is largely dependent upon the bearing and housing design, speed, temperature, method of lubrication, kind of rubbing surface, and the presence of foreign materials such as water, dust, and dirt.

Basically, greases are composed of a combination of a thickener, usually sodium or lithium soap, and petroleum oils or a synthetic fluid. The thickener is used to hold the oil which is released at a rate needed to lubricate the bearing adequately (3, 25) (8, 9). Additives are used to give greases special characteristics and properties to improve such qualities as oxidation resistance, film strength, water resistance, viscosity stability, and corrosion protection (6, 106).

Greases range from solid to semi-liquid. This is determined by the amount of thickener and the viscosity of the oil in the lubricant (8, 9).

In normal applications a number of greases may satisfy the lubrication requirements, but greases of different compositions have their own limiting characteristics and properties. A grease that is satisfactory in one situation may not supply adequate lubrication in another. Under severe operating conditions, special greases are an absolute necessity.

In selecting a grease for a particular application, consider: the consistency of the grease; its ability to resist structural breakdown caused by the shearing forces in the bearing; the effect of temperature change on the consistency of the lubricant; resistance to moisture and water; ability of the grease to follow the bearing's path of movement; starting torque of the grease at low temperatures; stability of the grease at high operating temperatures; and the operating speed of the machine.

A *housing design* that is used for grease may not be suitable for the use of oil because oil is more difficult to retain in the housing than grease. It is almost impossible to prevent some leakage of oil because the vapors, churned up when the machine is operating, follow the air currents and escape regardless of how well the bearing is sealed (3, 25).

For speeds up to 5,000 rpm., grease makes the simplest and cleanest lubricant. It is easily applied and the methods of sealing the housing against leakage are relatively simple. However, oil is frequently used as a lubricant for speeds under 5,000 rpm.

At very high speeds most greases do not make satisfactory lubricants because they create a high torque (1, 23). The severe churning action of the lubricant within a ball bearing tends to make the oils separate and run out of the bearing unless the right quality of grease is used. The separation of the oils leaves a gummy residue in the bearing which clogs the ball cages, retarding the free rotations of the balls and causing increased sliding friction between them and the races. Pure mineral oil is preferable to grease for lubricating the bearings of exceptionally high-speed machines, even though sealing the bearings is more complicated and difficult (9, 190).

The operating temperature of a bearing is an important factor in determining the suitability of grease as a lubricant, or the grade of oil to be used. Grease may be used where the operating temperature does not exceed 200° Fahrenheit (1, 23).

As yet, there is no universal standard for classifying the grades of greases, although many manufacturers consider No. 00 to be a semi-fluid cup grease and No. 5 to be fairly hard grease. Some manufacturers, however, number their grease products in the reverse order. The medium grades are commonly used because they are suitable for lubricating both ball and plain bearings, operating under normal shop conditions.

The grade of an oil is designated by its viscosity. Viscosity is the measure of the fluid characteristic of an oil at a given temperature. The Society of Automotive Engineers has classified the various weights of oils by numbers to designate their viscosity. That is, S. A. E. 40 indicates a high viscosity or heavy oil as compared to S. A. E. 10, which is a low viscosity or light oil.

Temperature, speed, pressure, and clearance are factors that must be taken into consideration when selecting an oil of the proper viscosity. As the temperature rises, the oil becomes more fluid. If the operating conditions are such that the oil is subjected to a high temperature, a high viscosity oil is required. But if the temperature remains low, a low viscosity oil is more efficient.

Bearings which operate at high surface speeds have close clearances and require low viscosity oils. On the other hand, bearings which operate at low surface speeds and have more clearance need high viscosity oils. The oils need sufficient adhesive characteristics in order to cling to surfaces regardless of the effect of centrifugal force and to maintain an oil film between the moving parts.

When the pressure on the bearings is light, low viscosity oils will effectively maintain an oil film. Heavy loads, however, require high viscosity oils. If high viscosity oils are not used with heavy loads, the oil film may break down, causing solid friction when the metallic surfaces come in direct contact.

Grades S. A. E. 10, 20, and 30 are satisfactory for lubricating most of the wood shop equipment. Some types of wood shop equipment such as portable machines are necessarily built to be very compact, with special bearings and gears. These parts are subjected to considerable strain for their size, and special lubricants are required.

A great variety of lubricants are made to meet industrial lubrication requirements. Manufacturers of equipment, therefore, commonly supply lubrication specifications for their machines. These recommendations should be closely followed if the expected service is to be received from the machine. If the manufacturer's recommendations are not available, the advice of a reputable bearing or lubricant company should be sought. It is well to remember that a lubricant that is satisfactory for one part of a machine may cause extensive damage when used for some other part.

An important factor to consider in using lubricants is their compatibility when mixed. If all the elements of the mixture are soluble or have an affinity for each other (3, 26), they are compatible. Producers of lubricants do not recommend mixing other manufacturer's products with their own. The reason is that modern lubricants have a large variety of complex petroleum base fluids, thickeners, and additives which may react adversely when mixed (5, 16). Greases that are incompatible may cause the grease mixture to become either thick or thin. With oils, coagulation and separation of additives may take place by mixing incompatible lubricants. This can cause improper lubrication and clogged oil passages. Incompatibility may take place slowly and not be noticed before bearing damage has occurred.

APPLICATION OF LUBRICANTS

The proper application of the lubricant to the bearing is as important for efficient bearing performance as is its selection. Bearings are too often over-lubricated or partially lubricated. Either situation results in poor service.

The oil level at speeds below 500 rpm. is of little importance, but for speeds over 500 rpm. the oil level should be kept at the center of the lowest ball. If too much oil is added the churning action will probably cause a temperature rise at high speeds. For this reason bearings that operate at very high speeds should not be in actual contact with the lubricant (8, 7). The oil mist that is created by the air currents is sufficient to lubricate the bearing. It is important to remember that a relatively small amount of lubricant is necessary if it is consistently present. Oil should not be added while the machine is running because the action of the bearing picks up a considerable amount of oil which reaches too high a level when the machine stops. A medium or light oil is suitable for speeds up to 7,000 rpm., but at higher speeds the lightest oils should be used.

When grease is used as a lubricant, fill the housing from one third to one half full. If the grease level is too high, it will churn and generate heat. This will cause the oils to separate and gradually lose their lubricating value. In case the bearing runs too hot after it is greased, remove the drain plug so that the excess grease can drain out.

Before attempting to apply a lubricant to a bearing, be sure to examine it carefully to determine its construction. Many of the bearings used on small machines supposedly have sufficient lubrication packed into them to last the life of the bearing. If the bearing is of the closed type, one that is sealed on both sides, no lubricant need be added. Bearings that are open on either side are not permanently lubricated and require periodic relubrication.

Wash the gear housing, gears, and open-type bearings of portable machines periodically with kerosene or petroleum solvent to remove the old lubricant. Most portable machines are then relubricated by filling the gear case not more than one half full of the recommended type of lubricant.

Lubricate the machine ways and adjusting devices with a lightweight oil till they work freely. At frequent intervals, wipe the bearing surfaces with a cloth dampened in kerosene to remove the dirt and gum. Apply a light oil immediately.

CLEANING BEARINGS

Ball bearings are made of very hard steel and will carry extremely heavy loads under normal operating conditions. Metal-to-metal contact under high pressure, however, subjects the component parts to severe damage in the event of sudden impact. For example, a sharp blow on the end of a shaft on which the bearing is mounted in a machine or a fall of only a few feet on a hard floor is likely to shatter some of the components, ruining the bearing for further use. Thus, a bearing must be handled carefully.

New bearings are ready for installation when they are received by the customer. At the factory, most open-type bearings are coated with a petroleum antirust compound and wrapped in antirust paper. The petroleum is compatible with most lubricants but is not intended to take the place of the type and grade of lubricant recommended for the bearing. The bearings should be left in the package and stored at a moderate temperature until they are needed (5, 116). At the time of installation, the proper lubricant should be applied.

A high percentage of all ball bearing failures is due to dirt and grit that enter the bearing. This may be caused by carelessness during assembly or by careless operation (4, 1). Hard particles, passing between the contact surfaces of the bearing, have an abrasive action which gradually wears away the metal and destroys the accuracy and efficiency of the bearing.

There is a tendency for greases to oxidize and become hard upon exposure to the air or to leave a gummy residue because of the separation and escape of the oils from the bearings. Either of these conditions gradually fills and clogs the bearing and prevents it from running freely. The addition of a light mineral oil will tend to minimize the drying and hardening of the grease and free the bearing. But lubricants gradually deteriorate and become contaminated because of an accumulation of moisture in the bearing, forming a sludge that is harmful to it. For these reasons, all bearings should be drained and flushed at regular intervals. The intervals at which they require cleaning are determined by the operating conditions. If conditions are exceptionally severe, the bearings will need to be cleaned more often.

Hot light oil will usually flush the ordinary contaminants from a mounted grease bearing. But when the contaminants are badly oxidized, a hot-water flushing emulsion may be needed to break down the oxidation and clean the bearing and grease cavity in the housing. After flushing with hot water, the hot-oil flushing process should be continued until all the water is cleared from the bearing. All lubrication holes and connections should be inspected to make sure they are clear of foreign matter. The bearing should then be filled with the proper amount of the recommended type and grade of lubricant.

If a grease lubricated bearing has a drain plug and the contamination is not extreme, the bearing may be cleaned by forcing fresh grease through the bearing until the old grease is forced out through the drain. The machine should then be run until the grease has drained to the proper level in the bearing before replacing the drain plug.

Bearings need cleaning whenever they come in contact with such foreign matter as airborne dust, metallic chips, filings, deteriorated lubricants, and chemicals which cause abrasive or corrosive action and damage to the finely polished surfaces.

Bearings can be cleaned in cold kerosene, petroleum solvent, or in lightweight oils that are not heavier than S.A.E. 10. Automotive flushing oil, transformer oil, and spindle oil are satisfactory and may be used either hot or cold (5, 116). The use of chlorinated solvents is not recommended because of the possibility of corrosion (6, 15).

A wire or mesh basket and a container to hold the cleaning agent are needed for cleaning bearings. The bearings are put in the basket and submerged in the cleaning solvent. The solvent container should be deep enough to allow the heavy contaminants washed from the bearing to settle away from the cleaning area.

In some cases bearings may need soaking in hot oil (200°-240°F.) for several hours to soften the highly oxidized greases. They should then be scrubbed with a stiff bristled brush. The cleaning process is completed by washing the bearings in a solvent (5, 116).

The use of compressed air for cleaning bearings is not advisable as it contains moisture which causes corrosion. Also, washing a bearing by spinning damages the polished surfaces because of lack of sufficient lubrication. During the cleaning process, bearings should never be run at high speeds by compressed air. If for some reason compressed air is needed, only filtered air should be used.

Clean, dry, unlubricated bearings are extremely vulnerable to the corrosive effects of the acidic moisture on the hands. Therefore a fingerprint neutralizer should be used when handling newly cleaned bearings. Bearings which are to be used immediately should be rotated in light oil. If not, they should be coated with a preservative compound to protect them from corrosion or mechanical shock. Bearings which are not to be used immediately should be wrapped in an antirust paper, foil, or plastic film (3, 30).

Permanently lubricated or sealed bearings are cleaned by wiping them with a clean cloth. Under no circumstances should they be immersed in a solvent. This will only dilute the lubricant and ruin the bearing.

To clean a ball bearing

1. Fill a solvent container with an adequate amount of the proper solvent needed to clean the particular bearing.
2. Put the bearing in a wire basket and submerge it in the solvent.
3. Soak the bearing in clean solvent until the contaminants are loosened. If contaminants still

remain, soak the bearings in hot oil and brush it briskly with a stiff bristled brush.

4. Slowly revolve the bearing in a petroleum solvent or kerosene and clean out any remaining substances. Be sure the bearing is thoroughly clean.
5. Wash your hands and put a fingerprint neutralizer on them.
6. Place the bearing in a clean, light oil and rotate it slowly by hand until all the solvent has been replaced by the oil. Oil has a tendency not to adhere to surfaces that are wet with solvent.
7. Inspect the bearing for defects or looseness, using the procedure described on "To Inspect A Ball Bearing," page 295.
8. Mount the bearing if it is in satisfactory condition and needed for immediate use. Use the procedure "To Mount A Ball Bearing," on page 298.
9. If the bearing is not for immediate use, coat it with a rust-preventative compound and wrap it in antirust paper, foil, or plastic film.
10. Store the bearing in a clean room that stays at a moderate temperature.

To clean an assembled bearing and housing (oil lubricated)

1. Remove the plug and drain the oil reservoir.
2. Flush the bearing with light oil heated to 160° to 180° Fahrenheit while the shaft is slowly rotated. If the lubricant has hardened in the bearing, replace the drain plug and run the machine for a few minutes, using the hot oil as a lubricant.
3. Drain the flushing oil from the housing and replace the plug.
4. Apply a sufficient amount of the proper lubricant to the bearing.

To clean an assembled bearing and housing (grease lubricated)

1. Clean all the surfaces around the bearing housing.
2. Place a drain pan or container under the bearing housing.
3. Remove all the grease drain plugs that are related to the bearing.
4. Flush light, hot oil through the bearing while rotating the shaft slowly. In cases of badly oxidized grease deposits, flush the bearing with hot water.
5. Continue the hot-oil flushing process until the hot-water emulsion is eliminated.
6. Inspect all lubrication holes and connections to be sure they are clear of foreign matter.
7. Fill the bearing with the recommended type and grade of lubricant.
8. Run the machine until the grease has drained to the proper level.
9. Replace the drain plugs.

INSPECTING BALL BEARINGS

Bearings should be examined each time a machine is disassembled. If any contaminants have entered the bearings or if the bearings have operated for a relatively long period of time, they should be thoroughly cleaned and inspected. When it is necessary to replace a damaged bearing with a used one, the used bearing should be cleaned and thoroughly examined to determine if it is in sufficient condition to warrant its use.

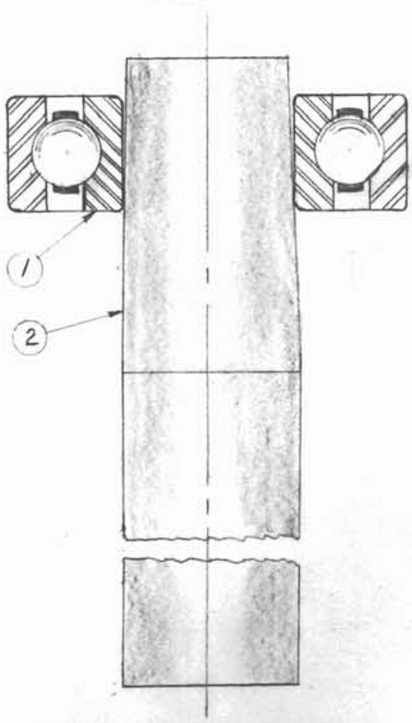
All components of a bearing must be carefully checked. The raceway surfaces should be examined for scratches, scores, and pits. The imperfections are caused by contaminants in the bearing, which accounts for many bearing failures. The lapping action of the contaminants places excessive wear on the balls and and raceways, allowing the bearing to vibrate and make an intermittent noise. In addition to the cracking and flaking, the balls may be discolored by insufficient lubrication, resulting in an abnormal temperature which may be sufficient to create a whistling sound and reduce bearing hardness (7, 4).

The function of the retainers is to separate and guide the balls in a natural path around the raceways. When misalignment exists in either the shaft or housing, a stress develops between the balls and the retainer. The retainer is soon damaged because the greatest sliding action takes place in this area. When the stress becomes great enough, sufficient heat is created to discolor the balls and cause excessive wear on the retainer and fracture in extreme cases (7, 12).

To inspect a ball bearing

1. Clean the bearing, following the procedure on page 293.
2. Examine the raceways for scratches, scoring, pits, and signs of irregular wear.
3. Examine each ball for flaking, cracks, discoloration, and irregular wear.
4. Examine retainers for cracks, loose rivets, distorted shape, and excessive wear.
5. Check the bearing for excessive internal wear, indicating worn balls and raceways.
6. Put a slightly tapered piece of material, metal or wood, approximately 12" long through the bore of the inner ring sufficiently tight to support the bearing with the axis in a vertical position (Fig. 20-3).
7. Spin the outer ring first to the right and then to the left by hand and notice whether it comes to an

20-3. Checking a ball bearing for defects: 1. Ball bearing. 2. Tapered spindle, wood or metal.



abrupt stop. An abrupt stop indicates the possibility of a flat spot on a ball, a rough raceway, the cage binding on the balls, or foreign matter in the bearing.

8. Spin the outer ring again first to the right and then to the left and notice whether there is an intermittent clicking sound as the ring rotates. Such sound indicates the possibility of a cracked or flaked ball, pitted surface on a raceway, or a piece of hard, foreign substance in the bearing.
9. Spin the outer ring again first to the right and then to the left and notice whether it turns smoothly without any abnormal sounds. This performance indicates that the bearing is suitable for use.
10. Turn the bearing over and repeat Steps 7, 8, and 9. If there are no defects and the bearing rotates smoothly, it is satisfactory for further use.

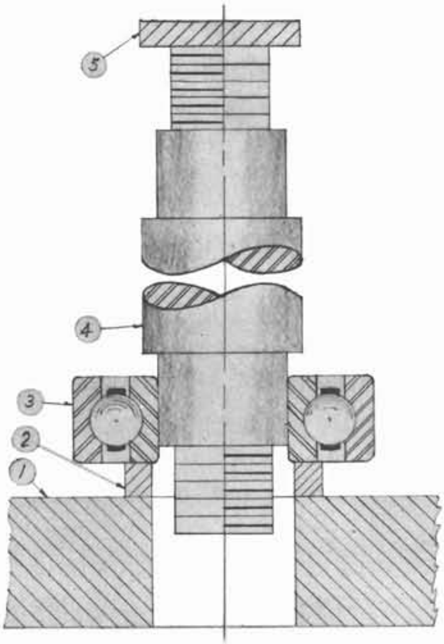
MOUNTING BALL BEARINGS

The successful mounting of ball bearings is dependent on careful planning of the preliminary steps. Handling of bearings, working procedures, and application of lubricants must be skillfully executed to assure satisfactory performance of bearings. Cleanliness is an essential factor. The working area, tools, shafts, housings, adjacent area of the machine, and the hands must be clean and dry to protect the machine components from contaminants. Clean washing solvents and lint-free cloths should be provided for cleaning up contaminants and drying machine parts. Clean bearings should not be opened until immediately before installation.

In most ball bearing applications, the shaft turns and its bearing ring has a press fit on the shaft to prevent slippage and wear. The nonturning ring has a close push fit in the housing that prevents turning. In each case the fit is sufficiently snug to hold each ring tight in its mating member.

Before attempting to mount a bearing, the shaft and housing seats should be carefully examined for obstructions that could prevent the bearing from seating properly, resulting in misalignment. Also, the shaft and housing should be checked for roundness and the size of each should be checked with the size of the bearing to insure a proper fit (5, 83). A bearing ring is thin in relation to the pressure exerted by the interference fit when it is mounted on the shaft. If a bearing is pressed on a shaft that is out of round, the ring will essentially take the shape of the shaft. This will change the shape of the bearing enough to cause unsatisfactory performance (6, 111).

The unfinished cast surfaces on the inside of a bearing housing usually have numerous pores that are filled with hard material. These surfaces should be cleaned and sealed with a nonsoluble engine enamel to keep loosened contaminants from falling into the bearing area (5, 114). All oil holes should be cleaned out and the bearing seats in the housing and on



20-4. Mounting a ball bearing onto a short shaft with an arbor press: 1. Face block 2. Split ring. 3. Ball bearing. 4. Shaft. 5. Arbor press ram.

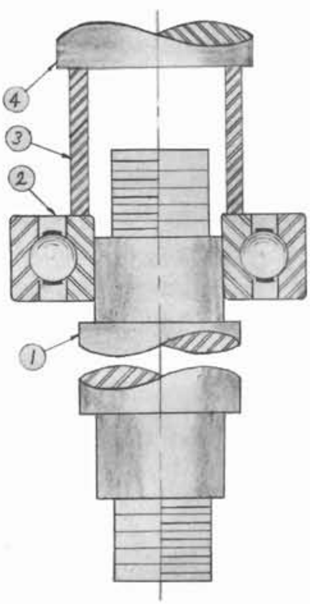
the shaft wiped dry and coated with a light oil to aid assembly.

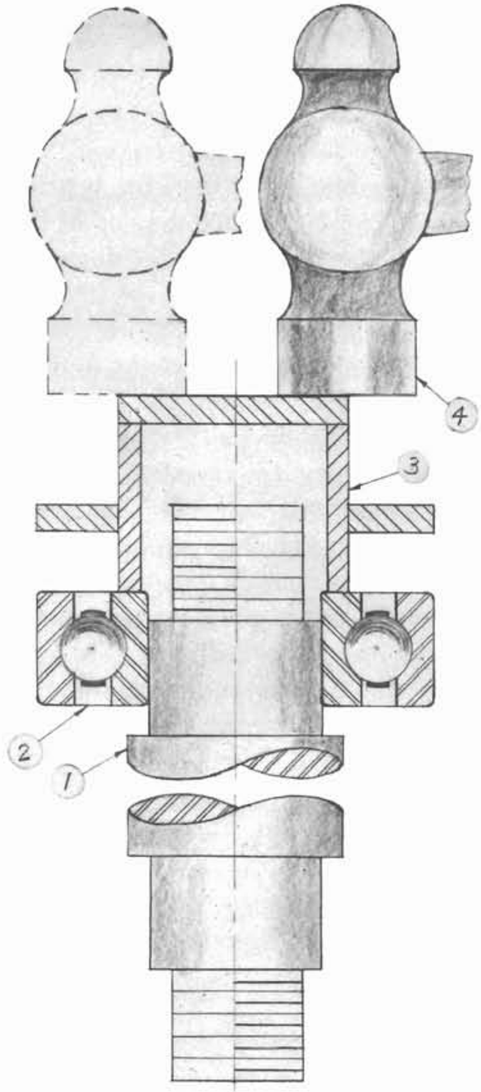
Ball bearings can be easily ruined during installation and removal. They are frequently damaged when the force to move the bearing on the shaft or in the housing is transmitted through the balls. Pressure should be applied only to the face of the ring which is being press fitted. Equipment is available for mounting and dismounting ball bearings. Some tools and machines are standardized by the bearing industry while others are designed for special types of bearings.

An arbor press may be used to advantage for mounting ball bearings. In some cases, a bearing and a split ring, which supports the inner race, may be laid on a face block which has a slot small enough to support the split ring but larger than the bearing bore (Fig. 20-4). Place the end of the shaft in the bore of the bearing and, being careful to see that the bearing is not cocked, press the bearing onto the shaft slowly and evenly until it is seated tightly against the shoulder.

In some situations, the position of the shaft may be reversed and the end supported beneath the arbor press table (Fig. 20-5). The bearing is set in position on top of the shaft seat and a clean piece of soft metal pipe of the proper diameter to rest on the inner race, and with squared ends, is set on the bearing. The shaft and pipe are checked for alignment with an arbor press ram, and, being careful to see that the bearing is not cocked, the bearing is slowly and evenly pressed onto the shaft until it is seated tightly against the shoulder.

20-5. Mounting a ball bearing onto a long shaft with an arbor press: 1. Shaft. 2. Ball bearing. 3. Metal tubing. 4. Arbor press ram.





20-6. Mounting a ball bearing with a tubular drift and hammer: 1. Shaft. 2. Ball bearing. 3. Tublar drift. 4. Hammer.

Ball bearings can be mounted with the aid of a tubular drift. The drift may be purchased but can be easily made in a variety of diameters and lengths depending upon the bearing size and the length from the end of the shaft to the bearing seat. The drift should be made of clean, soft, metal tubing or pipe. The ends should be square and the diameter should fit the race to be pressed onto the shaft. The top of the tubing should be capped, and a circular disk approximately the size of the outside diameter of the bearing should be mounted near the other end to prevent contaminants from entering the bearing (Fig. 20-6). The bearing can be mounted onto the shaft by hitting the drift with light hammer blows, alternating from one position to another and being careful not to cock the bearing. Under no circumstances should a drift size be used that would exert any force on the balls to move the press fitted race.

On some large bearings where the press fit is relatively tight, the thermal expansion method of mounting such bearings is recommended to prevent damaging the seating surfaces of the shaft and bearing bore. Bearings can be warmed to a temperature of 150° to 250° in a thermostatically controlled oven (6, 112). Overheating or prolonging the time of heating may damage the bearings by reducing their hardness. When a bearing has reached the required temperature, it should be slipped onto the shaft immediately and held firmly against the shaft shoulder until it is sufficiently cool to stay in place.

To mount ball bearings

1. Provide a supply of lint-free cloths and a container of clean washing solvent.
2. Clean the working area, tools, shaft, housing, and adjacent area of the machine.

3. Wash and dry the hands to prevent contaminants from being deposited on the machine components.
4. Carefully examine and remove any obstructions on the housing and shaft seats that would prevent the bearing from seating properly.
5. Check the housing and shaft seats for both roundness and for proper size in relation to the inside and outside diameters of the bearing.
6. Apply a coat of nonsoluble engine enamel to the unfinished surfaces on the inside of the housing.
7. Clean out all oil holes and lines.
8. Wipe the housing and shaft seats dry and apply a coat of light oil.
9. Use one of the following methods to mount ball bearings: (A) arbor press for short shaft; (B) arbor press for long shaft; (C) tubular drift; or (D) thermal expansion. These methods are described on pages 297 and 298. Procedures are on this page and next.
10. Assemble the machine, being careful that no contaminants get into the bearing or housing cavity.
11. Lubricate the bearing with the proper lubricant. Do not start the machine until the bearing has been lubricated.

A. Arbor press method for short shaft (Fig. 20-4)

1. Select a split ring that will support the inner race. Place it on a face block which has a slot small enough to support the split ring but larger than the bearing bore.
2. Place the split ring around the face block slot and lay the bearing on the split ring to support the inner race. Do not allow the split ring to exert any pressure through the balls.
3. Place the end of the shaft in the bore of the bearing and in line with the arbor press ram.
4. Be careful to see that the bearing is not cocked; then slowly press it onto the shaft until it fits firmly against the shoulder.

B. Arbor press method for long shaft (Fig. 20-5)

1. Support the shaft under the arbor press table in the proper position.
2. Place the bearing on the shaft.
3. Select a piece of clean, soft metal tubing of the proper diameter to rest on the inner race of the bearing and yet large enough to clear the shaft seat.
4. Square both ends of the tubing and remove any burrs and filings.
5. Place the tubing on the inner race. Keep it in line with the arbor press ram. You should not allow the tubing to exert any force through the balls.
6. Be careful to see that the bearing is not cocked; then slowly press it onto the shaft until it fits firmly against the shoulder.

C. Tubular drift method (Fig. 20-6)

1. Purchase or make a tubular drift. Be sure the ends are square and that all burrs and filings have been removed.
2. Support the shaft in a vertical

position in a vise. Damage to the shaft can be avoided by putting soft metal between the jaws and the shaft.

3. Place the bearing on the shaft and select a tubular drift that will fit on the inner race and yet clear the shaft seat. Do no allow the tubular drift to exert any force through the balls.
4. Be careful that the bearing is not cocked; then slowly drive it onto the shaft by lightly hitting the tubular drift with a hammer, alternating from one side to another until the bearing fits firmly against the shoulder.

D. *Thermal expansion method*

1. Place the bearing on a shelf in a thermostatically controlled oven and warm to a temperature of 150° to 250° Fahrenheit.
2. Support the shaft in a vertical position in a vise. Damage to the shaft can be avoided by putting soft metal between the jaws and the shaft.
3. Remove the bearing from the oven and slip it onto the shaft seat. Hold it firmly against the shoulder until it is sufficiently cool to stay in place.

DISMOUNTING BALL BEARINGS

When ball bearings are no longer serviceable because of normal causes, disassembly of the mechanism is required. This must be carefully done in an orderly manner to prevent damage to any of the components. A drawing of the mechanism or the mechanism itself should be studied to determine a procedure for disassembly. Each part should be placed in a planned pattern to facilitate reassembly.

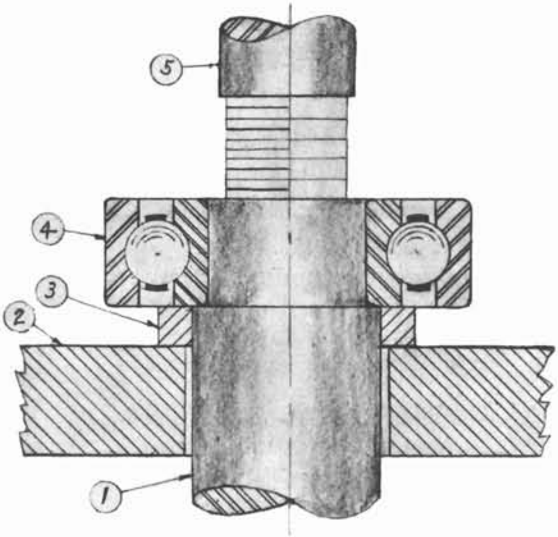
The removal of the bearing may be done with a suitable bearing puller or a semicircular drift. In either case, the pressure must be applied to the race with the press fit whether it be on the shaft or in the housing. Special care must be taken not to damage the seats or bearing races. Damage to a race may change the shape of the raceway and possibly the balls, causing them to run in an abnormal position. Even though the bearing is not to be used, it may be valuable for inspection purposes to determine the cause of bearing failure.

When removing a bearing, it should be moved carefully and slowly to see that it is not cocked on the seat. If a semicircular drift is used, light hammer taps should be applied to alternate positions on the press fit race.

If abnormal conditions existed in the operation of the bearing, all components of the machine which may be related to the problem should be carefully inspected before they are washed, in order to determine the cause of bearing failure.

To dismount a ball bearing

1. Study the construction of the machine carefully and work out an orderly procedure for disassembly of the portion necessary to remove the bearing.
2. With a supply of lint-free cloths and a container of clean washing solvent available, clean the work-



20-7. Dismounting a ball bearing with an arbor press: 1. Shaft. 2. Face block. 3. Split ring. 4. Ball bearing. 5. Arbor press ram.

ing area, tools, and the machine to be disassembled.

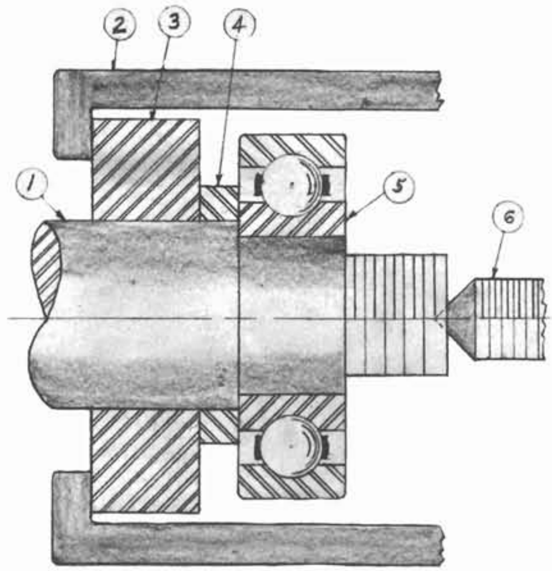
3. Remove the necessary components of the machine and lay them out in a planned order.
4. Remove the shaft and wipe the excess lubricant from the shaft and the outside of the bearing.
5. Use one of the following methods that is applicable for removing the bearing:

A. *Arbor press method (Fig. 20-7)*

1. Select a split ring that will support the inner race and place it on a face block which has a slot small enough to support the split ring but slightly larger than the diameter of the shaft.
2. Place the split ring around the face block slot and hang the shaft and bearing on the split ring. Do not allow the split ring to exert any force through the balls.
3. Place the arbor press ram against the end of the shaft and slowly press it out of the bearing, being careful not to cock the bearing.

B. *Bearing puller method (Fig. 20-8)*

1. Support the shaft in a horizontal position in a vise. Damage to the shaft can be avoided by putting soft metal between the jaws and the shaft.
2. Select a split ring that fits around the shaft and contacts only the inner race.
3. Fasten the split ring in place around the shaft and against the bearing.
4. Place the bearing puller jaws around the shaft close to the split ring.



20-8. Dismounting a ball bearing with a bearing puller: 1. Shaft. 2. Bearing puller. 3. Bearing puller jaws. 4. Split ring. 5. Ball bearing. 6. Bearing puller screw.

5. Tighten the bearing puller jaw bolts enough to hold the jaws firmly around the shaft and yet allow it to slip on the shaft.
6. Connect the bearing puller arms to the jaws and tighten the bearing puller screw against the end of the shaft. Continue tightening until the bearing is removed from the shaft seat.

C. Semicircular drift method (Fig. 20-9)

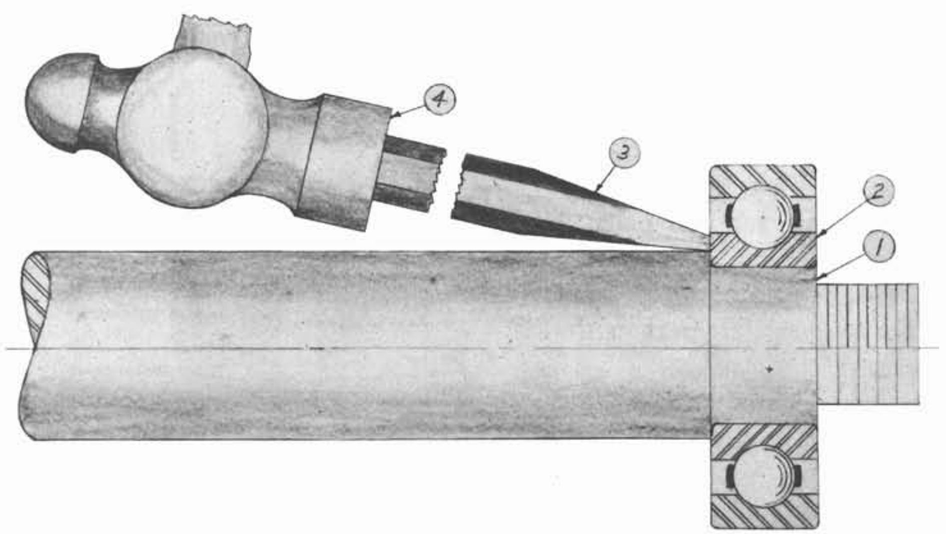
1. Support the shaft in a horizontal position in a vise. Damage to the shaft can be avoided by putting soft metal between the jaws and the shaft.
2. Place the semicircular drift against the inner race and drive the bearing off the shaft by lightly hitting the drift with a hammer, alternating from one side to another. Be careful not to cock the bearing or damage the seats.

HANDLING LUBRICANTS

The importance of keeping lubricants clean cannot be overemphasized. The following practices will aid in keeping lubricants in good condition:

1. Keep the cover tight on the lubricant container so that no grit, dust, or water can enter.
2. Use a clean piece of metal blade, like a putty knife, to remove grease from the container.
3. Be sure that grease guns and oil cans are clean before they are filled with a lubricant.
4. Thoroughly clean the lubricant fittings on the machine before the lubricant is applied.

20-9. Dismounting a ball bearing with a semicircular drift and a hammer: 1. Shaft. 2. Ball bearing. 3. Semicircular drift. 4. Hammer.



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