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ABSTRACT

The manual provides a subject reference for ball and roller bearings. The following topics are included: (1) bearing nomenclature, (2) bearing uses, (3) bearing capacities, (4) shop area working conditions, (5) bearing removal, (6) bearing cleaning and inspection, (7) bearing replacement, (8) bearing lubrication, (9) bearing installation, (10) bearing failures due to improper servicing, (11) installation running inspection, and (12) bearing adjustment theory. (VA)

Ball & Roller Bearings

(VT 102 064)

A Teaching Reference

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This publication was prepared initially by one of the member companies of the Farm and Industrial Equipment Institute. It has been reviewed and accepted by a Subject Matter Committee of the American Association for Vocational Instructional Materials. Through cooperative arrangements, it is now being made available for educational use through AAVIM.

CONTENTS

GLOSSARY

It is important that the reader familiarize himself with the following terms and their meanings. This is vital to comprehending the information in the rest of the manual.

Axial—parallel to the shaft or bearing bore.

Carburizing—addition to metal of the element carbon for hardening purposes.

Case harden—hardening the outer surface of metal to a given "case" or "shell" depth. while leaving the inner portion "soft" to absorb shocks and squeezing (see carburizing).

Creep—the very slow. steady rotation of a "push fit" bearing race, either inner or outer. in order to constantly keep changing the area of greatest load. to increase bearing life. "Push fit" bearing races creep because of the squeezing action of the bearing balls. causing the relatively loose push fit race to act like a cam and propel itself around and around its mounting. Remember that one rotation of a race by creep may result only after several thousand revolutions of the rest of the bearing.

Crowned—a very slight curve in a surface (may be on a roller or raceway).

Deflection—bending or movement away from normal due to loading.

End play—(Axial displacement)—that amount of axial movement in a shaft due to clearance in the bearings.

End Shake—end play (see above) within a bearing.

Heat treatment—heating, followed by fast cooling to provide required hardness or metallurgical structure.

Loading grooves—filling notches machined into side of races to permit loading of more balls or rollers.

Load line—a center line indicating the points of contact within a bearing through which the load would pass.

Load line angle—the angle of a load line with respect to the shaft center or bearing radial center line.

Misalignment—when bearings are not on the same centerline within good functional or working limits.

Preload—a load within the bearing, either purposely built in, or resulting from adjustment.

Press fit—mounting with interference, i.e., bore of bearing is smaller than OD of shaft, or OD of bearing is larger than bore of housing, or both.

Push fit—this means that the part of the bearing termed "push fit" can be slid into place by hand, *if it is square with its mounting.*

Raceway—the surface of the groove or path on which the balls or rollers of a bearing roll.

Radial—perpendicular to the shaft or bearing bore.

Radial clearance—(Radial displacement)—clearance within the bearing and between balls and races perpendicular to the shaft.

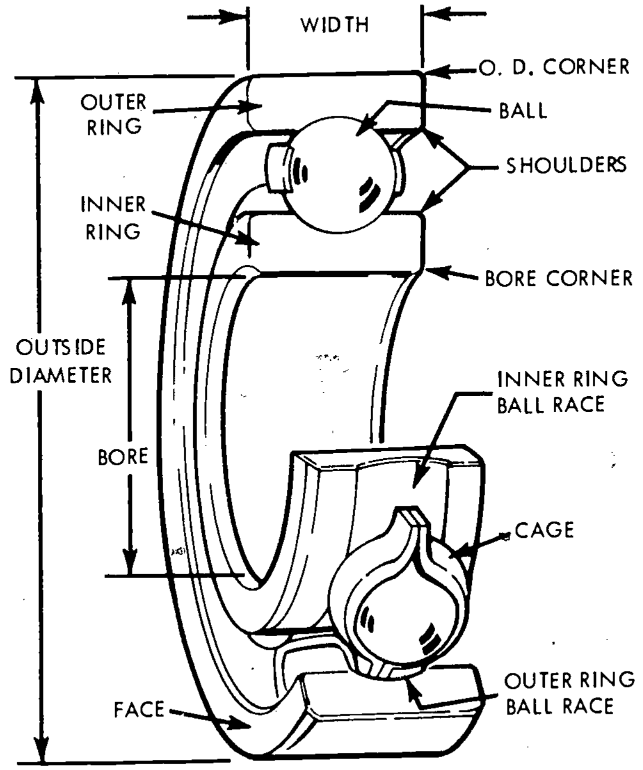
Radial load—a "round the shaft" load, that is. one that is perpendicular to the shaft—through the bearing.

Separable—either the inner or outer race or both may be removed from the bearing assembly.

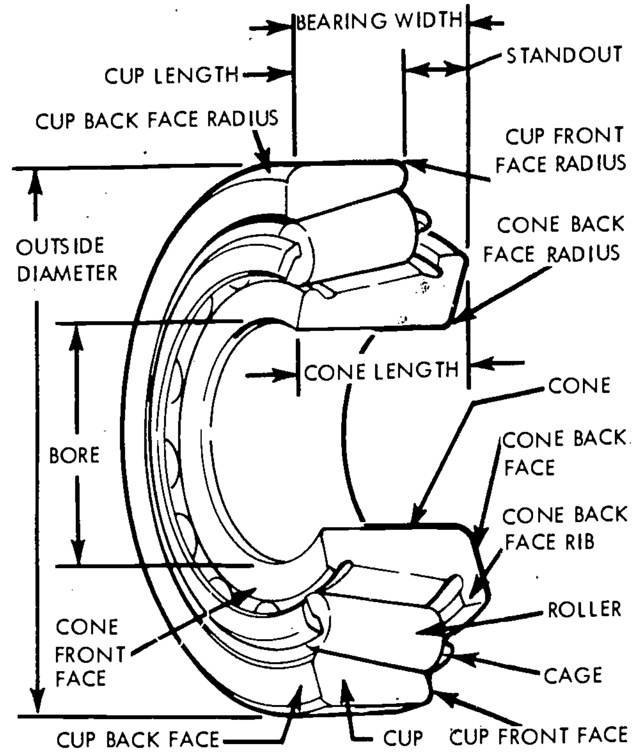
Spherical—ball-like, rounding, or like a portion of a ball.

Thrust load—a load which pushes or reacts through the bearing in a direction parallel to the shaft.

BEARING NOMENCLATURE

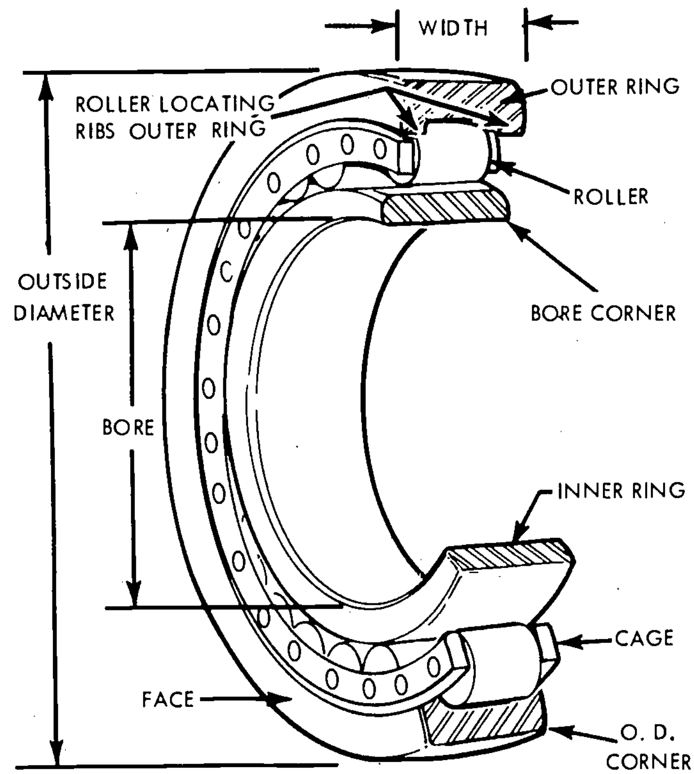


Ball Bearing



Tapered Roller Bearing

NOTE: The nomenclature of bearing parts is very similar from one type of bearing to another. This is true of all types, so the three types shown are representative of all bearings.

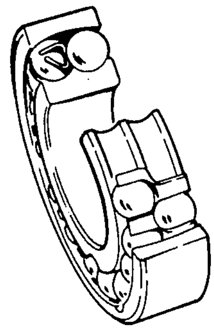


Straight Roller Bearing

BEARING USES

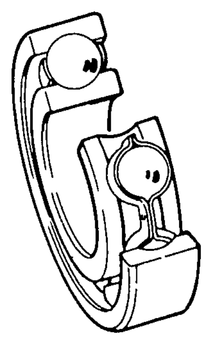
These illustrations are cross sections of various types of bearings in common use, and the paragraphs outline general usage theory.

Ball Bearings



Internally Self Aligning Bearings

This type of self aligning ball bearing has two rolls of balls rolling in a double channel inner race, against a concave outer race. The bearing will operate properly with the inner race at a considerable angle to the outer race (to the point of coming apart). Misalignment due to errors in mounting, shaft deflection and housing distortion will, therefore, not damage the bearing. It is also impossible for this bearing to exert any bending influence on a shaft. Self aligning ball bearings are used for radial ("around the shaft") loads and moderate thrust loads.

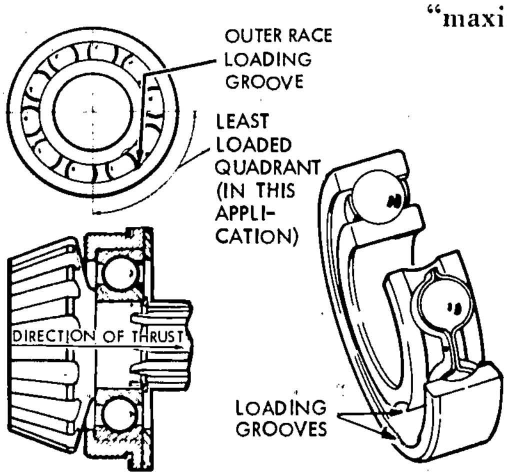


Single Row Deep Groove Bearings

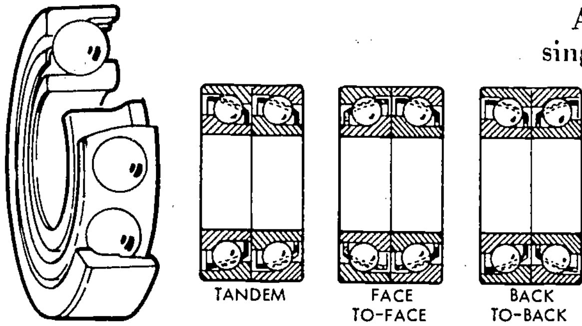
The single row deep groove ball bearing (also called "limited", non-loading groove and "conrad" type) has one row of balls rolling in a single, deep groove in each race. Because of the height of the lands and the close fit of the balls to the grooves. these bearings can stand a substantial thrust load, even at very high speeds. Careful installation is necessary, as these bearings demand more careful alignment between the shaft and housing than self aligning types. Single row deep groove ball bearings are used for radial loads and radial-thrust combinations. Because there is little relative movement between the inner and outer races, these bearings are often equipped with seals and shields, to exclude dirt and retain lubricant.

Loading Groove Bearings

Ball bearings manufactured with loading grooves (known as "maximum" type) have higher radial capacity than the limited type previously discussed, because more balls are introduced between the races. However, they are not as tolerant of thrust loads. When installed in an application where thrust loading may be a factor, they should be installed so that thrust loading is imposed on the loading groove side of the outer race. Sometimes the loading groove of the outer race is placed in the least loaded quadrant of the bearing mounting, and clamped there so that the loading groove cannot creep out of this position. When it is vital that a bearing outer race be tightly secured, necessary instructions will be given in the appropriate Service Manual.

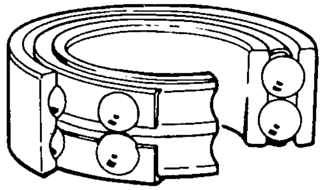


Single Row Angular Contact Bearings



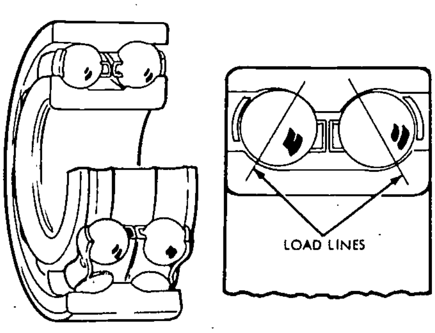
Angular contact ball bearings do not have grooves. A single row of balls roll between two high shoulders—one on the outer ring, one on the opposite side of the inner ring. They are used for heavy thrust loads, (in one direction only) sometimes combined with a moderate radial load. If the contacting faces are flush ground, these bearings can be mounted in tandem, for one direction thrust, or, for thrust in either direction, they can be mounted either face-to-face, or back-to-back.

Double Row Deep Groove Bearings



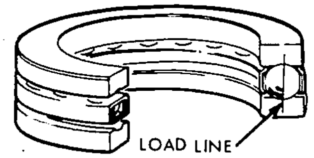
Double row deep groove ball bearings are made the same way and have the same uses as single row deep groove ball bearings, except that their capacity in any situation is higher because there are two rows of balls.

Double Row Angular Contact Bearings



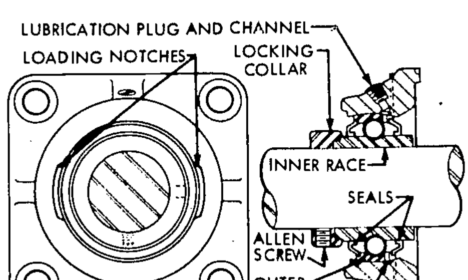
Double row angular contact ball bearings have the same uses previously discussed for single row angular contact, and operate in the same way as paired single row angular contact bearings, discussed above. However, they may be constructed with a predetermined internal preload, as indicated by the load lines. They have less axial displacement, or "end shake" than single row bearings, and therefore are better suited for use where a shaft must be held solidly both radially and axially, such as the transmission bevel pinion in tractors.

Ball Thrust Bearings



Ball thrust bearings are designed for axial thrust loads only. The load line through the bearing balls is parallel to the shaft. This results in high thrust capacity and minimum axial displacement.

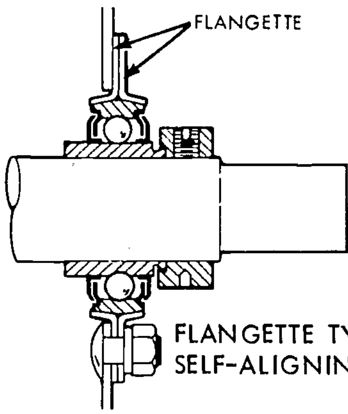
Sealed, Prelubricated Bearings



FLANGE TYPE
SELF ALIGNING

There are three general types of sealed, prelubricated bearings, as shown. The housing mounted type is handled the same, and has the same characteristics as any other ball bearing, except that it is sealed and prelubricated, and usually no provision for relubrication is made. The flange mounted self aligning variation is used mainly in very heavy duty applications, and may be provided with a means for renewing the lubricant. It is installed in its flange by inserting it into the loading notches of the flange until it

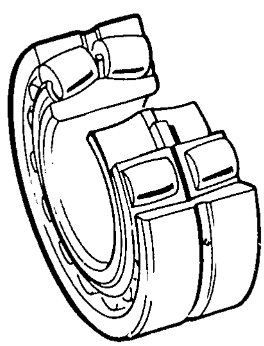
HOUSING MOUNTED TYPE



FLANGETTE TYPE
SELF-ALIGNING

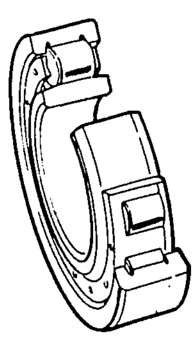
is centered, then revolving it into its seat. It is then locked to the shaft the same as the flangette type. The flangette type is usually used in lighter duty or low speed applications, and usually has no provision for relubrication. Both the flange and flangette types are generally installed on their shaft with a slip fit. It is very important that the shaft and bearing bore be clean, and that the bearing slip on easily. The flange or flangette is then tightly bolted into its mounting. The extended, or locking cam side of the inner bearing race must be *outward* on the shaft. The final step is engaging the locking collar on the cam of the bearing inner race, turning it in the direction of shaft rotation until tight, and then tightening the set screw in the locking collar to prevent loosening.

Roller Bearings



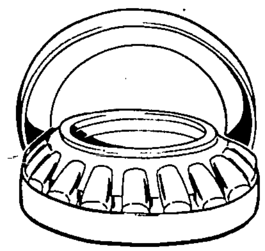
Spherical Bearings

Spherical roller bearings, due to the number, size and shape of the rollers, have tremendous capacity. Because of the rounded shape of the rollers, and the concave surface of both races, they are self aligning, and the full capacity of the bearing is available for work, even if some misalignment exists. They are, therefore, especially useful where shaft deflection may occur. Single row spherical roller bearings will withstand thrust loads in one direction only; double row in either direction.



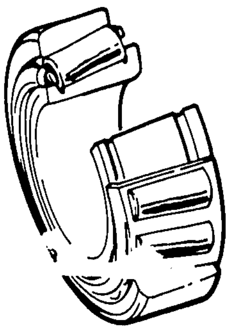
Straight Bearings

Straight roller bearings have very high radial capacity, but low tolerance for misalignment or thrust loads. If the length of the individual rollers in a bearing is *very* carefully matched, and lubrication is sufficient, they can be used for thrust loads. They may be operated at high speeds. Those which have locating ribs on only one race allow for some axial movement of the shaft in relation to the housing, and are easy to dismount. even if both rings are "press fit". They are sometimes made with two or more rows of rollers.



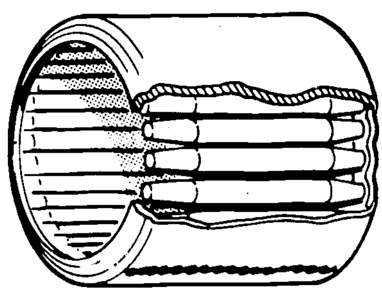
Spherical Thrust Bearings

Spherical roller thrust bearings are designed to carry heavy thrust loads. Because the raceways are spherical, and there is just one row of rollers, they are self aligning.



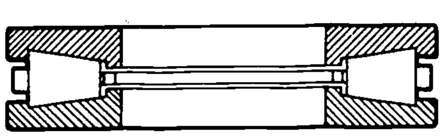
Tapered Bearings

Tapered roller bearings are constructed so that the roller center lines and raceway surfaces form an angle with the shaft center line. They are, therefore, suitable for carrying heavy combined radial and thrust loads. They are separable—the cup is mounted separately from the cone (inner race and rollers). Tapered roller bearings are normally adjusted in pairs. They are often "preloaded".



Needle Bearings

Needle bearings are constructed of a series of small diameter rollers, or needles, often in a formed shell. Usually there is no inner race, sometimes no outer race, or shell, the needles running directly on the shaft or housing, or inside the gear hub. They are usually used only for light load, no thrust applications. Some have rather high internal friction because no separator is used to keep the needles from rubbing against each other. Needle bearings are used mostly to align or guide shafts, or to separate shafts where one is inside another, or where one is piloted into another. However, there are some applications, particularly where space is at a premium, where special-made. extremely high capacity needles are used for heavy radial loads. Needles used in these heavy applications are of a size and/or hardness to classify them with roller bearings.



Thrust Bearings

Roller thrust bearings may be either tapered, as illustrated, or straight, and have the same characteristics and uses as previously discussed for ball thrust bearings, except that if a ball thrust and a roller thrust are constructed of the same materials, and are the same size, the roller thrust may have higher capacity.

BEARING CAPACITIES

Bearings of most manufacturers are coded by type, bore, O.D., and width, according to a standard SAE numbering code. Quite often, therefore, similar bearings will have similar numbers. *This does not mean that similar coded bearings can be substituted for each other!* Bearings having similar codes do not necessarily have equal capacities. When a bearing is called for in the parts catalog, this is the bearing that should be used in this position.

Capacity of bearings is determined by many factors, most of which are not visible, nor can they be appraised, without special equipment.

As has been mentioned before, a roller bearing has higher capacity than a ball bearing, if both are made of the same materials, and have the same dimensions. However, the ball bearing would have lower friction, and therefore will roll easier, because there is a smaller area of contact between a ball and its race than there is between a roller and its race.

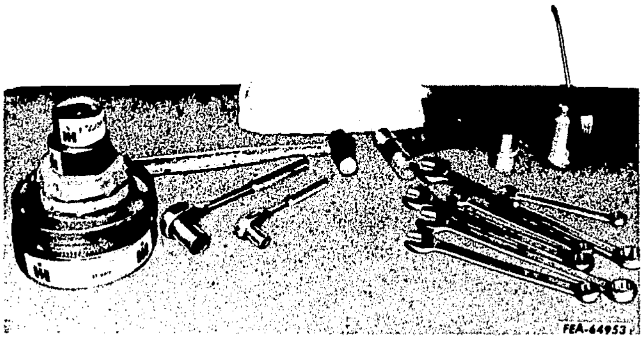
About the only visual comparison between bearing capacities is the number of balls or rollers. Ball bearings of the same size can have different numbers of balls. If one of two "same sized" bearings has loading grooves, and the other doesn't, the one with loading grooves will have more balls. The greater the number of balls, the higher the capacity is likely to be.

A further consideration in bearing capacity is the strength, hardness and wear resistance of the metal used. Carburizing and heat treatment are used to enhance these characteristics.

Roller bearings are made of medium carbon nickel molybdenum alloy steels. In order to gain desired hardness from heat treating, they are first "carburized". Carburizing is the addition, by various methods, of carbon to the outer surface of steel, to a depth of between .010 and .100 inch, depending on specifications. This actual "absorption" of carbon by the steel changes it to a high carbon (relatively hard) steel. Thus, carburizing is actually one form of the general category of case hardening.

Ball bearings are usually made of high carbon chrome steels. Both ball and roller bearings are heat treated to bring them up to specified hardness. (Roller bearings after carburizing.) Heat treating is a process wherein the parts are held in a furnace at a controlled temperature for a specified length of time, after which they are "quenched" in oil at a controlled temperature. Heat treatment, or hardening, lend to the metal a fatigue strength which results in its optimum capacity and service life.

Shop Area Working Conditions



Ideal working conditions.

Bad working conditions.

DO

1. Work with clean approved tools, in clean surroundings.
2. Clean outside of housings before exposing bearings.
3. Handle bearings with clean, dry hands, or better, use clean canvas gloves.
4. Work on a metal or metal covered bench.
5. Treat a used bearing as carefully as a new one, until the used one is proven to be defective.
6. Use clean solvents and flushing oils.
7. Lay bearings out on a clean surface.
8. Protect disassembled bearings from dirt and moisture.
9. Wipe bearings, if necessary, *only* with clean, lint-free rags.
10. Keep bearings wrapped in oil-proof paper when not in use.
11. Thoroughly clean the inside of housings before installing bearings.
12. Install new bearings as they come from the package, without washing, *if they are received in a sealed container.*
13. Keep lubricants clean when applying them, and cover the containers when not in use.

DON'T

1. Work in dirty surroundings.
2. Use dirty, brittle, or chipped tools.
3. Use unapproved tools or improper procedures.
4. Use wooden mallets or work on a soft wood bench.
5. Handle bearings with dirty or moist hands.
6. Spin uncleaned or dry bearings.
7. Spin *any* bearing with compressed air.
8. Use the same container for both cleaning and final rinse of used bearings.
9. Use cotton waste or dirty rags to wipe bearings.
10. Expose bearings to moisture and dirt.
11. Scratch or nick bearing surfaces.
12. Use gasolines containing tetraethyl lead, as the fumes may be injurious to health, as well as a fire hazard.
13. Remove grease or oil from new bearings received in sealed containers.
14. Use incorrect kind or amount of lubricant.

BEARING REMOVAL

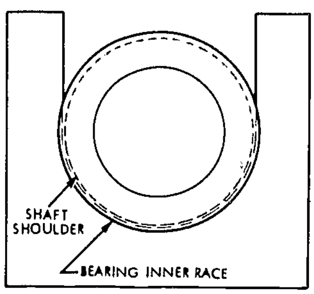
Clean the bearing housing before beginning disassembly, and continue cleaning as parts are removed.

Unless specific procedures are outlined, study the assembly, and, using the following illustrations, determine the best method to remove bearings. Proper removal methods will eliminate damage due to removal, and if the bearing was not damaged in service, it may often be re-used.

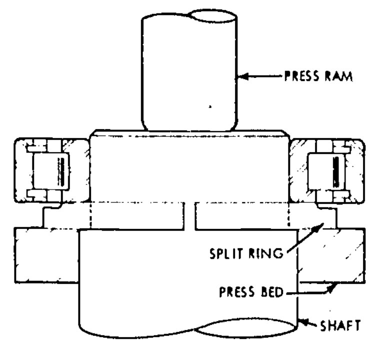
The best tool for removal is the hydraulic press, with its attachments, as illustrated. If this cannot be used, then various forms of push-puller tools are available, some of which are illustrated, in both hydraulic and mechanical versions. As a "last resort", hammering methods can be employed, although pounding must be avoided as much as possible.

Remember that the bearing ring which rotates is usually installed with a "press fit", while the stationary ring usually has a "push" fit", so that it can "creep". In some cases, notably tapered roller bearings, both races may be press fit.

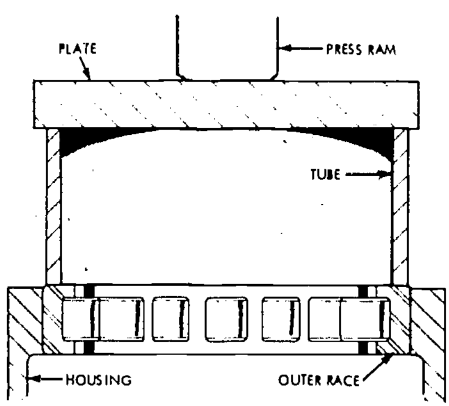
Always remove bearings by pressing, pulling, or hammering on the *press fit* race if at all possible. If not possible to work against the press fit race, *always* use a hydraulic press or a push-puller. Straight line removal is vital, as cocking the bearing will score the shaft or housing, and could damage the bearing. If the housing or shaft is scored, damage to a new bearing, and shortened service life will result. Never press, pull, or pound against bearing shields, seals, or separators.



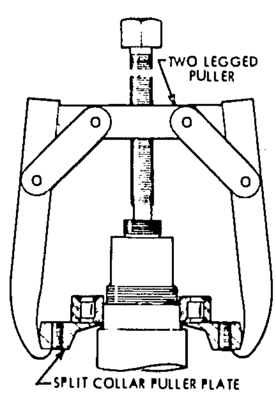
Supporting the inner (press fit) race with a piece of flat stock with a U-shaped cut-out.



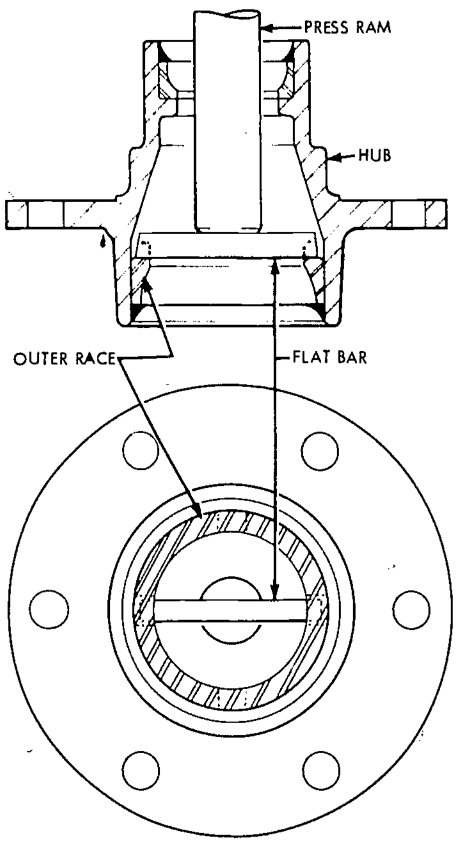
Supporting the inner race with a split ring.



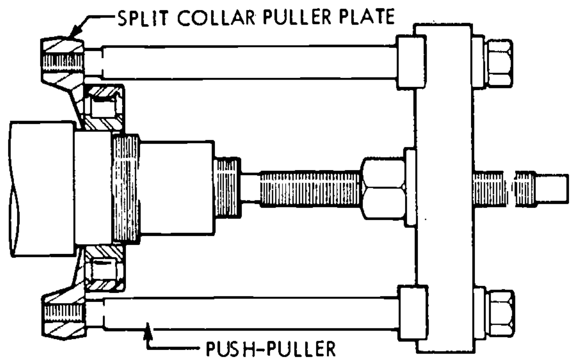
Pushing out a bearing having a press fit outer race, using a tube slightly smaller than the housing bore, and a flat plate on top of it to transmit ram pressure.



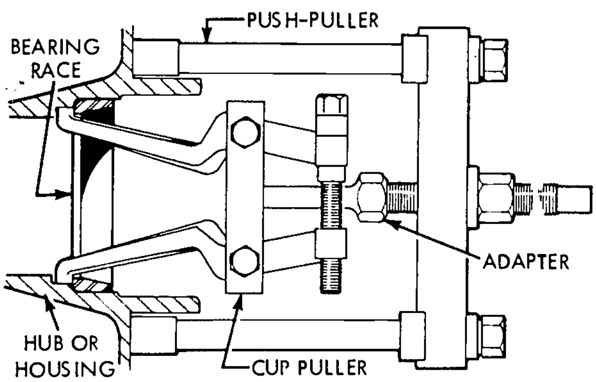
Proper use of a two legged puller and the split collar puller plate to remove a press fit inner race bearing. If the leg length is adjustable, they must be equal!



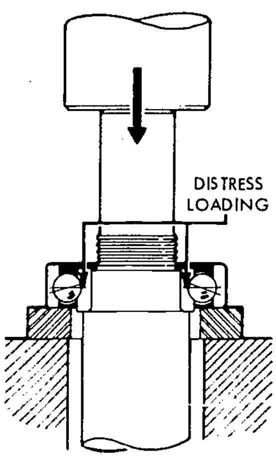
Pushing out a wheel hub outer race using a small flat bar to transmit ram pressure. (This procedure will work on any press fit outer race with the wide face exposed, and with an opening behind it).



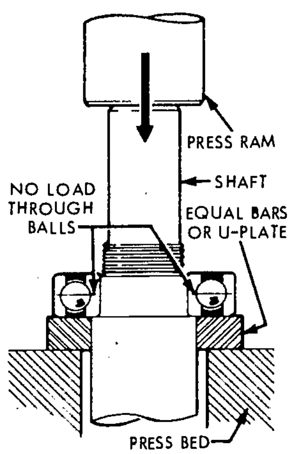
Proper use of the push-puller and split collar puller plate to remove a press fit inner race bearing. The push-puller has the advantage of breadth adjustment and lateral stability over the two legged puller. Length is adjusted by means of various length legs.



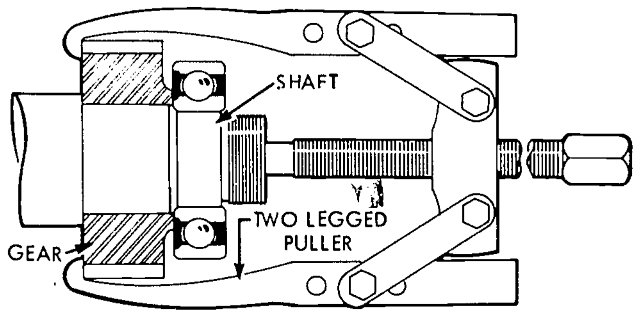
Proper use of the push-puller and cup puller to remove the press fit outer race of a tapered or spherical roller bearing.



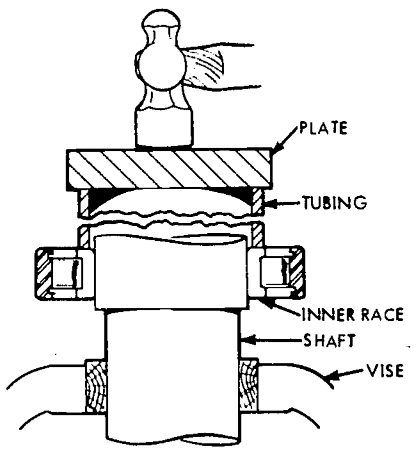
Wrong! Blocks are contacting the bearing outer race only.



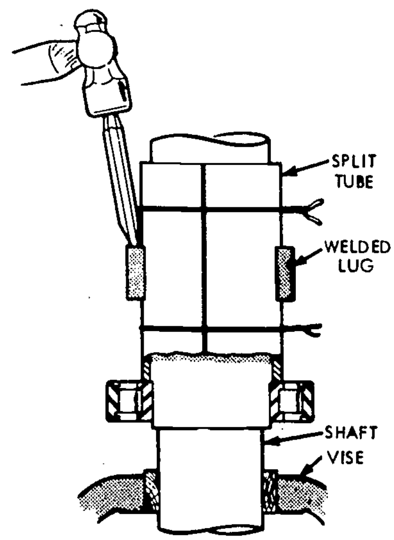
Right! Blocks are contacting inner ring; or both rings if bearing is flush faced.



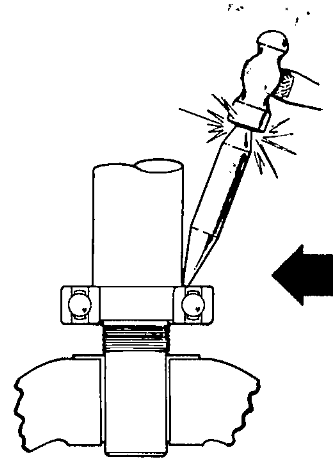
Proper use of a gear for a "puller plate" where there is not sufficient room behind the bearing for the split collar puller plate. Pushing the shaft out with the hydraulic press, if possible, is better. Exercise extreme caution not to nick gear teeth.



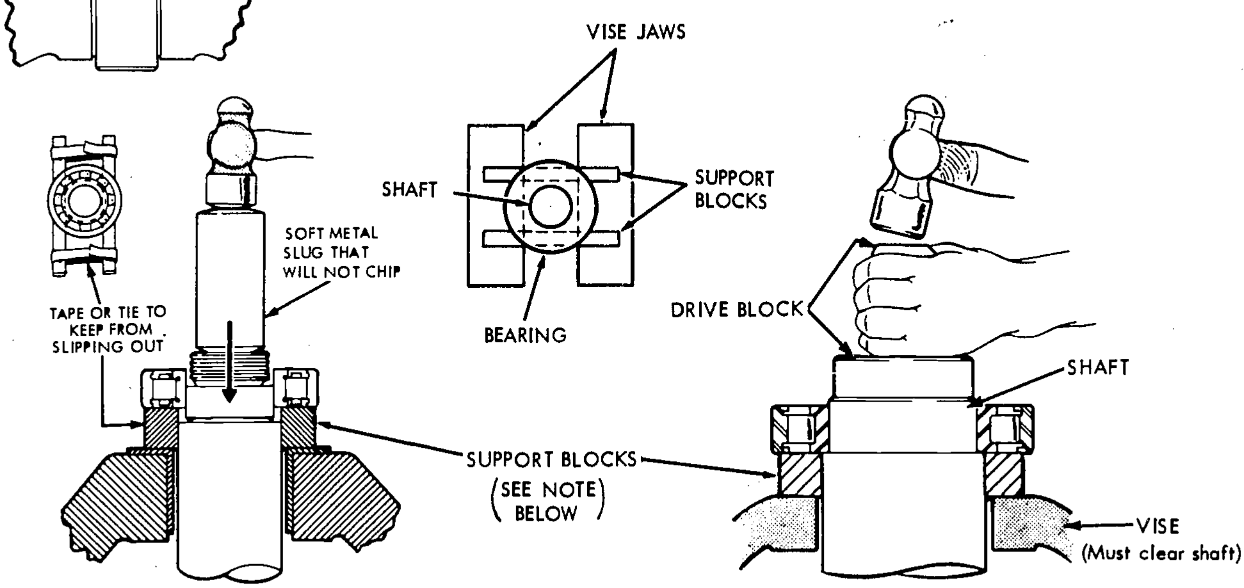
Proper use of tubing or pipe, flat bar and hammer to remove bearing. Note wood blocks in jaw of vise to protect shaft.



Where shaft is too long to permit hammering on the tube, use of a tube with welded lugs is advised. If there are obstructions on the shaft, the tube may be cut in two, then held in place on the shaft by wrapping the tube with tape or wire. Tap on alternate sides of the tube!

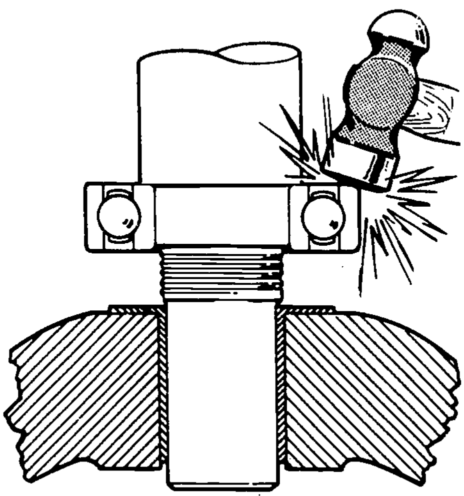


Wrong! Never do this—the punch may slip and damage the ball or roller separator, or shields and seals, if so equipped. Also, chips of metal can easily be thrown into the bearing.

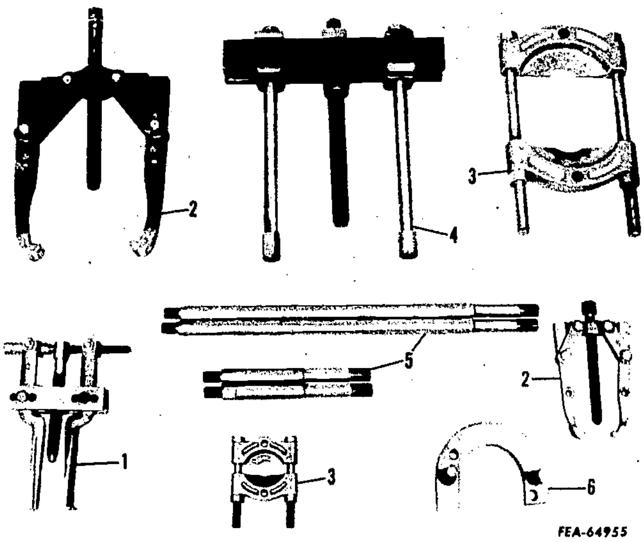


Two methods of properly driving the shaft out of a bearing, using a soft metal slug to protect the shaft. Remember, however, that pressing is better.

NOTE: For purposes of clarity, the support blocks are shown parallel to the vise jaws; however, they should be across the jaws.



Wrong! This will positively cause serious damage to the bearing balls and races. Even if the bearing is already ruined, this practice is bad, as it can easily damage the shaft.



1. Cup puller
2. Two legged pullers, with adjustable legs
3. Split collar puller plate
4. Push-puller
5. Legs for push-puller
6. Special U-plate puller

BEARING CLEANING AND INSPECTION

DO NOT TRY TO DETERMINE THE CONDITION OF A USED BEARING UNTIL IT HAS BEEN CLEANED.

DO NOT spin dirty bearings with compressed air. A dry bearing spun at high speeds will be damaged. The speed of a bearing being spun with air can easily reach 10,000 RPM and if a piece of dirt or steel flies off at this speed, someone could be seriously hurt. Rotate one ring, slowly, by hand when drying with air to expose all parts of the bearing.

Bearings having a shield or seal *on one side only*, or removable seals, can be cleaned, inspected, and handled in the same way as bearings without shields or seals. Bearings with permanent seals or shields on both sides must not be washed. Wipe them carefully to keep dirt out. If they turn smoothly and are not otherwise damaged, coat the outside with grease, and wrap with grease proof paper to keep them clean. If they stick, or turn roughly, replace them.

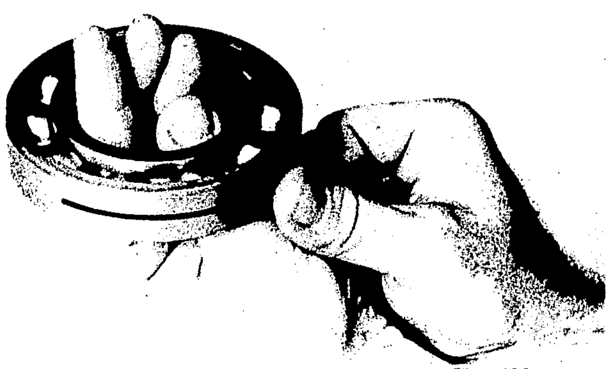
Solvents used for cleaning include naphtha, kerosene, etc., but petroleum solvents formulated especially for parts washing are best. Gasolines containing tetraethyl lead and other anti-knock compounds are poisonous when inhaled or absorbed in cuts, and should never be used. Nearly all of these solvents are very inflammable, so precautions must be taken to prevent fire.

The containers used for cleaning should be deep, clean, and well filled with solvent, and bearings must never touch the bottom of the container, where all the dirt will settle. (Use of a special parts washer for first cleaning is recommended, if at all possible.)

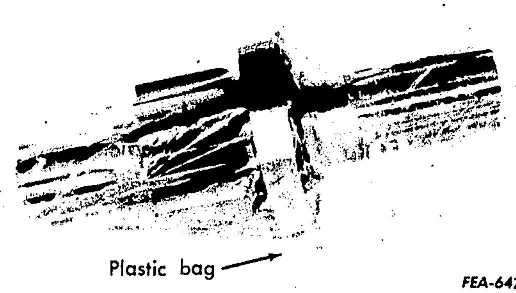
Let the bearings soak long enough to loosen the grease and dirt. This may take several hours—overnight is good practice. Then slosh the bearing around near the top of the container, turning the bearing slowly to expose all bearing parts. A short-bristled brush from which the bristles will not easily come out or break off will aid in removing dirt and grease. After all visible dirt is removed, rinse the bearing in a clean container of clean solvent, and immediately dip in oil or light grease before inspecting.

After cleaning, inspect the bearings to determine if they may be placed in service again. (If one bearing on a shaft fails, it is good practice to replace the other one, even if no visible damage occurred.)

A little tarnish, stain or corrosion on the *outside edge* of races is not harmful to bearing operation, and need not be removed. Cleaned bearings that cannot be separated may be inspected by holding the bearing horizontally and turning the outer race *slowly* as shown. Any bearings which stick, or run roughly, or have a clicking noise should be re-cleaned, and tried again. If the condition still exists, replacement is necessary.



Proper method of inspecting bearings.



A good method for protecting bearing assemblies temporarily for a few hours or overnight. This is not good for long-term storage, as moisture can condense inside of the bag.

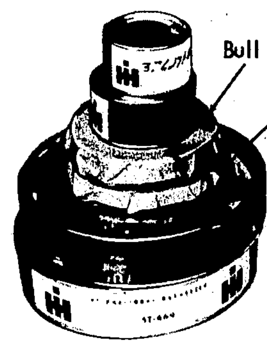
External visual inspection should reveal whether the bearings have broken or cracked races, dented seals or shields, cracked or broken separators, balls or rollers, and whether the bearing has been overheated, which will be indicated by a brownish blue or blue-black color. Any of these, if found, are cause for replacement.

Separable bearings should be inspected for flecked, pitted, or scratched areas on balls, rollers, or races, and for indenting in the races. These are also cause for replacement.

No accurate field inspection for excessive "end shake" exists. Unless it is known that a given bearing has none, only a haphazard comparison with a new bearing is possible. If excessive end shake is suspected, replace the bearing, even though no visible damage is present, as wear can occur which is not visible, especially if fine abrasives have mixed with the lubricant.

After inspection, the bearings should immediately be greased or oiled. If they are not going to be installed immediately, they should be double wrapped, or stored in a clean tightly covered pan or metal box.

If cleaned, re-usable bearings are not to be installed within a few hours after cleaning, or the next day, they should be wrapped in clean grease-proof paper, then put in a clean box or carton. If no carton is available, wrap again in waterproof paper. Mark the outside of the package to identify the bearing.



Properly wrapped and stored bearings. Bearings may be double wrapped, or single wrapped and kept in a properly identified used container.

BEARING REPLACEMENT

Bearings are the most critical mechanical element in any rotating device.

Because of this, bearing replacement (the selection of replacement parts) is a vital step in securing customer satisfaction with a repair job.

A study of bearings purchased from certain outside sources, as compared to correct bearings, revealed the following discrepancies:

1. Four were used bearings which had been cleaned and polished, and resold as new bearings. It was impossible to determine how much bearing life was left.

2. Two bearings received were limited type which had been substituted for the maximum type that was ordered.

3. Four bearings received were the wrong size (out of specifications).

4. Three bearings received were not in the manufacturer's original package.

5. Bearing with snap ring groove in outer race substituted for type with plain outer race. Also, the retainers packed with this bearing were of two different makes.

6. Bearing received had had its faces reground while assembled. A matched grinding pattern across the faces and grinding dust in the bearing were proof of this.

These discrepancies are, for the most part, the kind that are easily seen by a visual examination. There are other faults possible in bearings, just as harmful to life expectancy, which are not so obvious which, in fact, can only be determined by very intricate inspection methods.

Inspection methods of extremely precise nature are used by companies to obtain bearings of the highest possible degree of quality. All dimensions (bore, OD, width, etc.) are held within a few ten-thousandths of an inch, and small bearings may be held within 1/10,000 inch! The roller diameters in any given roller bearing are *all* within 1/10,000 inch! The balls in any ball bearing are all within 25/1,000,000 inch of the same diameter!

The *only* way, therefore, to be *sure* of getting proper service life and properly satisfied customers is to *use only manufacturer-approved bearings!*

Other considerations in bearing replacement include the fact that, if one bearing on a shaft fails, the other bearing or bearings on the same shaft should be replaced. Also a snap ring grooved bearing should never be used to replace a plain outer race type, even though all dimensions, and capacity, are exactly the same. The bearing with a snap ring groove in the outer race has a smaller corner radius at that point and, therefore, will not seat properly in the housing radius, causing the bearing to be distorted, overloaded or cramped, and rapid failure will certainly take place.

If a maximum type bearing is discarded from an installation, it must be replaced with a maximum type. (Maximum type have loading grooves, limited do not.) A maximum type bearing has about 25% more *design capacity* than a limited one of the same size. The service life of a maximum type may be from 5% to 100% greater than service life of a limited type, depending on load and operating conditions.

These are classical examples of possible damage from improper substitution which can have disastrous results. This helps to emphasize that *only proper genuine* service parts should be used.

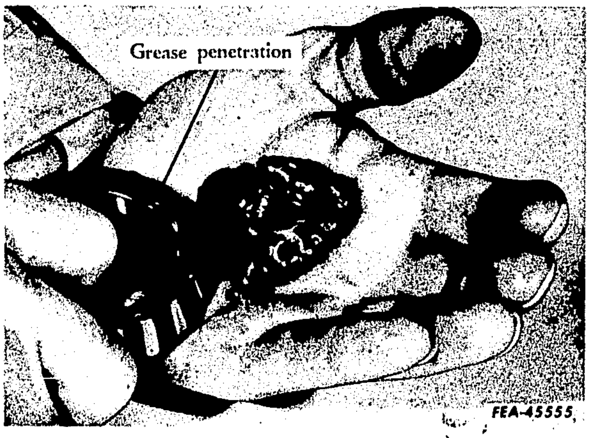
BEARING LUBRICATION

Little can be said about lubrication of bearings in farm and industrial equipment applications, as lubrication is almost always a "designed" feature.

The important things to remember are that it is vital to use recommended lubricants at proper intervals, and to add or apply them in the manner suggested. These recommendations are made only after the most careful research and testing. The loads placed on bearings, combined with the critical tolerances that must be maintained, demand absolute conformity to these recommendations.

Three general types of lubrication will be mentioned here, as they apply to a variety of applications.

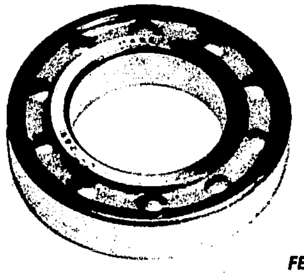
Bearings which run in oil or fluid, or which are flush lubricated, are simply dipped in oil prior to installation. Such bearing installations, where high speeds and heat are not problems, can be properly lubricated with heavy oils—even as heavy as SAE 90, in some instances. However, some of these heavy lubricants become highly corrosive in the presence of water and if water becomes mixed with them, corrosion will result, even though the heavier oils stick to bearings extremely well. Strict attention to change periods and use of recommended lubricants is again emphasized.



FEA-45555

In splash and flush lubricated installations where heat may be a problem, it is important to use a lubricant with high corrosion resistance. If a malfunction occurs in a hydraulic system (where final drive and hydraulic reservoir are common) to make it stay on high pressure, or the fluid level is low, fluid temperature can build up as fast as 5 degrees per minute! Thus, in only a few minutes, rear frame temperature can reach the boiling point of water. All water in the system will therefore vaporize and when the system cools, this water condenses on metal parts above the fluid. Therefore, if the lubricant being used does not have high corrosion resistance and excellent sticking qualities, bare metal will be exposed or the water will combine with the oil on the exposed metal and form a highly corrosive emulsion.

Packing bearings with grease prior to installation is a practice that applies to all unsealed bearings which are lubricated with any kind of semi-solid grease. Roller bearings may be packed by placing recommended type grease in the palm of one hand, and thrusting the bearing into it with a wiping motion until grease appears at the top of the rollers, all the way around the bearing. A better method is to use one of the commercial packing devices made especially for packing bearings. Pack ball and cylindrical roller bearings by filling from both sides to even with the outer edge of the cage, then turning the bearing a few revolutions to remove excess grease.



FEA-64957

Subsequent greasing is accomplished, usually with a pressure grease gun, in the manner described in Operator's Manuals.

An excess of lubricant in any bearing causes a tremendous increase in internal friction, thus higher temperatures, and may actually burn out the bearing. To prevent excess lubrication, many "semi sealed" bearings are equipped with a relief plug, as in many electric motors. Some re-lubricable sealed bearings are constructed so that the outer seal can turn outward to release excess lubricant, and allow old grease to be flushed out. Some bearings are mounted in a tightly sealed compartment, with no relief or escape for lubricant other than a normal seepage which keeps seals lubricated. This type of mounting seems to be increasing in popularity, and lubricant is only added to keep the lubricant in the housing fresh. It is absolutely vital not to over lubricate this type of mounting. Follow maintenance instructions!

BEARING INSTALLATION

Bearing installation is even more critical than bearing removal and the same general rules apply. If a bearing is not properly installed, early failure is certain.

Carefully clean all dirt and old grease off the shaft and housing. Inspect the shaft and housing for wear or scores, and replace as necessary.

Again, the best tool for bearing installation is the hydraulic press, with its attachments, followed by the push-puller, with hammering methods a poor third.

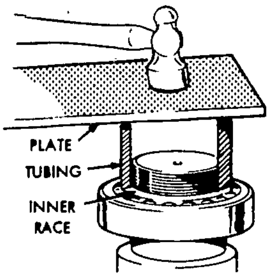
NOTE: Certain unusual assemblies require that bearings be installed with hammering methods, with pressure applied through the rolling members, or that shafts be driven into bearings which are already mounted. Where this applies, the necessary special instructions will be found in appropriate service literature.

Always install the bearing into its press fit location first. For instance, if the bearing being installed is a tapered roller, the cup is installed first, then the bearing placed on the shaft and the shaft installed. (Usually, both cup and cone are press fit). If a ball bearing is a press fit on its shaft, it is installed on the shaft first, then shaft with bearing is installed in the housing. In the unusual event that a ball bearing is a press fit on both races, special installation procedures are necessary which will be found in the appropriate service literature.

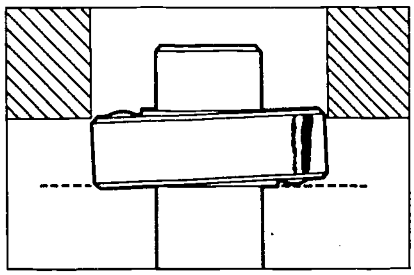
Often, one of the bearings on a shaft will be securely locked, both to the shaft and in the housing, while the other, or others are free to move axially as the shaft expands and contracts. This is not true, however, of tapered roller bearings and, of course, preloaded bearings.

A few drops of oil on bearing seats greatly eases mounting.

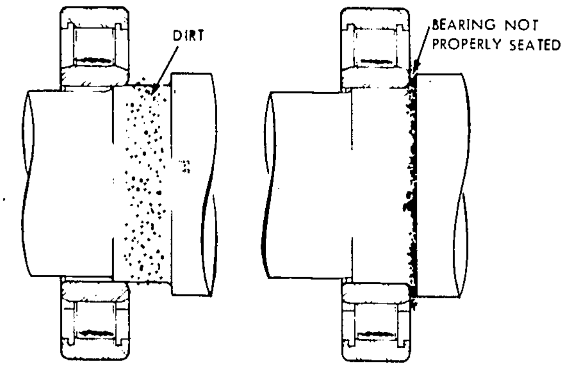
The following series of illustrations, with their captions, show many common methods of installation and point out some of the pitfalls of improper procedures.



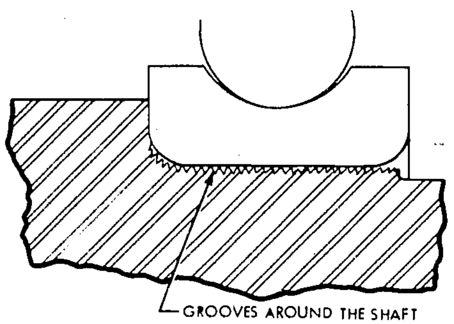
Proper method of using hammer to install press fit inner race on a shaft—tube clears threads, fits against inner race, and plate distributes blows.



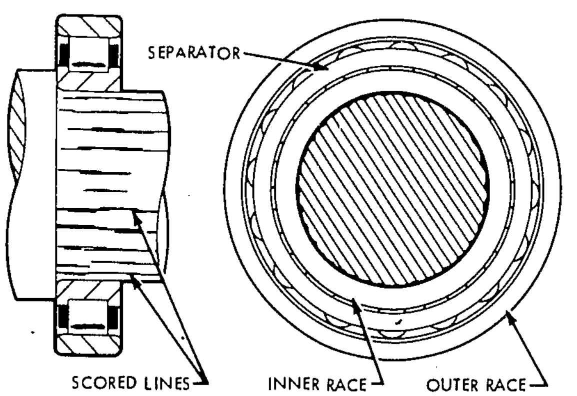
Wrong! Even though the outer race is only a push fit, it must be square with the housing as it is installed.



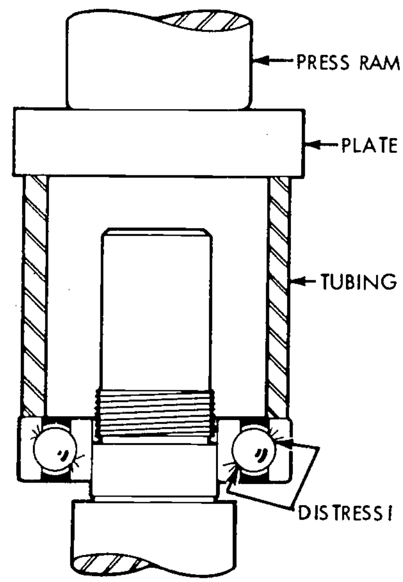
Wrong! This shows the result of improper cleaning of the bearing seat. The accumulation of dirt between the race and shaft shoulder will cause improper seating and shortened bearing life.



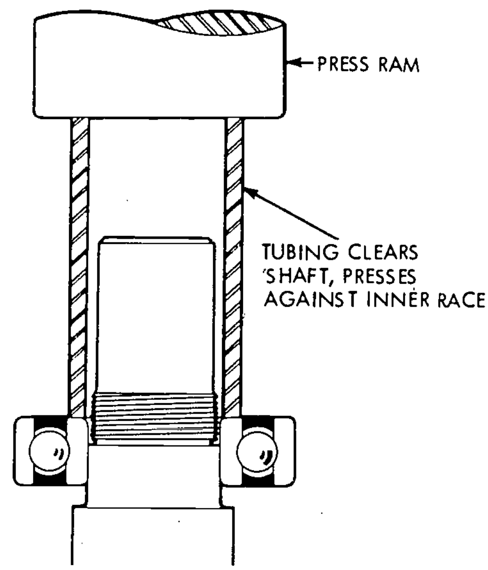
Wrong! The bearing seat on the shaft has grooves in its finish, perhaps from the old bearing turning on the shaft, or from improper finish on a rebuilt shaft (use new parts!) or from improper handling. A bearing installed under these conditions will soon peen these ridges down and start turning on the shaft, obviously leading to short life.



Wrong! A bearing installed on a scored seat will probably be distorted, resulting in improper internal clearance, or will peen the ridges down and turn on the shaft.

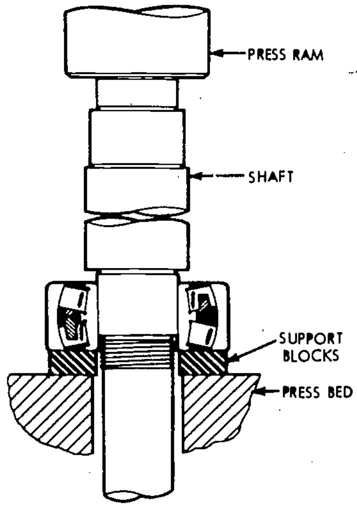


Wrong! Never press on the outer race of a shaft to install the inner race, or vice-versa.

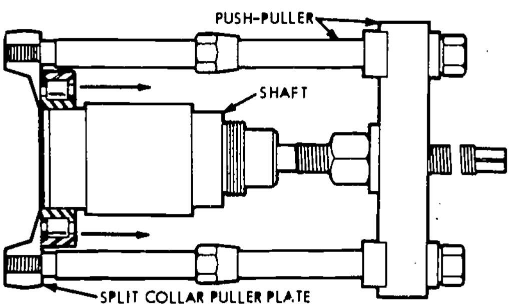


Proper method of pressing inner race on shaft.

NOTE: If bearing and seat have the correct diameter and the seat is straight, the bearing should go on smoothly, with uniform pressure all the way. If force required suddenly goes up, stop the pressure and make sure the bearing is not cocked on the shaft, and that no nicks or burrs on the shaft are causing trouble. If a bearing is forced on over a serious burr, or while it is cocked, the inner ring could be cracked, or the bearing seat or shaft be scored.



This is a good way to press a shaft into a bearing—the blocks supporting the bearing are the same size, the shaft threads clear them and everything is square.



Proper method of using push-puller and split collar plate to install a bearing.

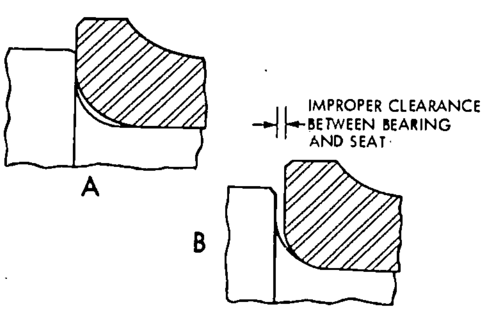
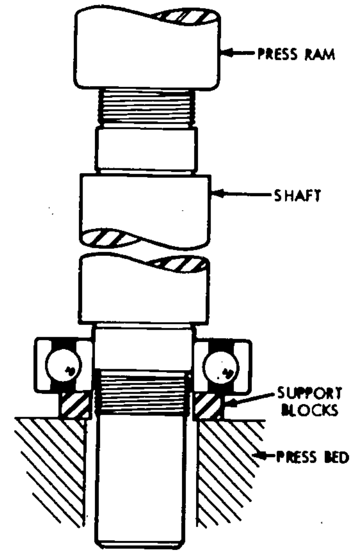
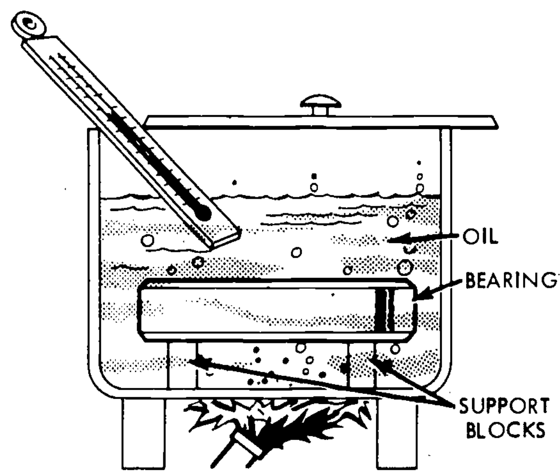


Fig. A shows how a bearing should seat against a shoulder. Fig. B shows the effect of using a bearing with the wrong shoulder (a snap ring type substituted for a non-snap ring type, for example), or of poorly grinding out the shaft shoulder after rebuilding a shaft. Use new parts! Installing a bearing having a round edge on one side, a square edge on the other, backwards, will also have this effect. Use new parts, correct parts, and install properly.

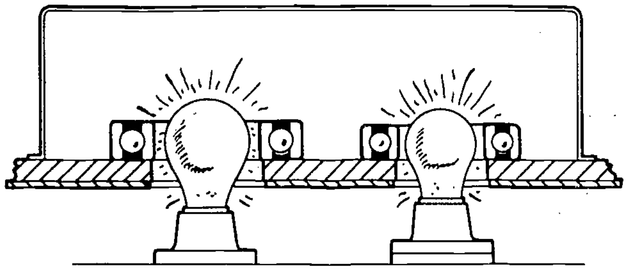


This is a better way to press a shaft into a bearing—everything is the same as the illustration to the left, except that the blocks contact only the inner race.

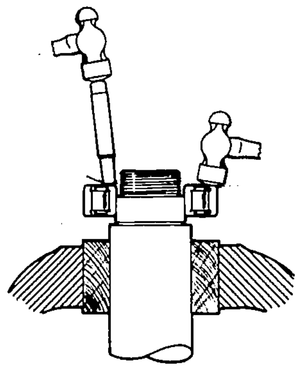


This is one method of heating a bearing so that it will slip into place over a shaft. Note that the bearing is supported above the bottom of the oil container, away from any particles of dirt that may be present. Also, the bearing thus will not get too close to the heat source. A direct flame on the bearing, or on the container bottom with the bearing resting directly on it, will almost always damage the bearing. Temperature must be held to no higher than 200 degrees F.

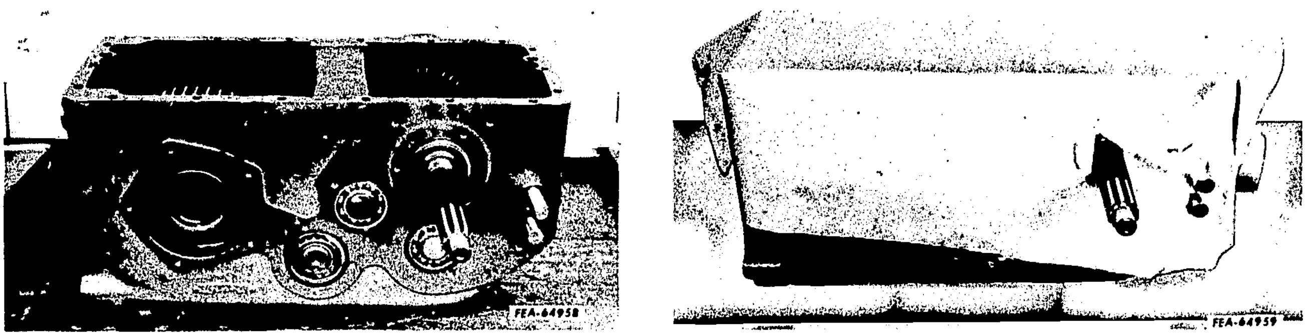
There is some danger that oil vapor may catch fire with this method, so use proper precautions.



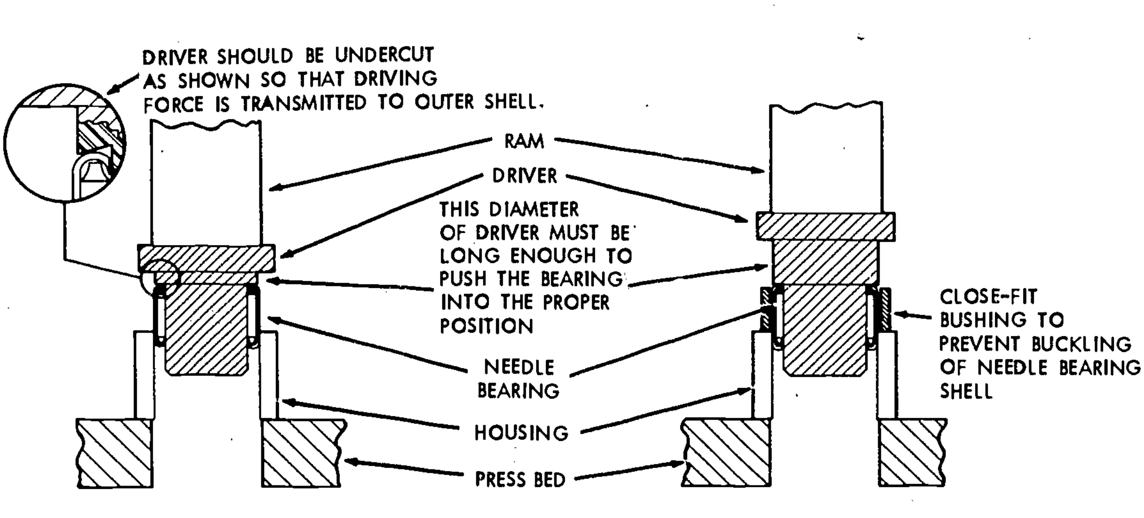
This is a better method of heating bearings, as the maximum temperature cannot possibly get higher than 175° or 200°, which is not harmful to any bearing. Also, the heated bearing can be handled more easily, because the outer race remains relatively cool.



Wrong! Never use a hammer or punch directly on any bearing! Serious damage to the bearing will surely be the result. See *"NOTE," page 18.*



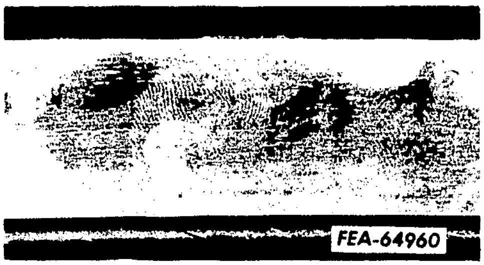
Always cover partially assembled units if they are to be left for an hour or longer. Exposed partial assemblies left standing, as at the left, will certainly collect harmful dust or dirt.



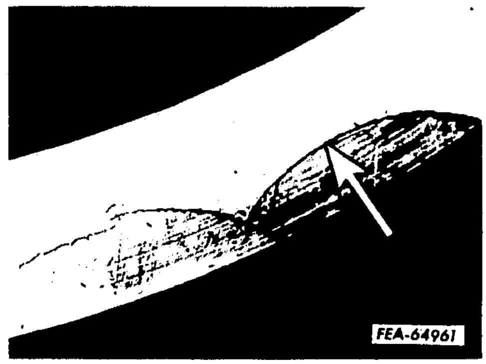
This shows two methods of properly installing needle roller bearings. The drawing on the left applies to those having a "light" press fit (will nearly push in by hand). If a needle bearing is installed with a relatively heavy press fit, it is very important to use a close fit bushing as a guide to prevent buckling of the bearing shell, which will lead to brinelling.

BEARING FAILURES DUE TO IMPROPER SERVICING

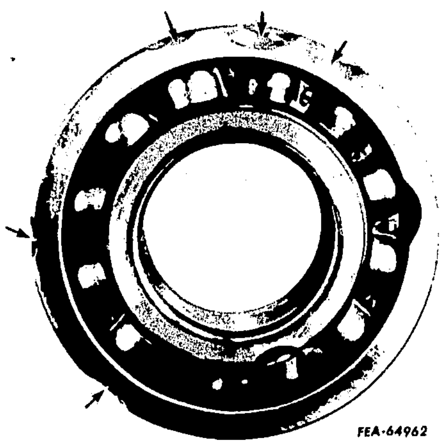
The following series of illustrations show many of the harmful results of improper servicing procedures.



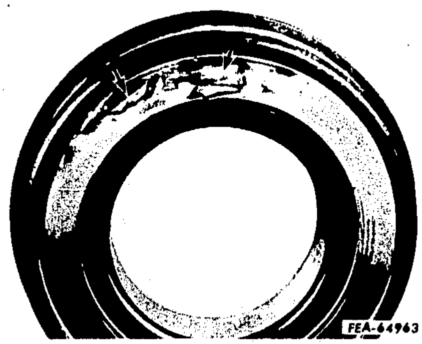
This corrosion, in the form of a fingerprint, was caused by handling an ungreased bearing with sweaty or moist hands.



The breaks in this race were caused by blows with a hammer.

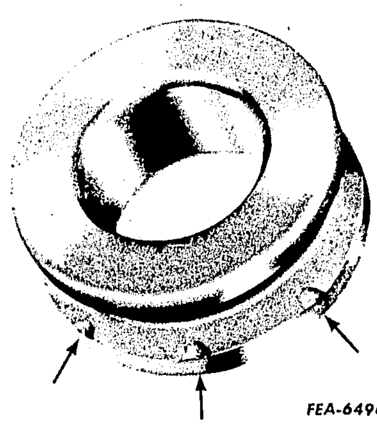


The nicks in this outer race were caused by using a chisel or drift to drive it out, or in.



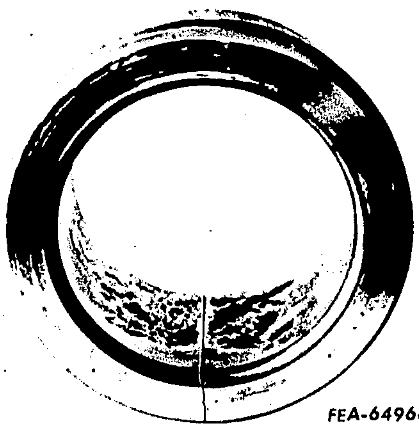
The damage to this bearing seal was caused by a drift slipping.

FEA-64964



FEA-64965

The notches (brinelling) in the outer edges of these races developed from normal use after installing with a hammer, pounding directly on the outer race. Note that the notches are spaced evenly, only part way around the race, and are about as far apart as the balls are in the bearing.



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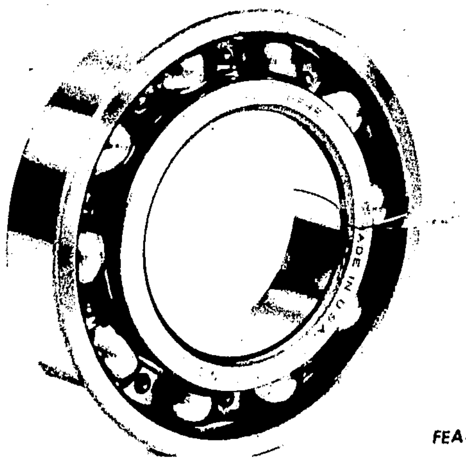
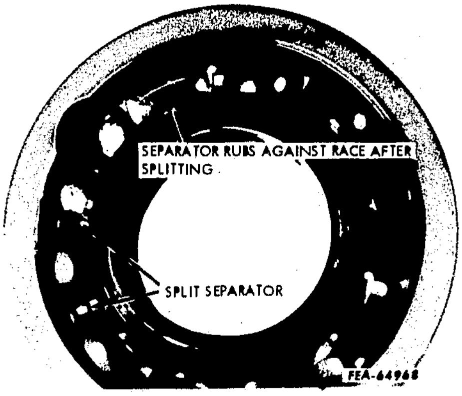
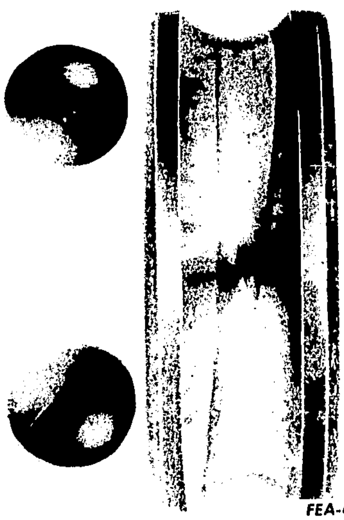


FEA-64967

The splits in these races were caused by cocking the races or forcing them on over a burr. The wear inside the races occurred afterwards because the races were then loose on the shaft.



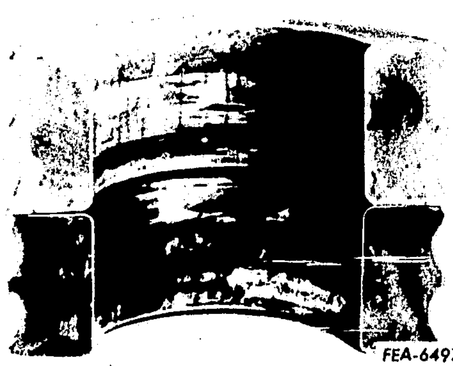
FEA-64968



FEA-64969

FEA-64970

The damage illustrated was all caused by misalignment. Note the crooked ball paths in the raceways, the squeezed, oval appearance of the balls and the wear on the separator, which was caused by rubbing against the race.



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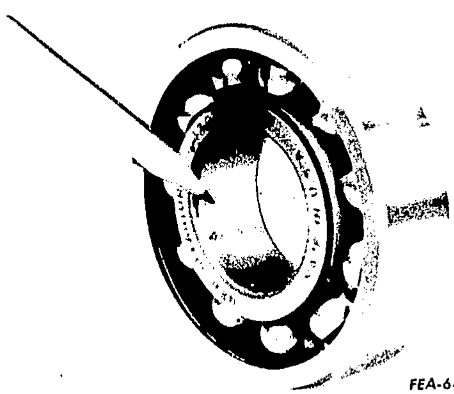
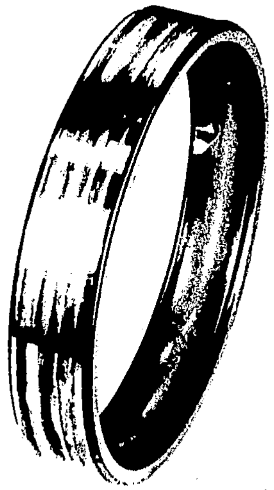


FEA-64973

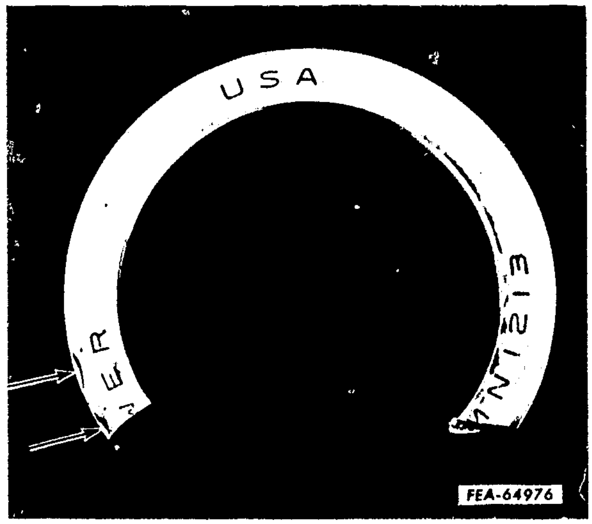
The wear on both of these races was caused by too loose a fit on the shaft, which allowed the race to turn on the shaft.

FEA-64974



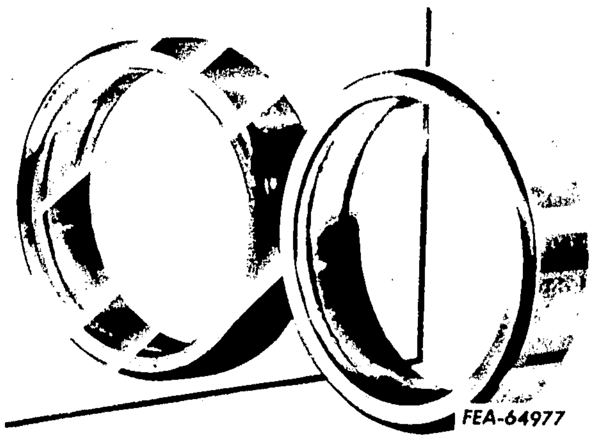
FEA-64975

This wear is caused by the outer race being too loose in the housing.



FEA-64976

This roller bearing thrust plate was broken because it was driven on after it cocked. Also, note the two nicks in the edge which correspond to roller spacing and size, indicating direct blows with a hammer.



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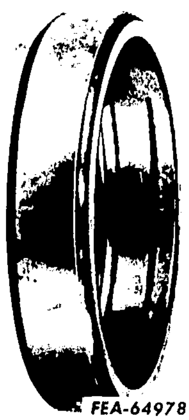
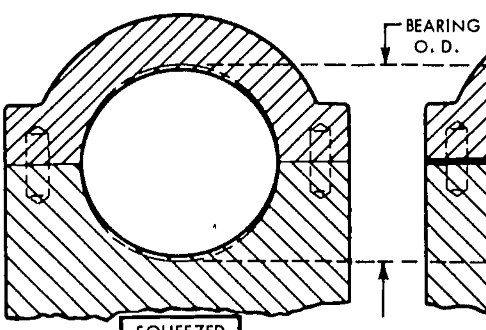
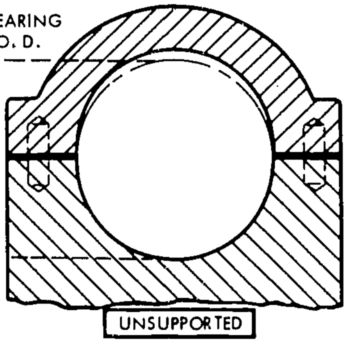
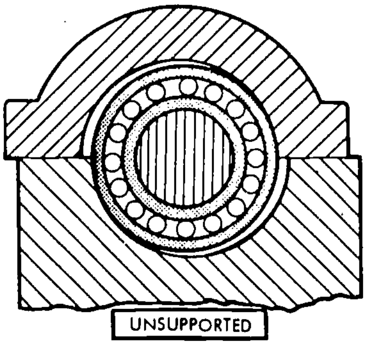


FEA-64978

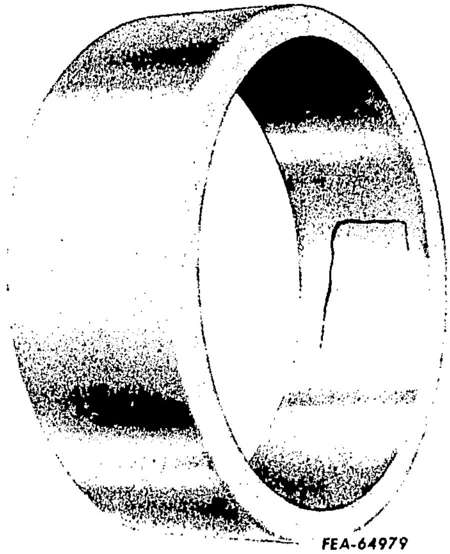
The flaking and pitting on opposing sides of these races was caused by distortion of the races by their housings or by dirt under the race, if damage occurs on only one side of the race. Probably, the housing was out-of-round, the retainer was put on off-center or shims should have been used and weren't or vice-versa. The line drawings below show the effect of the latter two conditions.







SQUEEZED	UNSUPPORTED	UNSUPPORTED
HOUSING IS OUT-OF-ROUND BECAUSE REQUIRED SHIMS WERE LEFT OUT	OUT-OF-ROUND BECAUSE UNNECESSARY SHIMS WERE INSTALLED	IMPROPERLY SUPPORTED BEARING O. D. IN TWO PLACES BECAUSE RETAINER WAS FORCED ON OFF-CENTER



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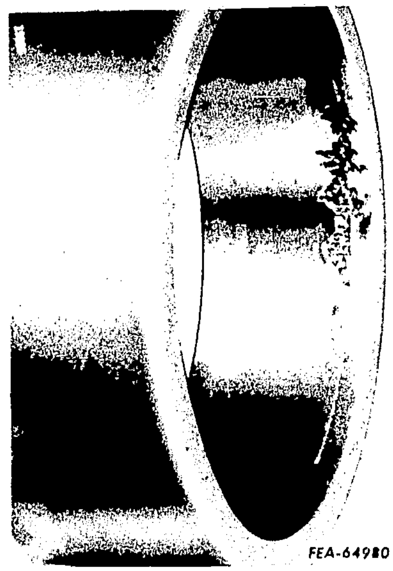

FEA-64980

The longitudinal cracks and pitting in these races was caused by improper fit of the race in their housing. The races did not turn, but there was a hollow, worn spot in the housing underneath the damaged areas, which caused the races to flex and become damaged as shown.

INSTALLATION RUNNING INSPECTION

After a bearing has been assembled into a machine, it should be checked for noise, running temperature and torque.

Operating noise is a good test of bearing performance. High noise levels can indicate damage by brinelling in assembly, excessive radial or thrust load, or misalignment. Sometimes noise indicates interference within the bearing itself, such as a separator which became dented while mounting.

Abnormally high shaft torque is a sign of serious trouble. The press fit may be too tight, causing excessive radial preload, or axial preload may be adjusted wrong. The shaft or housing may be bent, causing misalignment, or a cover plate may be damaged, causing misalignment, excessive preload, or interference.

Excessive noise and torque are usually accompanied by high temperature. Any temperature that causes the bearing lubricant to fail to stick to the bearing may be considered too high. Other reasons for high temperature are fluid friction from excessive grease or oil, excessively high speeds, high speeds combined with heavy loading, or the hydraulic system (in units having a common hydraulic and final drive reservoir) staying on high pressure. High temperature caused by excessive grease, especially in double sealed bearings, is usually cured by stopping the machine and letting it cool off. This allows the grease to "channel" and the bearing balls and rollers to turn without stirring all of the grease.

BEARING ADJUSTMENT THEORY

This portion of the manual is devoted to an explanation of *why* bearings are adjusted and installed as they are. Specific details and measurements involved are too numerous and varied to discuss here, but an understanding of some of the theories involved will help servicemen do a better job.

PRESS FIT AND CREEP

Bearings are usually installed with the rotating race a press fit and the stationary race a push fit. The amount of tightness or looseness depends on the kind of service involved and is a design feature.

Under normal load conditions for a given installation, a properly fitted race will not slip rapidly on or in its seat and wear is avoided. A ring fitted with the recommended looseness to a stationary shaft or housing is therefore able to creep very slowly, with the result that fresh portions of the ball races are continually brought into the heaviest loaded area, thus giving the bearing longer life.

A push-fitted ring of a bearing can move axially, thus diminishing the effect of excessive thrust loads and shaft expansion. Push fit on ring also greatly eases assembly.

The above rule is general and does not apply exactly to all conditions. Thus, for very heavy or vibrating loads, mounting fits for both shaft and housing are made tighter. For some highly precise applications, the stationary ring requires closer than a push fit to avoid radial looseness and deflection under load, and also sometimes to reduce or prevent creep.

The press fit of a bearing also has the effect of expanding the inner ring or contracting the outer ring, or both. This reduces the radial play within a bearing, thus giving the bearing less internal clearance and increasing its precision. Therefore, if interference is too great, (press fit too tight) all internal clearance is removed, resulting in preload, possibly overheating and early bearing failure.

The amount of interference or press fit varies from a few ten-thousandths of an inch for small bearings to several thousandths for large ones. If a shaft or housing becomes scored and worn for some reason and loses the necessary fit, do not try to bring the fit back by knurling or prick-punching the seat. This "repair" will iron out very quickly under load and looseness will return. Replace the shaft or housing!

PRELOADING

When a mechanical device including bearings is operated, reaction loads from gears, pulleys, etc., are transmitted through adjacent components to the bearings, and the various parts deflect. If the loads are heavy or the deflection is too great, preloading is employed in order to minimize the effect of this deflection. A bearing application (except single row ball bearings) may be preloaded to provide for a more proper running condition when dynamic loads and deflections are present. Such preload must be within the elastic limits or fatigue strength of the materials involved and usually is less than the deflection produced by heavy loading of the bearing application when the machine is running. Preloading eliminates the running clearance in the bearings when the machine is not operating, and confines the running bearing clearance to acceptable limits, unless exceptionally heavy loads are applied.

Thus it is important to preload bearing applications in accordance with service manual instructions for the application involved.

Some bearings are preloaded only to provide for a more positive location of other operating parts and deflection is not an important factor. In other instances, bearings which are internally preloaded (double row angular contact ball bearings often are) are used for more precise positioning of the components it helps support.

If a set of bearings which are preloaded are set too tight, they will heat up and fail. If they are set too loose, the supported parts will deflect too much, causing rapid wear on them.

BEARING SPACERS

When bearings are clamped in place by spacers, gear or pulley hubs, etc., a great increase in opportunity for error exists. The faces of these parts must be square and they must be the right size. This simply emphasizes the importance of using specified parts, not "home-made", rebuilt, or substitute parts.

Slight inaccuracies in this respect *may* not be harmful, but it is entirely possible for several to add up, to result in the conditions illustrated below.

Spacers must be thick enough to withstand clamping loads without buckling or distorting. In general, spacers are provided which have a thickness slightly less than the bearing inner ring thickness.