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AUTOMOTIVE DIESEL MAINTENANCE 1. UNIT VIII. ENGINE COMPONENTS--PART I.

HUMAN ENGINEERING INSTITUTE, CLEVELAND, OHIO

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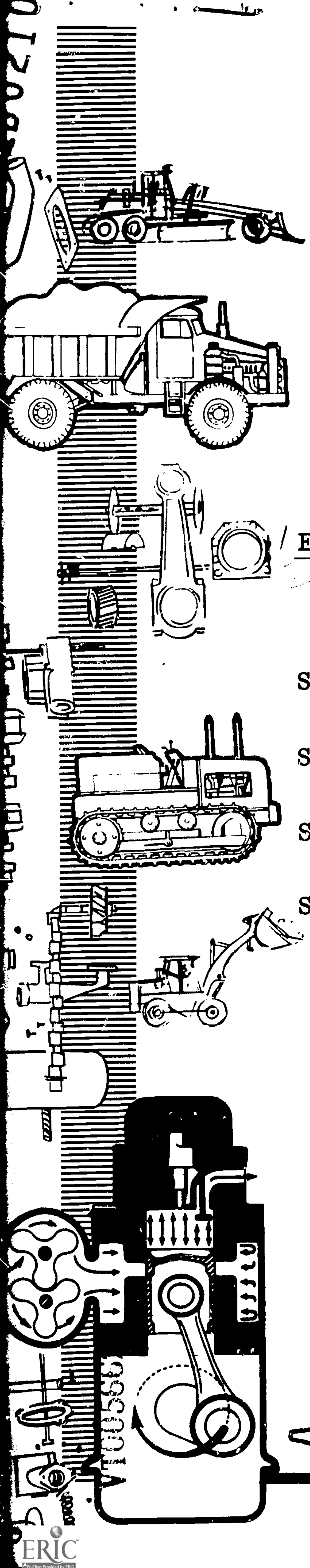
THIS MODULE OF A 30-MODULE COURSE IS DESIGNED TO DEVELOP AN UNDERSTANDING OF THE CONSTRUCTION AND MAINTENANCE OF DIESEL ENGINE CYLINDER HEADS AND CYLINDER ASSEMBLIES. TOPICS ARE CYLINDER ASSEMBLY (LINERS), CYLINDER HEADS, VALVES AND VALVE MECHANISMS, AND PISTON AND PISTON RINGS. THE MODULE CONSISTS OF A SELF-INSTRUCTIONAL BRANCH PROGRAMED TRAINING FILM "ENGINE COMPONENTS--PART I" 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, PROGRAMED TRAINING FILM, AND THE ELECTRONIC TUTOR MAY BE RENTED (FOR $1.75 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 - PART I — UNIT VIII

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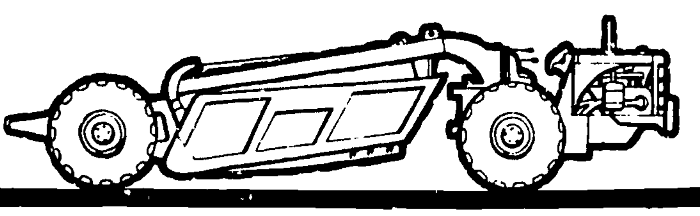

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SECTION A -- CYLINDER ASSEMBLY (LINERS)

In past units we have learned how a diesel functions, what is necessary to make it run, the four basic systems and how they are related to each other, and some of the malfunctions that can occur. In this unit we will cover some of the engine components more thoroughly, such as the cylinder assembly, the pistons and connecting rod assembly, and the valve and valve parts.

The cylinder assembly is that portion of the engine used to confine the gases of combustion, see Figure 1.

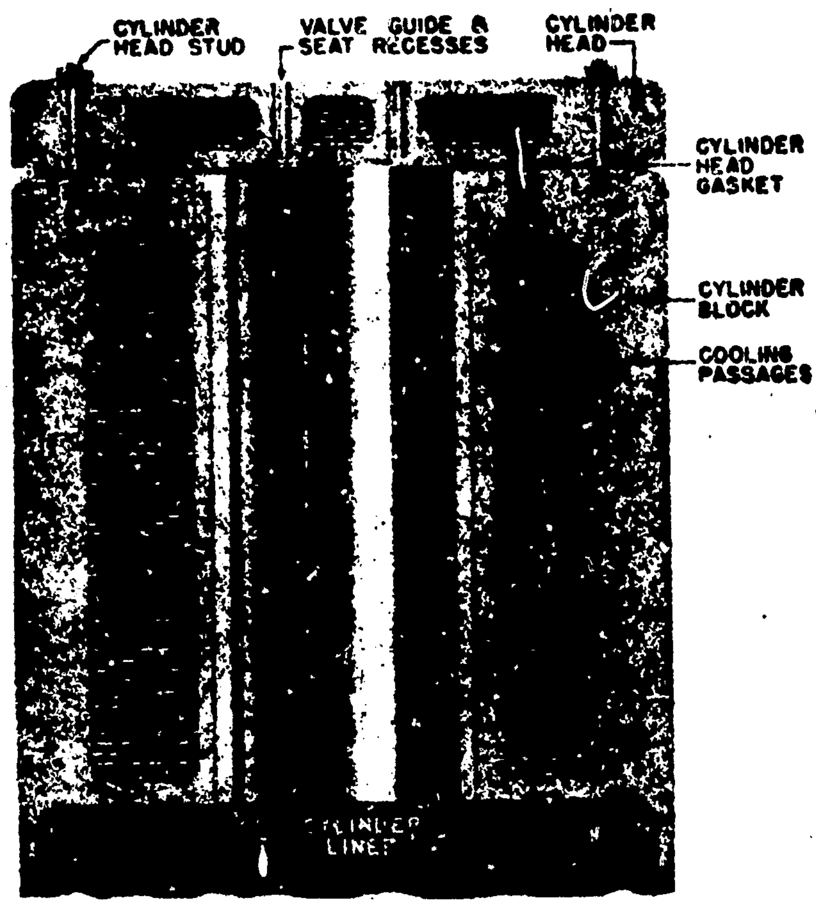


Fig. 1 Engine cylinder assembly.

The cylinder is the barrel in which the piston slides. The piston seals the gases and transmits the force of expansion to the crankshaft. The cylinder head, which will be covered later, seals the cylinder at the end opposite to the crankshaft.

A gasket (thin rubber seal) is placed between the cylinder head and the face of the cylinder block, see Figure 2.

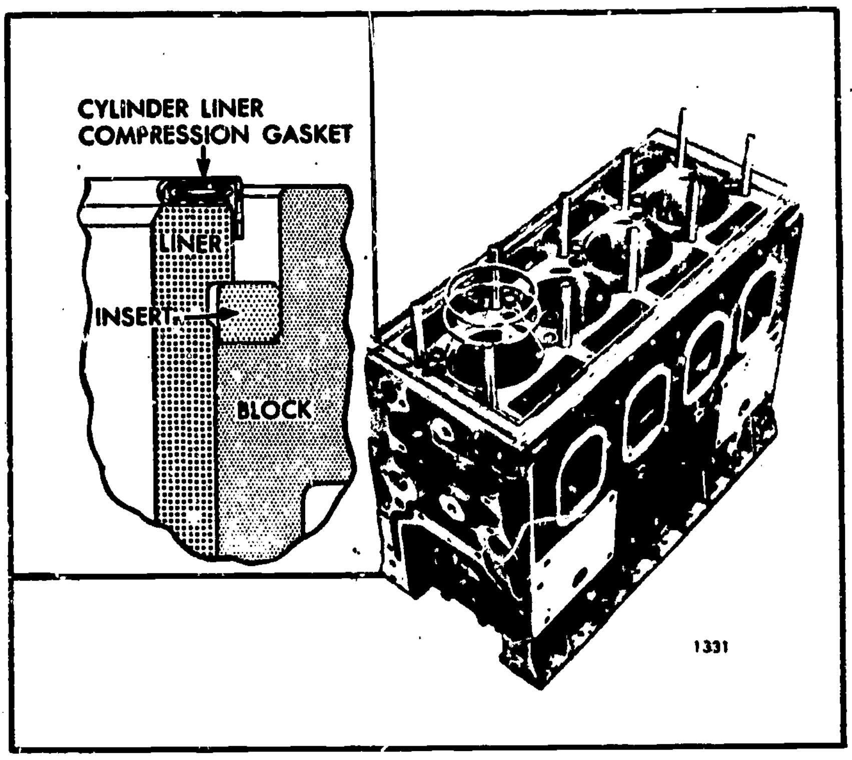


Fig. 2 Cylinder head seals and gaskets.

When the cylinder head studs are tightened, the gasket is compressed and a tight seal is effected.

CYLINDER LINERS - Most diesels have liners inserted into the block to allow for replacement of this wear area without reboring the block. These liners are sleeves, generally made of close-grained cast iron of steel and occasionally chrome plated, which fit snugly into the bores of the engine cylinder block.

Generally speaking, cylinder liners are of two types: wet and dry. In the GM engine the upper half of the liner is cooled by the water inside the cylinder block. At the air inlet ports, the liner is cooled by the air introduced into the cylinder through eighteen ports around the liner. In the new 16-71V turbocharged engines the lower half of the liner is cooled by water. It is cooled by air in the air box on other V-71 engines. The GM engine liner is considered a dry liner.

The wear on a liner and piston is directly related to the amount of abrasive dust and dirt intorduced into the engine combustion chamber via the air intake. This dust, combined with lubricating oil on the cylinder wall, forms a lapping compound that results in rapid wear. Therefore, to avoid pulling contaminated air into the cylinder, the air cleaners must be serviced regularly.

In Figure 3, notice the flange at the top of the liner. This flange fits into a counter bore or seat in the engine block and rests on a replaceable inset which permits accurate alignment of the liner. Compression is sealed with an individual laminated gasket for each cylinder.

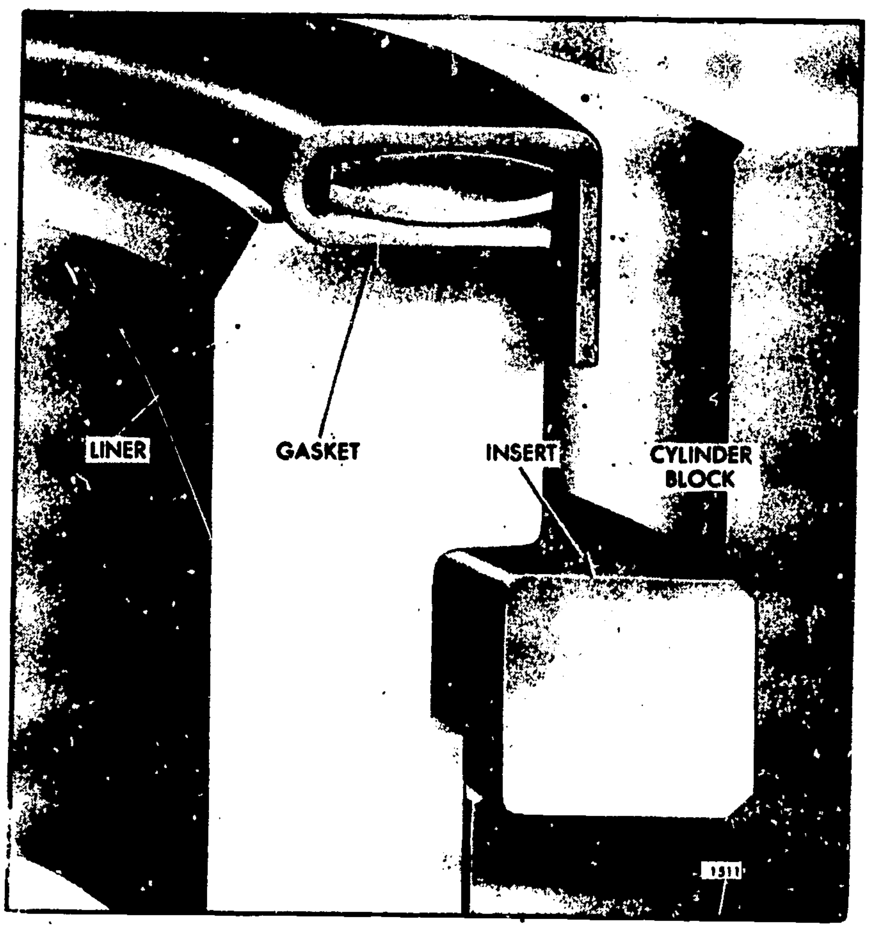


Fig. 3 Cylinder liner mounting.

CRACKED OR BROKEN LINER - Symptoms that may indicate cracks in wet liners are:

1. Excessive water in the lubricating oil.
2. Water in the cylinder when the engine is not operating - indicated by water emission from open indicator cocks when engine is turned over prior to starting.
3. A decline in expansion tank level greater than that from ordinary

evaporation.

4. Indication of gases in the coolant.

Visual inspection is necessary to determine the location of cracks in the liner. Figure 4 shows examples of cracked liners. Make the checking of cylinder liners for cracks a part of your regular inspection. If the engine is allowed to operate with cracked liners, the piston rings will wear very rapidly, water may enter the cylinder, and, in severe cases, the liner may break up.

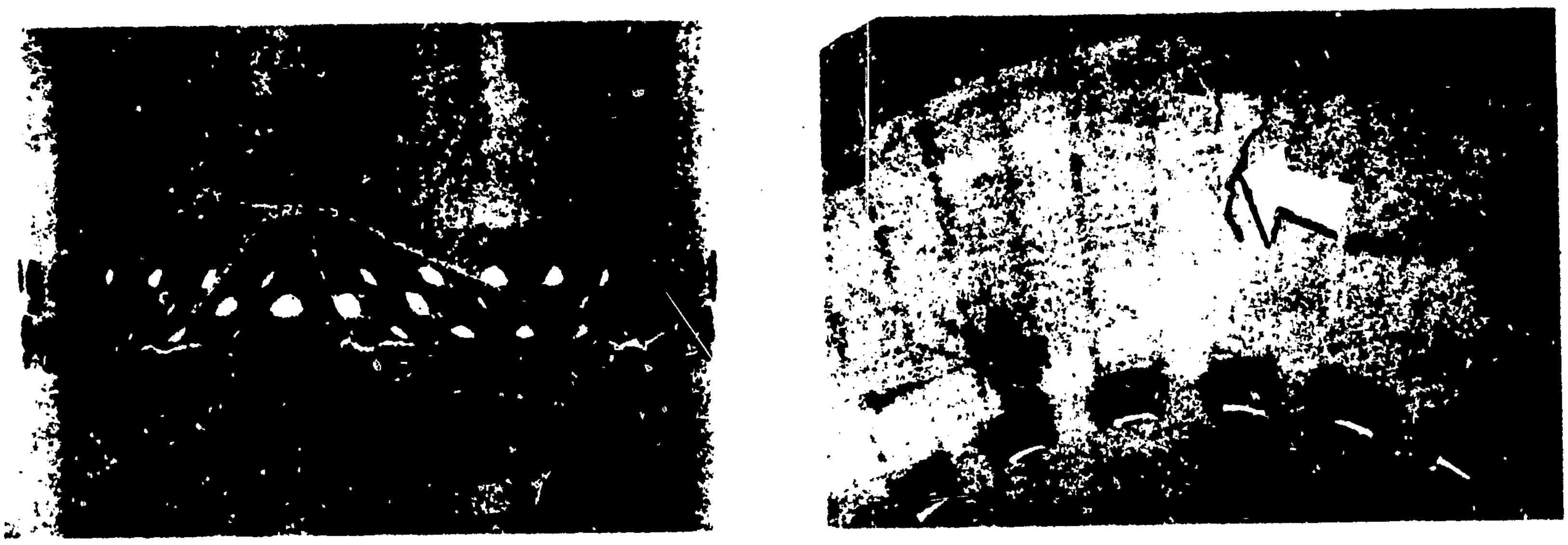


Fig. 4 Cracked cylinder liners.

Causes of broken liners may be due to:

1. Poor cooling of liner.
2. Poorly fitting pistons.
3. Liner improperly positioned.

Let's discuss poor cooling first. If the liners are not properly cooled, they become unevenly heated and will fail, as a result of metal fatigue.

Uneven heating of liners may be due to the collection of scale on the cooling passage surfaces. Scale can be kept to a minimum by additives in the coolant, but sometimes the additives break down, or hard water with a lot of mineral content is induced into the cooling system. In these cases, scale must be removed. Another tip to remember is that cold water must never be added to a hot engine, as there is a possibility of fracturing the liners because of the extreme temperature change.

When the pistons are fit poorly and cause excessive clearance between the liner and piston, the condition of "piston slap" occurs. This subjects the piston and liner to shock blows that may result in breakage, distortion, or at least excessive wear. Badly worn piston rings are also a source of excessive cylinder and piston wear.

Liners must be properly positioned. When installing a liner great care must be taken to be sure that it is properly seated. Oversize rubber sealing rings may cause liner distortion, wear, and possible breakage; see Figure 5.

Breakage in this case is due to over-compression of the oversized seal. When rubber is overcompressed, it loses its elasticity and becomes extremely hard.

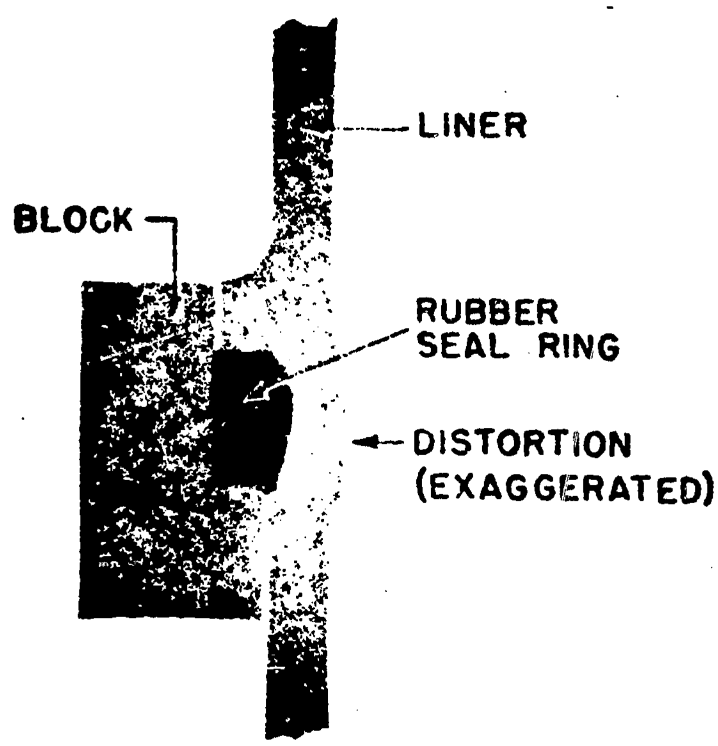


Fig. 5 Distorted cylinder liner (exaggerated).

The liner may also seat poorly because of metal chips or other foreign matter on the seating surfaces. Similarly, nicks, burrs, or improper billets on the seating surfaces may prevent proper positioning; see Figure 6.

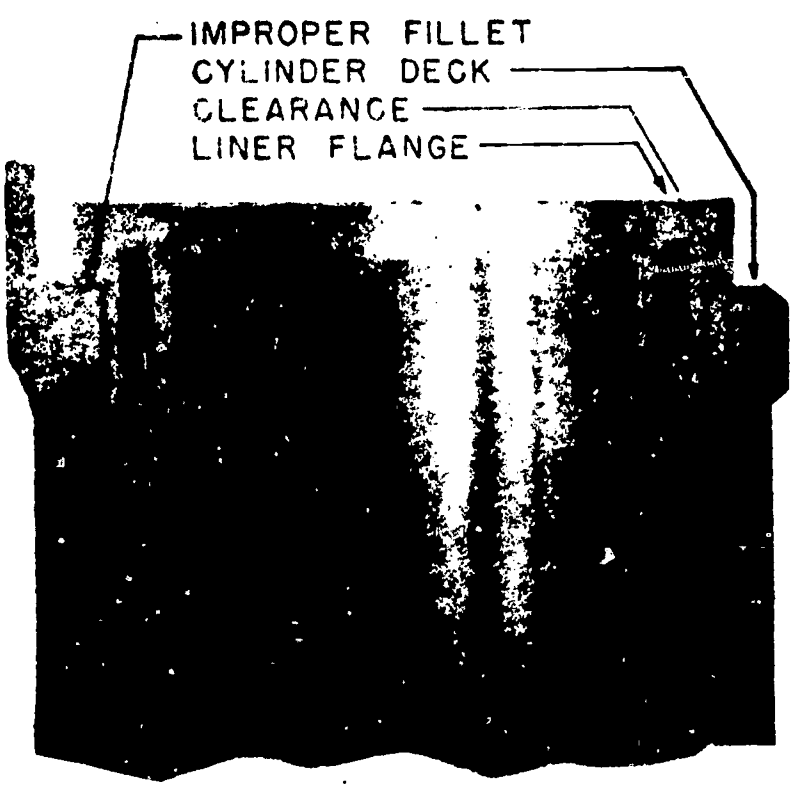


Fig. 6. Improper billet preventing seating.

SCORED LINERS - This problem, as shown in Figure 7, may be caused through low firing or compression pressure and unusually rapid wear of the piston rings. It can be detected by visual inspection through liner ports, through the crankcase housing, with pistons in the top position, or when the engine is torn down.

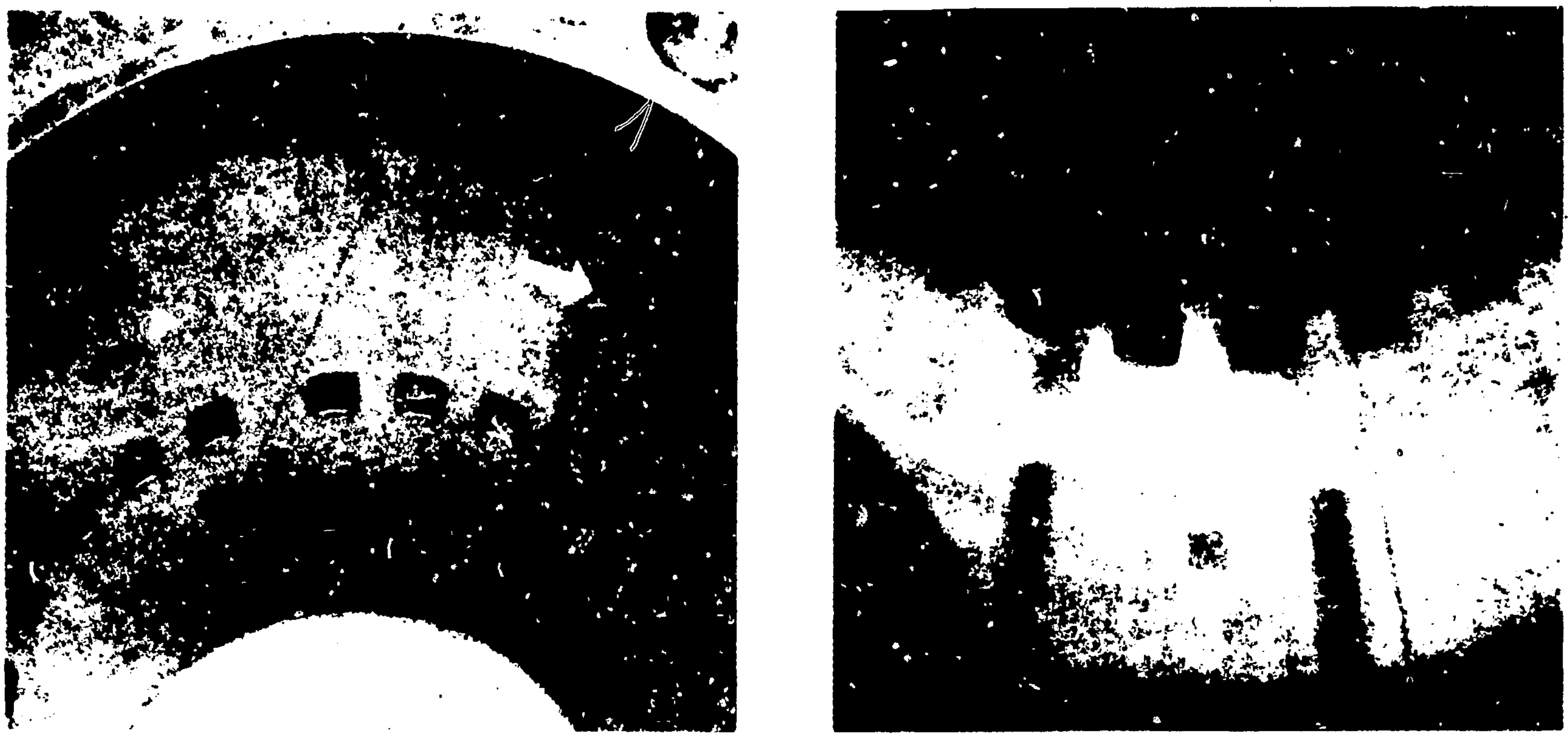


Fig. 7 Scored cylinder liners.

Scoring is merely deep or shallow scratching in a direction parallel to the axis of the cylinder liner; see Figure 7. In many cases, corresponding marks may be evident on the pistons and rings.

Scoring of cylinder liners is caused by:

1. Introduction of foreign particles.
2. Poor condition of piston or broken piston rings.
3. Improper lubrication.

Foreign particles, in the form of dust drawn into the engine with the intake air, mix with oil and act as a lapping compound. Small particles merely cause wear, whereas the larger ones cause scoring. As we learned before, air cleaners must be maintained regularly; manifolds and air boxes must be cleaned periodically. Dirty air boxes not only contribute to accelerated liner wear, but can lead to explosions through clogging of the air box oil drain. NEVER OPERATE AN ENGINE IN A DIRTY CONDITION - THIS IS A DANGEROUS PRACTICE.

Poor condition of pistons or broken piston rings, badly worn rings and pistons, or both, will allow blow-by of combustion gases. This will result in reduced efficiency, and a greater tendency toward scoring, because of the increased temperature. Furthermore, a badly worn piston ring may break and may cause the complete destruction of piston and liner.

Repair of scored liners is not recommended except in emergencies or in the field where new ones are not available. In some cases slightly scored liners can continue in service providing the cause of scoring is removed.

OBSTRUCTED LINER PORTS -- Clogging of air intake ports will result in loss of power, smoky exhaust, low compression pressure, low firing pressure, and increased fuel consumption. To check this condition, remove the air box covers and rotate the engine until each liner port is uncovered, see Figure 8. Clogging of ports can be minimized by regular inspection and removal of the carbon before the clogging becomes serious. Extreme care must be taken when removing carbon from the air box and liner, to prevent carbon entering the cylinder through the air ports. Rapid clogging is caused by (a) oil pumping, (b) inoperative air cleaners, and (c) air box drain obstructed.

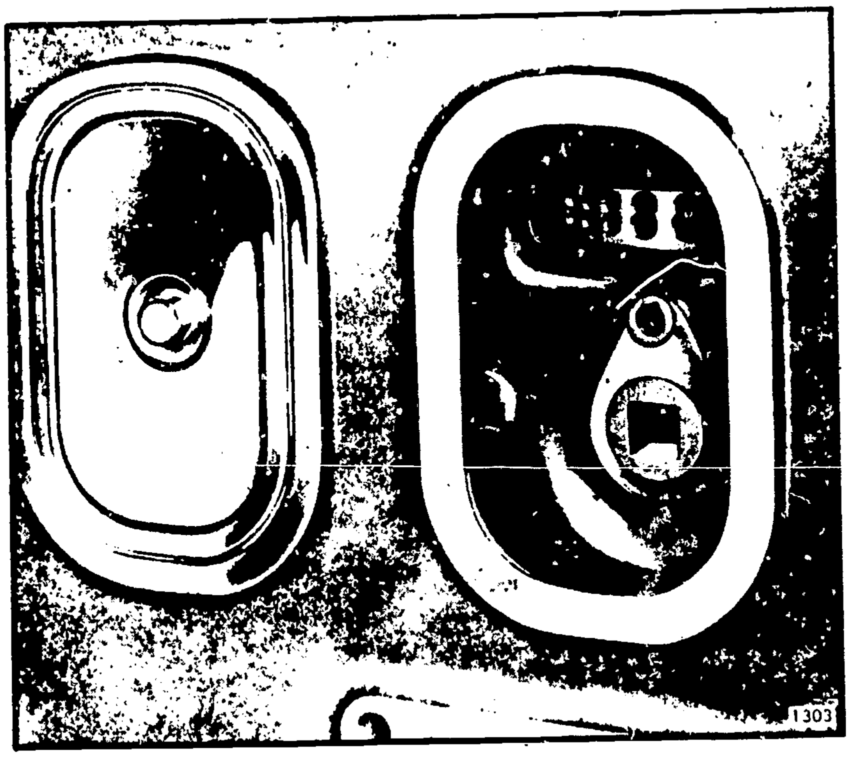


Fig. 8 Air box covers.

OIL PUMPING is caused by poor conditions of the rings, pistons or liners. That is, oil will be thrown up into the combustion space and the ring zone in large quantities. A lot of this oil may be blown out through the ports and collect there, forming gum. The incoming dust clings to this mass and forms carbon. Lube oil forced into the upper cylinders could also cause a runaway engine, resulting in the ultimate destruction of the engine.

AIR CLEANER INOPERATIVE - Failure of the air cleaner, or removal of the air cleaner, particularly in dusty atmosphere, will cause dirt particles to collect on gummy surfaces.

AIR BOX DRAIN OBSTRUCTED - Air boxes are fitted with drain passages to conduct oil that collects there to the sump. If these drains become obstructed, the ports will tend to clog up. More important, there will be a tendency toward air box explosions.

SECTION B -- CYLINDER HEAD

The cylinder head (GM inline 4 cylinder) shown in Figure 9 is a one-piece casting containing the cam followers and guides, push rods, rocker arms, exhaust valves, and injectors. This head has two exhaust valves; some have four exhaust valves. There are three rocker arms; one operates the injector, the other two operate the exhaust valves. Let's talk about some troubles that occur with cylinder heads in diesel engines.

CRACKED CYLINDER HEAD - The presence of water in a cylinder after a period of shut-down, or in the lubricating oil, may indicate a cracked cylinder head. The presence of combustion gases in the cooling water may also indicate a cracked cylinder head. This may be recognized by making the cooling system pressure tight, and then

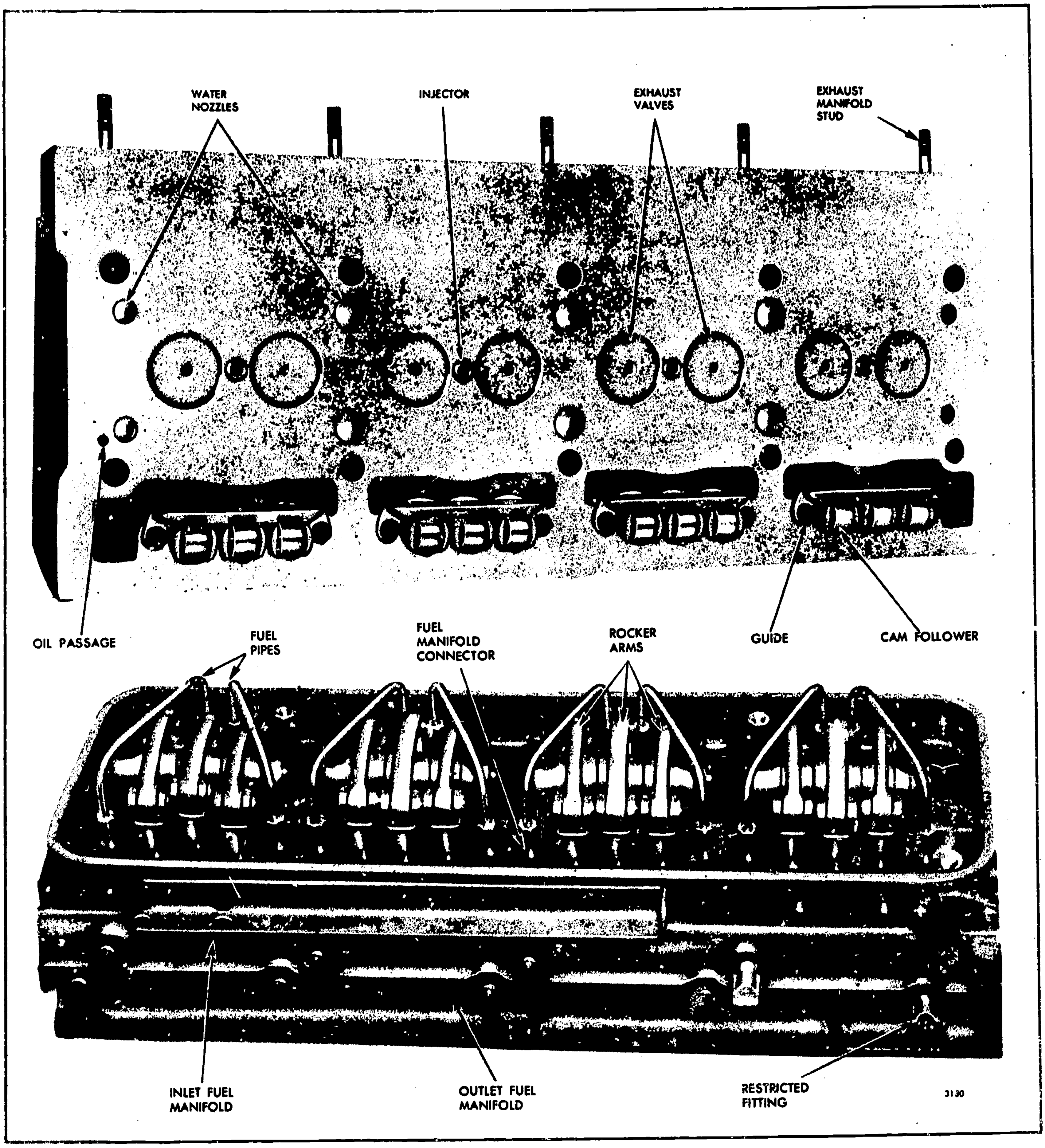


Fig. 9 Two valve cylinder head (GM in-line, 4 cycle).

tapping a test line into the expansion tank; see Figure 10. The test line is submerged in a container of water. As the cooling system is under pressure, and the combustion gases will pass into the cooling water and increase its pressure. A flow of gas from the end of the test hose will be apparent below the surface of the container. It should be remembered, however, that gas in the coolant may also indicate a cracked line, a leaky gasket, or air being drawn in through a leaky water pump. A cracked head will often cause combution gases to appear in the radiator upper tank while the engine is running.

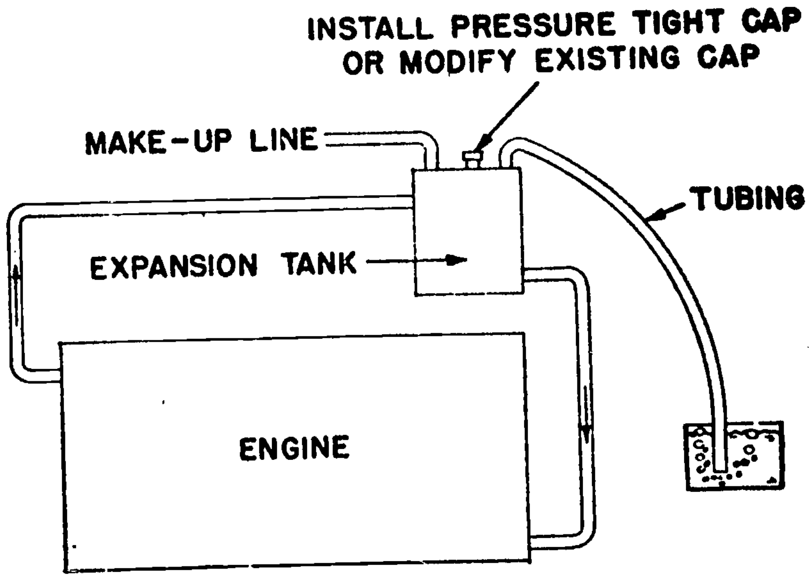


Fig. 10 Set-up to test for gas in the cooling waters.

If the head is removed from the cylinder, it may be checked for leakage by subjecting it to a hydrostatic test. Some success has been obtained in locating cracks by plugging the water outlet holes and filling the head with glycol type anti-freeze. This type anti-freeze will leak from even the most minute cracks. Large cracks may usually be located by cleaning the head throughly and examining it carefully.

Cracks in cylinder heads occur most frequently between "bridges" or narrow metal sections between valve and injector holes.

Frequent causes of cracked heads are:

1. Addition of cold water to a hot engine.
2. Restricted cooling passages.
3. Improper tightening of studs.
4. Obstruction in combustion chamber.
5. Overheating caused by low coolant.

An overheated engine should never be cooled quickly by adding cold water into the system. This may cause cracking, due to thermal stress. It is good policy to leave the engine running and to add water slowly until the temperature reaches normal. Do not shut down an overheated engine; the engine will cool more rapidly while idling.

Also when cooling passages become clogged or dirty, there is likely to be insufficient heat transfer, causing overheating of the metal. This can result in cracking due to overexpansion. Water passages can be best kept in good condition by using a "Perry Water Filter" to reduce hardness in the water.

Cylinder head studs must be drawn down evenly, in the proper order, using the correct torque, and in proper increments. Figure 11 shows what can happen when studs are not equally tight.

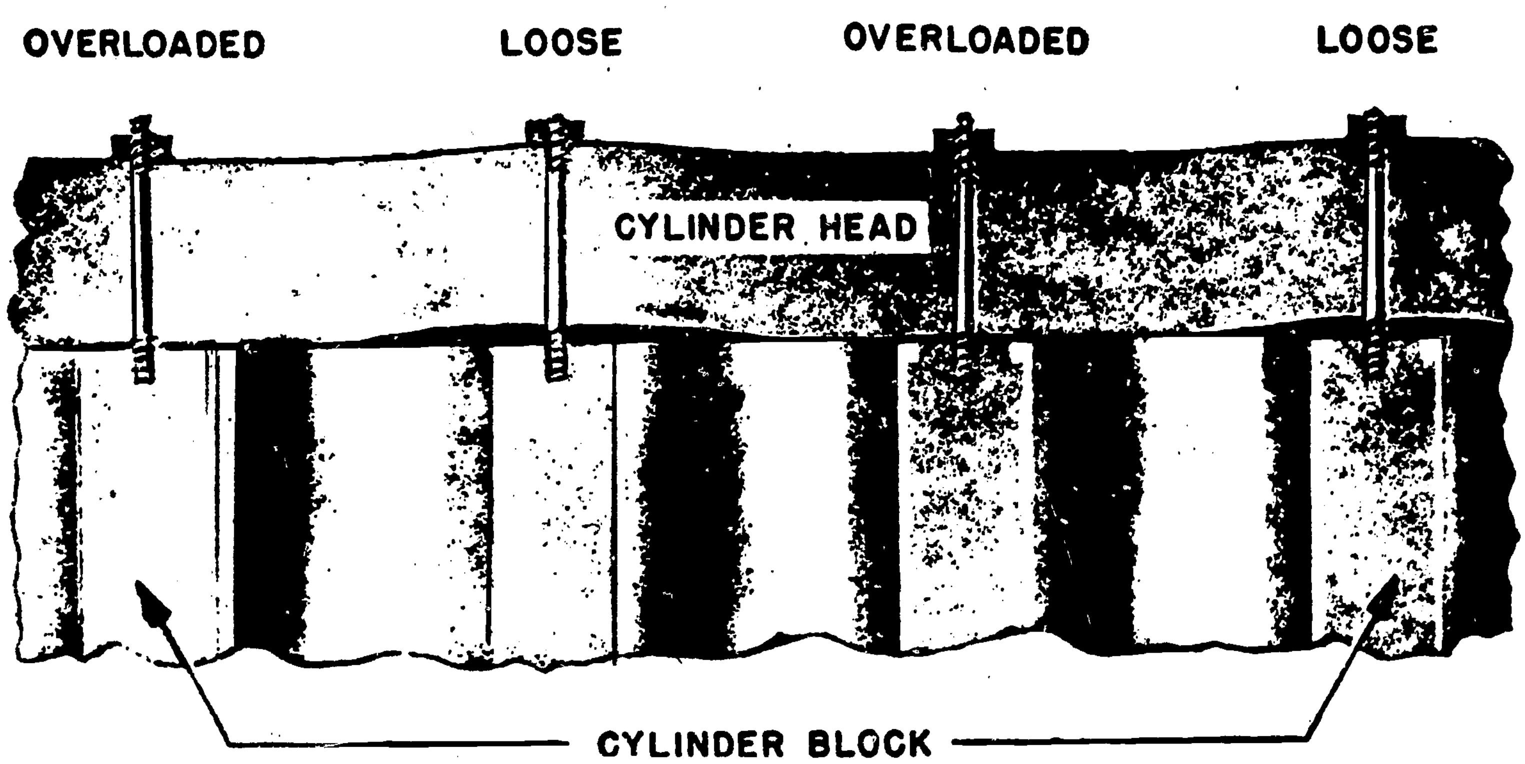


Fig. 11 Effect of uneven stud tightening.

In addition to gaps, the cylinder head gasket will be pinched in the region of the tight studs, and blow-by may occur near the loose studs.

Another cause of cracked heads is that foreign matter sometimes gets into the space between the piston and the head. The minute clearances required by the high compression ratios of diesel engines will not accomodate any large metal particles or appreciable quantities of water. In some cases, exhaust valves have broken loose and dropped into the combustion chamber, causing extensive damage to the piston, liner and head. Only thorough and PROPER MAINTENANCE of the valve mechanism can prevent this situation from happening.

Obviously great care should be exercised to prevent the entrance of any metal objects, such as tools, nuts, bolts, pieces of wire, and similar objects into the combustion chamber space during overhaul of the engine.

SECTION C -- VALVES AND VALVE MECHANISMS

Most diesel engines use the poppet type exhaust valve. This type is very dependable but is subject to certain problems as outlined below.

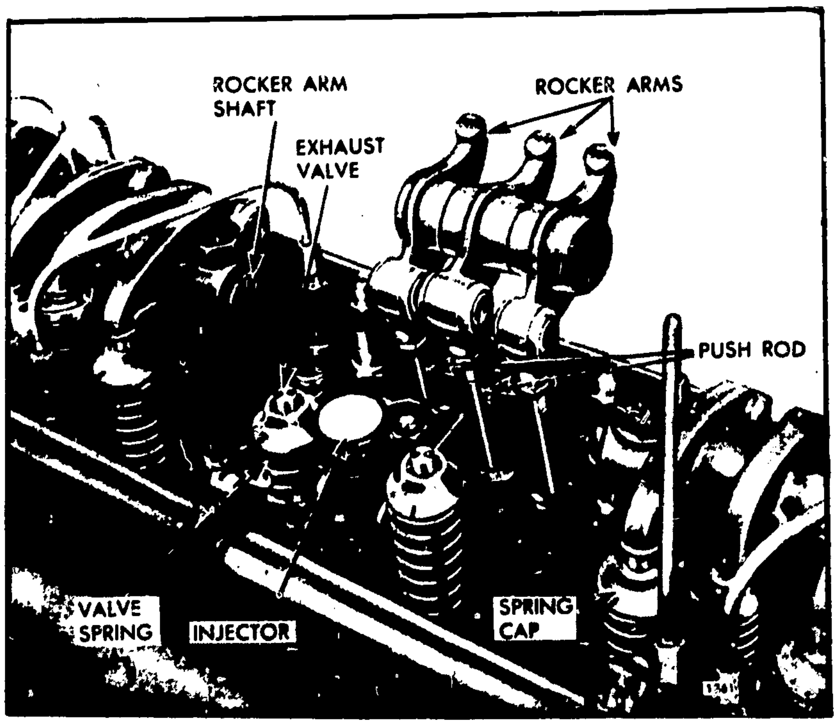


Fig. 12 Location of exhaust valves.

EXHAUST VALVE STICKING OPEN -- Sticking exhaust valves are characterized by: (1) an engine miss, evidenced by low exhaust gas temperature, and by (2) the noise of the cam follower, push rod, and rocker arm as they float between the camshaft and the valve stem. See Figure 12 to refresh your memory of valve and valve nomenclature.

Sticking of valves is a very serious problem. When a valve hangs open it prevents the cylinder from firing. The valve could also be struck by the upcoming piston and bent, making it impossible for the valve to seat properly.

Sticking valves can be caused by many things. The more common causes are:

1. Resinous deposits left by lube oil.
2. Resinous deposits left by fuel oil.
3. Weak valve springs.
4. Bent valve stem.

Oil deposits are usually caused by using an incorrect oil in the engine. A detergent type oil will help curb formations of gum deposits. When changing from a non-detergent oil to a detergent oil to clean a dirty engine, remember to use the new oil for a short time. The reason for this is that detergent oil breaks sludge particles loose - these particles hang in suspension in the oil and contaminate it very rapidly. Remember when changing oil under these conditions: always change the filter elements and clean the strainer case.

In the same manner as the lube oil, improper fuel oil can contaminate the engine by forming gum-like deposits. Make sure you use the correct fuel in diesel engines at all times.

WEAK VALVE SPRINGS will allow valves to hang open more readily when the stem becomes gummy. Weak springs will also allow the valve and valve gear to "float" at high speeds, thus reducing the efficiency of the engine. Valve springs become weakened from normal use. There are, however, several other factors that tend to weaken them. Probably the most common is corrosion. Corrosion and rusting are caused by moisture within the valve pockets. These destructive processes are aided by the formation of dilute acids from the small amounts of sulfur present in the fuel oil. Excessive temperatures will also weaken the springs.

BENT VALVE STEMS - Bent and warped valve stems will cause the valves to hang open. In this case, the valve may stick open periodically, depending on the position of the valve in relation to the guide and the temperature of the valve stem. Bent valve stems are usually the result of the valve head being struck either by the piston or during assembly.

Great care should be exercised when handling the cylinder heads to insure that the valves are not damaged. Setting the head on steel or concrete should be avoided; they should be placed only on wood or pasteboard. A valve should NEVER be pried open with a screwdriver or other bar; this could bend the valve stem and nick, scratch, or otherwise damage the valve seats.

Sticking valves can be remedied in many ways, depending on the cause. Kerosene is often used when the gum formations are slight. A mixture of equal parts of kerosene and lube oil should be put in an oil can and applied around the valve stem and guide. CARE must be taken to be sure that no appreciable amount settles in the cylinder, as it could cause a serious explosion. Various commercial gum solvents are on the market. However, these should be used only when the condition is slight and when time does not permit disassembly.

Bent valves, of course, must be replaced. Weak springs should be replaced. Repair of these two items is not advisable.

BURNED VALVES - Burned exhaust valves are characterized by irregular exhaust gas temperatures and usually an excessive exhaust noise. Burned valves are usually caused by:

1. Carbon particles between seat and valve head.
2. Insufficient tappet clearance.
3. Defective seat.
4. Valve head excessively ground.

The principle cause of burned exhaust valves is the lodging of small particles of carbon between the valve head and valve seat. These particles come from excessive deposits on the engine cylinder and head. The particles will hold the valve open just enough to allow the combustion gases to pass. As these gases pass through the opening at high velocities and temperature, the temperature of the valve is raised enough to cause the metal to burn. It is rare for the valve seats to burn, due to the cooling facilities around the seats. The valve ordinarily is cooled by the seat. When it cannot contact the seat due to the carbon particles, it becomes hotter, and eventually burns.

General maintenance of the engine always includes removal of carbon deposits. When scraping the carbon from the heads, extreme CARE must be exercised to insure that all carbon broken loose is removed, and not allowed to remain in crevices of the head. The scraping tool must not be allowed to nick or score the valve or valve seat. It is advisable always to remove the valves from the engine when scraping carbon. This will permit easier and more thorough cleaning of all ports. Carbon can best be removed by soaking in a hot tank, using a suitable cleaning mixture.

Insufficient tappet clearance can cause burnt valves. Tappet clearance adjustments should be checked periodically to be sure they are correct, and that the locking nuts are tight. It is always better to have the clearance a little more, rather than a little less, than that specified in the maintenance manuals.

Defective seats also can cause valve burning. Most engines, including GM, are equipped with valve seat inserts, see <ins>Figure 13,</ins> made of hard, heat-resisting, alloyed steel. Occasionally, these inserts will crack, allowing hot gases to leak and burning the insert and the valve at the same time. Sometimes, the metallic contact between the valve seat insert and countrebore is poor. This prevents heat from being carried away properly and results in the inserts gaining in temperature. High temperatures cause the inserts to shrink and become deformed. In extreme cases, hot gases may pass between the insert and the counterbore and burn the cylinder head. When this happens, the head may be permanently damaged.

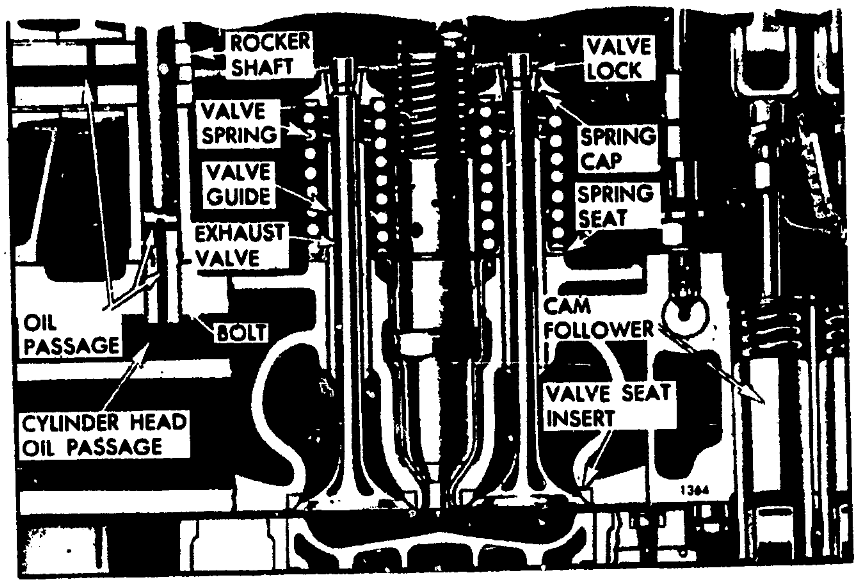


Fig. 13 Valve seat inserts.

Before inserting a valve seat, chill it with dry ice. At the same time, submerge the cylinder head in boiling water. Allow thirty minutes for this operation, then drive the insert into the counterbore. This must be done quickly, for the insert will soon regain its original temperature and expand to its original size.

Valves that are ground excessively, to a point where the edge is sharp, or nearly sharp, will burn easily. The sharp edge, see Figure 14 (a), is incapable of carrying away the heat. Figure 14(b) is the correct contour of a valve. It is recommended valves not be reground or repaired but replaced. Valve seats can be ground providing the proper tools are used.

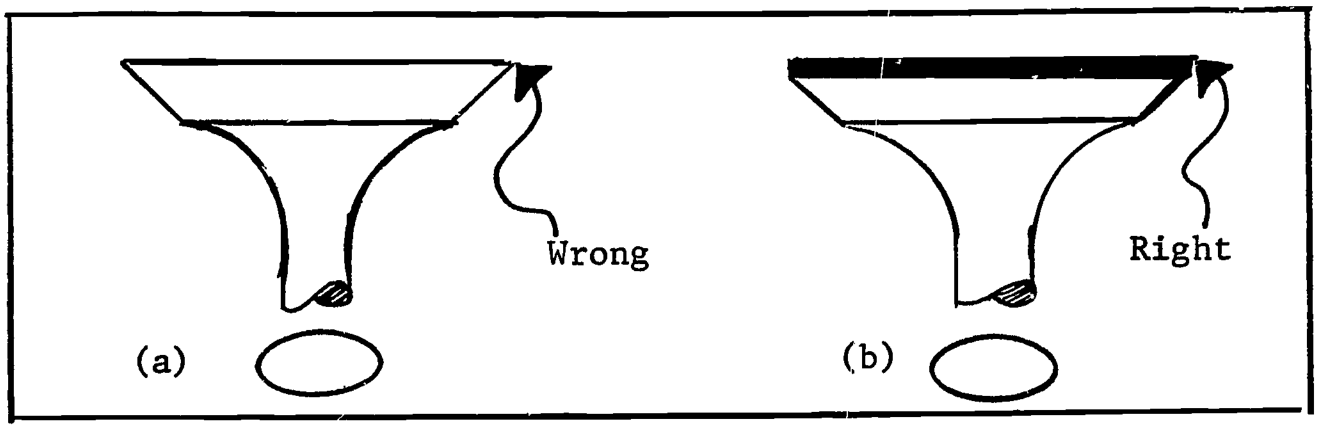


Fig. 14 Valve contour

BROKEN VALVE SPRINGS - Broken valve springs will cause excessive valve noise and, frequently, erratic exhaust gas temperatures. The actual breakage of the valve springs is not always the most serious consequence. When the spring is broken, it is liable to collapse enough to allow the valve to drop down in the cylinder, where it can be struck by the piston. Furthermore, the valve stem locks may fall out, causing the valve to drop into the cylinder.

Valve spring breakage can be minimized by following these precautions:

1. Care in handling.
2. Regular inspections.
3. Maintenance of protective coating.
4. Minimizing of corrosive conditions.

All valve springs must have a protective coating. Where this coating is nicked or scratched, a coating of paint or varnish, or enamel should be applied. Be sure to use clean lube oil in the engine, eliminate all water leaks, and keep vents open and clean.

SECTION D -- PISTON AND PISTON RINGS

The design of a piston for a diesel is very important. The trunk type piston, Figure 15, performs several functions, the most important of which are:

1. Provides the moving wall for changing the volume of the cylinder (crown).
2. Supports the rings used to seal the cylinder (ring grooves).
3. Takes the side thrust due to the crank and connecting rod angle (skirt).
4. Provides means of attaching the connecting rod to the piston (piston pin boss).
5. Conducts the heat absorbed from combustion away at a sufficient rate to prevent excessive temperatures.
6. Acts as a valve in opening and closing ports in two-stroke cycle engines.

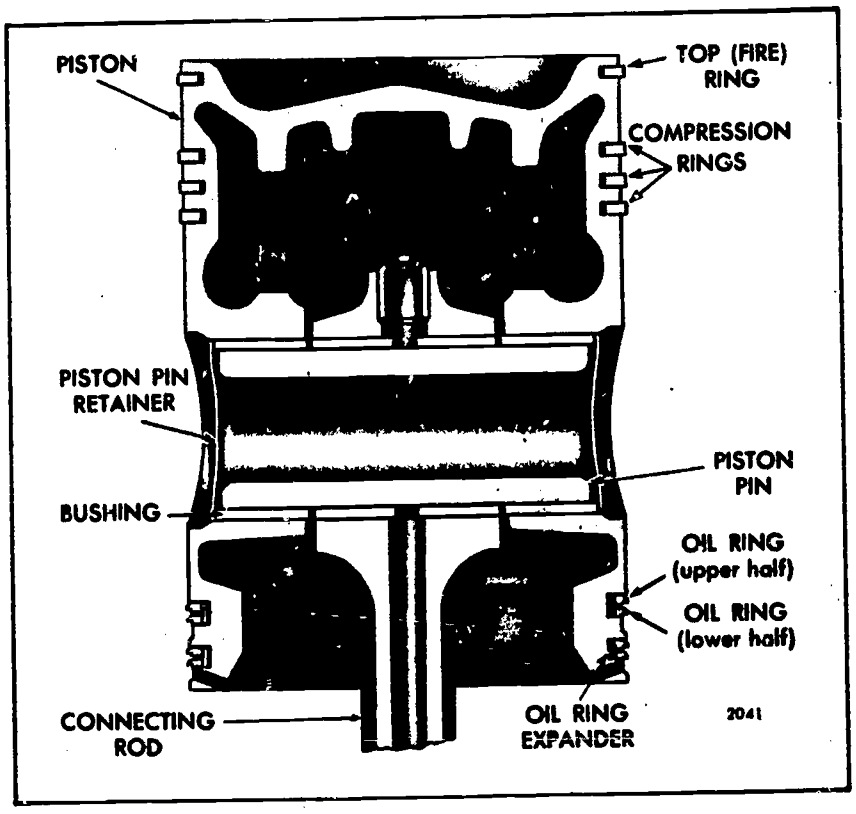


Fig. 15 Typical piston assembly.

The trunk type piston is subject to the following forces;

1. Gas pressure, bearing directly on the crown.
2. Side thrust, taken by the piston skirt.
3. Own inertia forces.

These forces combined with conditions of friction, heat, and dirt can cause several problems.

WORN PISTON - Excess piston-to-cylinder clearance is evidenced by piston slap and excessive oil consumption. Piston slap occurs when the piston shifts its thrust from one cylinder wall to the other. This happens just after top dead center and bottom dead center. Oil consumption increases as a result of the taper of the cylinder as it wears. The taper necessitates that the rings flex at each stroke of the engine. This causes excessive ring wear, which allows the lube oil to pass the rings and to be burned in the cylinder, resulting in excessive carbon deposits.

Piston wear is normal in diesel engines; however, the amount and rate of wear are increased by the following:

1. insufficient lubrication
2. improper starting procedure
3. overload
4. unbalanced load
5. dirty oil
6. dirty intake air
7. improper cooling water temperatures
8. improper fit

Insufficient lubrication of the cylinder walls causes excess wear, both on the piston skirt and rings, and on the cylinder liners. Lube oil provides a layer, or film, that cushions the piston within the cylinder and prevents metal to metal contact. Lube oil of insufficient viscosity, or which has been diluted by fuel oil or coolant, will also cause increased wear. Lube oil having too high viscosity will cause increased wear, particularly during cold weather starting.

Improper starting procedures probably account for the greatest amount of wear on pistons. During the engines shutdown period, oil drains into the crankcase. Several revolutions of the crankshaft are required to return the oil to vital parts. Engines that are raced, or have immediate heavy loads applied to them, during this critical period receive an excess amount of wear. Always allow the engine to run at part load and speed until lube oil pressures and temperatures, and coolant, reach their normal operating points.

Overloading the engine will place greater forces on the piston and will subject it to higher temperatures, thus increasing the rate of wear. Indiscriminate use of ether to aid starting will also cause extreme. overloading, resulting in increased wear and/or piston burning.

Unbalanced engines - engines must be balanced at all times to prevent excessive wear on piston(s). Frequent checking of the engine by (a) pyrometers, (b) rack settings, and (c) firings and compression pressures will assure a balanced engine.

Using dirty oil in an engine naturally will cause excessive wear. Make sure that engine oil is changed at regular intervals. Lube oil analysis for sediment will help establish the proper oil and filter change intervals.

Dirty air, like dirty oil, will also cause wear. Check air cleaner piping and connections for leaks. Replace dry type elements at 16" of water back pressure. Clean wet type cleaners frequently.

Engines that operate continuously at higher than normal temperatures will cause the lube oil to break down. The oil gets very thin, allowing excessive wear of the piston and liners. At cooler than normal temperatures, the oil is thick, and will not reach the parts requiring lubrication.

To determine when piston clearances are excessive, we need to measure the diameters of the piston and cylinder liner. Figure 16 shows where measurements should be taken on the piston. When readings exceed the minimal specifications, it should be discarded and replaced.

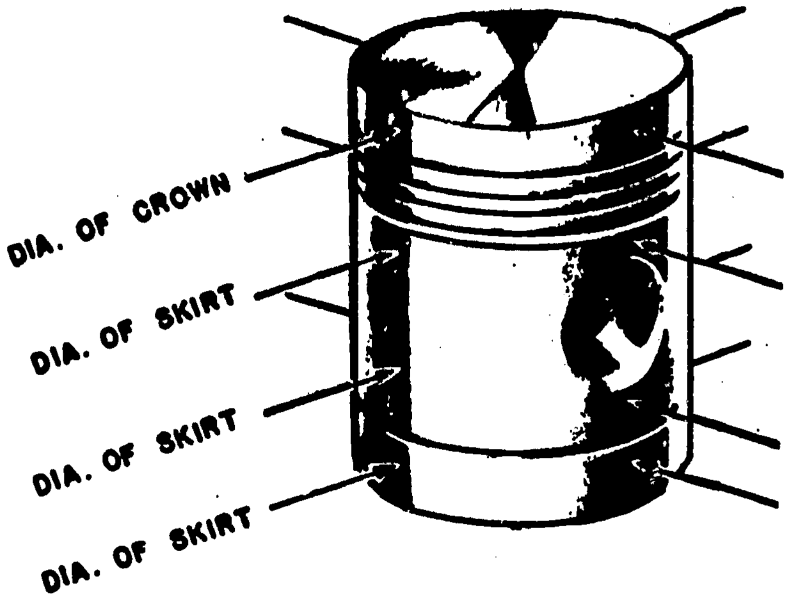


Fig. 16 Piston measurements.

PISTON RINGS - Piston rings are used to maintain gas-tight seals between the pistons and cylinders, to assist in cooling the piston, and to control cylinder-wall lubrication; see Figure 15.

About one-third of the heat absorbed by the piston passes through the rings to the cylinder wall. Although piston rings have been made from many materials, cast iron has proved the most satisfactory. It withstands heat, forms a good wearing surface, and retains a great amount of its elasticity after considerable use. There are two distinct classes of piston rings: compression rings and oil control rings.

The compression ring prevents gases from leaking by the piston during the compression and power strokes. All piston rings are split, to permit assembly to the piston and to allow for expansion. When the ring is in place, the ends of the split joint do not form a perfect seal; therefore, it is necessary to use more than one ring and to stagger the joints around the piston. If cylinders are worn, expanders (Figures 17 and 18) sometimes are used to ensure a perfect seal.

The bottom ring, usually located just above the piston pin, is an oil regulating ring. This ring scrapes the excess oil from the cylinder walls and returns some of it, through slots, to the piston ring grooves. The ring groove under an oil ring is provided with openings through which the oil flows back into the crankcase. In some engines, additional oil rings are used in the piston skirt below the piston pin.

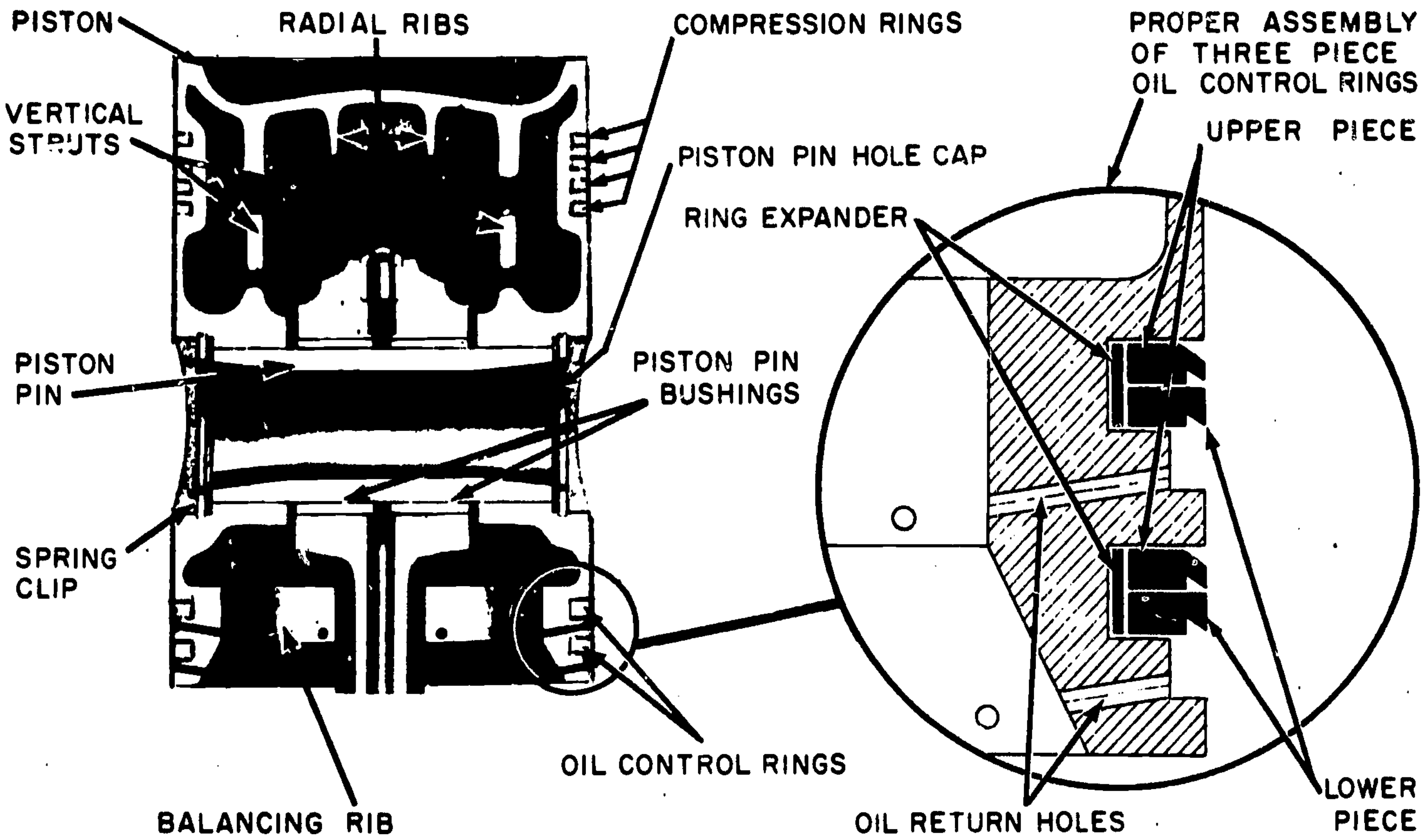


Fig. 17 Piston assembly and ring location.

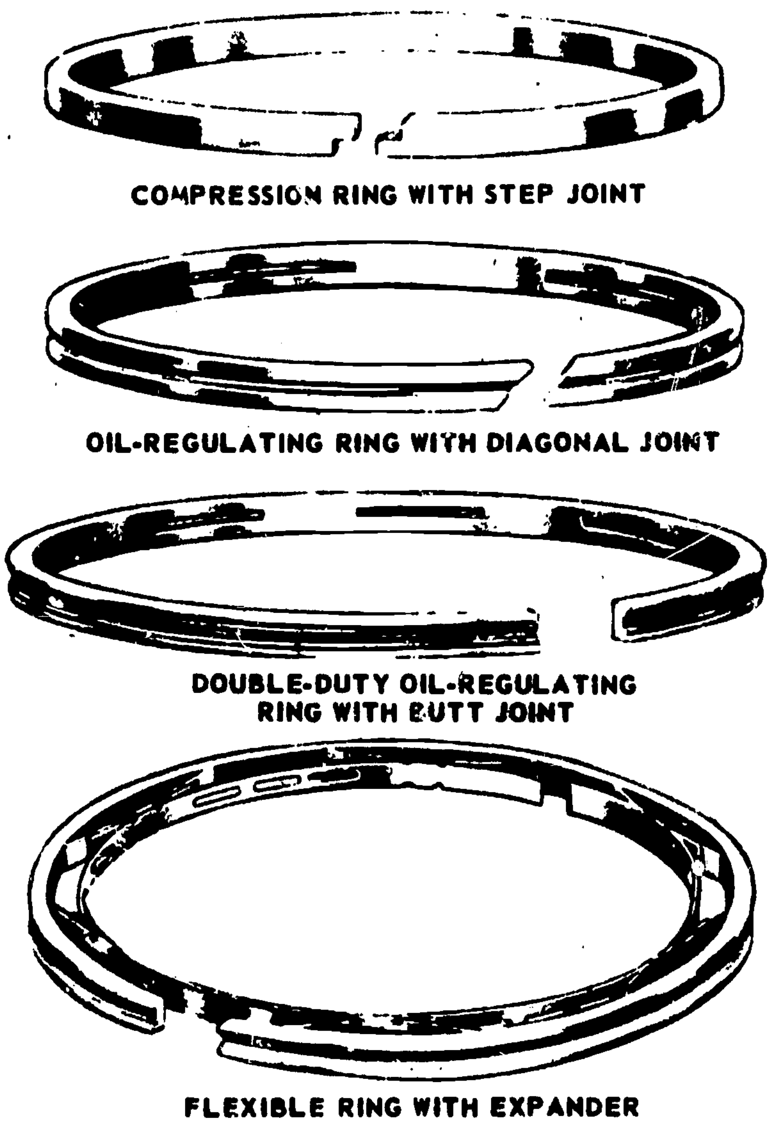


Fig. 18 Piston rings.

To install a new ring, first fit it proper side up by pushing it partway into the cylinder. Using the top of the piston for this purpose will locate the ring squarely in the cylinder. Check the gap between the end of the ring.

Rings must be fitted also for the proper side clearance, see Figure 19. If too much side clearance is given the rings, excessive wear on the ring grooves will result. If there is too little clearance, expansion may cause the rings' grooves to break.

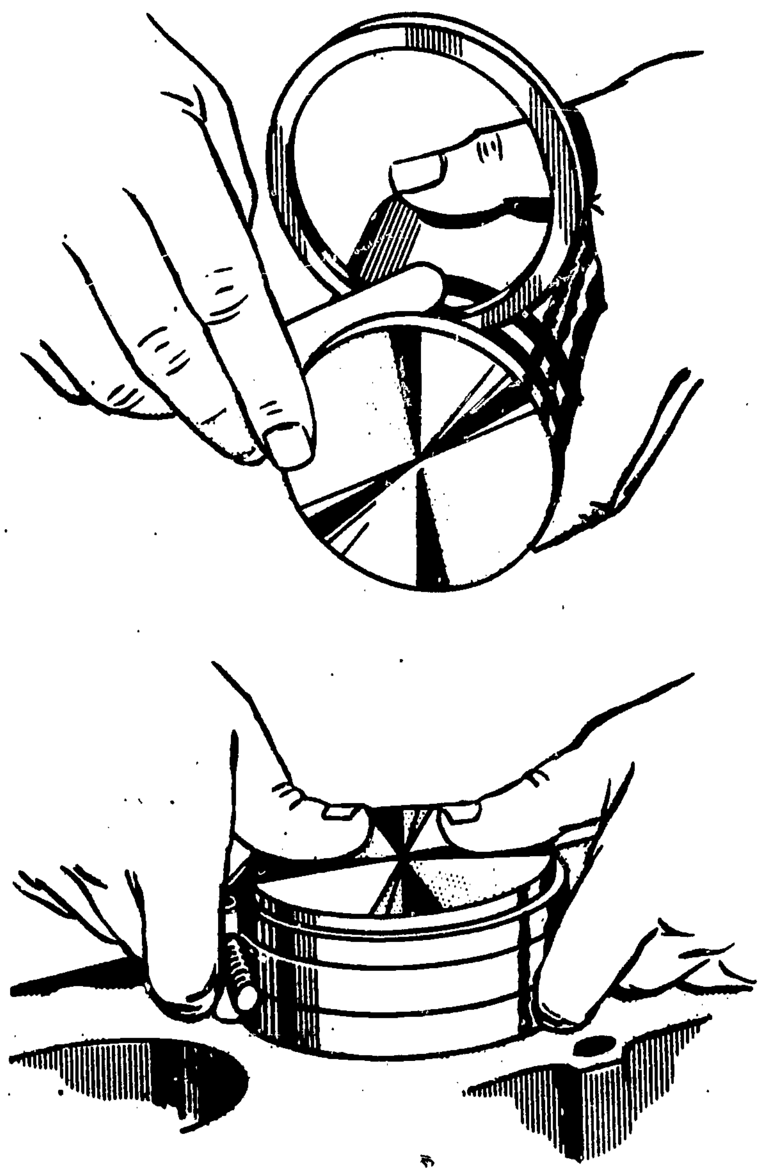


Fig. 19 Fitting and installing piston rings.

CONNECTING RODS - Connecting rods must be light and yet strong enough to transmit the thrust of the pistons to the crankshaft. Connecting rods are drop-forged from a steel alloy capable of withstanding heavy loads without bending or twisting. Holes at the upper and lower ends are machined to permit accurate fitting of bearings. These holes must be parallel.

The upper end of the connecting rod is connected to the piston by the piston pin. If the piston pin is locked in the piston pin bosses, or if it floats in both piston and connecting rod, the upper hole of the connecting rod will have a solid bearing (bushing) of bronze or similar material. As the lower end of the connecting rod revolves with the crankshaft the upper end is forced to turn back and forth on the piston pin. Although this movement is slight, the bushing is necessary because the temperatures and the pressures are high, see Figure 20.

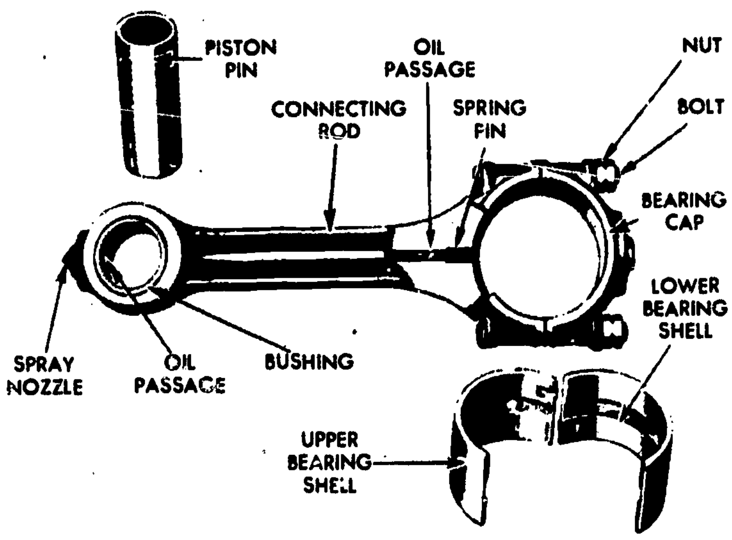


Fig. 20 Connecting rod assembly.

Most piston pin wear is caused by normal operation. It is often thought that such wear should be slight, compared to other shafts, such as the crank and main bearing journals. For this reason, operating personnel often neglect to give them the attention that they require. Piston pins are subject to wear. While the angular movement of the pin is small, the unit loading is very high, and the direction of rotation changes twice every revolution of the crankshaft. This condition causes a lubrication problem different from that of the crank and main bearing journals. The unit loading is necessarily high because of the limited size of the pins and the fact that the total load on the piston pin is approximately the same as that on the crank pin.

It is therefore, necessary that a close watch be kept on the piston pins. Every time a piston assembly is removed from the engine, the amount of wear of the piston pins and bearings must be determined. Micrometer calipers are used for these measurements and they should be made as indicated in Figure 21. Areas that do not contact the bearing must be avoided. Such areas include those between the connecting rod and the piston bosses, and areas under the oil holes and grooves.

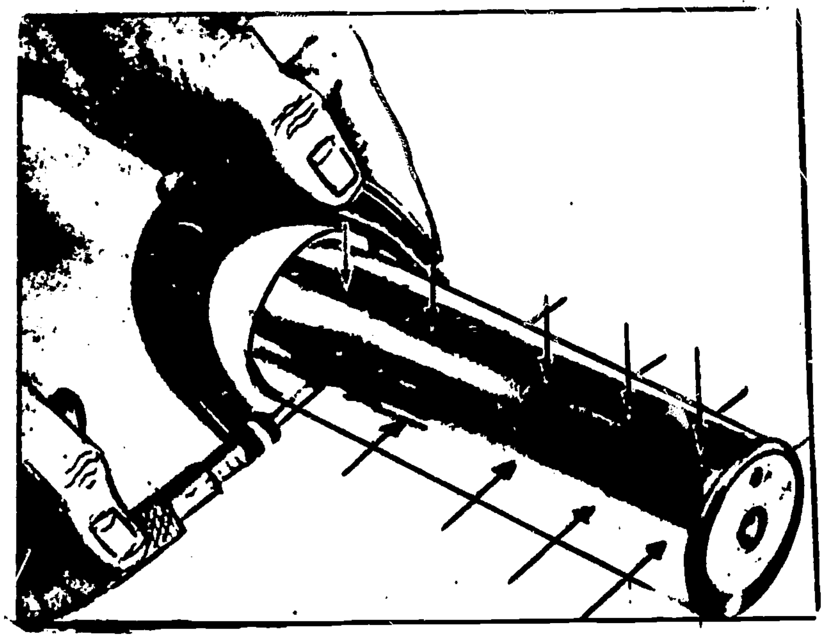


Fig. 21 Piston ring measurement.

CONNECTING ROD BOLTS - Connecting rod bolts are needed to hold the connecting rod bearing cap in position, and to support the load under certain conditions. The function of the bolts in four-stroke engines is far more important than in two-stroke engines, as the bolts are in direct tension on the intake stroke, of the four-stroke engine.

Overstressing of the connecting rod bolts is one of the chief reasons for their failure. When assembling the bolts, strict adherence to torque values must be followed.

Defective threads can cause considerable trouble. Stripped threads will allow the connecting rod to be loosened and cause serious damage to the engine. Whenever the rod bolts are removed, the bolt threads should be inspected to see that they do not tend to lay over. They should be clean cut and upright. If they are not, the bolt should be replaced. The nut that came off the bolt previously inspected, should be checked, particularly the threads, and also for cracks. When a nut starts to fail, it sometimes spreads out at the base sufficiently to be visible to the eye.

The nut should screw into the bolt easily and without excessive play. If there is considerable play, both the nut and bolt should be replaced at once. If the nut is tight on the threads, damaged or dirty threads are indicated. The threads of the nut and the bolt must be thoroughly cleaned before assembling. It is not enough just to wipe the threads with a cloth, as this forces dirt into the threads. A solvent and a stiff bristled brush should be used.

Figure 22 shows the right and wrong way to install cotter pins. It is very important that pins be installed correctly, to prevent possible loosening of the nuts and excessive engine damage.

INCORRECT CORRECT

Fig. 22 Installation of cotter pins.

That completes PART I of engine components. We hope you have picked up some good tips on maintenance of diesel engines.

DIDACTOR PLATES FOR AM 1-8D

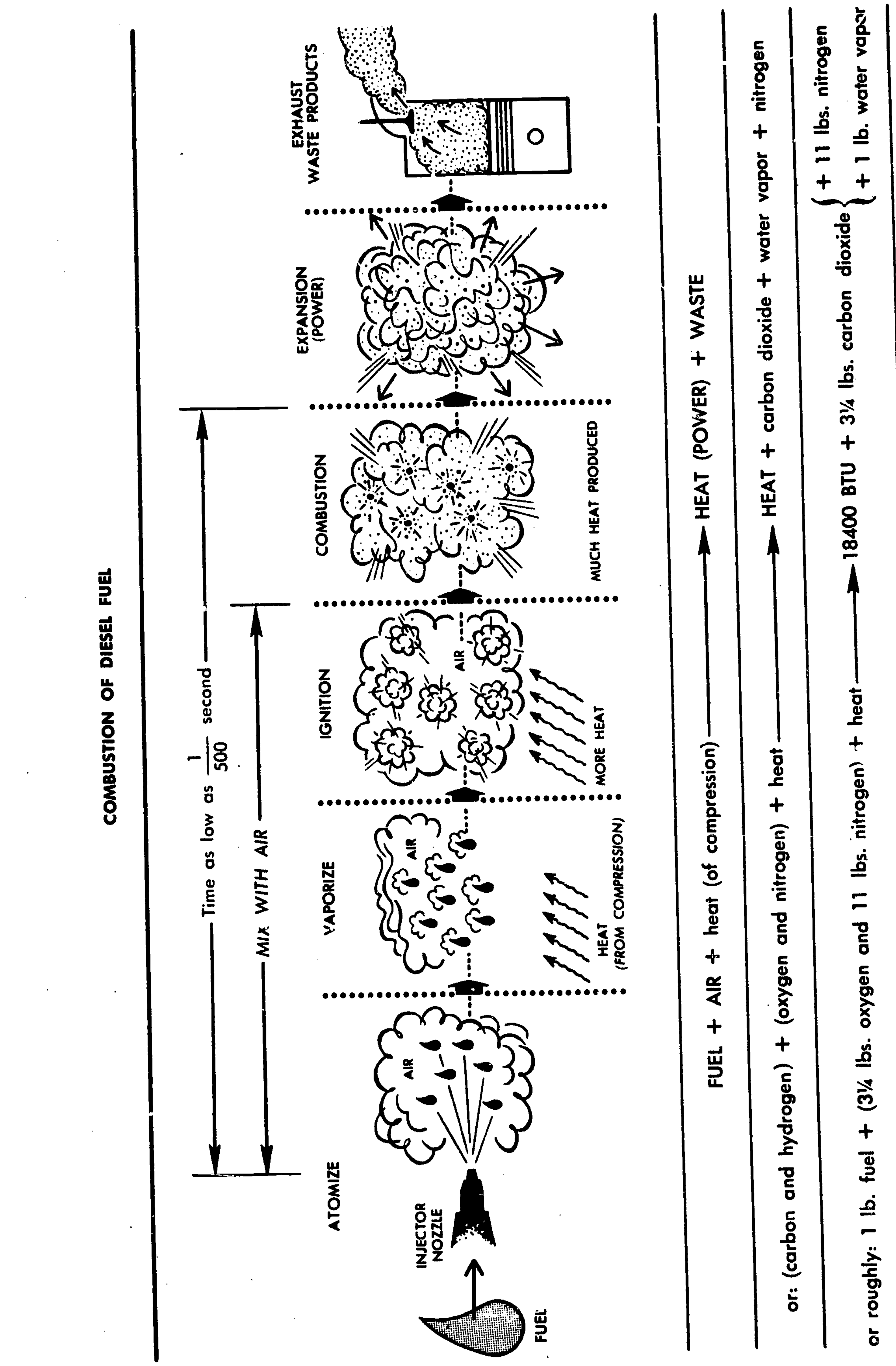
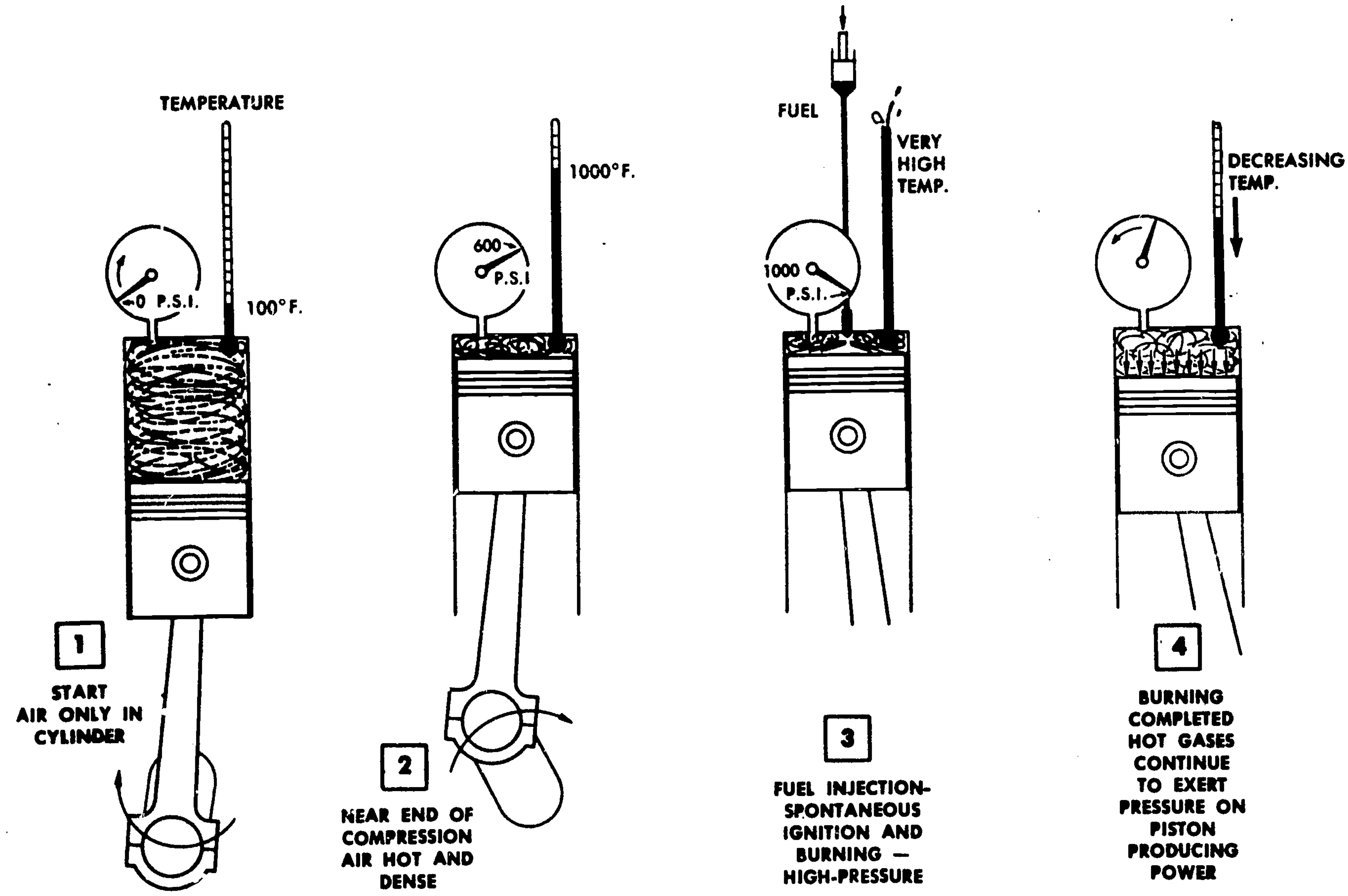


Plate I Combustion of diesel fuel.



<u>Plate II</u> The diesel combustion cycle.

Type of Engine Service	Typical Application	General Fuel Classification	Distillation: 90% Boiling Point (Max.)	Distillation: Final Boiling Point (Max.)	Cetane Number (Min.)	Sulfur Content (Max.)
Light Load and speed with considerable idling.	City Buses	No. 1-D	500°F	550°F	45	0.30%
Light Load and speed.	Generator sets, industrial and automotive equipment in city and suburban operation.	Winter No. 1-D	500°F	550°F	45	0.30%
		Summer No. 1-D	550°F	600°F	40	0.50%
Medium Load and speed.	Marine Pleasure Craft, Tractors, industrial equipment.	Winter No. 1-D	550°F	600°F	45	0.50%
		Summer No. 2-D*	625°F	675°F	40	0.50%
Heavy Load and high speed with idling.	Highway Trucks	Winter No. 2-D*	625°F	675°F	45	0.50%
		Summer No. 2-D*	625°F	675°F	40	0.50%
Heavy Load and high speed.	Heavy Duty Off-the-road Equipment, Trucks, Tractors.	No. 2-D*	675°F	—	40	0.50%

*NOTE: For most satisfactory engine life, use only those No. 2-D diesel fuel oils containing 0.50% or less sulfur; where minimum exhaust smoke is required or where long periods of idling or cold weather conditions below 32°F. are encountered, the more volatile or light distillate fuels are recommended.

<u>Plate III</u> Fuel oil selection chart.

ASTM Classification of Diesel Fuel Oils

	No. 1-D	No. 2-D
Flash Pt.; °F Min.	100	125
Carbon Residue; %	0.15	0.35
Water and Sediment; (% by Volume) Max.	Trace	0.10
Ash; % by Wt.; Max.	0.01	0.02
Distillation, °F 90% Pt.; Max.	550	675
Min.	-	540
Viscosity at 100°F; centistokes Min.	1.4	2.0
Max.	2.5	5.8
Sulfur; % Max.	0.5	1.0
Cetane No; Min.	40	40

Plate IV Classification of diesel fuel oils.

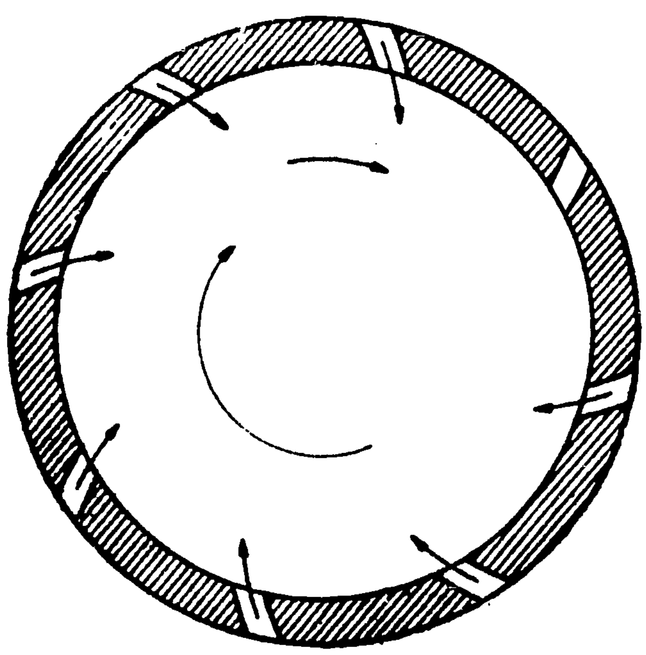


Plate V Turbulence in a two-stroke engine.

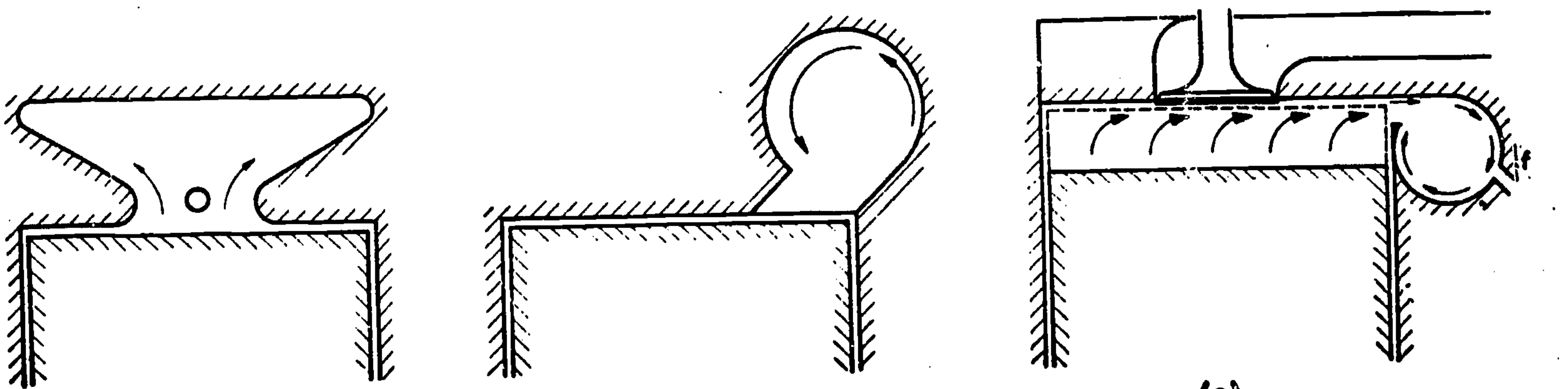


Plate VI Turbulence heads.

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AM 1-8 D
12/ 28/ 65

ENGINE COMPONENTS -- PART I

Human Engineering Institute

Press A — 1 . Check to see that timer is OFF

1

This unit supplements AM 1-8 text material by covering basic knowledge necessary to understand why a diesel operates. The unit will cover such concepts as: (1) combustion, (2) ignition, (3) air-fuel ratios, (4) ignition delay, (5) turbulence, (6) temperatures, (7) fuel qualities, and (8) smoke analysis.

Press A — 2

1

2

Because the diesel engine handles the entire job of vaporizing, mixing, and igniting fuel inside the cylinder in an extremely short time, conditions essential for good combustion must be provided. COMBUSTION is defined as a chemical reaction in which certain elements of the fuel combine with oxygen of the air, causing an increase in temperature of the gases. The main combustible elements are carbon and hydrogen; another combustible element, undesirable and contained in small amounts, is sulfur.

Press A — 3

1

3

Remember that nothing burns until it is in a gaseous form. This means that liquid fuel as it enters the cylinder, must be atomized or converted to vapor form before the burning process starts. Compression of the air charge in the cylinder provides heat for vaporizing. That alone, however, is not enough if the fuel is to be completely vaporized and burned in the space of a few thousandths of a second.

Vaporization can occur only from the surface of the liquid fuel. Therefore, to obtain this extremely rapid vaporization required, the fuel mass must be broken into a large number of small particles each presenting its surface to the heat.

Press A — 4

1

4

We can say, then, that before combustion can occur inside the cylinder ____________ of the fuel must take place. (Select the correct word).

A. mixing — 5
B. ignition — 6
C. vaporization — 7

1

5

No. You are right in saying that mixing of the fuel is required with oxygen; but, before this can occur the fuel must be vaporized through atomization. In other words it's broken into many small particles.

Press A — 7

1

6

No. Ignition is combustion. Remember, we said the fuel is a liquid when it enters the chamber and must be vaporized before the burning process (combustion) starts.

Press A — 7

1

7

OK. Vaporization is right. We can also say that combustion is a chemical reaction in which certain ______________ of the ____________ are combined with ________________ of the air, causing an ________________ in temperature of the gases. (Select the correct order of words).

A. particles, air, oxygen, decrease — 8
B. elements, fuel, oxygen, increase — 9
C. elements, fuel, particles, increase — 8

1

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8

You selected the wrong set of words. Remember, we said combustion was defined as a chemical reaction where certain elements of the fuel are combined with oxygen of the air, causing an increase in the temperature of the gases.

Let's move on.

Press A — 9

1

OK.

An excessive amount of _______________ contained in diesel fuel is undesirable for proper combustion.

Select the correct word:

A. nitrogen — 11
B. sulfur — 12
C. carbon — 10
D. hydrogen — 10

1

10

No. Carbon and hydrogen are desirable combustible elements. Sulfur content in fuel, especially diesel fuel, is kept to a minimum because of corrosion formation.

Let's move on. — 12

1

No. We did not mention nitrogen. Carbon and hydrogen are the desirable elements needed for combustion. Nitrogen is an inert gas, meaning it is inactive in the process of combustion.

Let's move on.

Press A — 12

1

12

OK. Sulfur is the element in diesel fuel that must be kept to a minimum. What sulfur there is in fuel burns as the fuel burns, and forms highly corrosive gases that are condensed by the cooled cylinder walls, especially when the engine operates under a low load and the cylinder temperature drops. Corrosion due to sulfur gases from fuel oil is frequently found in the exhaust system of diesel engines. Most manufacturers recommend the sulfur content not be over 0.5% by volume in diesel fuel for trouble-free operation.

Press A — 13

1

Now that we know the ingredients of combustion, let's see what really happens inside the cylinder.

As you read on, look at Plate I in your AM 1-8 Unit.

The oxygen necessary for combustion is obtained from the air drawn from the atmosphere through the blower. Air is a mixture of nitrogen and oxygen, with the oxygen content approximately 21 percent. During the process of combustion, the fuel oil particles are split into their component elements, hydrogen and carbon, and each element combines separately with oxygen of the air.

Press A — 14

1

14

Hydrogen combining with oxygen forms water, and carbon and oxygen combine to form carbon dioxide. If there is not enough oxygen present, part of the carbon will combine with oxygen and form carbon monoxide. When carbon monoxide is formed, the amount of heat developed by each unit of carbon is only 30 percent of the heat developed by the formation of carbon dioxide. The diesel engine produces very small amounts of carbon monoxide.

Approximately 14.5 pounds of air are required for the combustion of one pound of fuel oil. However, under such conditions some particles of oxygen diluted by nitrogen and products of combustion, will not be able to participate in the process of combustio[n] due to the exceedingly short time during which combustion must occur. Free carbon will be released, and some carbon monoxide will be formed. Therefo[re] to insure complete combustion of the fuel, an excess amount of air is always supplied to the cylinder.

Press A — 16

16

The ratio of the amount of air supplied to the quantity of fuel injected during each power stroke, both measured in pounds, is called the air-fuel ratio. When a diesel engine is operating at light loads, the air-fuel ratio is several times greater than 14.5 lbs. As the load is increased, the air-fuel ratio decreases; but even when the engine is overloaded, the ratio must be at least 25-30 percent greater than 14.5. It is undesirable to operate a diesel at idle speed for long periods of time because ______________. (Pick one).

A. the air fuel ratio is too low. — 17
B. too much carbon monoxide is formed. — 18
C. the burning sulfur creates highly corrosive gases. — 19

1

17

No. The air-fuel ratio is uncontrollable unless the filters are blocked or the blower is not operating properly. Excessive idling will create corrosive gases from the sulfur burning in the cylinder.

Let's move on.

Press A — 19

1

18

No. Remember, we said the diesel engine creates very little carbon monoxide. Excessive idling will create corrosive gases from the sulfur burning in the cylinder.

Let's move on.

Press A — 19

1

19

OK. The sulfur burning, and creating corrosive gases, is the correct answer. The burning gases from the sulfur condense because the ______________ than if the engine were at full load. (Pick one).

A. cylinder walls are expanded more — 20
B. piston rings allow more blow-by of air — 20
C. cylinder walls are cooler — 21

1

20

No. You are incorrect if you pushed A or B. The burning gases condense because of the coolness of the cylinder walls at idling speed. When a hot mass hits a cool surface, condensation takes place.

Let's move on.

Press A — 21

1

21

OK. You are correct.

Oxygen in the air serves to mix ______________ to allow combustion within the cylinder. (Choose the correct statement):

A. with the hydrogen and nitrogen fuel particles — 22
B. individually with each particle of the fuel — 24
C. with the carbon elements of the fuel — 23

1

22

No. Remember, we said the air contains nitrogen, not the fuel.

The correct answer was: mixes individually with each particle of the fuel to allow combustion.

Press A — 24

1

23

No. Besides the carbon element in fuel, there is also the hydrogen element. Both must split and mix with the oxygen particles.

Press A — 24

1

DIDACTOR

FILM NO. AM 1-8D

24

OK. You are right. We have covered a sequence of material in which it is important for you to understand what happens within the cylinder.

If you feel you know the material PRESS A — 26 to move on.

If you would like to review it again PRESS B. — 2

1

(x) C — 25

25

You have missed one or more of the questions in this sequence of material. You will be reviewing the material again. Please read carefully and think carefully before answering.

Press A — 2

1

26

In diesel engines, the fuel is ignited and combustion is started by the heat of compression alone. As mentioned before, the fuel enters the cylinder as a fine mist or spray. The cylinder at this moment is filled with almost pure air whose temperature is raised by compression to about 1000 to 1050 F. The particles of fuel pick up heat from the air, begin to turn into vapor and soon some vapor particles ignite. This ignition develops additional heat and helps to ignite other vapor particles something like a chain reaction.

Press A — 27

2

27

The time it takes to heat the fuel particles, turn them into vapor and bring about the combustion is called ignition lag, or IGNITION DELAY. The time involved depends on ignition quality of the fuel and certain characteristics, particularly engine speed and compression ratio. In present high speed engines, the time involved is from 0.0012 to 0.0030 of a second. This time decreases with an increase of speed due to improvement of air turbulence, and results in better heating of the admitted fuel. It will also decrease with an increase of compression ratio.

2

Press A — 28

28

Ignition delay can be defined as ______________ ______________.

A. the time it takes for the air to heat. — 29
B. the time it takes for the fuel particles to burn. — 31
C. the time it takes to vaporize the air particles. — 30

(Choose the correct answer).

2

No. The air is already heated when the fuel is injected into the cylinder. The correct answer was: the time it takes for the fuel particles to burn.

Press A — 31

2

30

No. The fuel is vaporized after it enters the cylinder. The temperature of the air in the cylinder, plus the compression, makes this vaporization possible. See Plate II.

Press — 31

2

Correct.

Ignition delay depends on certain factors involved; these are ______________, ______________, and ______________. (Choose A, B or C).

A. fuel quality, cylinder temperature, compression ratio. — 3
B. fuel temperature, compression ratio, type of engine. —
C. fuel quality, engine speed, compression ratio.

DIDACTOR

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32

No. You are right on two, but cylinder temperature is not one of the three we discussed for causes of ignition delay. The answer was: fuel quality, engine speed, and compression ratio.

Press A — 34

2

33

No. Fuel temperature, and type of engine do not alter the ignition delay. The answer we wanted here was fuel quality, engine speed and compression ratio.

Press A — 34

2

34

Correct.

The chain reaction combustion in a cylinder refers to ______________________.

A. air particles swirling to combine with fuel particles. → 35
B. one carbon particle uniting with an oxygen particle. — 35
C. vapor burning, creating heat to burn more vapor. — 36

2

35

No.

Remember, we said the particles of fuel pick up heat from the air, begin to turn into vapor and soon some begin to ignite. This ignition develops additional heat and helps to ignite other vapor particles.

Let's move on.

Press A — 36

2

36

Right.

Ignition quality is one of the most important properties of a diesel fuel. It is expressed by an index called the CETANE number. Present high speed diesel engines require a cetane number of about 50. This value compares to the octane rating of gasoline. The higher the cetane rating, the lower the ignition delay. The ignition quality of a fuel determines not only the ease of ignition and of starting cold engines, but also the kind of combustion obtained from the fuel.

Press A — 37

2

37

A fuel with a better ignition quality -- a higher cetane number -- gives easier starting at low temperatures. It also gives a quicker warm-up, smoother and quieter operation, lower maximum cylinder pressures, and more efficient combustion, hence, lower fuel consumption.

If a very low cetane rating is put into a high speed diesel, the result could be ______________.

A. pre-ignition — 38
B. delayed ignition — 40
C. no change in operation — 39

2

38

No. If the engine was timed correctly, you would be more likely to get delayed ignition, or maybe none at all, depending on how low the cetane number was. Certainly there would be misfiring pistons, considerable noise and high fuel consumption.

Press A — 40

2

39

No. There would be a definite change in engine performance. More than likely an ignition delay would occur, meaning the piston would be past top dead center before combustion took place. The engine would definitely be running rough, with misfiring of pistons and high fuel consumption.

Press A — 40

2

DIDACTOR

FILM NO. AM 1-8D

40

OK. Delayed ignition would be one of the symptoms, others would be rough engine operation, misfiring pistons, and high fuel consumption.

The VOLATILITY of diesel fuel is another important factor affecting engine operation. Volatility of fuel is indicated by the 90 percent distillation temperature. This is the temperature at which 90 percent of a sample of oil will boil off. The lower the temperature, the higher the volatility of the fuel.

Press A — 41

2

For small high speed diesel engines a higher fuel volatility is necessary to obtain low fuel consumption, low exhaust temperatures and minimum smoke. For heavy duty off-the-road equipment, the maximum 90 percent distillation temperature is 675 F.

The VISCOSITY of a fluid is the measure of its internal friction or its resistance to flow. In practice, viscosity is expressed by the number of seconds required for a certain volume of liquid at some standard temperature to flow out through an orifice or hole of a definite small diameter.

Let's go on.

2

Press A — 42

42

The longer it takes the fuel to flow through the hole, the higher its viscosity. Viscosity controls lubrication and friction between the moving parts and hence controls their wear. Lubrication of the parts in the fuel-injection system, such as the fuel injector, depends entirely upon the fuel for lubrication, and therefore its viscosity cannot be below a certain minimum. See Plate III and Plate IV for recommended classification of fuel oils.

Press A — 43

2

43

Before moving on to other characteristics of diesel fuels, let's see what you have learned so far.

The volatility of diesel fuel refers to the ____________ at which 90 percent of a sample of oil has ____________ off. (Choose the correct two words).

A. viscosity, burned — 44
B. temperature, distilled — 45
C. viscosity, distilled — 44

2

44

No. Remember, we said volatility of fuel oil was the temperature at which 90 percent of the sample of oil has distilled off.

Press A — 45

2

45

OK. That's correct.

Remember from the plates we saw that the distillation range of No. 2 diesel fuel used for off-the-highway equipment was ______ maximum to ______ minimum. (Choose the correct figures to fit the blanks. Do not look at your plates).

A. 575, 250 — 46
B. 700, 350 — 46
C. 675, 540 — 47

2

46

No. The correct answer is 675 maximum, 540 minimum. Extreme cold weather may change the requirement for fuel, see your maintenance manuals.

Press A — 47

2

47

OK.

If we used too low a viscosity fuel in the engine it might create ____________________

A. poor atomization of the fuel. — 48
B. poor lubrication of the injector parts. —
C. higher than normal fuel consumption. —

2

48

No. If the viscosity is too low, this would mean the fuel is like water, especially when the fuel is hot. Atomization would be no problem. The correct answer we wanted was: poor lubrication of the injector parts.

Let's move on.

Press A — 50

2

49

No. Fuel consumption has nothing to do with the viscosity, except it may be slightly higher if the fuel is too thin, which means the viscosity is low.

Press A — 50

2

50

OK. When the viscosity is too low, poor lubrication of the injector parts is the result. You have done well in answering the questions in this sequence of material. If you feel you know the material well enough and want to move on to new information PRESS B. — 52

If you want to review it again PRESS A. — 26

(x) C —

2

51

You have answered one or more questions wrong in this sequence of material. Therefore you will be reviewing it. Please read carefully and think before you answer each question.

Press A — 26

2

52

The flash point of a fuel is the minimum temperature to which an oil must be heated in order to give off inflamable vapors in a sufficient quantity to flash, or momentarily ignite, when brought in contact with a flame. Tests can be run to determine this characteristic -- check Plate IV for readings to be obtained.

Press A — 53

3

53

To sum up the importance of having and using the correct fuel in diesel engines, remember, if any of the following malfunctions occurs, it may be the result of using fuel that doesn't meet specifications:

1. Difficult cold-starting of the engine.
2. Reduced maximum power output.
3. High fuel consumption.
4. Smoky exhaust.
5. Rough and noisy engine operation.
6. Piston-ring and valve sticking.
7. Deposits of carbon and gummy substances on piston and cylinder liners.
8. Contamination of lubricating oils.
9. Excessive wear of various engine parts.

Press A — 54

3

54

Another important factor affecting proper combustion is TURBULENCE within the cylinder. As we mentioned before, in order to obtain efficient, smokeless combustion, the fuel injected into the cylinder must be broken up in very fine particles, be well atomized, and the fuel particles must be distilled uniformly through the whole combustion space. If proper turbulence of the air and fuel is not accomplished, the result will be incomplete combustion.

Press A — 55

3

55

In most diesel engines where mechanical to solid-injection of the fuel is used, distribution is accomplished by using nozzle tips with several holes, and by directing the fuel sprays so as to reach all portions of the combustion chamber. However, distribution of the fuel alone is not enough. The air must be sufficiently stirred up also. This is done by creating air turbulence. Hence, engines employing better means of air turbulence, naturally will have ________________.

A. less efficiency — 56
B. more power — 58
C. more smoke — 57

3

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56

No. If all the fuel particles unite with the oxygen particles, complete combustion will occur. Remember, we said that if enough air was not present to unite with the fuel particles, the carbon from the fuel would unite with the oxygen and form carbon monoxide. When this occurs, there is a considerable reduction in heat, making the engine less efficient.

Press A — 58

3

No. Incomplete combustion causes more smoke. If enough air is not present to produce complete combustion, the unburned fuel will escape as smoke from the exhaust.

Press A — 58

3

58

OK. Complete combustion means more power. Diesels are usually rated according to the maximum horsepower developed at the smoke limit. At a certain speed, a definite amount of air enters the cylinder. This is enough air to produce complete combustion of a certain amount of fuel, depending on the amount of turbulence present in the cylinder. If more fuel is injected, due to an overload condition, there will not be enough air present to burn the fuel, and it will escape as smoke.

Press A — 59

3

59

On the other hand, smoke (usually white in color) can also appear at light loads. At light loads, the average temperature within the cylinder may drop 500 F, due to the decreased amount of fuel being burned. Because of the lower temperature, the fuel ignites so late that the combustion is still going on when the exhaust valve opens. This also accounts for white smoke immediately after starting an engine.

Press A — 60

3

60

The fuel in a partially burned condition, escaping from the exhaust will be black. If the fuel is not igniting, or if lubricating oil is leaking into the chamber and burning, the smoke will be blue.

If an engine is smoking, we need to find out whether the majority of cylinders are responsible, or if one is causing the smoke.

Press A — 61

3

61

If the engine is equipped with an exhaust pyrometer for measuring the exhaust temperature, it is usually quite simple to determine which cylinder is smoking, as late burning which accompanies a smoke condition also causes high exhaust temperatures. Another method is to shut off the fuel from one cylinder at a time to note if the smoke disappears. Do not attempt this when the engine is at full load, because the other cylinder will be getting more fuel, resulting in overloading and smoking.

3

Press A — 62

62

If all the cylinders smoke, possibly the correct fuel is not being used, although it may be mechanical. If only one cylinder smokes, it is undoubtedly a mechanical malfunction.

Let's review.

In diesel engines, proper ______________ of the fuel-air is one thing that's required for complete combustion.

A. atomization — 63
B. mixture — 64
C. turbulence — 65

3

No. Remember, we talked about proper atomization of the fuel, not the air. We want both proper atomization and turbulence of the air, or circulation of the mixture.

Press A — 65

3

DIDACTOR

FILM NO. AM 1-8D

64

Proper mixture is good, but to get a good mixture, we must first have turbulence of the air so the fuel particles are able to unite continually with new parts of oxygen.

Press A — 65

3

65

OK. Turbulence is correct. A good mixture is essential too, but without the turbulence, the mixture will be poor.

Air turbulence in a GM engine is accomplished in the cylinder by ______________________.
(Choose one).

A. having the inlet ports below the compression rings. — 66
B. having the inlet ports cut at an angle. — 68
C. the use of the roots blowers. — 67

66

No. You have missed the first part of this course completely. The answer we wanted was: the ports are cut at an angle to create a swirling condition of the air, both for scavenging purposes and turbulence of the air after the piston has closed off the ports.

Press A — 68

3

67

No. It wouldn't matter what type of blower was used. If the ports were not cut at an angle in the liner, the air would enter straight and little turbulence would be accomplished.

Press A — 68

3

68

OK. You are correct. Plate V shows how this swirling motion is created inside the cylinder.

Smoke coming from the exhaust (black) under a light load condition can be caused by ______________.

A. not enough fuel injected. — 69
B. a pre-ignition condition. — 70
C. a late-ignition condition. — 71

3

69

No. The amount of fuel injected would still be proportional to the air being supplied. At light loads though, the cylinder temperature drops down, and the air-fuel mixture ignites later than if the temperature was high. The result is that combustion is going on when the valves open, or late-ignition occurs.

Press A — 71

3

70

No. It would be just the opposite: there would be a late-ignition condition due to the temperature drop in the cylinder or to light loads. The valves would open while the combustion is going on, causing the burning gases to escape.

Press A — 71

3

71

OK.

A smoking condition like we just described could also occur when ______________________.

A. the engine is running at full rpm. — 72
B. first starting the engine. — 74
C. the engine is burning lubricating oil. — 73

3

72

No. If the engine was running at full rpm, the cylinder temperature would be up, and combustion would be proper. The answer we wanted here was: when first starting the engine. This is when the cylinder walls would be cold, and a late-ignition condition would occur.

Press A — 74

3

73

No. Usually when lubricating oil is seeping into the combustion chamber and burning, the result is blue, not black, smoke. The correct answer is: when first starting the engine. This is when the cylinder walls are cold, and a late-ignition exists.

Press A — 74

3

74

OK. Let's move on.

One method which is used to see which cylinder is causing the smoke problem is to ________________. (Choose one).

A. cut off the air -- one cylinder at a time. — 75

B. cut off the fuel -- one cylinder at a time. — 77

C. run the engine at full load, then cut off the fuel -- one cylinder at a time. — 76

3

75

No. It would be very difficult to cut off the air from one cylinder at a time. The answer we wanted here was: to cut off the fuel to the cylinders -- one at a time, but not while the engine is running at full load.

Press A — 77

3

76

No. You are partially correct to cut off the fuel to each cylinder -- one at a time. But do not run the engine at full load while doing it, as this will cause overloading of the other cylinders and cause smoking.

Press A — 77

3

77

OK. You have done well on this sequence of material. Before going on to new material, if you would like to review this part to be sure you have it -- PRESS A. — 54

If you want to go on PRESS B. — 79

3

(X) C — 78

78

You have answered one or more of the questions in this sequence of material incorrectly. Since this material is important, you will be reviewing it once more. Please read carefully and take your time in answering.

Press A — 54

3

79

Turbulences are created in different ways by different manufacturers of engines. Plate VI shows some methods of accomplishing turbulence.

In Plate VI (a), turbulences are created by a restriction through which the air has to pass when the piston moves upward. The air velocity at the restriction is several times higher than before and after it, and the change of velocity creates a turbulent flow into which the fuel is injected from the fuel nozzle.

3

Press A — 80

DIDACTOR

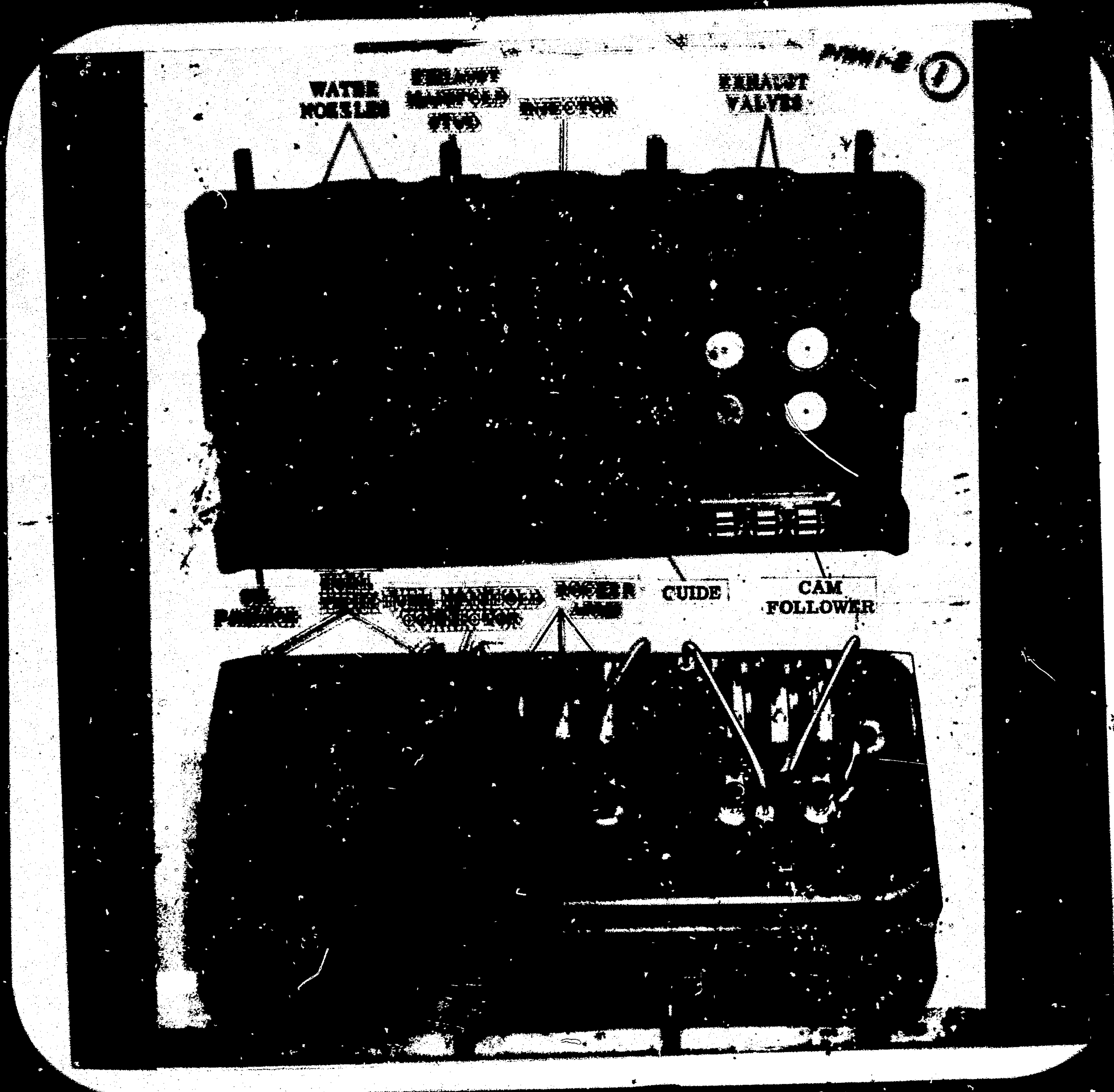
FILM NO. AM 1-8D

80

In Plate VI (b), the turbulences are created not only by the restriction, but also by forcing the air to travel on a circular path. In Plate VI (c), the principle is the same as (b) with one additional feature: when the piston approaches the (TDC) top dead center, it begins to partially cover the air passage between the cylinder and the turbulence chamber. This increases the air velocity in the passage, and thus makes more turbulent the flow of air into which the fuel is injected from nozzle (f).

This completes the lesson -- PRESS REWIND.

3



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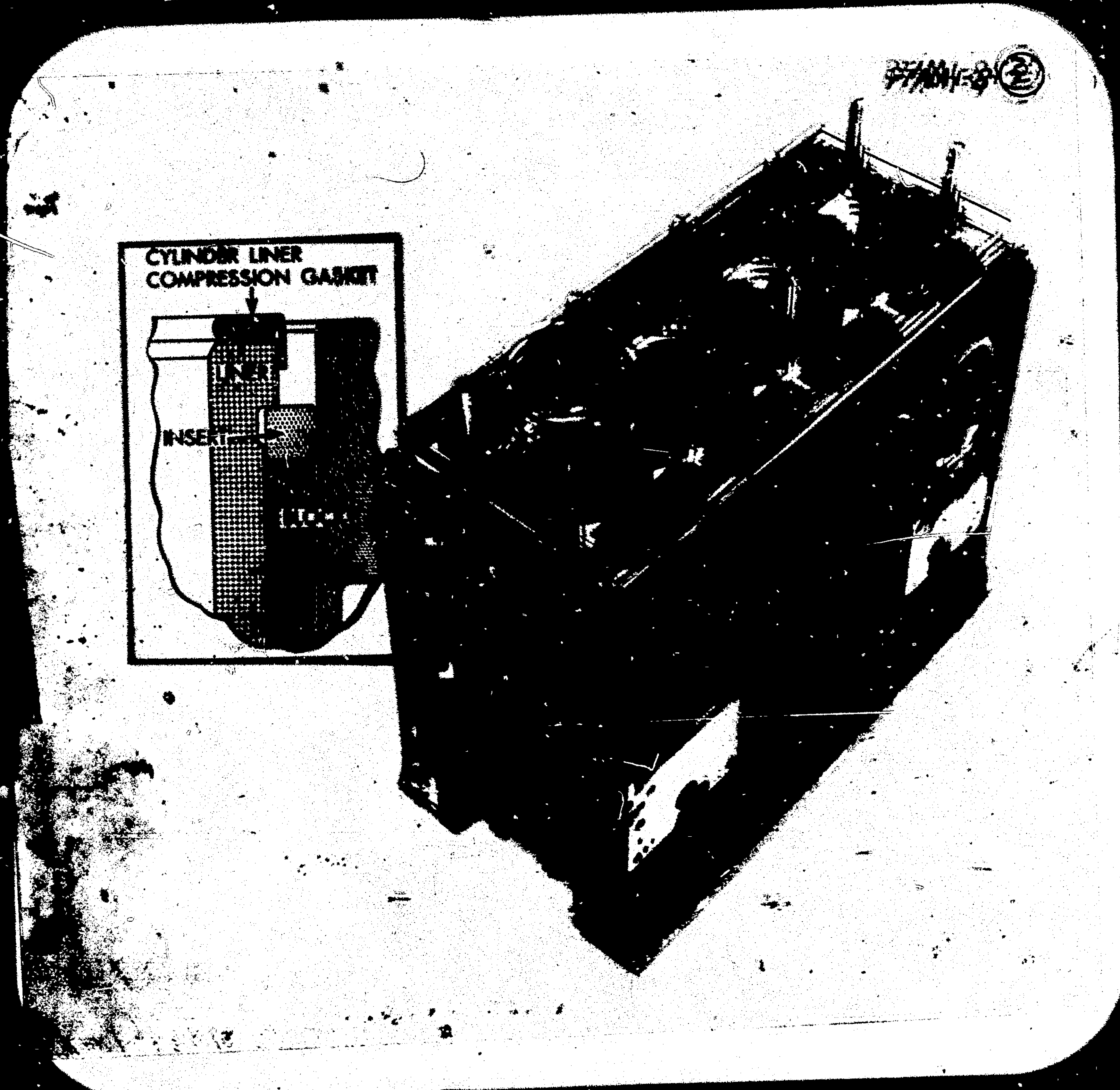

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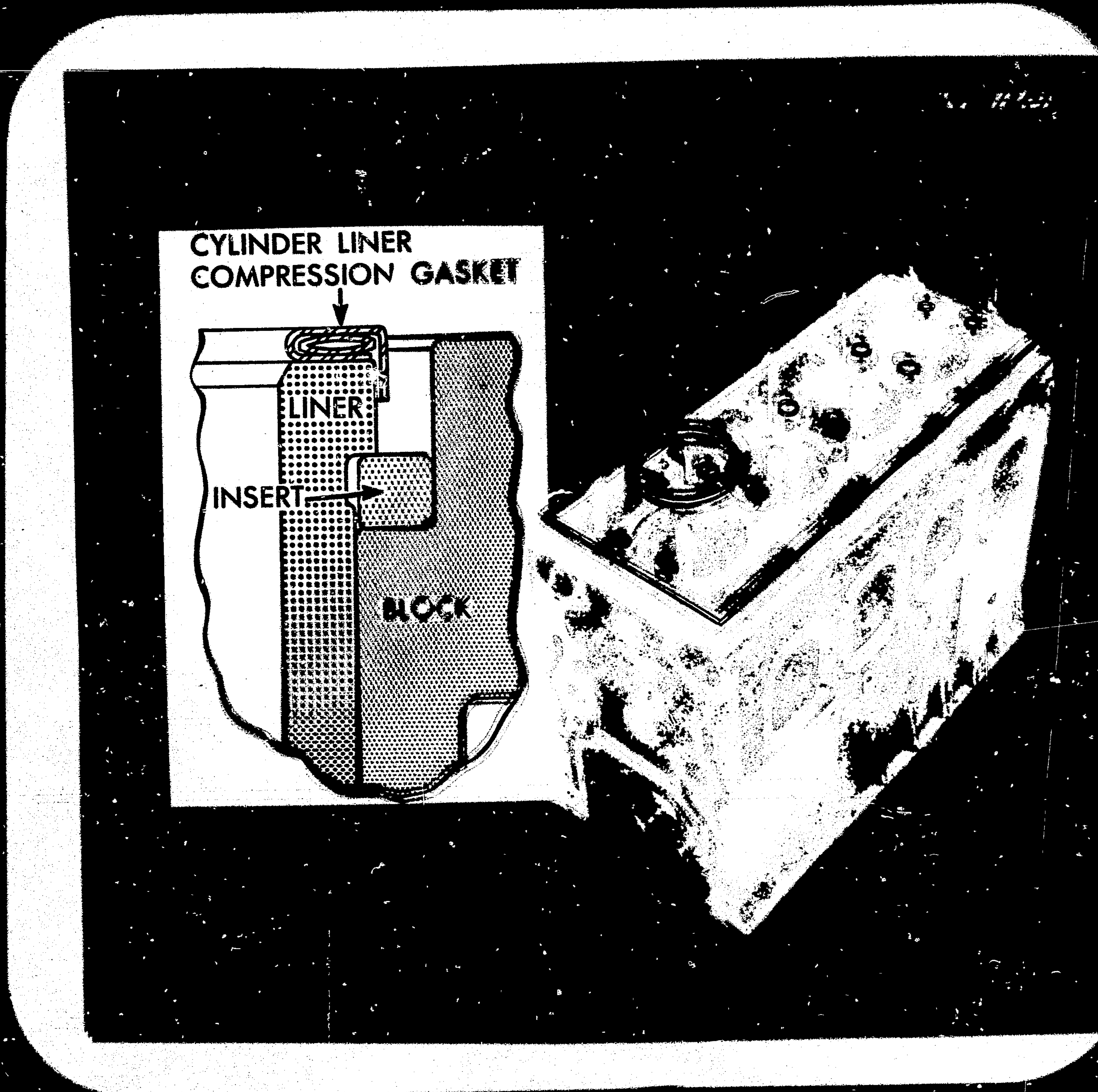

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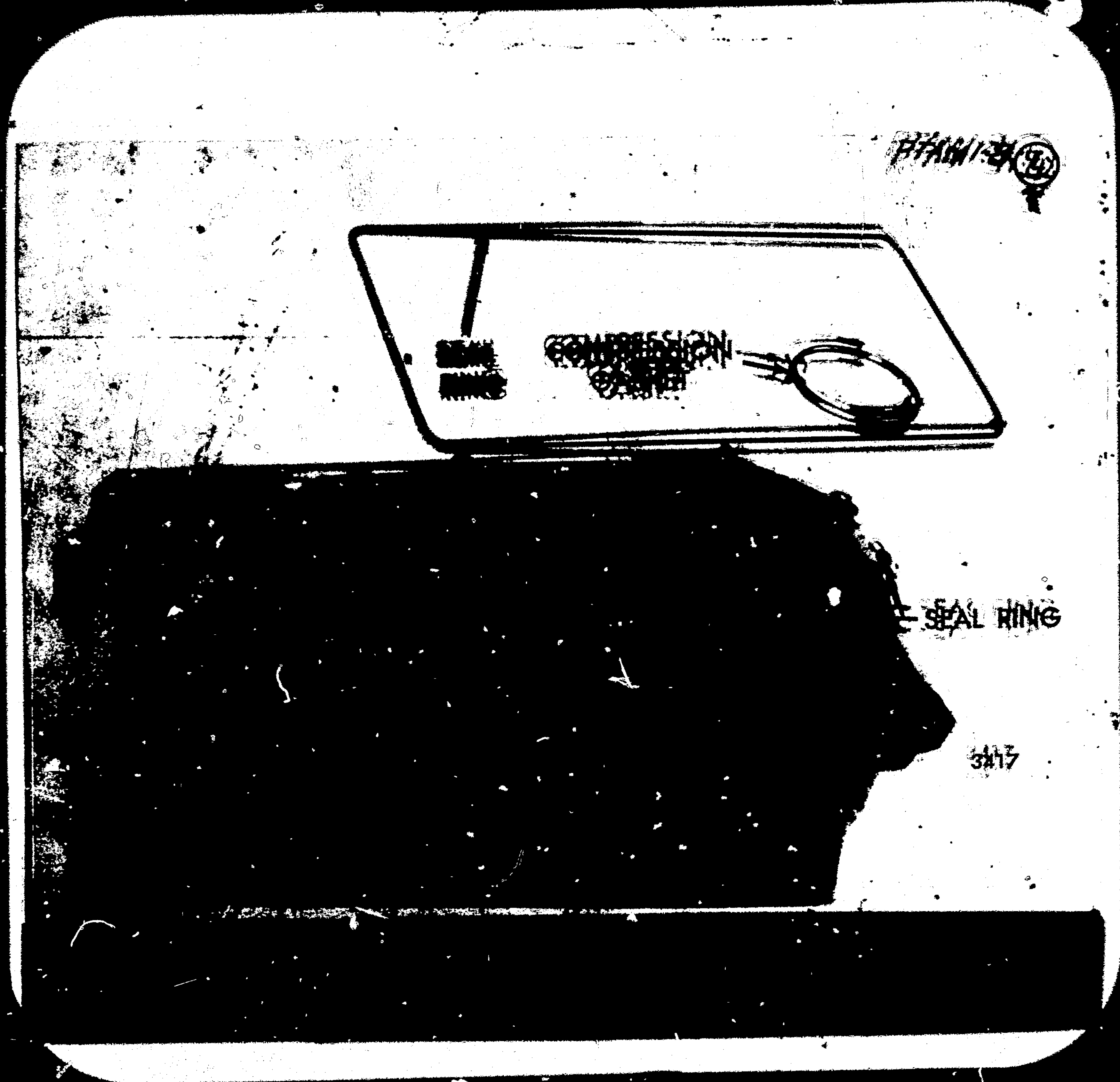
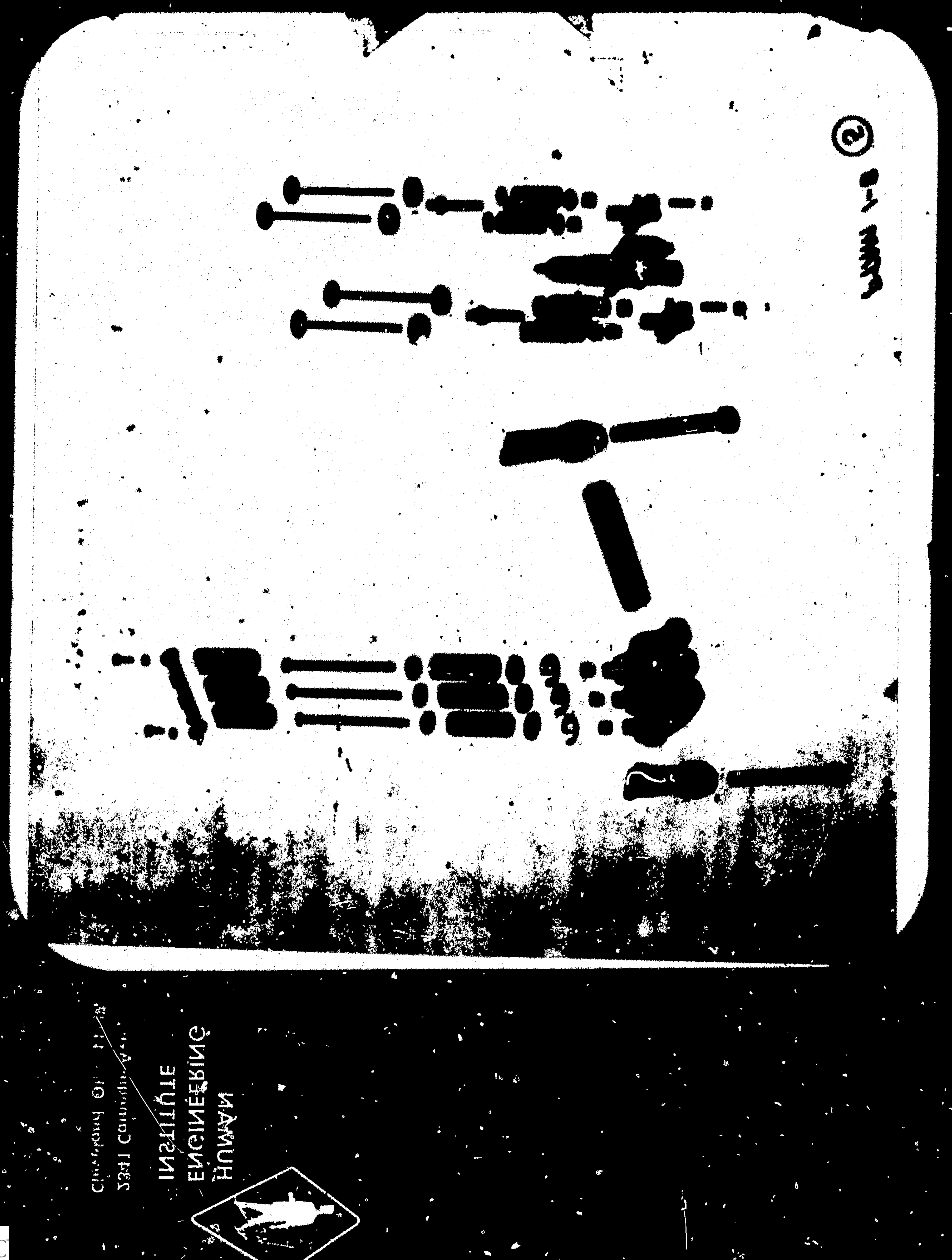

SEAL RINGS
COMPRESSION GASKET
SEAL RING
3417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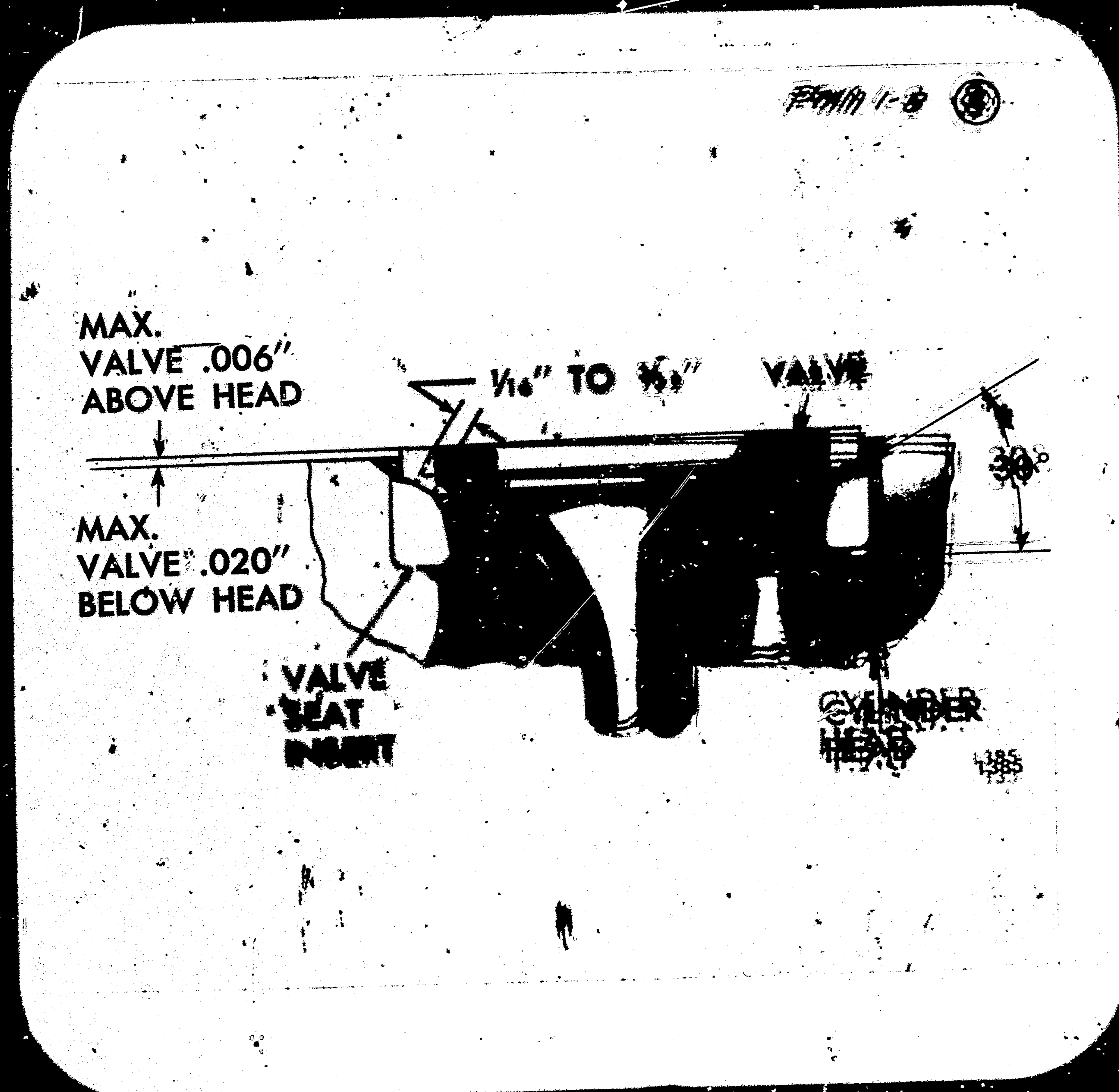
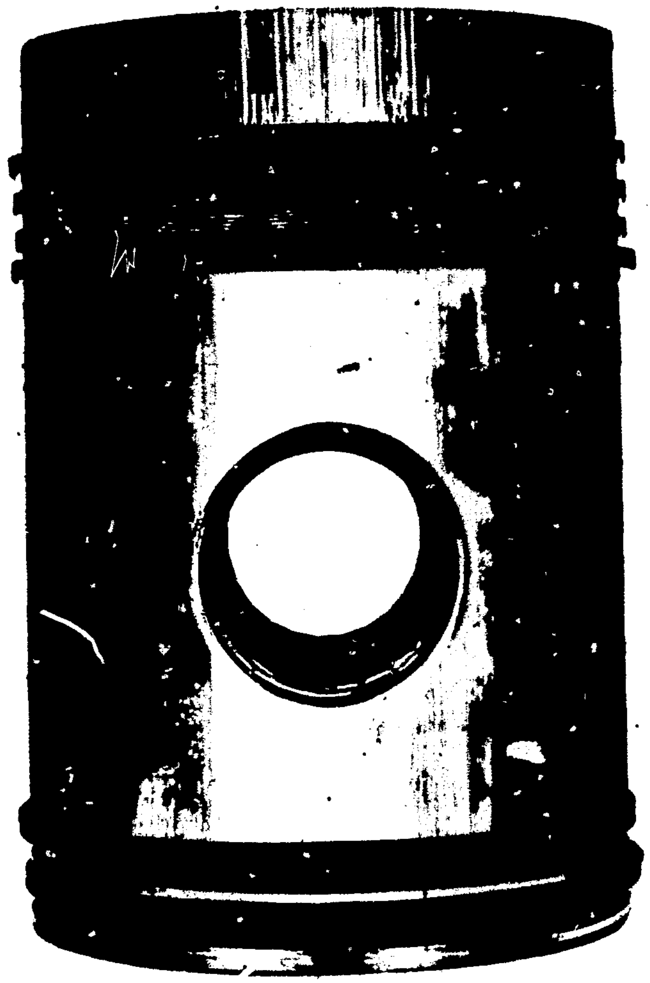

MAX.
VALVE .006"
ABOVE HEAD
MAX.
VALVE .020"
BELOW HEAD
VALVE
SEAT
INSERT
TO
VALVE
CYLINDER
HEAD
30°

PTAM 1-8 (9)



SLIGHTLY SCORED, USE ONLY AFTER REMOVING SCORE MARKS BY POLISHING WITH FINE EMERY OR HONING STONE

BADLY SCORED—UNFIT FOR USE

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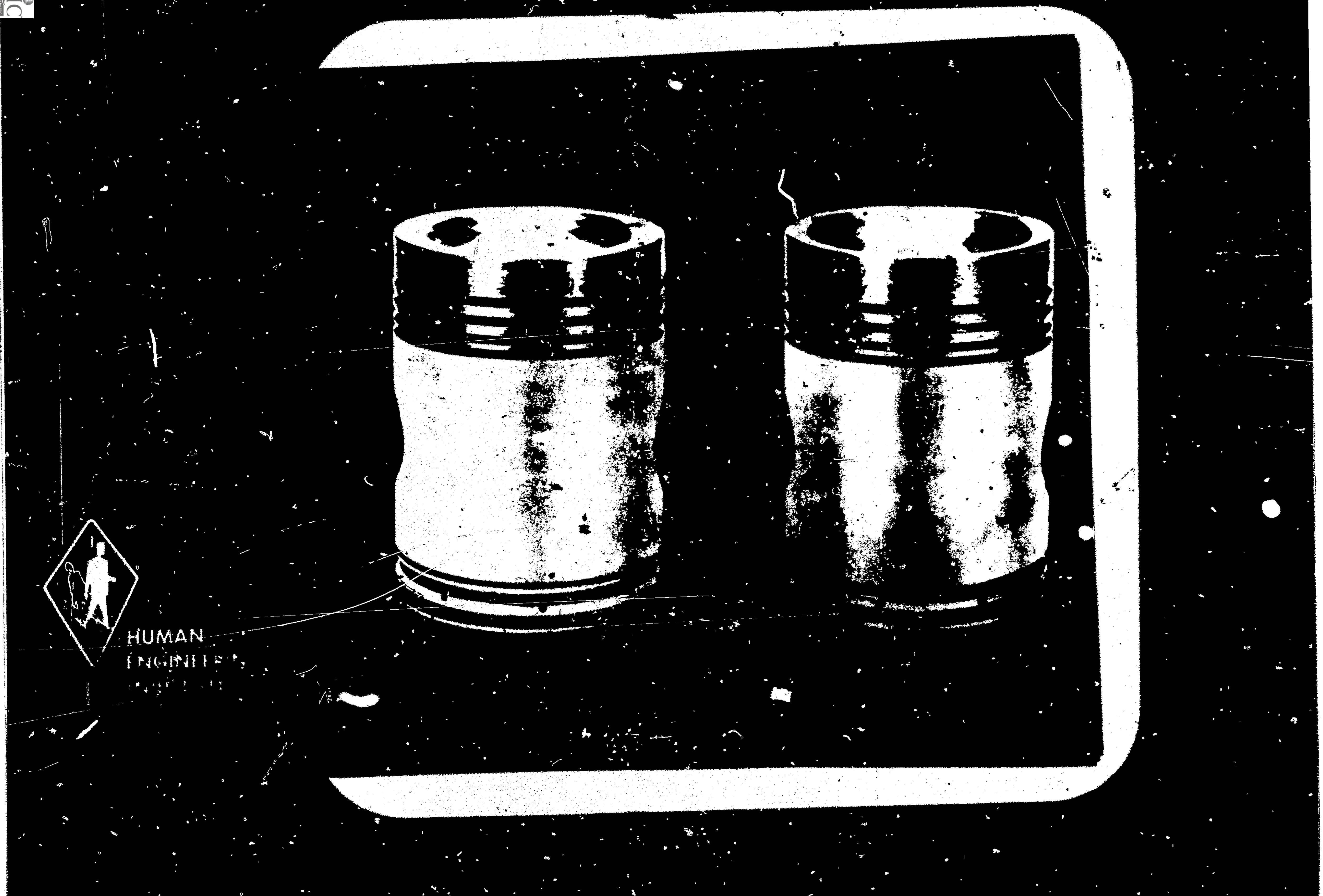
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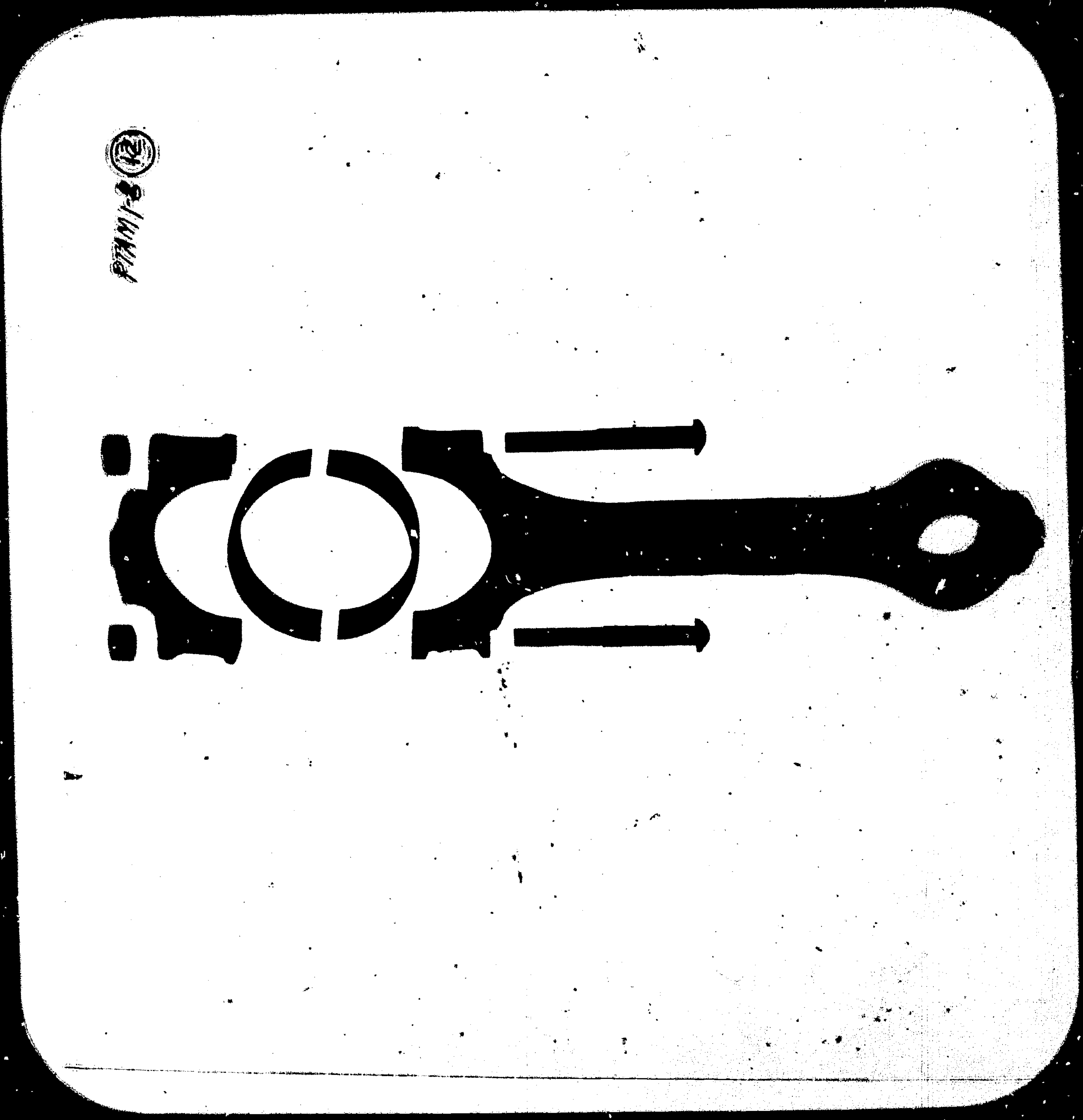

INSTRUCTOR'S GUIDE

Title of Unit: Engine Components I   Code: AM 1-8
12/28/65

FIRST --- Answer any questions which students may have concerning the previous tape - AM 1-7D

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

What parts make up the cylinder assembly as a unit.

The function of the cylinder liners, their construction, and how and when they are serviced

The construction (internal and external) of the cylinder head.

What the symptoms of a cracked cylinder head are, and how the head can be tested.

How is it determined whether a two valve or a four valve head is to be used on a given engine.

The function of the valves in a two-cycle engine, and how they operate.

What conditions create valve problems and how they can be remedied or prevented.

The construction and function of a 71 series piston and its related piston rings.

What to inspect for, and how to maintain the cylinder assembly.

SUGGESTED TRAINING AIDS

Cylinder head from a 71 series engine (with valves).

Cylinder liner and piston (with rings and connecting rod).

Wall charts -- Detroit Diesel - Cross Section - End View 71 Series, In-line and Vee.

Film Strip - Servicing the 71 Cylinder (25-SE-18) GM Diesel.

Vue cells -

AM 1-8 (1) (Cylinder head - 4 valve)
AM 1-8 (2) (Cylinder block sealing arrangement I - 71)
AM 1-8 (3) (" " " " ")
AM 1-8 (4) (" " " " V - 71)
AM 1-8 (5) (Exhaust valve assembly)
AM 1-8 (6) (Exhaust valve mechanism - 2 valve)
AM 1-8 (7) (Exhaust valve mechanism - 4 valve)
AM 1-8 (8) (Exhaust valve specifications)
AM 1-8 (9) (Scored pistons)
AM 1-8 (10) (Piston ring arrangement)

AM 1-8 (11) (Piston ring arrangement)
AM 1-8 (12) (Connecting rod assembly)

QUESTIONS for discussion:

Why are cylinder liners used in a diesel engine?

Are all cylinder liners designed the same way in general? (2 cycle vs. 4 cycle engines - wet vs. dry)

What are some of the indication of a cracked liner - wet and dry type?

What are some of the possible causes of the following conditions:
- a) Cracked or broken liner.
- b) Scored liner.
- c) Obstructed liner ports.
- d) Worn liner
- e) Oil pumping

What are the indications of a cracked cylinder head and where are these cracks most likely to occur?

How can a cylinder head be tested for cracks?

What are some of the possible causes of the following conditions?
- a) Cracked cylinder head.
- b) Burned or corroded cylinder head.
- c) Distorted cylinder head.

How many times can head gaskets and seals be reused - explain!

Is there a proper sequence or order for tightening cylinder head studs; if so -- why?

What is the function of the valves in a 2 cycle engine, and why do some heads have 2 valves and others 4 valves?

What are some of the possible causes of the following conditions and how are they remedied:
- a) Exhaust valve sticking open
- b) Burned valves
- c) Broken valve springs
- d) Bent or broken valve stems

What are some of the indications and causes of a worn piston?

Do all piston rings serve the same purpose?

Why are piston ring gaps staggered?

In an internal combustion engine (such as the GM engine we have been discussing) what portion of the energy which is produced in a cylinder is actually transformed into work? Where does the remaining energy go?