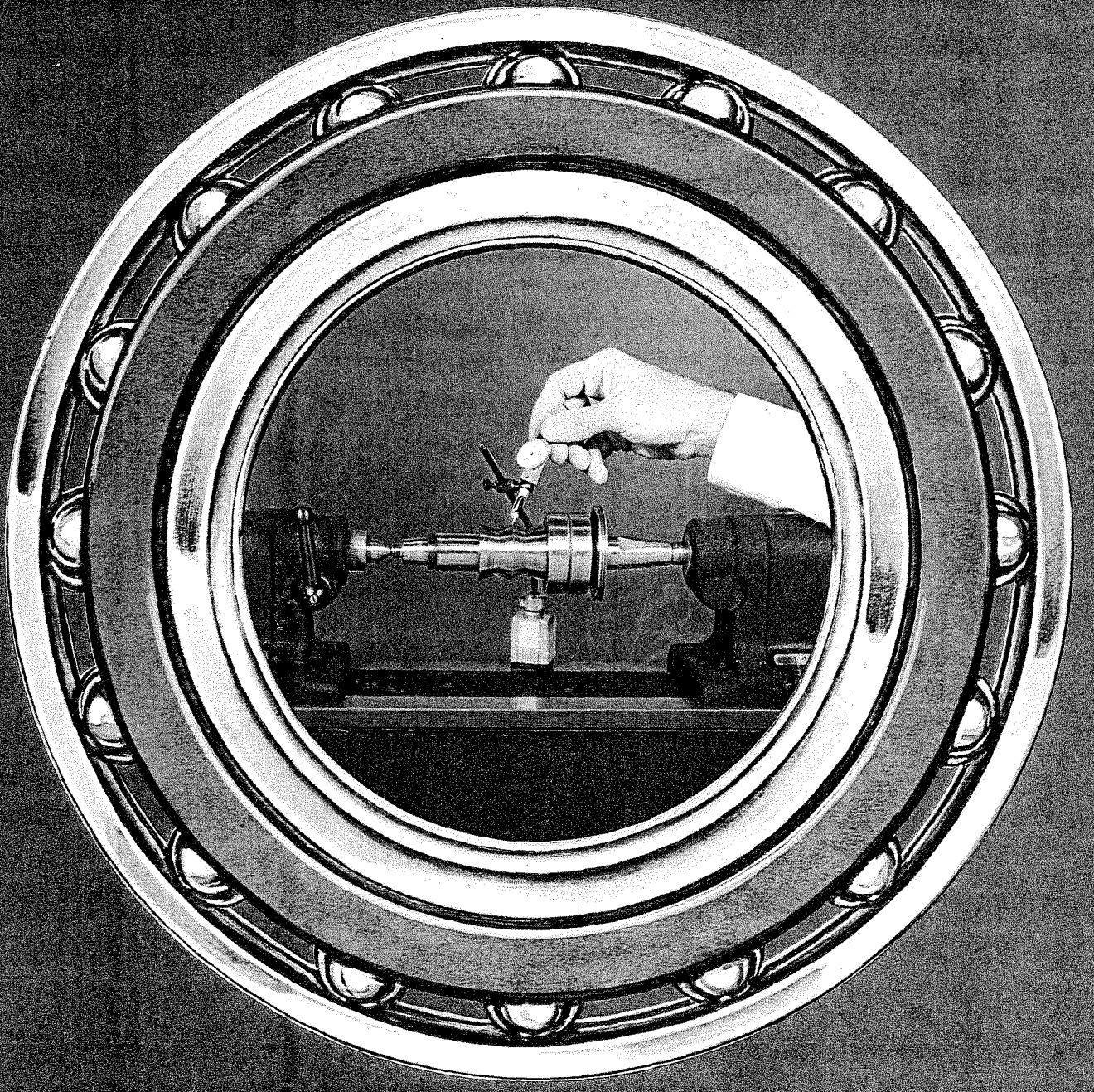
NEW DEPARTURE

Super Precision

BALL BEARINGS

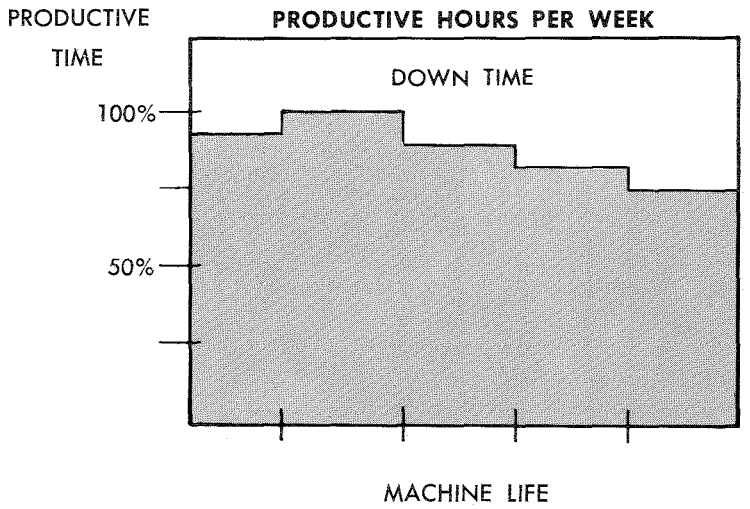


A REFERENCE MANUAL FOR THE REPAIR AND OVERHAUL OF PRECISION EQUIPMENT

CONTENTS

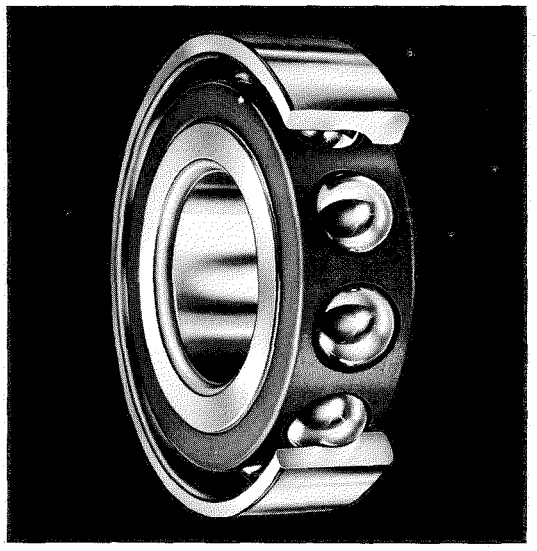
PREFACE

Man's Technological advance parallels his ability to measure more accurately. More accurate measuring, in turn, has led to more precision processing. This precision processing has created a greater need for super precision bearings. To justify the expense of equipment utilizing super precision bearings, the machine's ability to produce accurate parts in quantity must be fully utilized.



This publication outlines the *fundamental principles* involved in handling super precision bearings, *to enable you to obtain maximum life* and *accuracy.*

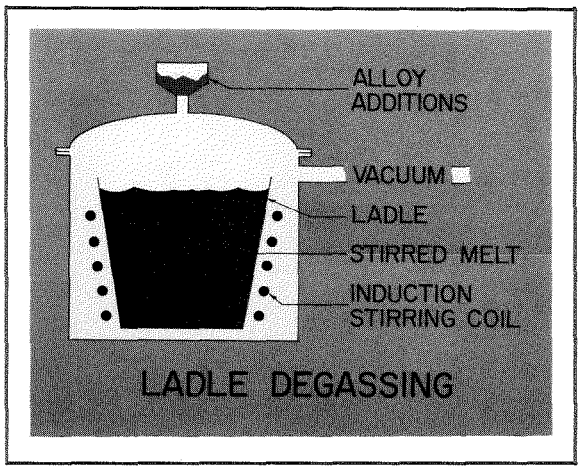
UNITED MOTORS SERVICE
DIVISION OF GENERAL MOTORS CORPORATION
CENTRAL OFFICE—DETROIT

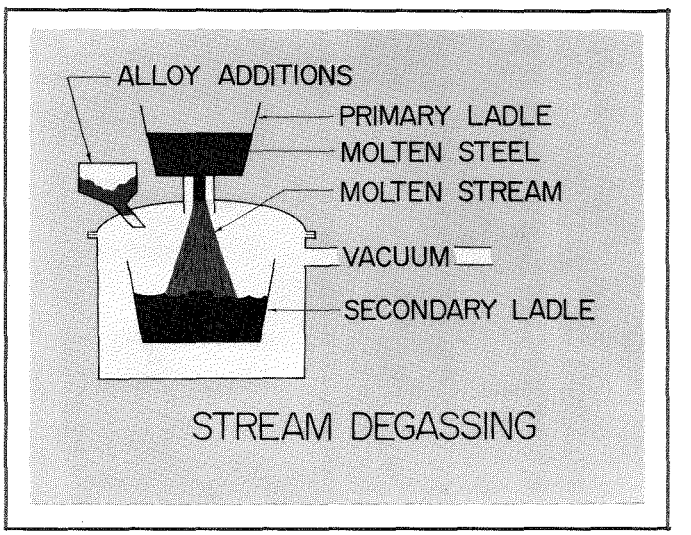


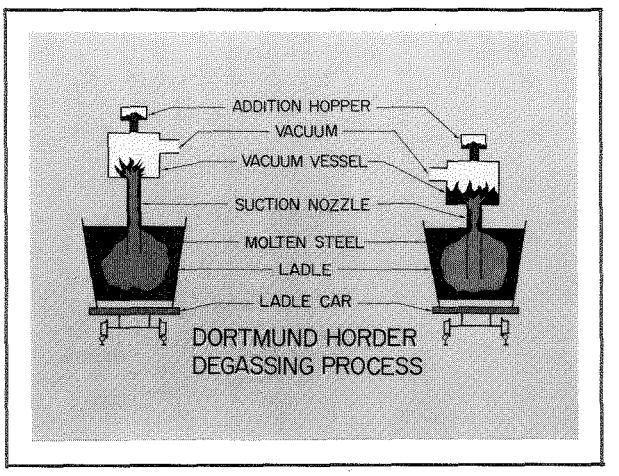
PRODUCT IMPROVEMENTS

Proper handling of bearings will enable the user to take advantage of the *greater reliability* and *increased endurance* offered by New Departure *NDur* ball bearings utilizing the latest technological break-throughs in metal processing, one of which is patented and available only in ball bearings made by New Departure.

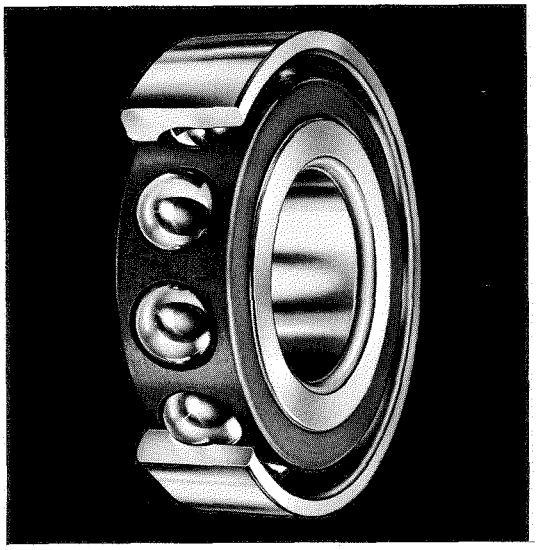
Today, New Departure's high carbon chrome bearings are made of vacuum processed steel. *Injurious inclusions* from oxides, silicates and aluminates have been minimized through the use of carbon as a deoxidizer. Products of carbon deoxidation are gaseous and consequently can be passed from the melt via the imposed vacuum. In contrast to this, conventional deoxidation practices for air melt steel result in solid products which are extremely difficult to remove from the melt.







IMPROVED RESISTANCE TO FATIGUE

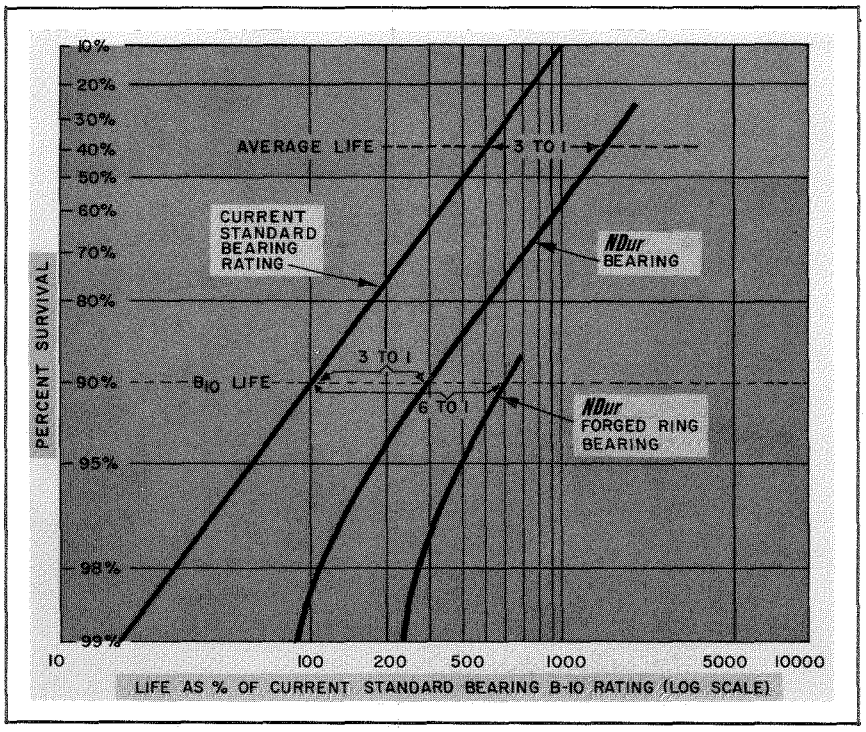


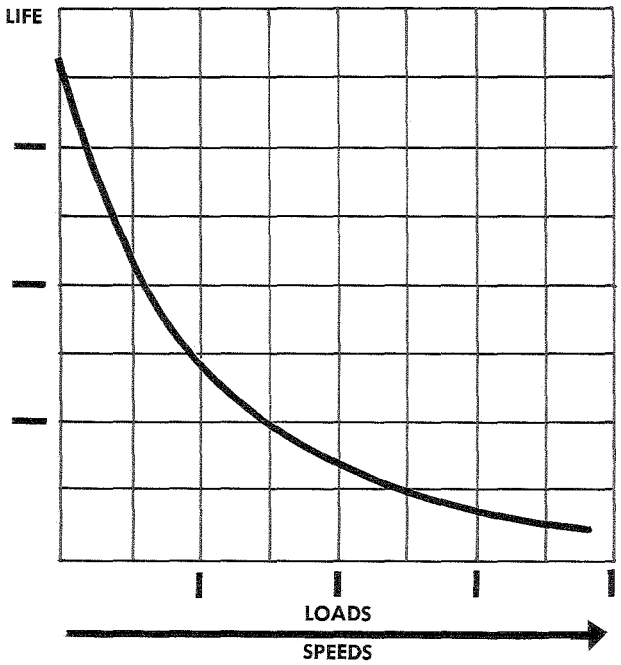
New Departure is using an exclusive process (Results Patented) to form a favorable compressively stressed layer which extends in from the surface providing maximum resistance to fatigue where the bearing stresses are greatest.

These technological advances add up to greater reliability and increased endurance.

NOTE: The *NDur* ratings have shifted far to the right, indicating increased life expectancy. The steep slope at the base of the *NDur* ratings indicates a reduction in early failures.

Only New Departure *NDur* bearings offer all these improvements.





LIFE FACTOR

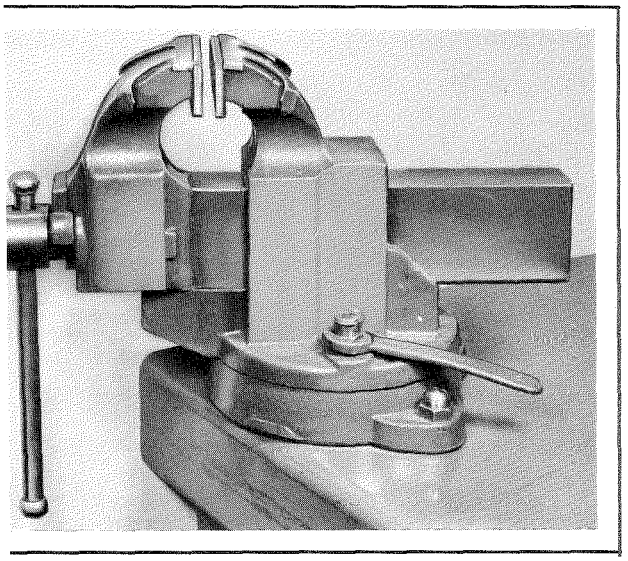
When machines are called upon to carry greater loads or speeds than they were designed to handle, shortened bearing life is to be expected.

Accidental damage, entry of coolant or contaminant or faulty lubrication will cause failure.

Regardless of the cause, all machines will, in time, need extensive overhaul.

Initially, most machines were sent back to the manufacturer for overhaul. Today, with the increase in the amount of super precision equipment and the profit loss resulting from equipment not in operational condition, many plants are equipping themselves to do their own overhaul.

EQUIPMENT



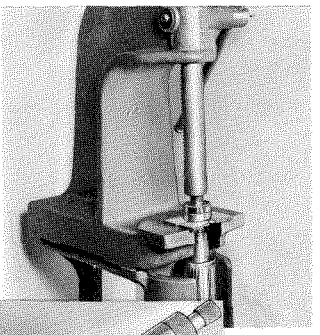
Overhaul facilities should include the following:

1. Dust-free work area with clean bench.

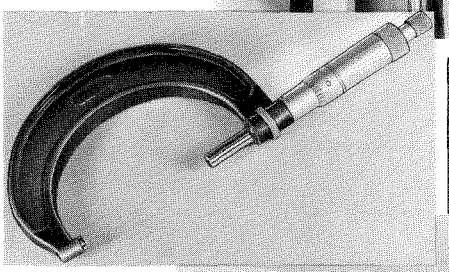
2. Assorted round cold-rolled drifts and ball peen machinist hammers. Do not use hardened cold chisels or drifts.

3. A vise having soft brass or composition jaw protectors for holding spindles.

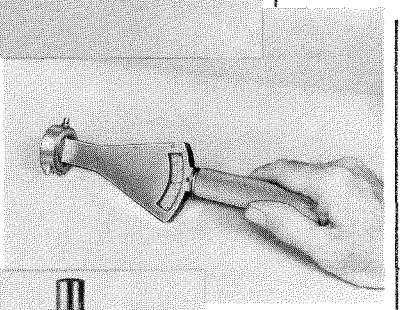
4. Arbor Press with sufficiently rigid and correctly formed plates to preclude transmission of load through ball and races.



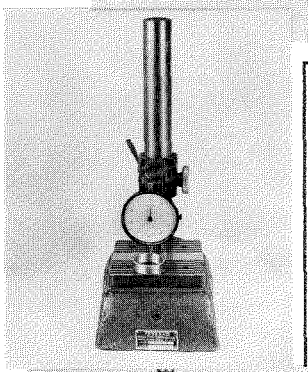
5. Outside and inside micrometer (essential .0001).



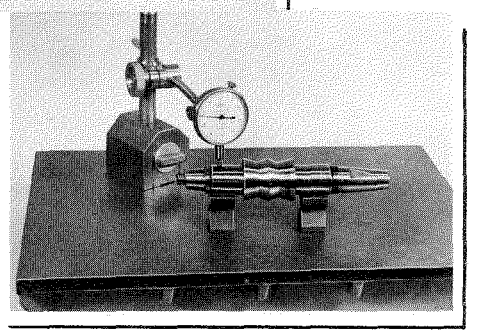
6. Hole or exploring gauge with .0001 dial indicator with suitable master ring or precision blocks.

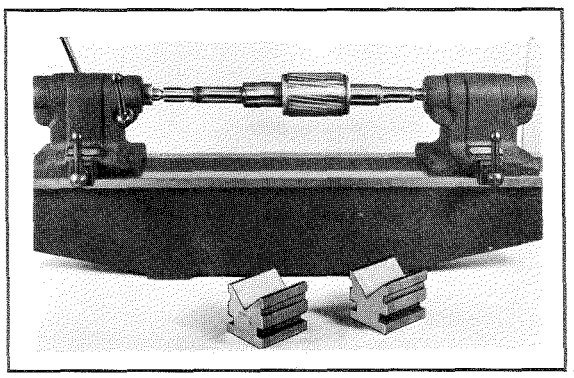


7. Comparator gauge with .0001 dial indicator with suitable master disc or precision blocks.



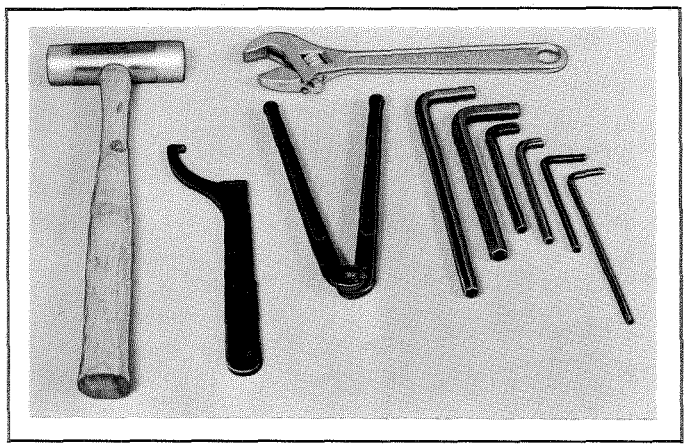
8. .0001 dial indicator with stand.
9. Surface plate and V blocks.





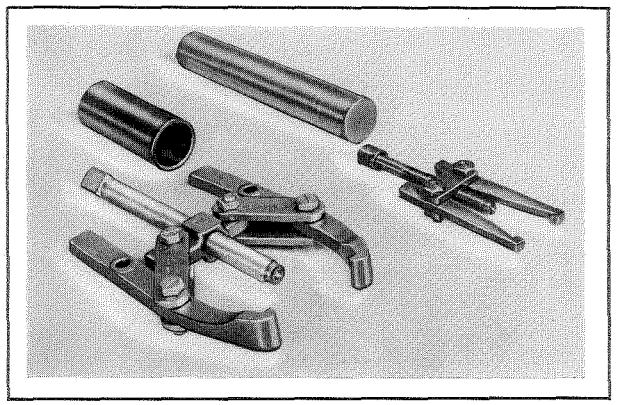
10. Bench centers or parallel V blocks.

(EQUIPMENT Continued)



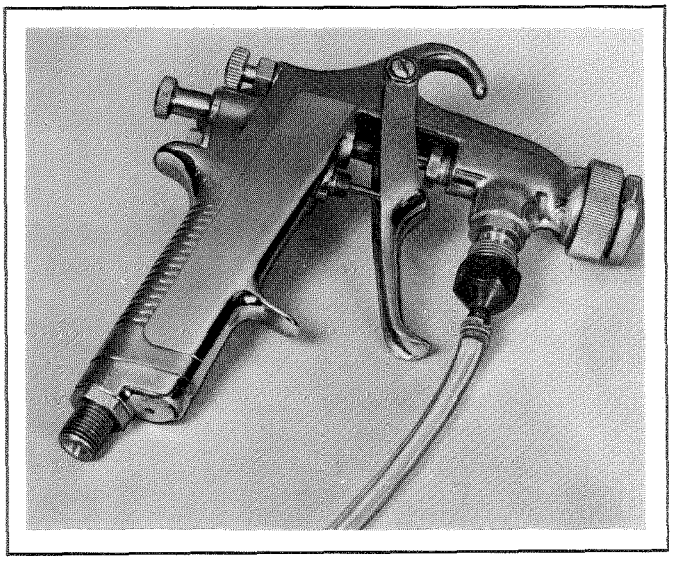
11. Weighted hammer with composition ends.

12. Suitable spanner, open end or adjustable wrenches.



13. Suitable Allen type socket wrenches.

14. Bearing puller with adapters.



15. Stethoscope.

16. Spray cleaner.

The use or value of the above will be covered in this publication as they are required during a typical overhaul.

DISASSEMBLY

Before disassembly is attempted, obtain the following:

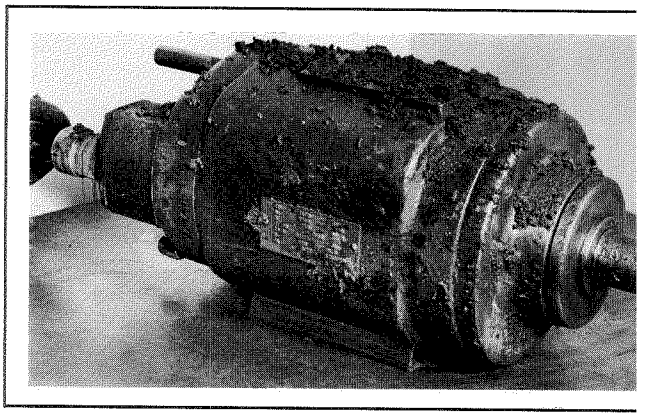
1. *History* of unit's malfunction. This will be helpful in determining the cause.

MALFUNCTION	POSSIBLE CAUSES
Out of roundness of work Unable to maintain tolerance Noise Chatter Rough or poor finish Other (such as physical damage)	*These malfunctions have a variety of causes. This is why it is necessary to obtain a history.*

Knowledge of the actual problem may indicate overhaul is not mandatory.

2. *A drawing* which clearly indicates the construction. This will help you disassemble without damaging bearings or other parts. If drawing is not available, make a detailed sketch as you disassemble. This will guide you during reassembly.

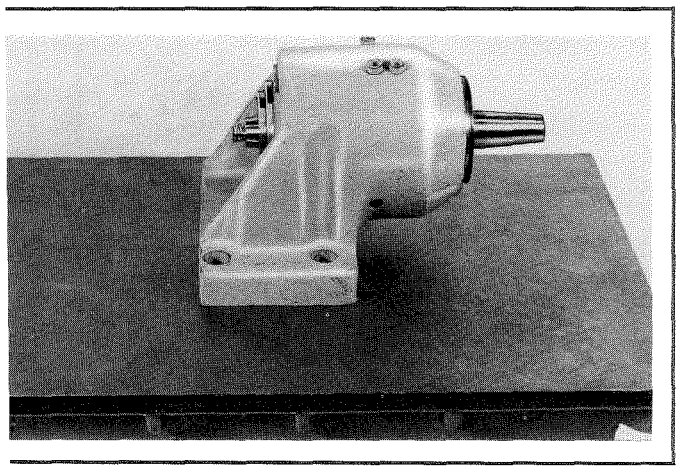
3. *Replacement bearings* should be requisitioned so they will be available for reassembly.



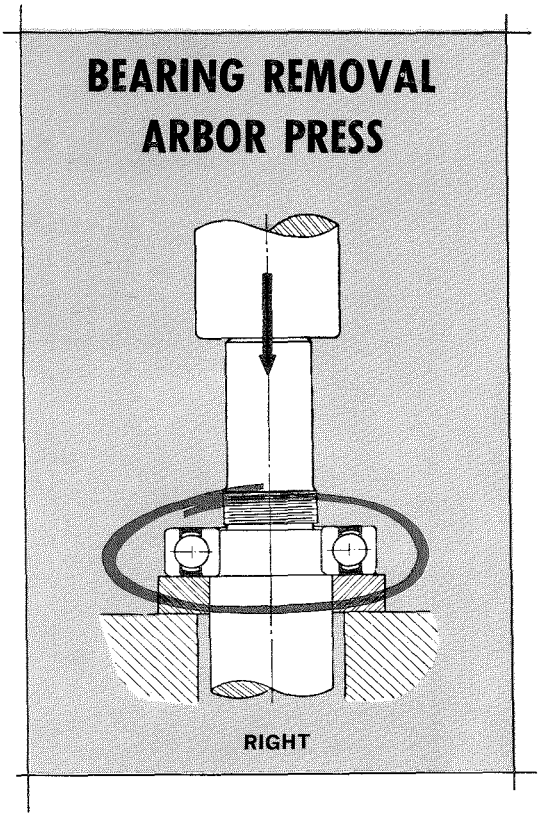
Disassembly begins after a thorough cleaning of all external surfaces. Be sure to close any lubrication openings to prevent contaminant from entering. This cleaning should be done in a ventilated area using solvent and stiff brush to dislodge the accumulation of oil, slush, grit and metal particles. Prevent corrosion of bare metal with coating of light oil.

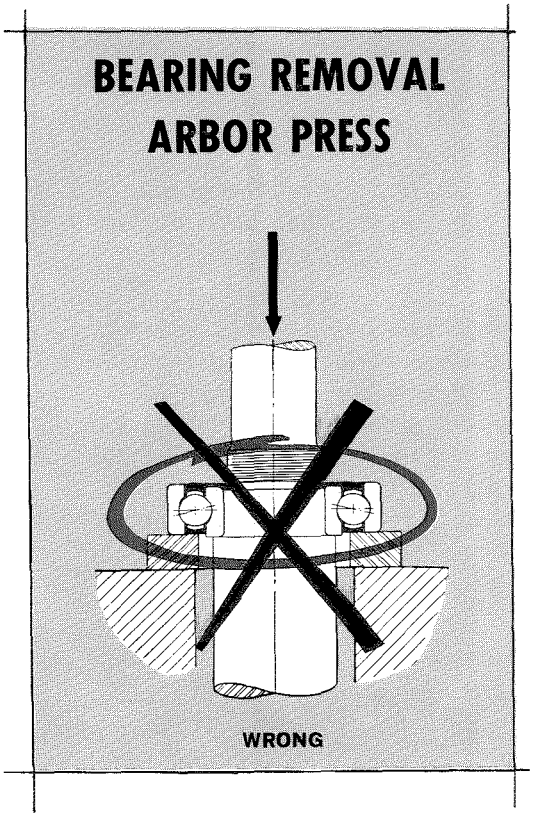
DISASSEMBLY (Continued)

Disassemble the spindle:



1. Remove all externally mounted parts, such as pulleys, dust covers and wheel holders.
2. Remove bearing lock nuts and washers. Relieve the preload on the non-floating bearings even though the locking nut does not block the bearing and shaft removal from the housing. This allows the outer rings to contract and move axially in the housing with little force.
3. Apply pressure gradually on the shaft. Rotate the shaft to prevent exerting a brinelling force on the bearing as the shaft moves out with the bearings. If necessary, tap shaft lightly, but be careful not to damage shaft threads or centers.
4. Once the shaft is withdrawn from the housing, remove the remaining bearings using an Arbor Press or bearing puller. Apply pressure while supporting the bearing race having the press fit. Never transmit pressure through the balls.
5. Place all parts in wire baskets and clean as outlined.





SPRAY CLEANER LIST OF MATERIALS

Item 1 One combination air conditioner and pressure-regulated gauge. By means of the pressure gauge and control valve, incoming air may be reduced to approximately 8 to 10 pounds pressure which is satisfactory for instrument and small bearings up to about 1 inch bore. Increasing pressure is necessary for larger bearings.

Item 2 Straight coupling.

Item 3 Approximately 15 feet of high pressure braid covered hose.

Item 4 Straight coupling.

Item 5 Commercial type painter's spray gun. For small bearings and instrument type bearings, use small type head.

Item 6 For larger bearings and other component parts, use larger type head.

Item 7 One straight coupling for solvent inlet.

Item 8 Approximately 10 feet flexible oil resistant transparent tubing.

Item 9 Five gallon glass bottle with dust excluding cap containing any filtered Stoddard cleaning solvent.

Item 10 One fritted glass filter, 90 mm x C for filtering solvent.

Item 11 Suitable spray booth with fume exhaust.

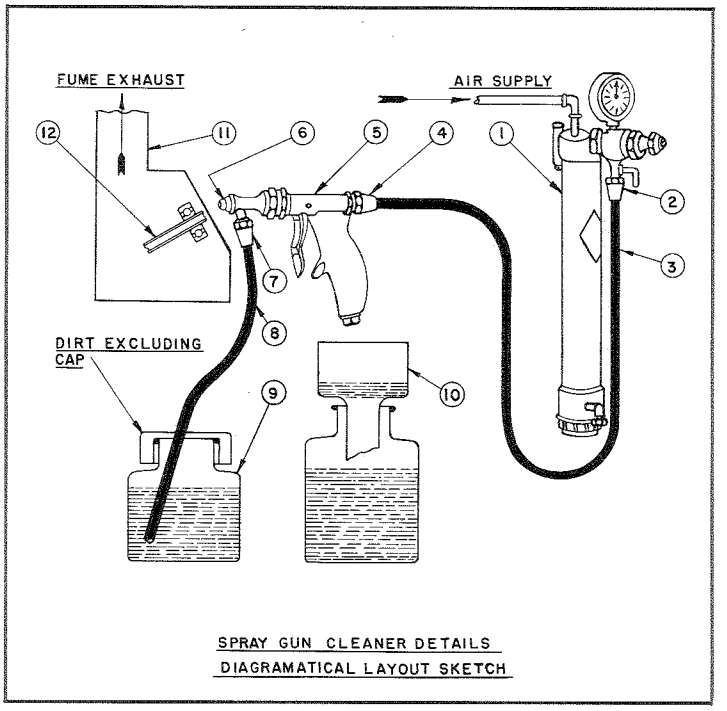
Item 12 Suitable arbors for holding bearings. Larger sizes may be held against a screen.

GENERAL INSTRUCTIONS

Total trigger depression provides cleaning spray until bearing becomes smooth at hand feel. Partial trigger depression will furnish dry air to blow out solvent and finish dry the bearing. Do not spin the bearings at high speed, but oscillate outer ring gently by means of spray and air.

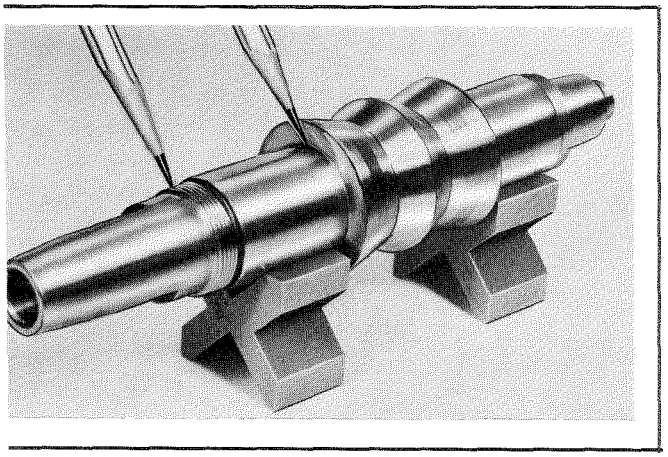
Absolute cleanliness of spindle parts and ball bearings is essential at all times. The immersion of bearings in open containers of solvents for cleaning purposes is to be discouraged. A spray cleaning device as shown has proven very satisfactory. No recirculating system is employed, the fluid being used only once and then dissipated by means of an exhaust fan after passing through the bearing. Pressure-regulated and filtered air is carried to a commercial-type painter's spray gun. The fluid, which may be any approved Stoddard solvent cleaner is syphoned from a glass container after having been previously filtered through a glass filter.

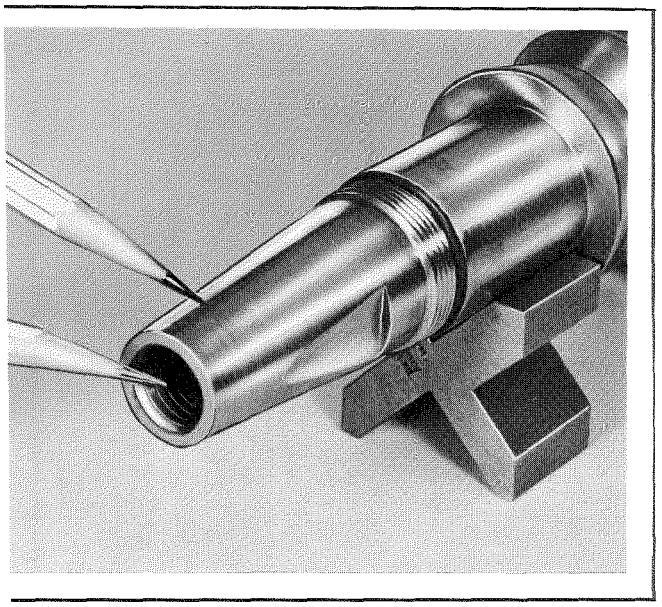
Alternate spraying and drying is accomplished by total or partial trigger depression. Bearings must be immediately oiled and wrapped in oil paper to prevent rust.

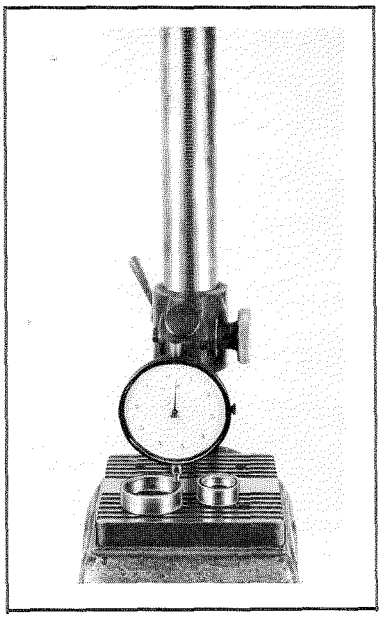


SPRAY GUN CLEANER DETAILS
DIAGRAMATICAL LAYOUT SKETCH

Now the parts are clean and ready for inspection.







INSPECTION

It is generally desirable to cover the work area with a clean brown paper and a flat metal plate. All tools should be clean and free from burrs and rust.

While the equipment and parts are being allowed to reach a common temperature for measurement purposes, visual inspection of parts can be started.

1. Setting the spindle housing on the flat plate will indicate any burrs which will throw the unit off when installed.
2. Look for signs of damage.
   - A. Pay particular attention to the *shaft shoulder* since nicks, gouges or heavy rust can cause misalignment of the inner rings when they are clamped by the lock nut. Excessive damage should be cleaned up with a precision grinder.
   - B. Examine threads, be sure they are free from burrs, nicks, etc. Use care in cleaning threads or removing burrs by stoning, since deformed or out of true threads can contribute to shaft runout.
   - C. Inspect the nose of the spindle. If damaged it should be reworked, new centers established, and the whole shaft re-trued in a precision grinder. This may necessitate building up the bearing seats.
   - D. Inspect the drive end and drive coupling.
3. Check preload springs and carrier. Recesses must be clean and free of burrs. The ends of the springs must be smooth and free from rough edges. The springs should not be cracked or bent. In a free state, the springs should be equal in length within .025 to .050.
4. Check spacers, lock nuts and slingers. All burrs must be removed. Non-spring loaded abutting faces must be flat and parallel within .0002 and square with the bore, spacers between inner races and outer races equal in length within .0002 except where the manufacturer specifies otherwise.
5. Examine the housing, all oil holes, cap screw holes and internal surfaces must be free of foreign matter. Remove burrs and raised metal. Blow all oil passages clean with a solvent spray. Do not use sealing material on joints of the lubrication system.

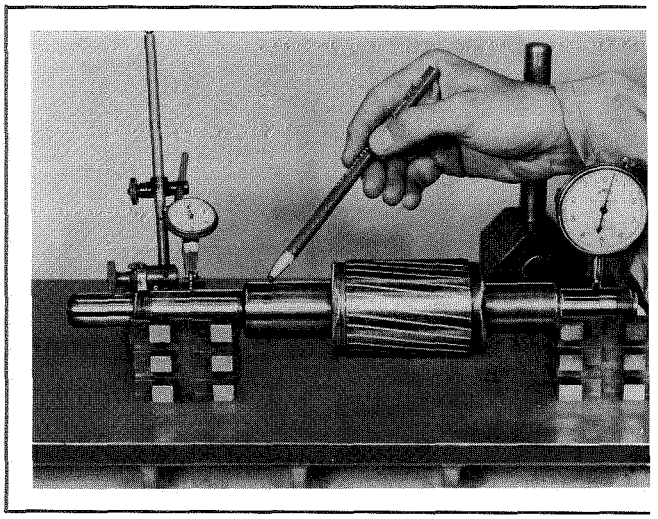
INSPECTION (Continued)

6. Mount spindle shaft on parallel V-blocks.

   A. To check the bearing seats, set dial indicator as shown. Rotate forward and backwards to determine any out of roundness. Moving the shaft axially will show taper. Both seats should be true within .0002 of each other. For high speed, within .0001.

   The bearing seats should be checked for diameter with comparator, ring gauges or a "jo" block set up. If spindle has been built up by plating or metal spraying, it should be ground to approximate size, lapped to the required dimension, then balanced.

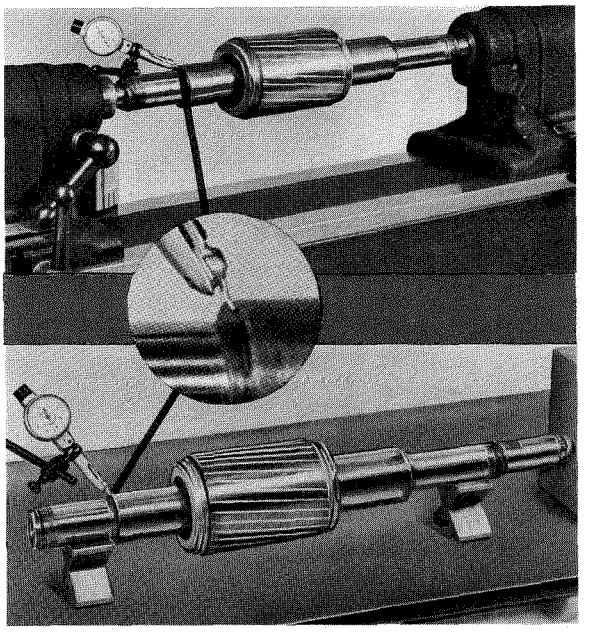
   a. Due to the wide variance in types of balancing equipment, we recommend you refer to the instructions provided with your equipment.



   B. To check squareness to face set dial indicator as shown. While the bench center method is preferred, parallel V-Blocks can be used. Hold against a weighted end block with a steel ball in the end of the shaft to provide a fixed pivot point. The face should be square within .0001 for precision work.

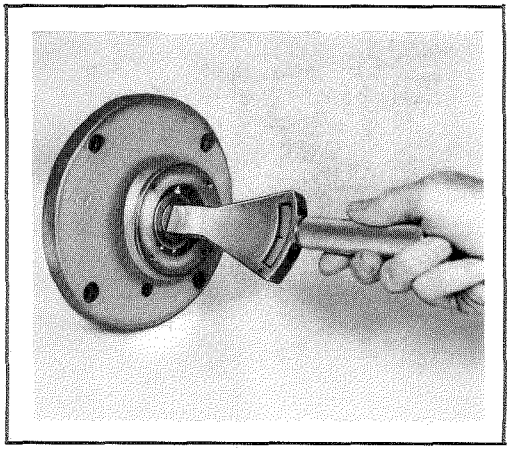
   C. Check nose and drive ends for runout. Mark high point of eccentricity on shaft where it can be seen during bearing assembly. Drive flange (if used), should be mounted to obtain its effect on readings.

   D. Check taper of shaft extensions, where used as a location surface for chucks, quills, or adaptors.



7. Check bore with 2 or 3 point hole gauge set to basic diameter with precision blocks or ring gauge. Rocking gauge in several positions will show out of roundness and diameter deviations. Axial movement will show taper.

8. Inspect bearings for smoothness and separator wear. Most bearings cannot be disassembled to permit viewing of balls, separator and raceways for wear or damage. Since bearings constitute a minor expense compared to the total overhaul cost, we do not recommend their re-use where there is the slightest doubt as to their condition.



INSPECTION (Continued)

9. Compare shaft and housing diameters with the following tables to see if they are within the limits specified. The ideal situation is a line to line fit between the rotating members and a sliding push fit in the stationary member or housing. Floating bearings must have .0001 to .0002 loose fit to permit axial expansion. In any event, .0001 looser than nose end.

SINGLE ROW RADIAL
SINGLE ROW ANGULAR CONTACT

Fits obtained from this table are for precision spindles and other similar parts requiring exceptional accuracy and rigidity in mounting. Bearing seats on shafts must be very accurately and smoothly finished. Where shafts are stationary or conditions such as heavy or vibratory loads, or special preloading are to be in effect, correct modifications of these fits may be obtained from your New Departure Sales Engineer.

SHAFT MOUNTING FITS

bearing bore numbers	bearing bore diameters				shaft revolving diameters				With the limits given, closer fits will result in practice. theoret. fit			
	max.	ABEC-5 min.	ABEC-7 min.	ABEC-9 min.	min.	ABEC-5 max.	ABEC-7 max.	ABEC-9 max.	loose	ABEC-5 tight	ABEC-7 tight	ABEC-9 tight
0	**.3937**	.3935	.39355	.3936	**.3936**	.3938	.39375	.3937				
1	**.4724**	.4722	.47225	.4723	**.4723**	.4725	.47245	.4724	**.0001**	.0003	.0002	.0001
2	**.5906**	.5904	.59045	.5905	**.5905**	.5907	.59065	.5906				
3	**.6693**	.6691	.66915	.6692	**.6692**	.6694	.66935	.6693				
4	**.7874**	.7872	.78725	.7873	**.7873**	.7875	.78745	.7874	**.0001**	.0003	.0002	.0001
5	**.9843**	.9841	.98415	.9842	**.9842**	.9844	.98435	.9843				
6	**1.1811**	1.1809	1.18095	1.1810	**1.1810**	1.1812	1.18115	1.1811	**.0001**	.0003	.0002	
7	**1.3780**	1.3778	1.3778	1.3779	**1.3779**	1.3782	1.3781	1.3780	**.0001**	.0004	.0003	.0001
8	**1.5748**	1.5746	1.5746	1.5747	**1.5747**	1.5750	1.5749	1.5748	**.0001**	.0004	.0003	
9	**1.7717**	1.7715	1.7715	1.7716	**1.7716**	1.7719	1.7718	1.7717	**.0001**	.0004	.0003	.0001
10	**1.9685**	1.9683	1.9683	1.9684	**1.9684**	1.9687	1.9686	1.9685	**.0001**	.0004	.0003	.0001
11	**2.1654**	2.1651	2.1652	2.16525	**2.1653**	2.1656	2.1656	2.16545	**.0001**	.0005	.0004	.0002
12	**2.3622**	2.3619	2.3620	2.36205	**2.3621**	2.3624	2.3624	2.36225				
13	**2.5591**	2.5588	2.5589	2.55895	**2.5590**	2.5593	2.5593	2.55915	**.0001**	.0005	.0004	.0002
14	**2.7559**	2.7556	2.7557	2.75575	**2.7558**	2.7561	2.7561	2.75595				
15	**2.9528**	2.9525	2.9526	2.95265	**2.9527**	2.9530	2.9530	2.95285				.0002
16	**3.1496**	3.1493	3.1494	3.14945	**3.1495**	3.1498	3.1498	3.14965	**.0001**	.0005	.0004	.0002
17	**3.3465**	3.3462	3.34625	3.3463	**3.3464**	3.3467	3.34665	3.3466				.0003
18	**3.5433**	3.5430	3.54305	3.5431	**3.5432**	3.5435	3.54345	3.5434				
19	**3.7402**	3.7399	3.73995	3.7400	**3.7401**	3.7404	3.74035	3.7403	**.0001**	.0005	.0004	.0003
20	**3.9370**	3.9367	3.93675	3.9368	**3.9369**	3.9372	3.93715	3.9371				
21	**4.1339**	4.1336	4.13365	4.1337	**4.1338**	4.1341	4.13405	4.1340				
22	**4.3307**	4.3304	4.33045	4.3305	**4.3306**	4.3309	4.33085	4.3308	**.0001**	.0005	.0004	.0003
24	**4.7244**	4.7241	4.72415	4.7242	**4.7243**	4.7246	4.72455	4.7245				
26	**5.1181**	5.1177	5.1178	5.11785	**5.1179**	5.1183	5.1182	5.11815				
28	**5.5118**	5.5114	5.5115	5.51155	**5.5116**	5.5120	5.5119	5.51185	**.0002**	.0006	.0004	.0003
30	**5.9055**	5.9051	5.9052	5.90525	**5.9053**	5.9057	5.9056	5.90555				
32	**6.2992**	6.2988	6.2989	6.29895	**6.2990**	6.2994	6.2993	6.29925				
34	**6.6929**	6.6925	6.6926	6.69265	**6.6927**	6.6931	6.6930	6.69295	**.0002**	.0006	.0004	.0003
36	**7.0866**	7.0862	7.0863	7.08635	**7.0864**	7.0868	7.0867	7.08665				

SINGLE ROW RADIAL
SINGLE ROW ANGULAR CONTACT

These housing fits for high precision spindles and other parts requiring exceptional accuracy and rigidity of support. Housing bores must be straight and brought to size by grinding or other methods capable of quality of finish equal to that of the bearing O.D.

Where revolving or soft housings, vibratory loads, or special preloads require modification of these fits, recommendations may be obtained from your New Departure Sales Engineer.

In practice, fits from the limits listed will average closer than those given under "Theoretical Fits".

HOUSING MOUNTING FITS

bearing bore numbers			bearing outer diameter				housing stationary							
							ABEC-5, 7					ABEC-9		
series			diameters				diameters			theoret. fit		diameters		theoret. fit
ex-lt.	light	med.	max.	ABEC-5 min.	ABEC-7 min.	ABEC-9 min.	min.	ABEC-5 max.	ABEC-7 max.	ABEC-5 tight	ABEC-5 loose	ABEC-7 loose	min.	max.	tight	loose
0			**1.0236**	1.0234	1.0234	1.02345	**1.0236**	1.0239	1.0238				**1.0236**	1.02375		
1			**1.1024**	1.1022	1.1022	1.10225	**1.1024**	1.1027	1.1026	.0000	.0005	.0004	**1.1024**	1.10255	.0000	.0003
	0		**1.1811**	1.1809	1.1809	1.18095	**1.1811**	1.1814	1.1813				**1.1811**	1.18125		
2	1		**1.2598**	1.2596	1.2596	1.25965	**1.2598**	1.2601	1.2600				**1.2598**	1.25995		
3	2	0	**1.3780**	1.3778	1.3778	1.37785	**1.3780**	1.3783	1.3782	.0000	.0005	.0004	**1.3780**	1.37815	.0000	.0003
		1	**1.4567**	1.4565	1.4565	1.45655	**1.4567**	1.4570	1.4569				**1.4567**	1.45685		
	3		**1.5748**	1.5746	1.5746	1.57465	**1.5748**	1.5751	1.5750				**1.5748**	1.57495		
4		2	**1.6535**	1.6533	1.6533	1.65335	**1.6535**	1.6538	1.6537	.0000	.0005	.0004	**1.6535**	1.65365	.0000	.0003
5	4	3	**1.8504**	1.8502	1.8502	1.85025	**1.8504**	1.8507	1.8506				**1.8504**	1.85055		
	5	4	**2.0472**	2.0469	2.0470	2.04705	**2.0472**	2.0475	2.0474				**2.0472**	2.04735		
6			**2.1654**	2.1651	2.1652	2.16525	**2.1654**	2.1657	2.1656	.0000	.0006	.0004	**2.1654**	2.16555	.0000	.0003
7	6	5	**2.4409**	2.4406	2.4407	2.44075	**2.4409**	2.4412	2.4411				**2.4409**	2.44105		
8			**2.6772**	2.6769	2.6770	2.67705	**2.6772**	2.6775	2.6774				**2.6772**	2.67735		
	7	6	**2.8346**	2.8343	2.8344	2.83445	**2.8346**	2.8349	2.8348	.0000	.0006	.0004	**2.8346**	2.83475	.0000	.0003
9			**2.9528**	2.9525	2.9526	2.95265	**2.9528**	2.9531	2.9530				**2.9528**	2.95295		
10	8	7	**3.1496**	3.1493	3.1494	3.14945	**3.1496**	3.1499	3.1498	.0000	.0006	.0004	**3.1496**	3.14975	.0000	.0003
	9		**3.3465**	3.3462	3.3462	3.3463	3.3464	3.3468	3.3467	.0001	.0006	.0005	**3.3465**	3.3467	.0000	.0004
11	10	8	**3.5433**	3.5430	3.5430	3.5431	**3.5432**	3.5436	3.5435	.0001	.0006		**3.5433**	3.5435	.0000	.0004
12			**3.7402**	3.7399	3.7399	3.7400	**3.7401**	3.7405	3.7404				**3.7402**	3.7404		
13	11	9	**3.9370**	3.9367	3.9367	3.9368	**3.9369**	3.9373	3.9372	.0001	.0006	.0005	**3.9370**	3.9372	.0000	.0004
14	12	10	**4.3307**	4.3304	4.3304	4.3305	**4.3306**	4.3310	4.3309				**4.3307**	4.3309		
15			**4.5276**	4.5273	4.5273	4.5274	**4.5275**	4.5279	4.5278	.0001	.0006	.0005	**4.5276**	4.5278		
	13	11	**4.7244**	4.7241	4.7241	4.7242	**4.7243**	4.7247	4.7246	.0001	.0006	.0005	**4.7244**	4.7246	.0000	.0004
16	14		**4.9213**	4.9209	4.9209	4.9211	**4.9212**	4.9217	4.9216	.0001	.0008	.0007	**4.9213**	4.9215		
17	15	12	**5.1181**	5.1177	5.1177	5.1179	**5.1180**	5.1185	5.1184				**5.1181**	5.1183		
18	16	13	**5.5118**	5.5114	5.5114	5.5116	**5.5117**	5.5122	5.5121	.0001	.0008	.0007	**5.5118**	5.5120	.0000	.0004
19			**5.7087**	5.7083	5.7083	5.7085	**5.7086**	5.7091	5.7090				**5.7087**	5.7089		
20	17	14	**5.9055**	5.9051	5.9051	5.9053	**5.9054**	5.9059	5.9058	.0001	.0008		**5.9055**	5.9057	.0000	.0004
21	18	15	**6.2992**	6.2987	6.2988	6.29895	**6.2991**	6.2997	6.2995	.0001	.0010	.0007	**6.29915**	6.2994	.00005	.00045
22	19	16	**6.6929**	6.6924	6.6925	6.69265	**6.6928**	6.6934	6.6932	.0001	.0010		**6.69285**	6.6931	.00005	.00045
24	20	17	**7.0866**	7.0861	7.0862	7.08635	**7.0865**	7.0871	7.0869				**7.08655**	7.0868	.00005	.00045
	21	18	**7.4803**	7.4798	7.4799	7.4800	**7.4802**	7.4808	7.4806	.0001	.0010	.0007	**7.4802**	7.4805	.0001	.0005
26	22	19	**7.8740**	7.8735	7.8736	7.8737	**7.8739**	7.8745	7.8743				**7.8739**	7.8742	.0001	.0005
28			**8.2677**	8.2672	8.2673	8.2674	**8.2676**	8.2682	8.2680				**8.2676**	8.2679		
	24	20	**8.4646**	8.4641	8.4642	8.4643	**8.4645**	8.4651	8.4649	.0001	.0010	.0007	**8.4645**	8.4648	.0001	.0005
30		21	**8.8583**	8.8578	8.8579	8.8580	**8.8582**	8.8588	8.8586				**8.8582**	8.8585		
	26		**9.0551**	9.0546	9.0547	9.0548	**9.0550**	9.0556	9.0554				**9.0550**	9.0553		
32		22	**9.4488**	9.4483	9.4484	9.4485	**9.4487**	9.4493	9.4491	.0001	.0010	.0007	**9.4487**	9.4490	.0001	.0005
	28		**9.8425**	9.8420	9.8421	9.8422	**9.8424**	9.8430	9.8428				**9.8424**	9.8427		
34		24	**10.2362**	10.2357	10.2357	10.2359	**10.2360**	10.2367	10.2365				**10.23605**	10.23645		
	30		**10.6299**	10.6294	10.6294	10.6296	**10.6297**	10.6302	10.6302	.0002	.0010	.0008	**10.62975**	10.63015	.00015	.00055
36		26	**11.0236**	11.0231	11.0231	11.0233	**11.0234**	11.0241	11.0239				**11.02345**	11.02385		

OPERATING CHARACTERISTICS FOR TYPICAL

MACHINE	SPEED RANGE IN RPM'S (See Note 1 & 2)	BEARING SIZE	BEARING GRADE (ABEC)	PRELOAD & RANGE
Tool Post Grinders	30,000—60,000	0—5	1, 3, 5	Manually Adjusted or Spring (Approx. "L")
Grinders—Wheelhead Motorized—Hi-Speed	50,000—100,000 and up	0—5	7, 9	Spring (Max. = "L")
Grinders Belt-Driven	Wide Range	0—12	5, 7, 9	Manually Adjusted Duplex L, X Preload
Grinders—Low Speed, Heavy-Duty, Precision	1,000—3,000	4—	5, 7, 9	Manually Adjusted Duplex X, T Preload
Work Heads	50—4,000	10—28	7, 9	Duplex X, T Preload
Lathes—Precision	100—4,000	0—20	5, 7	Manually Adjusted Duplex X, T Preload
Jig Borer Spindles	100—3,000	8—16	7, 9	Duplex X, T Preload
Light Duty Precision Milling Spindles	100—3,000	8—16	5, 7	Manually Adjusted Duplex X Preload
Precision Drilling Machines	100—5,000	0—8	5, 7	Manually Adjusted Duplex X, T Preload
High Speed Routers	10,000—25,000	1—5	5, 7	Spring

NOTE: For Operating Speeds, Lubrication and Bearing Replacement, always follow the Manufacturer's Recommendations. In Absence of this Information, the above may be used as a Guide.

1. See Chart Showing Suggested Limiting Speeds.
2. Average operating temperature: 100 to 125°F. If over 125°F, check for trouble, such as soft grease, excessive preload, misalignment, speed, etc.

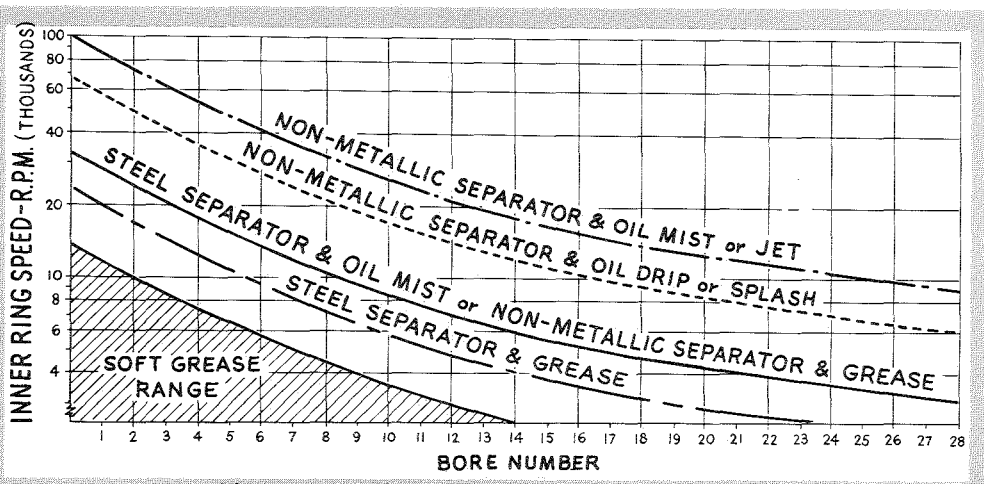
APPLICATIONS USING SUPER PRECISION BEARINGS

SEPARATOR TYPE	LUBE SYSTEM (1)	PRECISION BRG. TYPE	GREASE (N.L.G.I. Number†)	REMARKS
Non-Metallic	Oil Grease	Q0L00 Q20,000 3000 (3) Q3000	#3, 4 Grease	Usually belt-driven with self-contained lubrication system.
Non-Metallic	Oil: Mist or Wick	Q0L00 Q20,000	Grease may sometimes be used on special units—check limiting speed.	Make sure oil is clean and lubrication system is not contaminated. Check manufacturer's recommendations on Mist Lube adjustments.
Non-Metallic	Oil Grease	Q0L00 Q20,000	#3, 4	On slower speed units, steel separators can be used—check Limiting Speed and bearing availability.
Non-Metallic	Grease	Q20,000 QH20,000 Q30,000	#2, 3, 4	Use "T" preload for max. rigidity, low speed. Use softer greases for the lower speeds only.
Non-Metallic	Grease	Q0L00 Q20,000	#2, 3, 4	
Non-Metallic	Grease	Q0L00 QH0L00 Q20,000 QH20,000	#3, 4	"Jeweler's" lathes operate up to 12,000 rpm and may use grease or oil lubricated bearings.
Non-Metallic	Grease	Q20,000 QH20,000	#3, 4	
Non-Metallic	Grease	Q0L00 Q20,000 Q30,000	#3, 4	
Non-Metallic	Grease	Q3000, 3000 (3) QH20,000 Q30,000 5000* (3)	#3, 4	Precision "Sensitive" drills operate up to 10,000 rpm. *5000—Double row—steel separators only available.
Non-Metallic	Grease	Q3000 Q0L00 Q20,000	#4	Spring preload recommended for high speed. Manual adjustment frequently used—do not set up too tight.

†National Lubricating Grease Institute (N.L.G.I.) Number.
(3) Shielded.

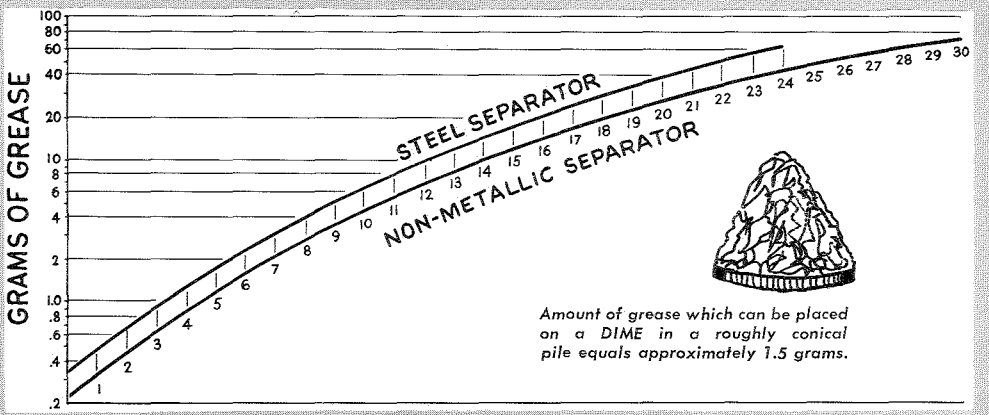
LUBRICATION

Now that all parts are clean and in good condition, the type of lubricant to be used should be determined. Two consistencies of grease are generally used. Use a #2 soft grease for low speeds and the heavier #3 or #4 high quality ball bearing greases for higher speeds, where channeling is beneficial. A spindle oil, having a viscosity 100 seconds Saybolt at 100° Fahrenheit is recommended. A turbine oil should carry a rating of 240 seconds Saybolt @ 100° Fahrenheit.



LIMITING SPEED & LUBRICATION REQUIREMENTS

Where heat is a factor, the following chart will help you determine the amount of grease to be added to a bearing.



BEARING BORE NUMBER

Since machines are sometimes operated over their designed speed, care should be taken not to exceed the speeds and amount of lubricant shown. (in the charts above)

LUBRICATION (Continued)

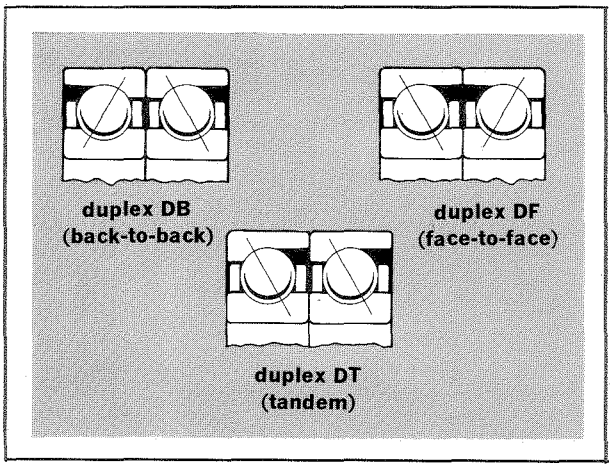
One pound cans are popular size containers as they can be easily covered. Some shops open a new can each day rather than risk an accumulation of contaminant over a period of time. Revolve the bearing as you work the desired amount of lubricant into the bearing. Be sure the grease is evenly distributed and the ball pockets are thoroughly coated.

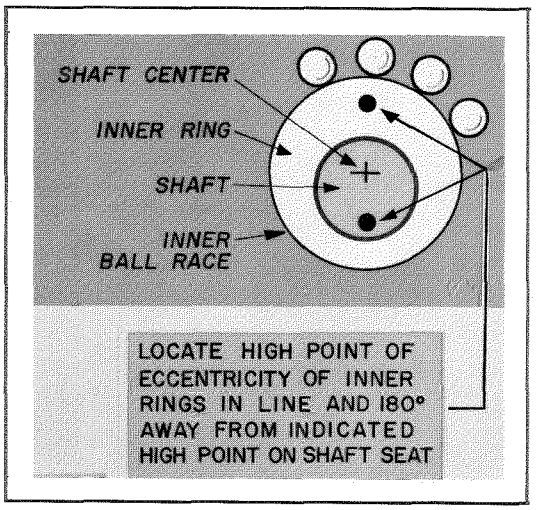
REASSEMBLY

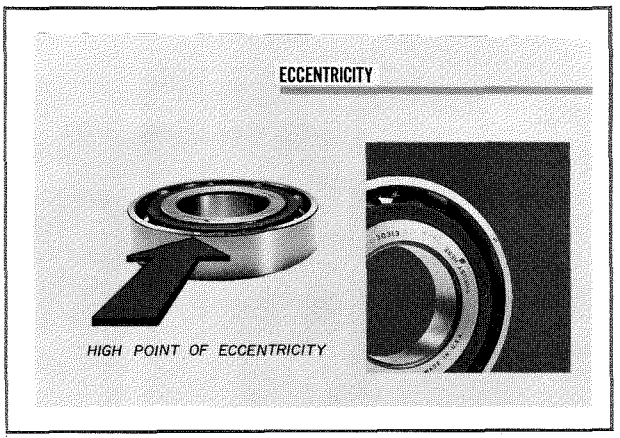
1. Cover the shaft and housing with a light coating of oil. This will inhibit rust and help in mounting the bearings.

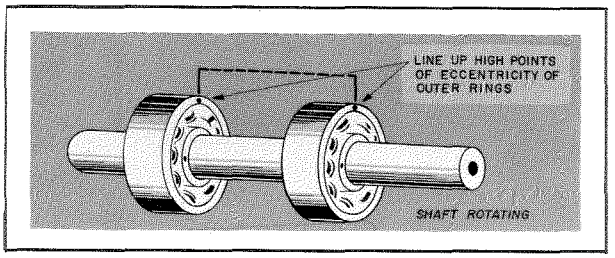
2. Refer to your drawing when assembling angular contact bearings so the thrust will be carried on the high race shoulders. The angular contact bearings are designed to support combinations of radial and unidirectional thrust loads. When two angular contact bearings are mounted with contact angles opposed (either in close DB or DF arrangement, or at opposite ends of a shaft), they will support combined loads with thrust from either direction.

3. Locate the high points on the shaft and housing seats. Position the high points as shown. This not only helps cancel out any inherent eccentricity of the bearing seat itself, but also alleviates fighting eccentricities between the bearings.

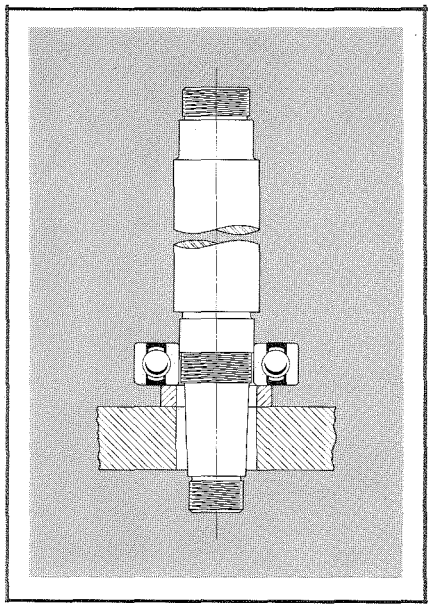


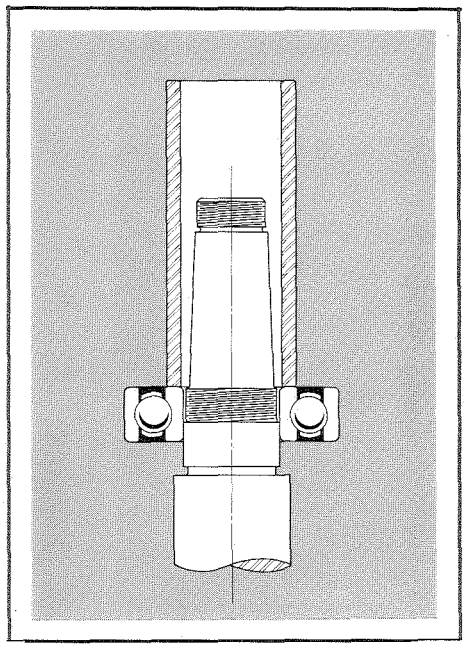






4. Mounting practice will vary depending on bearing size and equipment available.





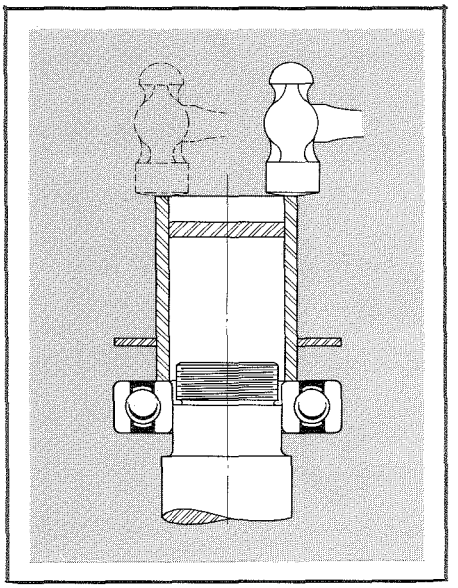
REASSEMBLY (Continued)

ARBOR PRESS METHOD

Using an Arbor Press, the bearing may be laid on a face block which contacts only the bearing inner ring and which has a hole diameter greater than the bearing bore, as shown in Figure 1. The shaft is pressed through the bearing until it is seated firmly against the shaft shoulder.

If the shaft is not too long, it can be supported beneath the table of the Arbor Press and the bearing pressed onto it by ram pressure against a piece of soft metal tubing, as shown in Figure 2. The tubing must be clean, inside and out, and the inside diameter of the tubing should be slightly greater than the bearing bore. The ends of the tubing should be square (with corners chamfered to avoid flaking) and should contact only the bearing inner ring. The shaft must be held in line with the ram of the Arbor Press to avoid cocking the bearing on the shaft seat.

When an Arbor Press is not available, the bearing can be driven onto the shaft seat by light hammer blows against the end of the soft metal tubing, as shown in Figure 3. These blows should be made alternately against opposite sides of the tubing face, and great care must be taken to avoid cocking the bearing as it is driven onto the shaft seat.



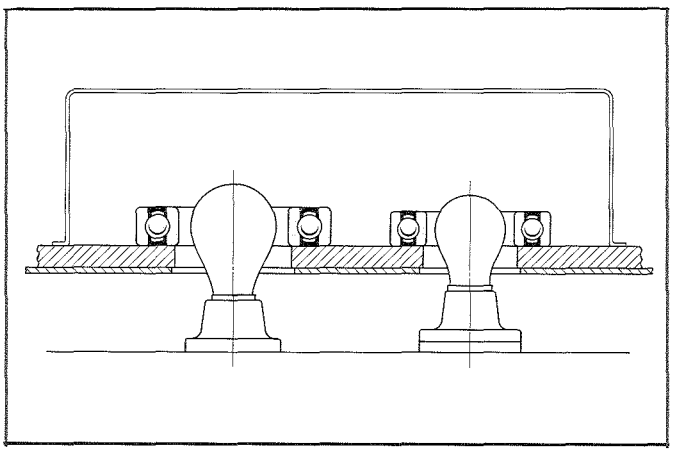
REASSEMBLY (Continued)

THERMAL EXPANSION METHOD

Two dry-heat methods are recommended.

In the first, bearings still sealed in their packages are placed on a shelf in an enclosure lined with foil reflector materials. Electric lamp bulbs warm the bearings. Temperatures from 150°F to 225°F are recommended.

The second method involves inserting a lamp bulb or electric heating element in the bearing bore, as shown in Figure 4. Temperature is controlled by predetermining the time required for heating and making sure the heating element is centered in the bearing bore. *Bearings should not be heated above* the recommended maximum, and prolonged heating should be avoided.

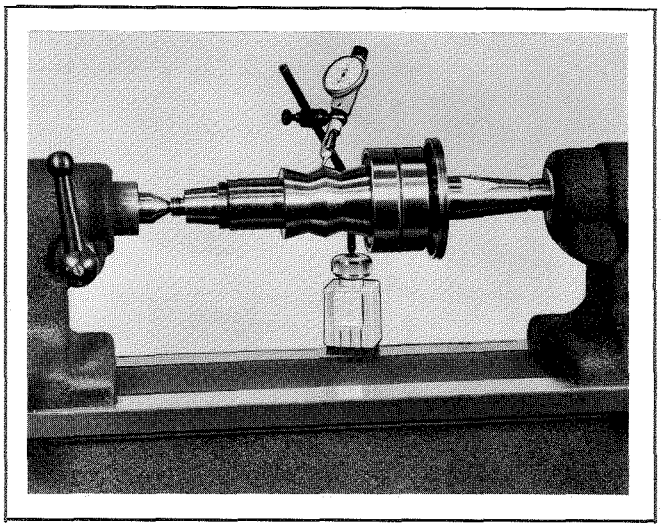


Immediately after removal from the heating device, the bearing should be slipped over the shaft to its required position and held firmly against its shaft shoulder (by hand or by gravity) until it contacts the shaft seat. Care must be taken not to cock.

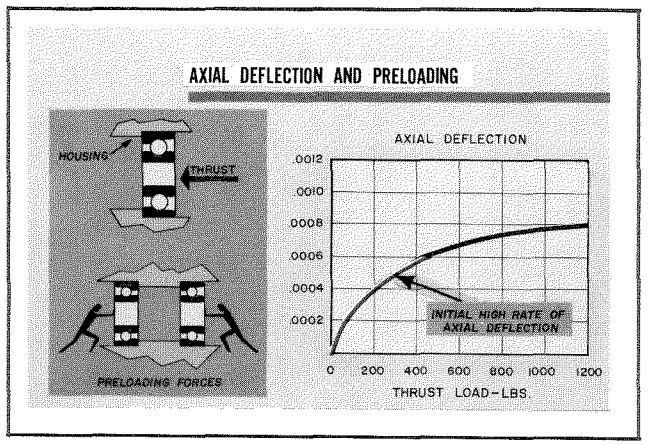
5. Tighten lock nut to draw bearing race up against shaft shoulder, check spindle for runout, if runout is greater now that the bearings have been mounted, recheck bearing mounting and abutting shoulders.

6. Use new locking washers, as the tang, once bent, is difficult to straighten and may fracture. If re-used, they can cause runout.

7. Tighten the locking nuts to apply the *preload**. Rotate the bearings while tightening. This will prevent cocking, enabling the balls to roll up into position on their contact angle.



**Preload is explained on the following page.*



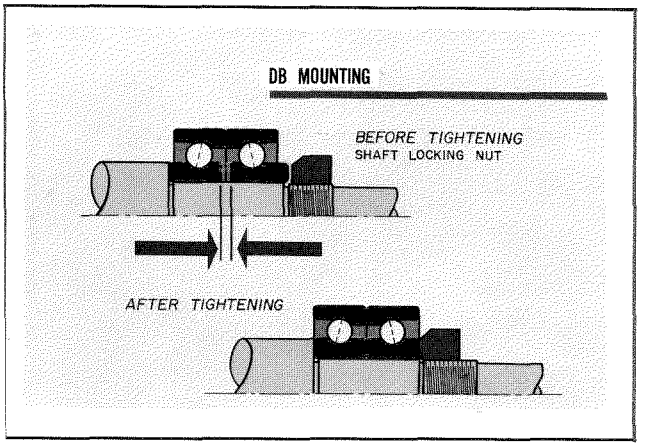
*PRELOADING

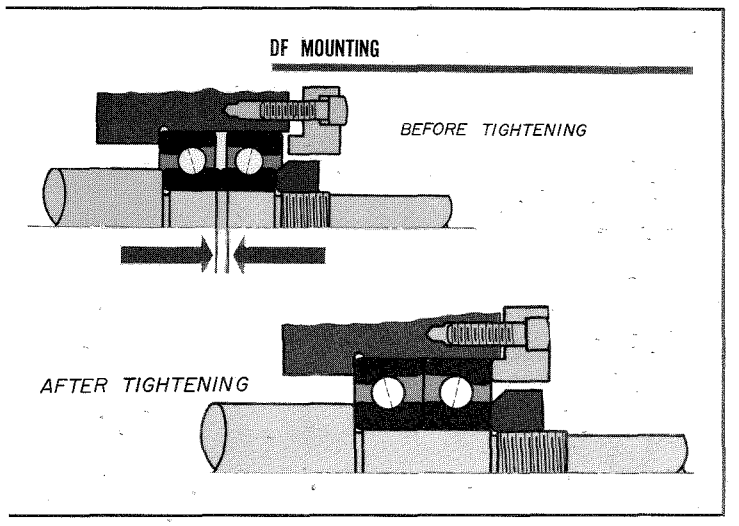
When anti-friction bearings are placed under load, a certain amount of initial deformation takes place in the rolling elements. The *rate* of this deflection decreases with successive increments of load, and results in greater bearing rigidity.

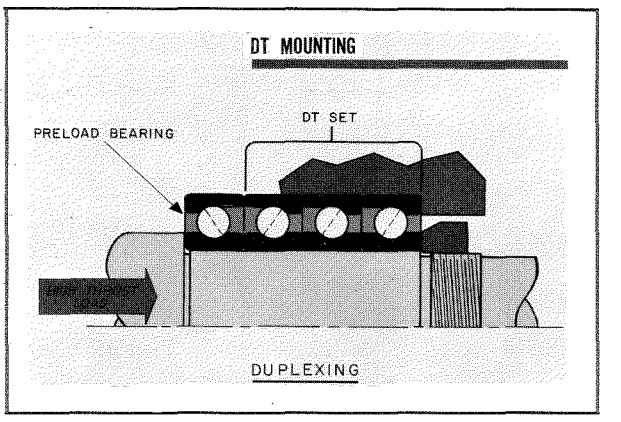
In the majority of spindle applications, it becomes necessary to eliminate that part of the curve where deflection is the greatest. This is accomplished by preloading, which is merely the application of an initial thrust load accomplished by clamping together the inner or outer rings of duplex angular contact bearings.

New Departure "DT Ground" angular contact bearings are made with an accurately controlled stickout of the rings and can be mounted "DB", "DF" or "DT". They are ground to certain predetermined values which will result in known values of preload when the rings are firmly clamped together.

For high speeds, light preload is generally recommended to prevent the bearings from heating up excessively.







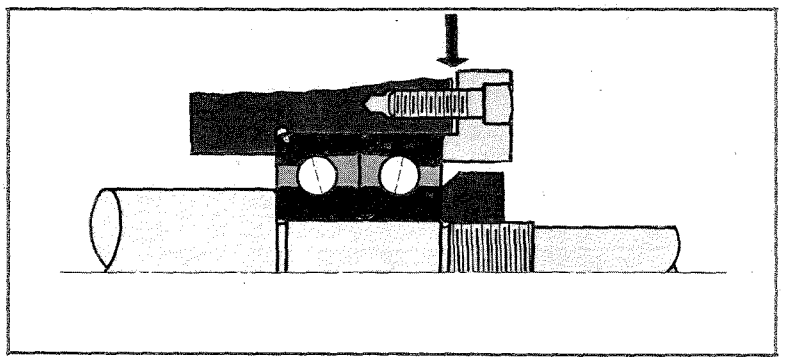
MOUNTED PRELOADS FOR SINGLE ROW ANGULAR CONTACT BEARINGS

The preloads listed assume a .0001 interference fit for inner rings of all extra light and light series bearings and up to and including No. 5 bore of medium and heavy series bearings. A .0002 interference fit is assumed for inner rings of medium and heavy series bearings above No. 5 bore. Line and line housings fits are assumed for all bearings. If tighter or looser fits are used, preloads will vary slightly from the values given, being heavier for tighter fits, and lighter for looser fits.
In the tables preloads are designated as L = light preload, X = medium preload, T = heavy preload.

Brg. Series	Ex. Light			25° Ex. Light			Light			25° Light			Medium		
Bore No.	OL00			HOL00			20200			H20200			20300		
	L	X	T	L	X	T	L	X	T	L	X	T	L	X	T
0	8	19	32	13	32	51	8	20	33	13	33	53			
1	9	22	37	15	37	60	10	25	43	17	43	68	12	31	52
2	11	28	46	18	46	74	12	30	51	20	51	82	17	42	70
3	13	32	53	21	53	85	15	39	65	26	65	105	20	51	85
4	16	41	68	27	68	110	21	53	88	35	88	140	28	69	115
5	22	54	90	36	90	145	25	63	105	42	105	170	38	94	157
6	28	72	120	47	120	190	39	99	165	66	165	265	50	125	210
7	33	81	135	55	135	220	52	130	215	87	215	345	66	165	275
8	37	93	155	62	155	250	65	160	270	110	270	430	81	200	335
9	42	105	175	70	175	280	72	180	300	120	300	485	97	245	410
10	48	115	195	80	195	315	80	200	335	135	335	535	120	295	490
11	54	135	230	90	230	365	100	250	415	165	415	665	150	370	615
12	60	155	255	100	255	410	120	300	505	200	505	805	170	430	715
13	69	175	290	115	290	465	145	360	600	240	600	960	195	485	810
14	84	205	345	140	345	550	150	370	620	250	620	990	220	545	910
15	90	220	370	150	370	595	160	400	670	270	670	1070	245	610	1020
16	100	260	435	170	435	695	185	465	770	310	770	1230	275	685	1140
17	115	280	465	190	465	745	215	540	900	360	900	1440	300	755	1260
18	120	295	495	200	495	795	235	585	980	390	980	1570	335	835	1390
19	130	330	550	220	550	880	265	660	1100	440	1100	1770	365	915	1520
20	140	355	590	235	590	940	300	745	1240	495	1240	1980	420	1050	1750
21	165	415	690	275	690	1100	335	835	1390	555	1390	2220	455	1140	1900
22	185	460	765	305	765	1220	370	920	1530	615	1530	2460	530	1320	2200
24	205	505	845	340	845	1350	420	1050	1750	700	1750	2810	590	1480	2460
26	235	580	970	390	970	1550	470	1170	1950	780	1950	3130	675	1680	2800
28	245	615	1030	410	1030	1640	545	1360	2260	905	2260	3620			
30	275	690	1150	460	1150	1840	640	1600	2680	1070	2680	4280			

Brg. Series	25° Medium			25° Heavy			35° Light			35° Medium			35° Heavy		
Bore No.	H20300			H20400			30200			30300			30400		
	L	X	T	L	X	T	L	X	T	L	X	T	L	X	T
1	16	41	64												
2	23	56	92												
3	27	68	108				29	74	117						
4	37	92	148	56	140	225	32	80	130	42	105	170	64	160	255
5	50	125	200	77	190	310	40	100	160	58	145	230	90	225	360
6	66	165	265	95	235	380	60	150	240	76	190	300	110	280	440
7	88	220	350	115	285	460	78	195	310	100	250	400	135	335	540
8	110	270	440	145	360	580	100	250	400	125	310	500	170	425	680
9	130	325	520	170	425	680	110	275	445	150	370	600	195	490	780
10	160	395	640	200	500	800	125	310	490	180	455	720	230	570	920
11	195	495	780	225	560	900	150	380	605	225	565	900	260	650	1040
12	230	570	920	260	650	1040	180	455	730	260	650	1040	295	745	1180
13	260	645	1040	310	775	1240	215	540	865	295	735	1180	355	890	1420
14	290	725	1160	370	925	1480	235	585	935	330	830	1320	425	1060	1700
15	325	815	1300	425	1060	1700	255	635	1010	370	925	1480	490	1220	1960
16	365	910	1460	465	1160	1860	290	735	1170	415	1040	1660	535	1330	2140
17	400	1000	1600	505	1260	2020	320	805	1290	460	1140	1840	580	1460	2320
18	445	1110	1780	575	1430	2300	365	910	1460	505	1260	2020	660	1650	2460
19	490	1220	1960				410	1030	1640	555	1380	2220			
20	560	1400	2240				460	1150	1840	640	1600	2560			
21	610	1520	2440				510	1280	2050	695	1740	2780			
22	705	1760	2820				565	1410	2260	800	2000	3200			
24	790	1970	3160				640	1600	2560	920	2290	3680			
26	900	2250	3600				740	1850	2950	1040	2610	4160			
28							820	2040	3270						
30							910	2270	3640						

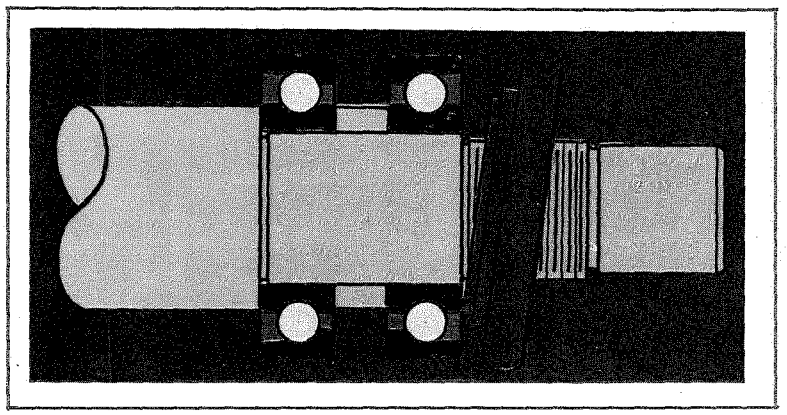
Continued from page 19



8. Make sure that the floating bearings on the drive end are free in the housing to allow for shaft expansion. See section on housing fits.

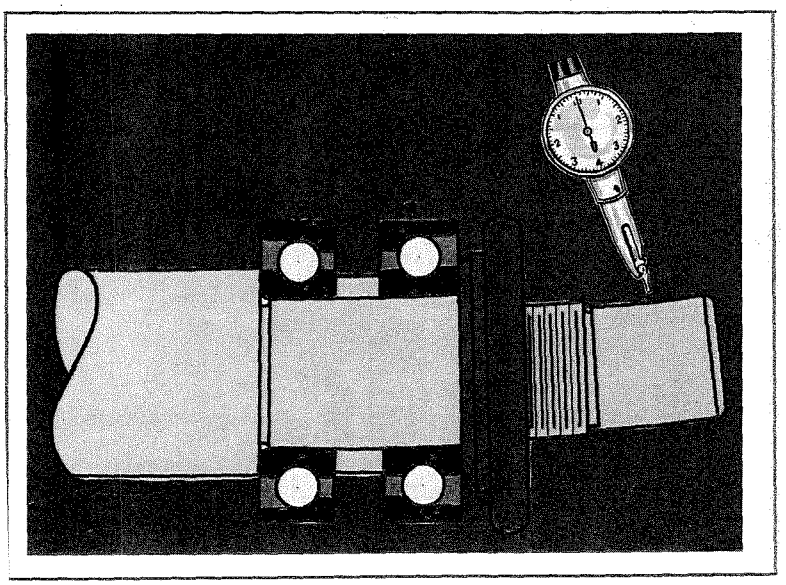
9. Install slingers, seals and closure caps. Insert feeler gauge to determine that closure caps do not bottom against the housing when they should be preloading the bearings.

10. After the bearings have been positively locked into position, check the spindle shaft for possible runout. If the indicator reading is greater than .0001 inch, it can be assumed the runout is the result of the threads being out of square with the lock nut.

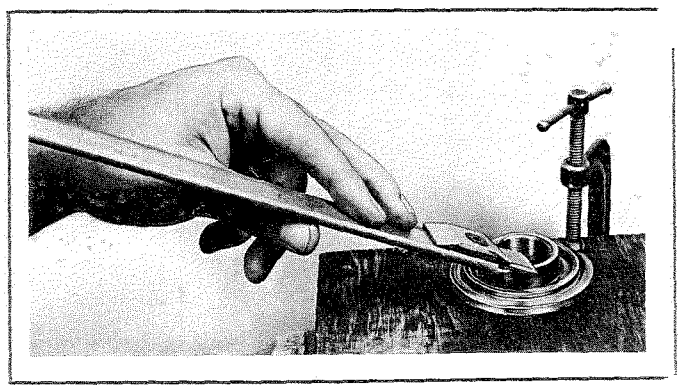


11. Mark high point of shaft on lock nut. Remove nut and hone or scrape face indicated.

12. Carefully hone or scrape; starting at the lock nut bore, and working toward the O.D. to produce a perfectly flat surface. Where the area to be scraped is narrow, begin at the high point and reduce the pressure on the scraper as it is moved to the right and left of the high point.



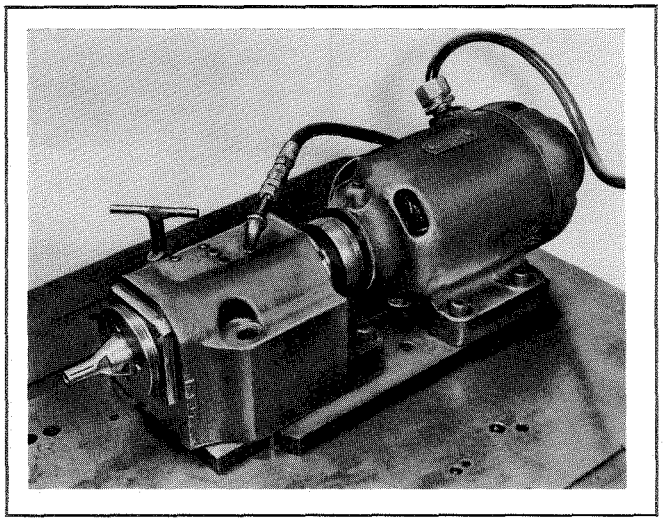
13. The nut should be run back on the spindle using the same amount of pressure each time until the spindle shows little or no runout. This lock nut is now matched to the spindle. The spindle is now ready for testing.



TESTING reassembled spindle:

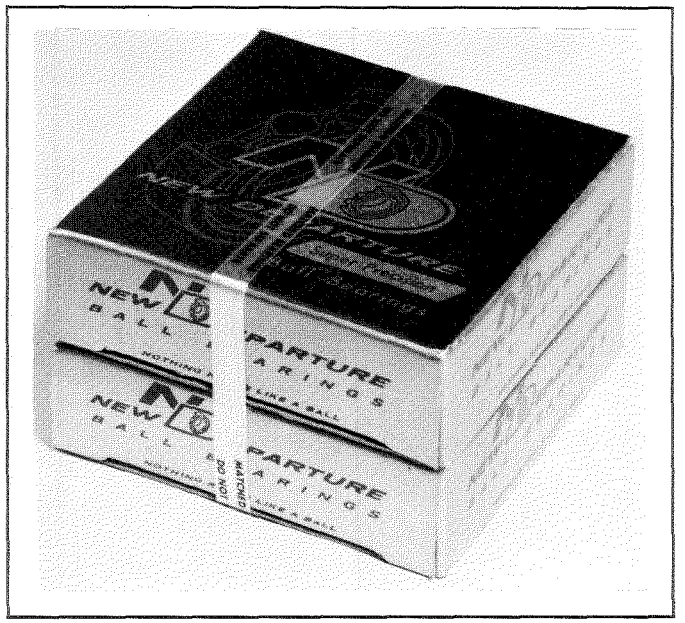
1. Attach air-oil mist lines if required. Never start a dry spindle.
2. Start and stop spindle several times to see that everything is in working order.
3. Bring up to operational speed. (Do not exceed name plate).
4. Check temperature of each bearing every 5 minutes. If heat develops, stop and restart.
5. Run at 15 minute intervals until temperature levels off.
6. Where time permits, run 3 to 4 hours at operational speed. If temperature levels off and there is no unusual sound, vibration or roughness, the unit is ready for service.

   Protect the spindle nose from accidental damage at all times.



PACKAGING

New Departure bearings are available in matched sets, individually boxed for maximum protection and bonded together by strong fiber reinforced tape. Each bearing is packaged in a transparent polyethlene bag, sealing out all contaminants yet permitting 100% visual comparison with the old bearings. The bearings in sets are matched to extremely close tolerances. This close match assures even distribution of the load between the bearings and minimizes fighting eccentricities.

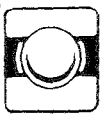


AVAILABILITY

New Departure offers a wide selection of sizes, contact angles, types of separators, preloads and three ABEC grades of super precision bearings (ABEC 5, 7, 9). Contact your nearest authorized Delco New Departure distributor for your bearing requirements. Provide him with the equipment manufacturer's, or bearing manufacturer's number. He will send you an equivalent New Departure super precision bearing. He will also be glad to review your stock and consolidate all brands of like bearings under the equivalent New Departure number.

An entire publication is devoted to bearing interchanges. This may be secured by requesting "Bulletin 2F10 Ball Bearing Interchange Guide."

INTERCHANGEABILITY

TYPE OF BEARING / Series	A.B.E.C. / Super Precision	New Departure / Basic #	Barden / Basic #	Fafnir / Basic #	MRC / Basic #	Norma / Basic #	SKF / Basic #
ANGULAR CONTACT							
Extra Light		0L00	100H	9100WI	100KR	7100	7000
Light		**20200**	**200H**	**200WI**	**200R**	**7200**	**7200**
Medium		20300	—	300WI	300R	7300	7300
Heavy		20400	—	—	400R	7400	7400
SINGLE ROW RADIAL (Non Loading Groove)							
Extra Light		3L00	100K	9100K	100KS	6100	6000X
Light		3200	200K	200K	200S	200	6200
Medium		3300	—	300K	300S	300	6300
Heavy		3400	—	400K	400S	400	6400
SEALED SINGLE ROW RADIAL (Non-Loading Groove)							
Extra Light		Z993L00	100FF	9100PP	100KSZZ	6100PP	—
Light		Z99500	200FF	200PP	200KZZ	200PP	—

Removable seals have been released for production on ABEC 5, 7, 9 bearings. They do not distort the outer ring. Fixed shields and seals are limited to A.B.E.C. 5 grades.

PREFIXES & SUFFIXES

Used to indicate following characteristics

Non-Metallic Separator		**Q**20200	200**H**	200WI**CR**	200R **Bake**	7200**L**	7200**T**
Machined Metal		**V**20200	200HJ**B**	200WI**MBR**	200R **Bronze**	7200**M**	7200**M**
	15° approx.	**20**200	200**H**	**2MM**200WI	200**R**	**L**7200	7200**TC**
Contact Angle	25° approx.	**H20**200	—	**3MM**200WI	7200	7200	7200**TA**
	35° approx.	**30**200	—	—	—	**H**7200	7200**TB**
	5	20200#**5**	—	—	200R#**5**	7200**B5**	7200CTC/**C78**
A.B.E.C. Tolerance	7	20200#**7**	200**H**	**MM**200WI	200R#**7**	7200**B7**	—
	9	20200#**9**	—	MM 200W1**FSI30**	200R#**9**	7200**B9**	—
Flush Ground for Duplex Mounting		20200**DTL**7*	200H5**D**	200WI**DU**	200R**D**	All	7200**G**
Preload	Light	20200DT**L**	200H5D	200W1CRDU**L**	200R#7 **Light**	7200B7**U3**	7200G05=50#
	Medium	20200DT**X**	—	200W1CRDU**M**	200RD#7 **Medium**	7200B7**U5**	7200G10=100#
	Heavy	20200DT**T**	—	200W1CRDU**H**	200RD#7 **Heavy**	7200B7**U7**	7200G2=200#

*"U" prefix indicates flush grinding, now applicable in ABEC 1 and 3 grades only.

BEARING TOLERANCES ABEC and ND STANDARDS

FOR BEARING TYPES SINGLE ROW RADIAL, SINGLE ROW ANGULAR CONTACT — SINGLE AND DUPLEX AND DOUBLE ROW.

INNER RING. All tolerances in number of ten thousandths (.0001″) except ring width which is shown decimally ND-1 tolerances are equal to or closer than ABEC practice.

BORE NOS.	BORE DIA. (INCHES)		BORE						REF. SIDE RUNOUT WITH BORE (Side Runout)			
			ABEC-1			ABEC 5	ABEC 7	ABEC 9	ND	ABEC		
	Over	Thru	dm	dmin	dmax	dm	dm	dm	1	5	7	9
			+ 0			+0	+0	+0				
0-3	.3936	.7087	— 3	— 4	+1	—2	—1½	—1	5	3	1	½
4-6	.7087	1.1811	— 4	— 5	+1	—2	—1½	—1	6	3	1½	½
7-10	1.1811	1.9685	— 5	— 7	+2	—2	—2	—1	8	3	1½	½
11-16	1.9685	3.1496	— 6	— 8	+2	—3	—2	—1½	10	3	2	½
17-24	3.1496	4.7244	— 8	—11	+3	—3	—2½	—2	10	3	2	1
26-30	4.7244	5.9055	—10	—13	+3	—4	—3	—2½	12	4	3	1
32-36	5.9055	7.0866	—10	—13	+3	—4	—3	—2½	12	4	3	1½
38-50	7.0866	9.8425	—12	—16	+4	—5	—4		12	4	3	

DUPLEX SETS ARE MATCHED TO CLOSER TOLERANCES THAN INDIVIDUAL BEARINGS AS SHOWN:

.00005 .0001 .00015 .0002

BORE NOS.	WIDTH VARIATION (Parallelism of Sides)				RADIAL RUNOUT (Eccentricity)				GROOVE RUNOUT WITH SIDE (Groove Parallelism				RING WIDTH** ABEC-1, 5, 7, 9*	
	ND	ABEC			ABEC				NDtt	ABEC			No Preload Requirement	With Preload Requirement
	1	5	7	9	1	5	7	9	1	5	7	9	+.000	+.000
0-3	5	2	1	½	4	2	1	½	6	3	1	½	—.005	—.010
4-6	6	2	1	½	5	2	1½	½	8	3	1½	1	—.005	—.010
7-10	8	2	1	½	6	2	1½	½	8	3	1½	1	—.005	—.010
11-16	10	2	1½	½	8	2	1½	½	10	3	1½	1	—.005	—.010
17-24	10	3	1½	1	10	3	2	1	10	4	2	1	—.005	—.015
26-30	12	3	2	1	12	3	3	1	12	4	3	1	—.005	—.015
32-36	12	3	2	1½	12	3	3	2	12	4	3	2	—.005	—.015
38-48	12	4	2		16	4	3		16	5	3		—.010	—.020

*Ring width tolerance for ABEC-9 brgs. 10 mm (.3937 inches) bore or smaller is .000 to —.001
††Reference values for assembled bearings
**Individual bearing width

OUTER RING

All tolerances in number of ten-thousandths (.0001"). Ring Width tolerances same as for Inner Ring.

BEARING BORE NUMBERS				BRG. OUTSIDE DIA. (INCHES)		OUTSIDE DIAMETER					
						ABEC-1			ABEC		
									5	7	9
Extra Extra Light	Extra Light	Light	Med.	Over	Thru	Dm	Dmin	Dmax	Dm	Dm	Dm
						+ 0			+0	+0	+0
0-3	0-1	0		.7087	1.1811	— 4	— 5	+1	—2	—2	—1½
4-6	2-5	1-4	0-3	1.1811	1.9685	— 5	— 7	+2	—2	—2	—1½
7-11	6-10	5-8	4-7	1.9685	3.1496	— 5	— 7	+2	—3	—2	—1½
12-17	11-15	9-13	8-11	3.1496	4.7244	— 6	— 9	+3	—3	—3	—2
18-22	16-20	14-17	12-14	4.7244	5.9055	— 8	—11	+3	—4	—4	—2
24-26	21-24	18-20	15-17	5.9055	7.0866	—10	—13	+3	—5	—4	—2½
28-36	26-32	21-28	18-22	7.0866	9.8425	—12	—16	+4	—5	—4	—3
38-40	39-40	30-34	24-28	9.8425	12.4015	—14	—18	+4	—5	—5	—3

DUPLEX SETS ARE MATCHED TO CLOSER TOLERANCES THAN INDIVIDUAL BEARINGS AS SHOWN:

.00005 .0001 .00015 .0002

BEARING BORE NUMBERS				O.D. RUNOUT WITH SIDE (O.D. Square With Side)				WIDTH VARIATION (Parallelism Of Sides)				RADIAL RUNOUT (Eccentricity)				RUNOUT WITH SIDE (Groove Parallelism With Sides)			
				ND	ABEC			ND	ABEC			ABEC				ND	ABEC		
Extra Extra Light	Extra Light	Light	Med.	1	5	7	9	1	5	7	9	1	5	7	9	1	5	7	9
0-3	0-1	0		4	3	1½	½	5	2	1	½	6	2	2	1	10	3	2	1
4-6	2-5	1-4	0-3	6	3	1½	½	6	2	1	½	8	2	2	1	12	3	2	1
7-11	6-10	5-8	4-7	8	3	1½	½	8	2	1	½	10	3	2	1½	12	4	2	1½
12-17	11-15	9-13	8-11	10	3	2	1	10	3	2	1	14	4	2	2	14	5	2	2
18-22	16-20	14-17	12-14	12	4	2	1	12	3	2	1	16	4	3	2	16	5	3	2
24-26	21-24	182-0	15-17	12	4	2	1	12	3	2	1	18	5	3	2	20	6	3	2
28-36	26-32	21-28	18-22	12	4	3	1½	12	4	3	1½	20	5	4	2½	24	6	4	2½
38-40	34-40	30-34	24-28	14	5	3	1½	14	5	3	1½	24	6	4	2½	28	7	4	2½

NOTE: Outer Ring Width Tolerances same as for inner ring.

CONVERSIONS—MILLIMETERS to INCHES

mm	inches	mm	inches	mm	inches	mm	inches	mm	inches
1	0.0394	51	2.0079	101	3.9764	151	5.9449	201	7.9134
2	0.0787	52	2.0472	102	4.0157	152	5.9843	202	7.9528
3	0.1181	53	2.0866	103	4.0551	153	6.0236	203	7.9921
4	0.1575	54	2.1260	104	4.0945	154	6.0630	204	8.0315
5	0.1969	55	2.1654	105	4.1339	155	6.1024	205	8.0709
6	0.2362	56	2.2047	106	4.1732	156	6.1417	206	8.1102
7	0.2756	57	2.2441	107	4.2126	157	6.1811	207	8.1496
8	0.3150	58	2.2835	108	4.2520	158	6.2205	208	8.1890
9	0.3543	59	2.3228	109	4.2913	159	6.2598	209	8.2283
10	0.3937	60	2.3622	110	4.3307	160	6.2992	210	8.2677
11	0.4331	61	2.4016	111	4.3701	161	6.3386	211	8.3071
12	0.4724	62	2.4409	112	4.4094	162	6.3780	212	8.3465
13	0.5118	63	2.4803	113	4.4488	163	6.4173	213	8.3858
14	0.5512	64	2.5197	114	4.4882	164	6.4567	214	8.4252
15	0.5906	65	2.5591	115	4.5276	165	6.4961	215	8.4646
16	0.6299	66	2.5984	116	4.5669	166	6.5354	216	8.5039
17	0.6693	67	2.6378	117	4.6063	167	6.5748	217	8.5433
18	0.7087	68	2.6772	118	4.6457	168	6.6142	218	8.5827
19	0.7480	69	2.7165	119	4.6850	169	6.6535	219	8.6220
20	0.7874	70	2.7559	120	4.7244	170	6.6929	220	8.6614
21	0.8268	71	2.7953	121	4.7638	171	6.7323	221	8.7008
22	0.8661	72	2.8346	122	4.8031	172	6.7717	222	8.7402
23	0.9055	73	2.8740	123	4.8425	173	6.8110	223	8.7795
24	0.9449	74	2.9134	124	4.8819	174	6.8504	224	8.8189
25	0.9843	75	2.9528	125	4.9213	175	6.8898	225	8.8583
26	1.0236	76	2.9921	126	4.9606	176	6.9291	226	8.8976
27	1.0630	77	3.0315	127	5.0000	177	6.9685	227	8.9370
28	1.1024	78	3.0709	128	5.0394	178	7.0079	228	8.9764
29	1.1417	79	3.1102	129	5.0787	179	7.0472	229	9.0157
30	1.1811	80	3.1496	130	5.1181	180	7.0866	230	9.0551
31	1.2205	81	3.1890	131	5.1575	181	7.1260	231	9.0945
32	1.2598	82	3.2283	132	5.1969	182	7.1654	232	9.1339
33	1.2992	83	3.2677	133	5.2362	183	7.2047	233	9.1732
34	1.3386	84	3.3071	134	5.2756	184	7.2441	234	9.2126
35	1.3780	85	3.3465	135	5.3150	185	7.2835	235	9.2520
36	1.4173	86	3.3858	136	5.3543	186	7.3228	236	9.2913
37	1.4567	87	3.4252	137	5.3937	187	7.3622	237	9.3307
38	1.4961	88	3.4646	138	5.4331	188	7.4016	238	9.3701
39	1.5354	89	3.5039	139	5.4724	189	7.4409	239	9.4094
40	1.5748	90	3.5433	140	5.5118	190	7.4803	240	9.4488
41	1.6142	91	3.5827	141	5.5512	191	7.5197	241	9.4882
42	1.6535	92	3.6220	142	5.5906	192	7.5591	242	9.5276
43	1.6929	93	3.6614	143	5.6299	193	7.5984	243	9.5669
44	1.7323	94	3.7008	144	5.6693	194	7.6378	244	9.6063
45	1.7717	95	3.7402	145	5.7087	195	7.6772	245	9.6457
46	1.8110	96	3.7795	146	5.7480	196	7.7165	246	9.6850
47	1.8504	97	3.8189	147	5.7874	197	7.7559	247	9.7244
48	1.8898	98	3.8583	148	5.8268	198	7.7953	248	9.7638
49	1.9291	99	3.8976	149	5.8661	199	7.8346	249	9.8031
50	1.9685	100	3.9370	150	5.9055	200	7.8740	250	9.8425

M2-225 10M 6-29-73