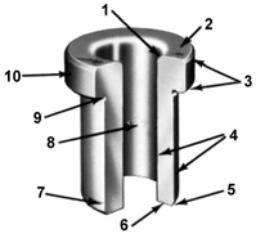
Guides, Tech Service, & Reference Charts

Technical Information

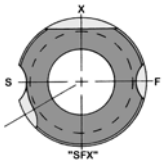
MEASUREMENTS and CONVERSIONS

UNITED **features**
an assortment of
TECHNICAL INFORMATION
in *SECTION V*,
including several types of
BUSHING USES,
DRILL SIZE CONVERSION TABLES,
INDUSTRY CONVERSION TABLES,
***UNITED FACILITIES* INFORMATION,**
PART NAME INDEX
and
PART NUMBER INDEX.



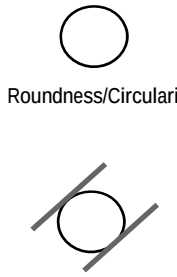
BUSHING CHARACTERISTICS Pg V7

HOW TO SELECT THE CORRECT BUSHING Pg V6



SFX HEAD
MULTI-USES
Pg V9

MACHINIST GUIDES Pg V2



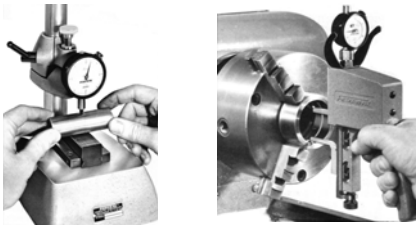
GUIDE FOR TOLERANCES & DIMENSIONING Pg V4

EASE IN

Pg V10 - V11

RADIUS BUSHINGS

PUSH RODS
Pg V18 - V19



DRILL BUSHING USES & INSPECTION
Pg V14

STRESS COINING METHODS Pg V17

FOR NEW SECTION W

STRESS COINING TYPES Pg V16

3 - HAAS CNC Turning Centers
Pg V15

28-Sunnen Stroker Automatic Honing Gauging Machines Pg V15

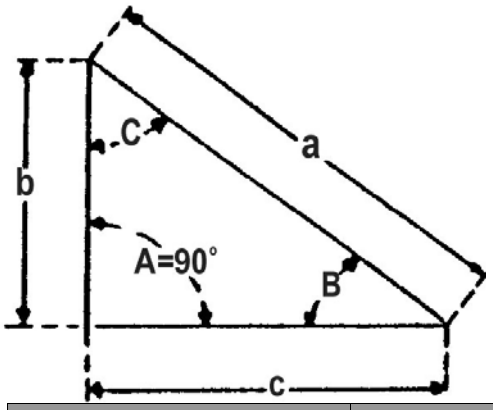
UNITED Headquarters DOWNEY, CA

UNITED FACILITIES AND EQUIPMENT LIST Pg V15

Technical Information

Machinists Guide
Angles and Triangles

RIGHT ANGLE TRIANGLES



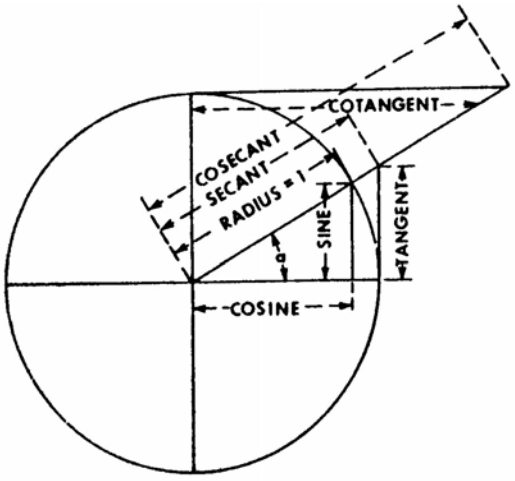
Solutions of Right-Angled Triangles

The sides of the right-angled triangle are designated ***a***, ***b*** and ***c***, as shown in the illustration to left. The angles opposite each of these sides are designated ***A***, ***B*** and ***C***, respectively.

Angle ***A***, opposite the hypotenuse ***a*** is the right angle, and is always one of the known quantities.

Sides and Angles Known	Formulas for Sides and Angles to be Found		
Sides ***a*** and ***b***	$c = \sqrt{a^2 \quad b^2}$	$\sin B = \frac{b}{a}$	$C = 90° \quad B$
Sides ***a*** and ***c***	$c = \sqrt{a^2 \quad b^2}$	$\sin C = \frac{c}{a}$	$B = 90° \quad C$
Sides ***b*** and ***c***	$c = \sqrt{a^2 \quad b^2}$	$\tan B = \frac{b}{c}$	$C = 90° \quad B$
Side ***a*** and angle ***B***	$b = a \times \sin B$	$c = a \times \cos B$	$C = 90° \quad B$
Side ***a*** and angle ***C***	$b = a \times \cos C$	$c = a \times \sin C$	$B = 90° \quad C$
Side ***b*** and angle ***B***	$a = \frac{b}{\sin B}$	$c = b \times \cot B$	$C = 90° \quad B$
Side ***b*** and angle ***C***	$a = \frac{b}{\cos C}$	$c = b \times \tan C$	$B = 90° \quad C$
Side ***c*** and angle ***B***	$a = \frac{c}{\cos B}$	$b = c \times \tan B$	$C = 90° \quad B$
Side ***c*** and angle ***C***	$a = \frac{c}{\sin C}$	$b = c \times \cot C$	$B = 90° \quad C$

FUNCTIONS of ANGLES



FORMULAS for finding the LENGTH of SIDES for RIGHT-ANGLE TRIANGLES when an ANGLE and SIDE ARE KNOWN.	
Length of Hypotenuse	Side Opposite x Cosecant Side Opposite x Sine Side Adjacent x Secant Side Adjacent x Cosine
Length of Side Opposite	Hypotenuse x Sine Hypotenuse x Cosecant Side Adjacent x Tangent Side Adjacent x Cotangent
Length of Side Adjacent	Hypotenuse x Cosine Hypotenuse x Secant Side Opposite x Cotangent Side Opposite x Tangent

FORMULAS for finding FUNCTIONS of ANGLES	
$\frac{\text{Side Opposite}}{\text{Hypotenuse}} = \text{SINE}$	$\frac{\text{Side Adjacent}}{\text{Side Opposite}} = \text{COTANGENT}$
$\frac{\text{Side Adjacent}}{\text{Hypotenuse}} = \text{COSINE}$	$\frac{\text{Hypotenuse}}{\text{Side Adjacent}} = \text{SECANT}$
$\frac{\text{Side Opposite}}{\text{Side Adjacent}} = \text{TANGENT}$	$\frac{\text{Hypotenuse}}{\text{Side Opposite}} = \text{COSECANT}$

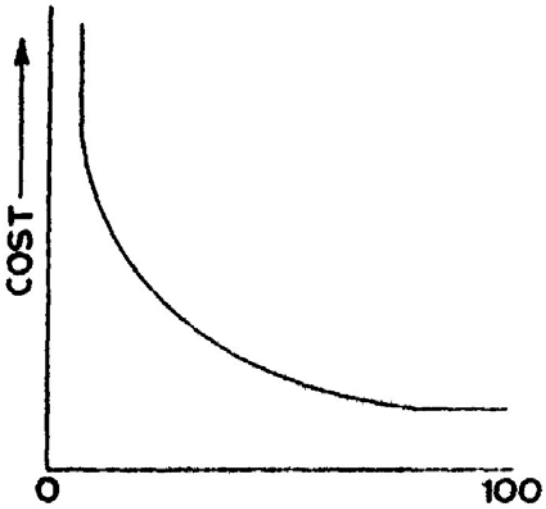
UNITED in Value, Precision and Reliability!

Machinists Guide
Surface Roughness

Technical Information

MACHINE FINISHES	VERY ROUGH ⟷ VERY FINE
ROUGHNESS VALUES	1000 500 250 125 63 32 16 8 4 2 1
Cutting Torch, Chip and Saw	
Hand Grind	
Disk Grind or File	
Lathe, Shaper, Mill	
Bore	
Drill	
Ream	
Surface Grind	
Cylindrical Grind	
Hone or Lap	
Polish or Buff	
Superfinish	

COST—TOLERANCE—SURFACE ROUGHNESS

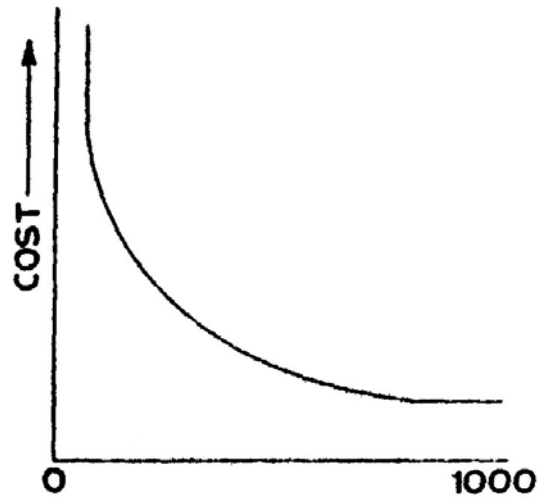


Tolerance Inches

The Relationships of Cost, Tolerance and Surface Roughness Are shown above and below.

Machining to Close Tolerances and Low Surface Roughness Consumes more time than does rougher work. Hence, the cost is higher.

SURFACE ROUGHNESS ASSOCIATED WITH COMMON PRODUCTION OPERATIONS		
RANGE of TOTAL TOLERANCE, INCHES	SYMBOL (in Micro-inches)	TYPICAL MACHINING OPERATIONS
0.062 to 0.125	1000Å	Flame Cutting
0.015 to 0.062	500Å	Snag Grind, Sand Casting
0.010 to 0.015	250Å	Saw, Forging, Permanent Mold Casting
0.005 to 0.010	125Å	Rough Turn, Drill, Shape, Mill, Bore
0.002 to 0.005	64Å	Smooth Turn, Shape, Mill, Bore, Ream
0.0005 to 0.002	32Å	Grind, Smooth Turn and Polish
0.0002 to 0.0005	16Å	Grind, Hone, Burnish
0.0001 to 0.0002	8Å	Grind, Hone, Burnish
0.0004 to 0.0001	4Å	Lap, Polish, Superfinish



Surface Roughness Micro-inches

12200 WOODRUFF AVE. • DOWNEY, CA 90241-5608 • TELEPHONE (562) 803-1521 / (800) 421-3466 IN CA / (800) 486-3466 • FAX (562) 803-6898 / (800) 486-3465
EMAIL united@ucc-udb.com WEBSITE www.ucc-udb.com

Technical Information

Guide for Tolerances and Dimensioning

SYMBOLS and THEIR CHARACTERISTICS

CHARACTERISTIC	ANSI Y14.5
Straightness	—
Flatness	▱
Roundness (Cirularity)	○
Cylindricity	⌭
Profile of a Line	⌒
Profile of a Surface	⌓
Parallelism	//
Perpendicularity (Squareness)	⊥
Angularity	∠
Position	⌖
Concentricity (Coaxiality)	◎
Symmetry	⌯
Mazimum Material Condition	Ⓜ
Diameter (Cylindrical)	⌀
Circular Runout	↗
Total Runout	TOTAL ↗
Datum Identification	-A-
Reference Dimension	(X.XXX)
Basic Dimension	X.XXX
Regardless of Feature Size	Ⓢ
Projected Tolerance Zone	Ⓟ
Datum Target	A / 1
Part Symmetry	NONE
Taper per Inch	T.P.I.
Shape of Tolerance Zone	Zone is total width. Specified where Zone is Circular or Cylindrical.
Radial Tolerance and Zone	.001 / .111
Sequence within the Feature Control Symbol	⌖ | A | B | C | ⌀ .02 Ⓜ ⌖ | ⌀ .02 Ⓜ | A | B | C

The allowances given in the tables on the right → have been found useful in the manufacture of machine parts. For special cases, it may be necessary to increase or decrease these allowances.

ALLOWANCES FOR FITS

RUNNING FITS

Diameter, Inches	For Shafts with Speeds under 600 rpm. Ordinary Working Conditions Allowances, Inches	For Shafts with Speeds over 600 rpm. Severe Working Conditions Allowances, Inches
Up to 1/2	-0.0005 to -0.001	-0.0005 to -0.001
1/2 to 1	-0.00075 to -0.0015	-0.001 to -0.002
1 to 2	-0.0015 to -0.0025	-0.002 to -0.003
2 to 3-1/2	-0.002 to -0.003	-0.003 to -0.004
3-1/2 to 6	-0.0025 to -0.004	-0.004 to -0.005

SLIDING FITS

Diameter, Inches	For Shafts with Gears, Clutches or Similar Parts which Must be Free to Slide Allowances, Inches
Up to 1/2	-0.0005 to -0.001
1/2 to 1	-0.00075 to -0.0015
1 to 2	-0.0015 to -0.0025
2 to 3-1/2	-0.002 to -0.003
3-1/2 to 6	-0.0025 to -0.004

STANDARD FITS

Diameter, Inches	For Light Service where Part is Keyed to Shaft and Clamped Endwise—No Fitting Allowances, Inches	With Play Eliminated—Part should Assemble Readily—Some Fitting & Selecting may be required Allowances, Inches
Up to 1/2	Standard to -0.00025	Standard to +0.00025
1/2 to 3-1/2	Standard to -0.0005	Standard to +0.0005
3-1/2 to 6	Standard to -0.00075	Standard to +0.00075

DRIVING FITS

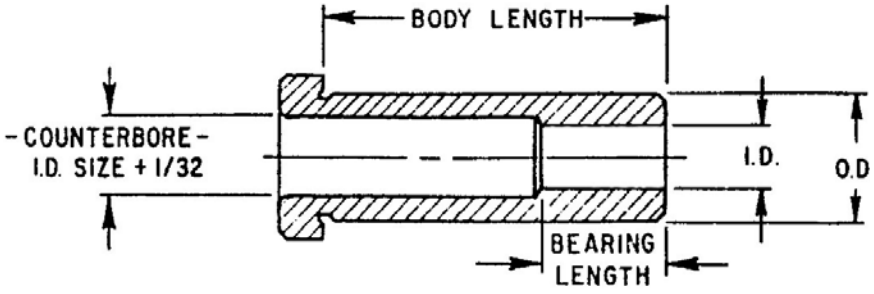
Diameter, Inches	For Permanent Assembly of Parts so Located that Driving Cannot be Done Readily Allowances, Inches	For Permanent Assembly and Severe Duty and where there is Ample Room for Driving Allowances, Inches
Up to 1/2	Standard to +0.00025	+0.0005 to +0.001
1/2 to 1	+0.00025 to +0.0005	+0.0005 to +0.001
1 to 2	+0.0005 to +0.00075	+0.0005 to +0.001
2 to 3-1/2	+0.0005 to +0.001	+0.00075 to +0.00125
3-1/2 to 6	+0.0005 to +0.001	+0.001 to +0.0015

FORCED FITS

Diameter, Inches	For Permanent Assembly and very Severe Service—Hydraulic Press Used for Larger Parts Allowances, Inches
Up to 1/2	+0.00075 to +0.001
1/2 to 1	+0.001 to +0.002
1 to 2	+0.002 to +0.003
2 to 3-1/2	+0.003 to +0.004
3-1/2 to 6	+0.004 to +0.005

Counterbore Tables

Technical Information



COUNTERBORE TABLES

For use when it is necessary to specify Counterbores in A.N.S.I. Standard or Thinwall Series Bushings in Ground or Unground O.D.s.

For SLIP, SLIP FIT and SLIP FIXED RENEWABLE TYPE BUSHINGS

Types: S, SF, and SFX — **Counterbore 1/32 Larger than I.D. leaving Bearing Length Shown.**

Bearing Length for I.D. Range Shown: O = No Counterbore X = Not Standard Manufacture

BODY LENGTH	.0135 To .0280	.0292 To .0469	.0520 To .0625	.0635 To .0995	.1015 To .1406	.1440 To .1875	.1890 To .2500	.2570 To .3125	.3160 To .4375	.4531 To .6875
1/4	1/4	5/16	O	O	O	O	O	O	O	O
5/16	5/16	5/16	5/16	5/16	O	O	O	O	O	O
3/8	5/16	5/16	5/16	7/16	7/16	O	O	O	O	O
1/2	5/16	7/16	7/16	7/16	7/16	O	O	O	O	O
5/8	5/16	7/16	7/16	7/16	7/16	O	O	O	O	O
3/4	5/16	7/16	7/16	7/16	5/8	5/8	O	O	O	O
1"	X	7/16	7/16	7/16	5/8	5/8	5/8	5/8	O	O
1-3/8	X	X	X	X	1	1	1	1	O	O
1-3/4	X	X	X	X	X	1	1	1	1-1/2	O
2-1/8	X	X	X	X	X	X	1	1	1-1/2	O
2-1/2	X	X	X	X	X	X	X	1-1/2	1-1/2	1-1/2
3"	X	X	X	X	X	X	X	1-1/2	1-1/2	1-1/2

For HEAD and HEADLESS PRESS FIT TYPE BUSHINGS

Types: P and H — **Counterbore 1/32 Larger than I.D. leaving Bearing Length Shown.**

Bearing Length for I.D. Range Shown: O = No Counterbore X = Not Standard Manufacture

BODY LENGTH	.0135 To .0280		.0292 To .0469		.0520 To .0625		.0635 To .0995		.1015 To .1406		.1440 To .1875		.1890 To .2500		.2570 To .3125		.3160 To .4375		.4531 To .6875	
	P	H	P	H	P	H	P	H	P	H	P	H	P	H	P	H	P	H	P	H
1/4	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
5/16	O	1/4	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
3/8	1/4	5/16	O	5/16	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
1/2	5/16	5/16	5/16	5/16	5/16	5/16	O	5/16	O	5/16	O	O	O	O	O	O	O	O	O	O
5/8	5/16	5/16	5/16	5/16	5/16	5/16	O	5/16	O	5/16	O	O	O	O	O	O	O	O	O	O
3/4	5/16	5/16	5/16	5/16	7/16	7/16	7/16	7/16	7/16	7/16	O	O	O	O	O	O	O	O	O	O
1"	5/16	5/16	5/16	5/16	7/16	7/16	5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8	O	O	O	O
1-3/8	X	X	X	X	X	X	5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8	O	O	O	O
1-3/4	X	X	X	X	X	X	5/8	5/8	5/8	5/8	5/8	5/8	1	1	1	1	O	1-1/2	O	O
2-1/8	X	X	X	X	X	X	X	X	X	X	5/8	5/8	1	1	1	1	1-1/2	1-1/2	O	O
2-1/2	X	X	X	X	X	X	X	X	X	X	X	X	1	1	1	1	1-1/2	1-1/2	1-1/2	1-1/2
3"	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1	1	1-1/2	1-1/2	1-1/2	1-1/2

Technical Information

How to Select the Correct UNITED BUSHING

DRILL BUSHINGS are precision tools that guide cutting tools into precise locations of a workpiece.

PROBLEM: During the drilling process, a drill point is brought to bear on a workpiece. Thrust causes deflection of the drill axis. As the drill bends, the point will wander on the workpiece surface until the thrust force is sufficient to cause the cutting edge of the drill to break through the workpiece metal. The actual point at which the cutting begins can be anywhere in the area traversed by the wandering drill point. **Accurate location under those circumstances is impossible.**

SOLUTION: To assure accuracy of hole location and to minimize drill bending and breakage**, mount a *UNITED* Drill Bushing directly above the intended hole location in a jig or fixture. The drill will then pass thru the bushing before engaging the workpiece. The bushing will support the drill as thrust is concentrated on the drill chisel point. Bending and wandering are eliminated and accurate hole size and location are assured.**

Drill Bushing Types are designed for Specific Applications. Select below. Refer to *Section A* for variations.

	**P**	**Headless Press Fit Bushings are used in single stage drilling operations**. They are the **least expensive** bushing type and are ideally suited for low production runs in low cost jigs or fixtures where bushings don't need replacement. To install, use a hand arbor to press the bushing into the drilled hole in the jig until the bushing is flush with the jig plate. **These plain bushings have hundreds of alternate uses** from I.D. gauges to molds for resistors. Headless bushings **allow closer spacing of holes** than others.
	**H**	**Head Press Fit Bushings are also used in single stage operations**. **The head provides an additional location reference** and prevents the bushing from passing through the jig when drilling pressure is extreme.
	**SF**	**Slip Fixed Renewable Bushings are ideally suited for use in long run production jobs** where a bushing needs occasional replacement. **T**hey are **used with either head or headless type Liners and are fastened in place with a lock screw that couples with a milled recess in the head**. They are used in **multiple operations such as drilling and reaming** performed on the same jig. With a simple turn, the bushing can be removed without removing the lock screw. **Thinwall** types are also available.
	**N**	**Nurlock Embedment Bushings are designed for use in jigs fabricated from plastic laminated castable materials**. These bushings will securely mold into these materials for a permanent bond. When properly installed, **they will not twist or pull out** under normal drilling conditions.
	**L**	**Liner Bushings are Headless Press Fit that are pressed permanently into a jig plate when renewable types of bushings are used**. The Liners remain in location throughout the life of the jig serving as an accurate location for the renewable bushings.
	**HL**	**Head Liner Bushings have a head and are used in a similar manner as headless liners**. These Head Liners usually necessitate **counterboring** in the jig to offset the head. Head Liners are **used where excessive pressure or pounding will occur from the drilling operation**.

Guides for Bushing Characteristics & Use

Technical Information

UNITED DRILL BUSHINGS

Bushing Materials	Bushings are usually made of premium tool steel. They are also manufactured from special materials such as alloy steels, tungsten carbide, graphitized steel, aluminum, bronze, brass and other alloys that will produce a variety of improved bushing effectiveness.
Bushings O.D.	Bushings with grinding stock on the O.D. are available (unground). O.D. is oversize (.015) so the toolmaker can custom fit bushing into jig or fixture.
Life of Bushings	Life of an average bushing is usually 5,000 to 10,000 pieces. Variables affecting bushing life are the skill of the operator, use of cutting fluid, tool sharpness and whether the operation is by hand or automatic drill machine.

Jig Boring and Grinding Size Chart

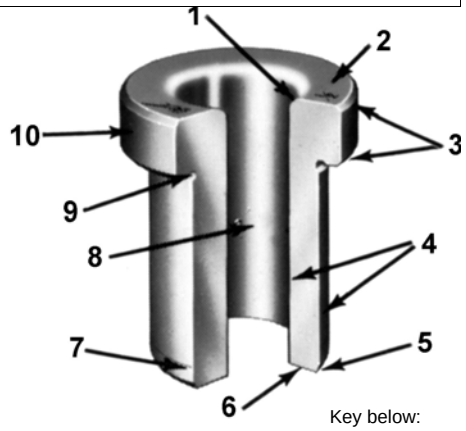
NOMINAL BUSHING O.D.	JIG BORE HOLE SIZE	BUSHING O.D.	
		PRESS FIT TYPE	SLIP FIT TYPE
13/64	.2037 .2040	.2046 .2043	.2031 .2029
1/4	.2507 .2510	.2516 .2513	.2500 .2498
5/16	.3132 .3135	.3141 .3138	.3125 .3123
13/32	.4069 .4072	.4078 .4075	.4062 .4060
1/2	.5007 .5010	.5017 .5014	.5000 .4998
5/8	.6257 .6260	.6267 .6264	.6250 .6248
3.4	.7507 .7510	.7518 .7515	.7500 .7498
7/8	.8757 .8760	.8768 .8765	.8750 .8748
1"	1.0007 1.0010	1.0018 1.0015	1.0000 .9998
1-3/8	1.3757 1.3760	1.3772 1.3768	1.3750 1.3747
1-3.4	1.7507 1.7510	1.7523 1.7519	1.7500 1.7497
2-1/4	2.2507 2.2510	2.2525 2.2521	2.2500 2.2496

Tips to Increase Bushing and Cutting Tool Life

1	Insert Press Fit Bushings with an arbor press. Lubricate the bushing O.D. and lead.
2	Follow recommended interference fits and do not over-press. Check I. D. for collapse before using.
3	Align drill with axis of bushing. Poor alignment wears out drills and bushings.
4	Use sharp cutting tools. Dull tools wear bushings and produce poor results
5	Cool your drilling operation with either a flow or mist lubricant. Drill life is increased many times.
6	Allow one to one-and-a-half times the drill diameter between the exit-end of the bushing and the work piece. Chips need to clear, or they will choke the I.D. of the bushing.
7	When drilling extremely close tolerance holes, hold the exit-end of the bushing flush against the workpiece. Use Slip Fixed Renewables whenever possible for this type accuracy.
8	Use the longest possible bushing guide while allowing for chip clearance.
9	Use the Slip Fixed Bushing in place of either Fixed or Slip. Its versatility will lower your costs.
10	Keep sets of bushings in your crib. You will lower your emergency costs.

REFERENCE: See our **Catalog Section A** for details of all types of Bushings available.

ORDERING: See page **A2** for format of Bushing Part numbers. On the following pages in Section A are Specifications.



Key below:

- 3,400 ADDITIONAL standard types / sizes not catalogued by competitors.
- COMPLETE EXTENDED RANGE sizes from 3/4" to 7" in length to 5" I.D.
- A FULL LINE of Circuit Board Bushings at standard catalog prices.
- *UNITED* manufactures precision parts and tooling to your specifications.
- THE MAJORITY of our bushings in stock are non-counterbored full bearing and are provided at catalog prices. If you have a preference, add the suffix NCB for non-counterbore and CB for counterbore. We reserve the right to provide counterbore in micro sizes and extra long lengths at catalog prices.

1. RADIUS blended and polished for smooth entry of drill.
2. SIZE clearly marked on each Bushing
3. HEAD double-chamfered and polished. Replaceable types are knurled for easier handling.
4. CONCENTRICITY .0003 to .0005 T.I.R. depending upon size.
5. 45° CHAMFERED and polished end eases entry into jig.
6. TOLERANCE on length held ±.010.
7. CONCENTRIC LEAD ground lead provided initial alignment.
8. HARDNESS in hole: Rockwell C61-65.
9. DOUBLE UNDERCUT keeps bushing flat against jig plate.
10. 100% FINAL INSPECTION of every Bushing.