# RADIAL GRINDING FIXTURE

## Grinding Cutters with Spherical Ends or Corner Radii

### INTRODUCTION TO THE FIXTURE

(LETTER DESIGNATIONS REFER TO PHOTOS 43, 44, and 45; NUMBERS ARE FROM FIGURE 45A.)

The K. O. Lee Radial Grinding Fixture is a precision bearing instrument for generating convex or concave radii on cutting tools. By means of its own crossfeed (A) and longitudinal (B) feed screws which control the corresponding Lower Slide (35) and Upper Slide (52), work held in various fixtures can be positioned ahead or back of the Pivot Point Vertical Axis of the fixture in order to grind predetermined convex or concave radii. This pivotal axis is identified by the vertical edge of the knife Center Gauge (see Photo 43) or intersecting surfaces of the 'V' Center Gauge wheel either is positioned in the self-locking taper of the Pivot Stud (49) after removal of the Cap for Center Gauge (40). The feed screw dials are graduated in thousands — .050 inch to a revolution of the handwheel — and are adjustable for desired 0 settings. Since the Saddle (50), on which the fixture bearing rests pivots around a vertical axis on a horizontal plane, it is possible to tilt by means of Adjusting Screw (4) the whole fixture back away from the wheel a fixed number of degrees for the purpose of setting clearance directly on the end of a cutter. The extent of the circumference of radius that can be generated is unlimited as the Fixture Turn Table (41) can be swiveled 360 degrees (RELATIVE TO THE SADDLE) about the Pivot Point Vertical Axis when the Table Adjusting Screws (E) are removed. The Turn Table (41) is calibrated in degrees. The Upper Slide and Lower Slide of the fixture can be locked by tightening their Gib Lock Screws (D). A Lever Arm (F) is provided to tilt the fixture further away from the wheel during the grinding process to allow indexing of the cutter or observation of grinding results.

### OPERATING INSTRUCTIONS

Three typical set-ups using the Radial Grinding Fixture are presented below to acquaint the operator with its great versatility. Set-up photos show the radial fixture on the B6062 model grinder; however, it can be mounted on any of the other K. O. Lee grinders. When it is mounted on the B300 or B360 grinder series, no cutter larger than 4 inches in diameter should be mounted on either the BA985 or the BA986 fixture. The BA985 fixture will mount cutters up to 12 inches in diameter on machine of model size BA900 and larger, however the maximum diameter for these machines is reduced to 9¼ inches when the BA986 fixture is in use.

### I GRINDING A CORNER RADIUS USING BA985 RADIAL GRINDING FIXTURE

A. Mount the BA985 fixture in approximately the center of the table, with spring-loaded locking screws and nuts (NUMBERS 42, 43 and 38) facing to the rear of the table slide, as shown in Photo 46. Secure the fixture to the table with two A657 T-slot bolts. Mount either a flared cup wheel or straight wheel at the left end of the spindle. Grind against a small edge on the face of a cup wheel; grind on the periphery of a straight wheel.

B. Remove the Cap for the Center Gauge (40) and install the knife Gauge

## RADIAL GRINDING FIXTURES

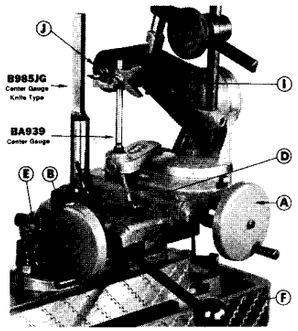



PHOTO 43

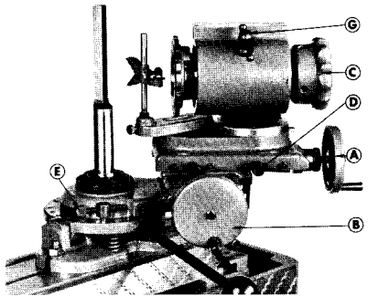



PHOTO 44

BA986 STANDARD EQUIPMENT LISTED BELOW
Includes all parts listed under BA985

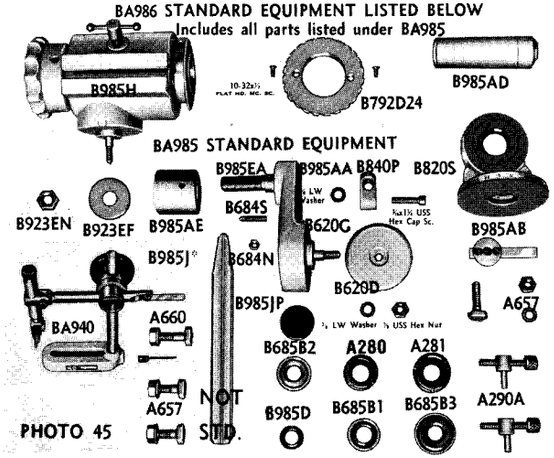



PHOTO 45

## BA985 RADIAL GRINDING FIXTURE STANDARD EQUIPMENT

**A280** Friction Collar, **A281** Friction Collar, **A290A** Table Adjusting Screw, **A657, A660** T-Slot Bolts, **B620D** Back Plate **B620G** Swivel Stud, **B684N** Nut, **B684S** Diamond Screw, **B685B1** 7/8" Cutter Bushing, **B685B2** 1" Cutter Bushing, **B685B3** 1¼" Cutter Bushing, **B820S** Swivel, **B840P** Swivel Block. **B923EF** Keyed Wheel Flange, **B923EN** Special Nut, **BA940** Tooth Rest, **B985AA** Swinging Arm, **B985AB** Swivel Index Bar, **B985AE** Diamond Holder, **B985D** Guide Bushing, **B985EA** Stud ¾", ***B985J** (optional) Center Gauge, **B985JP** Cap. (**BA939** Center Height Gauge, **B985JG** Center Gauge, Knife Type, are shown in **BA985** photo upper left.) Net Weight 51 lbs.

## BA986 RADIAL GRINDING FIXTURE STANDARD EQUIPMENT

**Includes all equipment listed for BA985 Model and the following: B792D24** Index Disc, **B985AD** Diamond Holding Arbor, **B985H** Housing and Spindle Assembly.

## AVAILABLE EQUIPMENT

**B792D** Index Discs 4, 6, 8, 20, 24, 28, 30, 32, 34, 36, 38, 40, 42, 44, 48, 52, 54, 56 divisions available. **B941** Collet Fixture, **B641C** Collets for B941 Fixture. Available sizes: 3/16" to 1" by 64ths, 1/64" to 11/64" by 64ths. **B641K** Straight Sleeves. Available sizes: 1 1/16", 1 1/8", 1 3/16" and 1¼". **B642K** No. 11 B&S Adaptor with Standard Milling Machine Taper Socket for holding B&S Cam Lock Tapers. Available in taper Nos. 10, 20 and 30. **B642T** Adaptor Sleeves. Available sizes: Morse 1, 2, 3 and 4; B&S 5, 7, 8, 9 and 10. **B844E** 6" 4-Jaw Independent Chuck mounted on No. 11 B&S Arbor. **B944** Adjustru 4" 6-Jaw Chuck mounted on No. 11 B&S Arbor. **B946** 4" 3-Jaw Universal Chuck mounted on No. 11 B&S Arbor.





## BA985 AND BA986 RADIAL GRINDING FIXTURES

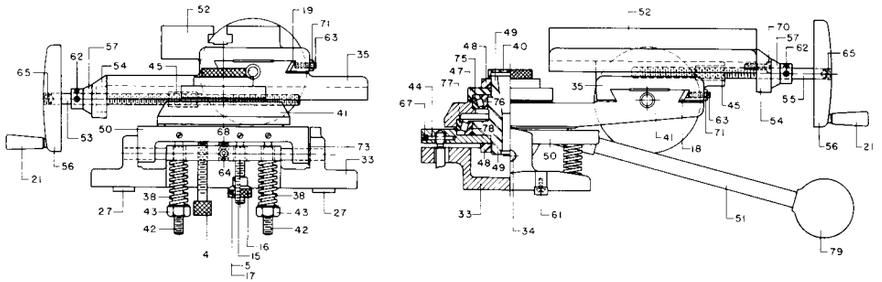
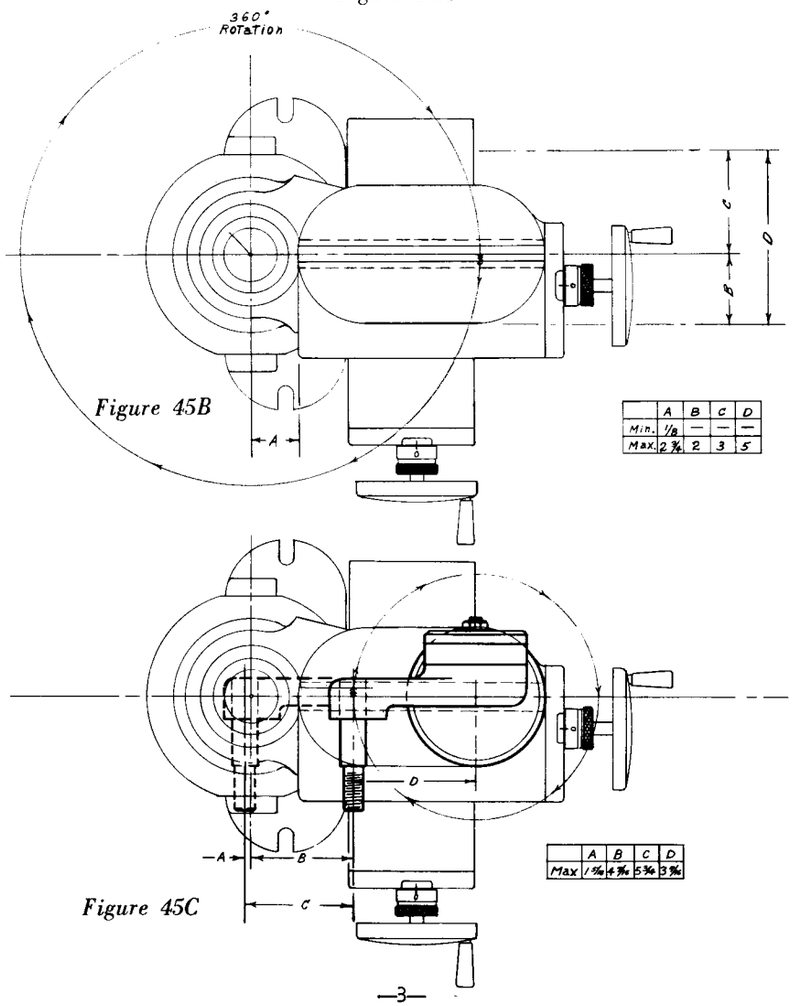


*Figure 45A*




| | A | B | C | D |
|---|---|---|---|---|
| Min. | 1/8 | — | — | — |
| Max. | 2 3/4 | 2 | 3 | 5 |

*Figure 45B*

| | A | B | C | D |
|---|---|---|---|---|
| Max | 1 5/16 | 4 3/16 | 5 3/16 | 3 3/16 |

*Figure 45C*

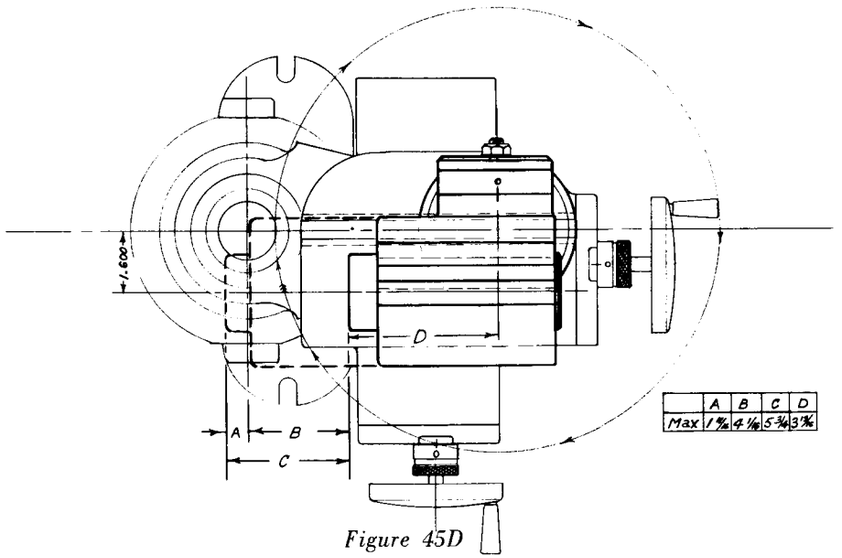



*Figure 45D*

(B985JG) if the cutter has no corner radii, or install the optional 'V' Gauge (B985J) if it already has corner radii. The crossfeed of the machine should be out far enough from the wheel so that the Gauge stands in front of the cup wheel or straight wheel.

C. Mount the cutter with peripheral cutting edges facing up as shown in Photo 46, or down if space permits a toothrest set-up from below. Mount the Swinging Arm (I) and lower swivel (H) on the fixture Upper Slide so that the cutter teeth, when mounted on the ¾ inch Stud (J), will be just short of the Pivot Axis. Lock the swivels and tighten the cutter on the Stud with the appropriate size of Friction Collar and Washer (B923EF) and Nut (B923EN) so that it can just be rotated about the Stud.

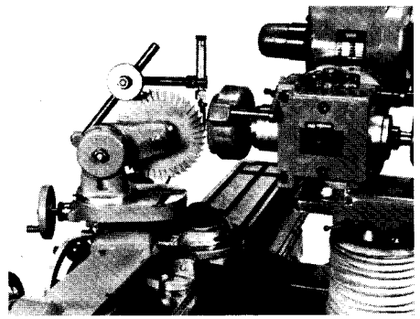


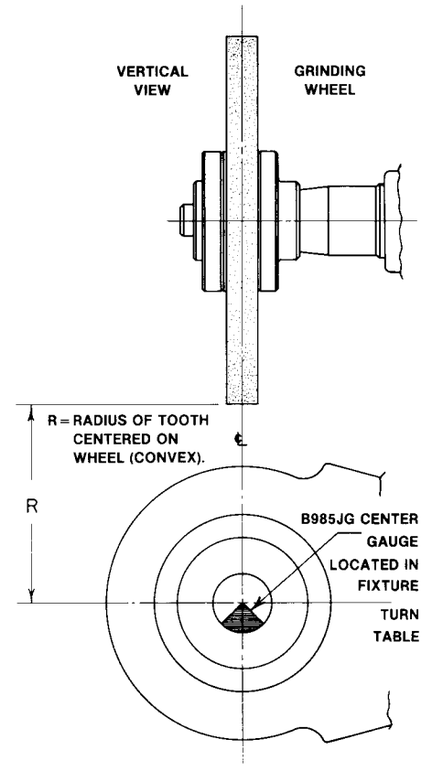
**PHOTO 46**

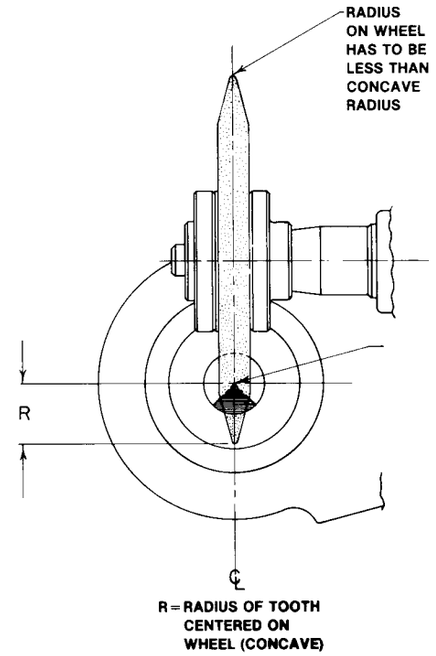
D. Mount the Universal Toothrest (BA940), shown in Photo 46, if cutter edge faces up at the point of grinding. Use the B620G Swivel Stud as shown. Use the spring-loaded micrometer so that the cutter can be rotated to bring a new tooth on centerline with the cutter center by placing the BA939 Height Gauge on the Upper Slide as shown in Photo 43.

On tilthead grinders, the clearance for both the periphery and side may be taken directly by tilting the wheelhead if the clearance is to be common. If more clearance is needed on the periphery than on the side teeth, create slide clearance by tilting the fixture Saddle (50) the desired amount for side teeth **(FIXTURE IS CALIBRATED IN 5 DEGREE INCREMENTS)**, but add an








additional amount for the periphery by checking the amount to rotate the cutter about its Stud mount from Tables 1 and 2 on pages 11 and 12. In the latter situation, the wheelhead tilt should be set at 0 degrees.

When the fixture is employed on a non-tilthead grinder, equal clearance for the side and periphery can be taken by tilting the fixture Saddle. Unequal clearance should be handled as explained above.

E. Insert the B985JG center gauge so that the flat of its "V" is positioned toward the peripheral edge of the grinding wheel. Line up the center of the wheel face and tooth radius with the center line of the center gauge, lightly touching a feeler gauge placed between the center gauge and the wheel. **NOTE:** Never touch the grinding wheel against the center gauge. Use a known size feeler gauge such as shim stock, for which crossfeed dial can be compensated.

F. Set the desired radius by moving the machine crossfeed handwheel (not the fixture slide), thus locating the fixture point axis the correct distance from the wheel. A concave radius can only be set by removing the center gauge first. Eliminate backlash in the machine crossfeed when setting the radius distance by making the final adjustment of the machine saddle toward the wheel. Saddle lock may be lightly applied, but always verify the final radius distance.

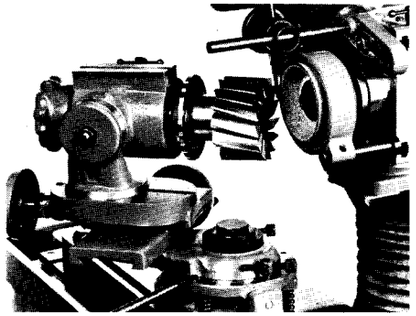


**PHOTO 47**

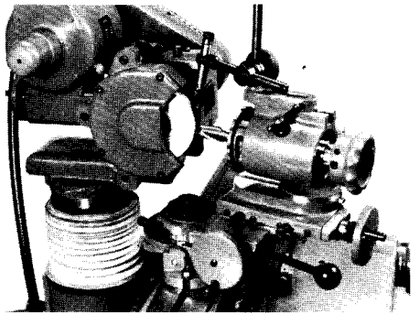


**PHOTO 48**

G. After the correct radius is established, use the slides of the fixture to blend the radius to the cutter. Usually the upper slide handwheel "A" will be used to feed the cutter into the wheel for stock removal. The crossfeed of the grinder must not be moved, as this will change the radius. See diagram page 5.

H. Proceed with grinding as in IV-D, 4, 5.

I. If the cutter has a steep helix or if for some other reason it is desirable to attach the toothrest to the wheelhead of the grinder (see Photo 47), the above set-up will still apply. Lever (F) can still be used to back the cutter tooth away from the wheel in order to index the cutter for the next tooth to be ground without moving the machine crossfeed. The grinding wheel rotation should be in the direction that holds the tooth against the toothrest. During the grinding process, it may be necessary to compensate for wheel wear by slight movement of the machine crossfeed.

J. Repeat the above steps for the radii on the left corners, working from the left edge of the wheel.

## II. GRINDING A CORNER RADIUS USING BA986 RADIAL GRINDING FIXTURE

**EXAMPLE:** Generating a radius on the flute ends of a spiral end mill.

A. Initial set-up is accomplished as follows:

1. Mount the fixture on the grinder table as in A-1, and 2, with the Upper Slide (52) set parallel with the grinder table and the Saddle (50) set at 0 degrees tilt.
2. By means of the B820S swivel, place the B985H Housing and Spindle Assembly on the fixture Upper Slide in a convenient position and lock temporarily with a 'T' slot bolt. Install the cutter shank into the Spindle Assembly by means of the B941 Collet Fixture and an appropriately sized B641C 5C Collet, if possible. For cutters with straight shanks larger than 1 inch, B641K straight sleeve adaptors can be used to mount the cutter in the spindle. If the cutter has a tapered shank, use a B642T taper adapter sleeve.
3. Locate the Spindle Assembly and cutter up to just short of the Center Gauge and lock the lateral swivel at 90 degrees and the vertical swivel at 0 degrees.





B. If the cutter helix is not too steep or the radius too large, mount the Universal Toothrest on the fixture in the manner described in I-D, except that the base of the BA940 toothrest will be placed on top of the B985H Housing and Spindle Assembly or on the Table of the fixture similar to the set-up in Photo 46. The teeth cutting edges will be faced up at the point of contact with the wheel, as in Photo 47, and the spindle lock (G) tightened with one tooth against the blade. If the cutter has a very steep helix and the radius to be ground is rather large, it may be necessary for the toothrest to be attached to the wheelhead, because in this position the flute end will be in a position to follow the toothrest blade **(BY ROTATION OF THE SPINDLE ASSEMBLY)** when the fixture is rotated about the Pivot Point Vertical Axis. In either case, if equal clearance is to be taken on both the periphery and the face of the cutter, set the toothrest by means of the Height Gauge so that the tooth face edge is on center with that of the Spindle Assembly.

1. For equal clearance on the periphery and the face, set the clearance for the tooth indexed by turning the Table Adjusting Screw (4) in a right-hand direction, reading the degrees on the dial of the fixture base.
2. If less clearance is desired for the end or face of the cutter than for the periphery, the cutter may be rotated by adjusting the micrometer toothrest enough to equal the **ADDITIONAL** amount of clearance desired over that already taken on thte fixture itself. (See I-D). If the toothrest is on the wheelhead, the cutter may also be rotated up by simply raising the wheelhead the required amount.
3. On tilthead grinders it is possible to create the necessary clearance on the radius by tilting the wheelhead. If the toothrest is mounted on this type of head (see Photo 47), then all the clearance must be of a common angle, and the blade end should be on center with the cutter center.

C. Continue the set-up by positioning the cutter edges against the Center Gauge, as in I-E, so that the lines drawn along the face and the peripheral edges of the cutter intersect the Pivot Point Vertical Axis of the Gauge.

D. Remove the Gauge and move the machine crossfeed handwheel as described in I-F in order to relocate the Pivot Point Vertical Axis relative to the cutter to produce the desired convex or concave radius. Grind the cutter as described in the same section.

E. If the toothrest has been placed on the wheelhead, read I-G.

F. Always sharpen the periphery of a milling cutter, if necessary, prior to creating the radius. This may be done as described in Part III.

## III. USE OF THE RADIAL GRINDING FIXTURE FOR SHARPENING THE PERIPHERY OF A HELICAL CUTTER

A. When using the BA986 fixture, holding a cutter with a helix as in Photo 47, position the B985H Spindle perpendicular to the axis of the grinding wheel spindle (PARALLEL WITH THE MOVEMENT OF THE MACHINE TABLE). This is done by putting its swivel base on the 90 degree setting, locking the swivel, and then swinging the fixture counterclockwise to a point that will align the Upper Slide of the fixture with the grinding machine table. Stops (E) are then set to hold the fixture rigidly in this position. It will be neces-

sary to use a dial indicator on the mounted cutter or on a test arbor mounted in the B985H in order to determine parallelism with the table travel.

B. Locate the toothrest on the right edge of the cup wheel (OPPOSITE TO THE POSITION AS SHOWN IN PHOTO 47) and attach to the wheelhead.

1. **On non-tilthead grinders,** put the toothrest blade end on center with the B985H spindle center or cutter center. Consult table II, page 12, for amount to raise the wheelhead.
2. **On tilthead grinders,** tilt the wheelhead to the desired clearance angle and then place the toothrest on the wheelhead, blade end on center with the cutter center.

C. Proceed to sharpen the periphery as described in the chapter on end mills.

## IV. SHARPENING OR CREATING BALL END MILLS*
(EXPLANATION IS FOR RIGHT-HAND END MILLS)

A. Mount the cutter as described in II-A and shown in Photo 48.

B. Position the cutter relative to the fixture Pivot Point Vertical Axis as described in I-E through I-G.

C. A ball end mill will necessitate mounting the toothrest on the wheelhead as shown in Photo 47, thus allowing the helical flutes to follow the fixed blade. The blade must be shaped to allow it into the narrow ends of the flutes. In order to clear other teeth than the one being ground, the use of a straight wheel will usually be necessary. Place the blade at the middle of the wheel width. With a straight wheel, all clearance will be generated by the periphery of the wheel when a micrometer toothrest blade is placed over the wheel and on center with it. Determine the amount to raise the blade **(BY MICROMETER)** from Table I, page 11. Finally, raise or lower the wheelhead to position the toothrest blade at the cutter center. When a straight wheel is used, no additional clearance need be taken on the fixture or its Spindle Assembly. Place the end of the mill in relation to the toothrest so that one flute catches the blade but does not touch the wheel. Experimentally rotate the fixture through an arc of 90 degrees counterclockwise while holding the fixture spnidle handwheel (C) with clockwise pressure. The ball end mill flute should follow around the toothrest blade without binding or bending the blade. Set fixture stops (E) for a swing of slightly less than 90 degrees counterclockwise from center. Center the cutter on the toothrest and set the machine table stops to keep it from moving right or left.

*Fixture may be difficult or impossible to use with end mills smaller than ½" diameter and/or those with very steep helix.

D. Sharpening Process:

**NOTE:** This infeed process can be used for any cutter whose radii are already formed and whose radius can be centered on either one of the fixture slides; this one slide becomes the only infeed moving the work relative to the wheel.

1. With the center axis line of the cutter directly in line with the high point of the toothrest blade, move the crossfeed in slowly until the cutter end just avoids the wheel.
2. Start the wheelhead motor, and with the cutter axis perpendicular to the





wheel periphery, lightly advance the machine crossfeed while holding the cutter against the toothrest with the handwheel (C). When the first sparks appear, stop the machine crossfeed and slowly rotate the fixture and the Spindle Assembly to follow one spiral flute through its arc swing to the left until the fixture stop is contacted.

3. Use the fixture tilting lever (F) to move the cutter away from the toothrest for examination of the grind. If the tooth land has been contacted uniformly, rotate the Spindle Assembly until the flute 180 degrees opposite the one just ground is available, and after returning the fixture to the center starting position, slowly release the lever until the new flute land contacts the wheel. At this point, immediately begin to rotate the fixture through its arc swing again, always holding the flute face firmly against the toothrest. After the first acceptable contact of the first flute with the wheel, the machine crossfeed must not be moved as doing so will destroy the true radius now established between the Pivot Point Vertical Axis and the periphery of the wheel.
4. After the first acceptable contact with the two flutes 180 degrees opposite each other on the cutter, all additional teeth should be contacted. At this point, infeed the fixture handwheel (A) .001 inch, sharpening all teeth prior to the next infeed on the fixture.
5. All flutes should be round ground, finishing with a final light cut on the primary land. If a secondary clearance appears necessary, it is produced by further adjustment of the micrometer toothrest above the wheel center and a consequent lowering of the wheelhead to put the blade on center with that of the cutter. At the end of the flutes, it will be necessary to finish gashing by a hand operation.

## V. OTHER USES OF THE RADIAL GRINDING FIXTURE

A. Forming Radii on the Grinding Wheel:

1. The diamond nib can be installed on either the Diamond Holder (B985AE), which is in turn installed on the Stud (J) of the BA985 Fixture, or it can be put into the B985AD Diamond Holding Arbor, which is in turn seated into the taper of the B985H Spindle Assembly.
2. Mount the Center Gauge into the fixture Pivot Stud (49).
3. Using the fixture Upper Slide and Lower Slide, bring the diamond point to the exact Pivot Point Vertical Axis of the fixture. Remove the Gauge and replace the Cap.
4. Raise or lower the wheelhead of the grinder until the diamond point is at the wheel spindle center. The diamond point should also be centered in the middle of the wheel width if the radius is to be centered on the wheel periphery.
5. Using **EITHER** the fixture Upper Slide **OR** its Lower Slide, position the diamond point beyond the Pivot Point of the fixture if a concave radius is desired in the wheel, or position the diamond point back of the Pivot Point to create a convex radius. Do not attempt to use both of the fixture handwheels to reposition the diamond point relative to the Pivot Point.
6. Using fixture stops (E), set the required arc swing of the fixture.

7. Begin to form the wheel with the diamond by advancing the machine crossfeed while swinging the fixture through a predetermined arc. It will often be possible to measure the amount of total infeed of the nib into the wheel by means of the machine crossfeed dial. Measure the amount of the radius after the point strikes the wheel **(FOR A CONCAVE RADIUS)**, or after the Gauge edge contacts the wheel **(FOR A CONVEX RADIUS)**.
8. If the convex radius is to be tangent to the side and periphery, it will be necessary to measure the radius distance in from the wheel side and set the grinder table stops.
9. If optical observation is involved, no measuring of crossfeed on the machine will be necessary as infeed into the wheel will take place until the formed radius conforms to the template on the observation scope.

B. Radius work on the corners of face mills up to approximately 10 inches diameter can be accomplished on the radial grinding fixture with the addition of the B992 Workhead mounted on the fixture Upper Slide. This workhead, having a standard taper of 50MM, may be adapted to 40MM taper or to B & S No. 11 taper.

C. Form tools and chip breakers can be held by the B989 Universal Workholding Fixture which can be mounted on the radial fixture Upper Slide.





# TABLES OF REFERENCE

## I. CLEARANCE ANGLES — STRAIGHT WHEELS

### *Relief Tables for High-Speed Steel Cutters*

### *I—Using Straight Wheels*

C = Distance in inches to set center of cutter and tip of tooth rest below (or above) center of wheel when grinding with a straight wheel.

| *Wheel Diameter (Inches)* | *C for 4° Relief Angle* | *C for 5° Relief Angle* | *C for 6° Relief Angle* | *C for 7° Relief Angle* |
|---|---|---|---|---|
| 3 | .104 | .131 | .157 | .183 |
| 3 1/4 | .113 | .141 | .170 | .198 |
| 3 1/2 | .122 | .152 | .183 | .213 |
| 3 3/4 | .131 | .163 | .196 | .227 |
| 4 | .139 | .174 | .209 | .242 |
| 4 1/4 | .150 | .185 | .222 | .259 |
| 4 1/2 | .157 | .195 | .235 | .274 |
| 4 3/4 | .165 | .207 | .248 | .289 |
| 5 | .174 | .218 | .261 | .305 |
| 5 1/4 | .183 | .228 | .274 | .319 |
| 5 1/2 | .191 | .239 | .287 | .335 |
| 5 3/4 | .200 | .250 | .300 | .350 |
| 6 | .209 | .261 | .313 | .365 |
| 6 1/4 | .218 | .272 | .326 | .381 |
| 6 1/2 | .226 | .283 | .339 | .396 |
| 6 3/4 | .235 | .294 | .352 | .411 |
| 7 | .244 | .305 | .365 | .426 |

## *II—Using Cup Wheels*

C = Distance in inches to set tip of tooth rest below or above center of cutter when grinding the peripheral teeth of cutters with a cup wheel.

| *Cutter Diameter (Inches)* | *C for 4° Relief Angle* | *C for 5° Relief Angle* | *C for 6° Relief Angle* | *C for 7° Relief Angle* |
|---|---|---|---|---|
| ½ | .017 | .022 | .026 | .031 |
| ¾ | .026 | .033 | .040 | .046 |
| 1 | .035 | .044 | .053 | .061 |
| 1¼ | .044 | .055 | .066 | .077 |
| 1½ | .052 | .066 | .079 | .092 |
| 1¾ | .061 | .076 | .092 | .108 |
| 2 | .070 | .087 | .105 | .123 |
| 2½ | .087 | .109 | .131 | .153 |
| 2¾ | .096 | .120 | .144 | .168 |
| 3 | .104 | .131 | .158 | .184 |
| 3½ | .122 | .153 | .184 | .215 |
| 4 | .139 | .174 | .210 | .245 |
| 4½ | .157 | .197 | .237 | .276 |
| 5 | .174 | .219 | .263 | .307 |
| 5½ | .192 | .241 | .289 | .338 |
| 6 | .207 | .262 | .315 | .368 |

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