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AUTOMOTIVE DIESEL MAINTENANCE 1. UNIT IX, ENGINE COMPONENTS.
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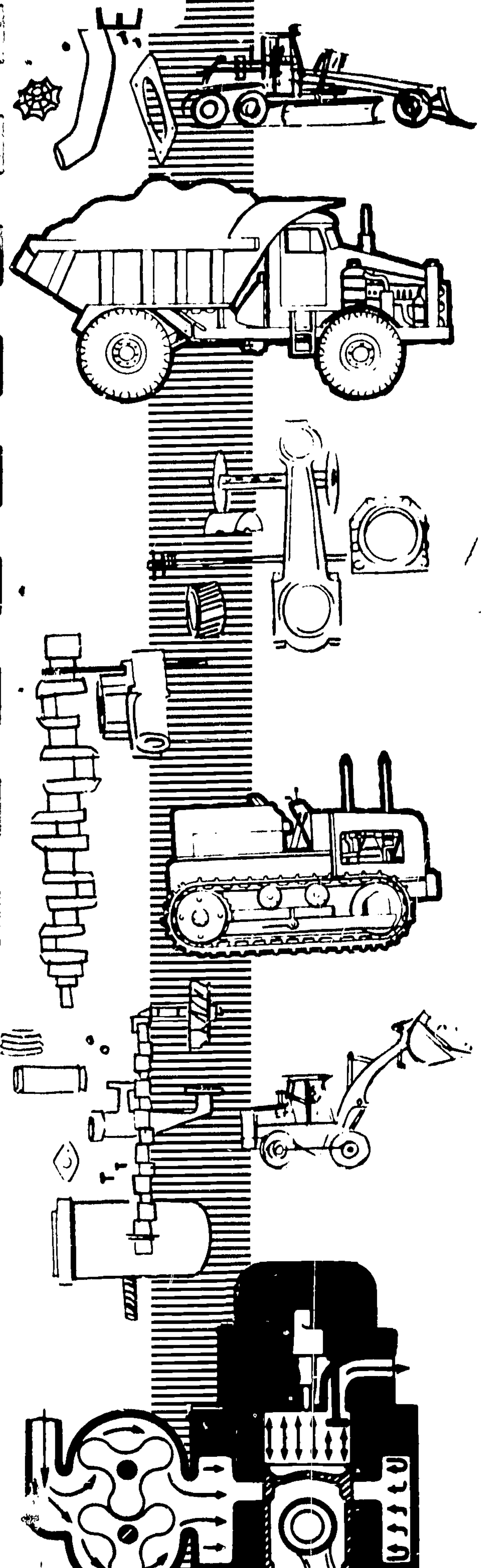
THIS MODULE OF A 30-MODULE COURSE IS DESIGNED TO DEVELOP AN UNDERSTANDING OF THE CONSTRUCTION, FUNCTION, AND MAINTENANCE OF DIESEL ENGINE CRANKSHAFTS, CAMSHAFTS, AND ASSOCIATED BEARINGS. TOPICS ARE SHAFTS AND BEARINGS, CAMSHAFTS, BEARINGS AND THEIR MAINTENANCE, AND DETECTING FAILURE. THE MODULE CONSISTS OF A SELF-INSTRUCTIONAL BRANCH PROGRAMED TRAINING FILM "ENGINE COMPONENTS--PART II" AND OTHER MATERIALS. SEE VT 005 655 FOR FURTHER INFORMATION. MODULES IN THIS SERIES ARE AVAILABLE AS VT 005 655 - VT 005 684. MODULES FOR "AUTOMOTIVE DIESEL MAINTENANCE 2" ARE AVAILABLE AS VT 005 685 - VT 005 709. THE 2-YEAR PROGRAM OUTLINE FOR "AUTOMOTIVE DIESEL MAINTENANCE 1 AND 2" IS AVAILABLE AS VT 006 006. THE TEXT MATERIAL, TRANSPARENCIES, PROGRAM TRAINING FILM, AND THE ELECTRONIC TUTOR MAY BE RENTED (FOR $1.7 PER WEEK) OR PURCHASED FROM THE HUMAN ENGINEERING INSTITUTE, HEADQUARTERS AND DEVELOPMENT CENTER,2341 CARNEGIE AVENUE, CLEVELAND, OHIO 44115. (HC)

STUDY AND READING MATERIALS



AUTOMOTIVE DIESEL MAINTENANCE 1

ENGINE COMPONENTS

UNIT IX

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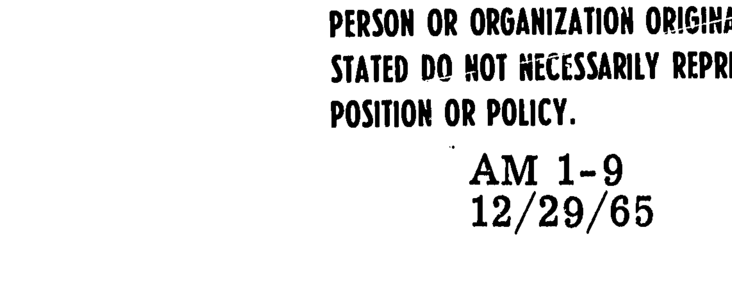

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SECTION A -- SHAFTS AND BEARINGS

The principal shafts (crankshafts and camshafts) and associated bearings (journal bearings and antifriction bearings) of a diesel engine are all subject to several types of trouble. Some of the troubles may be common to all of these parts; others may be related to only one part. The causes of troubles which may be common to all parts are: metal fatigue, lubrication difficulties, and operation of the engine at critical speeds.

METAL FATIGUE, with respect to crankshafts, camshafts, and bearings, may lead to shaft breakage or bearing failure. Fatigue, however, is only one possible cause, of several which may lead to such troubles.

Fatigue failure of journal bearings in diesel engines is usually caused by the cyclic peak loads encountered. Such failures are accelerated by improper or loose fit of the bearing shell in its housing, and by lack of adequate priming of the lubricating oil systems before starting the engine.

Severe overloading or overspeeding of an engine increases fatigue failure. Some indication of the cause of the failure may be obtained by noting which half of a bearing failed. Overloading of the engine will cause failure of the lower halves of main journal bearings, while overspeeding may cause the upper or lower halves to fail.

Crankshaft or camshaft failure seldom occurs. When it does occur, it may be due to metal fatigue. The causes of shaft fatigue failure are similar to the causes of journal bearing failure. Shaft fatigue failure may be caused by improper manufacturing procedures, such as improper quenching or balancing, and by presence of torsional vibration. Shaft fatigue failures generally develop over a long period of time.

The importance of LUBRICATION cannot be overstressed. Much that has been stated previously about proper lubricants, and adequate supply and pressure of lube oils also applies to crankshafts, camshafts, and associated bearings. Some of the troubles which may be caused by improper lubrication are: damaged cams and camshaft bearing failure, scored or out-of-round crankshaft journals, and journal bearing failure. Lubrication difficulties that must be guarded against are: low lube oil pressure, high temperatures, and lube oil contamination by water, fuel, and foreign particles.

As we progress through this course, we will discuss some of the above mentioned difficulties or conditions in more detail. In this unit we will cover some of the more common conditions you run across in relation to principal engine shafts and their associated bearings.

CRANKSHAFT - As the pistons collectively might be regarded as the heart of the engine, so the CRANKSHAFT may be considered its backbone. It ties together the reactions of the pistons and the connecting rods, transforming their reciprocating, or up and down motion, into a rotary motion. And it transmits mechanical energy through the flywheel, clutch, transmission, and differential to drive the vehicle.

In all 71 series engines, the crankshaft is a one-piece steel forging, heat treated to ensure strength and durability. The main and connecting rod journal surfaces and oil seal surfaces are induction hardened. Complete static (motionless) and dynamic (in motion) balance of the crankshaft has been achieved by counterweights incorporated in the crankshaft, as shown in Figure 1, to ensure smoother engine operation and to reduce vibrations.

There are two types of loads put on a crankshaft as it rotates in an engine -- a bending force and a twisting or torsional force. The shaft design is such that these forces produce very little stress on most of the crankshaft surface. Certain small areas which are called "critical areas", however, do sustain most of the load or force. See Figure 2.

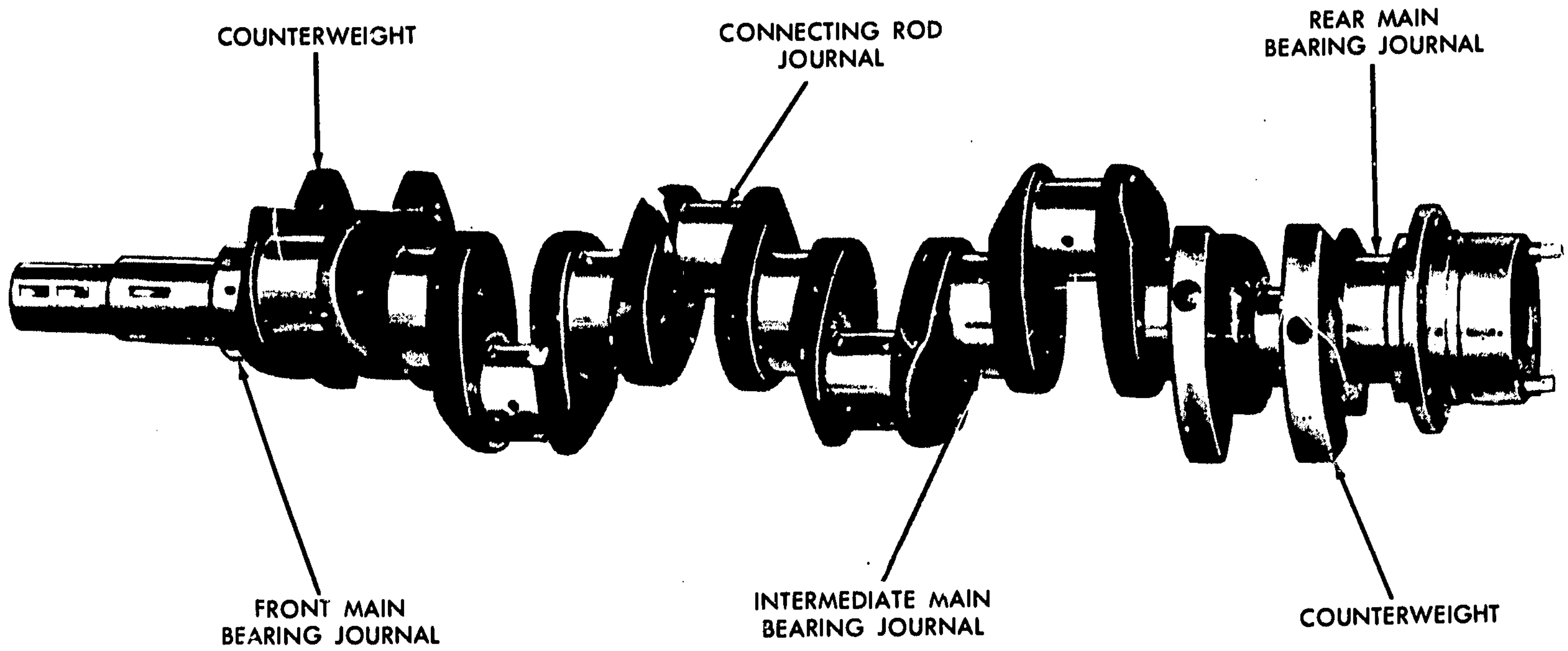


Fig. 1 Typical crankshaft.

Bending fatigue failures result from bending of the crankshaft which takes place once per revolution.

The crankshaft is supported between each of the cylinders by a main bearing and the load imposed by the gas pressure on top of the piston is divided between adjacent bearings. An abnormal bending stress on the crankshaft, particularly in the crank fillet, may be a result of misalignment of main bearing bores, bearings improperly fitted, bearing failures, a loose or broken bearing cap, or unbalanced pulleys. Also, drive belts which are too tight may impose a bending load upon the crankshaft.

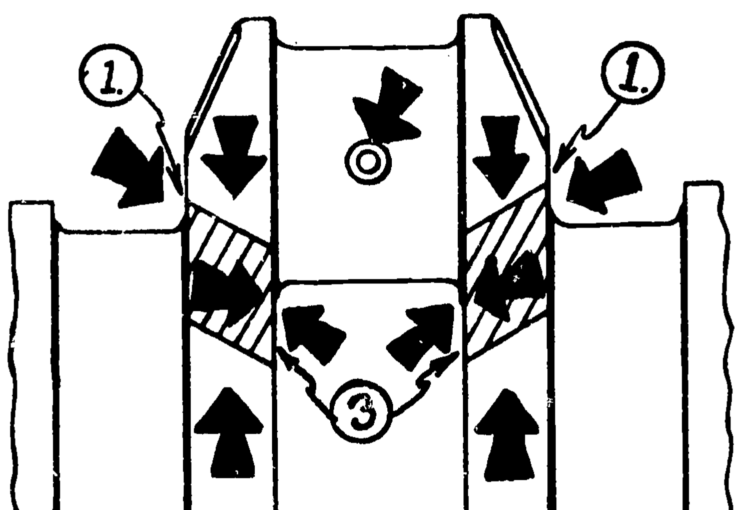


Fig. 2 Critical loading zones.

Failures resulting from bending start at the pin fillet and progress throughout the crank cheek, sometimes extending into the journal fillet. If main bearings are replaced due to one or more badly damaged bearings, a careful inspection must be made to determine if any cracks have started in the crankshaft. These cracks are most likely to occur on either side of the damaged bearing.

Torsional fatigue failures result from torsional vibration, which takes place at high frequency.

A combination of abnormal speed and load conditions may cause the twisting forces to set up a vibration, referred to as torsional vibration, which imposes high stresses at the locations shown in Figure 2.

Torsional stresses may produce a fracture in either the crankpin or the crank cheek. Crankpin failures are usually at the fillet, at 45° to the axis of the shaft.

A damaged or defective vibration damper, the introduction of improper or additional pulleys or couplings, are usual causes of this type of failure. Also, overspeeding of the engine, or resetting the governor at a different speed than intended for the engine application may be contributory factors.

CRANKSHAFT INSPECTION - An engine crankshaft is a large and expensive item. Just as the saying "an ounce of prevention is worth a pound of cure" applies to many things in life, a good job of crankshaft inspection can many times prevent its total failure.

In order to inspect the crankshaft, the oil pan must be drained and removed. Then remove the lubricating oil pump assembly, the main bearing caps, and the connecting rod bearing journals.

To do a thorough job of inspecting, the crankshaft should be wiped clean

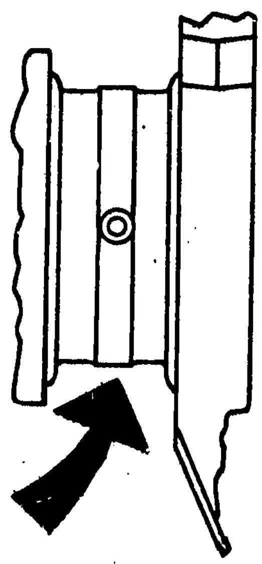


Fig. 3 Typical ridging of crankshaft.

with a clean, soft cloth. You will need a good light and someone to bar the engine over so that you will be able to locate any scoring, ridging, over-heated spots, cracks, or abnormal wear which may exist. Figures 3 and 4 will give you an idea of the most common conditions to look for.

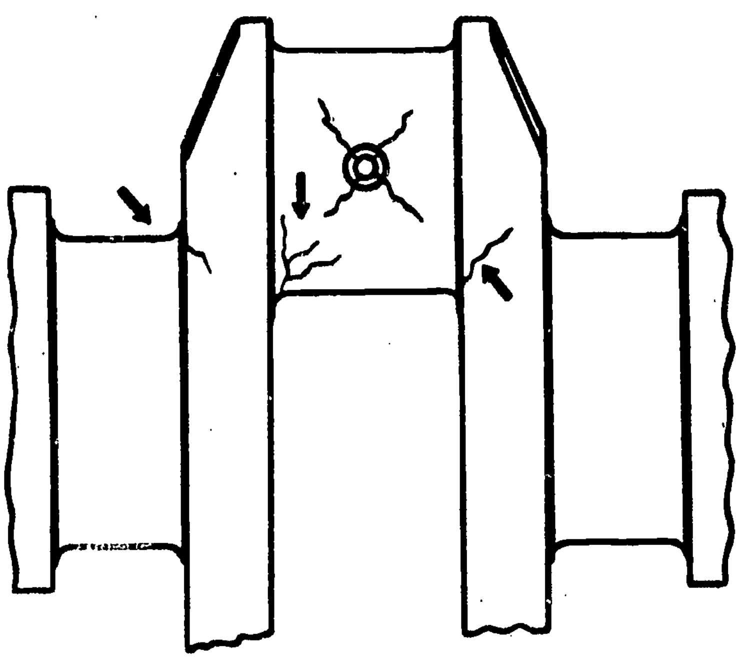


Fig. 4 Crankshaft fatigue cracks.

Crankshaft journal fillets, as previously referred to in Figure 2, must be in such condition so as to allow good bearing fit (see Figure 5). The fillet must blend smoothly into the journal and cheek, and must be free of scratches. All journal fillets must have a .130" to .160" radius between the crank cheek and the crank journal in the In-line 71 series engines and a .100" to .130" radius in the V-71 series engines.

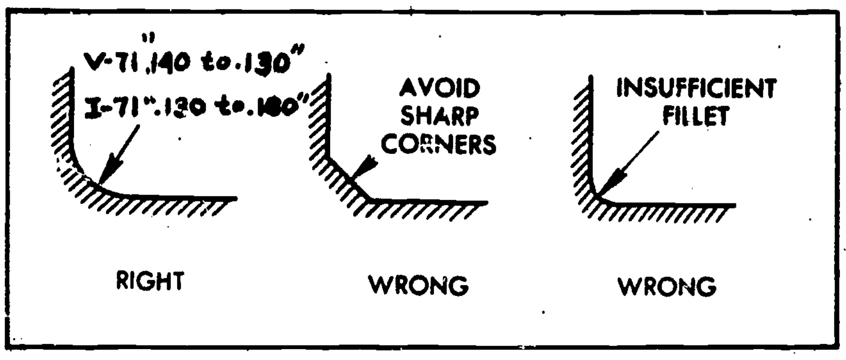


Fig. 5 Crankshaft journal fillets.

All connecting rod bearing journals can be measured with the crankshaft in the engine by using a micrometer. Journals should be checked periodically for out-of-roundness, excessive wearing, and excessive ridges and grooves on the journal surfaces. A micrometer reading must be taken at several points on each journal. Consult your maintenance manual for the exact procedures and the allowable tolerances.

The crankshaft should also be carefully inspected in the area of the rear oil seal contact surface for evidence of rough or grooved conditions. Any imperfections of the oil seal contact surface will result in oil leakage at this point.

As was mentioned before, total or complete crankshaft failure does not happen frequently. But, by knowing what conditions to look for on a crankshaft and on journal bearings, and knowing what these conditions can result in, you can stop many problems before they start by careful inspection and good care maintenance.

SECTION B -- CAMSHAFTS

The CAMSHAFT is a shaft with eccentric projections, called CAMS, designed to control the operation of valves, usually through various intermediate parts as described in the previous unit. Originally cams were made as separate pieces and fastened to the camshaft. However, in most modern engines the cams are forged or cast as an integral part of the camshaft.

To reduce wear and withstand shock action to which they are subjected, camshafts are made of low-carbon alloy steel, with the cam and journal surfaces carburized before the final grinding is done.

The cams are arranged on the shaft to provide proper firing order of the cylinders served. The shape of the cam determines the point of opening and closing, the speed of opening and closing, and the amount of the valve lift. If one cylinder is properly timed, the remaining cylinders are automatically in time. All cylinders will be affected if there is a change in timing.

However, the cams of the camshaft may be damaged as a result of improper valve tappet adjustment, worn cam followers, or the failure of camshaft gear.

Cams are likely to be damaged when a loose valve tappet adjustment or broken tappet screw causes the valve to jam against the cylinder head, and to jam the push rods against their cams. This will result in scoring or breaking of the cams and followers, as well as severe damage to the piston and cylinder.

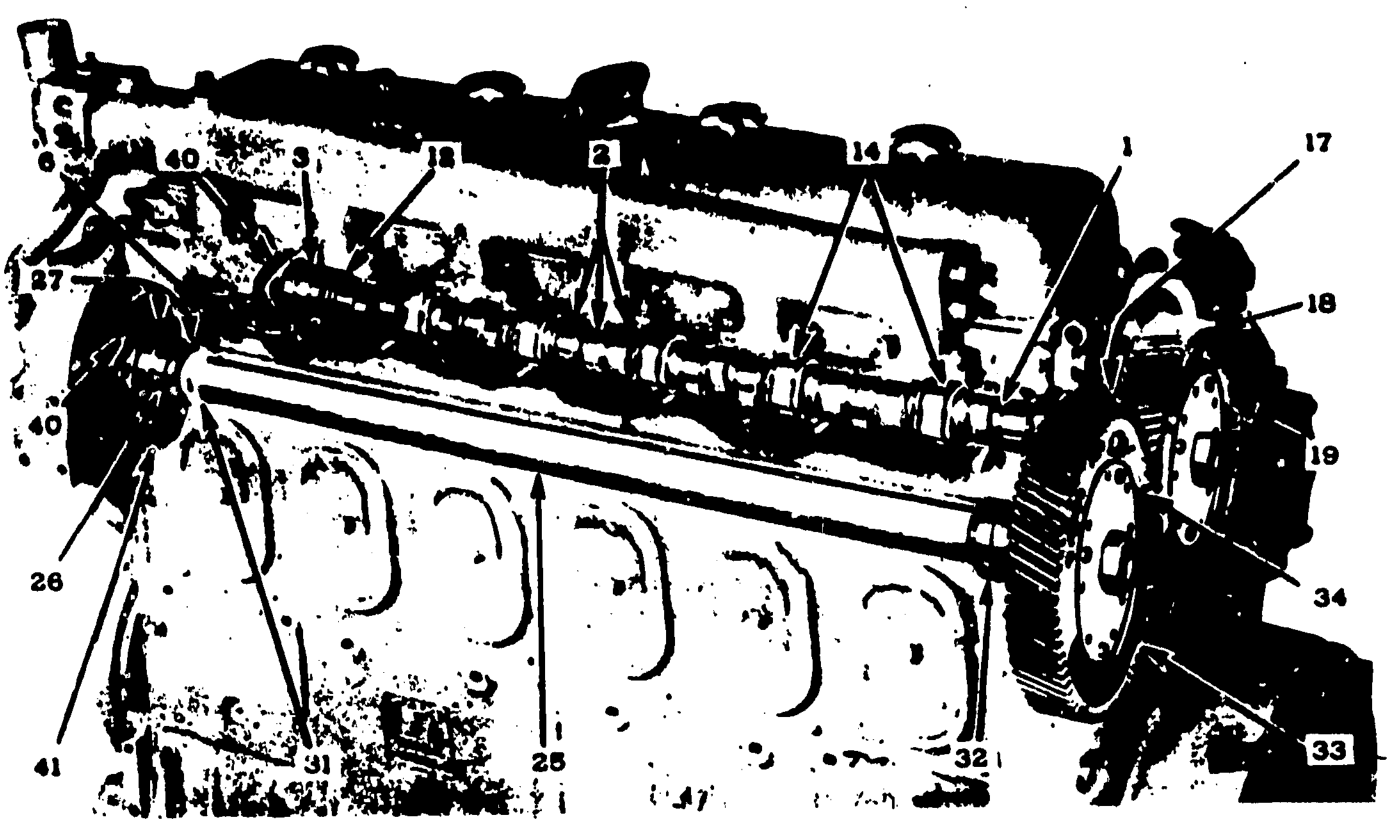
Valves must be timed correctly at all times, not only for proper operation of the engine, but also to prevent possible damage to the engine parts. Frequent inspections of the valve actuating linkage should be made during operation to determine if it is operating properly. Such inspections should include checking tappet clearances; checking for broken, chipped, or improperly seated valve springs; inspecting push rod springs; inspecting push rod end fittings for proper seating; and inspecting cam follower surfaces for grooves or scoring.

To insure good support, the camshaft is carried by a series of camshaft bearings, one bearing being located between each pair of cylinders, see Figure 6. The bearings are usually plain bushings or split sleeves; see Figure 7. If plain bushings are used, their bores are larger than the cams, so that the camshaft may be withdrawn endwise. If split bushings are used, the camshaft may be removed sidewise from the engine.

SECTION C -- BEARINGS AND THEIR MAINTENANCE

BEARING CORROSION - Corrosion of bearing materials is caused by chemical action of oxidized lubrication oils. Oxidation of oil may be minimized by changing oil at the designated intervals, and by keeping engine temperatures within recommended limits. Bearing failures due to corrosion may be identified by very small pits covering the surfaces. In most instances, corrosion occurs over small bearing areas in which high localized pressures and temperatures exist. Since the small pits caused by corrosion are so closely spaced that they form channels, the oil film is not continuous and the load-carrying area of the bearing is reduced below the point of safe operation.

Surface pitting of bearings may be due to high localized temperatures that cause the lead to melt. This is generally the result of very close oil clearances and the use of an oil having a viscosity higher than recommended. Early stages of the loss of lead, due to melting, will be evidenced by very small streaks of lead on the bearing surface.



1. Camshaft
2. Cam
3. Bearing--Camshaft Thrust
6. Washer--Camshaft Thrust
12. Thrust Shoulder--Camshaft
14. Bearing--Camshaft--Intermediate
17. Bearing--Camshaft--Rear
18. Gear--Camshaft--L.H. Helix
19. Weight--Integral Balance--Camshaft
25. Balance Shaft
26. Bearing--Balance Shaft--Front
27. Washer--Balance Shaft Thrust
31. Thrust Shoulder--Balance Shaft
32. Bearing--Balance Shaft--Rear
33. Gear--Balance Shaft--R.H. Helix
34. Weight--Integral Balance--Balance Shaft
40. Balance Weight
41. Hub--Balance Weight

Fig. 6 Camshaft and balance shaft bearings.

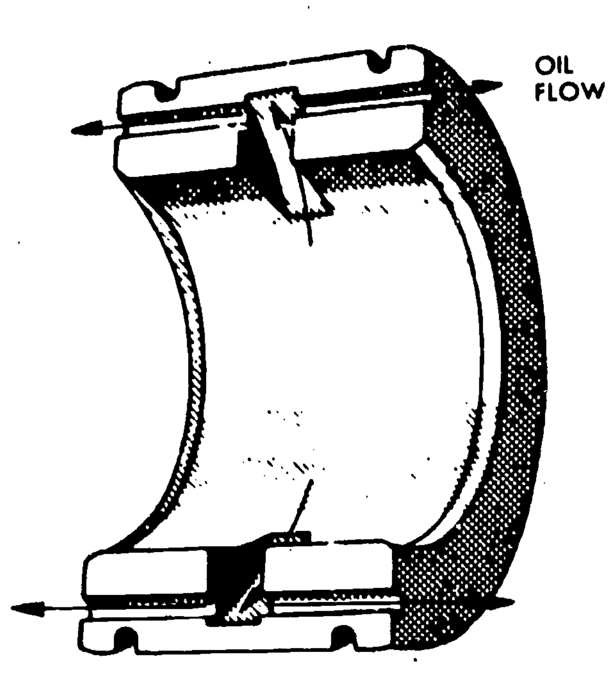


Fig. 7 Camshaft intermediate bearing (lower half).

Inadequate bond between the bearing metal and the bearing shell may lead to journal bearing failure. A poor bond may be caused by fatigue resulting from cyclic loads, or it may be the result of defective manufacturing. A failure because of inadequate bond is shown in Figure 8. In such failures, the bearing shell shows clearly through the bearing surface.

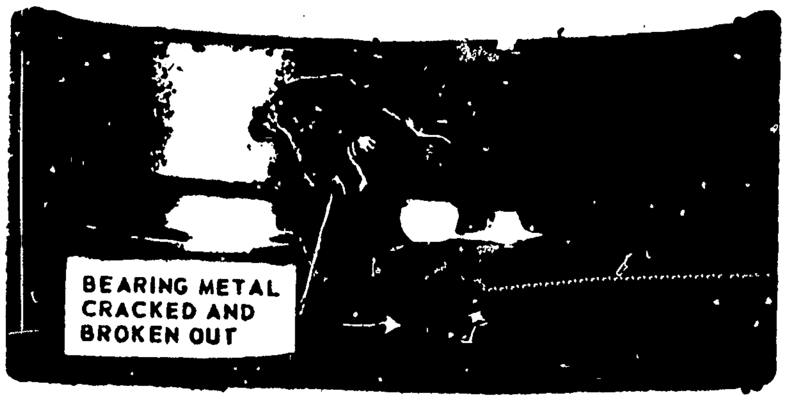


Fig. 8 Bearing failure due to inadequate bond.

Out-of-round journals cause journal bearing failures because of the resulting excessive bearing wear. As the bearings wear, excessive clearance is created; this leads to engine pounding and will allow oil leakage from the bearing, possibly reducing the flow of oil to other bearings. Overheating, which in turn causes the bearing material to melt, will result. To prevent bearing wear, the journals should be checked for out-of-roundness. Manufacturers require crankpins to be reground if the out-of-roundness exceeds a specified amount, but the amount varies from one manufacturer to another. Always check the engine manual for this type of data.

During every overhaul, the journals should be inspected for rough spots -- a burr or ridge may cause a groove in the bearing, and lead to bearing failure. If removal of rough spots is necessary, a fine oil stone and a piece of crocus cloth may be used for this operation. A clean cloth should be placed beneath the journal to catch all particles. It is advisable to place a coat of clean lubricating oil on the journal before the bearing is installed.

Misalignment of parts may lead to journal bearing failure. Misalignment of the main bearings can be caused by a warped or sprung crankshaft. This imposes heavy loads on the main bearings because of the force necessary to retain correct alignment between the bearing and journals.

A bent or misaligned connecting rod can be the cause of a ruined crank-pin bearing. A symptom of misalignment between the connecting rod bore and piston pin bushing bore is cracking of the bearing material at opposite ends of the upper and lower bearing shells. An indication of a bent connecting rod is heavy wear or scoring on the piston surface.

Faulty installation, as a cause of bearing failure, is usually a result of negligence or lack of experience. The important factor to keep in mind here is cleanliness. Hard particles lodge between the bearing shell and connecting rod bore, creating an air space. This space retards the normal flow of heat and causes localized high temperatures. Such a condition may be further aggravated by the bearing surface being forced out into the oil clearance space, creating a high spot in the bearing surface. The result may be a bearing failure similar to that shown in Figure 9.

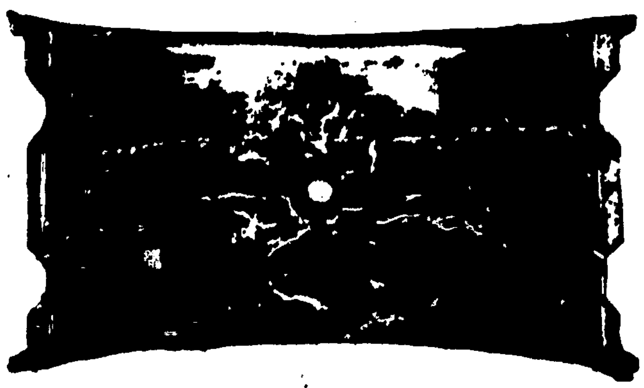


Fig. 9 Bearing failure resulting from wiping and excessive temperatures.

Foreign particles, excessive clearance or rough surface may cause poor contact between a bearing shell and a connecting rod. Poor contact is indicated by the formation of gumlike deposit (sometimes referred to as lacquer or varnish) on the back of a bearing shell.

Bearing failures may result from improper fit of the shell to the connecting rod. If the locking lip of a bearing does not fit properly into the recess of the bearing housing, distortion of the shell and failure of the bearing results.

Another source of trouble during installation is interchanging the upper and the lower shells. The installation of a plain upper shell in place of a lower shell, which carries an oil groove, completely stops the oil flow and leads to early bearing failure. The resulting damage not only ruins the bearing but may also extend to other parts, such as the crankshaft, connecting rod, piston, and wrist pin.

Failure to follow recommended procedures in the care of lubricating oil can cause bearing failures. The importance of an adequate supply of clean lubricating oil to the bearing surfaces cannot be over emphasized. The lack of proper amount of lubricating oil will cause the overheating of a bearing, causing a failure similar to that illustrated in Figure 10.

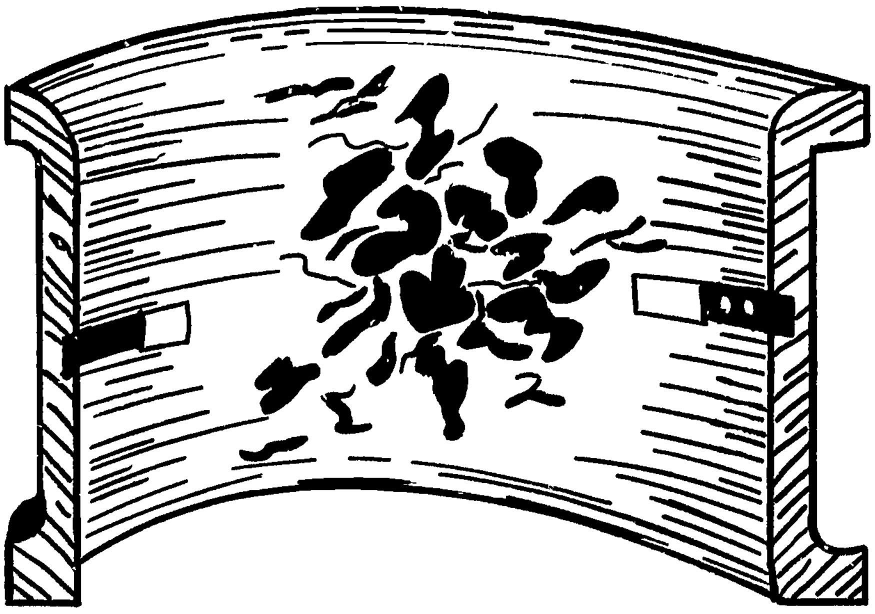


Fig. 10 Overheated bearing.

The maintenance of recommended oil pressures is essential to ensure an adequate supply of oil at all bearing surfaces. The oil pressure gauge is the best source of operational information to indicate satisfactory performance.

The use of approved low-corrosive lubricating oils is important. Recommended oil temperatures must be maintained. Recommended temperatures have been determined by extensive tests in laboratories and in service, and are sufficiently high to assure satisfactory circulation and sufficiently low to prevent excessive oxidation of the lubricating oil. When possible, oil must be analyzed at recommended intervals to determine if it is O. K. for further use. In addition to these precautions, regular service of oil filters and strainers must be maintained, and oil samples must periodically be drawn from the lowest point in the sump, to determine the possibility of the presence of abrasive materials or water. Strict adherence to recommended practices will reduce to a minumum the failure of bearings and other parts, caused by the use of contaminated oil or by an insufficient supply of clean oil.

SECTION D -- DETECTING FAILURE

Journal Bearing Failure - Severe bearing failures may be evidenced during engine operation by a pounding noise, or by the presence of smoke in the vicinity of the crankcase. Possible future failures may sometimes be detected by a rise in lubricating oil temperature, or a lowering of the lubricating oil pressure. Evidence of potential bearing failures may be detected during periodic maintenance checks or during engine overhauls by inspection of the bearing shells and backs for pits, grooves, scratches or evidence of corrosion.

The markings of the lower and upper bearing halves should always be checked in order that they may be installed correctly. Many bearings are interchangeable when new, but once they have become worn to fit a particular journal or crank pin, they must be reinstalled on that particular journal or pin. Each bearing half must be marked or stamped with its location (cylinder number) and the bearing position (upper or lower) to prevent incorrect installation.

Anti-friction Bearings - Troubles similar in nature and due to similar causes (see Table I) may be encountered with all types of frictionless bearings. However, the fact that many tapered roller bearings are adjustable, while other types generally are not, must be kept in mind when dealing with bearing troubles.

TABLE I

TROUBLE	CAUSES
DIRTY BEARING	Improper handling or storage. Use of dirty or improper lubricant Failure to clean housing Poor condition of seal
SPALLED OR PITTED ROLLERS OR RACES	Dirt in bearing Water in bearing Improper adjustment of tapered roller bearing Bearing misaligned or off square.
DENTED (Brinelled) RACES	Improper installation or removal Vibration while bearing is inoperative.
FAILED SEPARATOR	Initial damage during installation or removal Dirt in the bearing
RACES ABRADED ON EXTERNAL SURFACES	Locked bearing Improper fit of races
CRACKED RACE	Improper installation or removal (cocking)
EXCESSIVE LOOSENESS	Abrasives in lubricant

DIRTY BEARINGS will have a very short service life, so every possible precaution must be taken to prevent the entry of foreign matter into a bearing. Dirt in a bearing which has been improperly or insufficiently cleaned may be detected by noise when the bearing is rotated, by difficulty in rotating, or by visual inspection. A frictionless bearing should not be discarded until it has been definitely established that something in addition to dirt has caused trouble. This may be determined by properly cleaning the bearing.

SPALLED OR PITTED ROLLERS or races may be first recognized by the noisy operation of the bearing. Upon removal and after a very thorough cleaning, the bearing will be noisy when rotated by hand. (Never spin a frictionless bearing with compressed air.) Roughness may indicate spalling at one point on the raceway. However, the cleaning must be thorough since a small particle of dirt can cause an identical symptom.

Particular attention should be given to the inner surface of the inner race, since it is here that most surface disintegration first occurs. Pits may be covered with rust. Any sign of rust on the rollers or contact surfaces of the races is a probable indication that the bearing is ruined.

BRINELLED OR DENTED RACES are most easily recognized by inspection after a thorough cleaning. Brinelling receives its name from its similarity to the Brinell hardness test, in which a hardened ball is pressed into the material. The diameter of the indentation is used to indicate the hardness of the material. Bearing races may be brinelled by excessive and undue pressures occurring during installation or removal, or by vibration while the bearing is inoperative. If heavy shafts supported by frictionless bearings are allowed to stand motionless for a long time, and if the equipment is subject to considerable vibration, brinelling may occur. This is due to the peening action of the rollers or balls on the races.

Brinelled bearings must not be placed back in service. However, steps can be taken to prevent brinelling. Proper maintenance procedures will help a great deal, and the best insurance against brinelling caused by vibration is to rotate the shafts supported by frictionless bearings at regular intervals (at least once a day) during periods of idleness. This will prevent the rollers from resting too long upon the same portion of the races.

SEPARATOR FAILURE may become apparent by noisy operation. Inspection of the bearings may reveal loose rivets, failure of a spot weld, or cracking and distortion of the separator. Failure of separators can usually be avoided if proper installation and removal procedures are followed, and steps are taken to prevent the entry of dirt.

ABRASION (scoring, wiping, burnishing) on the external surface of a race indicates that relative motion has occurred between the race and the bearing housing or shaft surface. It is customary to make the race adjacent to the rotating member a press fit on, or in, that member. The race adjacent to the stationary member is usually made a push fit so that some creep will occur. Creep is a very gradual rotation of the race. This extremely slow rotation is desirable as it prevents repeated stressing of the same portion of the stationary race. Wear resulting from the proper creep is negligible and no damaging abrasion occurs. However, abrasion caused by locked bearings or the improper fit of the races must be prevented.

CRACKED RACES will usually be recognized by a definite thump or clicking noise in the bearing during operation. Cleaning and inspection is the best means of determining if a crack exists. Cracks usually form parallel to the axis of the race. The cracking of bearing races seldom occurs if proper installation and removal procedures are followed.

EXCESSIVE LOOSENESS may occur on rare occasions even though no surface disintegration is apparent. Since many frictionless bearings appear to be loose, even when new, looseness is not always a sign of wear. The best check for excessive looseness is to compare the suspected bearing with a new one.

Wear of bearings, causing looseness without apparent surface disintegration, is generally caused by the presence of fine abrasives in the lubricant. Taking steps to exclude abrasives and keeping lubricating oil filters and strainers in good condition is the best way to prevent this type of trouble.

Most of the troubles listed in Table I require the replacement of an antifriction bearing. The cause of damage must be determined and eliminated so that similar damage to the replacement bearing may be prevented.

Dirty bearings may be made serviceable with a proper cleaning, providing other damage does not exist. In some cases, races abraded on the external surfaces can be made serviceable, but it is generally advisable to replace abraded bearings. Dirty frictionless bearings must be thoroughly cleaned before rotating or inspecting them.

In conclusion, diesel engine bearing wear or failure can be attributed to the following conditions:

1. Over speeding
2. Improper bearings
3. Plugged oil passages
4. Poor oil quality
5. Abrasives in lubricant from inlet air or engine part failures
6. Insufficient oil due to excessive wear
7. Lugging or overloading
8. Excessive oil or bearing temperature.

DIDACTOR PLATES FOR AM 1-9D

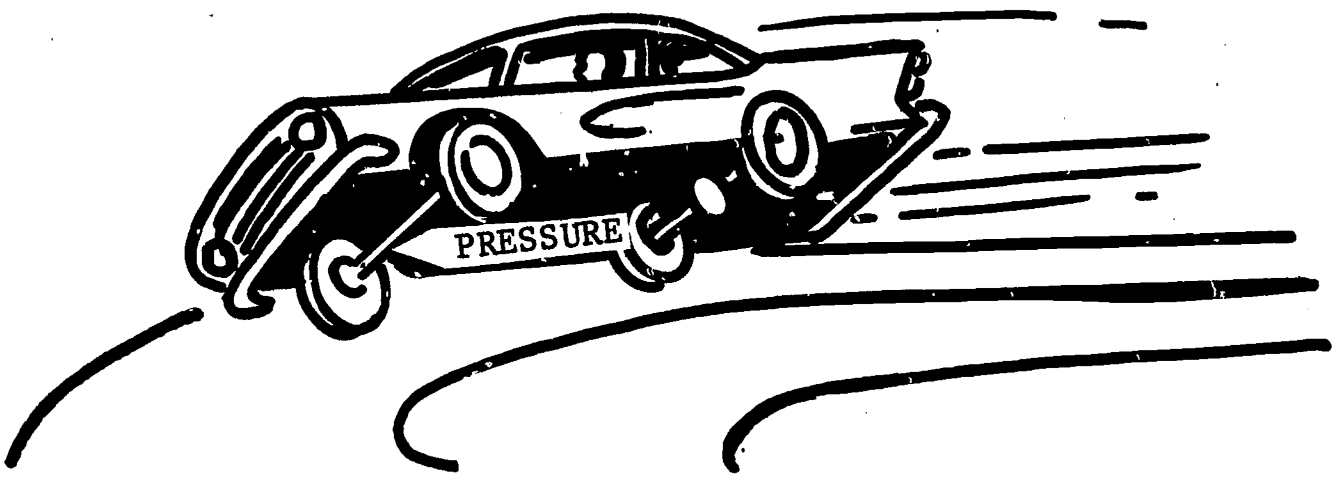


Plate I Example of thrust load.

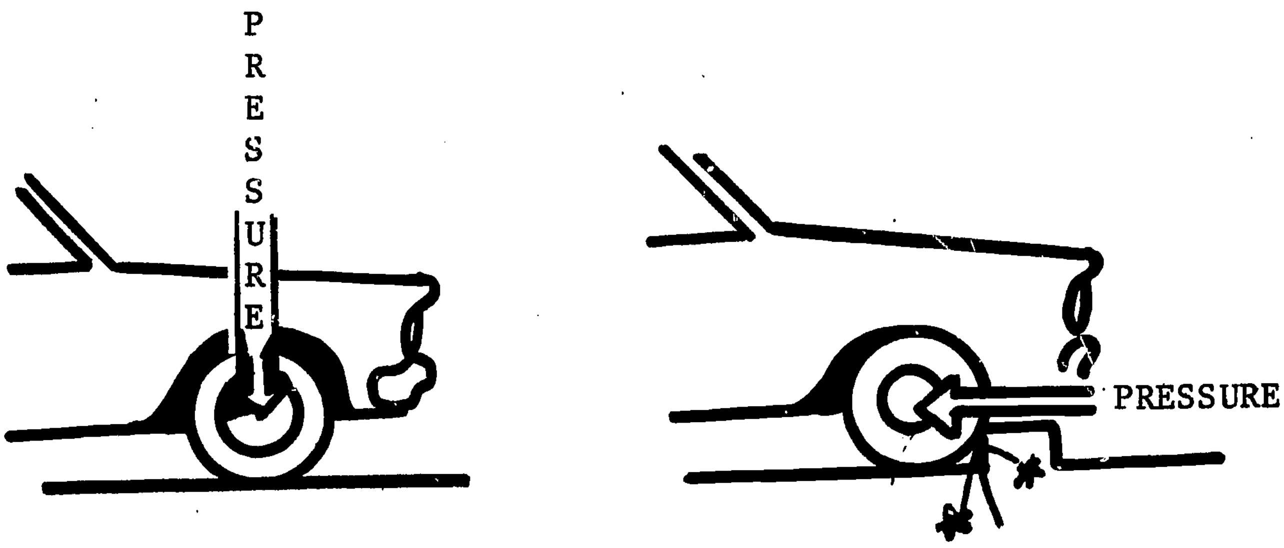


Plate II Examples of radial load.

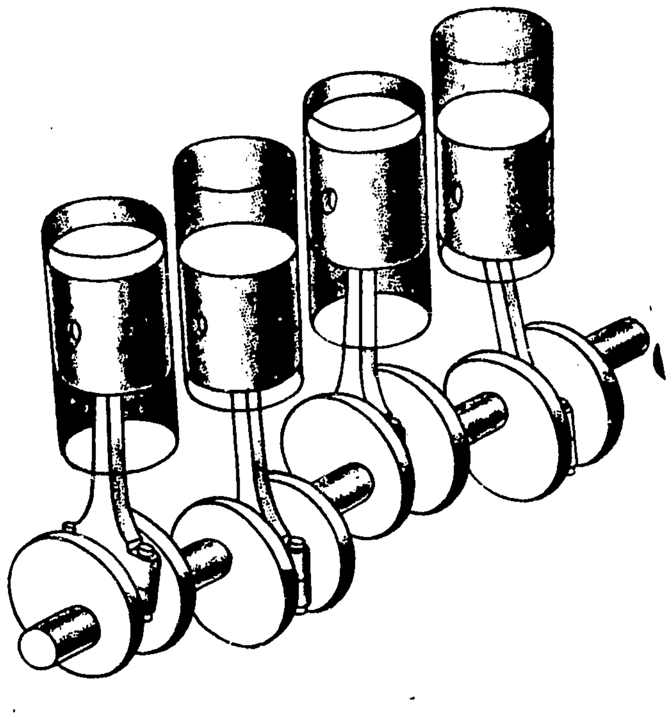


Plate III Crankshaft radial load.

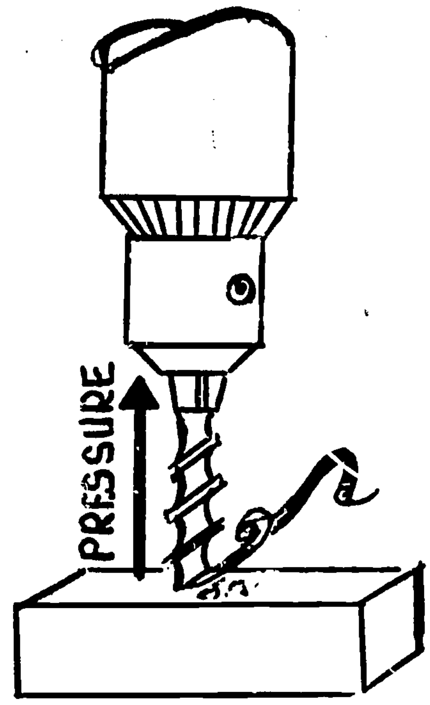


Plate IV Example of thrust load.

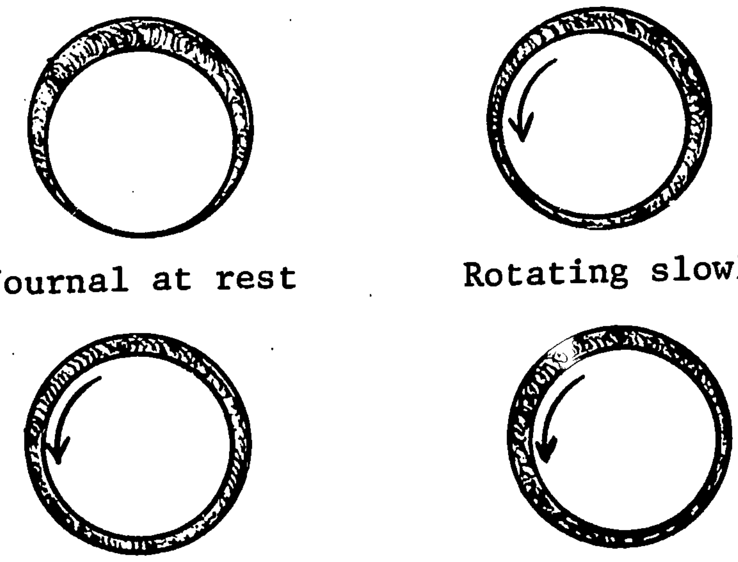


Plate V Spinning shaft drags oil into a wedge-shaped layer between journal and bearing, lifting up shaft.

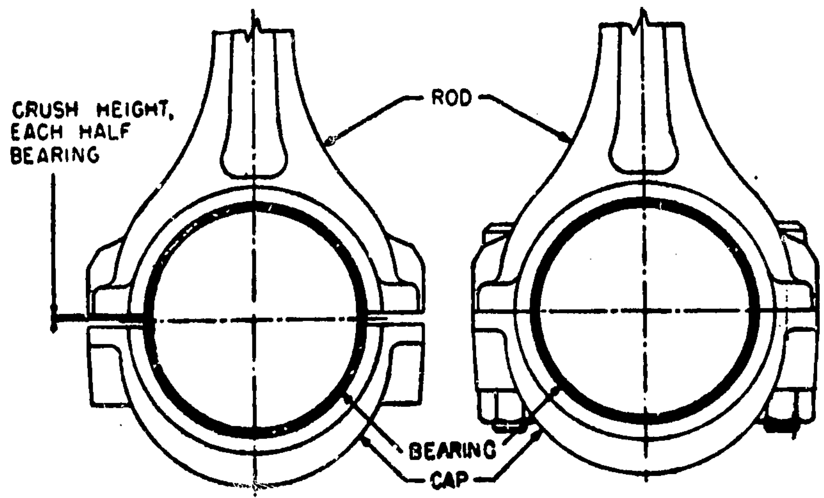


Plate VI Illustration of bearing crush.

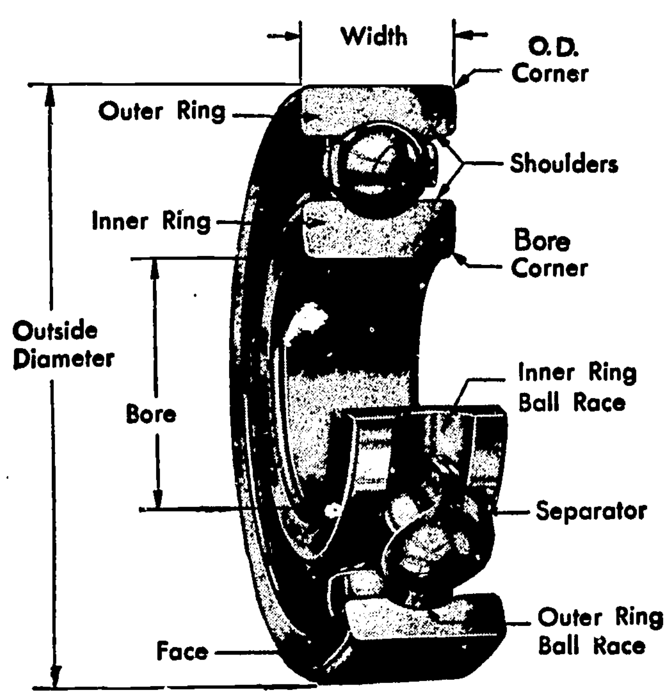


Plate VII Ball bearing.

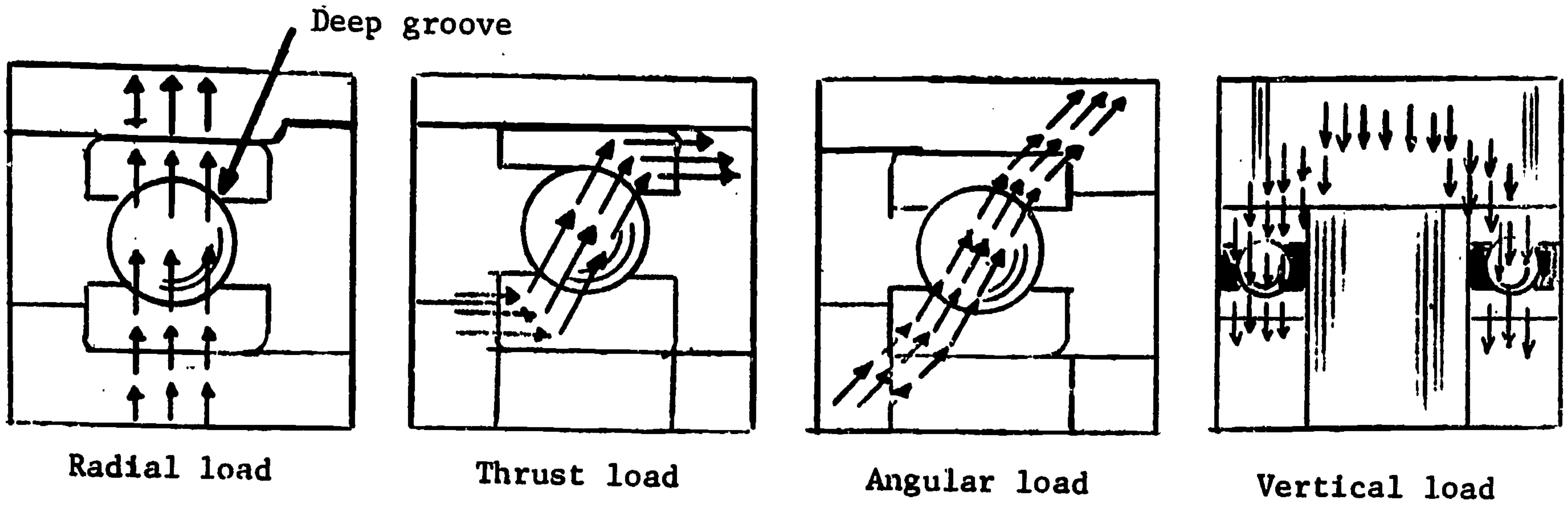


Plate VIII Ball bearings carrying radial, thrust loads.

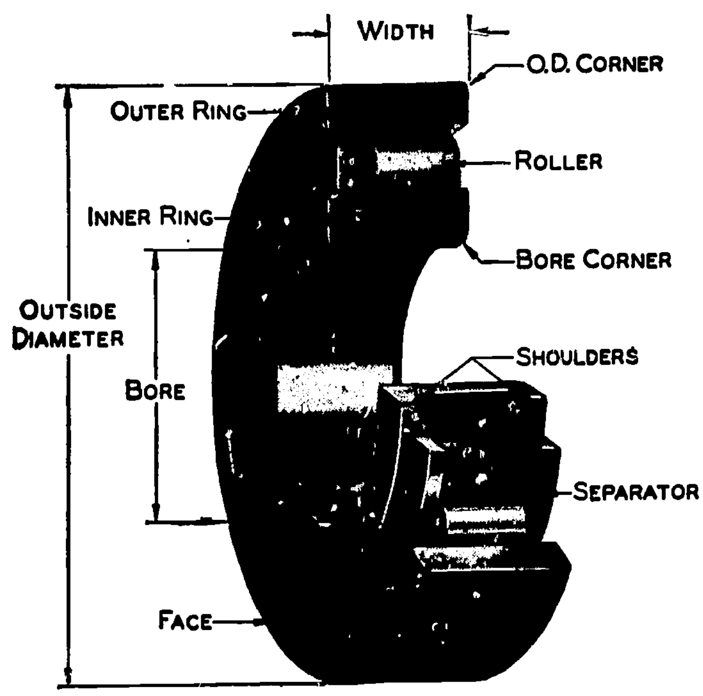


Plate IX Roller bearing.

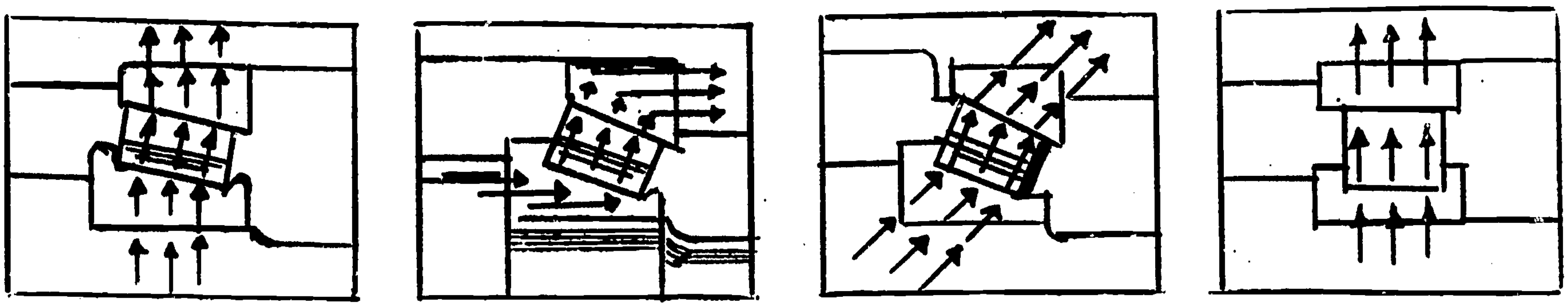
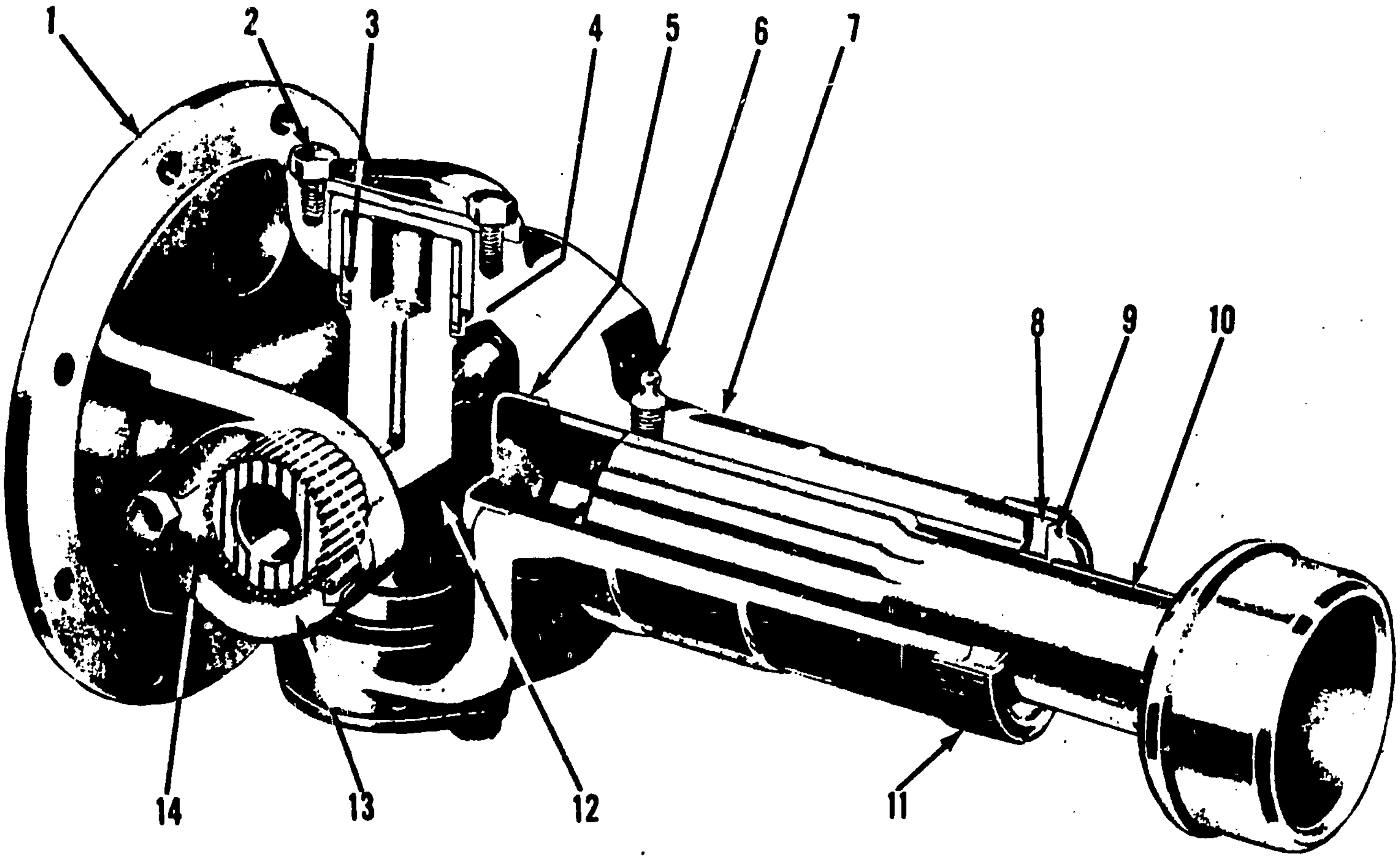


Plate X Applications for roller bearings.



1-Flange Yoke
2-Cap Screw
3-Gasket
4-Gasket Retainer
5-Sleeve Yoke Plug
6-Grease Fitting
7-Sleeve Yoke Assembly
8-Cork Washer
9-Steel Washer
10-Slip Stub Shaft
11-Dust Cap
12-Journal Cross Assembly
13-Bearing Cap Assembly
14-Lock Strap

Plate XI Cutaway of universal and slip joint.

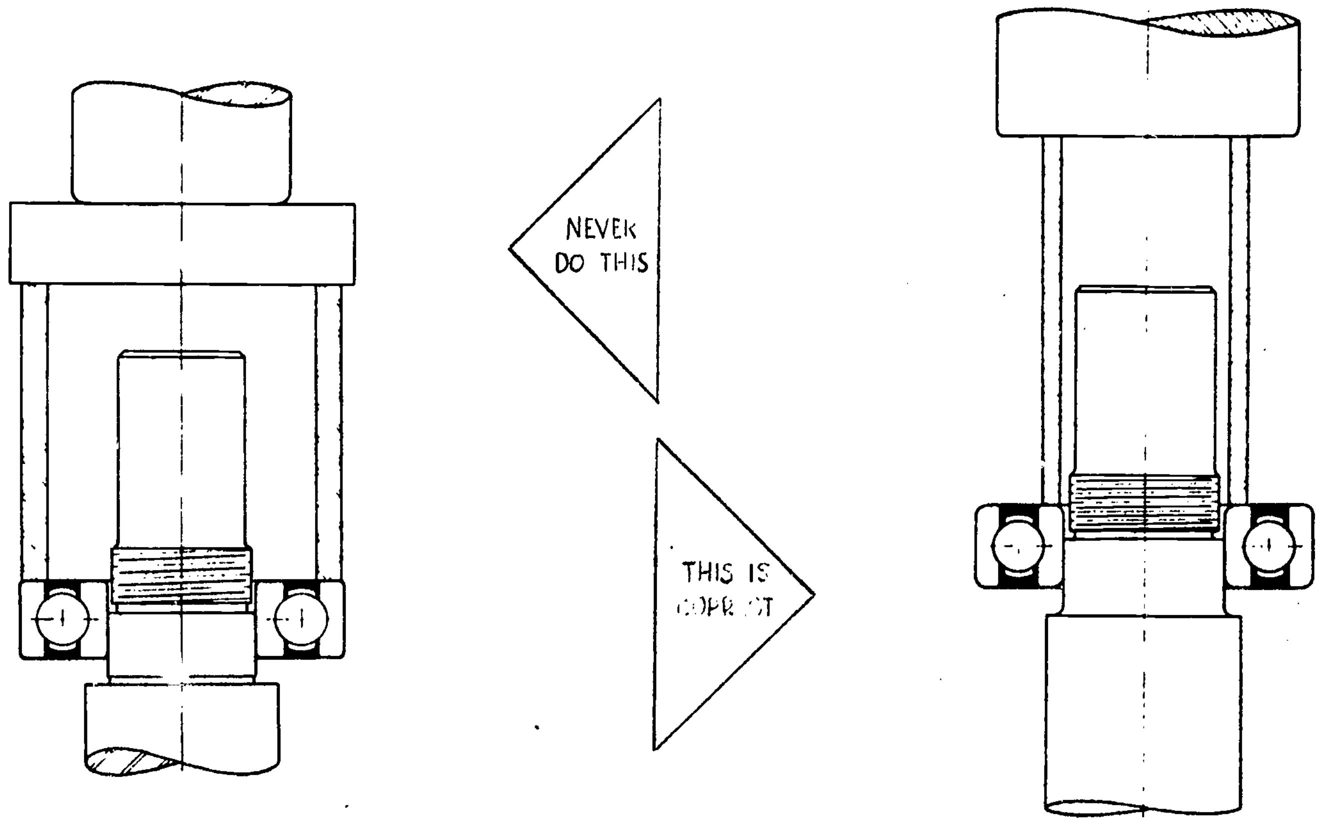


Plate XII Shaft mounting the bearing.

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ENGINE COMPONENTS - PART II

Human Engineering Institute

Press A 1 Check to see that timer is OFF

1

1

This program has been designed to supplement the classroom text AM 1-9 and covers the various types of bearings used in diesel equipment. Particular emphasis will be placed on their construction, operation, maintenance and inspection.

Bearings are used to support rotating shafts and other moving parts and to transmit loads from one engine part to another.

Press A 2

1

2

Two types of force or pressure act on bearings. THRUST LOAD refers to a pressure that acts parallel to, or along, the axis. An example of thrust load is the pressure on a wheel bearing of a car speeding around a curve, see Plate I.

RADIAL or axial load refers to pressure that acts perpendicular to an axis and can be on any part of the axis or circle. Plate II shows the radial force that is applied to the wheel bearings of a car. The pressure is directed to the top of the outer race of the bearing.

Press A 3

1

3

What are the two types of force or pressure that act on bearings?

A. Thrust and parallel. 4
B. Radial and axial. 5
C. Thrust and radial. 6

1

4

No. your answer is incorrect. Remember a thrust force or load runs parallel to an axis. The two types of force or pressure that act on bearings are thrust and radial.

Press A 6

1

5

No, your answer is incorrect. Radial and axial are the same type of force or load. The two types of force or pressure that act on bearings are thrust and axial.

Press A 6

1

6

"Thrust and radial" is the correct answer.

[illegible] main bearings on the crankshaft are an example [illegible] _________ load type bearings. (Choose the correct word.)

A. reduction 7
B. radial 9
C. thrust 8

1

7

No. We did not mention reduction type loads. Remember we said there were two kinds of loads or bearings: thrust type and radial or axial type loads. The journal bearings on the crankshaft are of the radial type. The pressure is perpendicular to the shaft, see Plate III.

Press A 9

1

8

No. You are confused. Remember we said that a thrust load was one that acts parallel to or along the axis. Another example of a thrust load is a hand drill. Pressure is applied on the chuck which is rotating and is parallel to the drill, see Plate IV.

Press A 9

1

9

"Radial" is the correct answer. Now let's see how a journal or sliding type bearing, typical of the main bearings on a crankshaft, absorbs the tremendous radial pressures that it receives without undue wear.

As we know, the purpose of the main bearings is to support the crankshaft as it is rotating, and to absorb the shock pressures from the pistons. Therefore these bearings must (1) reduce the friction between the moving surfaces by separating them with a film of oil, and (2) carry away the heat produced by a unavoidable friction.

Press A 10

1

10

Bearings reduce the friction between moving surfaces by____ __________.

A. separating them with a film of oil 13
B. being very highly polished. 11
C. carrying away the heat. 12

1

11

Your answer is partially correct. The highly polished surface of bearings is intended to help reduce friction. Bearings, however, reduce friction between moving surfaces even more by separating them with a film of oil.

Press A 13

1

12

No. your answer is incorrect. Bearings reduce friction between moving surfaces by separating them with a film of oil. "Carrying away heat" (which is caused by friction) is another function of a bearing.

Press A 13

1

13

"Separating them with a film of oil" is correct.

It's easy enough to push a log across the pond, but it is quite different to pull that same log up on the shore. This is just one of many examples of the difference between fluid and dry friction.

Fluid friction exists in the main bearings when oil is forced between the two surfaces under pressure. This is known as an oil wedge or film that lifts the one surface from the other and allows it to ride almost friction-free.

Press A 14

1

14

As the shaft is lifted, oil sticks to both surfaces (top and bottom). When the top surface is moved, the lubricant film "breaks" into layers like a deck of cards, with each layer dragging at the one below. Plate V shows a journal starting to move from a rest position to high speed. Notice the layer of film that is built-up between the shaft and the bearing.

Press A 15

1

15

For fluid to exist in the main bearings oil must ____________________.

A. be present in the bearing housing. 16
B. be forced between the two bearing surfaces under pressure. 18
C. be present in large quantities around the bearing. 16

1.

16

No, your answer is incorrect. For fluid friction to exist in the main bearings, oil must be forced between the two surfaces under pressure.

Press A 18

1

18

"Forced between the two surfaces under pressure" is correct.

One of the disadvantages of this type of bearing is the high starting friction that is involved. Until the oil pressure is built up and the engine parts can be lubricated sufficiently, the shafts are rubbing against the bearings. This is why it is vitally important to constantly watch oil pressure in a diesel engine. Also, a sufficient amount of oil must be supplied in the engine, because enough oil must be available under pressure to lift the shaft off the bearing, and maintain this separation.

Press A 19

1

19

Now we can see why it is important that oil is of a certain viscosity or has a "resistance to flow." In an engine the loads are constantly changing. This means the shaft is constantly trying to destroy the oil film. If the engine were using very light oil, this film would be sheared for short periods of time, allowing the metal surfaces to come in contact. However, if the oil had sufficient viscosity, it would resist the shifting of the shaft and prevent wiping of the bearing.

Press A 20

1

20

Bearings supporting the crankshaft must ______________.

A. be of the thrust load type to fight the constant change in pressure and reduce friction. 21
B. be lubricated with oil that has no resistance to change. 21
C. be of the radial load type and be lubricated with oil that has resistance to change. 22

1

21

No, bearings supporting the crankshaft are radial type bearings. Remember we also said the oil used in diesel engines must have a certain viscosity or resistance to flow. If it is too light, it will not withstand the constant load changes on the shaft.

Press A 22

1

22

OK. Crankshafts bearings have pressure exerted perpendicular to the shaft, making them radial type bearings. Also, the oil must have resistance to internal shearing (viscosity).

Usually main bearings in diesel engines are of the split half type. This is ______________.

A. so the oil can circulate better. 23
B. so the crankshaft can be removed easier. 25
C. so the bearings can be changed easier. 24

1

23

No. Whether the bearing is split or whole does not affect the lubrication as long as the correct tolerance is maintained. The answer we wanted was "so the bearings can be changed easier."

Press A 25

1

24

No. This would not affect the removal of the crankshaft. The answer we wanted was "so the bearings can be changed easier"

Press A 25

1

25

OK. As we mentioned earlier, main bearings are subject to fluctuating loads. This is also true of connecting rod bearings and piston pin bearings.

In a two stroke engine (GM), a load is always placed on the lower half of the main bearings and the piston pin bearings in the connecting rod; but upon the upper half of the connecting rod bearings at the crankshaft end of the rod. This is true because the forces of combustion are greater than the inertia forces created by the moving parts.

Press A 27

(XC) 26

2

26

OK You have answered one or more of the questions ~~incorrectly in this section of~~ material. You will be reviewing this data now. Please read carefully and think before you answer.

Press A → 1

2

27

Inertia forces can be explained as the resistance of a body to change motion. It is the tendency of an object to continue to move in the same direction. An example of this would be an automobile continuing to move after the power has been cut off. The inertia forces of reciprocating parts gradually change each cycle, and their direction is reversed every time a piston reaches top or bottom dead center.

In a four-cycle engine, the load is applied first on one bearing shell of the main bearing and then on the other shell. The reversal of pressure is the result of the large forces of inertia imposed during the intake and exhaust strokes. In other words, inertia tends to lift the crankshaft in its bearings during the intake and exhaust strokes.

Press A 28

2

28

In a two-cycle engine, the pressure is exerted on the ________________ halves of the main bearings in the crankshaft when the piston is on the downward stroke.

A. lower 31
B. upper 29
C. both 30

2

29

No. As the piston moves down on the power stroke the pressure is applied to the upper half of the connecting rod bearing at the crankshaft, but it is applied to the lower half of the main bearings that support the crankshaft.

Press A 31

2

30

No. It would not be applying pressure to both halves on the power stroke, it would have to be the lower half.

Please read more carefully and take your time in answering the questions.

Press A 31

2

31

OK. "Lower" is correct.

On a four-cycle engine the pressure is exerted on the __________ half(ves) of the main bearings during the power stroke and the ____________ half(ves) of the bearings during the intake and exhause strokes.

A. upper, both 32
B. lower, upper 33
C. lower, both 32

2

32

No, you are incorrect. Pressure could not be exerted against both the halves at once. The pressure is exerted on the lower half during the power stroke and the upper half during the exhaust and intake stroke.

Press A 33

2

33

OK. You have the idea now about radial load bearings and their operation. Before moving on to other types of bearings, let's talk a little about assembling bearing inserts.

As mentioned earlier in the program it is <u>very important</u> that bearing inserts have good contact with the housing or seat. To assure this, the diameter of the two inserts is slightly greater than the diameter across the parting surface when the bearing is in place. This amount is then compressed when the bearing is drawn up tight. Each half shell is made slightly in <u>excess</u> of an exact half circle.

Press A 34

2

34

The <u>excess</u> is called <u>CRUSH, see Plate VI</u>, and its purpose is to permit the shell to be firmly clamped in the bearing seat. If the bearing does not have the proper amount of crush, it will not be held securely and will have a slight degree of movement during operation.

Loose inserts will allow oil to work in between the back of the bearing and the housing. This cuts down the heat conduction and tends to raise the bearing temperature. Also, a certain amount of flexing will occur, which raises the bearing temperature and results in early bearing failure.

Press A 35

2

35

Bearing inserts are assured of a good contact with the housing or seat by ______________.

A. firmly clamping the inserts around the shaft. 36

B. making the diameter of the two inserts slightly smaller than the diameter across the parting surface. 36

C. making the diameter of the two inserts slightly greater than the diameter across the parting surface. 38

2

36

No, your answer is incorrect. Bearing inserts are assured of good contact with the housing or seat by making the diameter of the two inserts slightly <u>greater</u> than the diameter across the parting surface. Then, when the inserts are firmly clamped in the bearing seat this excess is compressed. This excess is called <u>crush</u>.

Press A 38

2

38

OK. The diameter of the inserts is made <u>greater</u>. This "crush" is necessary for good contact between the bearing inserts and the housing.

Lack of the proper crush can be caused by dirt between the surfaces. The dirt will act as shims and cause scoring of the surfaces. <u>Clealiness is very important in these areas.</u>

Bolt torque on crankshaft bearings is also very important for proper bearing performance. Maintenance manual specifications should be strictly followed when assembling these bearings. Any variation in bolt torque in this area could affect the crankshaft life, bearing crush, clearance, and of course bearing performance.

Press A 39

2

39

When flexing or movement occurs between the bearing, bearing cap, and shaft, it is usually the result of ______________.

A. too high of an oil pressure. 40

B. dirt or filings gathering between the surfaces. 42

C. too much bolt torque on bearing cap. 41

2

40

No, we did not mention oil pressure as a factor for flexing or movement. The answer we wanted here was that dirt or foreign material might be getting between the surfaces. Remember, we said that this situation causes improper crush, which results in bearing movement.

Press A 42

2

41

No. If too much bolt torque was applied to a bearing cap, one of two things would probably happen: (1) the studs would snap during tightening; or (2) the crankshaft would not move freely with the bearings installed.

The answer we wanted here was that dirt or filings may have worked between the surfaces causing improper crush which results in bearing movement.

Press A 42

2

42

OK. Dirt or foreign material of some kind working in between the surfaces can cause improper crush which may result in movement or flexing.

In a two-cycle engine, it is very unlikely that the _______________ half of the crankshaft main bearings will wear. Choose one.

A. upper 44
B. lower 43
C. loaded 43

2

43

No. The lower half and the loaded half are the same thing. Remember we said that on a two-cycle, the load is placed on the bottom half of the main bearings. The correct answer here was the upper half receives very little wear.

Press A 44

2

44

OK. You are correct. Most manufacturers recommend that when replacing the lower half of a bearing, it is well to replace the upper half also. Some shops replace all the bearings whenever one is found to be bad. Now let's discuss bearings with rolling contacts.

Properly designed and precision-manufactured bearings with rolling contact have the following advantages over plain bearings with sliding contact:

1. They will maintain a comparatively accurate alignment over long periods of time.
2. They can carry heavy momentary overloads without failure or seizure.

Press A 45

2

45

3. Their power loss due to friction is small.
4. They are particularly adapted to variable-speed operation because their coefficient of friction is practically independent of speed.
5. For the same reason they have a low starting resistance.
6. Their lubrication is simple and requires little attention. Due to small power loss, ball and roller bearings are often called anti-friction bearings.

Press A 46

2

46

Which of the following could be considered an advantage of bearings with rolling contacts over bearings with sliding contact?

A. They are immune to the effects of dirt. 47
B. Their power loss due to friction is small. 49
C. They are cheaper to produce. 48

2

47

No, your answer is incorrect. All bearings can be damaged by dirt. Remember dirt introduces friction and the purpose of the bearings is to eliminate friction. The advantage of bearings with rolling contacts that was listed on the previous frame is "their power loss due to friction is small."

Press A 49

2

47

No, your answer is incorrect. Bearings with rolling contacts are more expensive to produce than bearings with sliding contacts. The advantage of bearings with rolling contacts that was listed on the previous frame is "their power loss due to friction is small."

Press A 49

2

49

"Their power loss due to friction is small" is correct.

A disadvantage of both ball bearings and roller bearings is that they require precision-made outer and inner races which cannot be split into halves, and therefore can be used only on straight shafts either of constant diameter or with diameter decreasing toward the end of the shaft. Standard ball and roller bearings, therefore, cannot be used on crankshafts with several cranks. Another disadvantage is that their load capacity decreases with an increase of speed; finally, their cost is higher than that of plain bearings.

Ball bearings, see Plate VII, are more widely used than roller bearings because the extreme precision required for satisfactory operation is easier to obtain with ball bearings.

Press A 50

2

50

Ball bearings support the load on a series of hardened steel balls and are sometimes said to have point contact. Actually because of their resistance to deformity, they perform with very small contact areas.

A ball bearing consists of four main elements: (see Plate VII) (1) an inner ring or race, grooved on its inner surface; (2) an outer race grooved on its inner surface; (3) steel balls; and (4) a ball retainer or cage for spacing the balls so that they do not touch each other, thus reducing loss of power, wear, and noise.

2

Press A 51

51

The reason ball bearings are not used in place of sliding bearings for crankshaft bearings is______________________________.

A. they are not made to carry the heavy thrust loads. 52
B. their construction will not permit it. 54
C. they will not maintain accurate alignment. 53

2

52

No, this is not the reason we wanted here.

Actually ball bearings will carry momentary overloads very well. However, there is a better reason for not using them on crankshafts: they are made in one piece and cannot be slipped over the cranks because their construction will not permit it.

Press A 54

2

53

No. They do maintain accurate alignment. The correct answer is that ball bearings are made in one piece and cannot be mounted on the crankshaft - their construction will not permit it.

Press A 54

2

54

OK. It is because the ball bearing is constructed in one piece that it cannot be used on the crankshaft type of installation.

Ball bearings are more widely used than roller bearings because______________________________.

A. the extreme precision required for satisfactory operation is easier to obtain with ball bearings. 57
B. they require less lubrication and maintenance. 55
C. they can carry heavy momentary overloads without failure or seizure. 56

2

55

No, your answer is incorrect. Ball bearings are more widely used than roller bearings because the extreme precision required for satisfactory operation is easier to obtain with ball bearings. Both roller and ball bearings require less lubrication and maintenance than sliding bearings.

Press A 57

2

56

No, your answer is incorrect. Both roller and ball bearings can carry heavy momentary overloads without failure or seizure. Ball bearings are more widely used than roller bearings because the extreme precision required for satisfactory operation is easier to obtain with ball bearings.

Press A 57

2

57

OK. Ball bearings are more widely used than roller bearings because the extreme precision required for satisfactory operation is easier to obtain with ball bearings.

There are many types of ball bearings. However, most are a variation of the "deep-groove type", or non-loading-groove type. As shown in Plate VIII, the deep groove raceways are provided in each ring. These are formed to give the balls a contact angle perpendicular to the bearings axis (line drawn through points of contact of ball and races).

3

Press A 59
(XC)→58

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58

You have answered one or more of the questions in this sequence of material incorrectly and it will be well for you to review the material again. Please read carefully and think before you answer.

Press A 25

3

59

This type of ball bearing is the most widely used because of its versatility. It can handle radial loads and can accept almost any equal amount of thrust load in either direction, in combination with the radial load. Plate VIII shows examples of ball bearings and how they are designed for different loads.

ROLLER bearings are a development of ball bearings and have cylindrical, conical, or barrel-shaped rollers instead of balls, see Plate IX. The load capacity of roller bearings, for the same outside dimensions, is greater than the ball bearings, due to the larger contact area. However, they are more sensitive to misalignment. Bearings with conical, often called tapered rollers, and correspondingly shaped races can be adjusted for axial clearance by the use of shims. On large vehicle front wheels, the use of the castellated and cotter keys provide for adjustment.

Press A 60

3

60

The deep-groove or non-loading-groove type ball bearings are the most widely used bearings because ____________________.

A. they require little maintenance. 61

B. there is more need for thrust type bearings than radial types. 62

C. they have more versatility. 63

3

61

True, they do require little maintenance, but if you don't have a need for them, then the maintenance factor is of little concern. The answer we wanted here was that they have more versatility because they are able to absorb both radial and thrust forces.

Press A 63

3

62

No. Probably if a survey were taken, we would find more need for radial load type bearings than the thrust type. The point here is that these type bearings do both jobs, hence they have versatility.

Press A 63

3

63

OK. They have more versatility is the correct answer. They can absorb both thrust and radial loads equally well.

The load capacity of roller bearings, for the same outside dimensions, is greater than the ball bearings, due to the ____________________.

A. number of rollers as compared to balls. 64

B. axial clearance capabilities of roller bearings. 65

C. greater contact area of the roller bearing. 67

3

64

No, the number of balls or rollers has nothing to do with the carrying capacity of bearings. It's the contact area that gives the greater load carrying capabilities.

Press A 66

3

65

No, remember we said the tapered roller bearings have the axial clearance capabilities. The answer we wanted was that the greater contact area provided by the rollers enables the bearing to carry greater loads.

Press A 66

3

66

The greater contact area enables the bearing to carry more load is correct. The different loads that are applied to straight roller bearings and tapered roller bearings are shown in Plate X.

Another type roller bearing is called the needle bearing. These may be considered a special design type of a roller bearing. They are identified by the length of the rollers which do not run in a retainer as the ball bearings do.

Press A 67

3

67

Needle bearings are used where oscillation of the shaft occurs. They are capable of carrying heavy radial loads without taking up a large amount of space. Since the needles cannot be flange guided, this bearing has a high friction characteristic and operates best where the load is relieved periodically to give the needles a chance to relocate themselves. Plate XI shows one application of this type of bearing in a universal and slip joint from a 45 ton truck. The needle bearings assist the drive line to pivot in any direction, which accommodates any misalignment of the transmission and differential. Other applications of needle bearings are crankpins, wrist pins, and cam rollers.

Press A 68

3

68

Needle bearings are different from the ball or roller bearings in that ______________.

A. the needle bearings do not have a high friction characteristic. 69
B. there is less chance for misalignment. 70
C. they are not flange guided. 71

3

69

No. The needle bearings do have a higher friction characteristic because there is more surface contact. The correct answer here is that the needle bearings are not flange guided.

Press A 71

3

70

No. There is more chance for misalignment due to the needles not being flange guided as we mentioned earlier.

Let's move on.

Press A 71

3

71

OK. The needle bearings are not flange guided like the ball bearings.

Another difference between the ball bearing and the needle bearing is that the______________.

A. needles are housed in a retainer. 72
B. needles are not housed in a retainer. 74
C. needle bearing will take thrust load. 73

3

72

No. Remember we said the needles are not housed in a retainer and it is best if the load is periodically relieved to allow the needles to relocate themselves.

Press A 74

3

73

No. Remember we said the needle bearing operates best where radial loads are imposed. The correct answer here is that the needles are not housed in a retainer.

Press A 74

3

74

OK The needle bearing has no retainer to house the needles, the needles roll against each other within the bearing.

In Plate XI, the reason for using a needle bearing is_________________________.

A. to absorb the horizontal load when movement occurs. 77
B. to absorb the thrust load when movements occur. 75
C. to absorb the shock of the rotating universal. 76

3

75

No. Remember we said thrust load is applied to the side of the bearing. This application is applying a front or radial load, making it a horizontal pressure along the axis of the shaft between the differential and transmission of the thruck.

Press A 77

3

76

No. The needle bearing is used here to absorb the radial shocks or horizontal pressures applied from oscillations of the shaft. In older style engines, needle bearings were sometimes used in place of the pressed bronze bearings in the connecting rod assemblies. Here pressures were also applied intermittently and radially to the bearings.

Press A 77

3

77

Correct. As movement occurs, pressure is exerted on the axis, horizontal or radial to the needle bearing.

Now let's discuss the maintenance of bearings.

The most important precaution to be observed in handling or using bearings is to keep them clean. Dirt is their greatest enemy. It causes wear, destroys their accuracy, and shortens their life. Metal chips, grit, abrasives, dust etc., are all forms of dirt and must be avoided.

Press A 78½

(XC)→78

4

78

OK. You have answered one or more of the questions in this sequence of material incorrectly. Since it is important data, you will be going over it again to be sure you have it clear in your mind. Read carefully and think before answering the questions.

Press A 59

4

78½

Always have a perfectly clean work bench on which to place the bearings before and after cleaning. Place the bearing in a container of clean white gasoline, kerosene, stoddard solvent (Shell Sol, Stanisol), or similar solvents. "Swish" the bearing around in the solvent long enough to remove foreign particles. Never use air to clean bearings.

After cleaning always relubricate bearings. Immerse in a light clean oil or immediately repack with grease, and rotate the inner ring very slowly until all the solvent has been removed. Oil has a tendency to slip away from metal surfaces already wet with solvents, leaving the bearing surfaces unprotected and in danger of rust and corrosion.

Press A 79

4

79

One tip to remember about cleaning bearings is _________________________.

A. be sure all the cleaning solvent is removed after cleaning by washing the bearing in gasoline. 80
B. to immerse the cleaned bearing in light oil or repack with grease and rotate slowly. 82
C. be sure all solvent is removed before mounting or repacking the bearing. 81

4

80

No, sometimes the cleaning solvent is gasoline. The point is to remove all the solvent and relubricate with a light oil or grease to prevent unprotected surfaces being exposed to the air and creating rust.

Press A 82

4

81

You are partially right, the solvent must be removed but a light oil or grease must be applied to all surfaces to prevent rust.

Press A 82

4

82

OK. We should remember to immerse the cleaned bearing in light oil or repack with grease and rotate slowly. Now let's discuss some mounting tips for bearings.

The first and most important rule in press fitting ball bearings is that mounting pressure should never be applied in such a manner that it is transmitted through the balls. Apply the mounting force directly against, and only against, the ring which is being press fitted. Plate XII shows the area where contact and pressure should be applied when mounting a bearing.

Press A 83

4

83

For short shafts on relatively small assemblies, the best method is to use an arbor press, and a piece of tubing. The inside diameter (ID) of the tube should be slightly larger than the bore of the bearing. The outside diameter (OD) of the tube should be slightly less than the OD of the inner ring. It is important that both ends of the tube be forced square, with corners broken to avoid flaking. The tubes must be clean and free from scale, both inside and out to avoid the possibility of dirt falling into the bearing.

Press A 84

4

84

When press fitting a bearing on a shaft, it is best to apply pressure to the __________.

A. ball area of the bearing. 85
B. outer most portion of the bearing. 85
C. inner area next to the shaft. 86

4

85

No, there is a good chance of cracking the bearing this way. Remember we said the tube must make contact with the area of the bearing closest to the shaft, see Plate XII.

Press A 86

4

86

"Inner area next to the shaft" is the correct answer.

When using a tube to press fit a bearing the (1) ___ must be slightly larger than the (2) ___ of the bearing.

A. (1) shaft, (2) ID. 87
B. (1) OD, (2) bore. 88
C. (1) ID, (2) bore. 89

4

87

No, your answer is incorrect. The length of the tube was not mentioned. We are concerned here with the ID of the shaft in reference to the bore of the bearing; it must be slightly larger than the bearing bore.

Press A 89

4

88

No, remember we said the ID, not the OD, of the tube must be slightly larger than the bearing bore.

Press A 89

4

89

"The ID must be slightly larger than the bore" is the correct answer.

If the bearing seat is the correct diameter and without serious taper, the bearing should go smoothly, all the way to the shoulder, with uniform pressure. If it sticks and requires additional force at any point, stop the pressure. Inspect the bearing carefully to make sure that it is not cocked on the shaft. If you continue to force a bearing that is not started square, it is likely to scrape and seriously damage the bearing seat. If the bearing appears to be square with the shaft, continue the mounting pressure. If the bearing still resists movement, stop again, and make further checks to find the source of the trouble, which may be a serious burr on the seat, or a tapered seat. Excessive force or forcing the bearing onto a tapered seat may result in cracking the inner ring.

Press A 90

4

90

If a ball bearing sticks when fitting it you should ________________________.

A. stop the pressure and inspect the bearing. 93

B. expect some resistance and apply additional pressure. 91

C. apply additional lubrication to the shaft. 91

4

91

No, your answer is incorrect. If a ball bearing sticks when fitting it, you should stop the pressure and inspect the bearing before applying any additional pressure.

Press A 93

4

93

OK, if the bearing sticks when fitting it, you should stop the pressure and inspect the bearing before applying additional pressure.

Should additional pressure be needed to fit the bearing, use a brass hammer if the proper tool is not available. Carelessness in using hammers has cracked many a bearing. The brass hammer may be used as follows: apply the hammer alternately at opposite points, working around the tube to avoid cracking. Tap gently.

Press A 94

4

94

When using a brass hammer to press a bearing it is best to________________________.

A. strike the tube in one area to prevent cocking of the bearing. 95

B. strike the tube alternately, working around the edge of the tube. 97

C. try to insert the bearing with one blow if at all possible. 96

4

95

No. Striking the tube in one area will surely cock the bearing on the shaft. When using a hammer gently tap the tube alternately at opposite points.

Press A 97

4

96

No, definitely not. If the bearing is slightly cocked on the shaft, one blow could score the shaft, break the bearing, and who knows what else. Remember we said the hammer can be used by gently tapping the outer perimeter of the tube at opposite points.

Press A 97

4

97

OK. Let's move on to bearing removal precautions. Care must be taken in removing a bearing from a shaft or housing.

The same basic rule that applied to mounting a bearing, applies to bearing removal. When the bearing is to be pressed off a shaft, the applied force must be to the inner ring. If the bearing is to be pressed out of the housing, the removal force should be applied to the outer ring.

Press A 99

(XC)→98

5.

98

You have answered one or more of the questions in this sequence of material incorrectly. It will be best if you review now instead of moving on to new data. Take your time and answer carefully.

Press A → 77

5

99

When a bearing is to be pressed out of the housing, the removal force should be applied to__________.

A. the inner ring 100
B. the outer ring 101
C. both the inner and outer rings 100

5

100

No, your answer is incorrect. When a bearing is to be pressed out of the housing, the removal force should be applied to the outer ring.

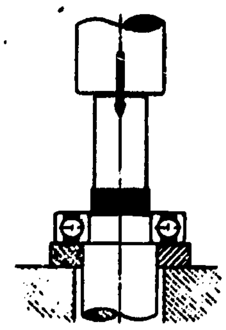
Press A 101

5

101

"The outer ring" is the correct answer.

An arbor press is one of the best demounting tools and should be used wherever it is adaptable. Rest the bearing inner ring or both rings against a pair of flat blocks the same size, as shown. Be careful to keep the shaft straight to avoid damage from cocking. Don't let the shaft strike the floor when it is suddenly released from the bearing. Use a firm steady pressure, and force the shaft out.

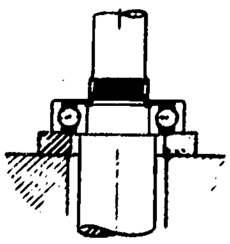


Press A 102

5

102

Take special care to make sure that the flat blocks under the bearing are placed so they cannot slip outwards, as shown. Here, if force is applied to the shaft, it is transmitted through the balls to the outer race and will result in breakage.

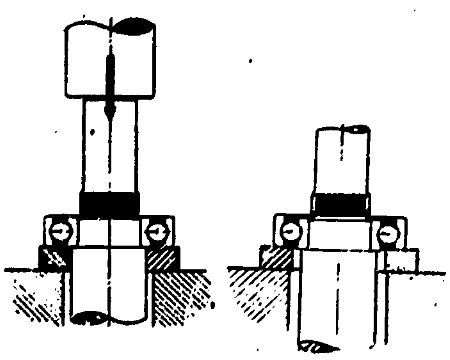


Press A 103

5

103

Which of the following is the correct method of removing a bearing?



105

5

104

No, your selected the incorrect method. The blocks should be placed under the bearing so they cannot slip out as shown in the figure you selected. If the blocks slip outwards, force applied to the shaft is transmitted through the balls to the outer race of the bearing and could result in breakage.

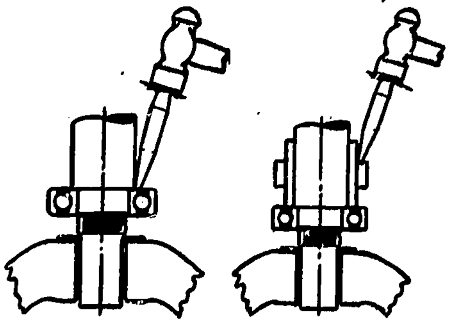
Go back and study the figures again.

Press A 104

5

105

OK. Now, the use of a hammer and drift pin as shown below left is bad practice because the drill may slip and damage the separator or shield, and there is always the danger of cocking the bearing or cracking a tightly fitted inner ring. If the hammer must be used use it with a piece of tubing, as shown below right.



Press A 106

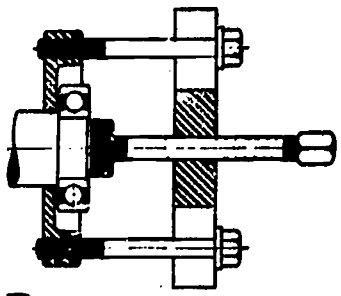
5

DIDACTOR

FILM NO. AM 192 1/17/66

106

If the arbor press is not available, use a puller of a type which can be inserted behind the bearing inner ring, such as shown below. Set the jaws so they will pull straight and will not slip over the inner ring to damage parts of the bearing. Exert an even pressure and pull straight. Unequalized pulling may cock the bearing, damaging it and the shaft.

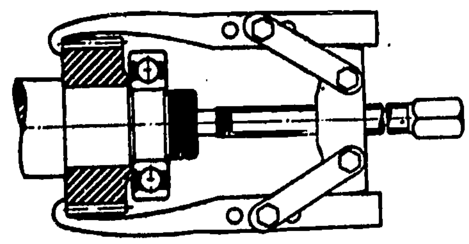


Press A 107

5

107

Sometimes gears or other machine parts do not allow the puller to contact the bearing directly. Several types of pullers with adapter pieces have been devised for more complicated bearing removal jobs, such as shown below.



Press A 107½

5

107½

Now let's review.

It is always best to remove a bearing carefully because ________________.

A. other parts than the bearing may be ruined. 109
B. bearings are expensive and you might want to reuse it. 108
C. your tools may be damaged. 108

5

108

No. This is a slight consideration. Removing a bearing carelessly might cause severe damage to the shaft or other parts.

Press A 109

5

109

OK. Other parts may be damaged, especially the shaft which could be badly scored or bent.

Perhaps the best tool to use, when possible, for mounting and removal of bearings is a(n) __________.

A. pair of pliers. 110
B. arbor press. 111
C. hammer. 111

5

110

No, definitely not the pliers. The brass hammer may be used when other means are unpractical. But extreme care must be taken with hammers. An arbor press is best to use.

Press A 111

5

111

OK. An arbor press is best to use whenever possible.

You have completed this lesson on bearings. It is hoped you know more about why bearings are important in today's moving world.

PRESS REWIND

5

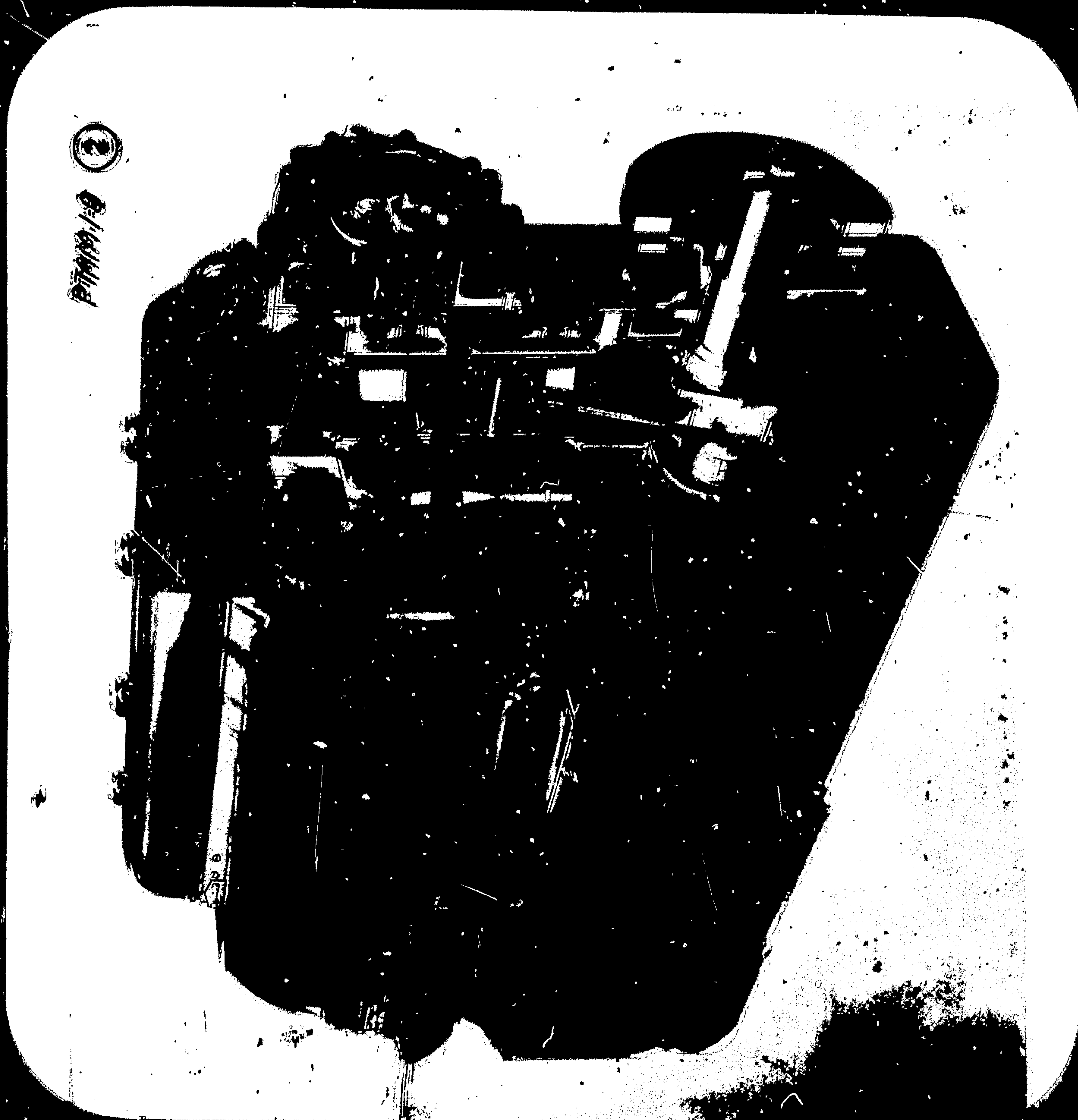
X C → 112

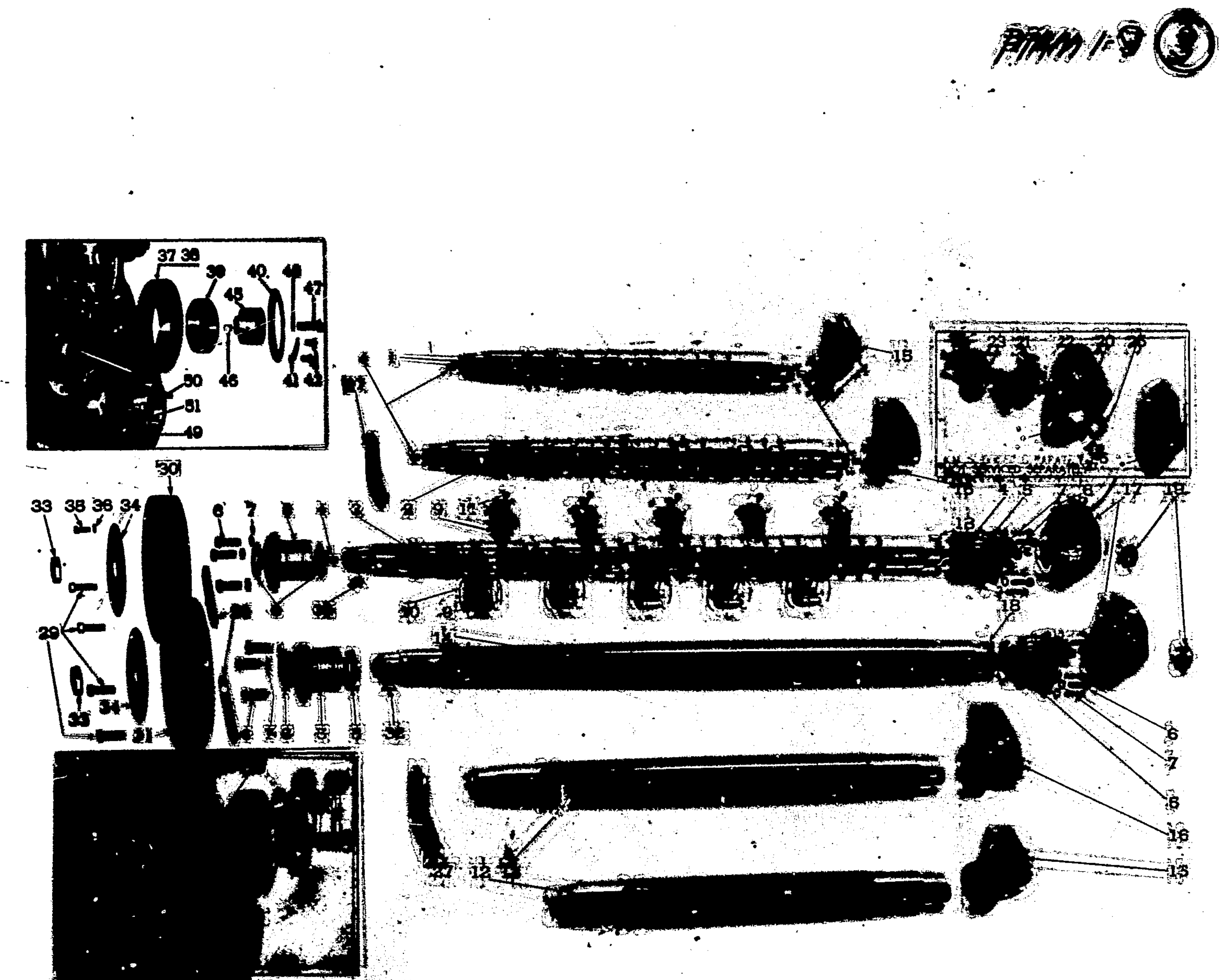
112

You have answered one or more of the questions in this sequence of material incorrectly. It will be best if you review the material again to establish it in your mind. Read carefully and take your time in answering.

Press A → 97

5





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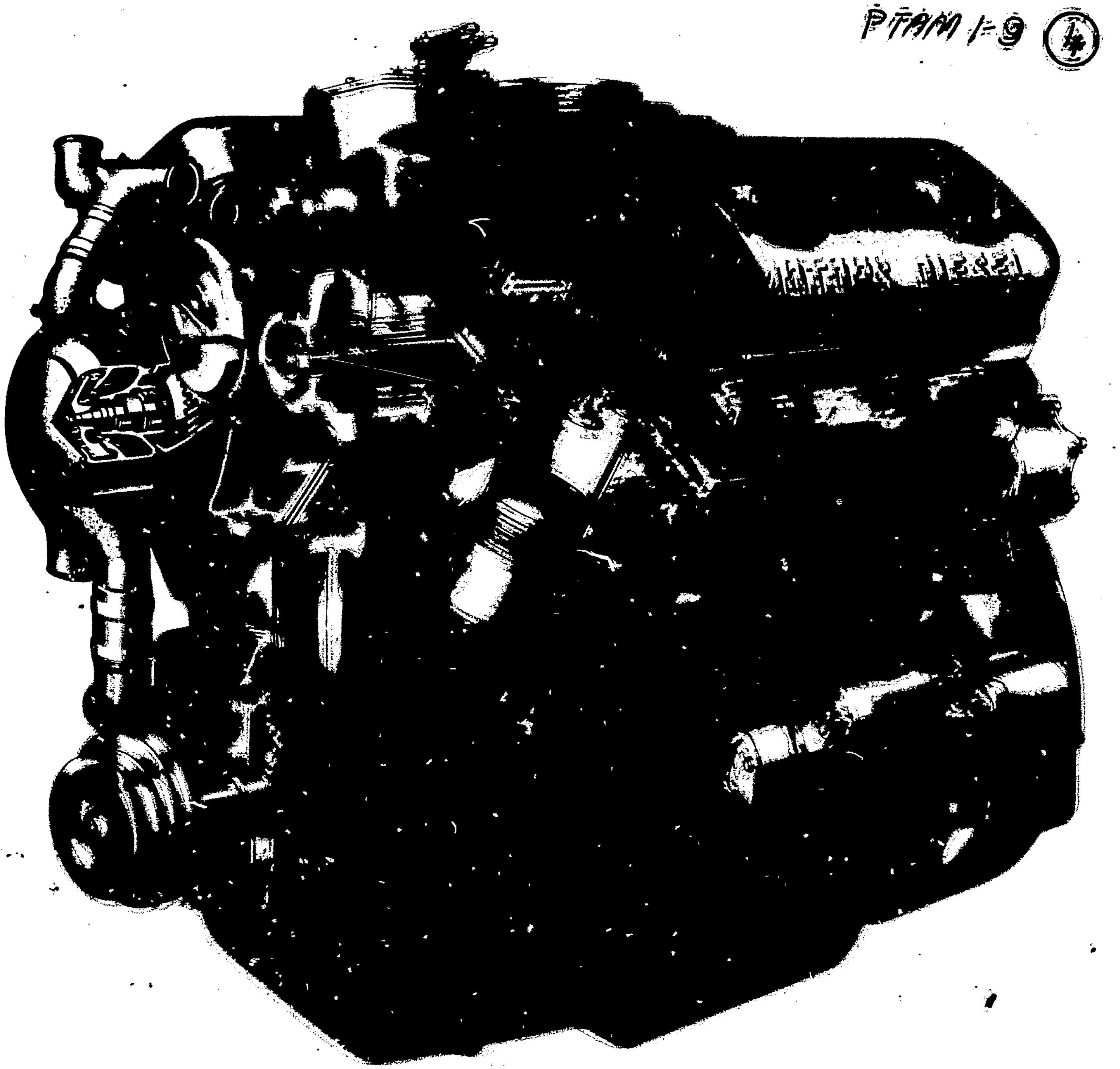
PTAM 1-9 (4)



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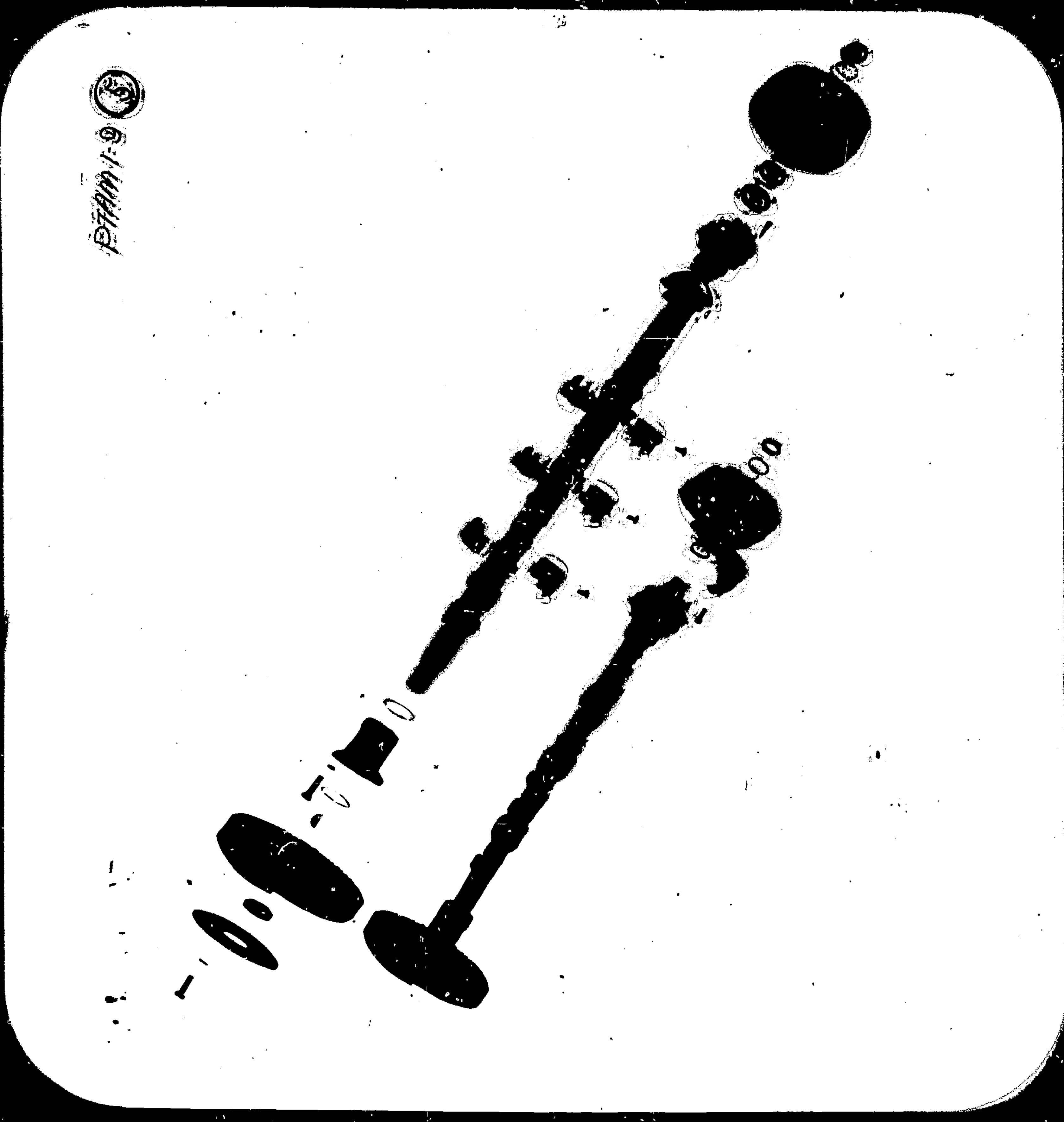
DTAM 1-9

INSTRUCTOR'S GUIDE

Title of Unit: Engine Components -- Part II   Code: AM 1-9

12-29-65

FIRST -- Be sure that all questions on the past unit and Didactor tape have been answered.

OBJECTIVES: By the end of this class session each student should understand:

1. Some of the troubles common to principal engine shafts and bearings.
2. How the crankshaft, camshaft and their associated bearings are lubricated.
3. The function and operation of the crankshaft, camshaft and their associated bearings.
4. What kind of failures and abnormal conditions can develop in a crankshaft, and where they are most likely to occur.
5. Crankshaft inspection practices.
6. What kind of failures and abnormal conditions can develop in a camshaft, and where they are most likely to occur.
7. The causes of bearing failure, what a failed bearing looks like and how to determine what caused it to fail.
8. The importance of cleanliness, precision, and care in handling bearings.
9. How proper and improper lubrication practices can determine the "life-span" of a bearing.
10. The departmental policy which determines when crankshaft, camshaft, and their associated bearings should be reconditioned or replaced.

LEARNING AIDS:

Wall charts -- End view of 71 Series GM Engine: both Inline and Vee.

Bearings -- bring in examples of bearings which are not suitable for use because of conditions such as scoring, ridging, cracks, overheated spots, wear, etc.

Show in class how shafts and bearings are gauged with a micrometer.

VUE CELLS:

AM 1-9 (1) -- Crankshaft
AM 1-9 (2) -- Engine shafts location - 71
AM 1-9 (3) -- Cam and balance shaft assembly - I 71
AM 1-9 (4) -- Engine shafts location - V 71
AM 1-9 (5) -- Camshaft assembly - V 71
AM 1-8 (12) -- Connecting rod bearings

Inline and Vee 71 Series Maintenance Manuals.

QUESTIONS FOR GROUP PARTICIPATION:

1. What are the various types of stresses encountered by the crankshaft?
2. What is meant by "metal fatigue", and what can be done to metals to prevent metal fatigue?
3. What are some of the more common conditions in a crankshaft which can bring about its destruction?
4. Where do we look for these conditions , and how do we determine what caused them?
5. What is crankshaft vibration; how and why is it counteracted?
6. What causes bearing corrosions and what are some of the steps taken to prevent it?
7. On a two-cycle engine, where are excessive bearing wear points most likely to occur? Main bearings as well as connecting rod bearings?
8. Can bearing halves be interchanged? Why?
9. What is meant by an "anti-friction bearing?"
10. In a diesel engine, bearing wear or failure can usually be attritubed to what conditions? (There are eight such conditions listed in the unit)
11. Why and how do these conditions affect the bearings?