



**Principles of**  
**TOOL ROOM**  
**GRINDING**

THE CARBORUNDUM COMPANY - NIAGARA FALLS, N. Y., U. S. A.



*Information on the*

**PRINCIPLES OF  
TOOL ROOM GRINDING**

*to aid you in the*

- ★ **Selection**
  - ★ **Identification**
  - ★ **Specification**
  - ★ **Application**
  - ★ **Care**
- of your grinding wheels**

THERE IS A PRODUCT BY "CARBORUNDUM"  
FOR EVERY ABRASIVE APPLICATION



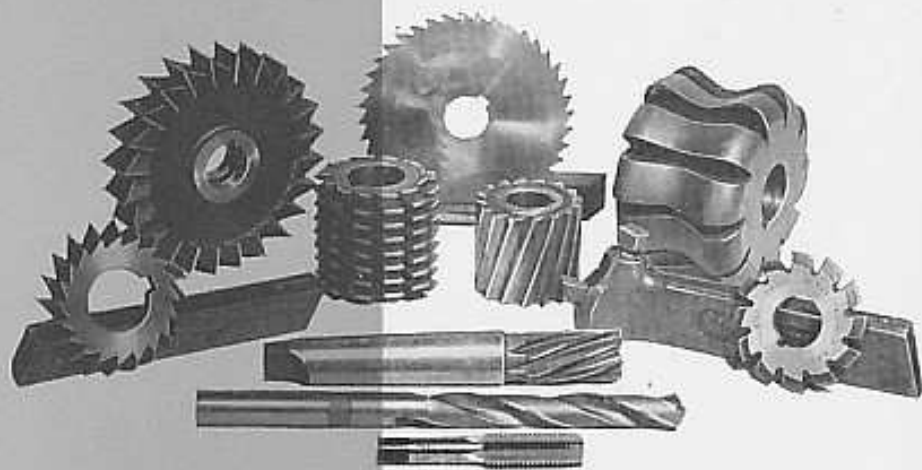
## *Preface*

DESIGNED as an aid to the more efficient production of high quality grinding, TOOL ROOM GRINDING sets forth the basic principles of correct grinding. The informative material of this book is offered as an aid to a better understanding of grinding wheels and their relation to the various tool sharpening and grinding operations. The recommendations as to procedures and wheel selection are a result of actual production surveys and will assist materially in the practice of correct grinding procedure and the selection of the proper wheel for specific operations.

Many of the drawings, photographs and charts illustrating various machines, typical tool setups and the results of correct grinding operations have been furnished by machine and tool manufacturers. We wish to express our appreciation to these companies for their cooperation and assistance in the publication of this book.

## TABLE OF CONTENTS

	Page
LATHE and PLANER TOOL GRINDING . . . . .	5
CUTTERS and REAMERS . . . . .	15
Typical Tool Setups . . . . .	29
Reamer Grinding . . . . .	41
MISCELLANEOUS TOOLS . . . . .	45
Drills, Taps, Broaches . . . . .	63
GRINDING OPERATIONS . . . . .	71
SPECIAL ABRASIVE PRODUCTS and TABLE OF WHEEL SPEEDS . . . . .	83



# LATHE and PLANER TOOL GRINDING

- ★ **Offhand Grinding..... 6**
- ★ **Machine Grinding..... 7**
- ★ **Seller's Standard Tools..... 9**
- ★ **Armstrong Standard Tools..... 11**

## OFF-HAND GRINDING

**OFF-HAND** tool grinding operations are performed generally on two types of equipment, bench and floor type grinding machines of either the dry or wet grinding variety.

The choice of a "dry" or a "wet" grind is mainly dependent upon personal preference, experience and the type of operation to be performed.

In grinding off-hand, the tool should be continually moving across the face of the grinding

wheel so as to avoid excessive grinding in one spot. In the grinding of tipped tools, the tool should be ground from the tip to the body to reduce the danger of chipping; the top is ground first, the front and side faces last. The wheel should be kept running true and cutting freely by frequent dressings with either a Huntington or a Star dresser.

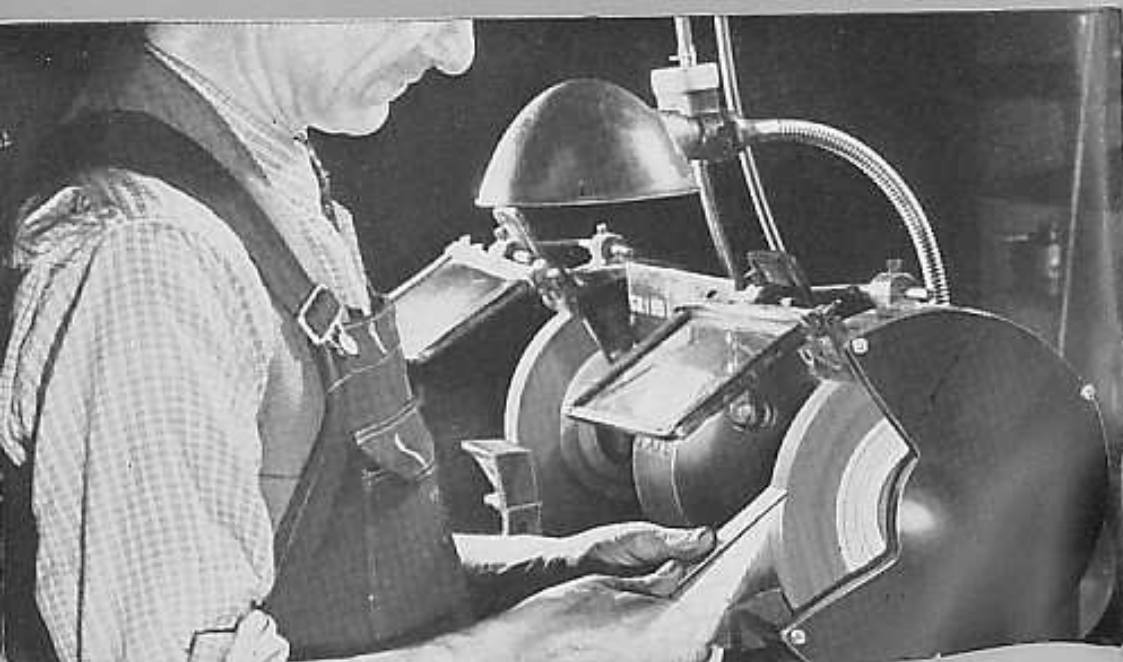
Increased wheel efficiency and life can be obtained in

instances where the grinding machine is powered by a variable-speed motor. The motor speed should be increased as the wheel diameter decreases due to wear. With constant-speed motors, the surface speed of the wheel becomes slower as the diameter diminishes, and the wheel takes on a softer action and wears away faster than when a constant surface speed is maintained.

Advantageous accommodation of both roughing and finishing operations on one machine can be realized through the use of a coarse grit wheel on one end of the spindle and a fine grit wheel on the other end of the spindle.

The bench type of grinder is intended for lighter grinding operations than can be performed on the considerably larger floor stand machine.

Off-Hand Grinding



## MACHINE GRINDING

**MACHINE**, or automatic, grinding differs from off-hand grinding in that the accuracy of the surface produced depends principally upon the accuracy of the grinding machine

itself rather than upon the skill of the operator.

Machine grinding procedure offers the following outstanding advantages over off-hand grinding:

1. Effects a saving of time for the operator.
2. Affords correct grinding angles.
3. Increases the life of the tool.
4. Permits use of harder wheel causing greater wheel life.
5. Increases production.
6. Tends toward finer quality of production.
7. Permits a smaller stock of tools.

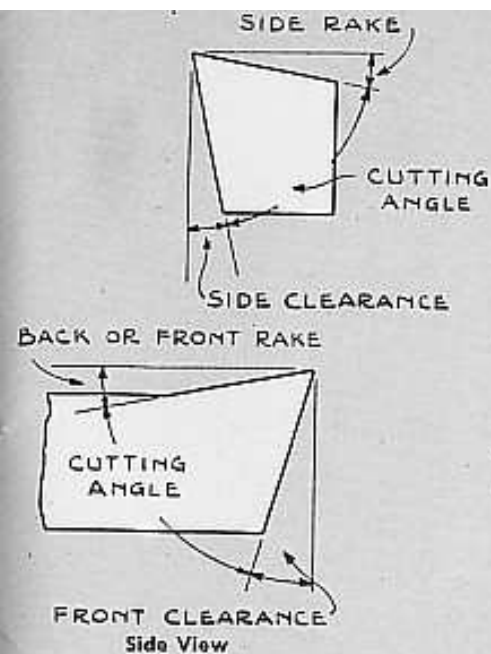
Too great emphasis cannot be placed upon the adoption of correct and uniform methods of grinding lathe and planer tools for production work. All grinding operations should be executed in strict accordance with specifications as established by the tool designer as each tool is specifically designed for certain operational limits.

In both the Sellers and Gisholt tool grinders the tool to

be ground is held in a chuck. This makes possible various adjustments so that any desired angle may be ground. Multiple reproduction of that angle can be effected by utilizing the same positions on the angular adjustments of the chuck.

Whenever necessary an adequate flow of coolant should be employed during grinding so as to eliminate the possibility of excessive localized heating.

#### Machine Grinding

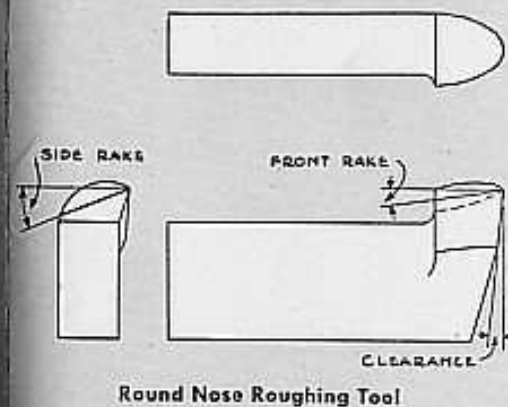


## TOOL ANGLES DEFINED

FOR purposes of discussion the angles of a tool are illustrated and defined. All angles on the top of the tool are called rakes—back rake and side rake. Angles on the side of the tool are termed clearances—front clearance and side clearance. The included angle between a rake and a clearance is the cutting angle. Cutting angles are usually  $60^\circ$  to  $75^\circ$  for cast iron to  $50^\circ$  for steel and wrought iron.

## SELLERS STANDARD TOOLS

THE following data and illustrations have been taken from the chart of standard tools as recommended by William Sellers & Company. The Sellers Company furnishes charts showing machine settings for producing correct angles with the Sellers Tool Grinder.



Round Nose Roughing Tool

	Clearance	Front Rake	Side Rake
Blunt tools for cast iron and the harder grades of steel.....	$6^\circ$	$8^\circ$	$14^\circ$
Sharp tools for wrought iron and softer grades of steel.....	$6^\circ$	$8^\circ$	$22^\circ$



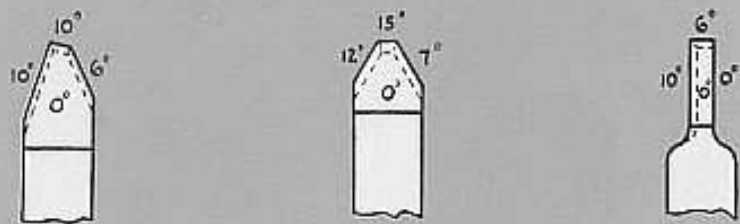
## SELLERS LATHE TOOLS



Finishing

Nicking

Side



Brass

60° V Thread

Square Thread

## SELLERS PLANER TOOLS

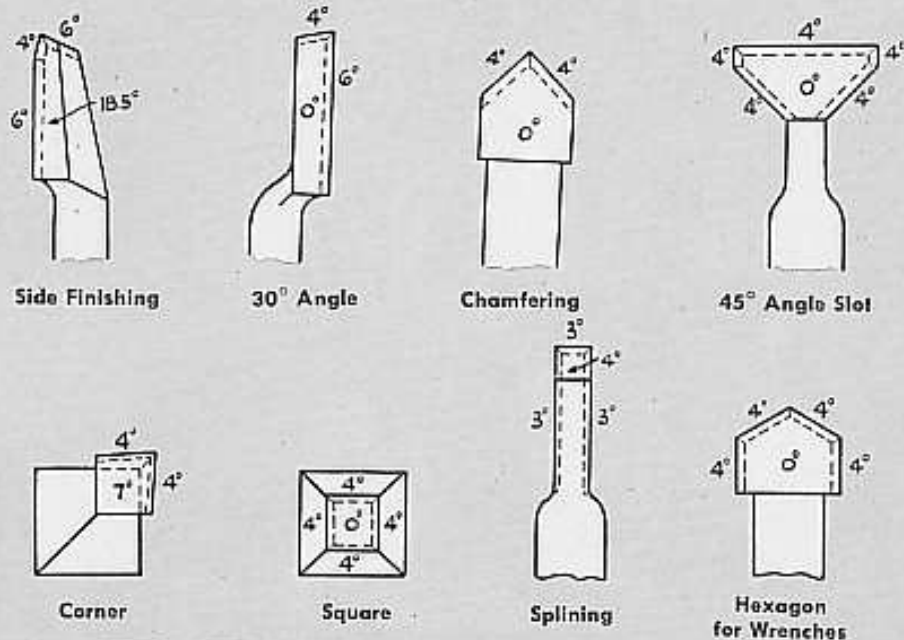


Finishing

Splining

Cutting Down

## SELLERS SLOTTER TOOLS



Side Finishing

30° Angle

Chamfering

45° Angle Slot

Corner

Square

Splining

Hexagon for Wrenches

## ARMSTRONG STANDARD TOOLS

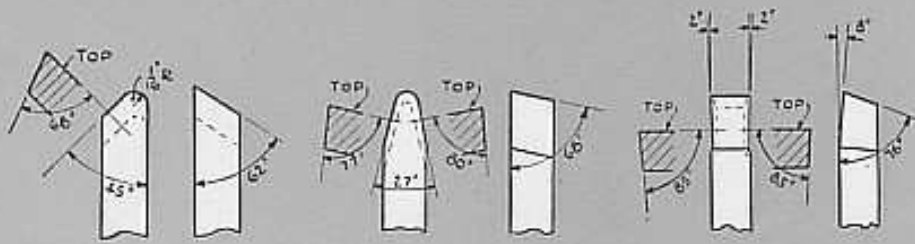


Tool Holder and Bit

**T**HE Armstrong Tool Holder System involves the principle of an inserted cutter in a permanent holder. The illustrations show the manner by which the "bits" should be ground for various operations. They may be ground in the

holder, but it is preferable to transfer them to a special grinding holder for sharpening. The drawings are furnished by Armstrong Brothers Tool Company, who also supply a chart suggesting settings for grinding on a Gisholt Tool Grinder.

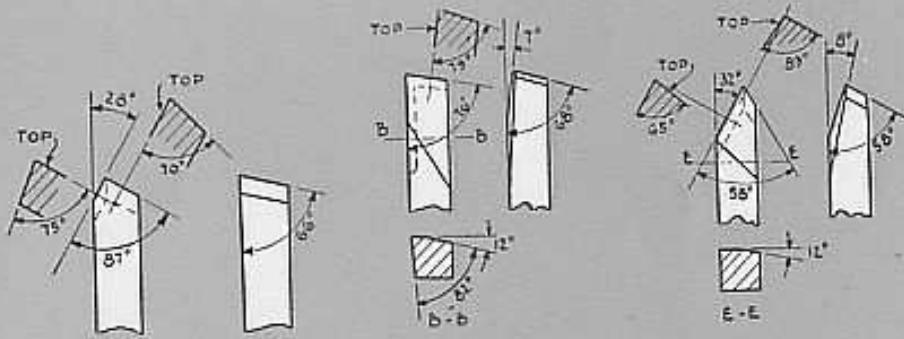
# ARMSTRONG LATHE TOOLS



R. H. Turning

Round Nose

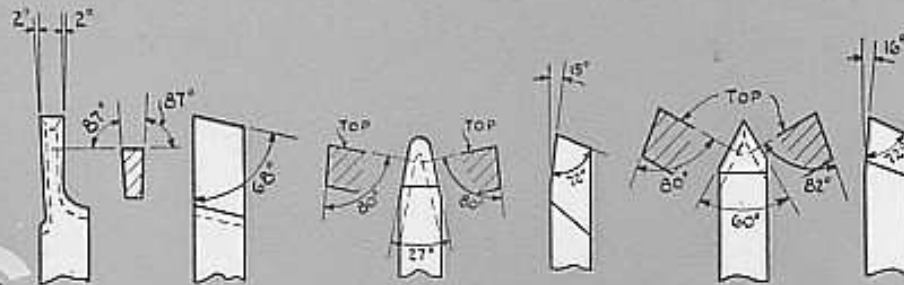
Square Finishing



R. H. Finisher

R. H. Roughing

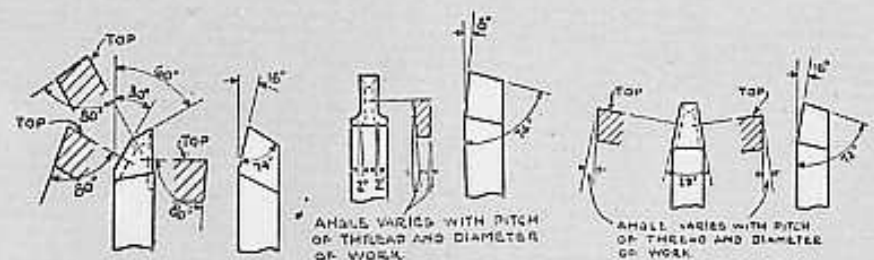
R. H. Side



Cutting off

Brass Turning

Thread

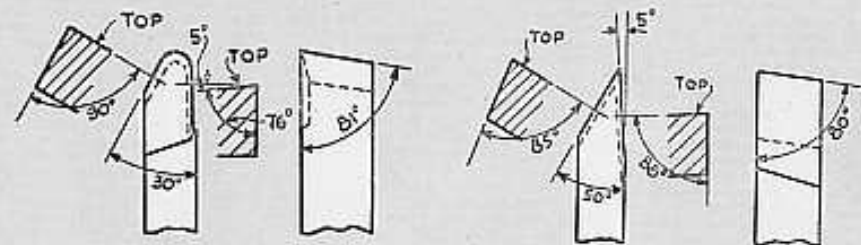


R. H. Thread Offset

Sq. R. H. Thread

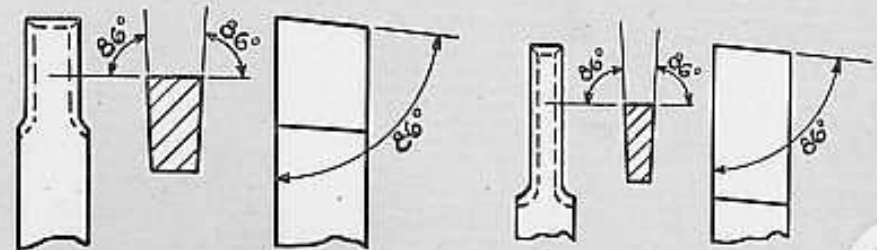
R. H. Acme and Worm

# ARMSTRONG PLANER TOOLS



R. H. Roughing

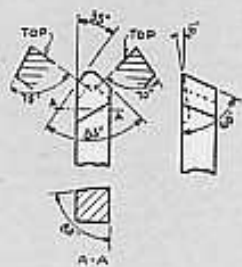
R. H. Corner



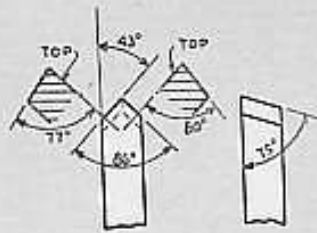
Square Nose

Parting

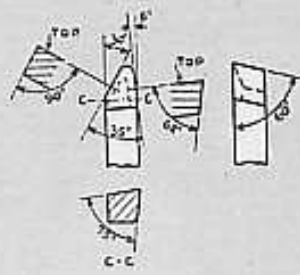




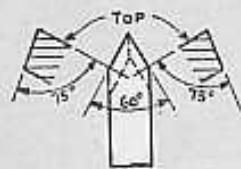
Roughing



Corner



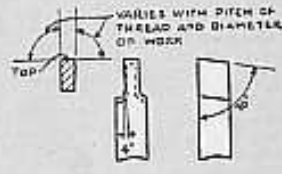
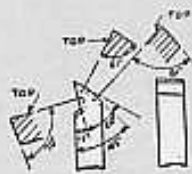
Roughing



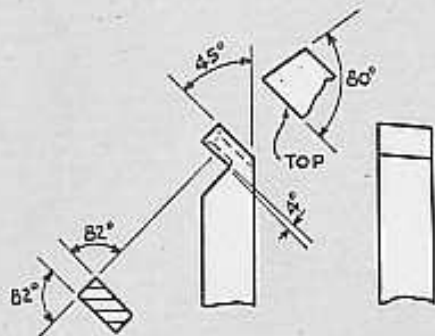
Thread



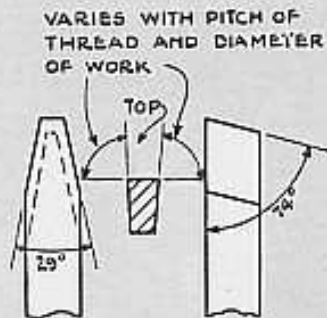
Thread



Sq. R. H. Thread



Recessing



R. H. Acme and Worm

# CUTTERS and REAMERS

- ★ Types of Cutters..... 16
- ★ Methods of Grinding..... 17
- ★ Producing a Clearance Angle.. 19
- ★ Setting the Cutter..... 22
- ★ General Instructions..... 24
- ★ Wheel Recommendations..... 26
- ★ Typical Tool Set-Ups..... 29

## DULL CUTTERS AND REAMERS UNECONOMICAL

CUTTERS and reamers are most economically used when sharp cutting edges are maintained by frequent grinding. A dull cutter proves uneconomical for several reasons:

1. Deterioration of a dull cutter is rapid, effecting a decrease in production.
2. Considerable tooth stock must be ground away to bring an infrequently ground, dull cutter into usable condition.

A frequently sharpened cutter will remove metal rapidly and when the cutter requires sharpening little stock removal is necessary for proper reconditioning.

## TYPES OF CUTTERS DIFFER

MILLING cutters are generally made according to two distinctly different design principles and each type requires sharpening methods peculiar unto itself.

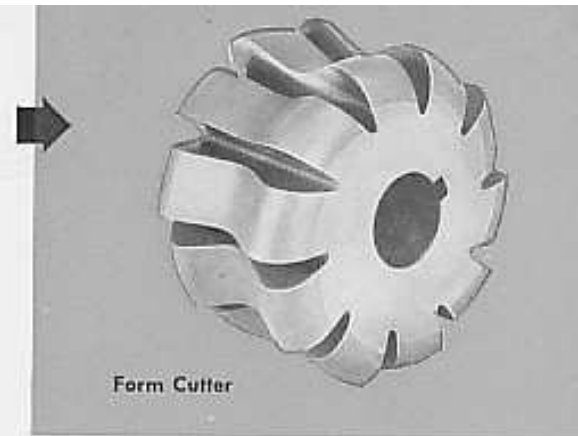
The first type of cutter is that which is sharpened by grinding on the top of the teeth back of the

cutting edge so as to produce the necessary clearance. Included in this group are milling cutters with straight and helical teeth, angular cutters, face mills, saws and reamers.

The second type, including formed cutters, gear cutters, taps and certain types of reamers, is sharpened by

grinding on the front faces of the teeth. Grinding in this fashion maintains a definite tooth profile. This profile must be retained as these cutters are used to provide a given form to their product.

Necessary clearance is produced in this type of cutter by relieving, or backing-off, the teeth when the cutter is made and, consequently, this factor need not be considered in sharpening.

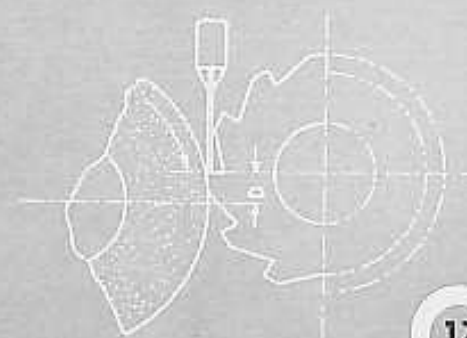
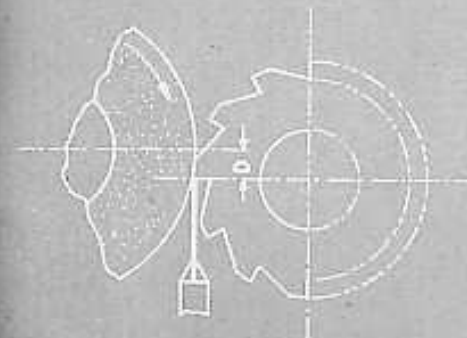
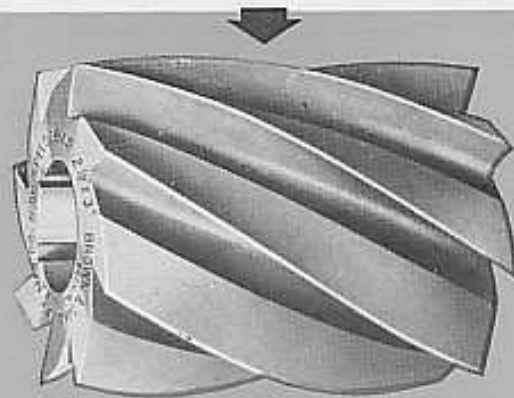


## METHODS OF GRINDING CUTTERS AND REAMERS

THERE are two methods of grinding cutters and reamers based upon the direction of rotation of the grinding wheel in relation to the cutting edges of the teeth. These methods are as follows:

- A. In Method A the grinding wheel rotates from the body of the tooth off the cutting edge. The rotation of the wheel holds the cutter on the tooth rest but the wheel raises a burr on the cutting edge, which must be removed by stoning. And, the wheel has a tendency to quickly draw the temper of the steel.
- B. Method B rotates the wheel from the cutting edge toward the body of the tooth. There is less danger of burning the tooth with this method but great care must be used to hold the cutter steadily upon the tooth rest as the rotation of the wheel often tends to turn the cutter away from the rest.

Spiral Milling Cutter





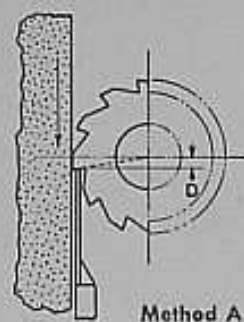
## Similar Methods Recommended for Cup Wheels

CUP wheels are also used for the grinding of cutters and reamers. The two methods of using cup wheels are similar to those used with plain wheels.

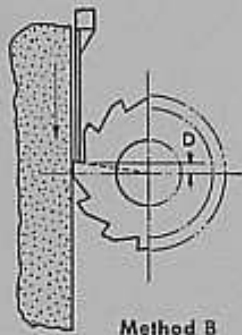
More care should be exercised in the use of cup wheels than in using plain wheels because of the greater area of contact between the wheel and work. All cuts should be light.

Plain wheels are usually used on cutters up to 4" in diameter while cup wheels are used on the larger sizes. Plain wheels should be used on only narrow lands and the cup wheels introduced for wide lands. The diagrams show in an exaggerated manner clearance produced by plain and cup wheels.

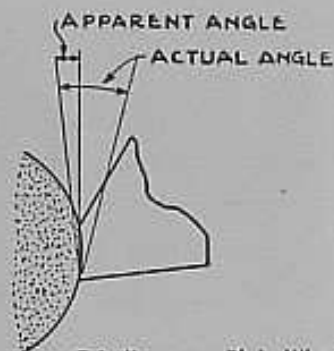
In using a plain wheel the actual angle at the cutting edge is much greater than the apparent angle. The apparent angle must be large enough so that the heel of the tooth will not drag heavily upon the work.



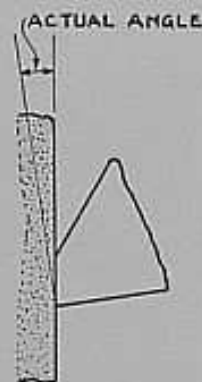
Method A



Method B



Grinding on a Plain Wheel



Grinding on a Cup Wheel

## Correct Clearance Essential

CORRECT clearance back of the cutting edge is essential. Insufficient clearance will cause the teeth to drag over the work resulting in friction and slow cutting. Too much clearance will cause the teeth to wear rapidly and produce chatter. Too much clearance is less objectionable than too little, however. The edge must be sharp and the clearance angle correct.

A secondary clearance of 9° to 30° depending upon the design produces a stronger tooth and provides easy control of the width of the land. The land should be about  $\frac{1}{2}$  to  $\frac{3}{4}$ " depending upon the cutter or reamer. When the land becomes too wide from many sharpenings the secondary clearance may be ground back to narrow the land to the correct width.

The proper clearance angle must be determined by experience. The following angles, recommended by the Cincinnati

Milling Machine Company, are advanced for general practice:

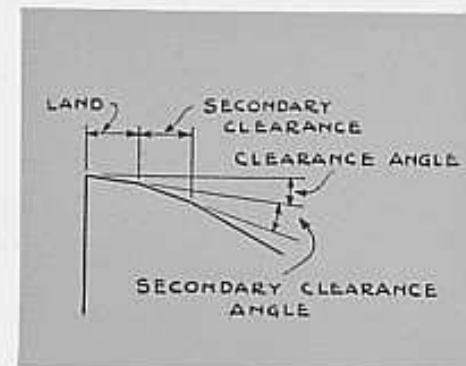


Diagram of tooth showing land, clearance angle and secondary clearance angle

### Ordinary Low

Carbon Steel.....	0° to 7°
Hard Steel.....	2½° to 5°
Steel Castings.....	6° to 7°
Cast Iron,	
Fast Feeds.....	3° to 7°
Bronze, Cast.....	10° to 15°
Tobin Bronze,	
Very Tough.....	4° to 7°
Copper.....	12° to 15°
Aluminum.....	10° to 12°

## PRODUCING THE PROPER CLEARANCE ANGLE

THE clearance angle is produced by properly locating the wheel, the cutter and the tooth rest. There are several methods of accomplishing this. The method employed depends upon the type of wheel used, the shape

of the work and the location of the tooth rest. The wheel may be plain or cup. The work may be straight or tapered, or have straight or spiral teeth. The tooth rest may be located on the wheel head or on the table.

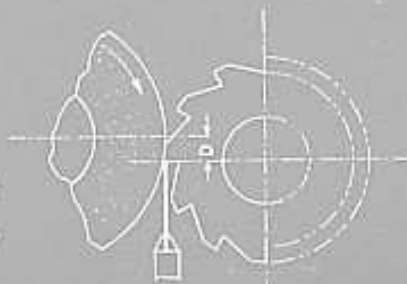
### *With a Plain Wheel*

WHEN using a plain wheel the clearance angle depends upon the diameter of the wheel, while with a cup wheel the diameter of the cutter is the determining factor. In general, the center of the wheel and the work are brought into the same plane with the tip of the tooth rest by adjustments of the table or the wheel head, or both, and the tooth rest and cutter set

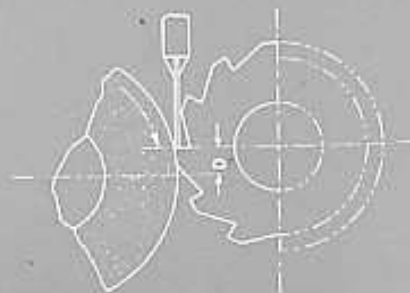
to give the desired clearance. A center gauge is used to line up the wheel, cutter and tooth rest in the same plane.

In using a plain wheel, the cutter center, the wheel center, and the tooth rest (mounted on the table) are brought into the same plane using the center gauge, and the table lowered or raised as shown in the illustrations below.

Method A



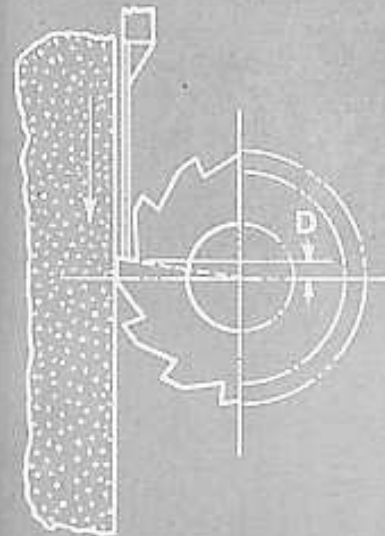
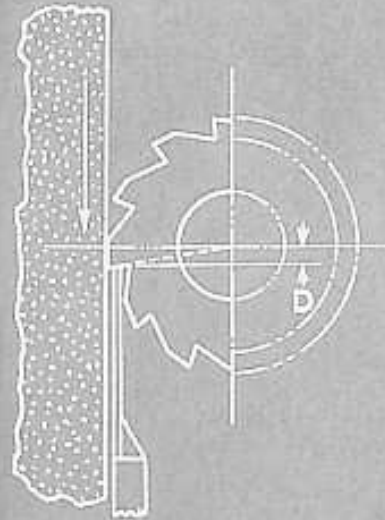
Method B



### *With a Cup Wheel*

IN using a cup wheel, the cutter center, the wheel center and the tooth rest (mounted on the wheel head) are brought into the same plane and the wheel head lowered or raised to give the required clearance. The distance the cutter or wheel is moved is represented by "D" on the illustrations.

Some machines have dials on the work head which are graduated in degrees so that the setting of the cutter is quite simple. Others have a system of gears in the work head for producing the correct angle and automatically indexing each tooth as the grinding proceeds. Otherwise a calculation must be made or tables consulted to determine the setting of the tooth rest. Tables are shown on page 23 which will illustrate the various tooth rest settings.





## SETTING THE CUTTER

TO determine the setting of the cutter when using a plain wheel, multiply the product of the clearance angle in degrees times the wheel diameter in inches by 0.0088. The result will be the distance in thousandths of an inch to raise or lower the cutter

and tooth rest (mounted on table) to obtain the correct clearance.

When using a cup wheel the setting may be computed in the following manner: multiply the clearance angle expressed in degrees by the cutter diameter . . . then multiply by 0.0088.

### When The Tooth Rest Is Mounted On The Wheel Head:

1. *Cup Wheel* . . . The wheel head is raised or lowered the required amount . . . with no adjustment of the tooth rest being necessary.
2. *Plain Wheel* . . . The wheel head is raised or lowered but the tooth rest must then be brought into line with the center of the cutter.

### When The Tooth Rest Is Mounted On The Table:

1. *Cup Wheel* . . . The wheel head is raised or lowered to avoid grinding on the tooth next to the one being sharpened, and the tooth rest adjusted the required amount.
2. *Plain Wheel* . . . The wheel head is raised or lowered the required amount. Care must be taken so that the tooth rest is then kept in line with the center of the cutter.

THE tooth rest is usually fastened to the table when grinding straight teeth so as to produce the same clearance angle throughout the entire length of the tooth. The tooth rest must be fastened to the wheel head when grinding spiral milling cutters on centers, except when the set-up is such that the cutter is free

to revolve and move longitudinally on the arbor, when it may be fastened on the table. When the tooth rest is fastened to the wheel head the setting must be such that the cutter will pass off the wheel before passing off the tooth rest. In grinding spiral mills the tooth rest must be set to follow the precise angle of the spiral.

**Note:** The movement between the wheel head and the table is only relative. The same effect is produced by raising or lowering the table and not moving the wheel head.

## Plain Wheel Clearance Table

FOR setting work center and tooth rest below center of wheel to obtain 5° to 7° clearance with wheels of different diameters when grinding on the periphery of the wheel.

Wheel Diameter	D for 5°	D for 7°	Wheel Diameter	D for 5°	D for 7°
2-1/4	.099	.139	4-1/4	.187	.262
2-1/2	.110	.154	4-1/2	.198	.277
2-3/4	.125	.169	4-3/4	.209	.293
3	.132	.185	5	.220	.308
3-1/4	.143	.200	5-1/4	.231	.323
3-1/2	.154	.216	5-1/2	.242	.339
3-3/4	.165	.221	5-3/4	.253	.354
4	.176	.246	6	.264	.370

**Note:** If the grinding wheel is so large that it strikes the next tooth, a smaller wheel should be chosen and the centers readjusted so as to be correct for the new diameter.

## Cup Wheel Clearance Table

FOR setting tooth rest to obtain 5° and 7° clearance when grinding peripheral teeth of milling cutters with a cup wheel.

Cutter Diameter	D for 5°	D for 7°	Cutter Diameter	D for 5°	D for 7°
1/2	.022	.030	2-3/4	.121	.165
3/4	.033	.045	3	.132	.180
1	.044	.060	3-1/2	.154	.210
1-1/4	.055	.075	4	.176	.240
1-1/2	.066	.090	4-1/2	.198	.270
1-3/4	.077	.105	5	.220	.300
2	.088	.120	5-1/2	.242	.330
2-1/2	.110	.150	6	.264	.360

## GENERAL INSTRUCTIONS

THE following method is generally used in sharpening a milling cutter. The cutter is set on an arbor and the tooth rest, wheel and work centers adjusted to give the desired clearance. The work is moved in to the wheel until sparks indicate contact. The cutter is then passed back and forth with the one tooth barely making contact with the wheel surface.

### Only Light Cuts Should Be Taken

IN grinding each tooth is traversed past the wheel with a steady motion taking only light cuts. The temper of the steel can be drawn by taking cuts over 0.002", by using too high wheel speed or too hard a wheel.

The cutter should be kept round by grinding the same amount from each tooth. If the wheel wears in going around the cutter the last tooth ground will be high. This condition will allow only a few teeth to perform any cutting and the operation is inefficient. To overcome this action the cutter should be gone around twice, starting the second

The tooth should then be carefully inspected to make certain the wheel is properly set to follow the former clearance. It is good practice to grind two adjacent teeth and then rotate the cutter and grind two teeth on the opposite side. It is then a fairly simple matter to check the straightness of the machine setting by measuring across the two opposite teeth.

time 180° from the first start, taking very light cuts at all times.

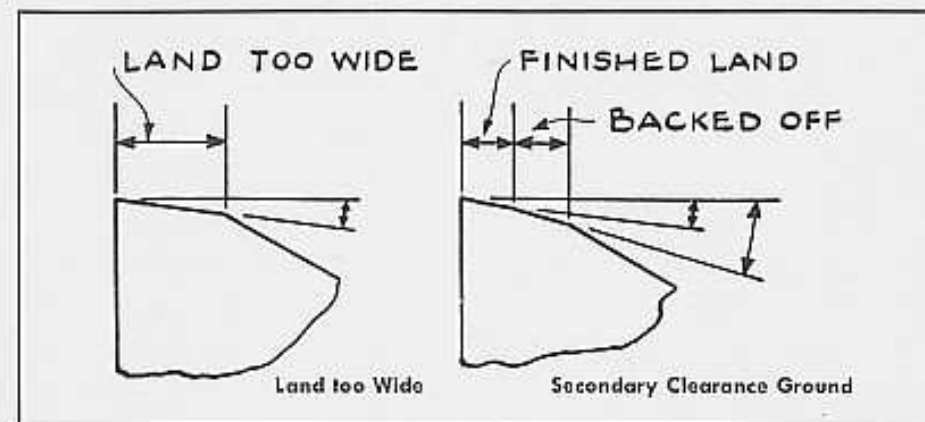
The mandrel or arbor on which the cutter is mounted must be straight and round and the hole in the cutter should be accurate.

Spiral cutters and mills are ground in the same manner except that the tooth rest is tilted to align with the spiral on the teeth, with a slight relief on the following corner.

The tooth rest should be flat on top except on the corner. It should also be a little wider than the grinding wheel to allow the cutter to move past the wheel when indexing teeth.

## Wide Lands

WHEN the lands of the teeth become too wide from frequent and continued grinding, as illustrated, the following procedure may be used:



1. Sharpen by grinding the land to the required clearance angle.
2. Grind the secondary clearance to bring the land to the correct width.

## Grinding Wheel Speeds Important

AS different sizes of grinding wheels are used on tool and cutter grinders it is important that the operator change the wheel r.p.m. when changing

wheels to give the correct s.f.p.m. (peripheral speed) to the wheel. Wheel speed has a marked effect upon grinding wheel action:

1. High Speeds—Wheel acts harder.
2. Low Speeds—Wheel acts softer.

Sometimes the operator can change the wheel speed so as to employ efficiently a wheel not suited to the work because of its grit or grade. Thus, if the wheel acts hard the wheel speed may be reduced and a softer action will result. The wheel may be speeded up should the action be too soft. Speed tables in s.f.p.m. and r.p.m. are shown on pages 94 and 95.

The following formulas may be used for calculating revolutions per minute (r.p.m.) and surface feet per minute (s.f.p.m.) or peripheral speed. The wheel diameter is in inches.

$$\text{r.p.m.} = \frac{12 \times \text{s.f.p.m.}}{3.1416 \times \text{wheel diameter}}$$

$$\text{s.f.p.m.} = \frac{3.1416 \times \text{wheel diam.} \times \text{r.p.m.}}{12}$$



## RECOMMENDED GRINDING WHEELS

### *for Efficient Operation*

**ILLUSTRATED** on the following pages are the various types of grinding wheels used on tool and cutter grinders and universal grinders. Recommended wheel gradings are shown for each type of tool in the section "GRADINGS OF TOOL ROOM WHEELS by 'CARBORUNDUM'."

Specific wheel gradings and wheel shapes are given for each operation on each tool. Each grinder should be supplied with an assortment of grits and grades to take care of varied grinding jobs. The factors affecting grinding wheel action should be carefully considered.

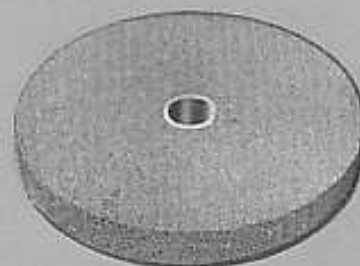
Several specific gradings are given for most of the wheel shapes. The first grading is the regular "ALOXITE" aluminum oxide vitrified wheel. This wheel is used principally where a large number of the same type of tool is to be ground and

where grit and grade can be specifically fitted to the job.

The second grading . . . the "ALOXITE" AA aluminum oxide vitrified wheel—is to be used in cases where there is a diversity of materials and sizes of tools to be ground. The AA wheel is especially adapted to hardened work. The AA wheel is easily distinguishable from the standard aluminum oxide wheel because of its pure white color . . . as compared to the regular "ALOXITE" wheel's bluish color.

The higher price of the AA wheel may be a factor in the determination as to which wheel will perform most efficiently and economically your tool room grinding. The somewhat greater operational visibility attributed to the white color of the AA wheel during grinding is considered by a number of users to be an advantageous factor.

## STANDARD GRINDING WHEEL SHAPES



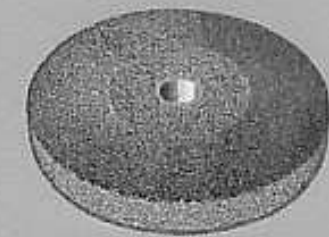
Type No. 1—Straight



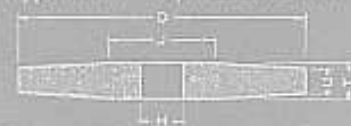
Type No. 12—Dish



Type No. 5—Recessed One Side



Type No. 4—Tapered Two Sides



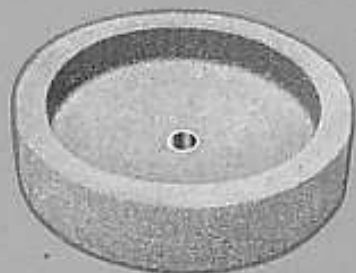
Type No. 7—Recessed Both Sides



Type No. 13—Saucer



## STANDARD GRINDING WHEEL SHAPES



Type No. 6—Straight Cup



Type No. 2—Cylinder

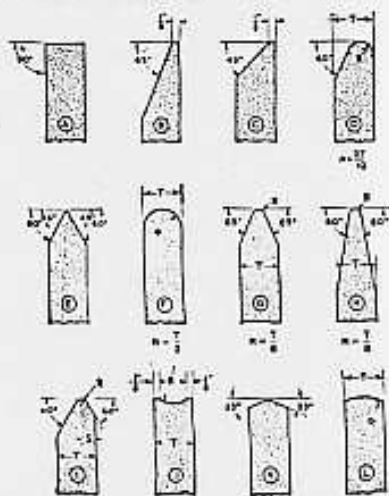


Type No. 11—Flaring Cup



### STANDARD GRINDING WHEEL FACES

For work requiring special contour wheels, straight wheel types can be furnished with any of the following standard wheel faces.



# TYPICAL TOOL

## Set-Ups

- ★ Setting-up Methods..... 30
- ★ Spiral Milling Cutter..... 30
- ★ Side Milling Cutter..... 31
- ★ End Mills with Shank..... 31
- ★ Large Face Mill Grinding..... 32
- ★ Grinding Corners of a Shell-End Mill.... 33
- ★ Helical Milling Cutter..... 33
- ★ Clearance Angle Grinding..... 34
- ★ Fellows Gear Shaper Cutter..... 35
- ★ Formed Gear Cutters..... 36
- ★ Truing..... 38
- ★ Cutter Setup ..... 39
- ★ Hob Grinding..... 40

## SETTING UP METHODS

THIS section concerns itself with the methods of setting up a variety of tools for sharpening. A description of grinding procedures accompanies the set up method for each tool. These are only typical set-ups and should not be construed as arbitrary. This statement is borne out in that certain illustrations show a cup wheel in use while others show a plain wheel. There being so much variance of opinion in the industry as to which wheel is more efficient under certain similar conditions, the advantages and disadvantages of each type have

been given in an earlier section. It is the responsibility of the tool room supervisor to determine whether the cup or the plain wheel is better suited to his needs and equipment.

For the purpose of emphasis we wish to point out again that the wheel head on which a plain wheel is mounted may be swiveled so that the amount of hollow grinding will be reduced. When using a cup wheel the wheel head should be set at an angle of  $1^{\circ}$  to  $0^{\circ}$  to provide clearance for the side of the wheel not engaged during the actual grinding operation.

## SPIRAL MILLING CUTTER

THE cutter should be mounted on a cutter bar supported by the foot-stock to prevent springing. The traverse may be obtained by moving the table or sliding the cutter on the cutter bar. So that the cutter does not run off the tooth rest stops should be used. If table traverse is used the tooth rest should be mounted on the wheel head but if the cutter is moved on the cutter bar the tooth rest should be mounted on the table but it must be mounted so as to be in line with the wheel face.

The recommended wheel face types for grinding this cutter are as follows:

a cup wheel type 6 or type 11, or, a plain wheel type 1. When using the cup wheel you should make certain that the wheelhead is swiveled slightly. This procedure will provide ample clearance for the back side of the wheel.

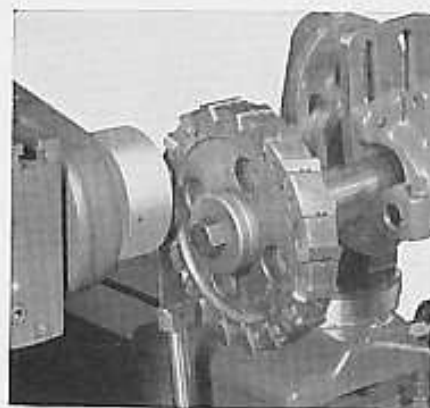


Grinding a spiral milling cutter

## SIDE MILLING CUTTER

THE land should be  $\frac{1}{16}''$  and the clearance angle about  $6^{\circ}$  with a secondary clearance of about  $12^{\circ}$  which should be as small as possible and yet prevent drag of the heel of the tooth on the work. The sides of the teeth are ground to the same specifications. The cutter should be thinner at the inside edge of the blade than at the outside edge.

The cutter is held on a stud mounted in the work head spindle, which is swiveled to the required angle for the clearance. A type 6 or 11 cup wheel may be used or a type 1 plain wheel. In using the plain wheel the



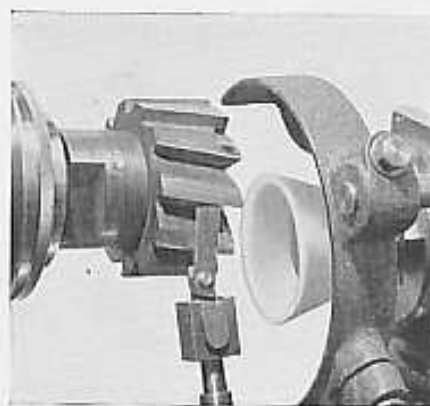
Grinding the sides of the teeth of a Side Milling Cutter

cutter arbor should be in a horizontal position and the wheel head may be raised or lowered to obtain clearance.

## END MILLS WITH SHANK

THE cutter shank is held on the taper of the work head spindle to duplicate the working position of the cutter in the milling machine. End mills with shanks should never be located on centers for sharpening. Center location tends to spring the mill causing the mill to be ground out of relation to the shank.

The tooth rest is fastened to the table and the work head is swiveled to procure the proper tooth clearance.



Grinding the end tooth on an End Mill with Shank



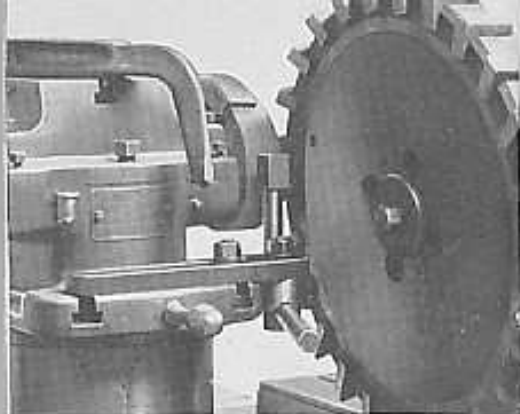
## LARGE FACE MILL GRINDING

LARGE face mills should be mounted on the face mill grinding attachment designed for the purpose. There are three operations in the grinding:

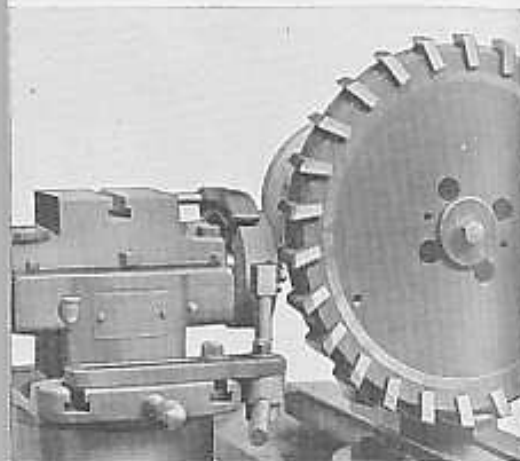
1. Grinding the face of the teeth.
2. Grinding the periphery of the teeth.
3. Grinding the corners of the teeth.

The grinding procedure in these operations is similar to that utilized in the sharpening of a shell end mill which is described on page 33.

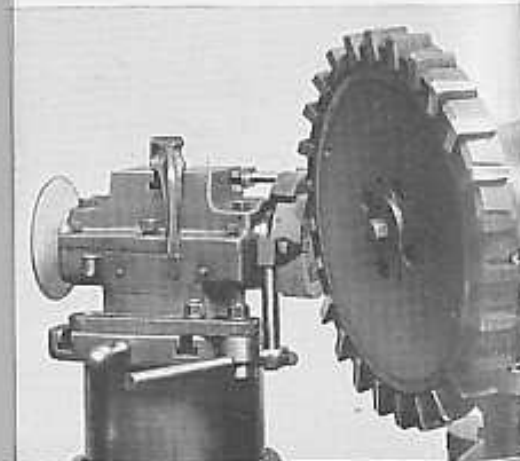
The corners of the teeth should be rounded off by first grinding a  $45^\circ$  flat and then angles of  $22\frac{1}{2}^\circ$  on either side as illustrated. The face edges should be  $\frac{3}{16}$ " wide and the remainder should be ground off at an angle of about  $7^\circ$  toward the center of the cutter. If a true radius is desired the radial grinding fixture may be used.



Grinding the face of the teeth on an 18" diameter Face Mill



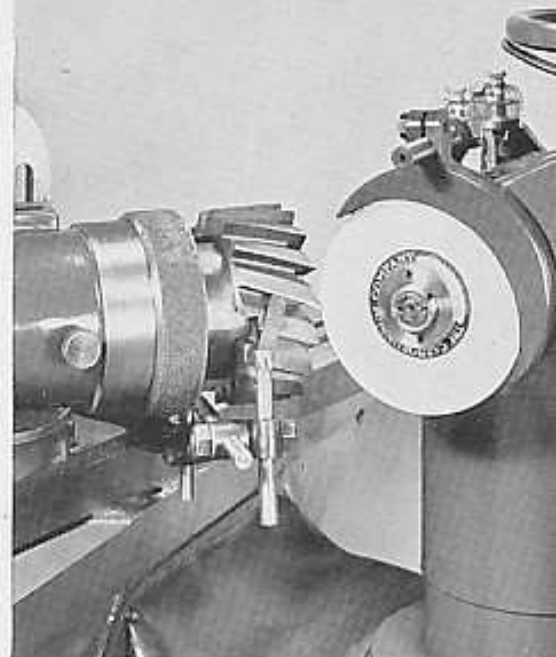
Grinding the periphery of the teeth on an 18" diameter Face Mill



Grinding the corners of the teeth of an 18" diameter Face Mill

## GRINDING THE CORNERS OF A SHELL END MILL

THE mill is mounted on an arbor which is supported by the work head. To obtain clearance the wheel head is raised or lowered and the work head is swiveled to an angle of  $45^\circ$ . Mounting the tooth rest on the work head is preferred as it allows the work holder to be adjusted without disturbing the tooth rest. Care should be taken to hold the face of the tooth against the tooth rest while grinding.



Beveling the corners of a Shell End Mill

## HELICAL MILLING CUTTER

THE cutter is mounted on an arbor between centers. The tooth rest should be given a slight radius and the cutting face of the wheel should be rounded convexly to about  $\frac{1}{16}$ " radius tapering back to the thickness of the wheel. The tooth rest is set so that its center only will be in contact with the cutter at a point on the vertical center line of the grinding wheel. A plain wheel type 1 is used.

There are other methods that may be employed. The wheel face may be left square and the wheel head tilted slightly. With this method allowance must be made in the tooth rest setting for the angle of helix so that the resulting clearance angle will be correct. With the same setting it can be seen that as the angle of helix is increased the clearance is reduced so that in a theoretical case an angle of  $90^\circ$  would result in a zero clearance.



Grinding a Helical Milling Cutter with steep angle of helix

## CLEARANCE ANGLE IMPORTANT IN GRINDING SAWS

**S**AWS are usually ground with a  $5^{\circ}$  clearance angle. As a means of compensation for wheel wear the saw should be divided into quarters. Grinding should be started on a new quarter with each complete rotation of the saw.

The saw can be mounted on a sliding shell on a cutter bar and moved across the wheel face by sliding it along the bar, or the table may be traversed. The tooth rest should be fastened to the wheel head or to the table dependent upon the wheel shape. Hard wheels should be used in grinding saws as the small teeth of the saw have a substantial amount of dressing action upon the grinding wheel.



Grinding the teeth of a Saw



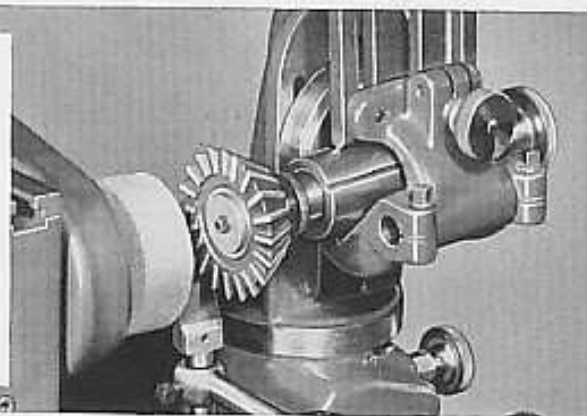
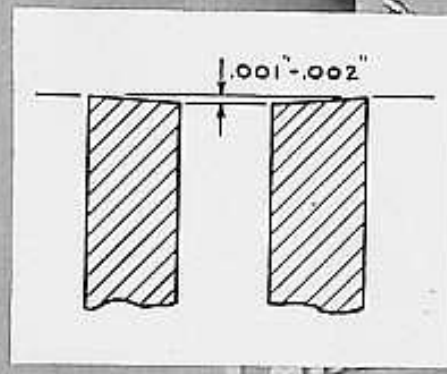
Grinding the teeth of an Angular Cutter

## ANGULAR CUTTER MOUNTING FOR GRINDING

**T**HE cutter is held on the end of the work head spindle which is swiveled to the angle of the cutter. The tooth rest is fastened to the work head and

a type 6 or 11 cup wheel is recommended for the grinding. In this operation the table is traversed across the wheel face with a horizontal motion only.

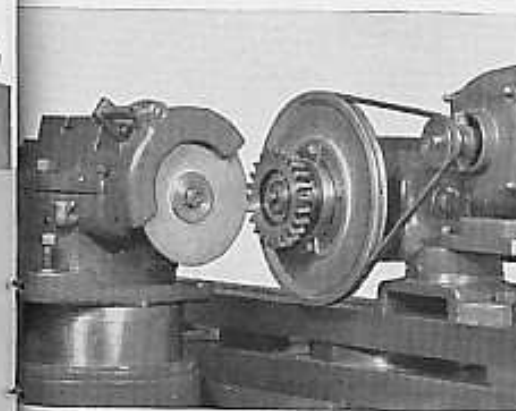
## Procedure For Grinding End Teeth Of Angular Cutter



Grinding the end teeth of an Angular Milling Cutter

**T**HE mounting of the cutter for grinding the end teeth of an angular cutter is similar to the mounting preparatory to grinding the angular teeth. The teeth are ground slightly low

at the center by swiveling the work head  $1^{\circ}$  to  $2^{\circ}$  (As illustrated by the sketch above). The work is traversed across the wheel face and the tooth rest is fastened rigidly to the table.



Grinding the face of a Fellows Spur Gear Cutter

## FELLOWS GEAR SHAPER CUTTER

**T**HIS is a plain grinding operation using the cylindrical grinding attachment. The cutter is held on a stud mounted in the work head which is set to a rake angle of five degrees.

## FORMED GEAR CUTTER GRINDING

FORMED cutters such as gear cutters must be ground radially and equidistantly using a dish wheel type 12, so as to preserve the form of the tool. The face of the wheel must align with the radial center line of the cutter as illustrated. An exception to this rule is found in offset cutters—See illustration.

Form cutters can be ground on a cutter grinder or on a surface grinder with the proper fixtures. The tooth rest is on the back of the tooth being ground. The grinding is simple, but the following precautions must be observed:

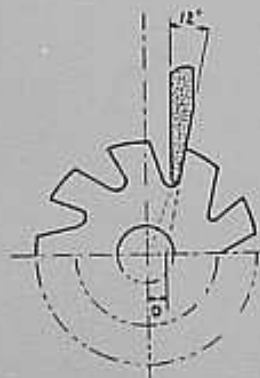
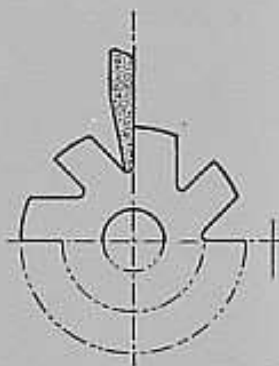
1. The wheel face must be aligned with the radial center line of the cutter except when grinding offset cutters.
2. The wheel face must be trued carefully with the diamond hold in a fixture.
3. The wheel must be located carefully with respect to the work.
4. The grinding is done on the side of a dish wheel and the feeds must be light.

Wide Formed Cutter

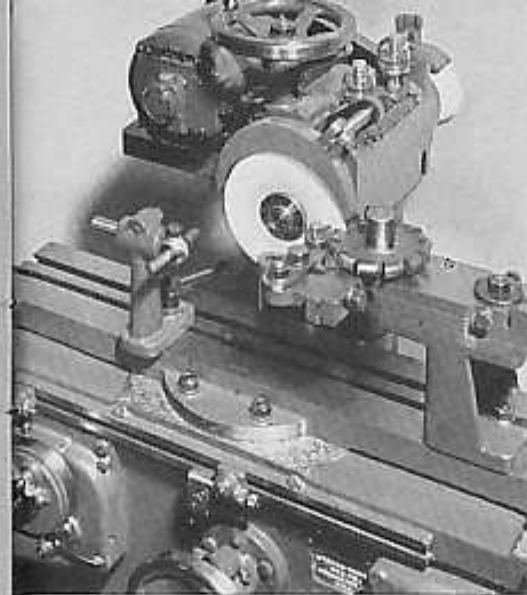


Narrow Formed Cutter

Position of wheel face and cutter for radial type cutter

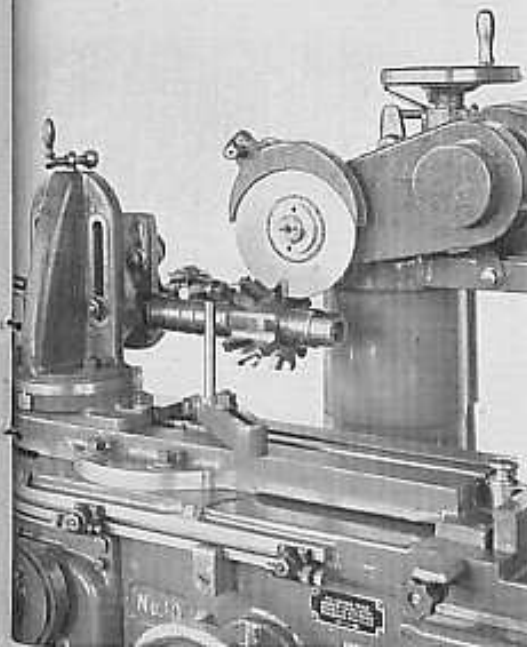


Position of wheel face and cutter for offset cutter



Grinding a narrow Formed Cutter

Grinding a Wide Faced Formed Cutter



## Narrow Formed Cutter Grinding

FORMED cutters having narrow formed cutting faces such as gear cutters can be ground as illustrated. The cutter is laid on the tool rest which is bolted to the table. The cutter is fed into the wheel by hand. A type 12 dish wheel is used. Great care must be used to grind the cutter radially and to maintain uniform height on the faces of the cutter teeth. This method is rapid but requires considerable skill and experience for correct performance. A gear cutter grinding attachment often assures a much more accurate result.

## Wide Formed Cutters

THE cutter is mounted on a gang arbor and is passed across the wheel face by traversing the table. A type 12 dish wheel is recommended for the operation. To insure correct spacing of the teeth, the backs of the teeth on a new cutter should be ground before grinding the face. Adjustment of the work to the wheel during grinding can be accomplished by revolving the cutter toward the wheel slightly by tapping lightly against the tooth rest holder. This rotates the cutter a very small amount, thereby maintaining the cutter face radia properly.



# TRUING THE GRINDING WHEEL

## *For Radial Grinding*

**BEFORE** grinding a cutter with the radial grinding attachment the wheel should be trued to the radius of the cutter to be ground. The diamond holder is placed in position and the slide set for the desired radius. There are two methods of doing this:

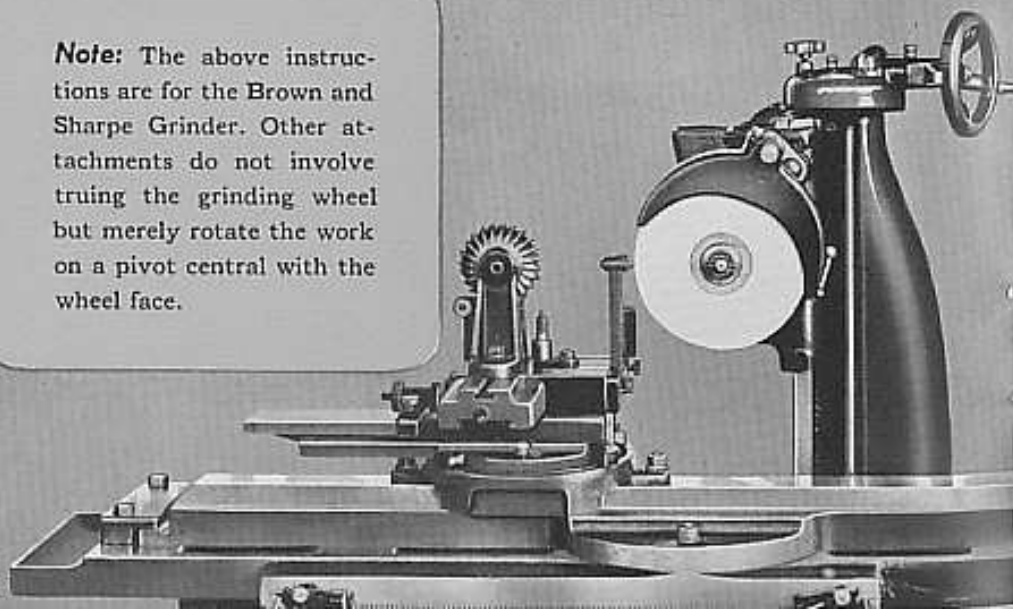
1. Lock the table longitudinally, the wheel running at right angles to it, swivel the diamond and feed the wheel to it with the cross feed on the table.
2. Set the wheel parallel with the table, bring the diamond into line with it and feed forward with the longitudinal table feed while the diamond is swiveled.

After the wheel is properly trued the table should be locked, the attachment work slide should be drawn back and the diamond removed. The

wheel should then be raised or lowered sufficiently to allow necessary clearance. The relation of wheel to the attachment pivot must be maintained.

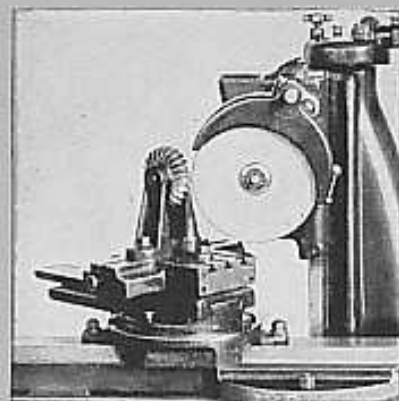
*Set-up for truing the grinding wheel for radial grinding*

**Note:** The above instructions are for the Brown and Sharpe Grinder. Other attachments do not involve truing the grinding wheel but merely rotate the work on a pivot central with the wheel face.



## *Convex Cutter Setup*

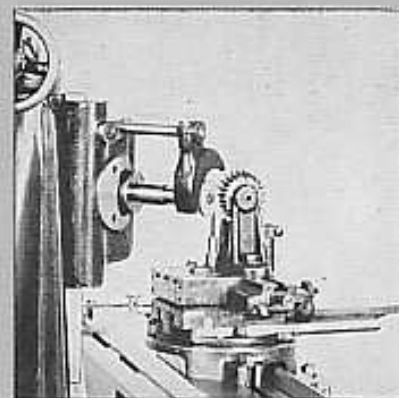
**FOLLOWING** the truing of the wheel to the correct radius, the tooth rest is set into position at the same height as the center of the work holder. The work is then brought forward to the wheel by moving the attachment work slide. The use of harder wheels will lessen wheel wear and consequent loss of the proper wheel shape.



*Grinding the teeth of a Convex Cutter*

## *Concave Cutter Setup*

**FOR** those cutters with small teeth the wheel diameter should be small enough to clear the teeth on either side of the tooth being ground (see illustration). The wheel is trued to the correct radius and the work adjusted as in setting up for grinding convex cutters. Frequent truing of the wheel will be essential as the small wheel running at a relatively low peripheral speed will wear quite rapidly necessitating dressing.

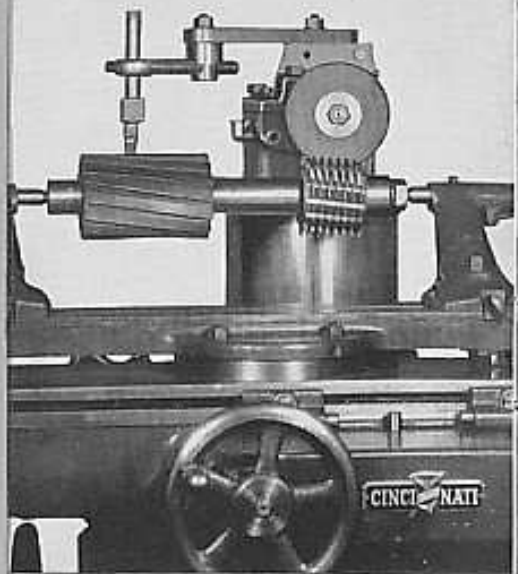


*Grinding one-half of an interlocking Concave Cutter*

## HOB GRINDING

**STRAIGHT-TOOTHED** hobs are ground in the same manner as formed cutters, radially on the faces of the teeth. Preserving the profile of the teeth is particularly important.

The method illustrated involves the use of a master form as a guide for the tooth rest. The master form is milled with the same spiral as the hob and its accuracy determines the accuracy of the hob following grinding. The wheel must be trued to a sharp edge, and angled identically with the cutter which milled the hob.



Grinding a Hob

## *Special Purpose Machine For Hob Grinding*

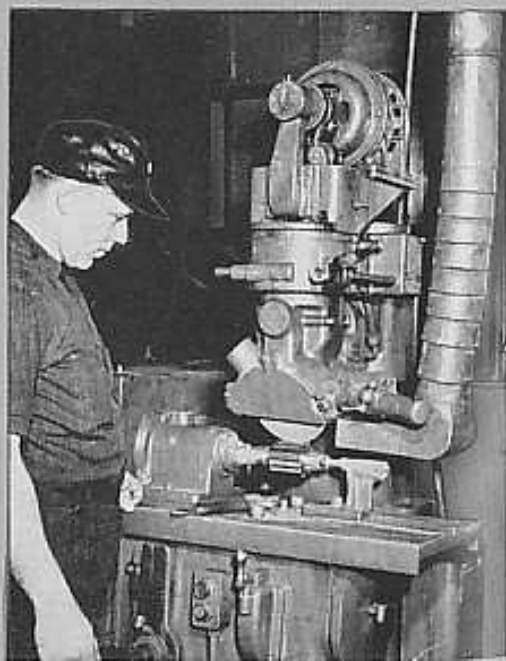
**ILLUSTRATED** is a special machine for sharpening hobs. This machine has a power table traverse and performs the indexing of the work spindle automatically.

These two precautions apply to the use of this machine:

1. Grind radially by truing the wheel and setting the wheel head correctly.
2. Grind the same amount from each tooth.

It is essential that these rules be followed, or the tooth angles will be altered which means the hob will not produce the correct shape on the work.

Grinding a Wide Faced Formed Cutter



# REAMER GRINDING

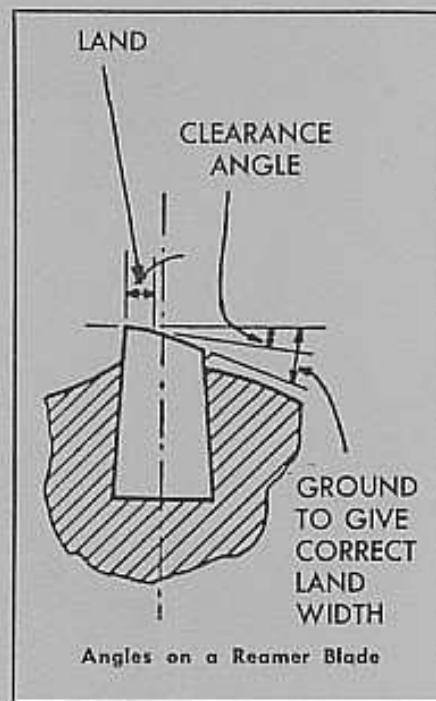
- ★ **General Information..... 42**
- ★ **Hand Reamers..... 43**
- ★ **Taper Reamers..... 44**
- ★ **Special Purpose Machine for  
Circular Reliefs..... 44**

## MORE ACCURACY REQUIRED IN SHARPENING REAMERS

THE sharpening of a reamer is a far more delicate operation than sharpening a milling cutter in that a higher degree of accuracy is required. An error of a few minutes in the clearance angle of a milling cutter does not perceptibly affect the results. The clearance angle of a reamer must be correct to within a few minutes or satisfactory results will not be obtained from its use.

Since a narrow land of constant width is required, two settings are necessary:

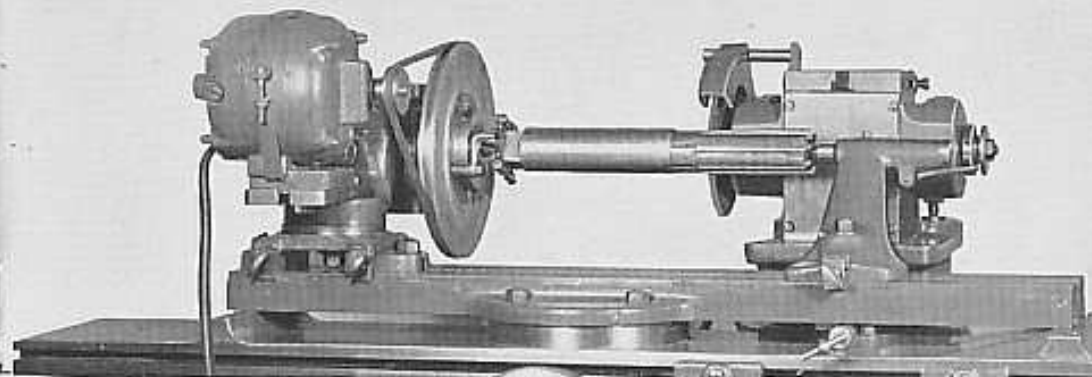
1. Sharpening the reamer by grinding the proper clearance angle.
2. Grinding off the heel of the blade to bring the land to the desired width.



## HAND REAMER FOR CAST IRON OR BRONZE

THE required clearance being so great, the cutting clearance of a hand reamer for cast iron or bronze cannot be ground by the cylindrical method. Also, the reamer will not cut so well as when each blade is ground sepa-

rately. The cutting clearance is first ground in the same manner as a milling cutter and then the blades are backed off or given a secondary clearance. The recommended width to which to grind lands is 0.20" to 0.25".



Cylindrical grinding the cutting clearance of a hand reamer

## HAND REAMER FOR STEEL

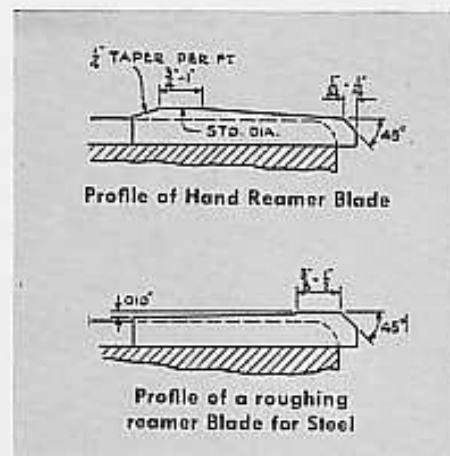
AS the land for hand reamers for steel is only 0.006" to 0.008" wide, the clearance can be ground cylindrically. The wheel must rotate so that the heel of the blade strikes the wheel first, or there will be no clearance.

The slight spring in the reamer as it strikes the grinding wheel gives the clearance required.

The illustration is repeated as the principle is the same as grinding a secondary clearance on a hand reamer.

## Roughing Chucking Reamer For Steel

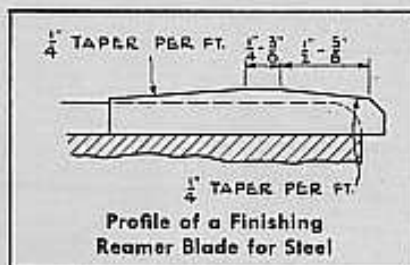
THE bevel corner of the blade should have sufficient clearance to prevent any drag on the heel of the blade as it is the bevel corner which does most of the work. A type 12 dish wheel should be used to avoid changing when setting up for the corners. The secondary clearance is ground first and then the cutting clearance is developed by the cylindrical method. The blade relief is then ground about 0.020" smaller than the hole diameter, allowing approximately  $\frac{1}{16}$ " length of cutting blade. The corners are ground last using the same wheel head settings as for grinding the secondary clearance.





## Finishing Chucking Reamer For Steel

THE cutting done by a finishing reamer is with the front taper and not with the corner. The cutting clearance should be ground cylindrically. To produce the clearance, the heel of the blade must strike the wheel before the cutting edge. The secondary clearance is ground leaving a land 0.006" to 0.008" wide.



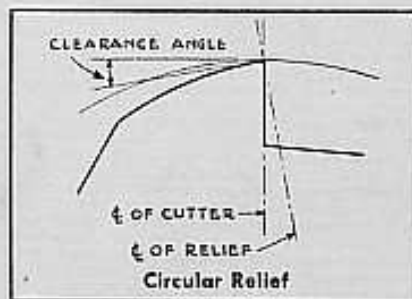
## TAPER REAMERS REQUIRE MORE CARE IN GRINDING

DUE to the taper and the diameter, more care must be exercised in grinding taper reamers. The land should not exceed  $\frac{1}{2}$ " in width. A collet should be used for gauging following grinding. A trial cut is then taken and the hole tested with a standard plug before the reamer is used.

The cutting edges of a straight tooth taper reamer must be straight if satisfactory results are to be obtained. Usually, stoning the teeth is sufficient. However, should the faces be too irregular to be straightened in this manner, they may be ground with a cup or plain wheel.

## Special Purpose Machine For Grinding Circular Reliefs

SPECIAL grinding machines have been designed for grinding a circular relief on the cutting edges of straight or taper reamers, or taps and cutters that have parallel or spiral blades. This is accomplished by truing the grinding wheel face to the correct radius by means of the diamond dresser. This operation affords maximum support to the wheel and, in addition, provides sufficient clearance.



# MISCELLANEOUS TOOLS

★ Regrinding Thread Chasers.....	46
★ Tangent Thread Chasers.....	47
★ Straight Thread Chasers.....	48
★ Tapered Thread Chasers.....	49
★ Tangent Thread Chasers.....	50
★ Tap and Die Chasers.....	52
★ Manufacturer's Recommendations.....	53
★ Milled Chasers.....	54
★ Tables.....	56
★ Circular Thread Chasers.....	60
★ Stoning.....	61

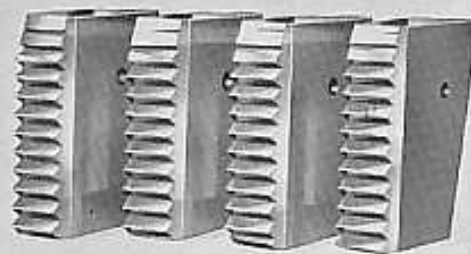
## REGRINDING OF THREAD CHASERS

THE proper regrinding of thread chasers is very important as it results in the die head operating without trouble and in the producing of threads that meet rigid specifications. It is greatly preferred to grind more frequently and obtain thereby high rates of production, rather than to reduce production for the apparent convenience of less frequent grinding. The character of the grind and the methods of obtaining it are very important also.

For purposes of discussion, thread chasers and their grinding are classified into three types as shown in the illustrations which show common examples of each type. While the sharpening of all chasers involves grinding either the cutting edge or the chamfer (throat angle) or both, the methods used may vary with the type of chaser.

Proper grinding equipment will result in more accurate threads at a lower cost per thread due to the more accurate grinding of the chasers. With proper fixtures the chaser can be swung under the grinding wheel so that the chamfer and face of the chaser can be ground at almost any angle and type of grind.

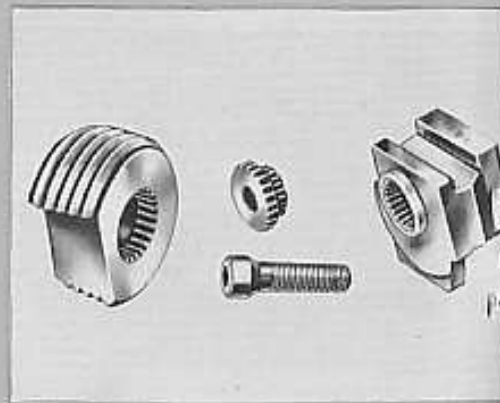
Fixtures are usually applicable to any grinder, such as surface grinders and tool and cutter grinders which have longitudinal, transverse and vertical adjustments as efficiency aids.



Collapsing Tap and Die Chaser



Circular Chaser

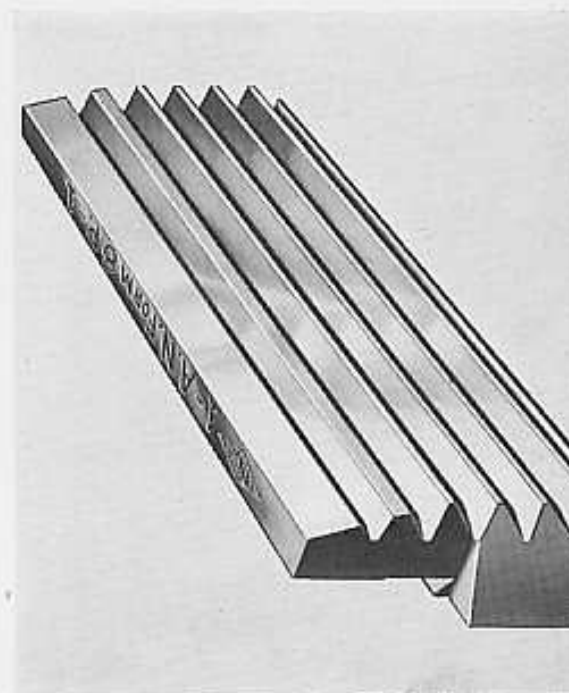


Insert Tap and Die Chaser

## Tangent Thread Chasers

TO facilitate better understanding of the principles involved in the grinding of thread chasers of this type, the chasers have been classified into three groups:

1. *Straight threads cut without the lead screw.* The chaser must act as a lead nut to draw the stock being threaded into the die. This action is controlled by the lead angle.
2. *Straight threads cut with the lead screw.* The leading action of the chaser is not required.
3. *Tapered threads.* The leading action of the chaser is not required.



Tangent Chaser

The following information has been supplied by the Landis Machine Company for their make of chaser. Chasers are given a rake angle in order that they may cut a thread freely and properly. This angle will vary with the machineability of the metal being threaded and must be deter-

mined by experiment. The table shown on the following page shows basic angles that may be used for starting points only. Chasers are usually supplied with a  $22^\circ$  rake angle. This table applies to Landis Machine Co. chasers only. A table for Jones & Lamson chasers is located on page 49.

## RAKE ANGLES FOR TANGENT CHASERS

Courtesy Landis Machine Co.

ANGLES ARE POSITIVE UNLESS OTHERWISE SPECIFIED

Material	Rake Angle	Material	Rake Angle
Cast Brass.....	5° negative to 0°	Seamless Steel Tubing.....	25° to 28°
Drawn Brass.....	10° to 22°	Annealed Nickel Steel.....	25°
Cast Iron.....	15°	Heat Treated Nickel Steel.....	18° to 22°
Wrought Iron.....	18°	Monel Metal.....	28°
Malleable Iron.....	18°	Manganese Bronze.....	0° to 10°
Cast Aluminum.....	10°	Copper.....	28°
Drawn Aluminum.....	28° to 33°	Bronze.....	10°
Basic Steel.....	22°	Bakelite.....	0°

## JONES AND LAMSON CHASERS

### For Straight Threads Cut without the Lead Screw

THESE chasers must be ground as illustrated.

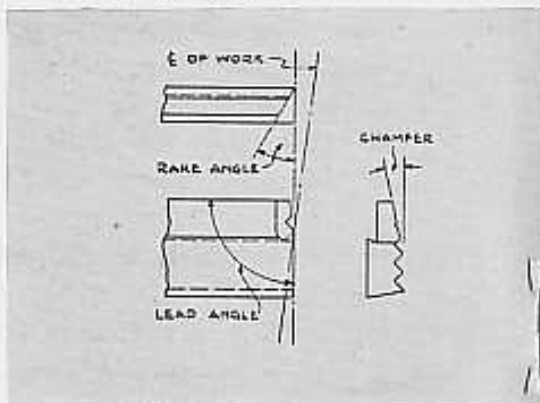
Special threads require individual lead angles which are determined by subtracting from 90 the angle of the special chaser holder in which the chasers are mounted and then adding 3 to the remainder. The angles of special chaser holders are stamped on their under surface or in the sliding-block slots.

The lead angles are such that the rear teeth of the chasers extend beyond the center of rotation when they are set in the chaser holder. Thus a hardened lead nut is formed which gives the die the self-leading feature.

The rake angle must extend from the throat through the first full tooth, which is the finishing tooth and must have the proper rake. The rake angle should include the second full tooth on those chasers designed for cutting threads of 20 pitch and finer. The chaser is said to have "lip" rake

when the rake angle is ground so that it includes the first or second full tooth. The cutting edges of chasers having this "lip" rake must not be beveled or rounded. Basic rake angles are shown in the table as a basis for determining the most efficient angle which should be found by experiment.

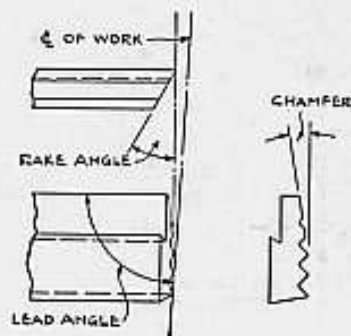
Chaser for threads cut without the lead screw



## Cut With Lead Screw

THE lead angle will vary from 86½° to 88° depending upon the size of the head and the diameter of the work. This applies to N.C. (U.S. Std.), Whitworth, and S.I. threads when cut with lead screws. The lead angles for all N.F. (S.A.E.) and B.S.F. threads should be 87. The lead angles for Acme, square (with 7½ side clearance), round and other special threads can be determined by subtracting the angle of the special chaser holders from 90.

These angles eliminate the self-leading feature of the chasers and allow the lead screw to feed the work into the die without conflict on the part of the chasers.



Thread Chaser for threads cut with the lead screw

The rake angle must extend across the entire width of the chaser. The table shown lists basic rake angles.

## Chasers For Tapered Threads

CHASERS for tapered threads without the taper attachment are similar to those for cutting threads with the lead screw. Lead angles will vary from 88 to 90 1/4 depending upon the head type and size, number of threads per inch and taper per foot.

The rake angles extend the full width of the chaser. Basic rake angles are shown in the table below. The chasers designed for tapered threads and cut with the taper attachment are similar to those designed for cutting a straight thread without a lead screw.

## RAKE ANGLES FOR VARIOUS MATERIALS

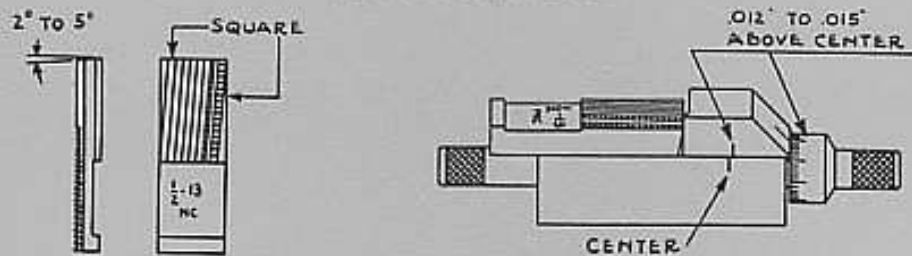
Courtesy Jones & Lamson Machine Co.

Material	Top Rake	Material	Top Rake
Cast Brass.....	5° neg. to 10° pos.	Wrought Iron.....	20° to 25°
Drawn Brass.....	10° to 20°	Steel.....	25°
Manganese Bronze..	25° to 30°	Alloy Steel.....	25° to 30°
Copper.....	30° to 35°	Monel Metal.....	25° to 30°
Cast Iron.....	20° to 25°		

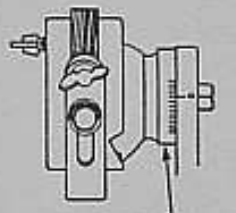
Note: The above angles are for all straight threading. For National Pipe Threading—¾" taper per foot—a 10° top rake is recommended on most materials except brass which require 0 to 8° depending on the analysis. As copper content increases the angle should be increased proportionately to the copper increase.



# STEPS IN GRINDING TANGENT CHASERS



1. Set jig to grind a 2° to 5° rake and straight across until chaser measures 0.015" above center in gage.
2. Set jig head to desired top rake angle and then set the chaser holding block to the angle necessary so that the land narrows parallel with the chamfer. This angle will vary with both the rake and chamfer angles.
3. Grind the top rake in until it cleans up the first full tooth, then grind the chaser until the reading is .006" to .008" above center in the gage.



JIG HEAD. SET THIS FOR TOP RAKE



CHASER HOLDING BLOCK SET SO THAT LAND NARROWS PARALLEL WITH CHAMFER



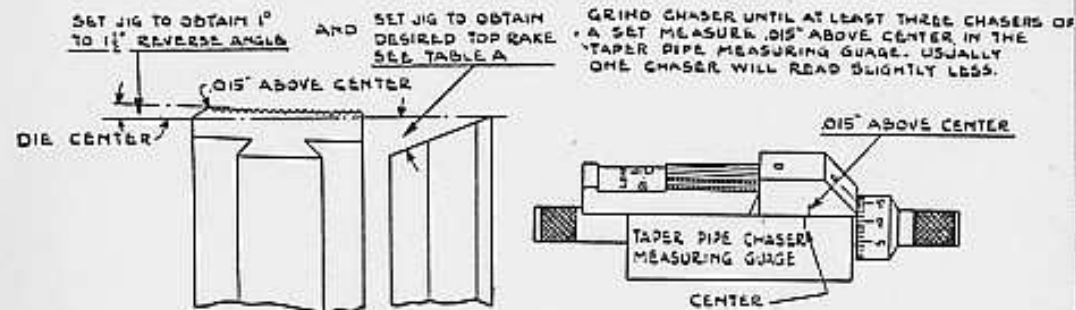
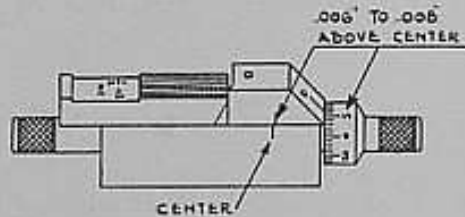
CHASER HOLDING BLOCK SET SO THAT LAND NARROWS PARALLEL WITH CHAMFER

THESE TEETH MUST BE TOO HIGH TO CUT. THEY FURNISH BEARING TO CONTROL THE LEAD.

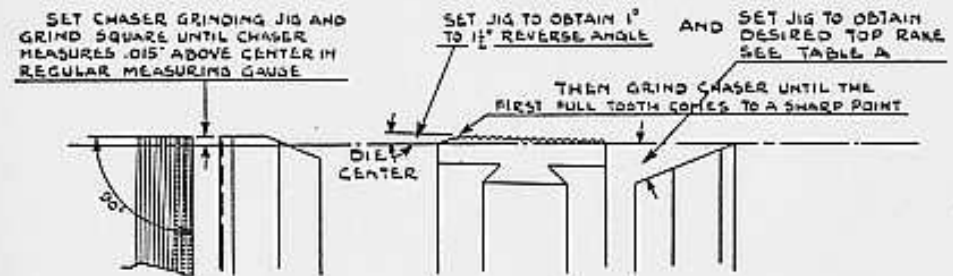


THESE TEETH DO THE CUTTING. IF TOO LOW CHATTER WILL RESULT. IF TOO HIGH THEY WILL START HARD.

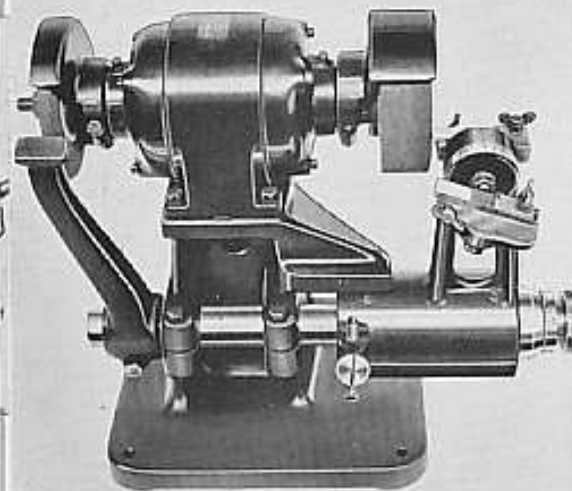
GRIND TOP RAKE IN TO CLEAN UP FIRST FULL TOOTH



Instructions for Sharpening National Taper Pipe Chasers. (3/4" taper per foot) using Taper Pipe Chaser Measuring Gauge



Instructions for Sharpening National Taper Pipe Chasers (3/4" taper per foot) using Standard Measuring Gauge



## GRINDING RAKE

## TAP AND DIE CHASER REGRINDING

THE angle of the throat or chamfer and the clearance and its curvature are important in the regrinding of tap and die chasers. Each chaser in the set should be chamfered the same depth and angle. This insures that each chaser will do its share of the cutting. The following table shows the relation between the angle and the number of threads:



### ANGLE OF CHAMFER IN RELATION TO THREADS

*Courtesy The Geometric Tool Co.*

Number of Threads Chamfered	U.S.S., V, Whitworth Thread Forms	Acme and similar Thread Forms
1	45	33
1½	33	22
2	22	15
3	15	

A long chamfer should be used where possible. A 22 (2 thread) chamfer is usually satisfactory. A 15 (3 thread) or even longer chamfer may be necessary on certain tough materials to produce the desired results. A short chamfer of 45 (1 thread) is usually used when threading close to a shoulder, but sometimes a 33 (1½ thread) chamfer may be

used. The longer the chamfer, the less the strain.

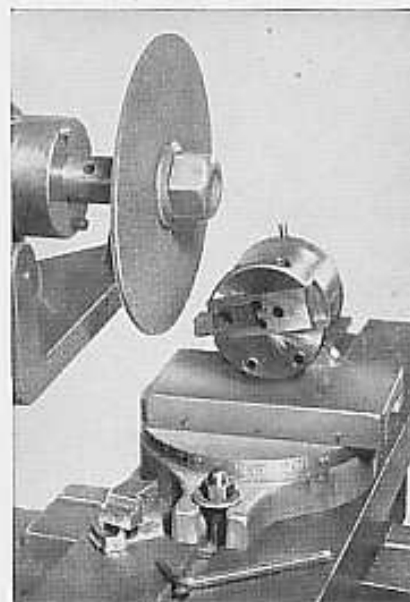
The width of the land must be the same on each chaser in the set. As the cutting edge is ground down nearer to the center in regrinding, the hook angle should be increased slightly. Increasing the hook angle gives the same effect as originally produced prior to the cutting edge's being ground.

## TAPPED CHASER GRINDING

### *Should Follow Manufacturer's Recommendations*

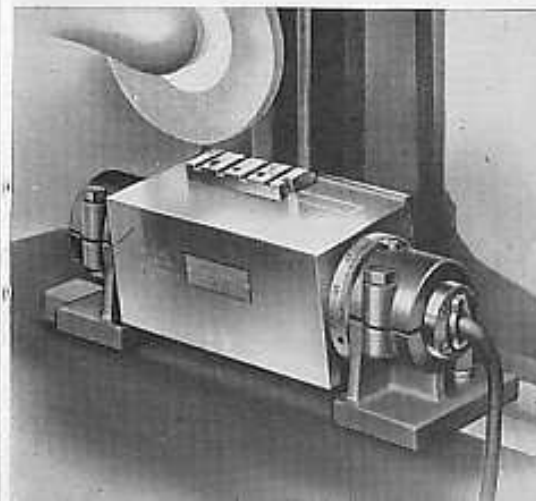
TAPPED or hobbled chasers may be ground on either the cutting face only or on the chamfer, except in those cases where the chasers thread against a shoulder. The cutting edge only should be ground under this condition.

Manufacturers' recommendations differ as to the grinding of tapped chasers. Some companies recommend that all grinding be done on the chamfer with only an occasional touching up on the cutting face because of the difference in design. The recommendation of the tool manufacturer should be followed on such operations.



Grinding the Face of a Die Tap Chaser

Grinding the face of a Chaser



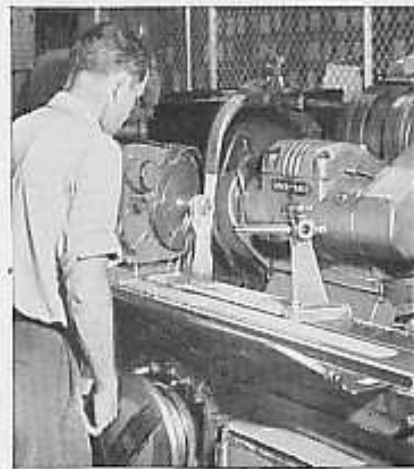
### **Important**

1. Grind each chaser alike.
2. Follow the original grind as closely as possible.
3. Take light cuts and do not grind in one spot.
4. Take a light finishing cut on each of the four chasers with the machine at the same setting.

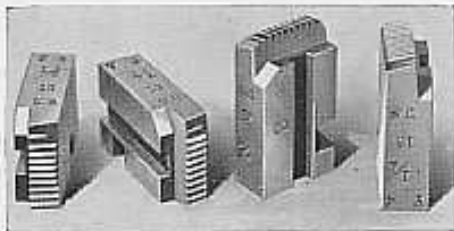
## MILLED CHASERS

MILLED CHASERS are ground on the chamfer for the most part, although they may be touched up on the face where necessary. Irregular and chattered threads result from too much stock being ground off the face of the chaser.

The bottom photograph on page 55 shows the appearance of each chaser in a set when the chamfer is evenly ground. Note that the advance of first thread on each chaser and the chamfer has slightly more clearance.



Grinding the Chamfer on a Chaser

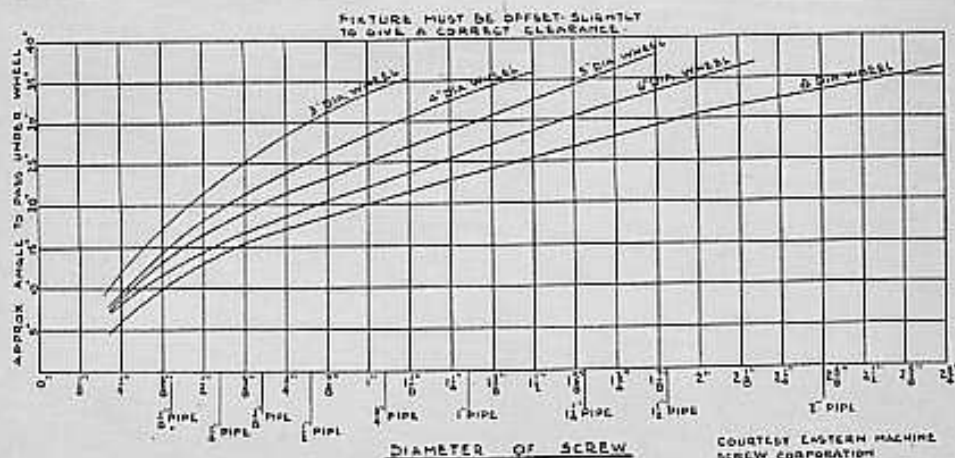


Milled Chasers with original grind



Milled Chasers after continued correct grinding

Chamfer Grinding Chart



**CORRECT**—This figure shows a good chamfer grinding. Note the slight clearance and a concave curvature about the same as the curve of the stock that is threaded.



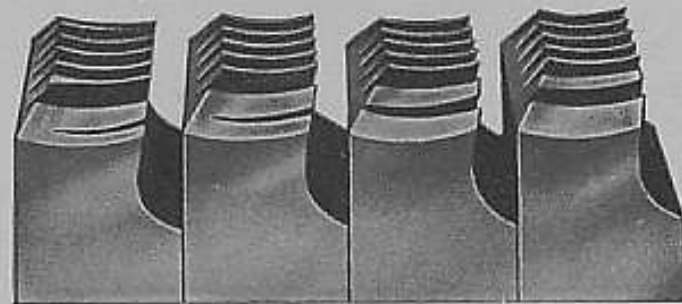
**INCORRECT**—The clearance is too great because the heel is ground low.



**INCORRECT**—The clearance is excessive from too much curvature.



**INCORRECT**—The clearance is convex and will rub and not cut.



**EVENLY GROUND CHASERS IN A SET**—Note the advance of first thread on each chaser when the chamfer is evenly ground and has slightly more clearance than the thread.

## Grinding Wheels Recommended For Efficient Operation

See page 114 of section "Gratings of Tool Room Wheels by 'CARBORUNDUM'."



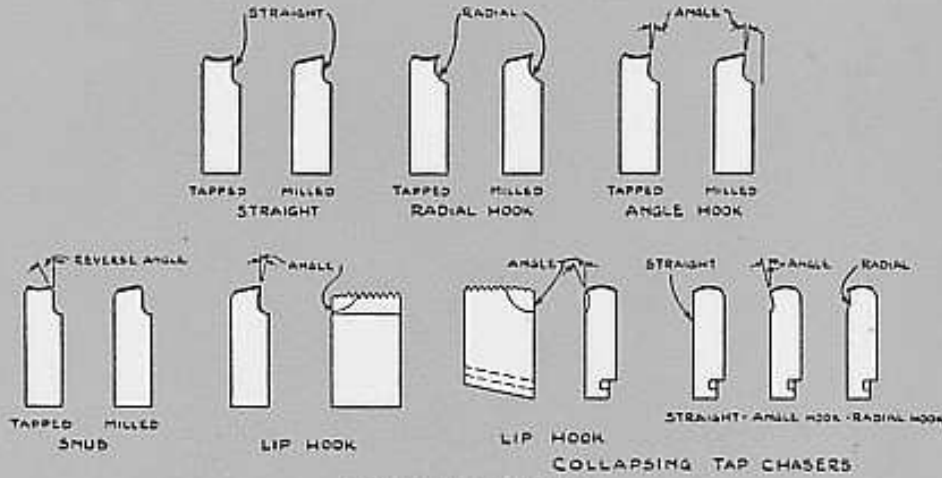
# TABLES

THE following tables show chaser grinds recommended by several manufacturers of chasers. It should be noted that these grinds may be varied to meet specific conditions in the shop.

Tapped and hobbled are terms meaning the same thing as applied to chasers. Tapped and hobbled chasers are the same. Other terms that have identical meanings are—snub, nega-

tive, and reverse angles.

Where differences occur from one manufacturer's recommendation to another, there is usually some difference in design that accounts for different angles recommended. However, there is a difference in opinion in some cases, as to the correct angles for a given operation. Always follow the manufacturer's recommendation.



Face Grinds on Chasers  
CHASER GRINDS RECOMMENDED BY  
THE EASTERN MACHINE SCREW CORP.

Material	Face Grind	Chamfer	Material	Face Grind	Chamfer
Brass, Cast	5°	30°	Monel Metal	15°	20°
Brass, Rod	5°	30°	Open Hearth Hot Rolled	5°	20°
Brass, Drawn	10°	30°	Machinery Steel	10°	20°
Bronze	10°	30°	Hard Rubber	Straight	30°
Copper	15°	30°	Steel Tube	15°	20°
Drop Forging	5°	20°	Tool Steel	15°	15°
Fibre	Straight	30°	Cast Iron	5°	30°
Aluminum	15°	20°	Malleable Iron	5°	30°

## TAP AND DIE CHASER GRINDS RECOMMENDED BY THE GEOMETRIC TOOL CO.

Material	Chasers for Die Heads		Chasers for Taps	
	Milled	Tapped	Straight	Taper
Cast Brass	7° Snub	7° Snub	Straight	Straight
Bar Brass	4° Hook	4° Hook	4° Hook	4° Hook
Brass Forging and Stamping	7° Hook	10° Hook	7° Hook	7° Hook
Brass Tubing	4° Hook	4° Hook	4° Hook	4° Hook
Cast Bronze	Straight	Straight	4° Hook	4° Hook
Bronze Rod and Tubing	7° Hook	10° Hook	7° Hook	7° Hook
Copper	10° Lip Hook	15° Lip Hook	Radial Hook	Radial Hook
Rubber	7° Snub	7° Snub	Straight	Straight
Fibre	7° Snub	7° Snub	Straight	Straight
Cast Iron	Straight	Straight	Straight	Straight
Malleable Iron	7° Hook*	10° Hook*	10° Hook	10° Hook
Bessemer and Open Hearth Screw Steel	7° Hook*	10° Hook*	7° Hook	7° Hook
Drawn Steel Tubing	7° Hook*	10° Hook*	Lip Hook	Radial Hook
Steel Forgings	7° Hook*	10° Hook*	Lip Hook	Radial Hook
Carbon Steels—S.A.E. 1010 to 1095	7° Hook*	10° Hook*	7° Hook	7° Hook
Nickel Steels—S.A.E. 2315 to 2350 and 2512	7° Hook*	10° Hook*	Lip Hook	Radial Hook
Nickel—Chromium Steel—S.A.E. 3115 to 3450	7° Hook*	10° Hook*	Lip Hook	Radial Hook
Chromium Steels—S.A.E. 5120-52100	7° Hook*	10° Hook*	Lip Hook	Radial Hook
Chromium Vanadium Steels—S.A.E. 6120-6195	7° Hook*	10° Hook*	Lip Hook	Radial Hook
Tool Steel	7° Hook*	10° Hook*	Lip Hook	Radial Hook
Stainless Iron and Steel	Lip Hook	Lip Hook	Lip Hook	Radial Hook
Wrought Iron	7° Hook*	10° Hook*	Lip Hook	Radial Hook
Iron and Steel Pipe (Taper Threads)	4° Hook*	4° Hook*	Lip Hook	Radial Hook
Iron and Steel Pipe (Straight Threads)	7° Hook*	7° Hook*	Lip Hook	Radial Hook
Cast Iron Pipe	Straight	Straight	Lip Hook	Radial Hook
Monel Metal	7° Hook	10° Hook	Lip Hook	Radial Hook
Aluminum and Aluminum Alloys	7° Hook	10° Hook	Lip Hook	Radial Hook

Where Specified Radial Hook — 15° Lip Hook — 15°

\*USE LIP HOOK WHEN CUTTING:

Diem. Incl.  
1/4" to 5/16"  
1/2" to 9/16"  
5/8" to 3/4"

In Die Head  
5/16" DS and K  
9/16" D and K  
3/4" D

Pitch  
24 and Coarser  
16 and Coarser  
14 and Coarser

## TAP AND DIE CHASER GRINDS RECOMMENDED BY MODERN TOOL WORKS

Material	Chasers for Die Heads		Chasers for Taps	
	Milled	Hobbed	Straight	Taper
Cast Brass.....	7° Snub	7° Snub	5° Hook	5° Hook
Bar Brass.....	4° Hook	4° Hook	5° Hook	5° Hook
Brass Forging and Stamping.....	7° Hook	10° Hook	10° Hook	10° Hook
Brass Tubing.....	4° Hook	4° Hook	5° Hook	5° Hook
Cast Bronze.....	Straight	Straight	5° Hook	5° Hook
Bronze Rod and Tubing.....	7° Hook	10° Lip Hook	10° Hook	10° Hook
Copper.....	7° Snub	7° Snub	Radial Hook	Radial Hook
Rubber.....	7° Snub	7° Snub	5° Hook	5° Hook
Fibre.....	Straight	Straight	5° Hook	5° Hook
Cast Iron.....	7° Hook*	10° Hook*	10° Hook	10° Hook
Malleable Iron.....	7° Hook*	10° Hook*	10° Hook	10° Hook
Bessemer and Open Hearth Screw Stock.....	7° Hook*	10° Hook*	Lip Hook	Radial Hook
Drawn Steel Tubing.....	7° Hook*	10° Hook*	Lip Hook	Radial Hook
Steel Forgings.....	7° Hook*	10° Hook*	Lip Hook	10° Hook
Carbon Steels—S.A.E. 1010 to 1905.....	7° Hook*	10° Hook*	Lip Hook	Radial Hook
Nickel Steels—S.A.E. 2315 to 2350 and 2512.....	7° Hook*	10° Hook*	Lip Hook	Radial Hook
Nickel—Chromium Steels—S.A.E. 3115 to 3450.....	7° Hook*	10° Hook*	Lip Hook	Radial Hook
Chromium Steels—S.A.E. 5120 to 52100.....	7° Hook*	10° Hook*	Lip Hook	Radial Hook
Chromium Vanadium Steels—S.A.E. 6120-6195.....	7° Hook*	10° Hook*	Lip Hook	10° Hook
Tool Steel.....	7° Hook*	10° Hook*	Lip Hook	Radial Hook
Stainless Iron and Steel.....	Lip Hook	Lip Hook	Lip Hook	Radial Hook
Wrought Iron.....	7° Hook*	10° Hook*	Lip Hook	Radial Hook
Iron and Steel Pipe—Taper Threads.....	4° Hook*	4° Hook*	5° Hook	10° Hook
Iron and Steel Pipe—Straight Threads.....	7° Hook*	7° Hook*	10° Hook	10° Hook
Cast Iron Pipe.....	Straight	Straight	10° Hook	10° Hook
Monel Metal.....	7° Hook	10° Hook	10° Hook	10° Hook
Aluminum and Aluminum Alloys.....	7° Hook	10° Hook	10° Hook	10° Hook

Where Specified Radial Hook = 15° Lip Hook = 15°

\*USE LIP HOOK WHEN CUTTING:

In Die Head

1/2" T and 9/16" W  
1/2" T and 9/16" W  
3/4" T and W

Diagn. Incl.

1/4" to 5/16"  
1/2" to 9/16"  
5/8" to 3/4"

Pitch

24 and Coarser  
16 and Coarser  
14 and Coarser

## TAP AND DIE CHASER GRINDS RECOMMENDED BY THE NATIONAL ACME CO.

Material	Hook Angle	Throat Angle (Chamfer)
Bessemer Screw Stock.....	10°	25°
Cast Iron.....	10°	25-30°
Malleable Iron.....	10°	25-30°
Tabin Bronze.....	10°	25-30°
Tool Steel.....	10-20°	15-20°
Drawn Steel Tubing.....	20-25°	20-25°
Vanadium Steel.....	15-20°	15-20°
Hot or Cold Headed Steel.....	15-20°	25°
Copper.....	20-25°	25°
Aluminum.....	15-20°	25°
Lead.....	15-20°	25°
Monel Metal.....	15-20°	25°
Nickel Steel.....	15-20°	15-20°
Open Hearth Steel.....	10-20°	25°
Cast Brass and Phos. Bronze.....	5° neg.	30-45°
Bar Brass.....	5° neg.	30-45°
Rubber.....	15° neg.	20-25°
Fibre.....	15° neg.	20-25°

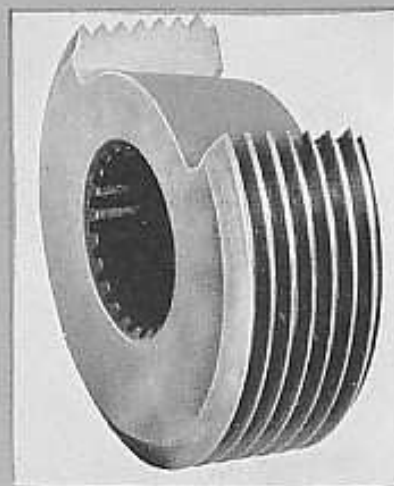
## TAP AND DIE CHASER GRINDS RECOMMENDED BY RICKERT-SHAFER CO.

Material	Die Chaser Face Grd.	Tap Chaser Face Grd.
Aluminum.....	Round Hook	Round Hook
Aluminum Die Casting.....	Straight	Straight
Brass Bar.....	5° Reverse	5° Reverse
Brass, Cast.....	5° Reverse	5° Reverse
Brass Forging and Stamping.....	5° Hook	5° Hook
Brass Tubing.....	5° Hook	5° Hook
Bronze, Cast.....	Straight	Straight
Bronze Rod and Tubing.....	5° Hook	5° Hook
Copper.....	Round Hook	Round Hook
Fibre.....	12° Reverse	12° Reverse
Iron, Cast.....	4° Hook	4° Hook
Iron, Malleable.....	4° Hook	4° Hook
Monel Metal.....	8° Hook	8° Hook
Pipe, Wrought Iron.....	10° Hook	10° Hook
Rubber.....	8° Reverse	8° Reverse
Nickel Steel.....	12° Hook	12° Hook
Screw Stock.....	10° Hook	10° Hook
Steel Forging.....	8° Hook	8° Hook
Steel Tubing.....	Round Hook	Round Hook
Stainless Steel.....	8° Hook	8° Hook
Tool Steel.....	12° Hook	12° Hook

## CIRCULAR THREAD CHASERS

THE hook is ground in order that the chaser may cut normally and the face angle is ground so that the threads at the throat will cut freely while those behind the throat will rub slightly and hold the lead. The chip clearance is to allow more room for the removal of the chip at the throat end of the chaser. The grinding sharpens the hook angle, the face angle, and the chip angle in one operation. Chasers requiring sharpening should have from 0.005" to 0.015" ground from the face. All chasers are ground uniformly on the hook angle.

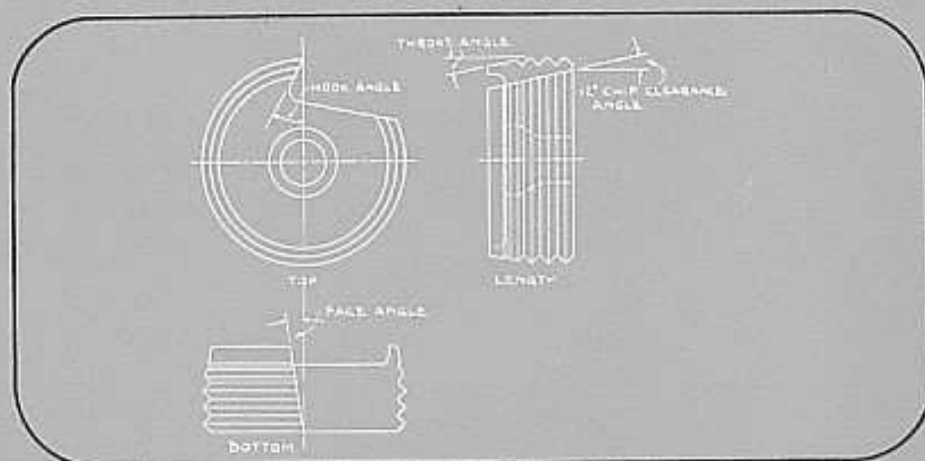
The circular chaser can be ground for any amount of clearance or rub that affords best cutting action. The optimum is obtained by taking a light or heavy cut on the face as required for the desired result. Chasers that are



Circular Thread Chaser

used on machines which allow the die head to "float" a large amount should have less stock removed from the face.

Circular Chaser Terms



## Grinding Wheels Recommended For Efficient Operation

See page 114 of section "Gratings of Tool Room Wheels by 'CARBORUNDUM'."

The following table of angles is basic for the different materials. These angles will vary with the material, the condition of the machine, the

speeds used and the coolant, and the length of throat allowed. With high speeds decrease the face angle and low speeds increase the face angle.

## Angles for Circular Chasers Recommended by the National Acme Co.

Material	Face Angle	Hook Angle	Chip Clearance	Material	Face Angle	Hook Angle	Chip Clearance
Bessemer Screw Stock	1°30'	25°	12°	Monel Metal..	1°30'	25°	12°
Alloy Steels...	1°30'	25°	12°	Cast Brass....	0°	5° neg.	12°
Cast Iron.....	2°	10°	12°	Brass Tubing..	1°	5°	12°
Malleable Iron	1°30'	20°	12°	Bronze.....	1°30'	20°	12°
Tool Steel....	1°	15°	12°	Rubber.....	2°30'	0°	12°
Steel Tubing..	1°30'	25°	12°	Fibre.....	2°	5° neg.	12°
Copper.....	2°	25°	12°	Taper Pipe....	0°	25°	12°
Aluminum....	2°	25°	12°				

## STONING CHASERS AFTER GRINDING

FOLLOWING grinding, chasers should be stoned lightly to remove the burr produced by the grinding and to eliminate "shaving." For this operation The Carborundum Company recommends their silicon carbide

slip stones No. 83 or No. 89. Each has a knife edge of a sharper angle than that on the chaser threads. The stoning should be light so as not to remove stock from the chaser but merely to clean the threads properly.





# DRILLS \* TAPS

## BROACHES

- \* **General Information—Drills..... 64**
- \* **Table of Drill Diameters..... 67**
- \* **Sharpening of Taps..... 68**
- \* **Grinding Faces of Taps..... 69**
- \* **Broaches..... 70**

## DRILLS ARE DIFFICULT TO GRIND

THE demands placed upon the modern high speed twist drill are perhaps greater than those placed upon any other small tool used in manufacturing. This is in spite of the fact that the drill often works under the most adverse conditions and little or no thought is given to its sharpening or conditioning. No other tool is so difficult to grind without the proper equipment. Comparing the results produced by a drill ground in a haphazard manner with those of a drill properly ground and working under ideal conditions reveals a tremendous loss of efficiency.



Group of Drills

There are several requirements for a perfect working drill, the lack of any one of which will result in high drilling costs and many imperfect holes.

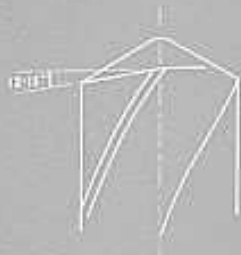
### 1 Equal Length of Cutting Lips



A must equal B



Both lips must be at the same angle



Correct Clearance

EACH lip must be of precisely the same length. If the lips are of unequal length the drill will produce oversize holes, one lip will do all the

cutting, and frequent sharpening will be necessary. High drill and labor costs result as much stock and time are wasted by frequent sharpening.

### 2 Correct and Equal Angle of the Cutting Lips

The angle of the cutting lips must be exactly identical for each lip. This angle is usually  $59^\circ$ . The lip having the smaller angle would produce no

work and again the hole would be oversize and frequent grinding would be necessary. Hence, the emphasis upon each lip angle being identical.

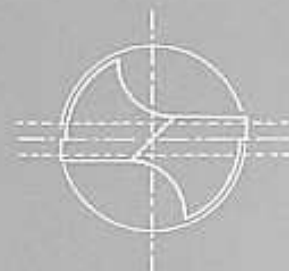
### 3 Correct Clearance Behind the Cutting Edges

Clearance is the relief behind the cutting edges. With too little or no clearance the drill will not cut and with too great clearance the drill will dig in. The clearance should be sufficient to insure free cutting and yet not enough to weaken the cutting edge. It should increase gradually from the periphery to the center of

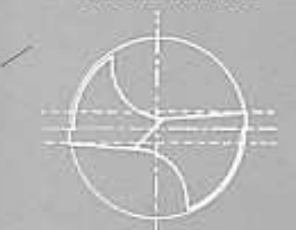
the drill. The clearance usually accepted as standard is  $7^\circ$  at the periphery, increasing toward the center to such an extent that the angle of the web intersection on the lips will be  $130^\circ$  to  $135^\circ$  to the cutting edge. Unequal clearance will result in either the frequent chipping of the cutting edge or the splitting of the drill body.



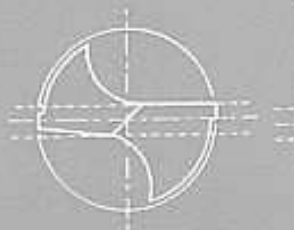
Correct Clearance



Web too thick



Web out of Center



Lips out of Index



Correct

## ④ *Correct Thickness of the Web or Chisel Point*

If the web is too thick, excessive power is required in drilling. If too thin, the point is weakened so that it cannot withstand the thrust of drilling and the drill will fail. Since the web increases in thickness as the shank is approached and since this central web does no cutting it is important that it should not be

thicker at the point than necessary. The point thinning, as this reduction in web thickness is called, should not be carried too far up the flute and it is very important that the exact center of the drill be maintained.

In general the web thickness at the dull point should be about one-eighth of the thickness of the drill,

## ⑤ *Machine Grinding of Drill Most Efficient Method*

Modern maintenance demands accurate machine grinding of drills, for in no other way can they be ground accurately and so produce efficient

drilling. A properly designed drill grinder will sharpen drills that will not only last twice as long, but also drill much faster and more accurately.

## ⑥ *Two Steps in Sharpening a Drill*

- A. Grind the cutting edge which develops the angle and clearance correctly.
- B. Thin the point (pointing) by off-hand grinding a groove on each

side of the flat between the cutting edges on a round faced wheel. Better results can be obtained by utilizing machines designed for the purpose which have fixtures for securing the drills properly.

## ⑦ *Salvaging Drills*

Drills broken or cracked in the web may be salvaged by cutting off the broken section with a thin cutting-off wheel and grinding the cutting

edge as in sharpening operations. The cutting-off wheel should be mounted on a tool or cutter grinder to facilitate efficient and easy action in cutting-off.

## *Grinding Wheels Recommended For Efficient Operation*

- GENERAL SHARPENING OFFHAND** . . . See page 116 of "Gratings of Tool Room Wheels by 'CARBORUNDUM' " section.
- MACHINE SHARPENING** . . . . . See page 116 of "Gratings of Tool Room Wheels by 'CARBORUNDUM' " section.
- POINT THINNING** . . . . . See page 118 of "Gratings of Tool Room Wheels by 'CARBORUNDUM' " section.
- CUTTING OFF** . . . . . See page 118 of "Gratings of Tool Room Wheels by 'CARBORUNDUM' " section.

TABLE OF DRILL DIAMETERS AND WEB THICKNESSES

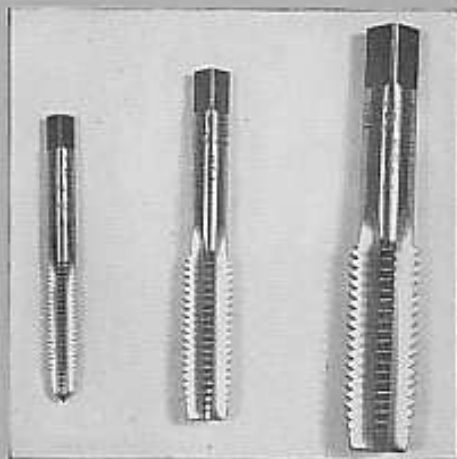
Web		Web		Web	
Diameter	Thickness	Diameter	Thickness	Diameter	Thickness
1/4"	.040"	19/32"	.078"	15/16"	.117"
9/32"	.043"	5/8"	.082"	31/32"	.120"
5/16"	.047"	21/36"	.085"	1"	.124"
11/32"	.050"	11/12"	.089"	1- 1/16"	.131"
3/8"	.054"	23/32"	.092"	1- 1/8"	.138"
13/32"	.061"	3/4"	.096"	1- 3/16"	.145"
7/16"	.064"	25/32"	.099"	1- 1/4"	.152"
15/32"	.068"	13/16"	.103"	1- 5/16"	.159"
1/2"	.071"	27/32"	.106"	1- 3/8"	.166"
17/32"	.075"	7/8"	.110"	1- 7/16"	.173"
9/16"	.078"	29/32"	.113"	1- 1/2"	.180"



## SHARPENING OF TAPS

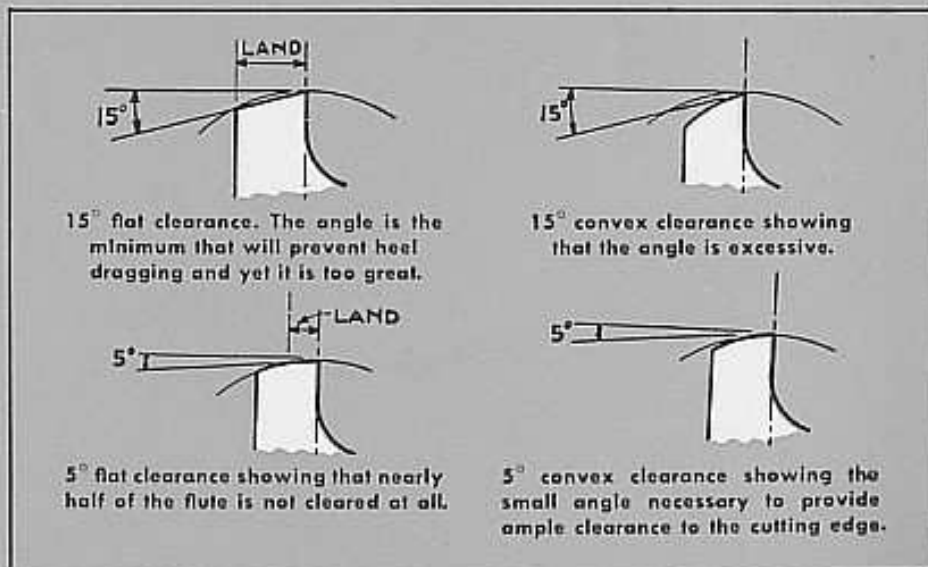
THE sharpening of taps consists generally of grinding the taper at the end and the clearance back of the cutting edge along this taper. Flutes must sometimes be ground, but if the taper and the clearance are properly ground the flute grinding can nearly always be eliminated.

The length of the relief is important and will vary with the type of tap. It is long on nut taps, short on plug taps, and almost zero on bottoming taps. On hand taps the relief usually extends 4 to 5 teeth back from the end. Each flute must have exactly the same angle or the tap will not start true. The accuracy of the grinding can be checked by turning the tap two-thirds through a nut and examining it from the opposite end. The clearance on taps is quite important and should be checked carefully.



Group of Taps

The illustrations below show the various types of clearances which may be produced by different methods and are designed to be self-explanatory.



## Sharpening By Offhand Grinding

TAPS may be sharpened by offhand grinding but a high degree of skill is required and the results are very often unsatisfactory. The flutes may be ground offhand by passing the tap under a grinding wheel which has been trued to the radius of the flute. The use of a tool and cutter grinder insures more accurate and satisfactory work than is possible with the off-hand method.

Broken teeth should be completely ground out. This procedure lowers the efficiency of the tap very slightly.

Should the relief become too long, particularly on bottoming taps, the tap may be shortened by cutting off the unwanted portion with a thin cutting off wheel. The mounting of the wheel on a tool and cutter grinder or regular cutting off machine is recommended for satisfactory results.

## Grinding Faces of Taps

THE faces of taps can be ground in a manner similar to the grinding of formed cutters. The work is held between centers and the tooth rest is mounted on the table with the blade against the face of the groove placed in the tap for chip clearance. Should

this positioning be impossible, the tooth rest blade should then be rested against the heel of the threads. Adjustment of the work to the wheel is accomplished by tapping the tooth rest lightly. This tapping revolves the work very slightly as is desirable.

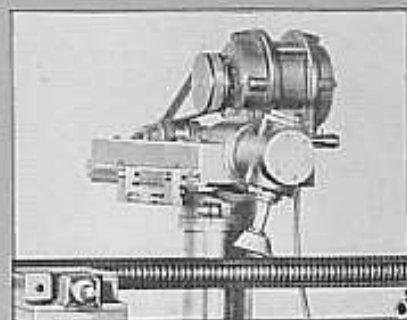
## Grinding Wheels Recommended For Efficient Operation

- SQUARING ENDS.....See page 130 of "Gradings of Tool Room Wheels by 'CARBORUNDUM' " section.
- CUTTING OFF.....See page 130 of "Gradings of Tool Room Wheels by 'CARBORUNDUM' " section.
- GRINDING RELIEF.....See page 128 of "Gradings of Tool Room Wheels by 'CARBORUNDUM' " section.
- GRINDING FLUTES.....See page 130 of "Gradings of Tool Room Wheels by 'CARBORUNDUM' " section.
- POLISHING FLUTES.....See page 130 of "Gradings of Tool Room Wheels by 'CARBORUNDUM' " section.

## BROACHES

### *Backing Off*

A cup wheel is recommended for the backing off operation which affords the teeth proper relief. The turning of swivel head slide enables rectangular or square broaches with angular-cut teeth to be sharpened easily. The teeth are undercut  $6^{\circ}$  to  $10^{\circ}$  to give a curl to the chip. The chip cut by each tooth is 0.001" to 0.007" depending upon the material being worked. The recommended clearance angle is  $30^{\circ}$ .

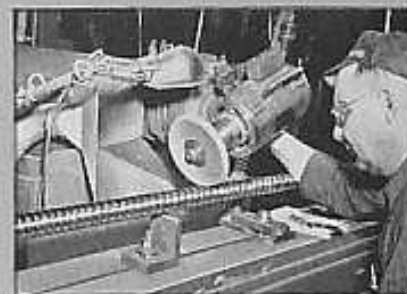


Grinding the Backs of the Teeth of a Broach

### *Sharpening Round Broaches*

THE procedure for sharpening round broaches is as follows: The broach is placed between the headstock and the tailstock center with a lathe dog driving the broach. The swivel head is set at the proper angle (0 to 12 degrees) and is then adjusted further until the grinding wheel is directly over the center of the broach.

The grinding wheel assembly is then followed by the hand wheel until grinding wheel is in the recommended position for efficient broach grinding.



Grinding the Faces of Broach Teeth

### *Grinding Wheels Recommended For Efficient Operation*

- BACKING OFF** ..... See page 112 of "Gradings of Tool Room Wheels by 'CARBORUNDUM'" section.
- FACE GRINDING** ..... See page 112 of "Gradings of Tool Room Wheels by 'CARBORUNDUM'" section.
- NOTCHING** ..... See page 112 of "Gradings of Tool Room Wheels by 'CARBORUNDUM'" section.

# GRINDING OPERATIONS

- ★ Surface Grinding..... 72
- ★ Cylindrical Grinding..... 75
- ★ Internal Grinding..... 78
- ★ Tool Post Grinders..... 78
- ★ Lapping in the Tool Room..... 80
  - Finishing Die and Molds
  - Plug Gages
  - Ring Gages
  - Thread Gages
  - Cylindrical Work

# SURFACE GRINDING

**SURFACE** grinding, one of the more important operations performed in the tool room, is designed to produce accurate flat surfaces from rough planed or milled work. The metal to be surfaced may be fully hardened,

case hardened, or in the annealed condition.

There are several types of surface grinders in general use. Tool rooms may have one or more of the types listed:

- 1 Plain Wheel, Reciprocating Table
- 2 Cylinder Wheel, Reciprocating Table
- 3 Plain Wheel, Rotary Table
- 4 Cylinder Wheel, Rotary Table

As a general rule, the more rigid the machine, the more accurate the results. The best policy is to avoid makeshift equipment and use only those machines designed for surface grinding. There are a few machines,

such as the Universal tool and cutter grinder, which can be successfully setup to perform satisfactory surface grinding in addition to those operations for which the machine was designed and manufactured originally.

## Plain Wheel, Reciprocating Table

**THIS** type of surface grinder is probably the most popular in the tool room for surfacing operations. Machines of this type are generally fitted with a magnetic chuck which may or may not be adjustable so that the work may be tilted.

Care should be exercised in grinding hardened work as it tends to warp during grinding. This warping is particularly prevalent when most of the stock is taken from one side, or when the work is thin. Hardened stock should be roughed carefully and finished all over, taking light cuts only.



**WHEEL** speeds range from 4500 to 5000\* s.f.p.m. and the grinding is usually done dry. Wheel in-feeds are dependent upon the grinding wheel and the work and can be determined best by experience. Usually, 0.002" to 0.010" is used for roughing with 0.00025" to 0.002" recommended for the finishing cuts.

Wheel wear becomes important when grinding large work on this

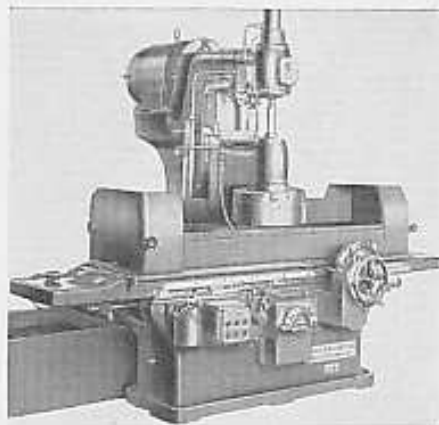
type of grinder, as excessive wheel wear will leave the work tapered if the wheel is fed down only at the start of the pass. Or, if the wheel is fed down at the start of the pass and again when returning across the work excessive wheel wear will cause the work to have a high center. This condition is avoidable by taking more passes with small wheel in-feeds which reduces the wheel wear considerably.

**Important:** Frequent light dressing with a diamond will keep the wheel running true and cutting freely.

**\*Note:** On later models of surface grinding machines designed for high reciprocating speeds, wheel speeds range as high as 6000 s.f.p.m.

## Cylinder Wheel, Reciprocating Table

**THIS** type machine is very popular in tool rooms. The cylinder wheel revolves over a reciprocating table which has no cross feed. The wheel head is set at an angle to provide clearance for the side of the grinding wheel which is doing no cutting. The contact between the wheel and the work is large, and grit and grade of grinding wheel are important. Coarse grit, soft grade and open structured wheels are a necessity for proper grinding results. The wheels should be trued and dressed with a Huntington or a Star type wheel dresser tool.



### GRINDING WHEELS RECOMMENDED FOR EFFICIENT OPERATION

See pages 140-143 inclusive of section "Gratings of Tool Room Wheels by 'CARBORUNDUM'."



## Plain Wheels, Rotary Table

IN grinding circular work this type of machine is of particular advantage as the work revolves under the traversing wheel. The chuck, which is usually magnetic, rotates in a fixed position while the wheel head, mounted on an arm similar to that on a shaper, reciprocates over the work. Parallel work is easily obtained. This machine is useful for grinding the sides of milling cutters, saws, discs, etc. Operating speeds are about 5000 s.f.p.m. Tapered circular work can be ground properly and easily by tilting the chuck head the required amount.



### GRINDING WHEELS RECOMMENDED FOR EFFICIENT OPERATION

See pages 138 and 139 of section "Gradings of Tool Room Wheels by 'CARBORUNDUM'."

## Cylinder Wheel, Rotary Table

TO meet production demands this type of grinder is made in several sizes and has a magnetic chuck which rotates under a cylinder wheel. Because of the large area of contact between the wheel and the work soft, coarse open wheels are recommended.

### GRINDING WHEELS RECOMMENDED FOR EFFICIENT OPERATION

See pages 140-143 inclusive of "Gradings of Tool Room Wheels by 'CARBORUNDUM'" section.



## CYLINDRICAL GRINDING

CYLINDRICALLY ground work is more accurate than turned work. For most work a vitrified wheel is used, but elastic wheels are sometimes used for fine finishing. The machine should have a good foundation—preferably of concrete. Vibration causes inaccurate work and prohibits the production of good

finishes. Where the machine is located on a second floor, it should be placed as near a support as possible so that vibration will be reduced to a minimum.

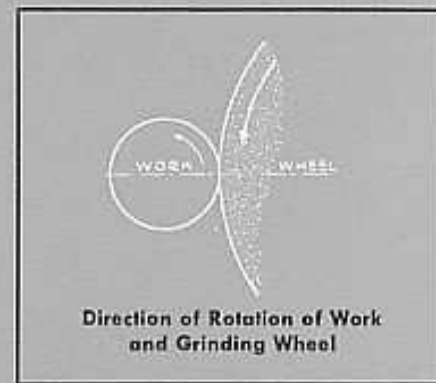
Cylindrical grinding may be done on either a regular cylinder grinder or a universal grinder set up for cylindrical type work.

### Procedure

THE work is held between the headstock and the tailstock. The headstock must be aligned with the platen travel or tapered work will result. The operator cannot rely entirely upon the graduations on the headstock. As a further check toward insuring accuracy, the operator should locate a piece of round stock, grind it and then check the O.D. for parallelism. Work mounted on an arbor must be mounted carefully as an error in mounting is transferred to the work.

If the work has been hardened the centers should be lapped with a 60 lap to remove the

scale. This insures accuracy in the ground piece. The work is usually driven by a dog on one end of the piece which brings up against a driving pin on the face plate. In grinding long, narrow work, back rests used at close intervals will prevent



springing of the work when it passes the grinding wheel.

The direction of rotation of the work should be opposite to that of the wheel (see Illustration, Page 75).

The work speed may be from 15 to 60 feet per minute de-

pending upon the work. The speed may be faster for finishing cuts than for roughing cuts. The wheel speed should be increased if the wheel acts soft and reduced if the wheel acts hard. General recommended work speeds are as follows:

- 1 ROUGHING . . . 20 to 30 feet per minute
- 2 FINISHING . . . 30 to 40 feet per minute

The traverse speed should be in proportion to the width of the wheel and the finish desired. The following rules may be used:

- 1 Heavy machines— $\frac{1}{2}$  to  $\frac{3}{4}$  of the wheel width for each revolution of the work.
- 2 Light machines— $\frac{1}{3}$  to  $\frac{1}{2}$  of the wheel width for each revolution of the work.
- 3 Very fine finish— $\frac{1}{4}$  to  $\frac{1}{3}$  of the wheel width for each revolution of the work.

The depth of cut (wheel in-feed) will vary with the finish desired and is also dependent upon whether the grinding is done with or without a coolant. When grinding cast iron, a nar-

row traverse and a heavier cut are used. Lighter feeds are required for dry grinding. In general, the following depths of cut may be recommended for the grinding of ordinary metals:

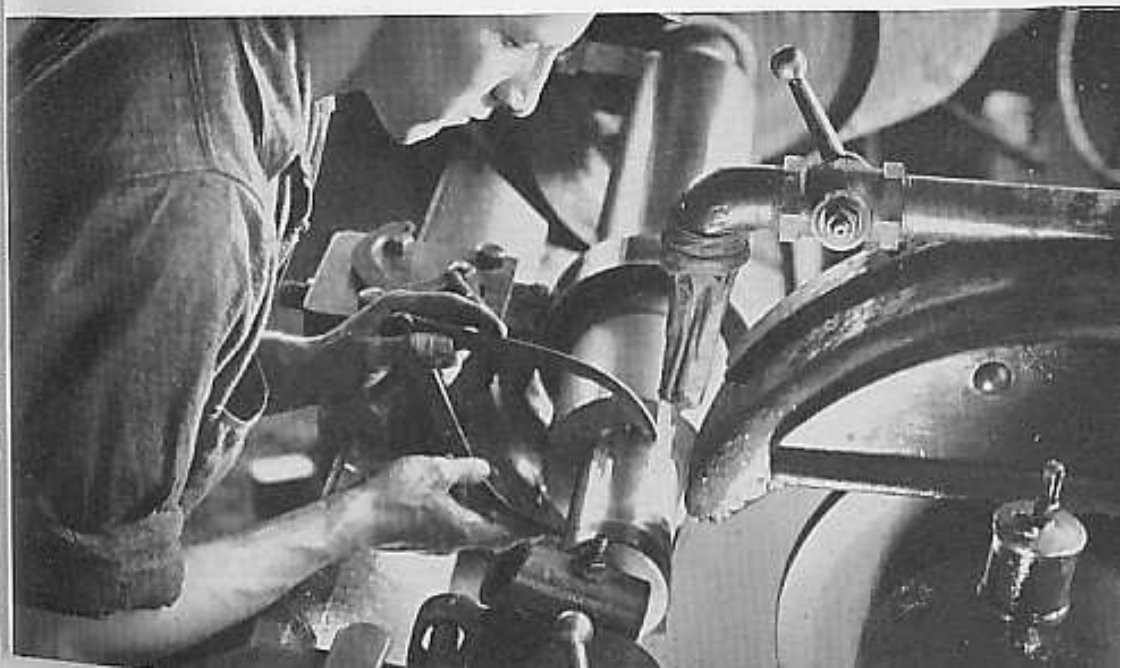
- 1 ROUGHING . . . 0.001" to 0.004"
- 2 FINISHING . . . 0.00025" to 0.0005"

Allowances for grinding will vary with the diameter and length of work. Generally an allowance of 0.006" to 0.010" is accorded work that is short and not to be hardened. For long and large work that is to be hardened 0.020" to 0.030" should be allowed. When not enough allowance is given the work will not grind out. When too much allowance is given

the grinding time is too long. The wheel should be trued and dressed with a diamond to insure running truth and rapid cutting rates on operations.

A solution of water and sal soda is recommended for wet grinding operations of this sort.

The allowance for lapping for removal of wheel marks may vary from 0.0002" to 0.0004", depending upon the type of work.



## INTERNAL GRINDING

INTERNAL grinding may be done on a Universal tool and cutter grinder by means of an internal grinding attachment. This attachment consists of a spindle driven from the regular wheel spindle and used in conjunction with the cylindrical grinding attachment which holds and drives the work. Allowances on the work for grinding should be a little less than those afforded for external grinding. Softer wheels are used than for cylindrical grinding because of the greater



contact between the work and the wheel. Mounted wheels may be used for the grinding of most small work.

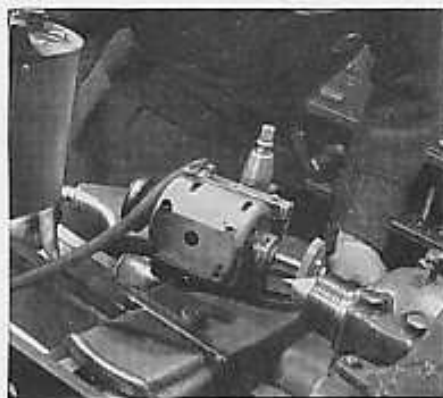
### GRINDING WHEELS RECOMMENDED FOR EFFICIENT OPERATION

See pages 138-141 inclusive of section "Grindings of Tool Room Wheels by 'CARBORUNDUM'."

### *Tool Post Grinders*

TOOL post grinders are small motor or air driven grinders which may be employed on diversified grinding operations. As these grinders are portable they can be easily mounted on various machines to produce many varieties of work.

Tool post grinders are not restricted in use to a single type of grinding. That is, the same grinder may be used for both internal and surface grinding. (See illustrations.) This versatility of



Cylindrical Grinding

application makes them especially valuable in the small shop where capital output for machine equipment is necessarily restricted.

The correct grinding wheel to use on any specific operation will depend upon the type of operation, the material and various other factors such as individual shop experience, machine equipment available, etc.

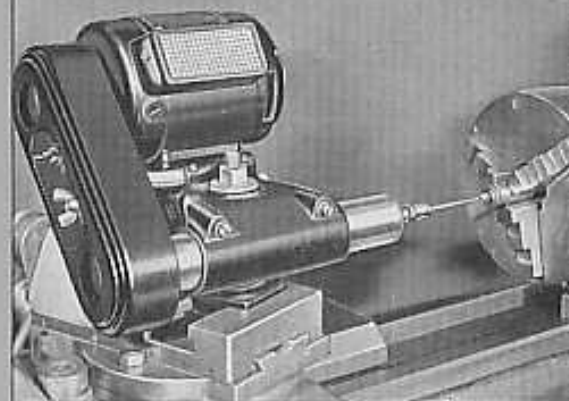
However, it is possible to use a single grading on many operations on several materials by making a compromise on rate of stock removal, finish or wheel wear. The grinding wheel gradings recommended in this section are general purpose wheels only, and not rigid specifications.

In general, the silicon carbide gradings should be used for cast iron, brass, etc., while the aluminum oxide gradings are best on the steels. It is recommended that several grits and grades of grinding wheels be kept at hand so that a variety of work can be ground efficiently. The following factors should be considered:

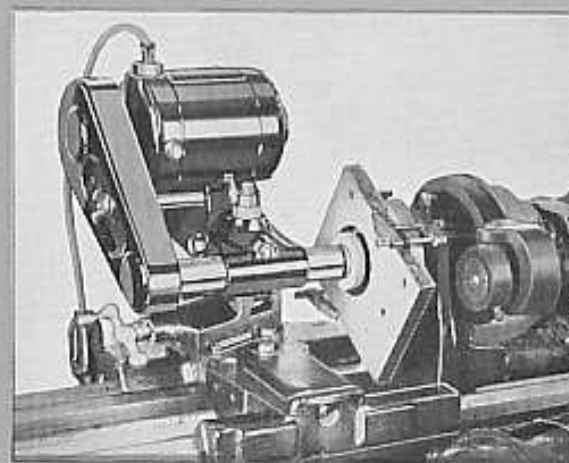
1. The harder the work, the softer and finer the grinding wheel.
2. The larger the area of contact between the wheel and the work the softer and coarser the wheel.

### GRINDING WHEELS RECOMMENDED FOR EFFICIENT OPERATION

See pages 138 and 139 of section "Grindings of Tool Room Wheels by 'CARBORUNDUM'."



Internal Grinding with a Mounted Wheel (Note shank support for grinding a small deep hole.)



Internal Grinding

Surface Grinding on a Shaper





## LAPPING IN THE TOOL ROOM

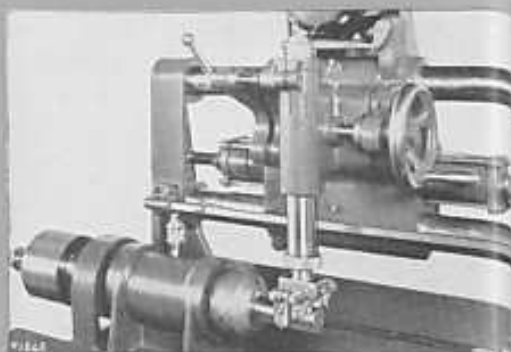
THERE are numerous lapping or polishing operations performed in the tool room. The Carborundum Company manufactures a complete line of finishing compounds for any material or operation.

Several principles of lapping should be considered for more efficient finishing:

- 1 The material of which the lap is made has a decided influence upon the speed, accuracy and finish of the work. The harder the lap the slower the cut, the greater the accuracy the duller the finish and the more rapid the wear on the lap.
- 2 Laps should be softer than the material to be lapped.
- 3 Speed of the lap is of no importance under 800 s.f.p.m. Higher speeds improve finish but slow up cutting action.

### *Write for Complete Information*

LITERATURE giving detailed information on lapping will be furnished you upon request. Simply contact the Carborundum District Sales Office serv-



ing the territory in which your plant is located or address your requests for information to The Carborundum Company, Niagara Falls, New York.

## *Finishing Dies and Molds*

FINISHING compound should be used with abrasive sticks for the final shaping and rough finishing operations. The combined action of the com-

pound and the stick produces a fine finish with no sacrifice in cutting speed.

For finishing, the following are recommended:

1. **ROUGHING:** R7 Fine with a wood or cast iron lap.
2. **ROUGH FINISHING:** H440 Coarse with an orange stick.
3. **FINISHING:** H440 Medium with a chrome leather lap.
4. **POLISHING:** W440 Extra Fine with a hard white felt lap or, if a higher polish is desired, use H46 Medium as recommended with a soft rag lap.

## *Lapping Plug Gages*

FOR hand lapping plug gages an allowance of 0.0002" is sufficient when the ground surface is excellent. Lap with a split adjustable ring type lap of grey iron. Rotate the gauge and oscillate the lap over the surface using H440 Coarse for rapid stock removal and H440 Medium for high finish. The

pressure between the lap and the work should not be great as crushing of the abrasive will result. Polishing is accomplished satisfactorily by applying H46 Fine Compound. The compound should then be allowed to dry and then buffed with a soft, clean dry cloth. The softer the cloth used the higher the polish.

## Lapping Thread Gages

**T**HREAD gages are lapped with laps similar to those used for plug and ring gage surfaces with the exception that the proper threads are cut in the working surface of the lap. The direction of rotation of the

gage is reversed in order to lap both thread profiles equally and the lap is returned to the starting point. The grade of lapping compound that is to be used will depend upon the number of threads per inch—

10 to the inch and coarser .....	W 40 Medium
Finer than 10 to the inch .....	W 40 Fine
For extra fine work use or follow with W 440 Extra Fine	

## Lapping Ring Gages

**T**O overcome the tendency of ring gages to become bell-mouthed during the lapping operation many tool makers allow extra width on the ring. This excess is cut off after the lapping operation has been completed.

The ring should be revolved at

about 250 r.p.m. and the compound applied to an expanding cast iron or brass lap in the hole. H440 Medium compound is recommended for small holes and H440 Coarse for larger ones. The holes should be polished in the same manner as the plug gages.

## Lapping Cylindrical Work

**C**YLINDRICAL work is lapped by rotating the work and applying the compound to either half of a "lemon squeezer" lap lined with leather. As

the work rotates the lap should be oscillated to avoid lines. The grade of compound will depend upon the fineness of the finish desired:

For Rough Ground Surfaces .....	W 7 Coarse
For Smooth Ground Surfaces .....	W 7 Medium
For Fine Ground Surfaces .....	W 7 Fine
For High Polishes After Above .....	W 440 Extra Fine

# SPECIAL ABRASIVE PRODUCTS *and* TABLE OF WHEEL SPEEDS

★ "MX" Wheels—Mounted Wheels— Sticks .....	84
★ "ALOXITE" Tool Room Stick .....	86
★ Coated Abrasives .....	88
★ Diamond Wheels .....	90
★ Table of Wheel Speeds .....	94

# "MX" . . . WHEELS · MOUNTED WHEELS STICKS

DEVELOPED by "CARBORUNDUM" engineers primarily to facilitate the removal of disturbed metal caused by previous machining or grinding operations, "MX" offers a new type of bond. This new type of bond produces five unusual features for "MX":

**1. CUSHION ACTION.** Because of its composition, "MX" is unusually resilient. It has a soft cushion-like cutting action which reduces any tendency towards vibration or chatter . . . and it is fast and effective . . . it gives a smooth, uniform finish.

**2. SELF-CLEANING.** "MX" is also self-cleaning to a marked degree. It seldom loads up even when working on the softer metals or alloys.

**3. VERSATILE.** The wide range of operations on which "MX" is used

proves it to be one of the most versatile of all abrasive tools. It has been used successfully for finishing and polishing steel and steel alloys, copper, aluminum, aluminum alloys, magnesium, etc.; also for production operations connected with resins, rubber, plastics, and glass.

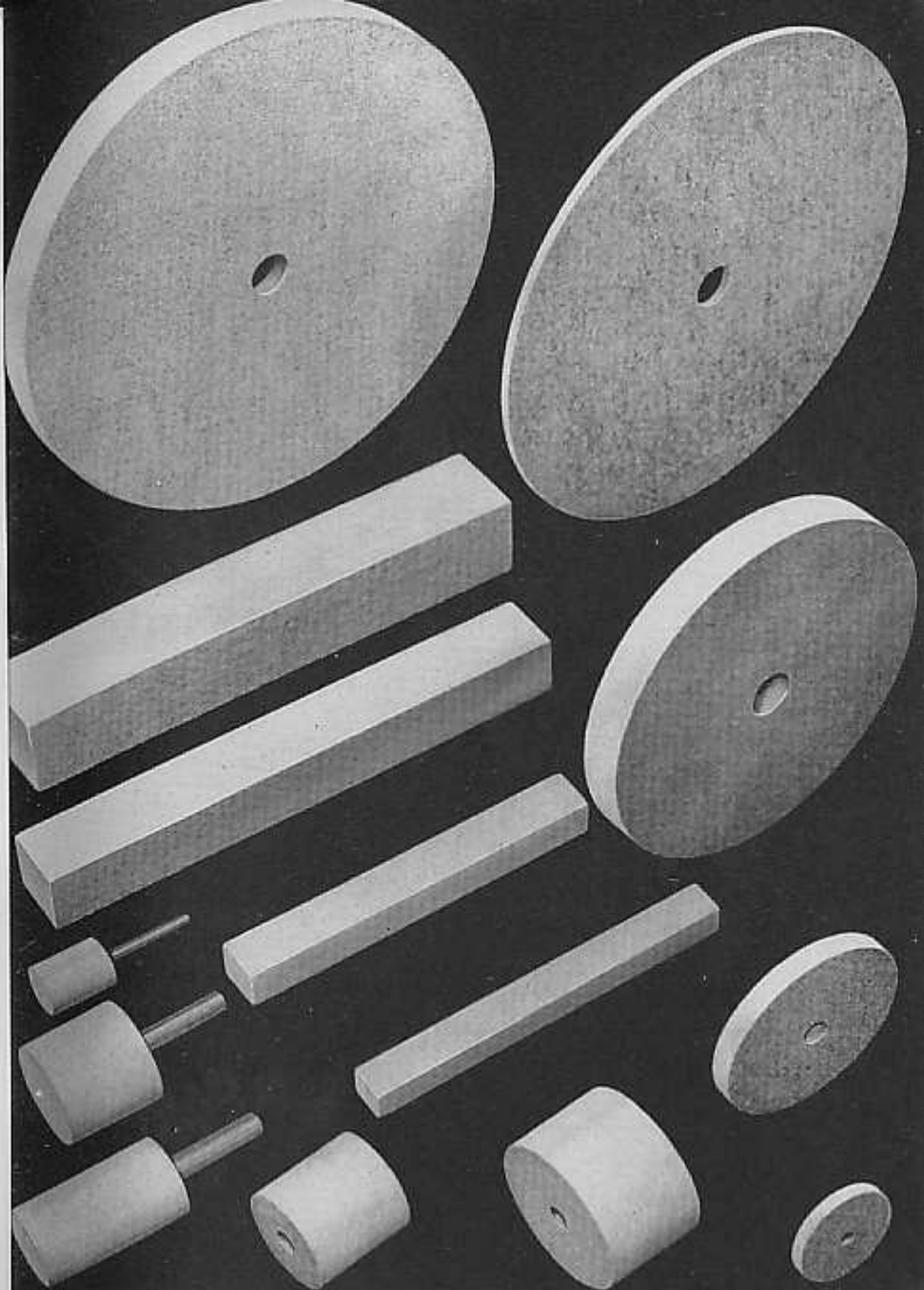
**4. SAFE OPERATION.** "MX" Wheels normally operate at the high speeds usually employed with organic wheels. "MX" Wheels possess high tensile strength and resistance to impact and heat shock.

**5. LONG LIFE AND RE-USE.** "MX" works fast . . . wears slowly . . . and is usable "right down to the arbor hole." "MX" Wheels may be dressed down and combined for re-use on various operations.

## *Send for Information Concerning "MX"*

Literature pertaining to "MX" Products and their many possible applications in your factory is available to you upon request. Contact the "CARBORUNDUM" District

Sales Office serving the industrial territory in which your plant is located, or you may address your inquiry direct to The Carborundum Company, Niagara Falls, New York.





# "ALOXITE"

## TOOL ROOM STICKS

Tool makers and general mechanics will find that "ALOXITE" Aluminum Oxide Sticks are fast cutting . . . and, in addition, that they hold their shape.

These sticks are made in round, triangular, square, and half-round shapes. They are used for quickly and smoothly touching up the edges and corners of dies and molds, jigs, metal patterns, gear

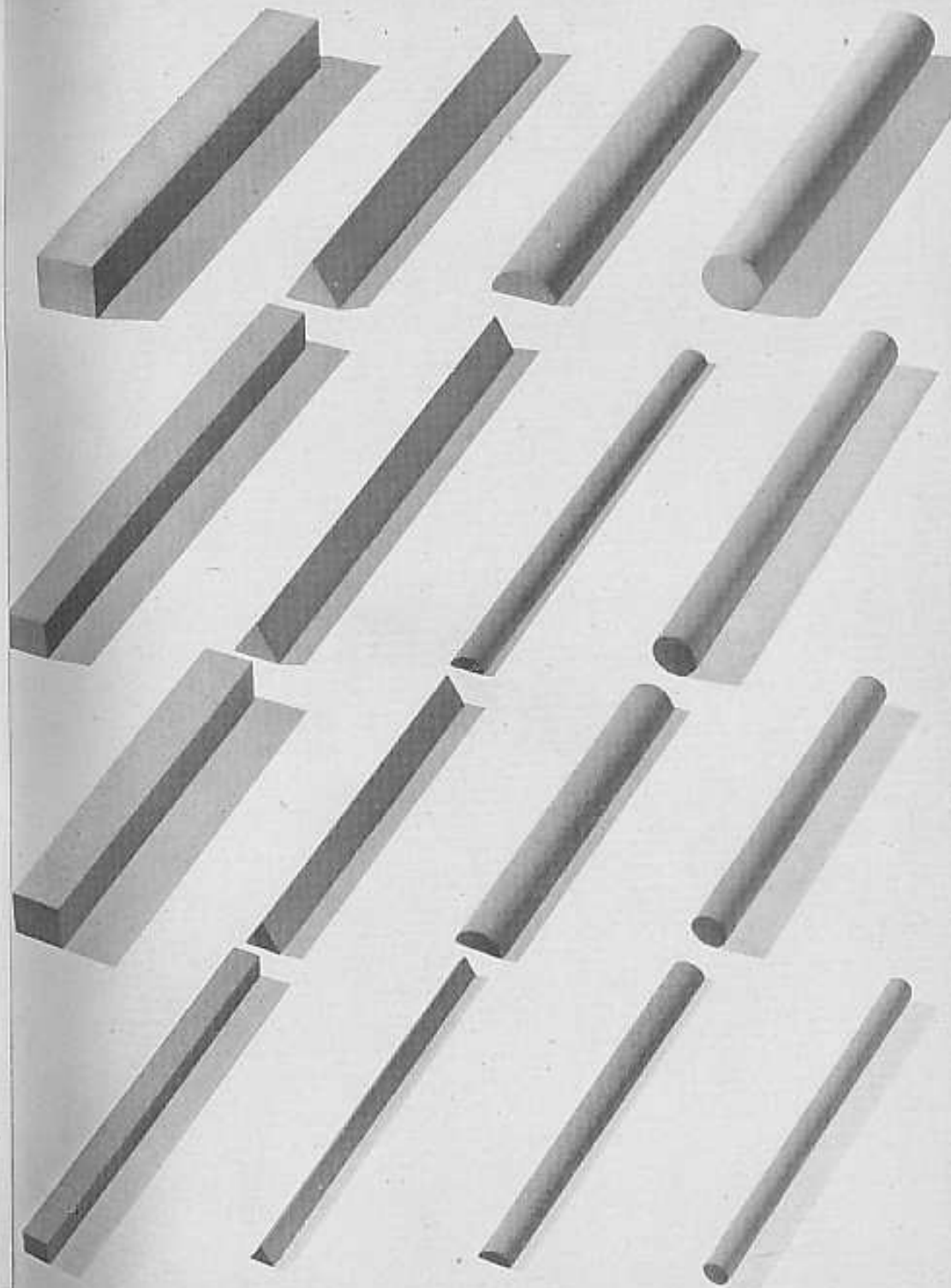
bushings—for stoning up work—for countless uses where the steel file doesn't cut the metal . . . or where the space is too small in which to use a grinding wheel.

They are manufactured in four and six inch lengths . . . and in fine, medium, and coarse grits. Every "ALOXITE" stick is graded hard enough to stand up . . . and, at the same time, cut fast and fine.

### *Write for Complete Information*

Literature containing information and specifications pertaining to the complete "CARBORUNDUM" line of "ALOXITE" Tool Room Sticks will be forwarded to you promptly at your request.

Contact the "CARBORUNDUM" District Office serving the industrial territory in which your plant is located . . . or you may write direct to The Carborundum Company, Niagara Falls, New York.



# COATED ABRASIVES

by "CARBORUNDUM"

In addition to the grinding wheels of many types illustrated on preceding pages, The Carborundum Company also produces a *complete* line of coated abrasives.

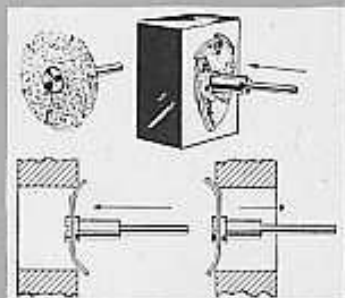
Each product in the "CARBORUNDUM" Coated Abrasive line is manufactured for a specific purpose with application to a definite range of abrasive requirements.

## Contact "CARBORUNDUM" for Information

Literature containing information and specifications concerning the use of Coated Abrasives manufactured by "CARBORUNDUM" will be provided upon request.

Contact the "CARBORUNDUM" District Sales Office serving the industrial territory in which your plant is located . . . or, address your request direct to The Carborundum Company, Niagara Falls, New York.

Burring Hole Edges with Flexible Slotted Abrasive Cloth Discs.



Typical Metal Finishing Operations with Coated Abrasives



# DIAMOND WHEELS

by "CARBORUNDUM"

The technical requirements of higher tool efficiency and greater speed in production will often demand the properties possessed by the Diamond Wheel (for cemented carbide tools and

hard vitreous materials only).

Developed initially by The Carborundum Company over ten years ago, this type of wheel has been improved and developed to its present position of wide use.

## Standard Diamond Wheel Types

Diamond Wheels by "CARBORUNDUM" are manufactured in a variety of cup and dish wheel shapes in addition to plain or straight wheels for a wide range of grinding operations.

They are also produced in the form of "cutting-off" wheels 1" to 12" in diameter for parting operations. Small wheels, 1/2" and smaller in diameter are made with diamonds throughout the wheel. Wheels larger than 1/2"

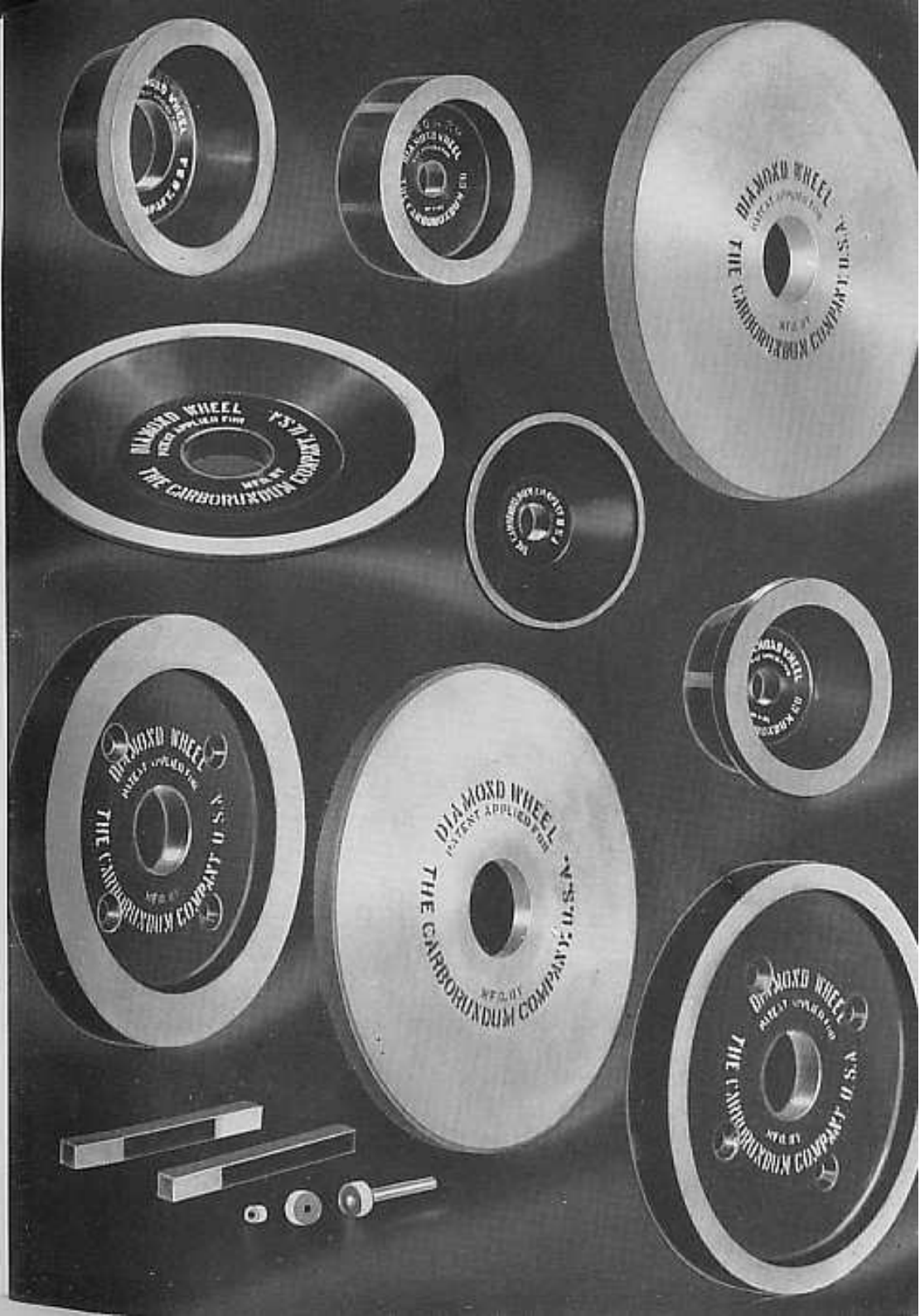
diameter are usually produced with a diamond coating on the grinding surface.

Small points are mounted on mandrels and are used for internal grinding, die work, and other similar operations. In addition, diamond wheels in various diameters and thicknesses are also manufactured with a variety of formed faces, in both "V" and rounded types, for use in grooving and forming operations.

## Standard Grit Sizes

Diamond Wheels manufactured by The Carborundum Company are available in grit sizes that will fulfill the requirements of all cemented carbide grinding . . . from rough grinding to the very

finest finish grinding. Coarse grit sizes result in higher rates of stock removal and coarser finishes. Fine grits lower the rate of stock removal and produce better finishes to meet requirements.





Standard grit sizes are:  
80, 90, 100, 120, 150, 180, 220,  
240, 320, 400, 500.

Additional grit sizes are also obtainable as they may be needed to meet your requirements.

## *Standard Diamond Wheel Bond Types*

Diamond Wheels by "CARBORUNDUM" are available in three bond types:

**RESINOID** gives a maximum cutting rate, and produces a wheel that requires very little dressing, remains sharp for long periods of time, builds minimum wheel pressure, gives low wheel loss per grind, is easy for the operator to use, and offers greater protection to heat sensitive carbide tips.

**METAL** is recommended for off-hand grinding and cutting off operations. It is exceptionally

durable and wheel breakdown or disintegration is minimized. Furthermore, it holds form extremely well—resisting wear on radius work and on small areas of contact as well as on form grinding. **VITRIFIED** covers a range of cutting rates and efficiencies intermediate between resinoid and metal bonds.

For grade recommendations of Diamond Wheels, refer to the "Gradings" section of this book. You will note that the Diamond Wheel gradings require a special and separate marking system.

## *For Complete Information Contact "CARBORUNDUM"*

Literature giving complete information on Diamond Wheels by "CARBORUNDUM" will be provided at your request. Our representatives will be pleased to assist you in the selection of a Diamond Wheel to meet your requirements.

Contact the "CARBORUNDUM" District Office serving the industrial territory where your manufacturing plant is located . . . or, address your request direct to The Carborundum Company, Niagara Falls, New York.

# Table of Grinding Wheel Speeds

### LOW SPEED TABLE

Diameter of Wheels in Inches	4,000 S. F. M.	4,500 S. F. M.	5,000 S. F. M.	5,500 S. F. M.	6,000 S. F. M.	6,500 S. F. M.
1	15,279	17,189	19,098	21,008	22,918	24,828
2	7,639	8,594	9,549	10,504	11,459	12,414
3	5,093	5,729	6,366	7,003	7,639	8,276
4	3,820	4,297	4,775	5,252	5,729	6,207
5	3,056	3,438	3,820	4,202	4,584	4,966
6	2,546	2,865	3,183	3,501	3,820	4,138
7	2,183	2,455	2,728	3,001	3,274	3,547
8	1,910	2,148	2,387	2,626	2,865	3,103
10	1,528	1,719	1,910	2,101	2,292	2,483
12	1,273	1,432	1,591	1,751	1,910	2,069
14	1,091	1,228	1,364	1,500	1,637	1,773
16	955	1,074	1,194	1,313	1,432	1,552
18	849	955	1,061	1,167	1,273	1,379
20	764	859	955	1,050	1,146	1,241
22	694	781	868	955	1,042	1,128
24	637	716	796	875	955	1,034
26	588	661	734	808	881	955
28	546	614	682	750	818	887
30	509	573	637	700	764	828
32	477	537	597	656	716	776
34	449	505	562	618	674	730
36	424	477	530	583	637	690

The American Standards Association Safety Code for the Use, Care and Protection of Abrasive Wheels Will be Mailed on Application.

REVOLUTIONS PER MINUTE  
FOR VARIOUS SIZES OF GRINDING WHEELS  
TO GIVE PERIPHERAL SPEED  
IN FEET PER MINUTE AS INDICATED

### HIGH SPEED TABLE

7,000 S. F. M.	7,500 S. F. M.	8,000 S. F. M.	8,500 S. F. M.	9,000 S. F. M.	9,500 S. F. M.	10,000 S. F. M.
26,738	28,648	30,558	32,467	34,377	36,287	38,197
13,369	14,324	15,279	16,234	17,189	18,144	19,098
8,913	9,549	10,186	10,822	11,459	12,096	12,732
6,684	7,162	7,639	8,117	8,594	9,072	9,549
5,347	5,730	6,111	6,493	6,875	7,257	7,639
4,456	4,774	5,093	5,411	5,729	6,048	6,366
3,820	4,092	4,365	4,638	4,911	5,184	5,457
3,342	3,581	3,820	4,058	4,297	4,536	4,775
2,674	2,865	3,056	3,247	3,439	3,629	3,820
2,228	2,387	2,546	2,706	2,865	3,024	3,183
1,910	2,046	2,183	2,319	2,455	2,592	2,728
1,671	1,790	1,910	2,029	2,148	2,268	2,387
1,485	1,591	1,698	1,804	1,910	2,016	2,122
1,337	1,432	1,528	1,623	1,719	1,814	1,910
1,215	1,302	1,389	1,476	1,563	1,649	1,736
1,114	1,194	1,273	1,353	1,432	1,512	1,591
1,028	1,102	1,175	1,249	1,322	1,396	1,469
955	1,023	1,091	1,159	1,228	1,296	1,364
891	955	1,018	1,082	1,146	1,209	1,273
835	895	955	1,015	1,074	1,134	1,194
786	842	899	955	1,011	1,067	1,123
743	796	849	902	955	1,008	1,061

The American Standards Association Safety Code for the Use, Care and Protection of Abrasive Wheels Will be Mailed on Application.

## PRODUCTS IN THE "CARBORUNDUM" LINE

### *Abrasive Wheels*

#### ABRASIVE WHEELS

Silicon Carbide  
Aluminum Oxide  
Diamond

for:

Centerless Grinding  
General Purpose  
Grinding

Internal Grinding  
Off-Hand Grinding  
Portable Grinding  
Roll Grinding  
Surface Grinding  
Tool Room  
Grinding  
Cutting-Off  
Snagging  
Cylindrical Grinding

### *Coated & Bonded Abrasive*

#### COATED ABRASIVES

Paper, Cloth, and  
Combination  
Sheets, Rolls, Discs  
Special Shapes

#### BONDED ABRASIVES

Cylinder Honers

Sticks, Stones & Rubs  
Specialties  
Superfinishing Stones  
Special Forms  
for:

Wood  
Leather  
Metal

### *Abrasive Grains & Compounds*

#### ABRASIVE GRAIN

for:

Polishing  
Lapping  
Pressure Blasting

#### ABRASIVE COMPOUNDS

for:

Finishing

### *Special Products*

#### SUPER REFRACTORIES

Bricks  
Special Shapes  
Cements

#### RESISTORS

for:

Electronic Circuits

#### HEATING ELEMENTS

for:

High Temperature  
applications

## Sales Offices and Warehouses in

NEW YORK

CHICAGO

PHILADELPHIA

DETROIT

CLEVELAND

ST. LOUIS

BOSTON

PITTSBURGH

SAN FRANCISCO

BUFFALO

CINCINNATI

ATLANTA

GRAND RAPIDS

## THE CARBORUNDUM COMPANY

Niagara Falls, New York  
United States of America

"CARBORUNDUM", "ALOXITE", and  
"MX" are trade-marks of, and indi-  
cate manufacture by, The Carborun-  
dum Company and are registered  
in the United States Patent Office.

Form No. A-1016 1-45  
Printed in U. S. A.

There is a Product by "CARBORUNDUM"  
for Every Abrasive Application.