OPERATOR'S INSTRUCTION BOOK

No. 1
CUTTER and TOOL GRINDER

★

Publication No. M-1943

This Booklet should be Filed in the Tool Crib and Issued by Tool Check only

THE CINCINNATI MILLING MACHINE CO.,
CINCINNATI 9, OHIO, U.S.A.

THIS booklet gives, in a condensed form, tables and data which are necessary to set up and grind all the ordinary types of milling cutters on the CINCINNATI No. 1 Cutter and Tool Grinder. Of course, a wide variety of small tool room work can also be economically and accurately ground with the aid of the standard attachments. Detail instructions for the operation, lubrication and adjustment of the machine are given to help the new operator to understand more fully the operation and care of his machine.

At the time of writing, this booklet was completely up to date. However, due to continual improvements in design, it is possible that descriptions contained herein may vary slightly from the machine delivered to you. This merely implies that the machine has been improved to better fulfill your requirements.

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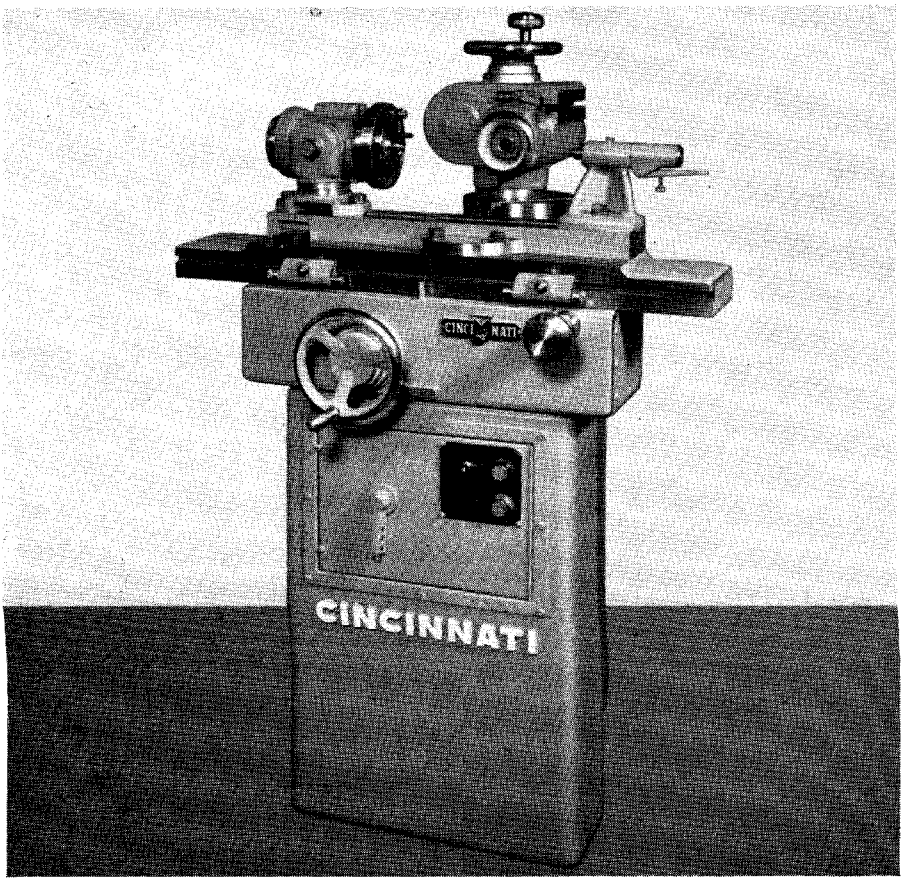


Figure 2A
CINCINNATI No. 1 Cutter
and Tool Grinder

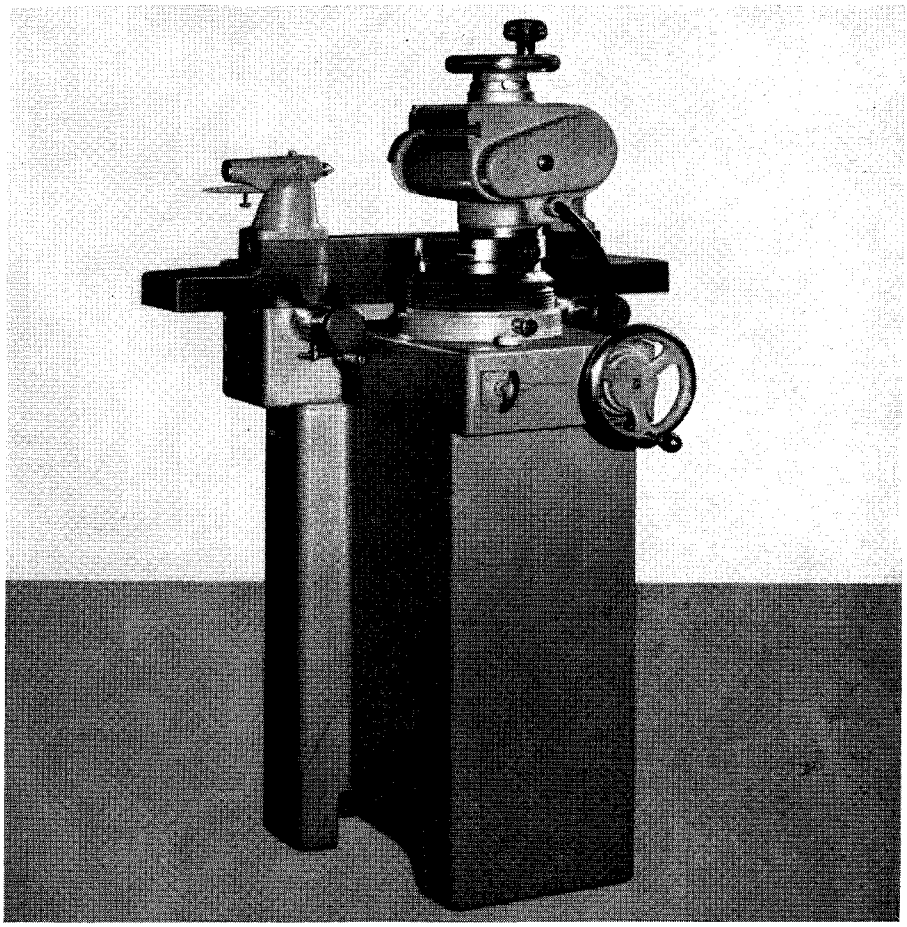


Figure 3A
Cincinnati No. 1 Cutter
And Tool Grinder

ILLUSTRATION REFERENCE NUMBERS

For your convenience in quickly finding illustrations referred to in the text, we have given all illustrations the same number as the page on which they appear. For example, Figs. 9A and 9B are all on page 9.

The design and specifications of these machines are subject to change without notice.

SERIAL NUMBER

The serial number is stamped on the front of the bed to the right of the wheelhead slide adjusting handwheel.

CONTENTS

DIMENSIONAL DRAWING

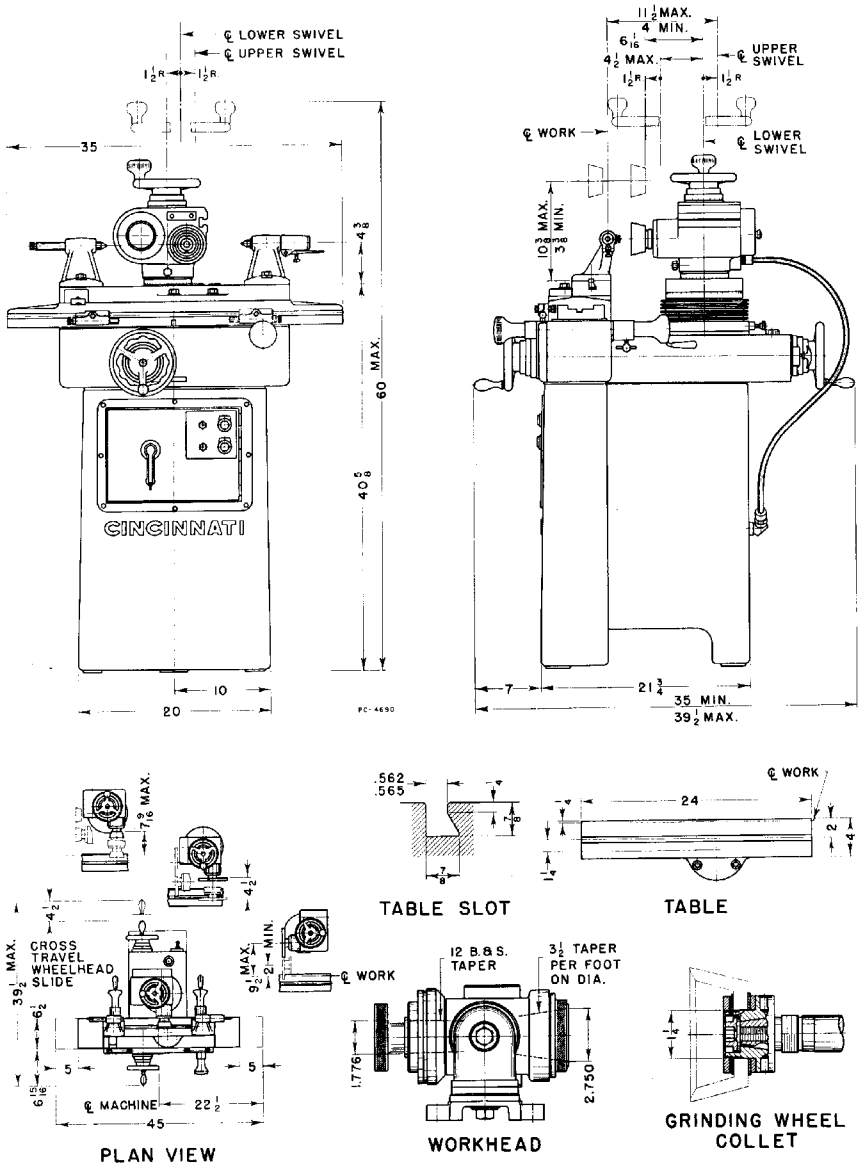


Figure 6A
Dimensional Drawing

GENERAL SPECIFICATIONS

CAPACITY	
Swing over Table	8″ diameter
Length between Right and Left-Hand Tailstocks	15″
Length between Tailstock and Workhead	11½″
Face Mills on Workhead	8″ diameter
Formed Cutters (using 6″ Wheel)	5½″ diameter
TAPER HOLE IN WORKHEAD SPINDLE — One End	No. 50 Series National Standard
TAPER HOLE IN WORKHEAD SPINDLE — Other End	Modified No. 12 B. & S. or No. 5 Morse
TABLE	
Slots (Number)	One- $\frac{.562}{.565}$
Working Surface	4″ x 24″
RANGE	
Longitudinal Movement of Table	10″
Table Swivels	180°
Swivel Table Adjustment (Taper per Ft.)	Toward Wheelhead 2″; Away from Wheelhead 1½″
Table Graduations in Center	90°
Cross Movement of Wheelhead Slide	4½″
Cross Range Gained by Wheelhead Eccentricity	3″
Total Cross Range of Wheelhead	7½″
Vertical Movement of Grinding Wheel Spindle	7″
Swivel Movement of Grinding Wheel Spindle	360°
Centerline of Spindle to Top of Table (vert.)	Max. 9⅛″ Min. 2⅛″
Centerline of Spindle to Work Center (vert.)	Above 4¾″ Below 2¼″
Centerline of Spindle to Work Center (horiz.)	Max. 8½″ Min. 1″
Centerline of Spindle to Backside of Table (horiz.)	Max. 9¼″ Min. 1¾″
GRINDING WHEEL SPINDLE SPEEDS (two)	6260 and 3730 rpm
Grinding Wheel Speeds — 6″ Dia. Wheel	5860 fpm
Grinding Wheel Speeds — 3½″ Dia. Wheel	5740 fpm
ELECTRICAL EQUIPMENT	See Below
FLOOR SPACE FOR OPERATING	39½″ x 45″
SHIPPING DATA	
Net Weight (approximately)	950 pounds
Shipping Weight, Domestic	1225 pounds
Shipping Weight, Export	1350 pounds
Size of Case, Export	50″ x 48″ x 40″
Volume of Case, Export	56 cu. ft.
CODE NAME	NOONE

INSTALLATION INSTRUCTIONS

The successful installation and operation of the machine requires that the following instructions be carefully observed.

Foundation. A special foundation is not required. Any substantial floor, wood or concrete, fairly flat, and sufficiently heavy to withstand the weight of the machine, will be satisfactory. However, do not locate the machine close to vibrating equipment, as vibration transmitted to the machine will result in a poor finish on the cutting edge of the cutter being sharpened.

Lifting the Machine. The machine may be lifted by a crane with a rope sling placed through the toe holes at the bottom of the base, as shown in Figure 8A. Before lifting the machine be sure that all slides are moved to their innermost positions and are securely clamped.

The ropes or cables used in lifting the machine should be capable of withstanding a weight of about 1300 pounds. Do not lift this machine by a rope slung around the wheelhead pile or sliding table.

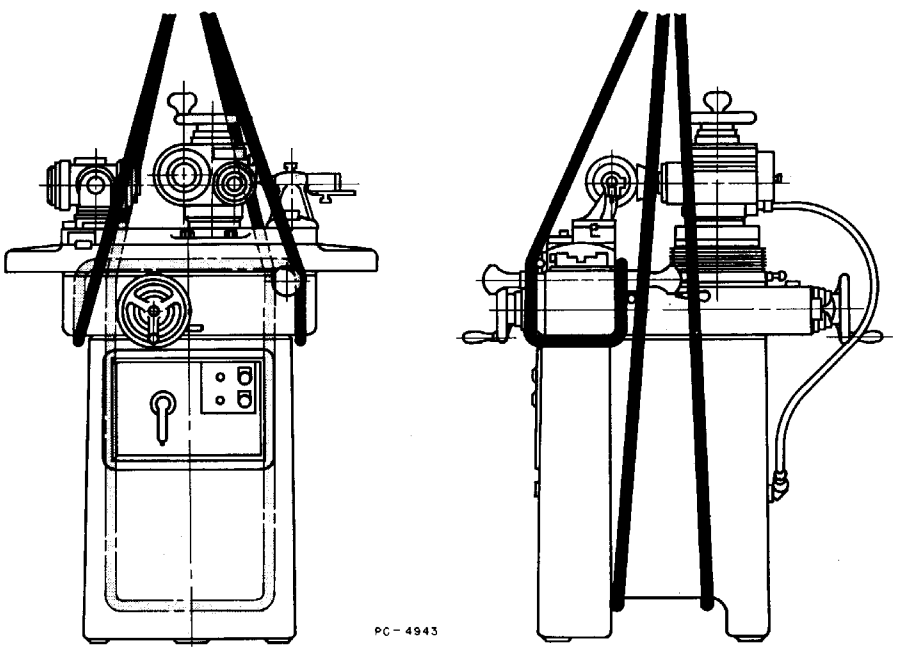


Figure 8A
Method of Lifting

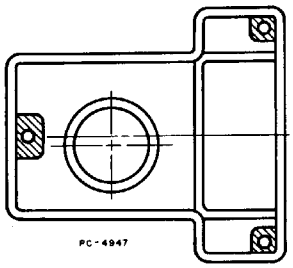


Figure 9A
Areas on Underside of Base in Contact with Floor

The effects of a vibrating foundation may be reduced or entirely eliminated by mounting the machine on a rubber base $\frac{3}{8}$" or $\frac{1}{2}$" thick. This base may be made by placing a good grade of oil proof sheet rubber between two thin steel sheets. Of course, the rubber selected should have sufficient unit strength to withstand the weight of the machine, which may be as much as 1300 pounds with fixtures. There are three bearing pads under the machine contacting the floor, indicated in Figure 9A.

Leveling. After the machine has been moved to its proper location, it must be carefully leveled. Use an accurate micrometer level for the operation. A carpenter's level or the bulb in a machinist's combination square is not good enough. Place laminated shims under the bearing pads of the base, alternating metal and felt shims, until the table is level in both directions. Shims should be large enough so entire bearing pads, under the base, is resting on the shim, so as to evenly distribute the weight of the machine. Then drive additional wedges beneath the three bearing pads under the base to evenly distribute the weight of the machine, and recheck for level. It is necessary, of course, that the machine table and leveling instrument be absolutely clean and free of burrs to obtain the most accurate results.

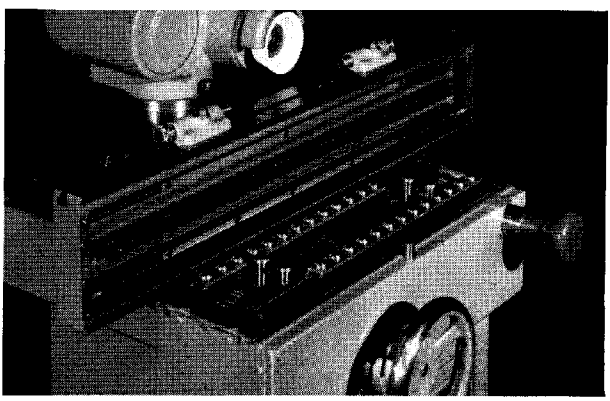


Figure 9B
Table Slide Ways

Assembling the Table and Table Slide. When you receive a CINCINNATI No. 1 Cutter and Tool Grinder, the table and slide will have been removed as a unit. Before replacing this unit, carefully wash the ways and

balls with naphtha, and dry with a cloth having no lint. After placing the balls in the cages, support the table unit with a crane, or on a bed-high box, and carefully slide it on the ways. *Caution*: Push table slowly over ways to avoid damage to ends of ball cages. Replace the bumper block at the left hand end of the slide.

LUBRICATION

The lubricants recommended in the table on page 11 have been selected for their adaptability to a specific job. Use oils having the specifications indicated, and apply as directed.

Absence of oiling devices on the wheelhead indicates that the spindle is grease packed and lubricated for life, and requires no attention. *Do not attempt to add oiling devices to grease packed spindles.* The design is not suitable for oil; it will thin the grease to a fluid condition; it may run out the ends of the spindle to the wheels, or inward to the driving belt.

The table slide rides on precision steel balls, which are separated by a flat bronze cage. Ball tracks under the table slide and on top of the saddle are made of hardened steel, ground in position. *This construction requires no lubrication.*

The wheelhead motor is equipped with pre-lubricated sealed bearings, and requires no attention.

The wheelhead elevating screw and nut rides in a reservoir of oil which is sealed at the factory. No further filling is necessary.

If the machine is operated more than one shift, it should be lubricated immediately before each starting time. A lubrication schedule tag tied to the machine will serve as a convenient reminder, and a central lubrication department will do a much better and more thorough job of oiling.

LUBRICATION

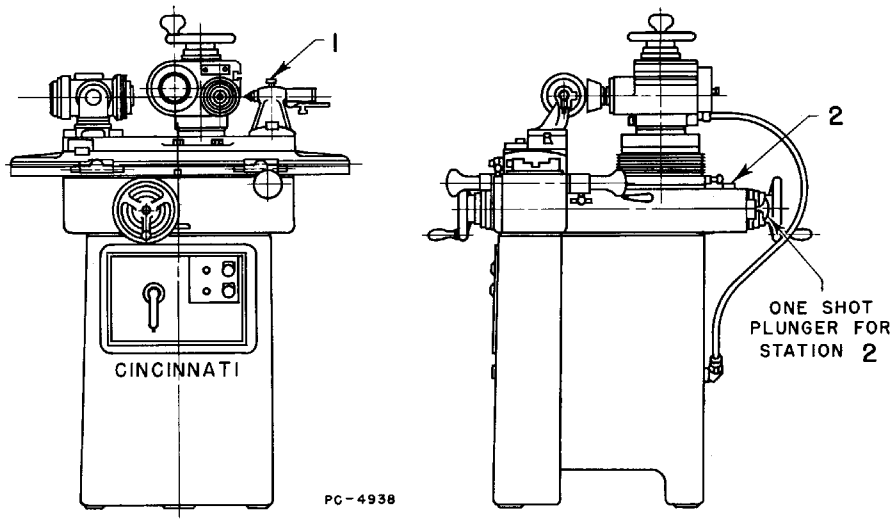


Figure 11A
Lubrication Diagrams

LUBRICATING INSTRUCTIONS AND SPECIFICATIONS

When to Oil	Station Number	Instructions	Parts Lubricated	Specifications
Daily	1	Oil with a bench oiler.	Tailstock.	P-55. A rust and oxidation inhibited oil. Viscosity 200-220 S.U.S. at 100° F.
	2	Use oil pot to fill. Pull out plunger and allow it to return itself. (3 times twice daily).	Wheelhead slide, vee and flat ways, cross feed nut and screw.	

Note.—Wheelhead spindle is grease packed, lubricated for life, and requires no attention. Do not attempt to add oiling devices to grease packed spindles.

Anti-friction table rides on precision steel balls. Ball tracks beneath table slide and on top of saddle are hardened and ground. This construction requires no lubrication.

Elevating screw and nut ride in a reservoir of oil. No lubrication is necessary.

P-55 is The Cincinnati Milling Machine Co. Specification Number.

OPERATING INSTRUCTIONS

Starting Machine for the First Time. After the machine has been properly installed, wash off the slushing oil and dirt accumulated in transit, with naphtha or a similar solvent of grease. Then fill all oiling stations with the grade of lubricant specified on page 10.

The grinding wheel spindle may now be started by pushing the wheelhead "START" button.

Electrical Control Panel. The electrical controls, Figure 12A, are conveniently located on the right-front of the machine base. The built-in push button station, Figure 13A, includes the Master "START-STOP" buttons and toggle switch labeled "WHEELHEAD" for selecting the direction of rotation of the grinding wheel spindle. The switch has three operating positions:

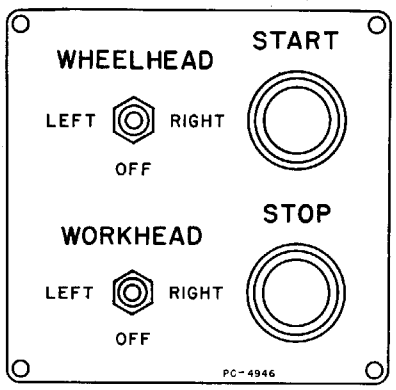


Figure 12A
Push Button Station

1. The center or "off" position, in which the grinding wheel spindle motor is stopped.
2. Switch thrown to the left, in which the grinding wheel spindle rotates in a counter-clockwise direction. (See "Direction of Grinding Wheel Rotation", page 19).
3. Switch thrown to the right, in which the grinding wheel spindle rotates in a clockwise direction. (See "Direction of Grinding Wheel Rotation", page 19).

A plug-in receptacle is provided on the left-hand side of the machine base for connecting or disconnecting the workhead motor on those machines equipped with either the Cylindrical Grinding Attachment or the Small End Mill Grinding Attachment when it is supplied with a motor drive. The attachments are controlled by a toggle switch marked "WORKHEAD" at the lower left of the push button station (Figure 12A).

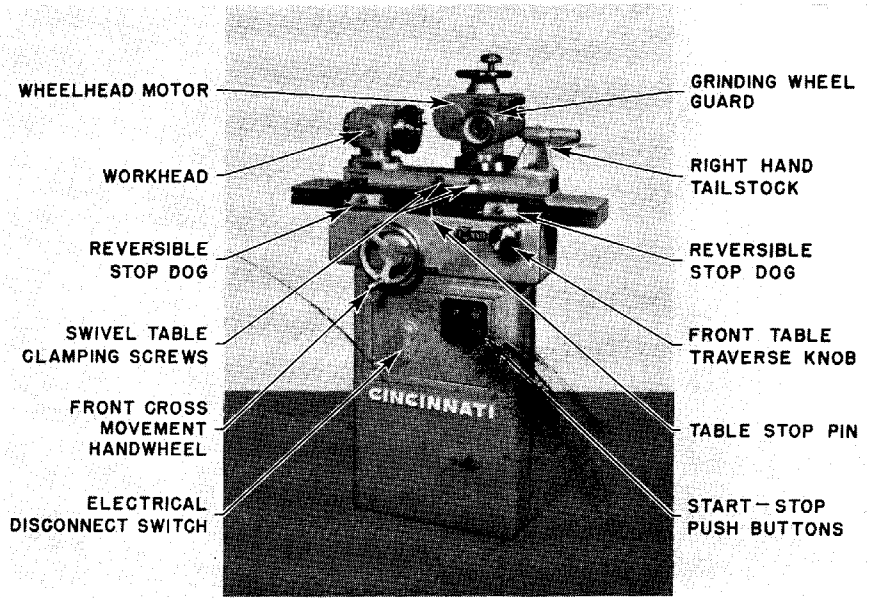


Figure 13A
Functional Diagram—Front

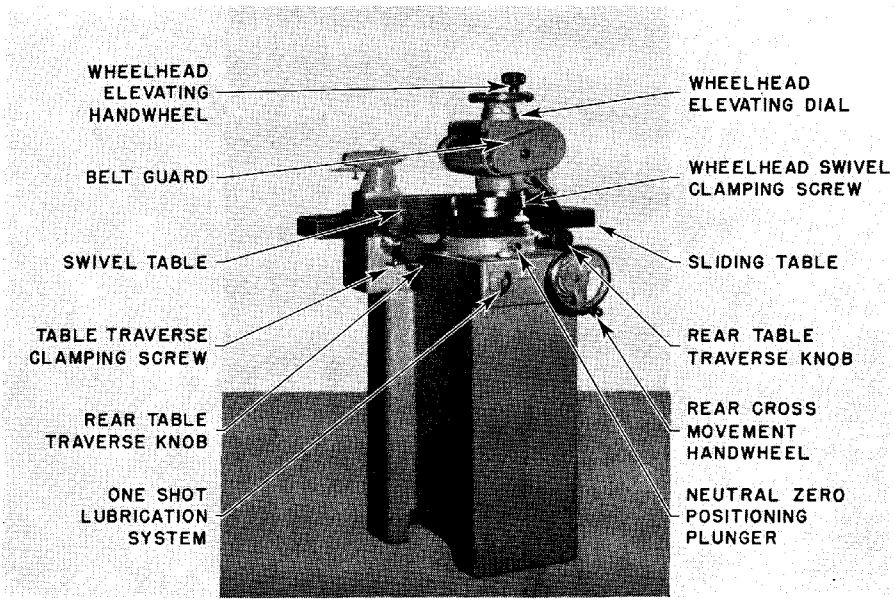


Figure 13B
Functional Diagram—Rear

Table Traverse. Duplicate control knobs enable you to operate the machine at the front, right-hand of the table (Figure 14A); or at the rear, right or left-hand side of the wheelhead column (Figure 15A), depending upon the nature of the job being performed. Front and rear control knobs, (Figures 14A and 15A) are connected directly to the pinion which engages the table rack. The rear control knobs will be used in the majority of operations.

The table slide may be locked in position by tightening either of the two table locking screws (Figure 15A) in the brackets behind the rear control table traverse knobs.

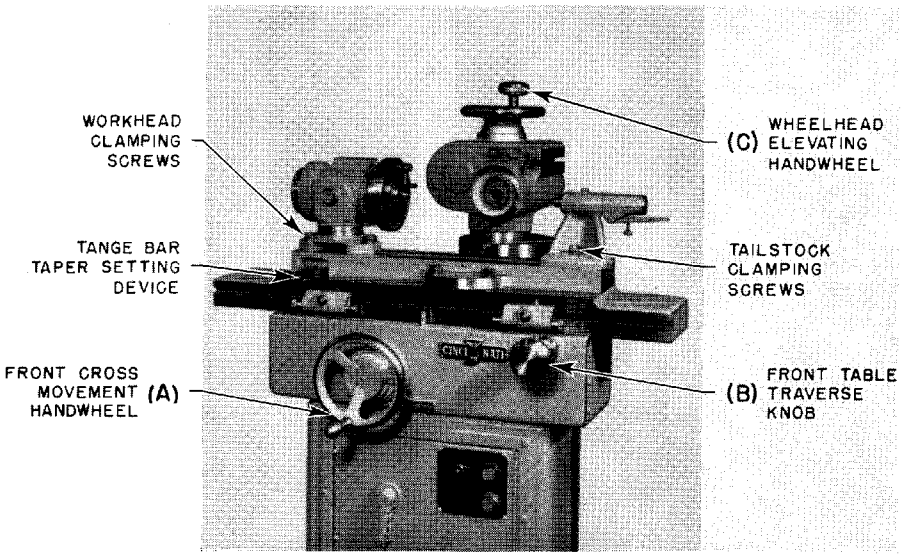


Figure 14A
Front Operating Controls

Cross Adjustment (Wheelhead Slide). The wheelhead slide is provided with dual control. A pair of handwheels, one at the front and one at the rear (Figures 14A and 15A) allows you to choose the most convenient position for moving the grinding wheel toward or away from the table in position for either surface grinding or cutter sharpening operations. The rear handwheel will be used in the majority of operations.

Clockwise rotation of the Cross Adjustment handwheel (Figure 15A) moves the grinding wheel away from the machine table; while counter clockwise rotation of it moves the grinding wheel toward the table. Counter-clockwise

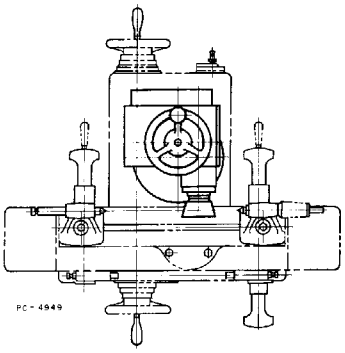


Figure 16A
Ample Capacity for Grinding Both Long and Large Diameter Centers.

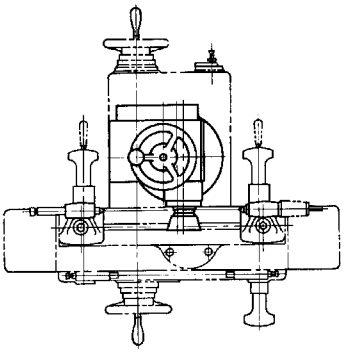


Figure 16B
Plenty of Range for Cylindrical Grinding Work up to 8" in Dia.

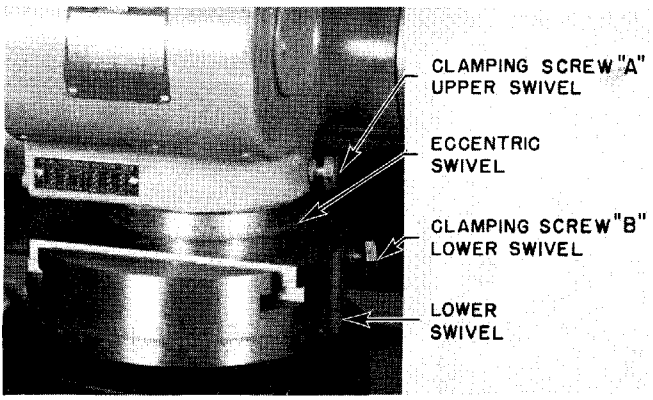


Figure 16C
360° Eccentric Wheelhead

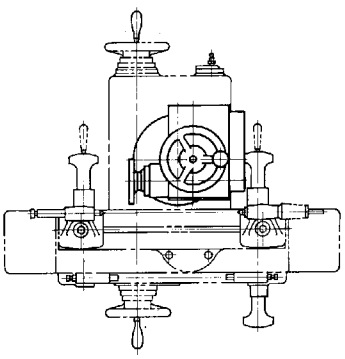


Figure 16D
Sufficient Range for Slab Mills and Other Arbor Mounted Cutters.

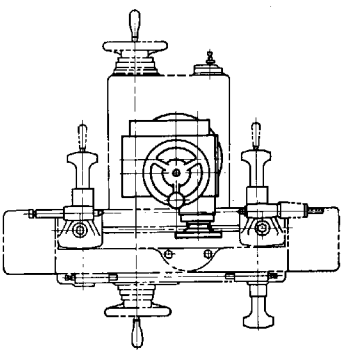


Figure 16E
Adequate Wheelhead Movement Over the Table for Surface Grinding.

with a retractable "ON-CENTER" positioning plunger (Figure 17A). When the plunger is engaged (guide pin aligned in the slot in sleeve, Figure 17A) raise or lower the wheelhead, as the case may be, until plunger engages locating hole in the joining surface of the wheelhead column.

After obtaining the zero setting, the plunger can be disengaged by pulling it out and rotating it one-half turn in either direction so that the guide pin seats against sleeve (Figure 17A).

Note.—Be sure plunger is disengaged before attempting to raise or lower wheelhead column.

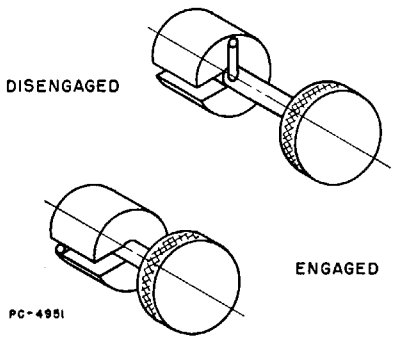


Figure 17A
Retractable "Neutral-Zero" Positioning Plunger

360° Eccentric Wheelhead Swivel. The eccentric wheelhead swivel in conjunction with the adjustable wheelhead pile enables you to position the grinding wheel to suit any particular grinding application.

This additional movement of the wheelhead in the horizontal plane is obtained through two independent angular (360°) adjustments. The upper swivel (Figure 16C) carrying the grinding wheel is mounted eccentrically with respect to the lower swivel (Figure 16C) which is attached to the top of the wheelhead column. Both the upper and lower swivels may be rotated through 360°.

The eccentric arrangement (Figure 16C) adds 3" of range to the 4½" conventional movement of the cross adjustment (wheelhead slide). This not only permits positioning the grinding wheel directly over the table for surface grinding (Figure 16E), but in most instances eliminates the need

for spindle extensions when the wheelhead is moved to the extreme operating position (Figure 16A) when reconditioning miscellaneous small tools and cutters.

Swiveling the Wheelhead. Loosen clamping screw "A" (Figure 16C), swivel grinding wheel to the desired setting, then retighten screw. For additional range provided by rotating the lower swivel loosen lock screw "B" (Figure 16C), swivel the wheelhead to the desired setting, then tighten screw. Each swivel may be rotated through 360°.

Spindle and Grinding Wheel Speeds. The wheelhead motor, running at 3000 rpm drives the wheel spindle at 6260 and 3730 rpm. The drive is from a two step pulley on the motor shaft through a tooth-grip belt to a double step pulley on the wheel spindle (Figure 18A). This is a positive drive and no adjustment is ever required.

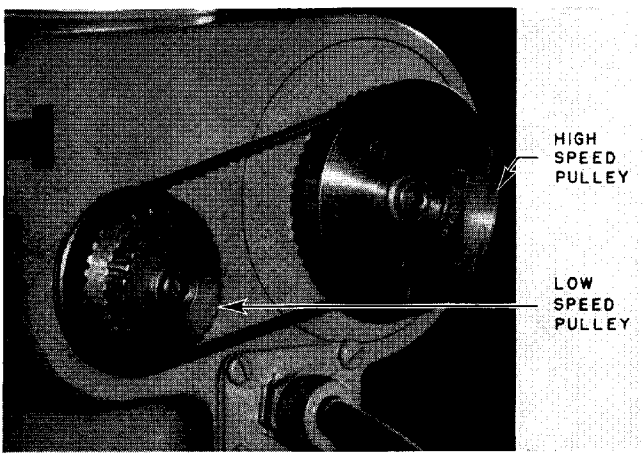


Figure 18A
Grinding Wheel Drive with Guard Removed

When using 6" diameter grinding wheels and over, shift the belt to the inside pair of the double step pulleys, and when using smaller wheels, shift it to the outside pair of double step pulleys (Figure 18A).

Shifting the belt from one set of pulleys to the other is accomplished as follows:

1. Stop the spindle motor.
2. After loosening the knurled screw in the sheet metal guard at the rear of the wheelhead, remove the guard.

3. Shift the tooth-grip belt to the desired set of pulleys being sure the teeth in the belt mesh with those in each pulley.

4. Replace guard and tighten knurled screw.

The surface speed of the grinding wheel should be between 5000 and 6500 feet per minute to obtain the longest life and best cutting action of the wheel.

If the wheelhead motor is changed to one with a different speed, the pulley diameters must be increased or decreased to keep the proper wheel speed. Surface speeds can be determined from the following formulae:

$$\text{rpm (spindle)} = \frac{\text{rpm of motor} \times \text{dia. pulley or motor}}{\text{dia. pulley on wheelhead}}$$

$$\text{surface spring wheel (ft./min.)} = \text{rpm spindle} \times \frac{3.14 \times \text{dia. wheel}}{12}$$

Direction of Rotation of Grinding Wheel. The normal direction of rotation of the grinding wheel is towards the cutting edge of the tooth, as shown in Figure 19A. The chief advantage is important—there are no burns left on the cutting edges of the teeth to be removed by a time consuming oil stone operation. Clockwise rotation of the grinding wheel (Figure 19A) can be obtained by throwing grinding wheel spindle switch to the right (See "Electrical Control Panel", page 12).

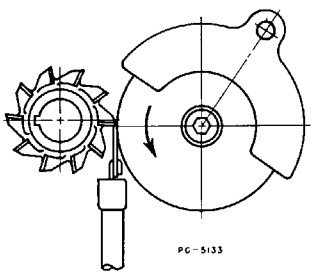


Figure 19A
Grinding Wheel Rotating Towards the Cutting Edge.

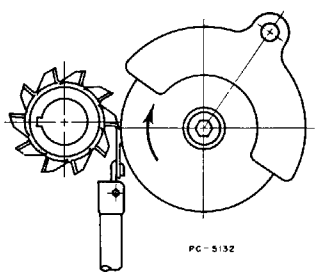


Figure 19B
Grinding Wheel Rotating Away From the Cutting Edge

However, if you believe that the grinding wheel should rotate in the opposite direction (counter-clockwise) as shown in Figure 19B, throw the grinding wheel spindle switch to the left. (See "Electrical Control Panel", page 12).

Swivel Table Adjustments. The workhead and/or the tailstocks are mounted on an auxiliary swiveling table, carried by the machine sliding table. This table provides the means by which the work may be swiveled clockwise or counter-clockwise to grind tapers. The swivel table may be clamped or unclamped in any position by means of the swivel table clamping screws (Figure 21A).

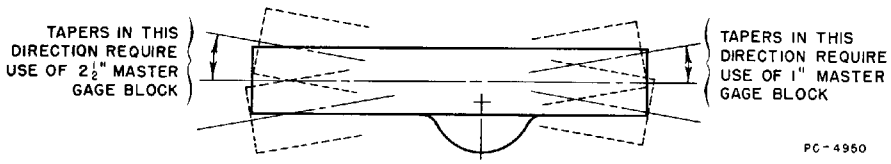


Figure 20A
Swivel Table and Master Gage Block Settings

To assist in accurately setting up for taper work, the left-hand end of the machine table is provided with a unique taper setting device that assures accurate grinding of tapers up to 2" per foot, without resort to a "cut and try" technique. Based upon the trigonometric function of the tangent of the angle, the "Swivel Table Tange-Bar Taper Setting Device" (Figure 21A) enables you to adjust the swivel table to the correct taper per foot simply by inserting precision gage blocks between the swivel table taper setting master gage block (Figure 21A) and a stud on the sliding table (Figure 21A).

For example, if you desire to set the table to grind a tool having 0.050" taper per foot, proceed as follows:

1. Loosen swivel table clamping screws (Figure 21A) and position swivel table until there is sufficient room to insert master gage blocks supplied with the machine and precision gage blocks equal to the .050" taper per foot desired.

   Selection of the 1" or 2½" master gage block depends upon the direction in which the machine table is swiveled in order to provide the desired taper. (Figure 20A).

2. Insert master gage block so that it contacts locating pin on swivel table. Then insert precision gage blocks between master gage block and locating pin on sliding table.

3. Position swivel table until locating pin on swivel table contacts the top of the master gage block.
4. Righten swivel table clamping bolts.

Computation of the gage block setting, when the included angle of the taper is known, is obtained by multiplying one half the tangent of the included angle by 12. Replacing either the known value of ½ the tangent of the included angle by 12 or the given value of taper per foot from the centerline, as the case may be, with the corresponding precision gage blocks enables you to accurately position the swivel table to grind the taper.

Greater settings of the table, as sometimes required when grinding longer cutters, may be readily obtained by loosening the clamping bolts and swiveling the table to the desired angle indicated by the graduated scale.

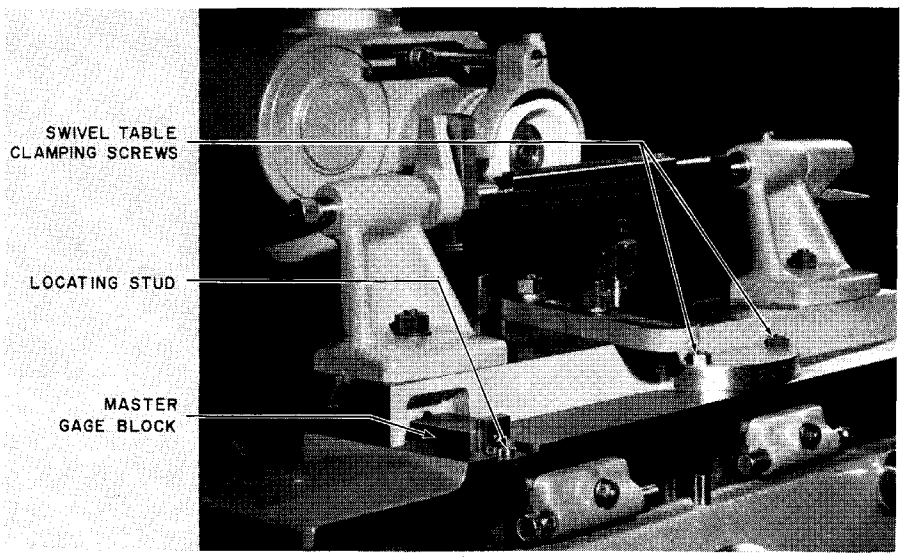


Figure 21A
Tange Bar Taper Setting Device

In the normal position of the swivel table, the center of the wedge slot is offset 1¼" from the pivot stud, towards the wheelhead. Since the table may be swiveled 180°, the normal cross range is increased 2½" as shown in Figure 22A. A secondary advantage in swiveling the offset table 180° is that the center of gravity of any attachment and its cutter is shifted 2½" towards the front table way; an important point to remember when grinding heavy parts which overhang the table on the grinding wheel side.

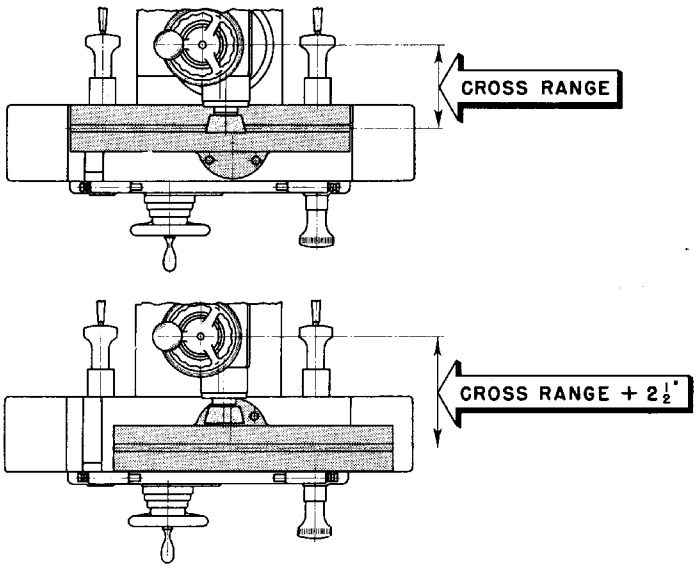


Figure 22A
Swivel Table Rotated 180°

Setting Up the Tailstock and Workhead. Tightening the table clamping wedge bolts always locates the tailstock and/or the workhead from the straight side of the table. The retractable center in the tailstock normally used on the right-hand end of the table is not only adjustable for tension, but is interchangeable and may be removed and inserted in the opposite end of the tailstock in the event it is desirable to utilize the tailstock on the left-hand end of the table. To transfer the retractable center from one end of the tailstock to the other, simply loosen hexagon lock screw; withdraw center mechanism and insert in opposite end of tailstock. Retighten lock screw.

Table Dogs. Spring cushioning table dogs, when set as shown in Figure 21A, not only govern the length of table traverse, but absorb the shock at the end of each stroke and smoothly reverses the direction of table motion. The dogs may be reversed and the fine adjustment used when positive table stop is desired.

Centering Gage. The centering gage (Figure 23A) is for the purpose of quickly aligning a cutter tooth with the tailstock and center of the grinding wheel spindle when setting up the machine. This is accomplished with the gage placed on top of the machine table.

Notice that the opposite sides of the small diamond shaped gage-plate are machined. By merely swiveling the plate to bring the machined side in contact with the cutter tooth, both right and left hand cutters may be centered. (Figures 23B and 23C).

Quite often a preliminary step in the set up requires that the wheelhead column be set to zero or neutral. That is, the center of the grinding wheel must be the same height from the table as the tailstock and/or workhead centers. This is accomplished by engaging the "Neutral-Zero" position plunger as described on page 18 and illustrated in Figure 17A.

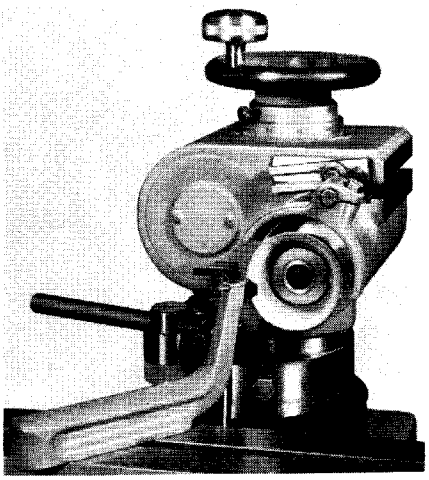


Figure 23A
Centering Gage

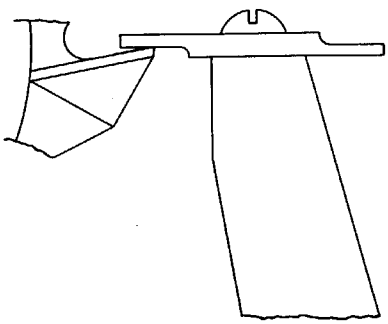


Figure 23B
Centering Gage on Table Set for Right-Hand Cutter

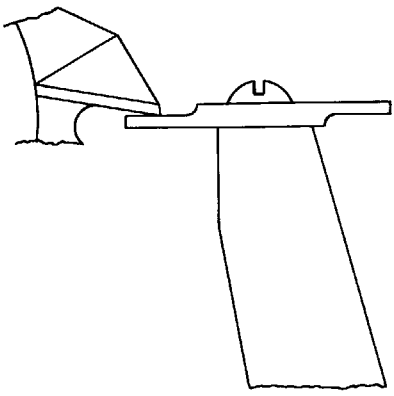


Figure 23C
Centering Gage on Table Set for Left-Hand Cutter

Grinding Wheels. When grinding a high speed steel cutter or reamer, use a soft wheel. The soft wheel breaks down more easily and is therefore less liable to burn the cutter. Since a soft wheel wears away quickly, it is desirable to dress it often to obtain a good surface on the wheel and therefore a good finish on the work. A carbon steel cutter can be ground with a harder wheel of fine grain, without drawing the temper. Some jobs, particularly surface grinding, require wheels not listed in the table. We can supply them, when required, at extra cost. See pages 48 and 49 for list of wheels and their uses.

Truing the Wheel. The grinding wheel must be trued occasionally to obtain a good finish on the clearance angles of the cutter, for a good finish makes a keen cutting edge. For this operation, the wheel truing attachment shown in Figure 24A is supplied. Use the differential hand control to give the table a uniform motion, because the diamond will produce a much better surface on the wheel if it is traversed uniformly.

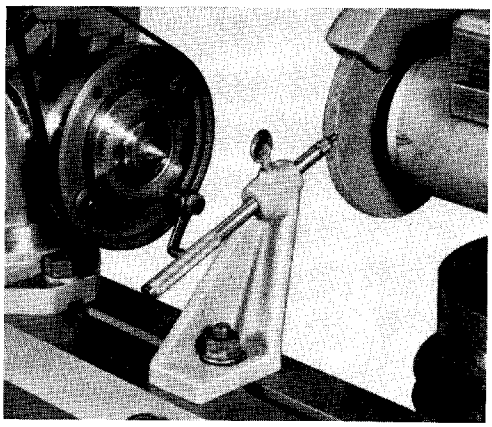


Figure 24A
Grinding Wheel Truing Attachment

Pause momentarily after each pass of the diamond across the wheel, allowing the truing tool to dissipate some of the heat which is generated. This simple precaution will greatly increase the life of the diamond. Remember that it is more economical to reset a worn diamond than to continue using it, because of the possibility of damaging it beyond further use.

Do not take a cut of more than .001" across the face of the wheel.

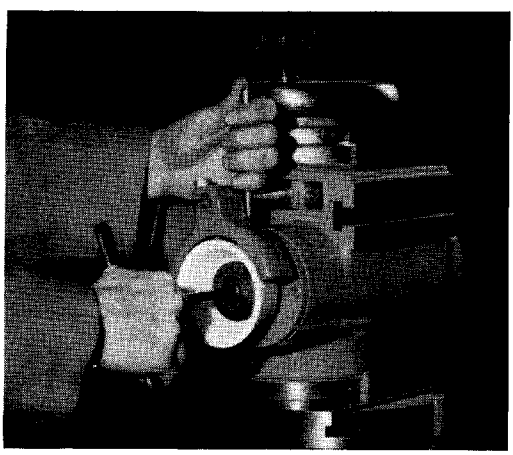


Figure 24B
Grinding Wheel Collets are Quickly Interchanged by Removing Socket Head Screw

Grinding Wheel Collets. Always use compressible washers or blotting paper washers between the sides of the wheel, collet and washer. This prevents unnecessary strains on the wheel center by distributing the clamping pressure evenly. Mount the wheel and collet on the spindle taper. Insert the socket head screw through the collet and thread it into the spindle nose. Tighten collet utilizing "T" wrench and pin wrench, inserted in the back of the collet, as shown in Figure 24B.

Clearance Setting Dials and Dog. The clearance setting device for the left hand tailstock, illustrated in Figure 25A, must be set in conjunction with dog A. Clamp the dog to the mandrel, on which the cutter is mounted, with the pin inserted in the hole in the clearance setting plate. Loosen thumb screw B, rotate the cutter to the desired clearance as indicated by the graduations at C, then tighten the thumb screw and remove the setting dog. This device is employed when using a cup wheel.

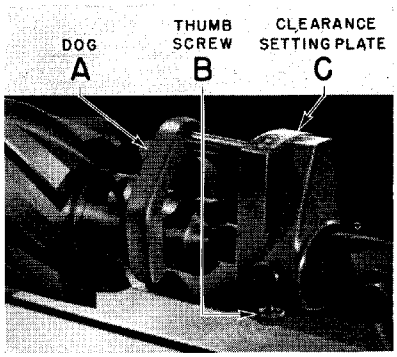


Figure 25A
Clearance Setting Device on Left-Hand Tailstock

Three diameters on the workhead are graduated for convenience in setting up the job as well as providing an accurate determination of clearance angles. (Figure 25B).

a. Clearance setting dial at one end of the spindle housing.
b. Clearance and set-up graduations for the vertical swivel bearing.
c. Clearance and set-up graduations for the horizontal swivel bearing.

A knurled thumb screw in front of the head (not visible) tightens the spindle in position, while the vertical and horizontal swivels are each tightened with a single wrench.

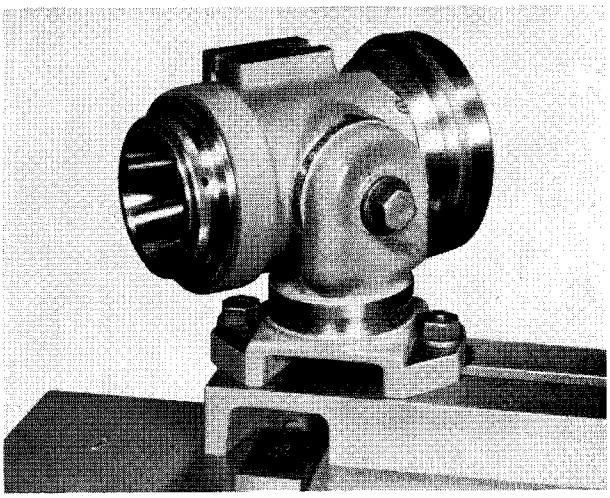


Figure 25B
Clearance Setting and Set-up Graduations on Workhead

Tooth Rest. Typical tooth rest blades are shown here, with brief comments on the uses for each type. When the requirements for blades are thoroughly understood, other shapes can readily be fabricated to suit special types of cutters.

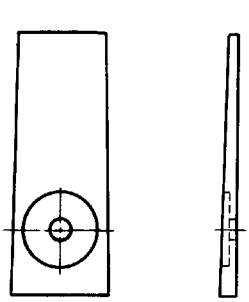


Figure 26A

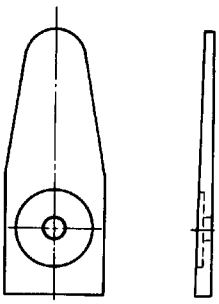


Figure 26B

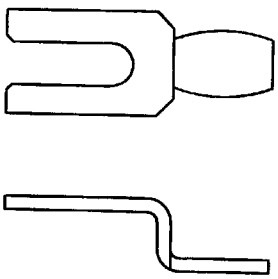


Figure 26C

Figure 26A—Straight blade. Used with adjustable holder for grinding straight fluted reamers, side mills, end mills or any type of straight fluted cutter.

Figure 26B—Tooth rest blade with a radius end. Used for sharpening shell end mills and small end mills.

Figure 26C—Offset tooth rest blade. Used for sharpening large diameter, coarse pitch spiral milling cutters and large face mills that have angular blade inserts.

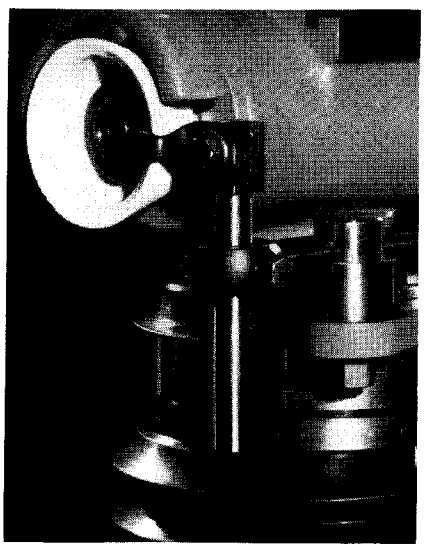


Figure 26D
Plain Tooth Rest

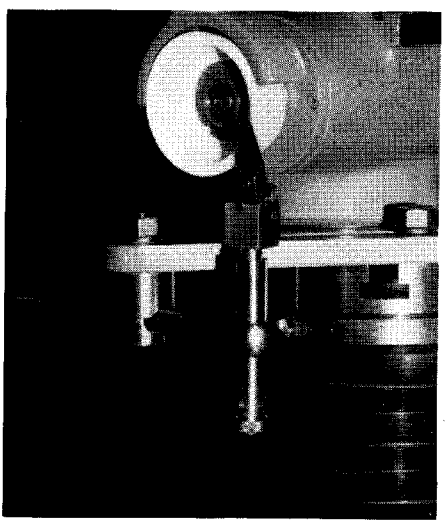


Figure 26E
Universal Tooth Rest

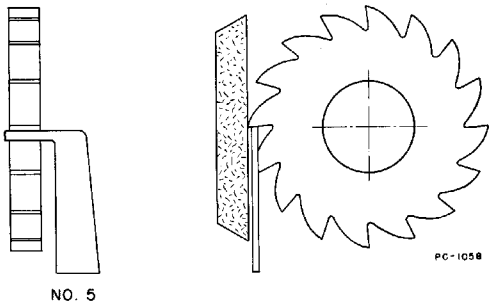


Figure 27A

Figure 27A—L-shape tooth rest blade for sharpening metal slitting saws and straight tooth plain milling cutters with closely spaced teeth. These blades are not carried in stock, but they can readily be made in the average shop. Use oil hardening tool steel.

Good Housekeeping. Because of the four operating positions — front and rear, right and left — provided by the front and rear dual controls, it is advisable to keep the floor clean and free of loose parts and attachments. In other words, practice good housekeeping in the vicinity of your machine. A cabinet for the attachments, wheels, wrenches, etc. will prove a big help. It can readily be made by your shop carpenter, or we can supply a "Cabinet for Tools", at extra cost.

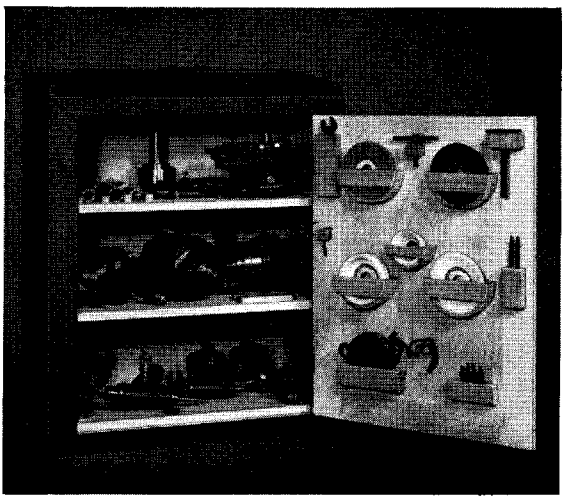


Figure 27B
Cabinet for Tools

SAFETY PRECAUTIONS

Wear Goggles. Eliminate the possibility of eye injury by wearing goggles or some approved form of eye shield.

Wheel Guards. Do not run the machine without wheel guards.

Flanges, Washers, and Nuts. All abrasive wheels must be mounted between flanges.

Washers or flange facings of compressible material shall be fitted between the wheel and its flanges. If blotting paper is used, it should not be thicker than .025". If rubber or leather is used, it should not be thicker than $\frac{1}{8}$". If flanges with babbitt or lead facings are used, the thickness of the facing should not exceed $\frac{1}{8}$". The diameter of the washer shall be the same size or slightly larger than the flange diameter.

All surfaces of wheels, washers, and flanges in contact with each other should be free from foreign material. (See List of Wheels, pages 48 and 49).

Inspection and Storage of Wheels. Competent men should be assigned to the mounting, care, and inspection of grinding wheels.

Immediately upon receipt, all wheels should be closely inspected to be sure that they have not been injured in transit. Inspect for cracks by tapping gently (while suspended) with a light implement, such as the handle of a screw driver. Wheels must be dry and free from sawdust when applying this test. If they sound cracked they must not be used. Note that organic bonded wheels do not emit the same clear metallic ring as do vitrified and silicate wheels.

Extreme care should be exercised in the storage of wheels. They should be stored in a dry place and should be supported by pegs in racks.

Operating Rules and General Data. Run all new wheels at full operating speed for at least one minute before applying the work, during which time the operator should stand at one side.

Work should not be forced against a cold wheel, but applied gradually, giving the wheel an opportunity to warm and thereby minimize the chance of breakage. This applies to starting work in the morning in cold rooms, and to new wheels which have been stored in a cold place.

Grinding on the flat sides of straight wheels is often hazardous and should not be allowed on such operations when the sides of the wheel are appreciably worn, or when any considerable or sudden pressure is brought to bear against the sides.

When tightening the spindle end nut, care should be taken to tighten it just enough to hold the wheel firmly; otherwise the clamping strain is liable to damage the wheel or associated parts.

Do not use wheels of a larger diameter or a greater thickness than specified for this machine. (See list of wheels, pages 48 and 49).

The space about the machine should be kept light, dry and as free as possible from obstructions.

All machines, except those permanently set up with the Mist Grinding Attachment, should be attached to a dust exhausting system.

Dust Collectors. As a health measure, dust collectors should be connected to all machines. Those grouped together may be serviced with a central system, while isolated machines should be equipped with an individual unit.

CLEARANCE ANGLES

For Milling Cutters

Milling cutters ground on CINCINNATI No. 1 Cutter and Tool Grinders fall into two distinct classes, each class being sharpened by a method peculiar to itself.

Into the first class fall the cutters which are sharpened on the periphery or outside diameter by grinding a cutting and clearance angle behind the cutting edge. The great majority of milling cutters are of this type, of which an ordinary spiral mill is an example. This type of cutter can be renewed and used over again when the teeth are ground down too small.

The second class includes cutters which are form relieved and which must be sharpened by grinding the front faces of their teeth. These cutters have a definite profile for producing a given outline, the cutter profile being preserved when sharpening by grinding the front faces of the teeth only. The clearance is produced during the manufacture of the cutter. Gear cutters, form milling cutters, etc.

When setting up for grinding *radial* tooth form relieved cutters, bring the center of the cutter in line with the face of the grinding wheel. For *undercut* form relieved cutters, proceed as before, swivel the table or cutter through an angle equal to its rake angle and then align the face of one cutter tooth with the face of the wheel. If the rake is marked on the cutter in thousandths of an inch, (Dimension "D" in Figure 39A), offset the center of the cutter from the face of the wheel by this amount. Set the face of a cutter tooth against the face of the grinding wheel, and set the tooth rest against the heel of the tooth. To adjust the work to the wheel, revolve the cutter towards the wheel a slight amount by adjusting the micrometer tooth rest. The faces of the teeth will then be ground to maintain the correct cutter profile. (Also see discussion under "Gear Cutter Sharpening Attachment, page 37).

The clearance angle is the most important consideration when grinding a milling cutter which is included in the first class. New cutters should be sharpened before they are used, because the clearance angle may not be correct for the material to be machined.

Chatter in the finish milled surface may be caused by an incorrectly ground cutter, or by a poorly designed cutter. It may also be due to the shape of the part being milled; method of clamping the work; type of fixture; locating points and pads; and finally, the condition of the milling machine on which the job is milled.

The clearance angle should be carefully selected for all types of cutters. The value of the clearance angle plays an important role in obtaining good cutter performance, high cutting efficiency, and long cutter life between grinds. It is desirable in all cases to use a clearance angle as small as possible, so as to leave more metal for heat dissipation, and insure maximum strength of the cutting edge. Any clearance angle greater than required by the cut will weaken the cutting edge, and may cause failure under heavy duty operation. It will also increase the likelihood of chatter, resulting in a poor finish on the machined surface and reducing the life of the cutter.

Generally accepted values of clearance angles are given in the table below.

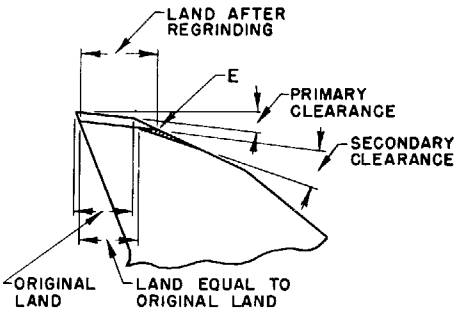


Figure 31A
Clearance Angles and Land. Repeated sharpenings increase width of land, until interference develops at point "E". To eliminate interference, reduce width of land by grinding secondary clearance.

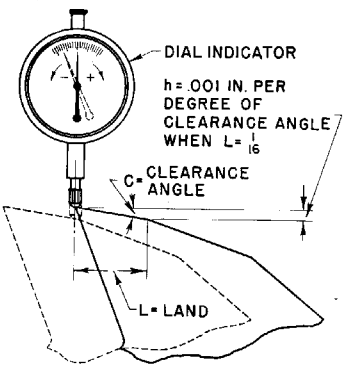


Figure 31B
Measuring the Clearance Angle with a Dial Indicator

Approximate Clearance Angles for High Speed Steel Milling Cutters

Work Material	Primary Clearance Angle	Secondary Clearance Angle
Alloy Steel	3—5°	3—5°
Mild Steel	3—5°	3—5°
Cast Iron	4—7°	3—5°
Bronze (Hard)	4—7°	3—5°
Brass	10—12°	3—5°
Aluminum	10—12°	3—5°

After you have once found the best clearance angles for a particular job, then write down the part number of the work-piece, the part number of the cutter, and the clearance angles, so that you can duplicate the results. Suggested record on page 56.

Drawings of inserted cutter teeth are shown in Figure 32A. The enlarged section of the blade, Figure 32B, shows three types of corner for shell end mills and face mills.

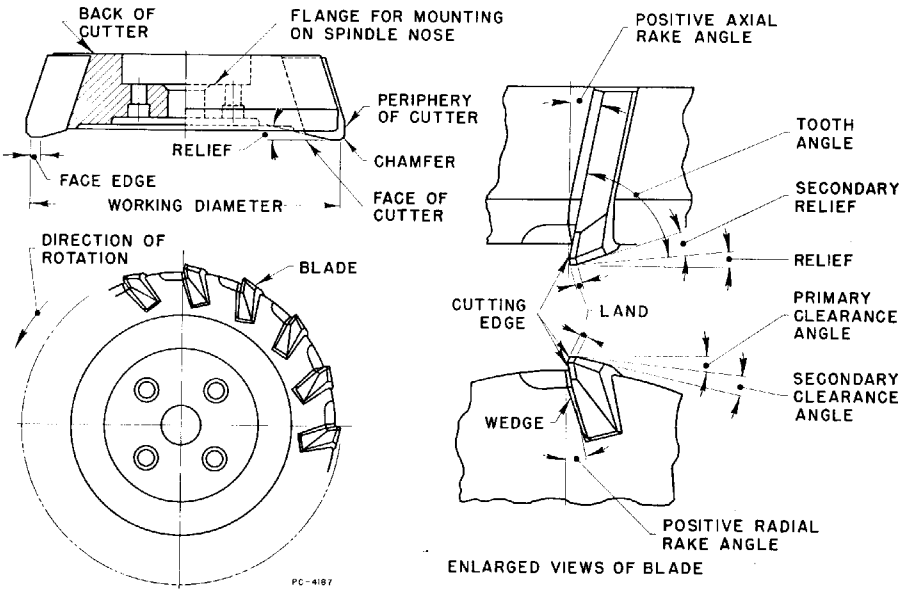
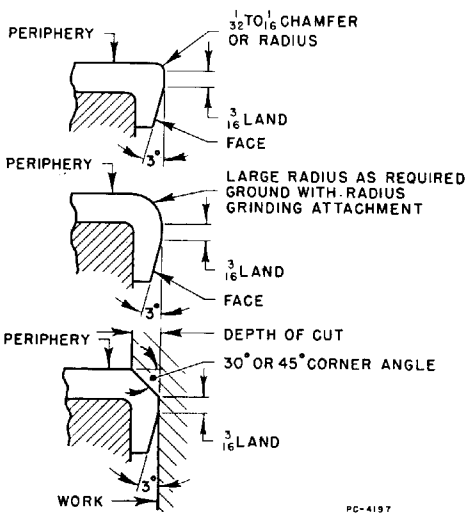


Figure 32A

Nomenclature of Face Milling Cutter. Relief angle should be 3° to 5° and width of land from 1/64" for small face mills to 1/16" for large face mills.



SHARP CORNER

For milling up to an approximate sharp corner.

RADIUS

For milling a radius. The corners of the teeth are ground to the same radius as desired on the work with the aid of the No. 1 or No. 2 Radius Grinding Attachment.

CHAMFER

For milling flat surfaces without projecting shoulders. Grind to 30° corner angle for longest cutter life and for deep cuts. Grind to 45° corner angle for best finish on the work.

Figure 32B
Three Types of Corners
For Shell End Mills and Face Mills

ATTACHMENTS

Surface Grinding Attachment. The surface grinding attachment is used for grinding flat forming tools, lathe tools, planer tools, flat thread

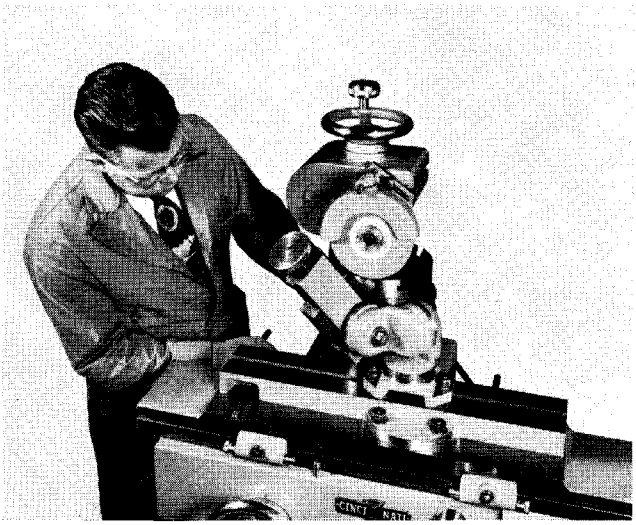


Figure 33A
Surface Grinding Attachment Set in Vertical Position for Grinding a Lathe Tool

chasers, drifts, chisels, and work of like nature. The attachment consists of a swivel vise with an intermediate support between the vise and the base, which allows the vise to be swiveled in two planes. (Figure 33A). The regular workhead support may be removed and placed between the vise support and the base, making the vise adjustable in three planes. (Figure 33B). It is then possible to completely grind almost any flat tool without removing it from the vise, thereby maintaining greater accuracy between the ground surfaces.

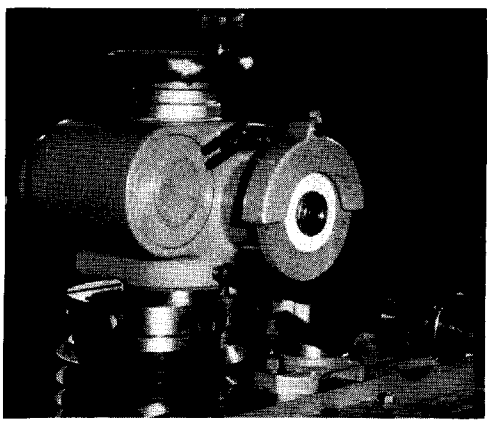


Figure 33B
Vise in Horizontal Position

The intermediate support may be removed and the vise body mounted directly on its base (Figure 33A) which allows a maximum distance of 6 1/16" between the center of the wheel spindle and the top of the vise. With the wheelhead set at 90°, work up to 4" wide can be ground with this setup. The vise jaws are 4" wide by 1 15/16" deep, and open up to 2 1/2".

Cylindrical Grinding Attachment. The cylindrical grinding attachment can be used for all types of straight or taper cylindrical grinding; such as reamers, lathe centers, mandrels, tap or drill shanks; and for facing operations, such as cutter hubs, gear shaper cutters, collars, nuts, etc. Small machine parts, made in small quantity or experimental lot sizes may also be economically ground with the cylindrical grinding attachment, if dry grinding is permissible.

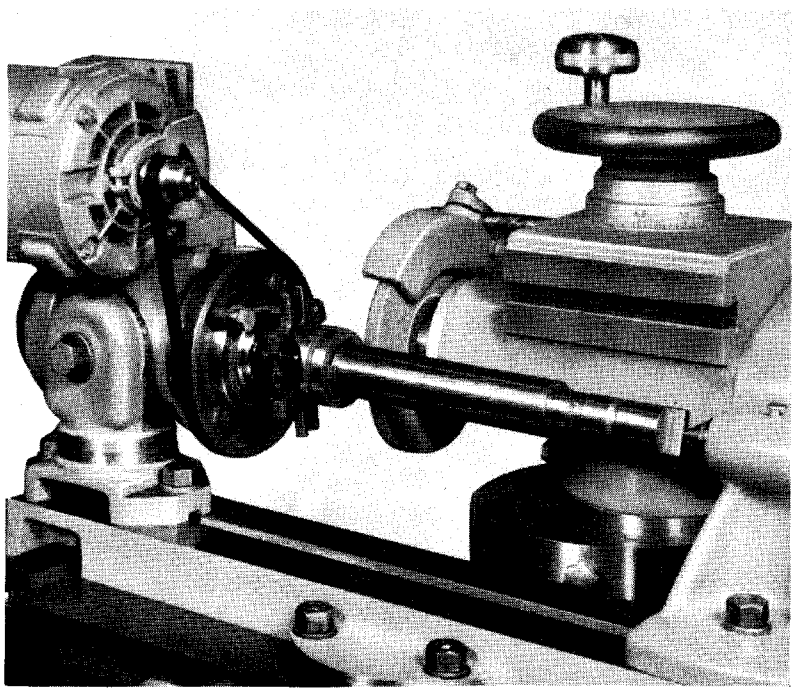


Figure 34A
Cylindrical Grinding Attachment

This attachment is designed to rotate the work between dead centers, in a chuck, or on a stud. (Figure 34A). Right or left-hand rotation may be selected as desired through a two-way switch built into the push button station of Universal machines. (Late designs only.) To set up for cylindrical grinding work which can be held between centers proceed as follows:

1. Place the centering gage on the table, adjust the column to the zero mark, and clamp in place.
2. Fasten the workhead to the table, and lock the workhead spindle in position with the knurled thumb screw.
3. Place the pulley on the workhead dial, and fasten securely with the two screws and clamps provided.
4. Loosen the headless set screw through the workhead dial, allowing the pulley and dial to rotate freely on the spindle.
5. Place the workhead motor and endless belt in position, and clamp securely.
6. Fasten the driving dog in position on the pulley.
7. Set the table to zero (as shown by the scale on the end) or to the desired taper.

When grinding the sides of thin cutters, saws, washers, etc., it is necessary that the workhead spindle and work rotate together, since the chuck which holds the work is driven by the spindle. To accomplish this result, loosen the knurled thumb screw through the workhead casting and tighten the headless set screw through the workhead dial, which allows the spindle to rotate with the pulley.

Use the differential table traverse crank for finishing. For roughing, disengage the differential unit and use the front or rear table traverse knobs.

The pulley on the workhead rotates at 360 rpm if the standard 1750 rpm workhead motor is used. Use any desired wheel. If wheel shape No. 1Y or No. 6Y-112 is used, they should be trued with the truing attachment.

Internal Grinding Attachment. This attachment is ordinarily used for grinding holes in cutters, jig bushings, arbor collars, etc. To set up, proceed as follows:

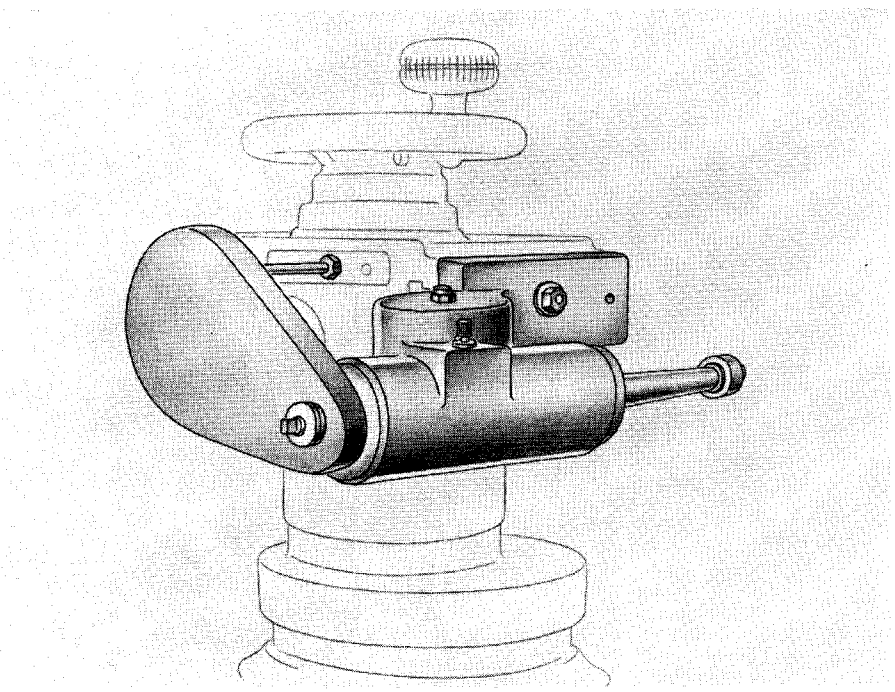


Figure 36A
Internal Grinding Attachment

1. Remove wheel guard and grinding wheel.
2. Fasten the driving pulley on the end of the wheel spindle.
3. Mount the attachment on the finished surface of the wheelhead by means of the tee-bolt inserted in the tee slot. Place the belt over the two pulleys, and tighten the attachment in place. See that the belt is tight.
4. Place the centering gage on the table and adjust the column to zero.

The spindle runs at 13,150 rpm with the machine driving belt on the small step of the pulley, and 19,590 rpm with the belt on the large step. We recommend that the high speed be used, to get the surface speed of the

wheel as near as possible to the proper figure. For roughing, use the rear knob control. For finishing, use the front table feed control, and set the table dogs. Holes up to 3" long can be ground with this attachment.

The best results will be obtained when the grinding wheelhead has been adjusted vertically to center the attachment spindle with the work. This may be done with the aid of the centering gage, as shown in Figure 23A. The wheel should grind on the side of the hole towards the front of the machine. To obtain accurate work, align the workhead spindle parallel to the top of the table and parallel to the table traverse, using an aligning bar and an indicator gage on a stand. The best finish will be produced by taking light cuts of about .0005" per pass.

Gear Cutter Grinding Attachment. Since gear cutters are form relieved, the only correct way they can be sharpened is to grind the *faces* of the teeth. (Figures 38A and 38B). To accomplish this result, it is necessary that the feed or adjustment of the cutter to the grinding wheel should be a *rotary or circular adjustment*, as provided for in the Cincinnati Gear Cutter Sharpening Attachment.

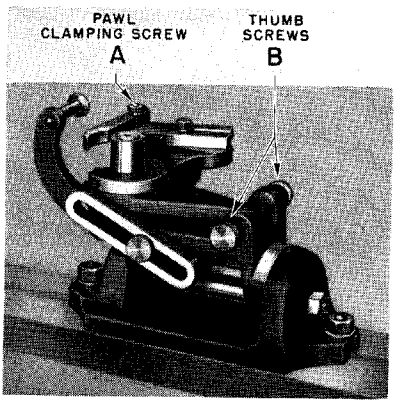


Figure 37A
Gear Cutter Grinding Attachment

When grinding a new cutter for the first time, it is necessary to grind the *backs* of the teeth before grinding the cutting edge. This extra operation need only be done once, but it is necessary because the pawl locates from the back of the teeth, and if they are all ground uniformly, more accurate results can be obtained.

To set up for the first grinding of an ordinary gear cutter, proceed as follows: (See Figure 38C).

1. Fasten the extension on the left end of the wheel spindle.
2. Place wheel shape No. 12Y-155 in position.
3. Set the wheelhead to 90° and clamp in place.
4. Clamp the attachment on the table, to the left of the wheel, with the pawl side *away* from the wheel. See that the upper swiveling part of the attachment is set to zero on the degree readings.

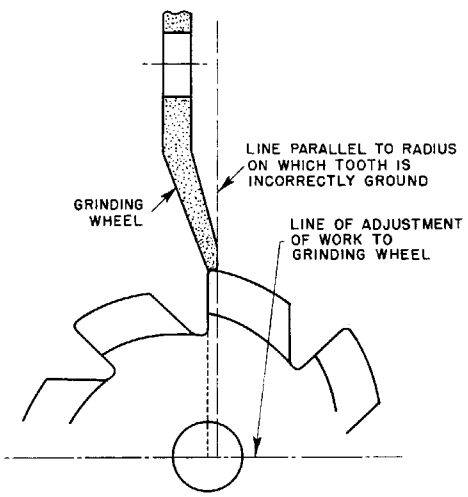


Figure 38A
The Wrong Way to Grind a Radial Tooth Gear Cutter. The face of the tooth is ground in a plane parallel to the radius, deforming the tooth profile

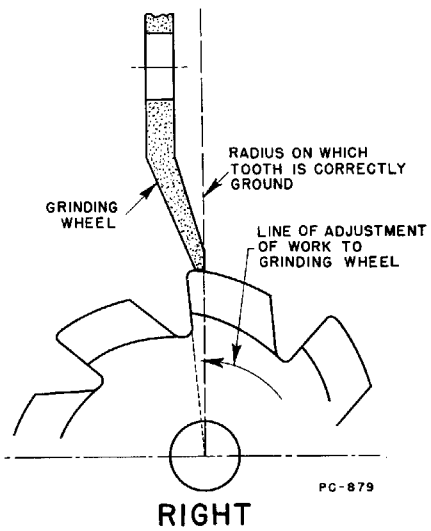


Figure 38B
The Correct Way to Grind a Radial Tooth Gear Cutter. The face of the tooth is ground in a radial plane

5. Place the cutter on the stud in the reverse position, so that the back of the tooth can be ground.

6. Set the centering gage on top of the wheelhead and adjust the head vertically until the cutter and gage are about central. Remove the gage and adjust the saddle in or out, and at the same time rotate the cutter by hand on the stud to bring the back of the tooth in the same plane with the face of the wheel.

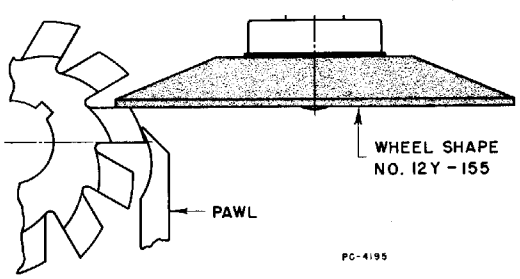


Figure 38C
Grinding the Backs of the Teeth of a New Gear Cutter

7. Place the edge of the pawl on the *outside diameter* of the tooth being ground, and clamp in place by tightening knob "A". (Figure 37A).

8. To index for grinding the back of the next tooth, traverse the table to the left, moving the cutter away from the wheel. Lift the cutter off the stud by hand. Hold it lightly against the solid pawl with one hand while grinding.

Due to deformations set up in hardening, the amount ground off one tooth may be greater than the next tooth, but there will then be a uniformity between the back of the teeth (the locating side for grinding) and the outside diameter. Notice that during the first grinding operation the pawl is fixed, while for the second or sharpening operation, the pawl swivels and acts as a stop when indexing to the next tooth. To continue with the sharpening operation (radial tooth cutters only):

9. Swivel the attachment centering gage up to the top of the attachment, and rotate the cutter by hand on the stud to bring the face of one tooth against the gage. Loosen knob "A" and contact the back of the tooth with the pawl, and then swing the gage out of the way. (Figure 37A).
10. Adjust the saddle to bring the face of a tooth in line with the face of the grinding wheel. Do not re-adjust the saddle while the cutter is being ground, except to compensate for wheel wear.
11. Loosen one thumb screw "B" and tighten the other one to rotate the face of the tooth towards the grinding wheel. (Figure 37A).
12. Grind one tooth, move the attachment away from the wheel by means of the table motion, index to the next tooth, grind, and so on.
13. If the cutter is not ground enough, re-set screws "B" and repeat the grinding operation.

If the teeth are provided with rake or undercut, of course they can not be ground radially, but must be ground in a plane tangent to the base circle, as shown in Figure 39A. Line up the point of one cutter tooth with the attachment gage, as before, swivel the table to the degree of undercut, adjust the saddle to bring the face of the tooth in line with the face of the wheel, and grind. (Also see discussion on page 30.). If the cutter is not ground enough, adjust the saddle towards the wheel to compensate for wheel wear, and repeat the operation.

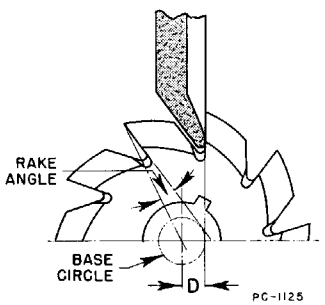


Figure 39A
Gear Cutter with Undercut Teeth

Roughing gear cutters are sometimes made with alternate right and left side rake on the teeth to produce a better cutting action. These stagger tooth cutters can be ground by using the standard gear cutter grinding attachment. When setting up, proceed as for the regular cutter, then tilt the upper part of the attachment the amount of the side rake, which is usually seven to ten

degrees. Set the gage to the outer edge of the tooth and clamp the pawl in position to rest on the back of the tooth. Adjust the saddle until the edge of the wheel just touches the outer edge of the tooth, then proceed to grind every other tooth. For the second operation, tilt the upper part of the attachment the same amount in the opposite direction, touch up the outer edge of the tooth with the wheel, and proceed to grind.

The cutter stud on the attachment is $\frac{7}{8}$" diameter, but adapter bushings of 1", $1\frac{1}{4}$", $1\frac{1}{2}$", $1\frac{3}{4}$", and 2" outside diameter are supplied for cutters with these hole diameters. (Metric sizes are: stud 22 mm and bushings 27 mm, 32 mm, 40 mm, 45 mm, and 50 mm. O. D.) Gear cutters or any cutter of similar design up to $5\frac{1}{2}$" outside diameter and up to 2" hole diameter can be ground on this attachment.

Small End Mill Grinding Attachment. Small end mills up to $4\frac{1}{2}$" cutter length and 1" maximum cutter diameter can be conveniently ground with this attachment. Small end mills and plain milling cutters with helical teeth are similar in sharpening procedure.

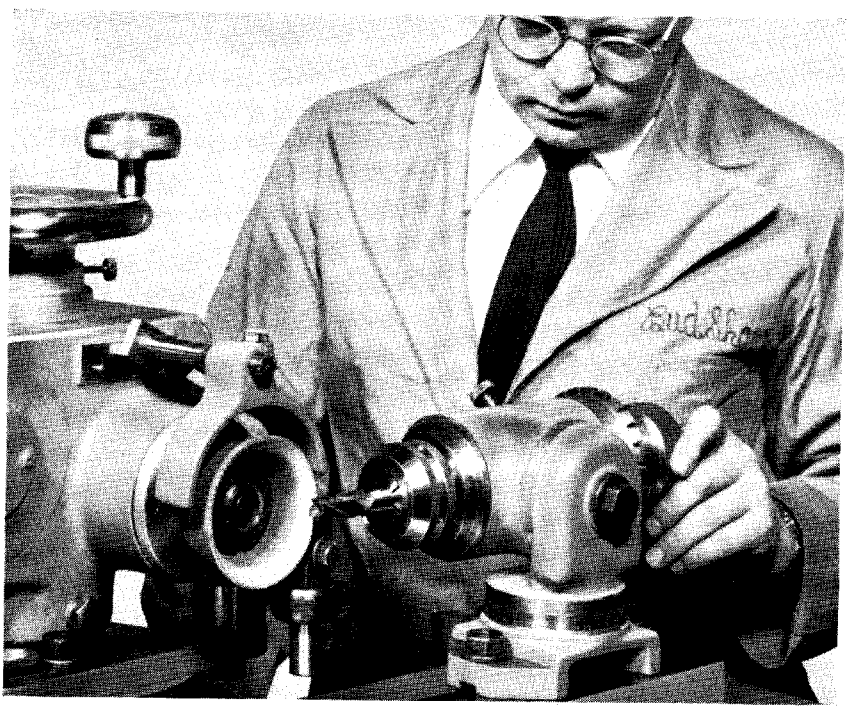


Figure 40A
Small End Mill Grinding Attachment

Radius Grinding Attachment. For quickly and accurately sharpening small ball-end cutters, double-end cutters, and die-sinking cutters having straight or helical flutes. With the addition of motor drive parts, it may also be used for grinding straight and taper tracer fingers for die-sinking machines.

There are two slides, each having a convenient adjustment for the purpose of setting the cutter to the desired radius. The bracket bolted to the machine table contains an anti-friction pivot upon which the attachment can be swiveled 360 degrees. The base of the fixed bracket is equipped with movable stops, having screw adjustment to accurately limit the amount of swivel motion of the cutter.

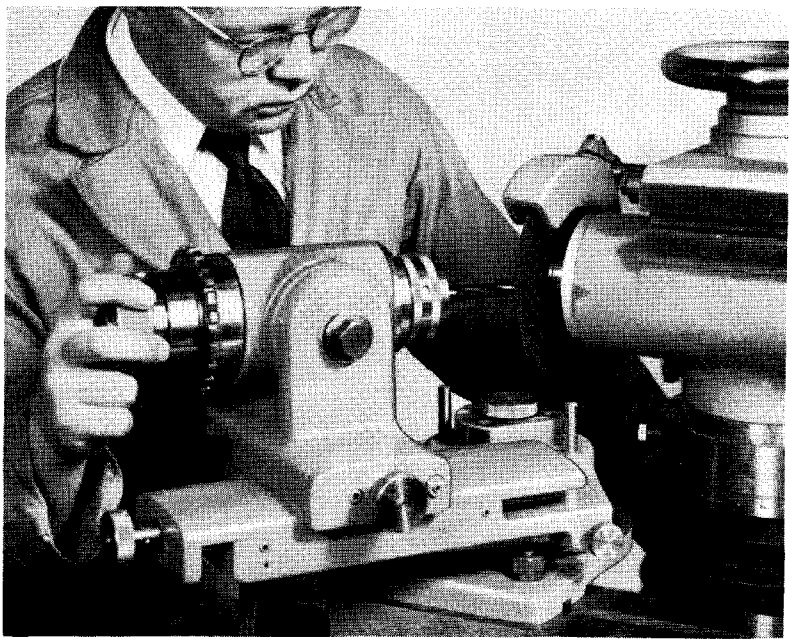


Figure 41A
Radius Grinding Attachment

The index plate at the rear of the workhead spindle has 24 notches. With this device, the attachment will handle straight fluted cutters having 1, 2, 3, 4, 6, 8, 12 and 24 flutes, without the necessity of a tooth rest. When grinding cutters with helical flutes, the universal tooth rest supplied with the machine may be used. The capacity of the attachment is 0″ to 2″ radii, 4½″ cutter length and 4″ maximum cutter diameter.

When setting up the radius grinding attachment for grinding ball end cutters, proceed as follows:

1. **Mounting Attachment and Cutter.** Mount radius grinding attachment on left end of machine table with small end mill grinding attachment workhead housing mounted in horizontal (zero) position (Figure 42A).

   Remove the knurled collet clamping nut from the nose of the workhead spindle, insert the desired collet, depending upon the diameter of cutter, and replace clamping nut. Always lock the workhead spindle by means of the "workhead spindle clamping screw" when loosening or tightening the collet clamping nut.

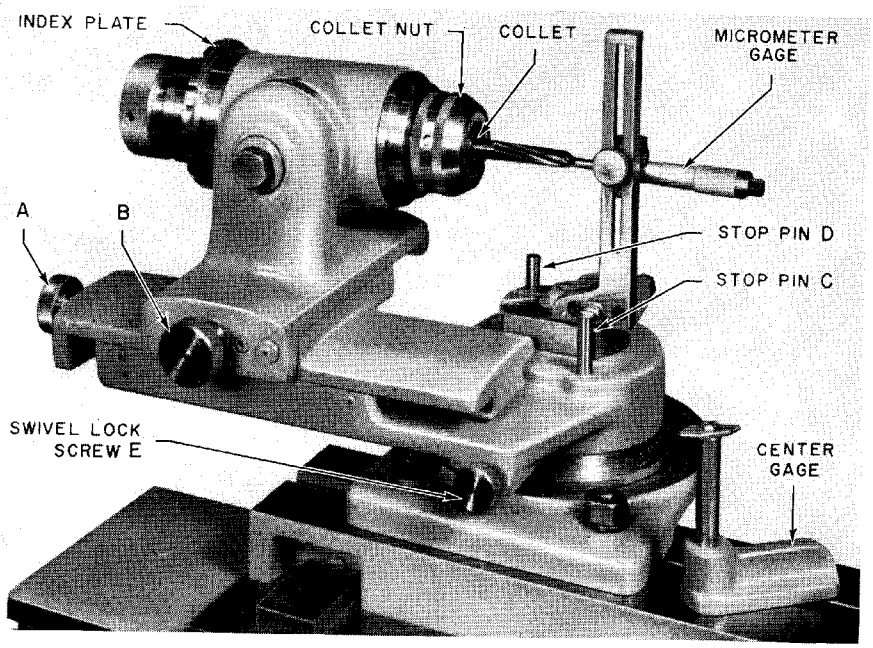


Figure 42A
Positioning Ball Nose Cutter for Grinding

2. **Centering Cutter.** Position attachment so face of cutter is toward wheelhead. Align scribed line on swivel housing with zero on graduated scale. Tighten swivel lock "E", Figure 42A. Using centering gage, provided with attachment (Figure 42A) raise or lower wheelhead until pointer on gage is aligned with zero mark stamped on spindle housing.

3. **Positioning Cutter for Radius.** Move grinding wheel away from cutter, using machine controls, and back up attachment slides far enough to allow micrometer gage to be mounted in tapered hole of attachment. Locate against positive stop "C". Set micrometer barrel to proper height using center gage supplied with attachment (Figure 42A) and adjust to desired radius. (For example: a ¼" radius, set micrometer at .250" which brings the cutter .250" beyond the pivot point). Turn crank "A" (Figure 42A) until periphery of cutter contacts spindle of micrometer. Turn micrometer gage 90° against other stop pin "D" (Figure 42A). With micrometer still set at .250", turn crank "B" until face of cutter contacts micrometer spindle. Remove micrometer gage and replace with tapered plug.

4. **Positioning Table and Wheelhead Slide.** Loosen swivel lock screw "E" (Figure 42A) and position table and wheelhead so point of cutter swivels directly in front of grinding wheel face (Figure 42A). Set left-hand table dog so table cannot be further traversed to the right.

5. **Contacting Grinding Wheel.** Position attachment so grinding wheel is perpendicular to periphery of the cutter. With grinding wheel running, hold a thin piece of tissue paper between cutter and grinding wheel. Turn wheelhead adjusting handwheel slowly until grinding wheel tears paper.

6. **Grinding Face and Radius.** Swivel attachment through 90° and feed in with crank "F" (Figure 42A) until wheel starts cutting. Grind all teeth at this setting. After all teeth are ground, rotate cutter 180° from first tooth and again move in with crank "F" a small amount. Continue to grind cutter in this manner until original setting is reached. Grinding wheel will not start cutting on face of cutter until zero or original setting of crank "F" is reached. Further feeding beyond original setting is necessary to grind cutter face and will not change the predetermined radius.

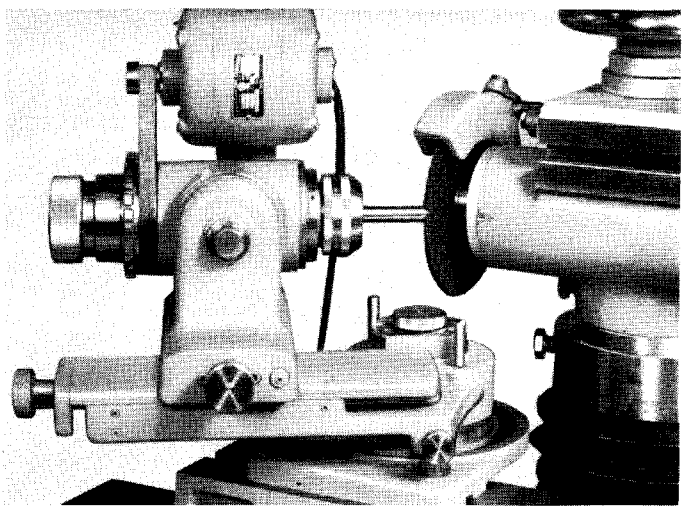


Figure 43A
Grinding a Tracer Finger on the Radius Grinding Attachment

ADJUSTMENTS

Adjusting the Workhead Spindle Bearings. The workhead spindle is held against end thrust by means of a positive serrated lock nut arrangement located at the No. 12 B. & S. end of the spindle. Under ordinary hand pressure on either end of the spindle, no end play can be noticed. Should you find free end play, adjust the bearing in the following manner:

1. Loosen lock screw "A" (Figure 44A) through the lock ring.
2. Lightly tap the ring to free it from the adjusting nut. Slide the ring off the adjusting nut.
3. Hold the spindle with one hand and, with a spanner wrench, tighten serrated nut, until there is no evidence of looseness. Each serration is equal to approximately .001". Hence, movement of the adjusting nut can be measured accordingly.
4. Replace lock ring by slipping it over serrated adjusting nut, Figure 44A.
5. Retighten lock screw "A".

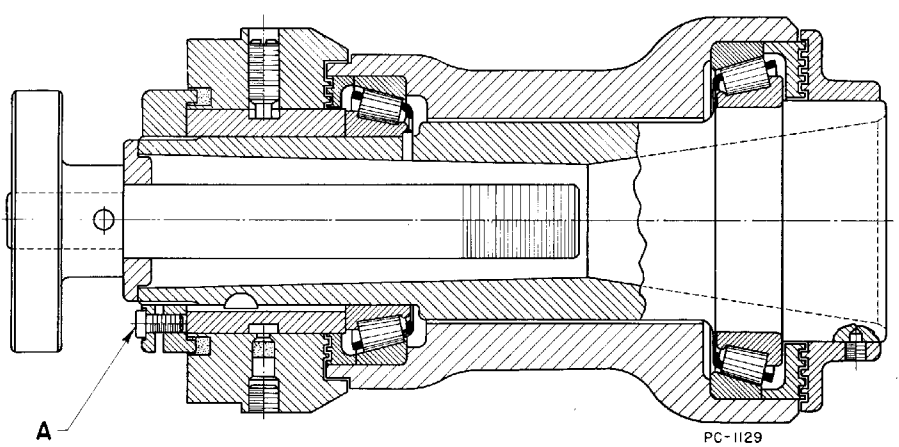


Figure 44A
Workhead Spindle Bearing Adjustment

CLEARANCE ANGLE SETTINGS

In grinding the clearance angle with the side of a cup or the periphery of a disc type grinding wheel, the desired clearance is generally obtained by setting the center of rotation of the grinding wheel below the center line of the cutter by a predetermined amount "A", while the cutting edge, supported by a tooth rest, is maintained in a fixed relation to the grinding wheel. This will cause the grinding wheel to produce a land on the back of the tooth, inclined with respect to the tangent, to the cutter periphery by a small angle, which is the clearance angle.

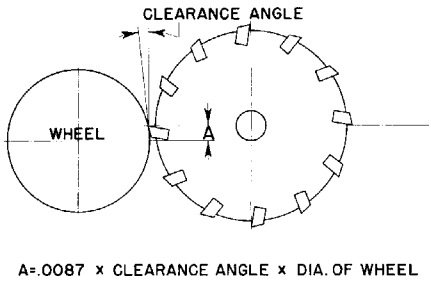


Figure 45A
Left Hand Face Mill

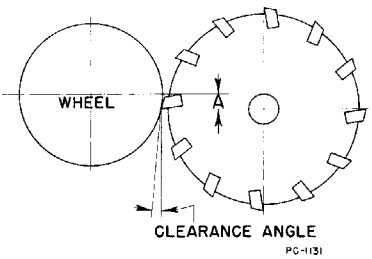


Figure 45B
Right Hand Face Mill

Wheel Dia.	CLEARANCE ANGLE									
	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°
	DISTANCE A IN INCHES									
3	.026	.052	.078	.104	.130	.156	.182	.208	.235	.261
4	.034	.069	.104	.139	.174	.208	.243	.278	.313	.348
5	.046	.087	.131	.174	.218	.261	.305	.348	.392	.435
6	.052	.104	.157	.209	.262	.363	.365	.418	.470	.522
7	.061	.122	.163	.244	.304	.365	.426	.487	.548	.609
8	.069	.139	.209	.268	.347	.418	.487	.557	.628	.696
9	.078	.157	.235	.313	.391	.470	.548	.606	.705	.793
10	.087	.174	.261	.348	.434	.522	.609	.696	.783	.870

The values of "A", which increases with the diameter of the grinding wheel, apply to plain milling cutters with either straight or helical teeth, and slotting cutters, mounted on arbors and supported between centers; to grinding the sides of side mills or the face of shell end mills mounted in the universal workhead.

REAMER CLEARANCE TABLES

(When Using Cup Wheels Only)

SIZE OF REAMER	TABLE 1 Hand Reamer for Steel. Land of Cutting Clearance .006 Wide		TABLE 2 Hand Reamer for Cast Iron and Bronze. Land of Cutting Clearance .025 Wide		TABLE 3 Chucking Reamer for Cast Iron and Bronze. Land of Cutting Clearance .025 Wide	
	Vertical Adjustment for Cutting Primary *Clearance Angle	Vertical Adjustment for Cutting Primary and Secondary Clearance Angles	Vertical Adjustment for Cutting Primary *Clearance Angle	Vertical Adjustment for Cutting Primary and Secondary Clearance Angles	Vertical Adjustment for Cutting Primary *Clearance Angle	Vertical Adjustment for Cutting Primary and Secondary Clearance Angles
1/2"	.012"	.052"	.032"	.072"	.040"	.080"
9/16"	.012"	.057"	.032"	.072"	.040"	.080"
5/8"	.012"	.062"	.032"	.072"	.040"	.090"
11/16"	.012"	.067"	.035"	.095"	.040"	.100"
3/4"	.012"	.072"	.035"	.095"	.040"	.100"
13/16"	.012"	.077"	.037"	.095"	.045"	.125"
7/8"	.012"	.082"	.040"	.120"	.045"	.125"
15/16"	.012"	.087"	.040"	.120"	.045"	.125"
1"	.012"	.092"	.040"	.120"	.045"	.125"
1 1/16"	.012"	.097"	.040"	.120"	.045"	.125"
1 1/8"	.012"	.102"	.040"	.120"	.045"	.125"
1 3/16"	.012"	.106"	.042"	.122"	.045"	.125"
1 1/4"	.012"	.112"	.045"	.145"	.050"	.160"
1 5/16"	.012"	.118"	.045"	.145"	.050"	.160"
1 3/8"	.012"	.122"	.045"	.145"	.050"	.160"
1 7/16"	.012"	.127"	.045"	.145"	.055"	.175"
1 1/2"	.012"	.132"	.048"	.168"	.055"	.175"
1 9/16"	.012"	.137"	.050"	.170"	.055"	.175"
1 5/8"	.012"	.142"	.050"	.170"	.060"	.200"
1 11/16"	.012"	.147"	.050"	.170"	.060"	.200"
1 3/4"	.012"	.152"	.052"	.192"	.060"	.200"
1 13/16"	.012"	.157"	.052"	.192"	.060"	.200"
1 7/8"	.012"	.162"	.056"	.196"	.060"	.200"
1 15/16"	.012"	.167"	.056"	.196"	.064"	.200"
2"	.012"	.172"	.056"	.216"	.064"	.224"
2 1/16"	.012"	.172"	.056"	.216"	.064"	.224"
2 1/8"	.012"	.172"	.059"	.219"	.064"	.224"
2 3/16"	.012"	.172"	.059"	.219"	.064"	.224"
2 1/4"	.012"	.172"	.063"	.223"	.064"	.224"
2 5/16"	.012"	.172"	.063"	.223"	.064"	.224"
2 3/8"	.012"	.172"	.063"	.223"	.068"	.228"
2 7/16"	.012"	.172"	.063"	.223"	.068"	.228"
2 1/2"	.012"	.172"	.065"	.225"	.072"	.232"
2 9/16"	.012"	.172"	.065"	.225"	.072"	.232"
2 5/8"	.012"	.172"	.065"	.225"	.075"	.235"
2 11/16"	.012"	.172"	.065"	.225"	.075"	.235"

*See note, following page.

REAMER CLEARANCE TABLES

(When Using Cup Wheels Only)

SIZE OF REAMER	TABLE 1 Hand Reamer for Steel. Land of Cutting Clearance .006 Wide		TABLE 2 Hand Reamer for Cast Iron and Bronze. Land of Cutting Clearance .025 Wide		TABLE 3 Chucking Reamer for Cast Iron and Bronze. Land of Cutting Clearance .025 Wide	
	Vertical Adjustment for Cutting Primary *Clearance Angle	Vertical Adjustment for Cutting Primary and Secondary Clearance Angles	Vertical Adjustment for Cutting Primary *Clearance Angle	Vertical Adjustment for Cutting Primary and Secondary Clearance Angles	Vertical Adjustment for Cutting Primary *Clearance Angle	Vertical Adjustment for Cutting Primary and Secondary Clearance Angles
2 3/4"	.012"	.172"	.065"	.225"	.077"	.237"
2 13/16"	.012"	.172"	.065"	.225"	.077"	.237"
2 7/8"	.012"	.172"	.070"	.230"	.080"	.240"
2 15/16"	.012"	.172"	.070"	.230"	.080"	.240"
3"	.012"	.172"	.072"	.232"	.080"	.240"
3 1/16"	.012"	.172"	.072"	.232"	.080"	.240"
3 1/8"	.012"	.172"	.075"	.235"	.083"	.240"
3 3/16"	.012"	.172"	.075"	.235"	.083"	.243"
3 1/4"	.012"	.172"	.078"	.238"	.083"	.243"
3 5/16"	.012"	.172"	.078"	.238"	.087"	.243"
3 3/8"	.012"	.172"	.081"	.241"	.087"	.247"
3 7/16"	.012"	.172"	.081"	.241"	.090"	.247"
3 1/2"	.012"	.172"	.084"	.244"	.090"	.250"
3 9/16"	.012"	.172"	.084"	.244"	.090"	.250"
3 5/8"	.012"	.172"	.087"	.247"	.093"	.253"
3 11/16"	.012"	.172"	.087"	.247"	.093"	.253"
3 3/4"	.012"	.172"	.090"	.250"	.097"	.257"
3 13/16"	.012"	.172"	.090"	.250"	.097"	.257"
3 7/8"	.012"	.172"	.093"	.253"	.100"	.260"
3 15/16"	.012"	.172"	.093"	.253"	.100"	.260"
4"	.012"	.172"	.096"	.256"	.104"	.264"
4 1/16"	.012"	.172"	.096"	.256"	.104"	.264"
4 1/8"	.012"	.172"	.096"	.256"	.104"	.264"
4 3/16"	.012"	.172"	.096"	.256"	.106"	.266"
4 1/4"	.012"	.172"	.096"	.256"	.106"	.266"
4 5/16"	.012"	.172"	.096"	.256"	.106"	.266"
4 3/8"	.012"	.172"	.096"	.256"	.108"	.268"
4 7/16"	.012"	.172"	.096"	.256"	.108"	.268"
4 1/2"	.012"	.172"	.100"	.260"	.108"	.268"
4 9/16"	.012"	.172"	.100"	.260"	.108"	.268"
4 5/8"	.012"	.172"	.100"	.260"	.110"	.270"
4 11/16"	.012"	.172"	.100"	.260"	.110"	.270"
4 3/4"	.012"	.172"	.104"	.264"	.114"	.274"
4 13/16"	.012"	.172"	.104"	.264"	.114"	.274"
4 7/8"	.012"	.172"	.106"	.266"	.116"	.276"
4 15/16"	.012"	.172"	.106"	.266"	.116"	.276"
5"	.012"	.172"	.110"	.270"	.118"	.278"
5 3/8"	.012"	.172"	.118"	.278"		

*Note.—If a cylindrical grinding attachment is available, use it for grinding the cutting primary clearance. Then the first column in Table 1 should be disregarded.

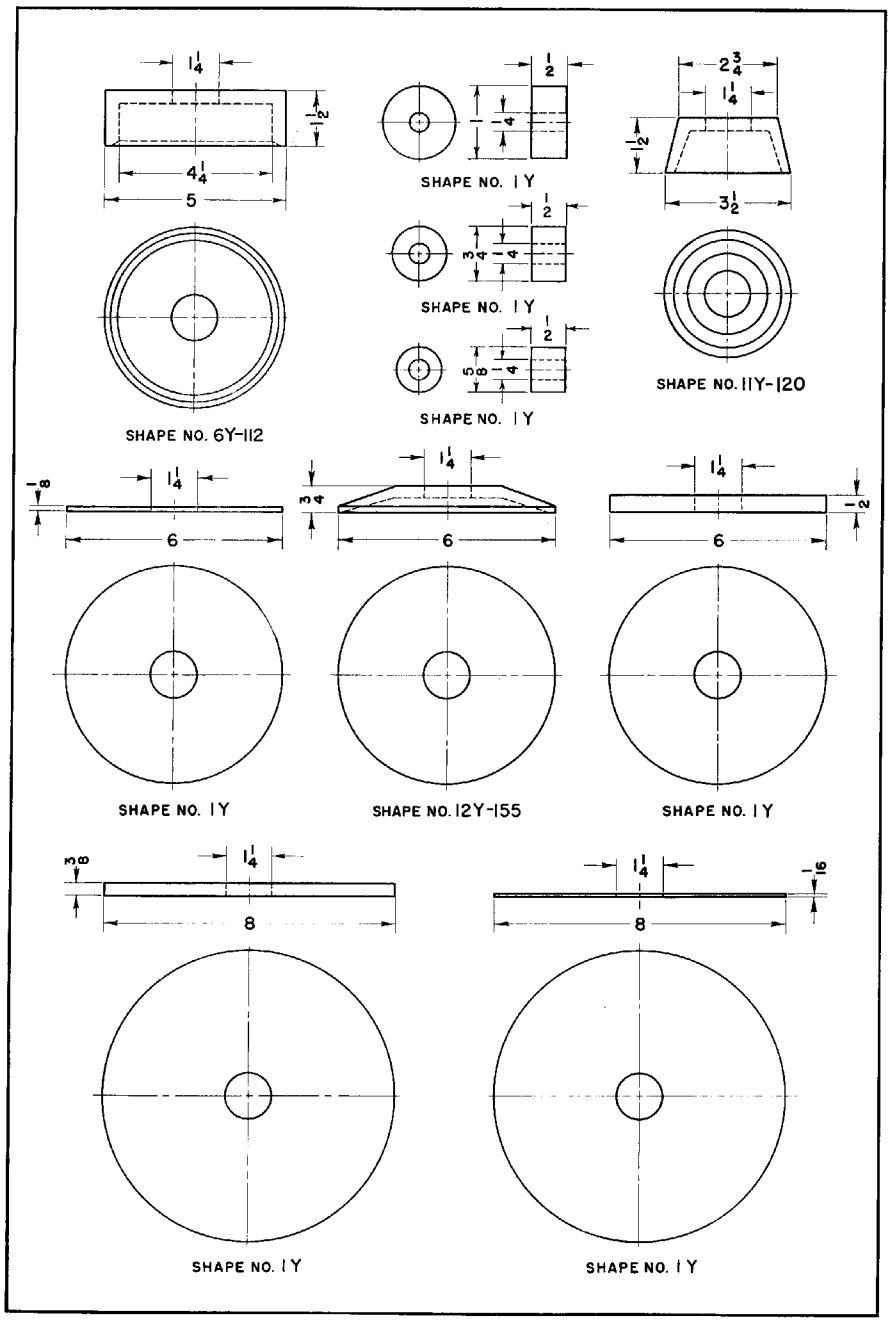


Figure 48A
Grinding Wheels Used on CINCINNATI No. 1 Cutter and Tool Grinder

TABLE OF GRINDING WHEELS AND THEIR USES

(See Figure 48A)

For Carbon Steel and High Speed Steel Cutters

Cincinnati Milling Machine Co. Size and Shape Number	USES
6″ x ¾″ x 1¼″—12Y-155*	Gear Cutters, Formed Cutters, Hobs, Taps, Boring Cutters.
3½″ x 1½″ x 1¼″—11Y-120*	Reamers, Plain Helical Cutters, Slotting Cutters, Face Mills, Angle Mills, End Mills.
5″ x 1½″ x 1¼″—6Y-112*	Flat Forming Tools, Lathe and Planer Tools, Screw Machine Tools, Work Rest Blades, Straight Edges, Gages, Drifts.
6″ x ½″ x 1¼″—1Y*	Cylindrical Grinding, Surface Grinding.
⅝″, ¾″ or 1″ x ½″ x ¼″—1Y	Internal Grinding.
8″ x ⅜″ x 1¼″—1Y	Face Mills, Steep Angle Helical Cutters.
6″ x ⅛″ x 1¼″—1Y*	Plain Helical Cutters, Reamers, End Mills, Angle Mills.
8″ x 1/16″ x 1¼″—1Y	Cutting Off Bar Stock, Tubing, Damaged Cutters, Etc.

It is contrary to safety code to use shape 27 and 30 (8″ dia.) with our standard collet. Supplied with the machine. Flanges for 8″ diam. wheels must be at least 3″ in diameter. Such a collet can be supplied at extra cost.

*Supplied as standard equipment with the machine.

STANDARD EQUIPMENT SUPPLIED WITH THE MACHINE

1. Universal Workhead—includes center; three collets—modified 12 to 9 B. & S. or 5 to 3 Morse taper, 12 to 7 B. & S. or 5 to 2 Morse taper and 12 to 10 B. & S. or 5 to 4 Morse taper*; base plate; one intermediate support; ejector rod; draw-in bolt and washer; two table wedge bolts. Accommodates cutters with either the No. 12 B. & S. taper (No. 5 Morse taper optional) or the No. 50 Series National Standard taper.

2. Right-hand Tailstock.

3. Left-hand Tailstock with Clearance Setting Dial.

4. Two Table Wedge Bolts for Tailstocks.

5. Double End Wrench (7/8″ and 9/16″ openings).

6. Two Taper Setting Blocks for Swivel Table.

7. Open Wheel Guard for 5″ Wheels (Shape 6Y-112).

8. Open Wheel Guard for 3½″ Wheels (Shape 11Y-120).

9. Closed Wheel Guard for 6″ Wheels (Shapes 12Y-155 and two 1Y's).

10. Clearance Angle Setting Dog.

11. Center Gage.

12. Universal Tooth Rest with Two Blades and One T-Bolt and One Wedge Bolt.

13. Plain Tooth Rest Holder with Offset Blade.

14. Wheel Spindle Extension, Screw Type—[illegible]

*Your selection of taper hole in workhead spindle governs which set of reducing collets and work center are supplied.

STANDARD EQUIPMENT (Continued)

15. One Pin Wrench for Grinding Wheel Collet.

16. T-Wrench for Grinding Wheel Collet Lock Screw.

17. One Collet Wrench.

18. Grinding Wheel and Collet Assembly. Shape 12Y-155—6" x ¾" x 1¼" Hole—Dished.

19. Grinding Wheel and Collet Assembly. Shape 11Y-120—3½" x 1½" x 1¼" Hole—Flaring Cup.

20. Grinding Wheel and Collet Assembly. Shape 6Y-112—5" x 1½" x 1¼" Hole—Straight Cup.

21. Grinding Wheel and Collet Assembly. Shape 1Y—6" x ½" x 1¼" Hole—Straight.

22. Grinding Wheel and Collet Assembly. Shape 1Y—6" x ⅛" x 1¼" Hole—Straight.

23. Diamond Bracket.

24. Diamond Holder with Diamond.

25. Electrical Equipment as follows:

    1. ½ hp totally enclosed ball bearing motor, in precision dynamic balance. 220 to 550 volts, 50 (3000 rpm) or 60 (3600 rpm) cycle A.C. for grinding wheel spindle.

    2. Magnetic starter for above motor provides overload and under-voltage protection.

    3. Disconnect switch built-in and mechanically interlocked with electrical compartment door.

    4. Complete electrical wiring, in accordance with "Machine Tool Electrical Standards."

EQUIPMENT SUPPLIED AT EXTRA COST

Not Included in Price of Standard (Basic) Machine

1. Small End Mill Grinding Attachment—accommodates straight cylindrical collets—1/8", 3/16", 1/4", 5/16", 3/8", 7/16", 1/2", 5/8", 3/4", 7/8", 1", or 3, 4, 5, 6, 7, 8, 10, 13, 16, 18, 20, 22, 24, 25, 28, 30 and 32 mm; and six taper collets— Modified Nos. 5 and 7 B. & S. and Nos. 2 and 3 Morse taper (a small collet adapter is required for collets smaller than 1/2" or 13 mm size.) Specify inch or millimeter size collets. Attachment is supplied with No. 40 Series National Standard taper spindle nose and includes twenty-four division master index plate, five index guide plates having 2, 3, 4, 6 and 8 equally spaced divisions and plunger type indexing mechanism. Collets and collet adapter not included.

   Additional equipment for above attachment:

   (a) Straight Cylindrical Collets—inch sizes from 1/8" to 1/2" in increments of 1/16"; millimeter sizes 3, 4, 5, 6, 7, 8, 9, 10, 13, 14 and 15 mm. Requires Collet Adapter (See item b).

   (b) Collet Adapter—for use with above collets (Specify English or inch or millimeter).

   (c) Straight Cylindrical Collets—inch sizes from 5/8" to 1" in increments of 1/8"; millimeter sizes 16, 18, 20, 22, 25, 26, 28, 30 and 32 mm.

   (d) Taper Collets—Modified Nos. 5 and 7 B. & S. and Nos. 2 and 3 Morse tapers.

   (e) Motor Drive Equipment—1/25 hp, totally enclosed. Operates from extra capacity of secondary of included transformer.

2. Cylindrical Grinding Attachment—includes universal chuck with reversible jaws; universal grinding dog; and complete electrical equipsible jaws; universal grinding dog; and complete electrical equipment (1/4 hp, 1800 rpm motor.) Specify taper in Universal Workhead spindle (No. 12 B. & S. or 5 Morse).

3. Surface Grinding Attachment—includes vise, intermediate support, two table wedge bolts and base plate.

4. Intermediate Support for above.

5. Internal Grinding Attachment— includes straight grinding wheel shape No. 26 (1" x 1/2" x 1/4" hole), No. 29 (5/8" x 1/2" x 1/4" hole), and No. 31 (3/4" x 1/2" x 1/4" hole). (Requires use of Cylindrical Grinding Attachment.)

EQUIPMENT SUPPLIED AT EXTRA COST—Continued

6. Gear Cutter Sharpening Attachment—(Max. dia. 5½″). Includes five bushings: specify inch or millimeter (1″, 1¼″, 1½″, 1¾″ and 2″; or 27, 32, 40, 45, and 50 mm O. D.).

7. Radius Grinding Attachment—Capacity 0″ to 2″ radii, 4½″ cutter length and 4″ maximum cutter diameter. Utilizes same workhead as Small End Mill Grinding Attachment. For additional equipment for use with above attachment see a, b, c, d, and e under Item 1.

8. Grinding Wheel Collets and Collet Parts.
Specify if collets are for 8″ dia. wheels.

9. Standard Grinding Wheels—without grinding wheel collet, collet nut, lock washer, or spacing collar. Machine includes one set of wheels, (a), (b), (c), (d),, and (e).
   (a) Shape 12Y-155 dished—6″ diam. x ¾″ x 1¼″ hole.
   (b) Shape 11Y-120 flaring cup—3½″ diam. x 1½″ x 1¼″ hole.
   (c) Shape 6Y-112 straight cup—5″ diam. x 1½″ x 1¼″ hole.
   (d) Shape 1Y straight—6″ diam. x ½″ x 1¼″ hole.
   (e) Shape 1Y straight—1″ diam. x ½″ x ¼″ hole.
   (f) Shape 1Y straight—8″ diam. x ⅜″ x 1¼″ hole.
   (g) Shape 1Y straight—6″ diam. x ⅛″ x 1¼″ hole.
   (h) Shape 1Y straight—⅝″ diam. x ½″ x ¼″ hole.
   (i) Shape 1Y straight—8″ diam. x 1/16″ x 1¼″ hole.
   (j) Shape 1Y straight—¾″ diam. x ½″ x ¼″ hole.

10. Collets for Universal Workhead:
   (a) Modified No. 12 B. & S. to: 4 B. & S., 5 B. & S., 6 B. & S., 7 B. & S., 8 B. & S., 9 B. & S., 10 B. & S., or 11 B. & S.
   (b) Modified No. 12 B. & S. to: 1 Morse, 2 Morse, 3 Morse, or 4 Morse.
   (c) Modified No. 5 Morse to: 1 Morse, 2 Morse, 3 Morse, or 4 Morse.
   (d) Modified No. 5 Morse to: 4 B. & S., 5 B. & S., 6 B. & S., 7 B. & S., 8 B. & S., 9 B. & S., 10 B. & S., 11 B. & S.
   (e) No. 50 Series to 40 Series (National Standard taper).
   (f) Draw-in Bolt for No. 50 Series to 40 Series National Standard taper reducing collet.

EQUIPMENT SUPPLIED AT EXTRA COST—Continued

11. Draw-in Collet Attachment for Universal Workhead. Specify taper hole in spindle (No. 12 B. & S. or 5 Morse.) (See Item 12 for collets).

12. Straight Cylindrical Collets for above Attachment.
    (a) Inch sizes from $\frac{1}{8}$" to $1\frac{1}{8}$" in increments of $\frac{1}{64}$".
    (b) Decimal sizes from .125 to 1.125. Specify exact size.
    (c) Millimeter sizes from 3 mm to 28 mm in increments of 1 mm.

13. Spring Chuck and Spring Collets—chuck mounts directly into Universal Workhead spindle. Collet range: $\frac{1}{8}$", $\frac{3}{16}$", $\frac{1}{4}$", $\frac{5}{16}$", $\frac{3}{8}$", $\frac{7}{16}$", $\frac{1}{2}$", $\frac{5}{8}$", $\frac{3}{4}$", $\frac{7}{8}$", 1".

14. Diamond Truing Rod—with diamond.

15. Tooth Rests—
    (a) Universal Tooth Rest—complete assembly including plate and Item "b" below.
    (b) Micrometer Adjustable Blade Holder with two blades—for Universal Tooth Rest.
    (c) Plain Tooth Rest—complete assembly including plate and Item "d" below.
    (d) Plain Blade Holder with offset blade for Plain Tooth Rest.

16. Tooth Rest Blades—
    (a) Flat Top.
    (b) Round Top.
    (c) Off-Set (For Plain Tooth Rest only).

17. 4" 3-Jaw Universal Chuck—mounts in Universal Workhead spindle. Includes one set of non-reversible jaws. Specify taper hole in spindle (No. 12 B. & S. or 5 Morse).

18. 4" 4-Jaw Independent Chuck—mounts in Universal Workhead spindle. Includes one set of jaws. Specify taper hole in spindle (No. 12 B. & S. or 5 Morse).

19. Belt—main drive (tooth grip).

EQUIPMENT SUPPLIED AT EXTRA COST (Concluded)

20. Wrenches—
    (a) Double end—7/8" and 9/16" opening.
    (b) Collet nut wrench.
    (c) T-Wrench for Wheel Collet.
    (d) Spanner wrenches for Items 1, 1B, and 7.

21. Cutter Sharpening Arbors—includes set of collars and nut:
    7/8" and 1" diam. x 8 3/16" usable cutter length; 1 1/4", 1 1/2", 2" diam. x 8 3/4" usable cutter length.

22. Differential Table Traversing Attachment—interchangeable with right front table traverse handle, 3/8" table travel per revolution.

23. Indexing Attachment for Universal Workhead—includes one twenty-four notch plate.

24. Spindle Extensions—Screw Type—2" and 4" lengths for 1 1/4" dia. hole wheels.

25. Raising Blocks—2" used with workhead and surface grinding attachment. Includes long tee belt.

ORDERING REPAIR PARTS

You will receive quicker service when ordering repair parts if you will adhere to the following procedure:

1. **State amount wanted.**

2. **Give part number and name or description of part, and where obtained.**

   (*a*) Part number stamped on part.

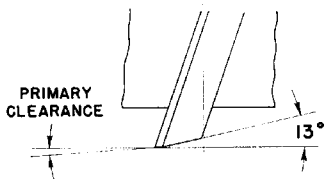
   (*b*) Prior invoice.

3. **Give complete serial number of machine.** This number will be found stamped on the front of the bed, to the right of the wheelhead slide adjusting handwheel.

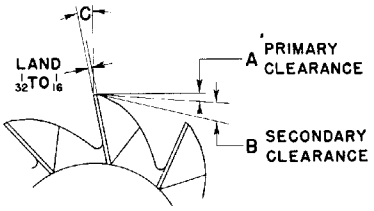
4. **Specify each individual piece required.** If only certain parts of a unit are required, never use the word "complete"; it always raises the question as to how much of the unit to supply. In some cases, due to the nature of the parts, it will be less costly to you for us to supply additional related pieces, especially if part wanted is obsolete.

5. **Specify how and where to ship.** Do not say "Ship quickest way". Be definite and state the agency desired, that is:—Air Mail, Parcel Post, Special Delivery, Express, Motor Freight, Rail Freight, etc.

NOTES



SIDE CUTTING EDGE



PERIPHERAL CUTTING EDGE

PC-965

Figure 57A

Write it down. When considerable experimenting with the variable factors in cutter sharpening has produced higher production and longer cutter life, we recommend that the clearance angles and "land" be entered in a table such as the one shown here. Then the superior results, once obtained, can again be duplicated without loss of time.

Cutter No.	A	B	C	D	E	Part Number and Material of Work

ALPHABETICAL INDEX

ALPHABETICAL INDEX—Continued

ALPHABETICAL INDEX—Concluded