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AUTOMOTIVE DIESEL MAINTENANCE 1. UNIT IV, MAINTAINING THE COOLING SYSTEM--DETROIT DIESEL ENGINES.
HUMAN ENGINEERING INSTITUTE, CLEVELAND, OHIO
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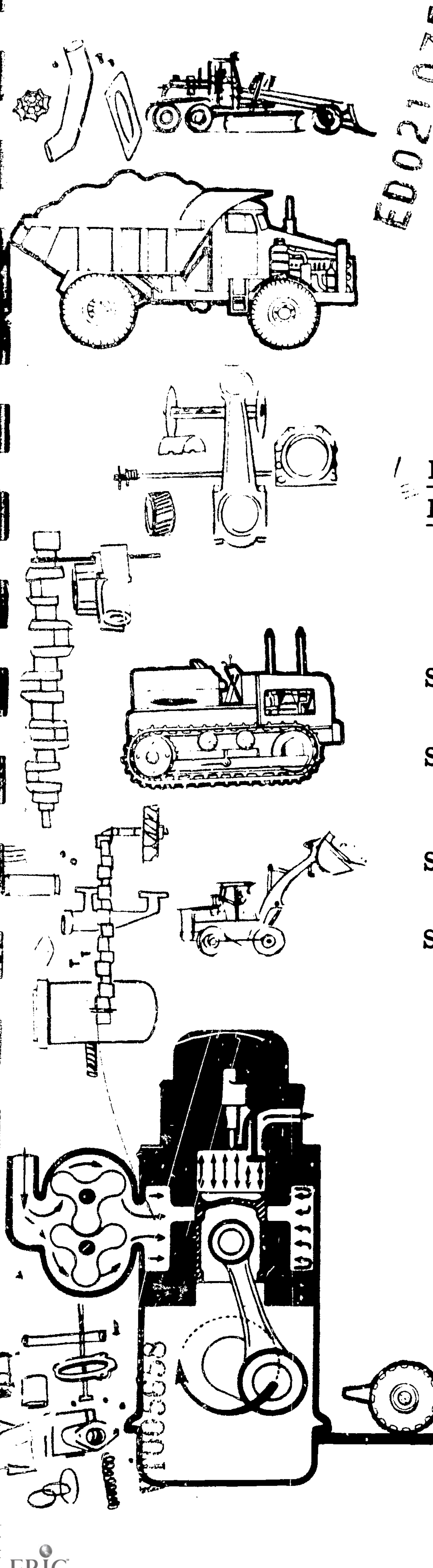
THIS MODULE OF A 30-MODULE COURSE IS DESIGNED TO DEVELOP AN UNDERSTANDING OF THE OPERATION AND MAINTENANCE OF THE DIESEL ENGINE COOLING SYSTEM. TOPICS ARE PURPOSE OF THE COOLING SYSTEM, CARE MAINTENANCE OF THE COOLING SYSTEM, COOLING SYSTEM COMPONENTS, AND TROUBLESHOOTING TIPS. THE MODULE CONSISTS OF A SELF-INSTRUCTIONAL BRANCH PROGRAMED TRAINING FILM "DIESEL AUTOMOTIVE MAINTENANCE--HEAT TRANSFER" 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

MAINTAINING THE COOLING SYSTEM --
DETROIT DIESEL ENGINES

UNIT IV

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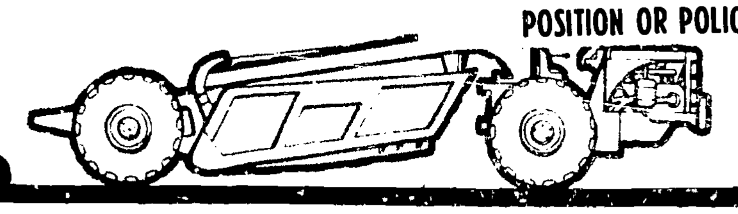


HUMAN ENGINEERING INSTITUTE

SECTION A -- PURPOSE OF THE COOLING SYSTEM

The purpose of the cooling system is to keep the engine operating at its most efficient temperature. Cylinder wall temperature must not increase beyond 400 to 500 F. Temperatures higher than this will cause the lubricating oil film to break down and to lose its lubricating properties. But it is desirable to operate the engine at temperatures as close to the limits imposed by oil properties as possible.

Since the engine is quite inefficient when cold, the cooling system includes devices that prevent normal cooling action during engine warmup. These devices allow the working parts of the engine to reach operating temperature quickly and to shorten the inefficient cold-operating time. Then, when the engine reaches operating temperatures, the cooling system begins to function. Thus the cooling system cools rapidly when the engine is hot, and it cools slowly or not at all when the engine is warming up or cold.

The GM cooling system has a centrifugal type water pump that circulates the engine coolant. The system uses thermostats to maintain normal engine operating temperature of 160 to 185 F.

Basically, here is how the cooling system works. The coolant is drawn from the lower portion of the radiator by the water pump and is forced through the oil cooler housing and into the cylinder block. From the cylinder block the coolant passes through the cylinder heads, and -- when the engine is at normal operating temperature -- through the thermostat housings into the upper part of the radiator. The coolant then passes down a series of tubes, where its temperature is lowered by a stream of air from the fan.

When the coolant is below operating temperature, it is stopped at the thermostat housing. A bypass tube provides water circulation within the engine during this warmup period. This bypass arrangement allows the engine to heat up uniformly, and also heats up the coolant faster.

SECTION B -- CARE MAINTENANCE OF THE COOLING SYSTEM

DRAINING THE COOLING SYSTEM -- To drain the coolant, open the cylinder block and radiator drain cocks and remove the pressure cap. Removal of the pressure cap allows air to enter the cooling passages and helps to drain completely.

To be sure that all the coolant is drained from the system, all the system drains should be opened. When freezing weather is expected, all units not protected by antifreeze should be completely drained. Any water trapped in the cylinder block or radiator will freeze, expand, and cause damage - thus the necessity for opening all drains. Leave the drain cocks open until the system is finally refilled.

THE USE OF CORROSION INHIBITORS -- A corrosion inhibitor should be added to the coolant during the summer. Corrosion inhibitors coat the metal surfaces in the cooling system with a thin film. This film prevents the oxygen in the coolant from forming rust. Corrosion inhibitors are classified into two types, chemical and soluble oil. When a soluble oil type inhibitor is used, it should not exceed 1% of the total cooling system capacity. Rust inhibitors should never be used in a system which uses a cooling system filter and conditioner. These special cooling system filters include a chemically activated filter element, an electrocorrosion plate, a settling sump and other component parts to assure protection of the cooling system. Engines equipped with a filter and conditioner need not be flushed; however, when the cooling system is drained, the filter should be cleaned thoroughly and a new element installed. Before the initial installation of a cooling system filter and conditioner, the system should be thoroughly cleaned and flushed.

USING ANTIFREEZE SOLUTIONS -- High boiling point antifreeze solutions are used during the winter because of high coolant temperatures found in diesel engines.

Alcohol base antifreeze has too low a boiling point for diesel use. Most high boiling point antifreeze solutions include a corrosion inhibitor which will protect the cooling system through the winter season. Additional additives should not be used when a system is protected by this antifreeze solution. In the spring, the antifreeze solution should be drained and discarded.

If the cooling system is protected by a water filter and conditioner, and antifreeze is added, the filter element must be removed. Antifreeze and the filter element are not compatible.

FLUSHING THE SYSTEM -- If a coolant filter is properly maintained, the cooling system need not be flushed. If no filter is used, the cooling system should be flushed each spring and fall. Flushing cleans the system of anitfreeze in the spring and removes the rust inhibitor in the fall. Flushing should be performed as follows:

1. Drain the previous season's solution from the unit.
2. Refill with clean water. (If the engine is hot, fill the unit slowly, to prevent rapid cooling and distortion of engine castings.)
3. Start the engine and operate it for 15 minutes to thoroughly circulate the water.
4. Drain the unit completely.
5. Refill with the solution required for the coming season.

A clean cooling system will reduce engine wear by eliminating hot spots. This will increase the operating time between engine overhauls.

USING COOLING SYSTEM CLEANERS -- If the engine ever heats when the fan and water level are o.k., it is necessary to clean and flush the entire cooling system. Scale formation can be removed by using a good, safe descaling solvent. Immediately after using the descaling solvent, use a neutralizer. It is important that the directions printed on the container of the descaler be followed.

After the solvent and neutralizer have been used, completely drain the engine and radiator and reverse-flush the system before you fill it.

REVERSE-FLUSHING PROCEDURE - Reverse-flushing is done by forcing pressurized hot water through the system opposite the normal direction of flow. This action loosens up the scale deposits and forces them out.

When reverse-flushing, the water pump should be removed. Then the radiator and engine should be done separately. This prevents dirt and scale deposits from clogging the radiator tubes or being forced through the pump.

If scale deposits in the radiator cannot be removed by chemical cleaners or reverse-flushing, it may be necessary to remove the upper tank and clean out the individual radiator tubes with flat steel rods. Water is circulated through the radiator core from the bottom to the top during this operation.

CLEANING CONTAMINATED ENGINES - When the cooling or lubricating system of an engine becomes contaminated, it should be flushed thoroughly before the engine is damaged seriously. One possible cause of such contamination is a cracked oil cooler core. Here oil is forced into the cooling system while the engine is operating. With the engine stopped, coolant will leak into the lubricating system.

Coolant contamination of the lubricating system is very harmful to engines during the cold season. During this time the cooling system is usually filled with ethylene glycol antifreeze. If mixed with the oil in the crankcase, this antifreeze forms a varnish which quickly immobilizes moving engine parts.

To remove such contaminants from the engine, both the cooling system and lubrication system must be thoroughly flushed as follows:

1. Prepare a mixture of Calgon (or its equivalent) and water at the rate of two ounces (dry measure) to one gallon of water.
2. Remove the engine thermostat(s) to permit the Calgon and water mixture to circulate through the engine and radiator.

3. Fill the cooling system with Calgon solution.
4. Run the engine for five minutes.
5. Drain the cooling system.
6. Repeat Steps 1, 2, 3 and 4.
7. Fill the cooling system with clean water.
8. Let the engine run five minutes.
9. Drain the cooling system completely.
10. Install engine thermostat(s).
11. Close all the drains and refill the system with fresh coclant.

MISCELLANEOUS COOLING SYSTEM CHECKS - The other components of the cooling system should be checked periodically to keep the engine operating at peak efficiency. The cooling system hoses, thermostats, and radiator pressure cap should be checked and replaced if found to be defective. All external leaks should be corrected as soon as found. The fan belt must be adjusted to provide the proper tension. The fan shroud must be tight against the radiator core to prevent re-circulation of air which may lower the cooling efficiency.

SECTION C -- COOLING SYSTEM COMPONENTS

WATER PUMP IN THE V 71 - The centrifugal water pump is mounted on the engine balance weight cover and is driven by the water pump drive gear. The pump circulates coolant through the oil cooler, cylinder block, cylinder heads and the radiator. See Figure 1.

A curved vane impeller is placed on one end of the tapered shaft and held in position by a self-locking nut. A drive gear is pressed onto the opposite end of the drive shaft. Two ball bearings support the shaft in the water pump housing. The larger of the two bearings is used at the drive gear end, and takes the thrust load. See Figure 2.

An oil seal is used ahead of the forward bearing. A spring-loaded, face type water seal is used at the impeller end of the pump.

LUBRICATION - The ball bearings are lubricated by splash from the water pump drive gear.

REPLACING THE PUMP SEAL - The water pump seal can be replaced without removing the pump from the engine, by removing the impeller.

Use special tool, J 4974-01, to remove the impeller from the pump shaft.

CAUTION: Protect the ceramic seat on the impeller from damage at all times during pump overhaul. Always lay the impeller on a bench with the ceramic seat up to prevent damage.

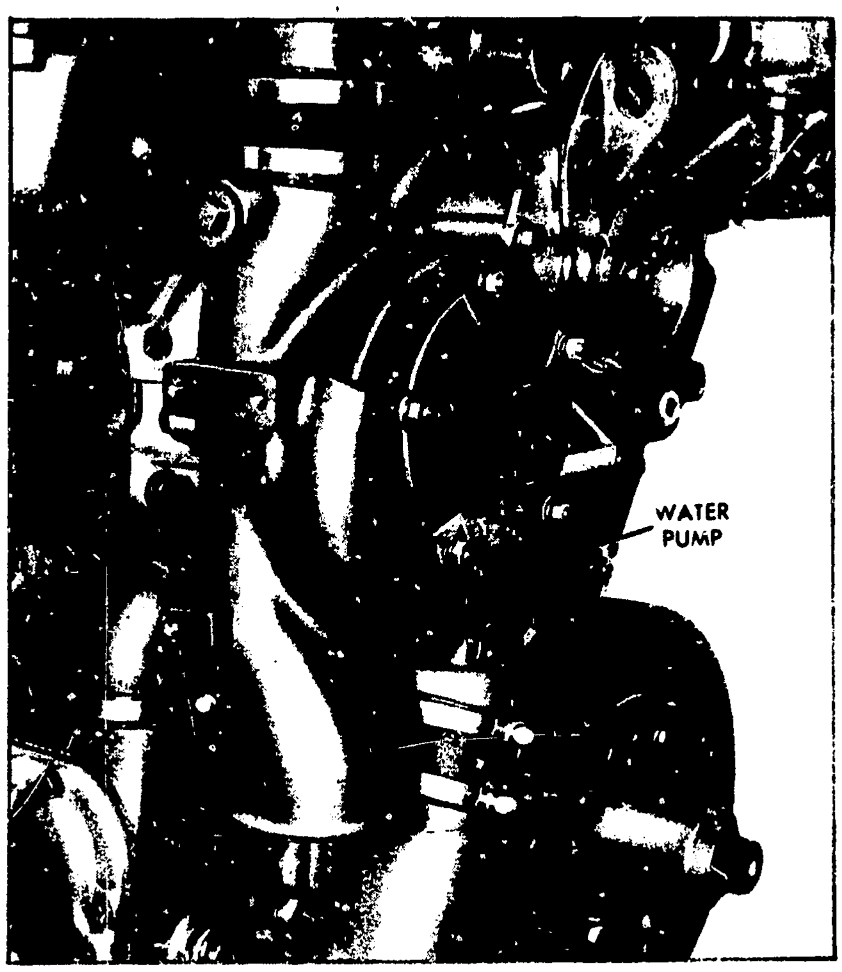


Fig. 1 Water pump mounting.

Using a pair of pliers on the seal at the opening in the pump housing, pry the seal out of the housing.

Use a suitable hollow tool (to slide over the seal face and spring) to tap a new water seal into the pump housing.

Inspect the ceramic seat for cracks and scratches. Also, check the bond to the impeller and replace the impeller if necessary.

Apply a thin film of oil to the ceramic seat of the impeller and place it on the tapered shaft. Place the washer and lock nut on the shaft and tighten to 30 to 35 ft-lbs torque.

NOTE: Surfaces of the water seal and the ceramic seat on the impeller must be clean and free from dirt and metallic particles before assembling.

Measure the clearance between the impeller and the pump housing. There should be a minimum of .015". Clearance can be checked by placing a feeler gauge in the water outlet opening.

Be sure to use a new gasket between the cover and the pump body.

When removing or installing the water pump, be very careful not to damage the teeth of the pump drive gear.

Remember to inspect the pump seals and remove them only if they are cracked or worn. Always use new seals for replacement.

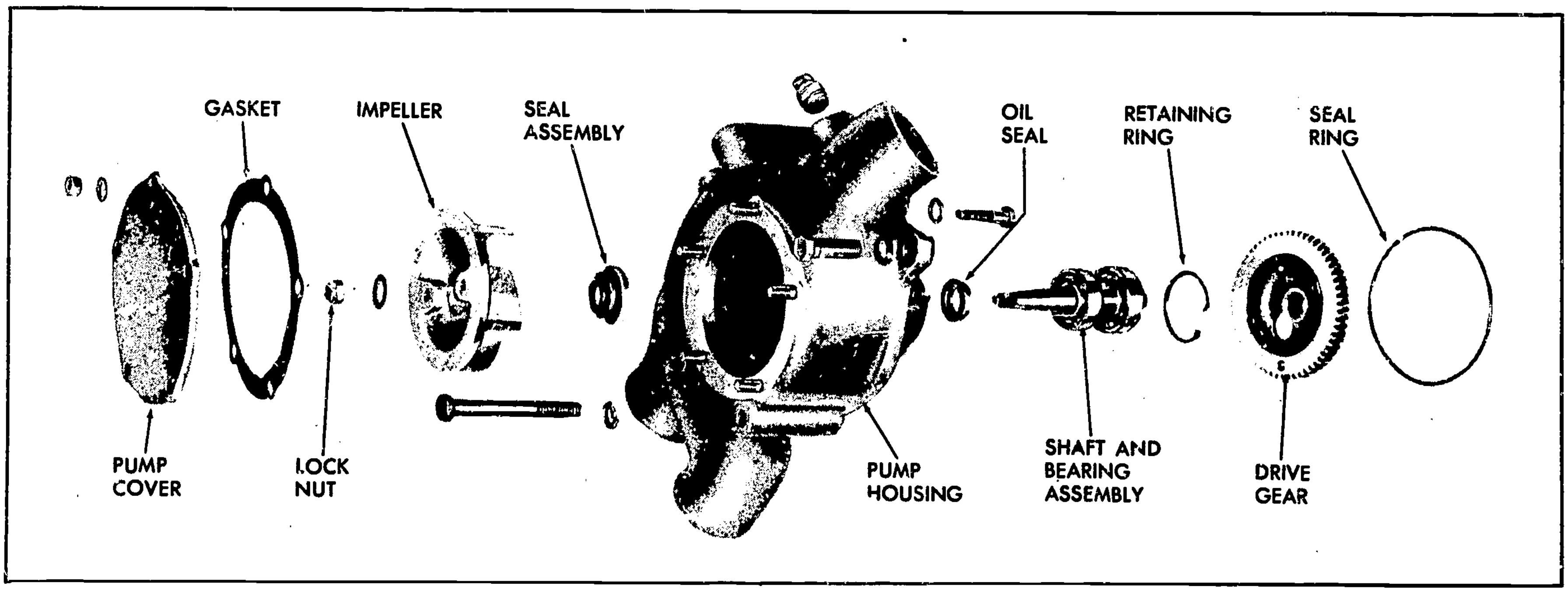


Fig. 2 Water pump details in V-71.

INSPECTING - Wash all the pump parts thoroughly in clean fuel oil and blow them dry with compressed air.

Check the ball bearings and races (look for indications of corrosion or pitting). Apply light engine oil to the bearing balls. Hold the inner race and revolve the outer race slowly by hand to check for free rolling of the balls on the races.

Rough spots in the bearings are enough cause for rejection.

When assembling the pump, remember to apply a film of oil to the outside diameter of the oil seal. Then apply oil to the shaft and slide it and the bearings into the pump housing.

CAUTION: When replacing the drive gear on the shaft, support should be placed directly between the shaft and the base of the press. The pump housing or studs should not be allowed to touch the press while the gear is being installed.

WATER PUMP IN THE IN-LINE 71 ENGINE - The centrifugal water pump (Figure 3) circulates the coolant through the cylinder block, cylinder head, radiator, and oil cooler. The drive end of the pump shaft is supported by a sealed double-row combination radial and thrust ball bearing. The pump shaft serves as the inner race of the bearing.

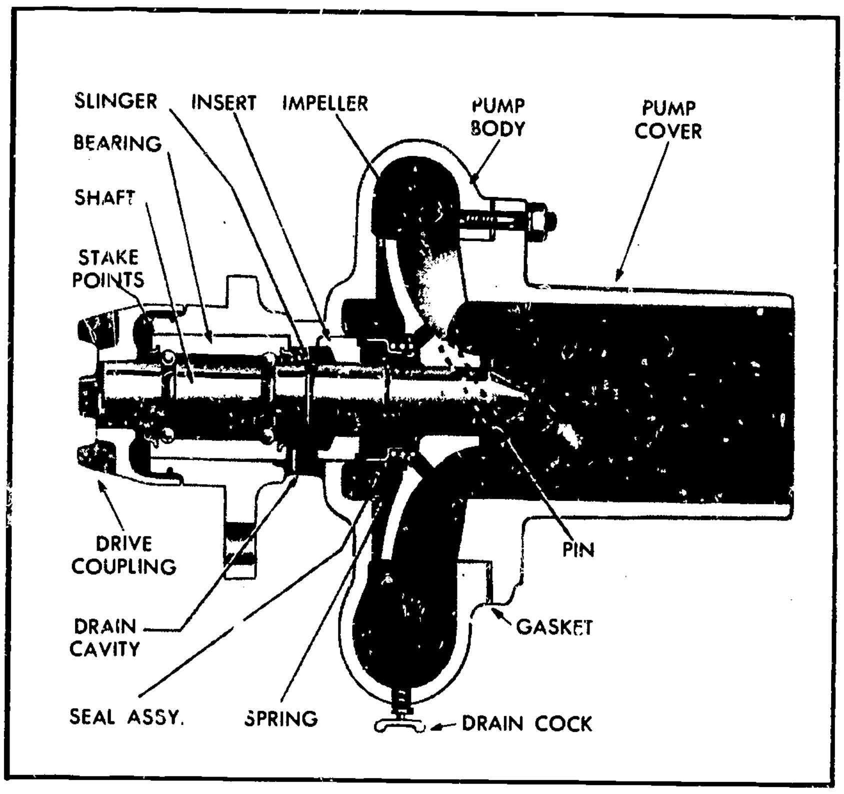


Fig. 3 Water pump assembly.

A spring-loaded seal assembly and a water slinger (located between the seal and the bearing) prevent the coolant from moving along the shaft to the bearing. A carbon washer in the seal assembly pushes against a steel insert which is pressed into the pump body. The insert should be replaced when it shows wear. See Figure 4.

The pump is mounted at the front end of the blower and is driven by the lower blower rotor shaft. A drive coupling is pressed onto the end of the pump shaft. This coupling has an integral oil thrower that shrouds the flange end of the pump body and deflects the oil away from the bearing.

NOTE: The sealed ball bearing is filled with lubricant at the time it is put on the pump shaft, and no further lubrication is required.

INSPECTION - After taking apart the pump, clean all the parts except the shaft and bearing assembly. The sealed pump shaft bearing must not be immersed in a cleaning fluid. Dirt can be washed in, and the fluid cannot be removed entirely.

Revolve the pump shaft bearing slowly by hand. If rough spots are found replace the shaft and bearing assembly.

Check the impeller and seal components for wear, and replace them if necessary. The seal comes as an assembly and includes the carbon washer, seal, ring, guide and spring. A seal assembly is also included with a service replacement impeller.

Look at the studs in the pump body. If it is necessary to replace a stud, use a good grade of sealant on the threads. Drive the stud in at 10 to 12 ft-lb torque.

The replacement pump body includes the studs and an insert.

THERMOSTAT -- The temperature of the coolant is controlled by blocking thermostat(s), located in the thermostat housing at the front of the engine. One thermostat is used in an in-line engine whereas two thermostats are employed in 6 and 8V engines; four thermostats are used in 12 and 16V engines.

OPERATION - At water temperatures below 160 F, the thermostat valve remains closed. This blocks the flow of coolant through the radiator. The coolant bypasses the radiator and flows directly to the water pump and then it is circulated through the engine cylinder block and heads.

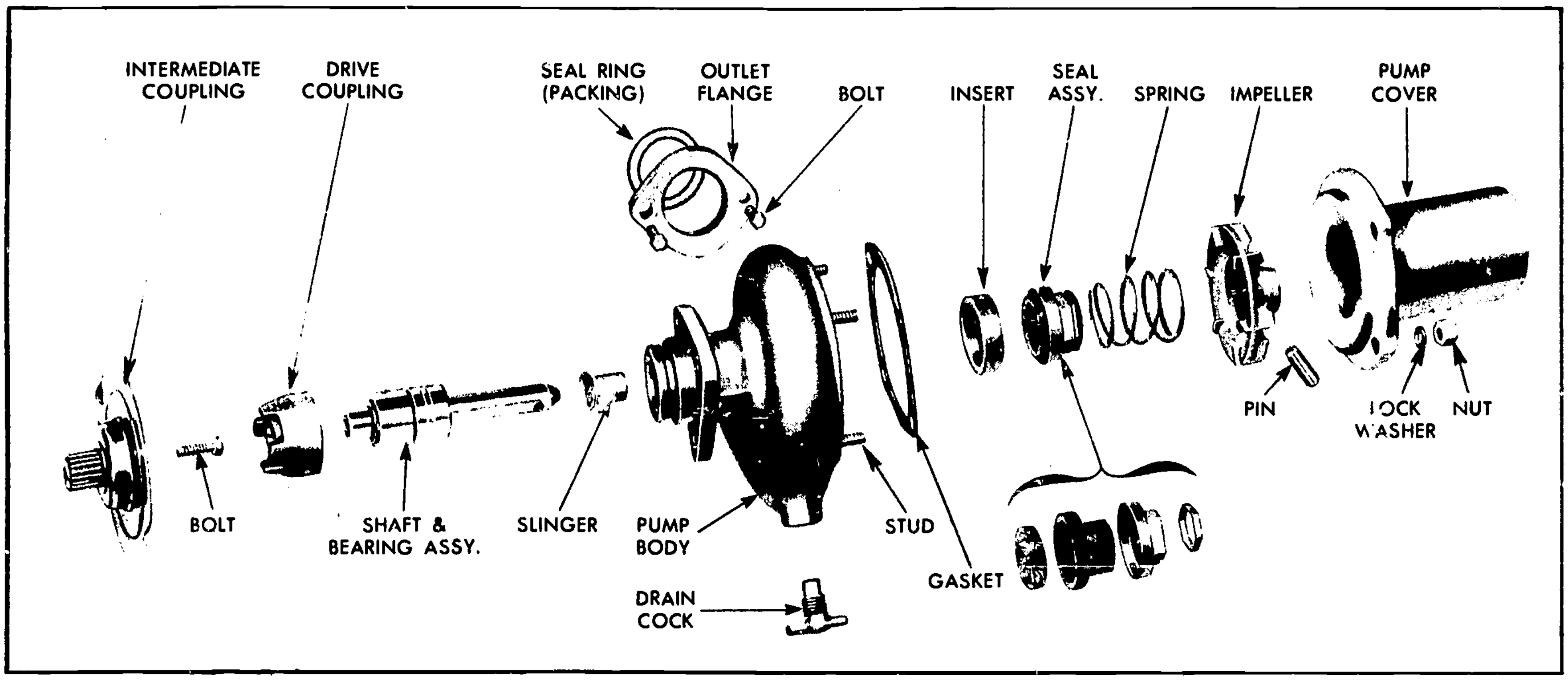


Fig. 4 Water pump details in the In-line 71.

As the coolant temperature rises above 170 F, the thermostat valve starts to open and the coolant passes through both the radiator and the bypass tube. The valve will open fully when the coolant temperature rises to about 185 F.

A properly operating thermostat is essential for efficient operation of the engine. If the engine operating temperature changes from the normal range the thermostat(s) should be removed and checked. See Figure 5.

INSPECTING THE THERMOSTAT - A "full-flow" blocking-type bypass system protects the engine during high load operations under cold weather conditions. About 80% of the maximum pump delivery is obtained through the bypass with the thermostats closed. Change of water temperature in the block happens because of the large bypass capacity in the "V" type engines. An added feature of the system is the equalization of coolant flow and temperature through the two cylinder banks. Since each bank has its own thermostat(s) and housing, complete closure of the thermostat(s) in one of the housings, with the thermostat(s) in the other housing open, results in practically no difference between the two "water-out" temperatures.

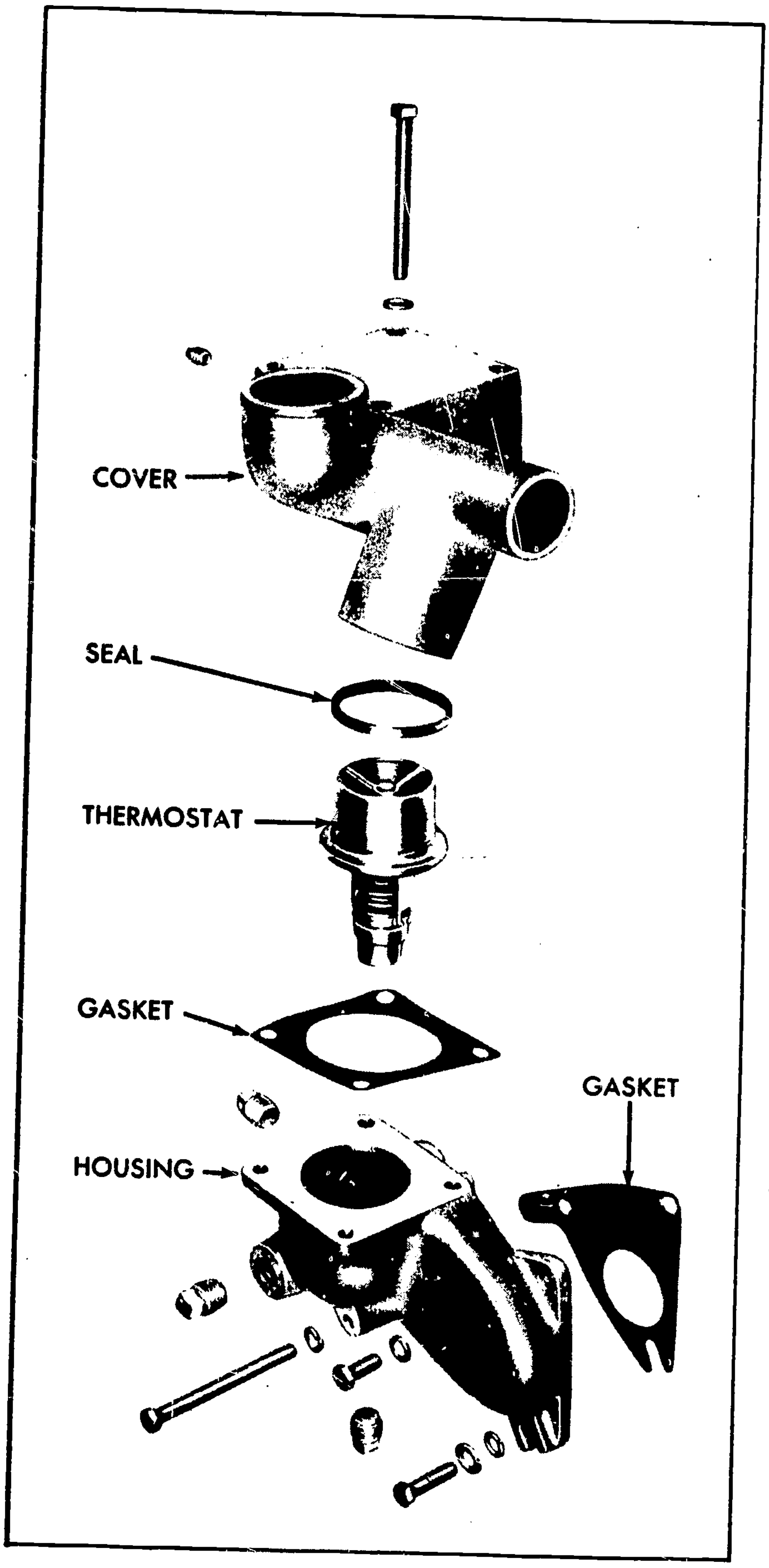


Fig. 5 Typical thermostat housing and relative location of parts.

A thermostat may be checked by immersing it in a container of how water (Figure 6). Put a thermometer in the container but do not allow it to touch the bottom. Agitate the water to get an even temperature throughout the container. As the water is heated, the thermostat should begin to open when the water temperature is about 165 or 170F. (the opening temperature is usually stamped on the thermostat). The thermostat should be fully open at about 180 or 185F. It is recommended that the thermostat be replaced after an engine overhaul.

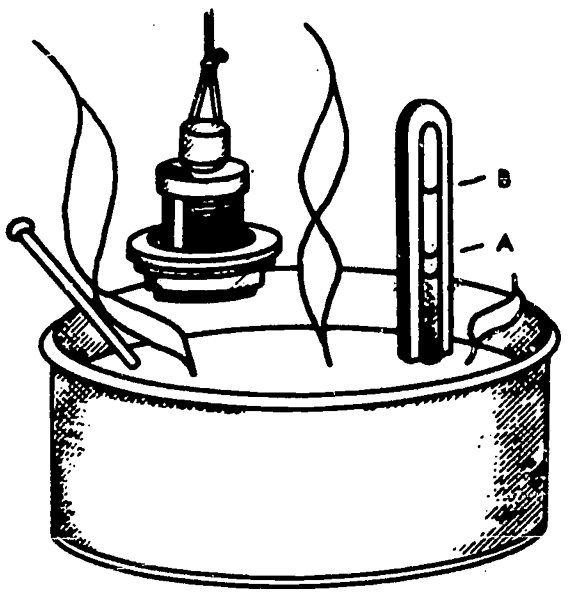


Fig. 6 Method of checking thermostat operation.

RADIATOR - The radiator consists of a radiator core with a top tank and a bottom tank. The top, or inlet tank, contains an outside pipe called the radiator inlet, and has a coolant baffle inside and above, or at the inlet opening. The radiator filler neck is attached to the upper part of the top tank, and has an outlet to the overflow pipe. The bottom tank also has an opening called the outlet.

The radiator has tubular cores which consist of a large number of vertical tubes and many horizontal air fins around the tubes. These fins assist in carrying away the heat from the water traveling through the tubes. The tubes are constructed of very thin metal, and the water passages are very small. This permits a small amount of cooling liquid to be exposed to a large cooling surface.

In addition to this cooling, the air being forced by the fan through the radiator carries away heat.

Flexible hose is used to carry water from the engine to the radiator and from the radiator back to the engine. IT IS IMPORTANT that these hoses be checked regularly for leaks and deterioration. Air must not get into the cooling system: cooling efficiency would be reduced.

To increase the cooling efficiency of the radiator assembly, a fan shroud is placed around and slightly behind the fan. The fan shroud helps to circulate the air coming through the radiator. The shroud is necessary because the radiator is rectangular and the fan is round, causing some parts of the radiator to be exposed in relation to the pulling force of the fan, see Figure 7.

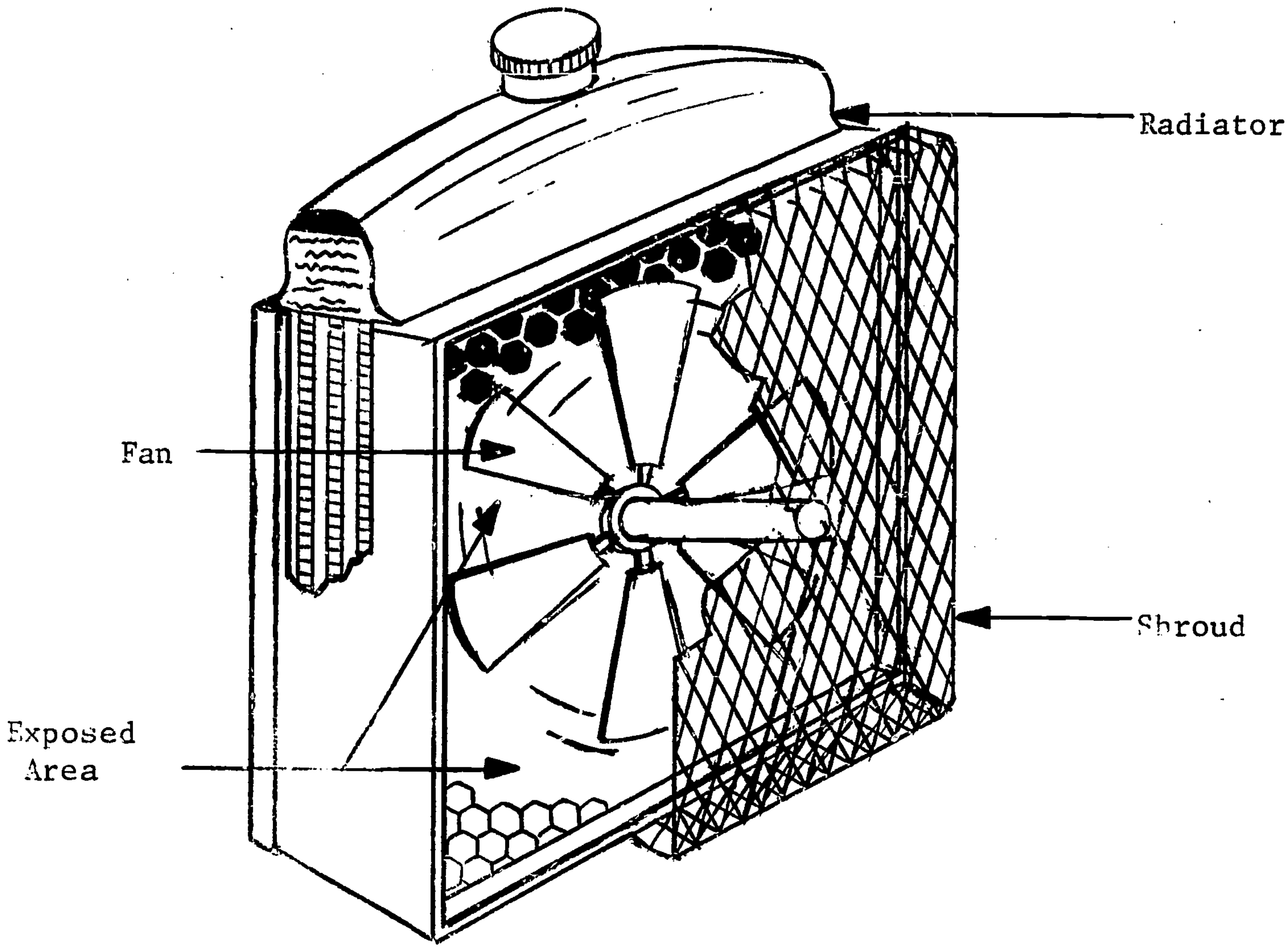


Fig. 7 Radiator and fan construction.

The radiator life will be increased if the choice of coolants is limited to either clean soft water with a rust inhibitor or a mixture of water and a high boiling point antifreeze. (The use of any other kind of antifreeze is not recommended.)

Hard water in the cooling system forms scale in the radiator core, engine cylinder block, and heads. This scale slows cooling and causes hot spots wherever it forms. It clogs the tubes in the radiator core as well.

If the engine overheats, be sure that there is enough coolant in both engine and radiator. Also see that the fan belts have the proper tension.

If these items check out, the overheating can probably be eliminated by cleaning and flushing the cooling system, following the instructions given in the first section of this unit.

Remember -- all grease, oil, dirt and other obstructions must be removed from the outside of the fins of the radiator core. This is done so that the entire area of the core may easily transmit heat to the air stream. When cleaning the core, the grille, fan guard and fan shroud should be covered. To clean the fins, a heavy spray of a good grease solvent (such as oleum or methyl chloroform) should be sent through the core in a direction opposite to that of the operational air flow. Never use gasoline, fuel oil, or kerosene.

> NOTE: To reduce danger from breathing in poisons in the cleaning agent, the work area must be thoroughly ventilated.

When removing the radiator, first remove the pressure cap and drain the cooling system.

Detach the radiator and attach a chain hoist and a suitable lifting hook (through the filler neck or otherwise). Draw the hoisting chain taut to steady the radiator.

Be sure to remove all bolts, lockwashers and nuts which attach the radiator shell to the base.

> CAUTION: Since the shroud is very close to the tips of the fan blades, great care must be used when the radiator is removed to prevent damage to these parts.

Clean all radiator parts thoroughly. Remove dirt, scale and other deposits. Examine each part closely for cracks or other damage. Core fins should be straight and evenly spaced to permit full flow of cooling air. All core tubes should be clean, both inside and outside, and have no leaks. Check all radiator hoses for deterioration and cracks. Replace them when necessary.

THE PRESSURE CAP - Most radiator caps (Figure 8) are designed to permit a pressure of about seven pounds in the system before its valve opens. The pressure raises the boiling point of the coolant and permits higher operating temperatures without the loss of coolant because of boiling. An additional valve in the radiator cap opens when the engine cools. Engine cooling sometimes creates a vacuum causing the collapse of hoses and other parts not internally supported. The vacuum valve in the cap only opens when the pressure within the cooling system drops below the outside atmospheric pressure. See Figure 9.

CAUTION: Always remove the pressure cap slowly and carefully to avoid a possible flash of hot coolant.

Check both valves periodically for proper opening and closing pressure to guard against possible damage from either excessive pressure or vacuum.

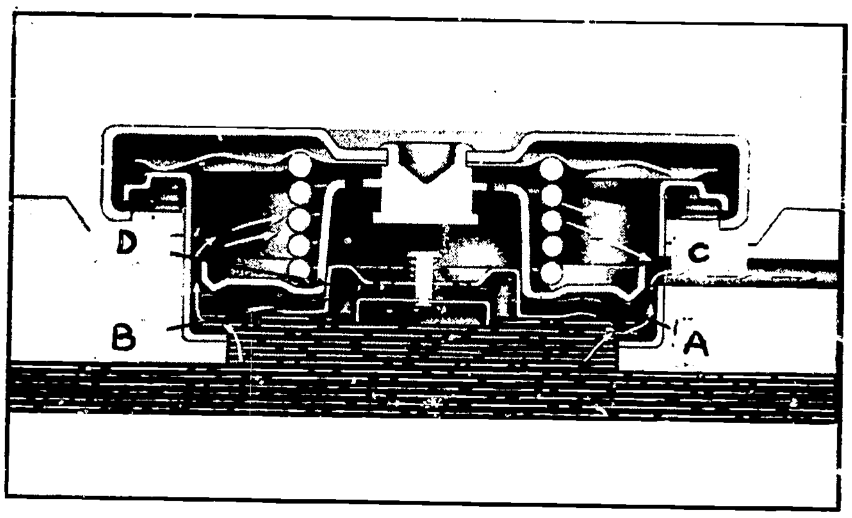


Fig. 8 Pressure control cap (pressure valve open)
A. Seat-pressure valve
B. Seat-vacuum valve
C. Valve-pressure
D. Valve-vacuum

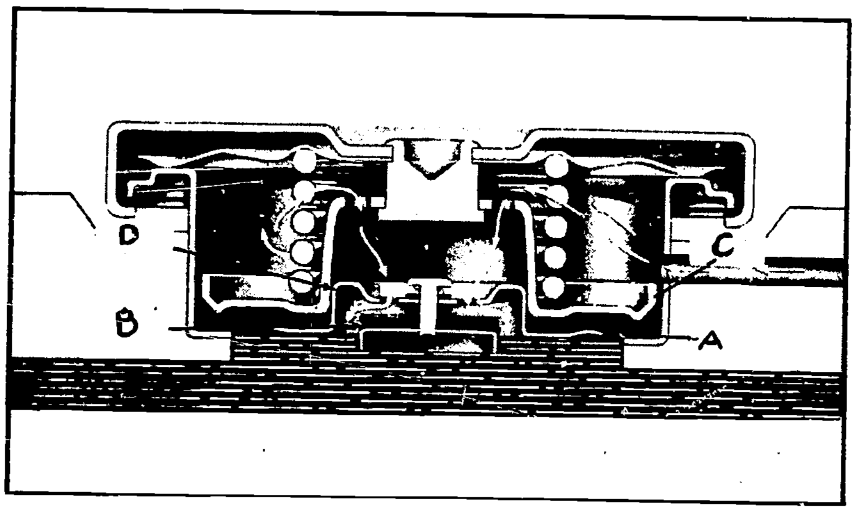


Fig. 9 Pressure control cap (vacuum valve open)
A. Seat-pressure valve
B. Seat-vacuum valve
C. Valve-pressure
D. Valve-vacuum

COOLING SYSTEM FAN - The fan used for cooling the radiator is belt driven drom the crankshaft pulley. It is bolted to a combination hub and pulley which is carried on a double row ball bearing and a single row ball bearing.

The ball bearings are packed with lubricating grease at the time they are installed in the fan hub. In addition, the cavity of the fan hub is also packed with grease. Further lubrication of the fan shaft bearings is seldom required unless the fan hub and pulley is overhauled.

The fan blades should run in a vertical plane paralleled with and a sufficient distance away from the rear face of the radiator core to insure that they will not damage the core. Bent fan blades reduce the efficiency of the cooling system and tend to throw the fan out of balance.

ADJUSTING THE FAN BELT - The fan belt should be neither too tight or too loose. Too tight a belt adds undue load on the fan bearings and shortens the life of the belt. Too loose a belt allows slippage and lowers the fan speed, causing excessive belt wear and leading to overheating.

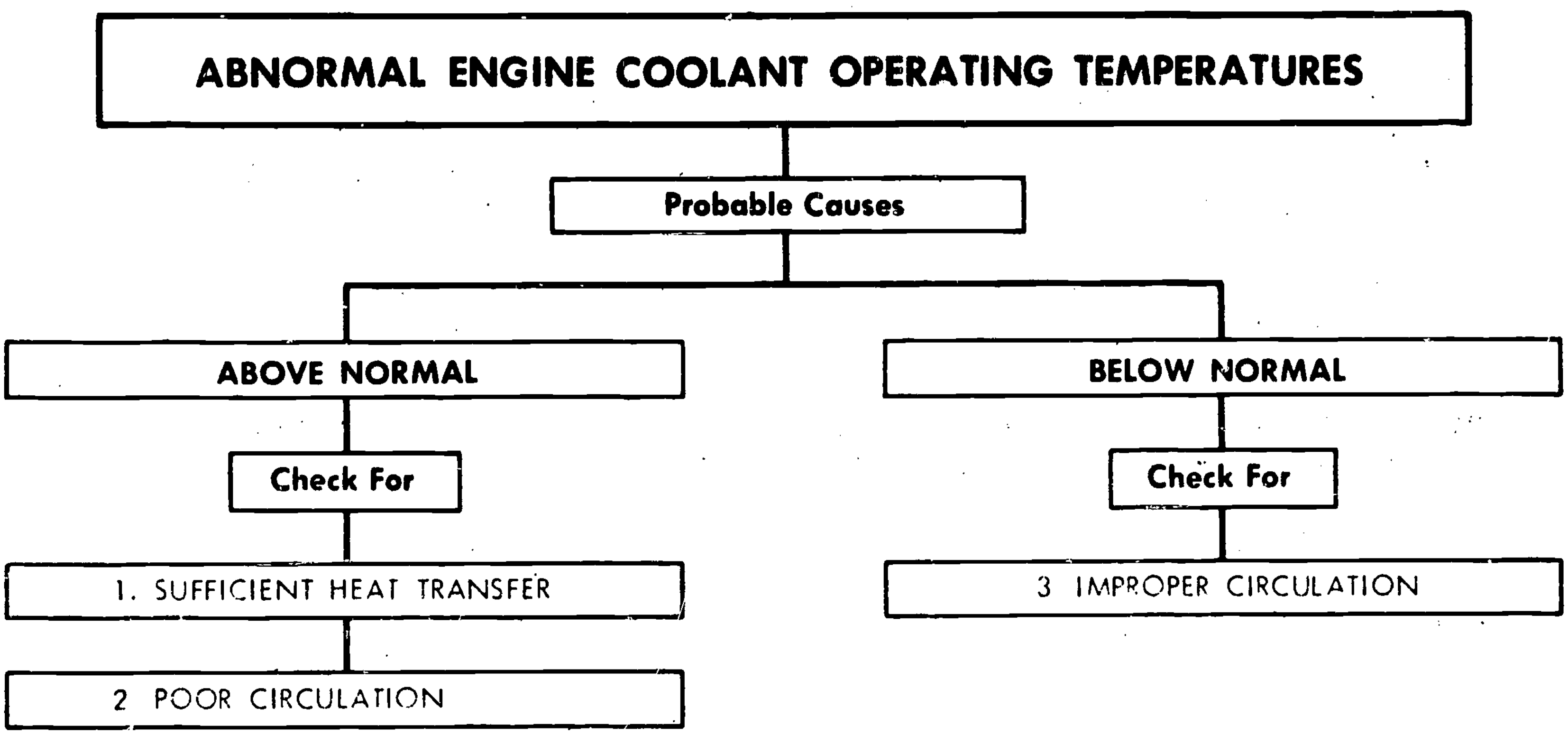
Adjust the belt by loosening the bracket bolts and the adjusting bolt on top of the bracket. Move the bracket up to tighten or down to loosen the belt. Tighten the nuts after the belt has been adjusted.

The belt should have enough slack so that it can be pushed inward about 1/2" to 3/4" from a straight line between the rims of the two pulleys. Push in midway between the pulleys. The straight line can be determined by placing a straight edge on the rims of the pulleys. DO NOT TIGHTEN belts too tight as bearings may be damaged.

BELT CLEANING - Belts often slip or squeak because of the glaze which forms due to dirt or steam cleaning. To clean a belt, wipe it off with hydraulic brake fluid. Cleaning in this manner will eliminate most cases of squeaking.

REMOVAL AND INSTALLATION OF FAN BLADES - The fan blades may be removed from the hub if enough clearance exists between the fan blades and the inner face of the radiator core (with belt guard and fan guard removed). If the blades cannot be removed in this manner, the fan, hub and bracket may be removed as an assembly from the support, and then the blades can be removed from the hub.

SECTION D - TROUBLESHOOTING TIPS



SUGGESTED REMEDY

1. The cooling system should be cleaned and thoroughly flushed to remove scale deposits.

   The exterior of the radiator core should be cleaned to open plugged passages, permitting normal air flow.

   Loose fan belts should be adjusted to the proper tension to prevent slippage.

Check for an improper size radiator or inadequate shrouding.

Repair or adjust inoperative shutters.

Repair or replace inoperative temperature-controlled fan.

2. Check the coolant level and fill it up to the filler neck if the level is low.

   Inspect for collapsed or disintegrated hoses. Replace all faulty hoses.

   Thermostats may be inoperative. Remove, inspect, and test the thermostats -- replace them if found faulty.

   Check the water pump for a loose or damaged impeller.

   Check the flow of the water through the radiator. A clogged radiator will cause an inadequate supply of water on the suction side of the pump. Clean the radiator core.

   Remove the pressure cap and operate the engine, checking for combustion gases in the cooling system. The cylinder head must be removed and inspected for cracks and head gaskets replaced if combustion gases are entering the cooling system.

   Check for an air leak on the suction side of the water pump. Replace defective parts.

3. The thermostat may not be closing. Remove, inspect, and test the thermostat. Install a new thermostat if necessary.

   Check the thermostat seal. Replace if necessary.

   Check for an improperly installed heater.

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PTAM 1-4D

DIESEL AUTOMOTIVE MAINTENANCE
- HEAT TRANSFER

Human Engineering Institute

Press A — 1 10/65

1

1

Heat can be transmitted from one place to another in many ways. Some of these ways are slow and roundabout, and others are very fast and straight to the point.

Scientists have studied all these ways and classified them into three general types: conduction, convection, and radiation.

Press A — 2

1

2

Not all substances are good conductors of heat. Metals like copper and silver are much better conductors than materials like wood, glass, paper, and water. The ability of a substance to conduct heat is measured by what is called its THERMAL CONDUCTIVITY. The greater its THERMAL CONDUCTIVITY, the better it conducts heat.

Press B — 3

1

3

Copper conducts heat better than plywood, so we can say that copper has greater thermal ____________.

A. convectivity — 4
B. conductivity — 5
C. transference — 4

1

4

No. The term we were looking for was neither "convectivity" nor "transference". We said copper "conducts" heat better than plywood. You can find the word "conduct" in the word "conductivity"-- which is the correct answer. Copper has greater THERMAL CONDUCTIVITY than plywood.

Press A —

1

5

O. K. Copper has greater thermal conductivity than wood; it conducts heat better than wood.

When we fry an egg in a frying pan, heat is conducted from the pan to the handle. If the handle is covered with wood we will feel less heat, because the thermal conductivity of the wood is less than the thermal conductivity of the metal handle.

Press C — 6

1

6

Laboratory experiments have indicated that the amount of heat which travels through a metal rod is proportional to:

1. the time (how long heat is applied).
2. the cross-section (how thick the rod is - its diameter).
3. the difference in temperature between the opposite ends.

Also, the travel of heat through a metal rod is inversely proportional to the length of the rod. In other words, the longer the rod, the harder it is for heat to get from one end to the other. The shorter the rod, the easier it is for the heat to move the length of the rod.

Press A — 7

1

7

Let's go over that last frame part by part to see if everything is clear:

If a candle is held under one end of a copper rod the other end will be hottest after ________________.

A. one minute. — 8
B. two minutes. — 8
C. one hour. — 10

1

Remember what we said? The amount of heat that flows through a rod is proportional to the time that the heat flows. As we hold the candle under one end of the rod for a longer period, we will get more heat transmitted to the other end. If you're having trouble with the word "proportional", press A. If you understand the idea that amount of heat flowing through a rod is proportional to time,

Press B.

1

If weight is proportional to size, then the bigger something is, the more it weighs; and the smaller something is, the less it weighs. If happiness is proportional to wealth, then the more money you have, the happier you'll be; and the less money you have the less happy you'll be.

Study these examples until you understand "proportional" then

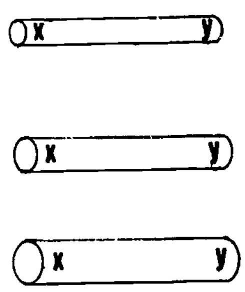
Press A

1

O. K., the longer we heat one end of a copper rod the more heat will be conducted to the other end.

Now, if the X end of each of these three rods is heated with the temperature and time constant, which Y end will become warmest?

A. B. C.



1

Think back: we said the amount of heat conducted through a rod is proportional to the thickness of the rod. In other words, the thicker the rod, the more heat is conducted through it.

So C was the correct answer, since it was the thickest rod.

Press A

1

O. K. The thickest rod conducts the most heat. Now, we put 5 candle flames under one end of a rod. If you think this would not conduct more heat to the other end than if there were one candle, Press A.

If you think it would conduct more heat to the other end, Press B.

If you're not sure, Press C.

1

No. The more heat you apply to one end, the more is conducted to the other. More candles make more heat. Remember, heat is always conducted from the warmer end to the cooler end.

Press B

1

Sure. More candles make more heat -- so more heat is conducted to the other end. The heat is always conducted from the warmer end to the cooler end.

Press B

1

The longer the rod, the ____________ heat is conducted to the opposite end.

A. more
B. less
C. I don't know.

1

16

Think. The longer the distance heat has to travel, the more is going to be "lost" raising the temperature of the rod itself. So, the longer the rod, the less heat will be conducted to the opposite end.

Press A — 17

1

17

OK. Now let's consider another kind of heat transfer -- CONVECTION. Why can a poor conductor of heat like water be heated so quickly when it's placed in a pan over a hot flame? This heating is due to convection. Water at the bottom of the pan is heated first. Because of a rise in temperature, it expands; being lighter than the cold water above, it rises to the top, letting cold water come to the bottom from the sides. This action sets up a flow of water called a convection current. This current keeps the water stirred up as it heats.

Press A — 18

1

18

In a diesel engine, the by-pass tube allows this reaction to take place when the thermostats are closed. As the water heats, it rises to the top of the engine, forcing the cooler water to the bottom - resulting in uniform heating of the engine.

When water is heated in a pan the heated water becomes __________ than the cooler water.

A. thinner — 19
B. heavier — 20
C. lighter — 21
D. darker — 20
E. thicker — 20½

1

19

The water might be called "thinner" but there's another word that we think is better. Go back and see if you can find the better word.

Press B — 18

1

20

No. The heated water does not become heavier, darker, or thicker -- it becomes lighter. That's why it rises to the top and allows the heavier (cooler) water to sink to the bottom to become heated.

Press A — 21

1

20½

No. The heated water does not become heavier, darker, or thicker -- it becomes lighter. That's why it rises to the top and allows the heavier (cooler) water to sink to the bottom to become heated.

Press A — 21

1

21

OK. As the water is heated, it becomes lighter and rises to the top allowing the heavier (cooler) water to sink to the bottom and become heated. The current that is set up is called a __________ current.

A. heating — 22
B. convection — 24
C. conduction — 22
D. stirring — 24
E. radiation — 22

1

22

No. This current is a convection current. If you answered "conduction" or "radiation" you may be mixing up the different kinds of heat transfer. Neither conduction nor radiation are forms of current.

Press B — 24

1

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FILM NO. PTAM 1-4D

23

"Stirring" or "heating" current might be logical answers, but the one we were looking for was convection current. The three types of heat transfer - remember - are conduction, convection, and radiation.

Press C — 24

1

24

OK. Convection currents stir up the water so it heats faster. They also affect air the same way.

Hot air heating systems for houses use the same principle: air heated in a furnace in the basement rises through an outlet in or near the floor. Then it rises up one side of the room, and across the room, to return to the furnace by another opening.

Press A — 25

1

25

If you blocked off the cold air return in a system like we just described, would the air still get heated?

A. Yes, but less efficiently. — 28
B. Yes, exactly as it would before. — 26
C. No, because it couldn't return to the furnace. — 26
D. I don't know. — 27

1

26

No. The air would still be heated -- but not as efficiently. Blocking the cold air return off would stop the air from returning to the furnace where it would be heated rapidly. But even without going back to the furnace, there would still be convection currents in the room, and warm air from the furnace would still enter from below.

Press B — 28

1

27

Yes, it still would heat the air -- but less efficiently. Blocking off the cold air return would stop the air from returning to the furnace, where the flames could heat it rapidly -- but even without going back to the furnace, there would still be convection currents in the room, and warm air from the furnace would still enter the room and cause convection currents there.

Press B — 28

1

28

OK. Now let's consider the third type of heat transfer -- RADIATION. When the sun comes over the horizon in the early morning the heat can be felt as soon as the sun becomes visible. This heat, called radiation, travels at the speed of light -- 186,000 miles per second. In fact, heat waves are waves - of a longer wave length - having all the general properties known to light. The essential difference between the two is that heat rays, sometimes called infrared rays, are invisible to the human eye.

Press A — 29

1

29

Both heat rays and light rays travel at:

A. 186,000 miles per minute — 30
B. 186,000 miles per second — 31
C. 186,000 feet per second — 30

1

30

No. Light travels much faster than that. It's 186,000 miles per second. A ray of light could travel across the U. S. A. faster than you can blink.

Press B — 31

1

31

OK. Light and heat waves travel at 186,000 miles per second. Another name for heat waves is __________ waves.

A. ultraviolet — 32
B. radiation — 33
C. infrared — 34

1

32

No. You've got it mixed up. Ultraviolet rays are very short; the long heat rays are called infrared rays.

Press C — 34

1

33

No, "radiation" is a general word; it might refer to heat or light. The term we were looking for is infrared.

Press B — 34

1

34

OK. We can remember that infrared waves are heat waves by thinking about red-hot metal and red flame.

Press A — 36

X C — 35

1

35

You missed one or more of the questions we gave you. Let's go through them again. If you get them all right, we'll move on to the next section.

Take your time and read for facts.

Press C — 1

1

36

OK. A practical example of radiation is found in every home where a fireplace is used as a means of heating. Contrary to most beliefs, the heat entering a room from a fireplace is practically all in the form of infrared rays originating in the flames, coals, and stone or brick walls. Most of the air heated in the fireplace does not enter the room: it's carried up the chimney as a convection current.

Press A — 37

2

37

A fireplace, as we explained, is an example of __________ heating.

A. radiation — 40
B. convection — 38
C. conduction — 39

2

38

Convection currents carry the hot air up the chimney -- but it's radiation that heats the room itself.

Press C — 40

2

37

No. The only thing heated by conduction in this case is the bricks or stones of the fireplace. It's radiation that heats the room.

Press A — 40

2

40

OK. Radiation from the flames, coals and bricks or stones of the fireplace heats the room.

Now, what about heat transfer in diesel engines? Heat is developed in diesels by:

1) air compression in the cylinders
2) combustion of fuel in combustion chambers
3) friction between rubbing surfaces

As long as the temperature of the engine is greater than the surrounding air, heat flows from the engine.

Press A — 41

2

41

We said that as long as the temperature of the engine is greater than the surrounding air, heat flows from the engine. This is because of:

A. conduction — 42
B. radiation — 43
C. convection — 42

2

42

No, neither conduction nor convection causes the heat flow from engine to the surrounding air.

Press C — 43

2

43

OK. Heat from the engine radiates into the surrounding air (when the engine is hotter than the surrounding air). Conduction may carry heat from one metal part to another and convection currents may exist where the surrounding air is heated, but the main type of heat transference here is radiation.

Press B —

2

44

Combustion, compression and __________ produce heat in a diesel.

A. friction —
B. transference
C. radiation

2

Transference is a general term, and not the answer we were looking for. Here's why: Heat transference does not produce heat -- it only refers to a transfer of heat from one body to another (or into the air). Go back and choose a better answer.

Press C

2

No. Radiation is not the correct answer. Radiation is a method of heat transfer, not production. Choose another answer.

Press A

2

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FILM NO. PTAM 1-4D

47

Yes - heat is produced by friction of moving parts, as well as by compression of the air in the cylinder, and by combustion.

Heat transfer within the engine occurs by convection, conduction and radiation. Heat transfer from the engine, however, occurs chiefly by convection of heat in the exhaust gases and in the cooling water flowing from the engine, and by radiation from the hot external engine surfaces of the engine to the cooler surrounding air.

Press B — 48

2

48

_______ type(s) of heat transfer take(s) place inside the engine.

A. One — 49
B. Two — 49
C. Three — 50

2

49

No. Actually, all three types of heat transference occur within the engine.

Press A — 50

2

50

OK. All three types of heat transference -- conduction, convection and radiation -- take place within the engine. Heat transfer from the engine occurs chiefly by _______ of heat in the exhaust gases and in the cooling water flowing from the engine, and by _______ from the hot external engine surfaces to the cooler surrounding air.

A. radiation/conduction — 51
B. convection/radiation — 52
C. conduction/convection — 51

2

51

No. Let's go back and take a look at our explanation again. Read carefully, because the question we asked in the last frame will be coming up again.

Press B — 47

2

52

In a diesel engine about 1/3 of the heat energy is converted into useful work, about 30 percent is lost as heat in the exhaust gases, and another 30 percent is carried away by the cooling system.

The remaining amount (about 7%) is removed from the engine by the lubricating oil, the fuel, and the air.

Press A — 53

2

53

About _______ of the heat energy in a diesel engine is converted into useful work.

A. 1/2 — 54
B. 1/4 — 54
C. 1/3 — 55

2

54

No. Actually, one third of the heat energy of a diesel engine is converted into useful work.

If you want to review the part that explained this, Press A. — 52

If you'd like to go on, Press C. — 55

2

55

OK. One third of the heat energy is converted into useful work.

About how much heat energy is lost or taken away by the coolant of the cooling system?

A. 1/2 or 50% — 56
B. 1/3 or 30% — 57
C. 1/4 or 25% — 56

2

56

No. About 30 percent of the heat energy is removed by the cooling system. We rounded off to one third. If you want to review the frame where we explained this,

Press A. → 54

If you want to go on,

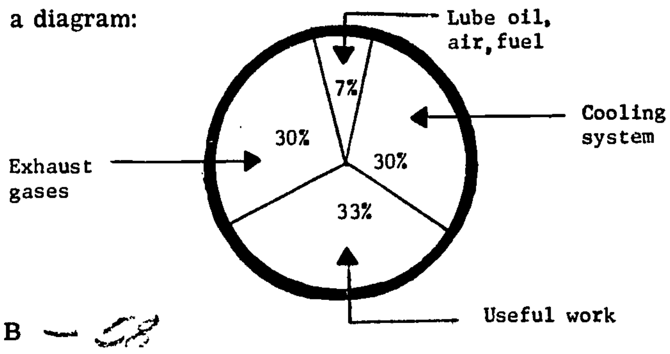
Press C — 57

2

57

OK. About 1/3 (actually 30 percent) of the heat energy in the fuel is lost or removed by the coolant of the cooling system.

Here's a diagram:



Press B — 58

2

58

The heat lost through the exhaust and by radiation depends mostly on the engine load and cannot be controlled directly.

Cooling must be provided for internal combustion engines for several reasons. One is to prevent breakdown due to overheating of the lubricating oil film separating the engine rubbing surfaces.

Press B — 59

2

59

We just said that cooling must be provided to prevent breakdown due to __________ of the oil film separating the engine rubbing surfaces.

A. overheating — 61
B. contamination — 60
C. dilution — 60

2

60

No. The cooling system is not designed to help contamination or dilution problems in the oil. The cooling system -- as its name implies -- keeps the oil from breaking down from overheating. (Of course this isn't the only reason for having a cooling system -- it's just one of the reasons).

Press A — 61

2

61

OK. The cooling system helps prevent oil breakdown due to overheating.

It also helps prevent:

1) loss of strength due to overheating of the metal and
2) excessive stresses in or between the engine parts due to unequal temperatures within the engine.

Press B — 62

2

62

We said the cooling system helps prevent excessive stresses in or between the engine parts due to ________ temperatures within the engine.

A. high — 63
B. unequal — 65
C. changing — 64

2

63

No. High temperatures alone don't cause stress in and between metal parts. The stress problem comes from the difference in temperature between metal parts.

Press C — 65

2

64

Changing temperatures might be said to cause stresses in and between metal parts -- but a better answer is difference. Change in temperature alone wouldn't cause much trouble unless it comes unusually fast -- even then the real problem is that the metal doesn't heat up or cool at the same rate. This is because metals expand at different rates as heat is applied.

Press A — 65

2

65

OK. The real problem is unequal temperatures, in the metal parts of an engine. These unequal temperatures cause different expansions of the metal -- and, thus cause stresses to develop.

The cooling system helps prevent this problem of unequal temperatures.

Press A — 67

2

66

You have missed one or more of the past questions. Let's go back and review the material: if you answer the questions correctly we'll go straight on to the next section.

Good Luck!

Press C — 36

2

67

We have just explained three reasons why the cooling system is important. If you want to review these reasons press A. — 68 Otherwise, press B and we'll discuss air problems in cooling.

3

68

Cooling systems help prevent:

1) breakdown due to overheating of the lubricating oil film separating the engine rubbing parts,
2) loss of strength due to overheating of the metal in the engines,
3) excessive stresses in or between the engine parts due to unequal temperatures in the engine.

Press C — 69

3

69

It is important to keep air out of the cooling system. One reason is corrosion: when air and water mix and meet on metal, they begin to corrode the metal surface. Another reason is that air conducts heat less efficiently than water -- so the more air in the system the less efficiently it cools the engine.

Press B — 70

3

70

Air conducts heat __________ water.

A. as well as
B. better than
C. not as well as

3

DIDACTOR

71

Think. Do you know why materials like cork, and foam plastic make such good insulators? One reason is that they have hundreds of air bubbles in each cubic inch.

Air conducts heat very poorly, so it makes a good insulator -- and this is the reason why it's bad to have air in the cooling system.

Press C — 72

3

72

OK. Air is one of the best insulators -- so it's one of the worst things to have in the cooling system. After all, the cooling system cools by conducting or carrying the heat away; so a comparatively good conductor is required. We learned earlier in this lesson that water is not classified as one of the best conductors of heat, but it does carry heat away more efficiently than air.

Press B — 73

3

73

Another reason for keeping air out of the cooling system is that air and water together cause ___________:

A. corrosion of metal. — 75
B. evaporation of fluid. — 74
C. hydrolysis of the water. — 74

3

74

No. The fluid won't evaporate in a closed system -- nor will hydrolysis take place because of the presence of air. Hydrolysis would require an electric current.

Press A — 75

3

75

OK. Air and water act together to corrode metal -- so we do our best to keep air out of the cooling system.

Now, what about pressure in the cooling system? Does pressure effect the boiling point of water? If you think so, Press A; if you think not, Press B; if you don't know, Press C.

A — 78
B — 76
C — 77

3

76

Actually, pressure does affect boiling point. For an explanation of this (and how it applies to cooling systems),

Press A — 78

3

77

If you ever boiled water in the mountains, you'd find that water is affected by differences in pressure. (Air pressure, as you probably know, is less at higher altitudes.) For more on this,

Press C — 78

3

78

OK. Pressure differences do affect boiling points: The higher the pressure, the higher the boiling point; the lower the pressure, the lower the boiling point.

This is one of the reasons why a closed pressure-type cooling system is used on internal combustion engines. In other words, when a pressure cap is used it allows the cooling system to build up a pressure greater than normal atmospheric pressure. This in turn means that the boiling point of the coolant in the system is increased or raised. The result is that the coolant will be able to handle more heat without boiling away.

Press B — 79

3

79

So, the higher the pressure in a cooling system is, the ________ the boiling point of the water or coolant will be.

A. lower — 80
B. faster — 80
C. higher -- 81

3

80

No. The boiling point is neither lower nor "faster" as pressure becomes higher.

Press C — 81

3

81

OK. Higher pressure makes for a higher boiling point. This is one reason for closed, pressure-type cooling systems: higher pressure lessens the danger of the coolant loss through boiling.

Press B — 82

3

82

Water boils at 212 F at sea level: What happens if the pressure cap is removed from the cooling system when the temperature of the water is 212 F? At sea level pressure, the water would ________________.

A. remain at 212 F but wouldn't boil. — 83
B. boils and the temperature of the engine would increase because of the lack of coolant. — 84
C. cool because air would enter the system. — 83

3

83

No. The water boils because, with the pressure cap off, the water is at sea level or normal atmospheric pressure. The boiling point of water under this condition is 212 F, so it would boil away.

As for air cooling the water; it wouldn't help at all. As a matter of fact, we know that air in the system will create problems.

Press C — 84

3

84

OK. With the pressure cap off, the water pressure goes to sea level pressure -- and, at 212 F, boils.

Also, air will get into the cooling system, creating the problems we discussed a while ago. So, remember to keep those pressure caps tight!

Press A — 86

X C — 85

3

85

You missed a question or two in the last section -- so let's go back and have a review.

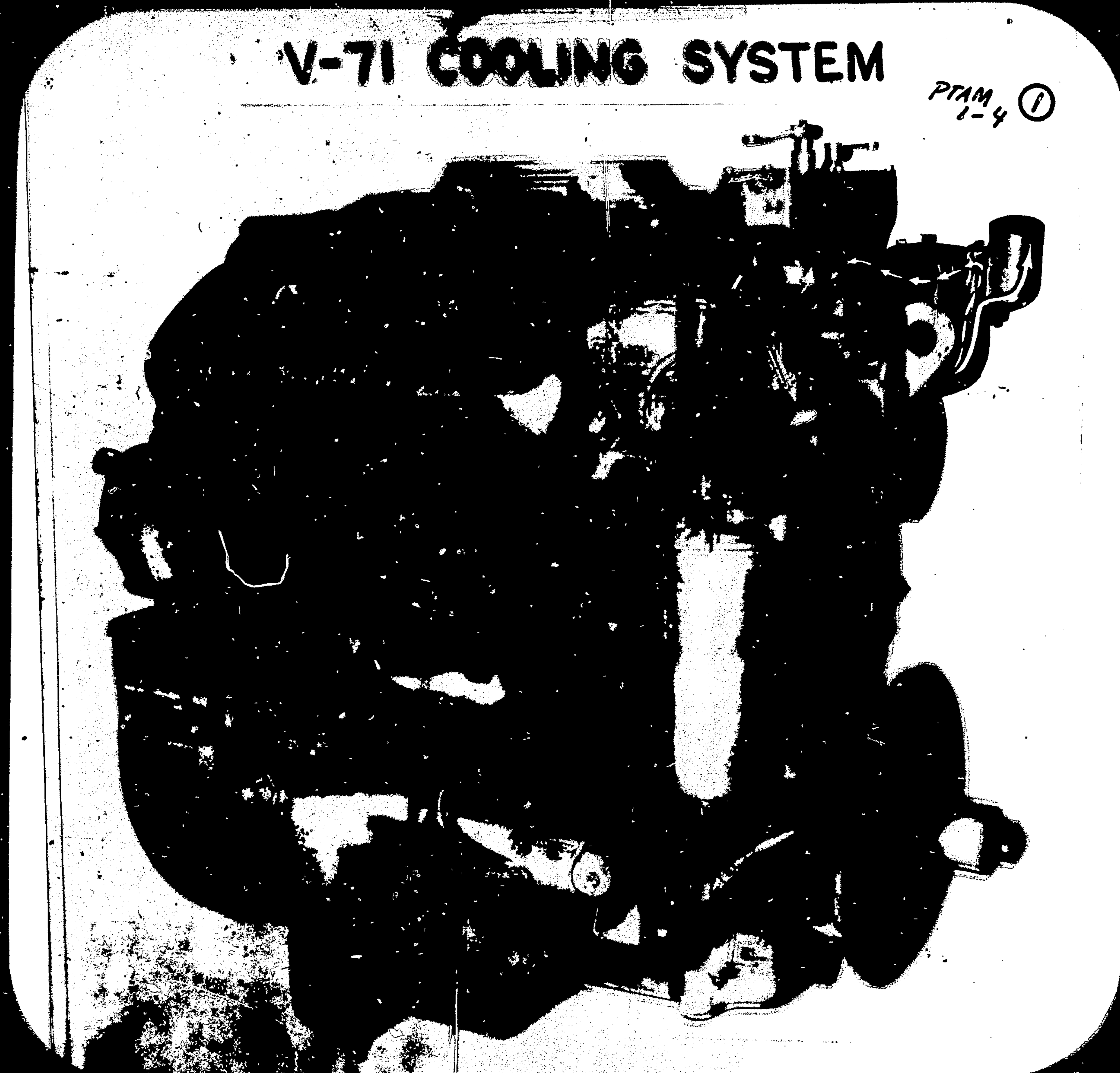
Press C — 67

3

This completes the lesson on facts about the cooling system. If you want to review the last sequence of material -- PRESS B, if not, press the REWIND button.

B — 67

3



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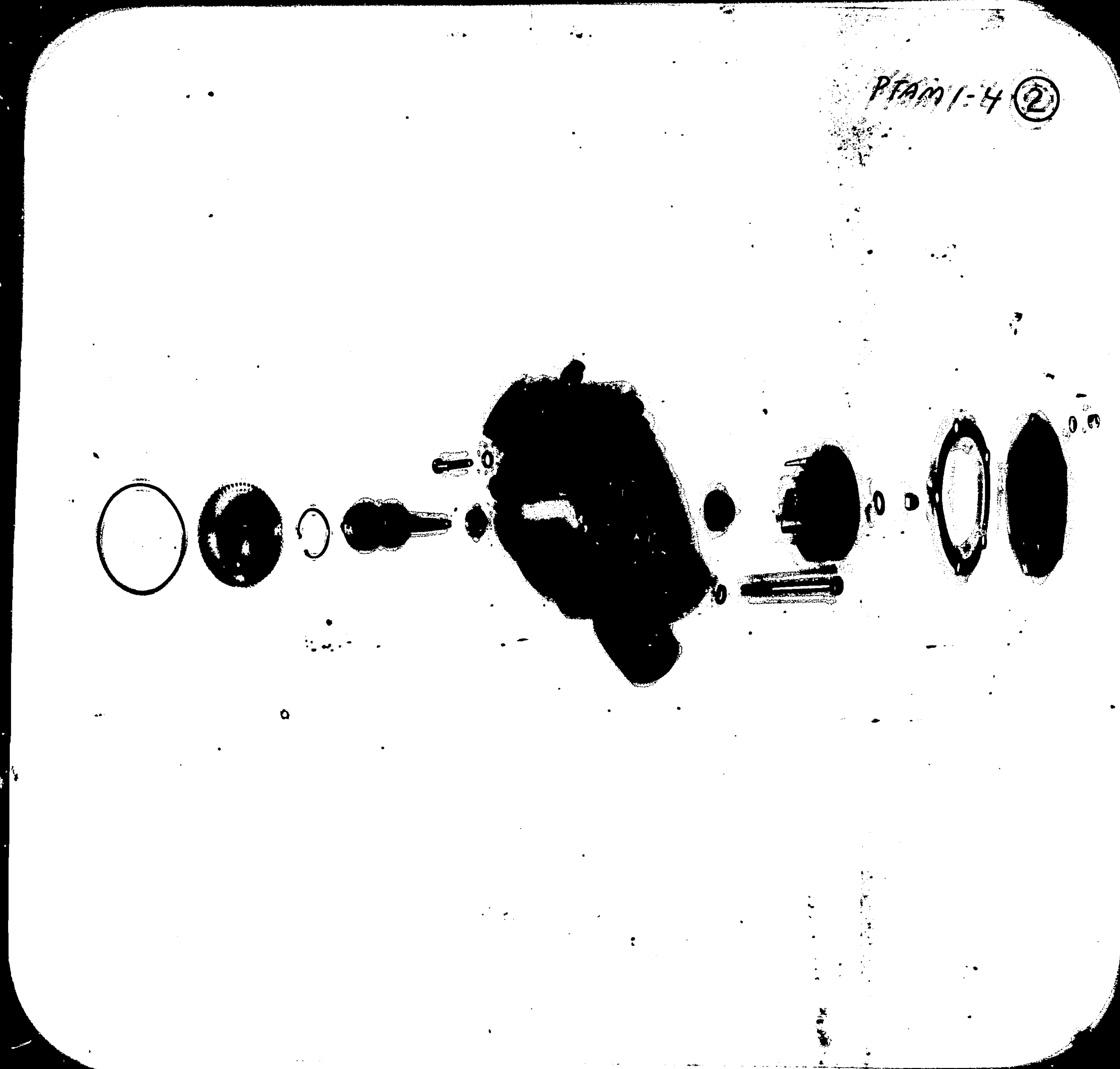

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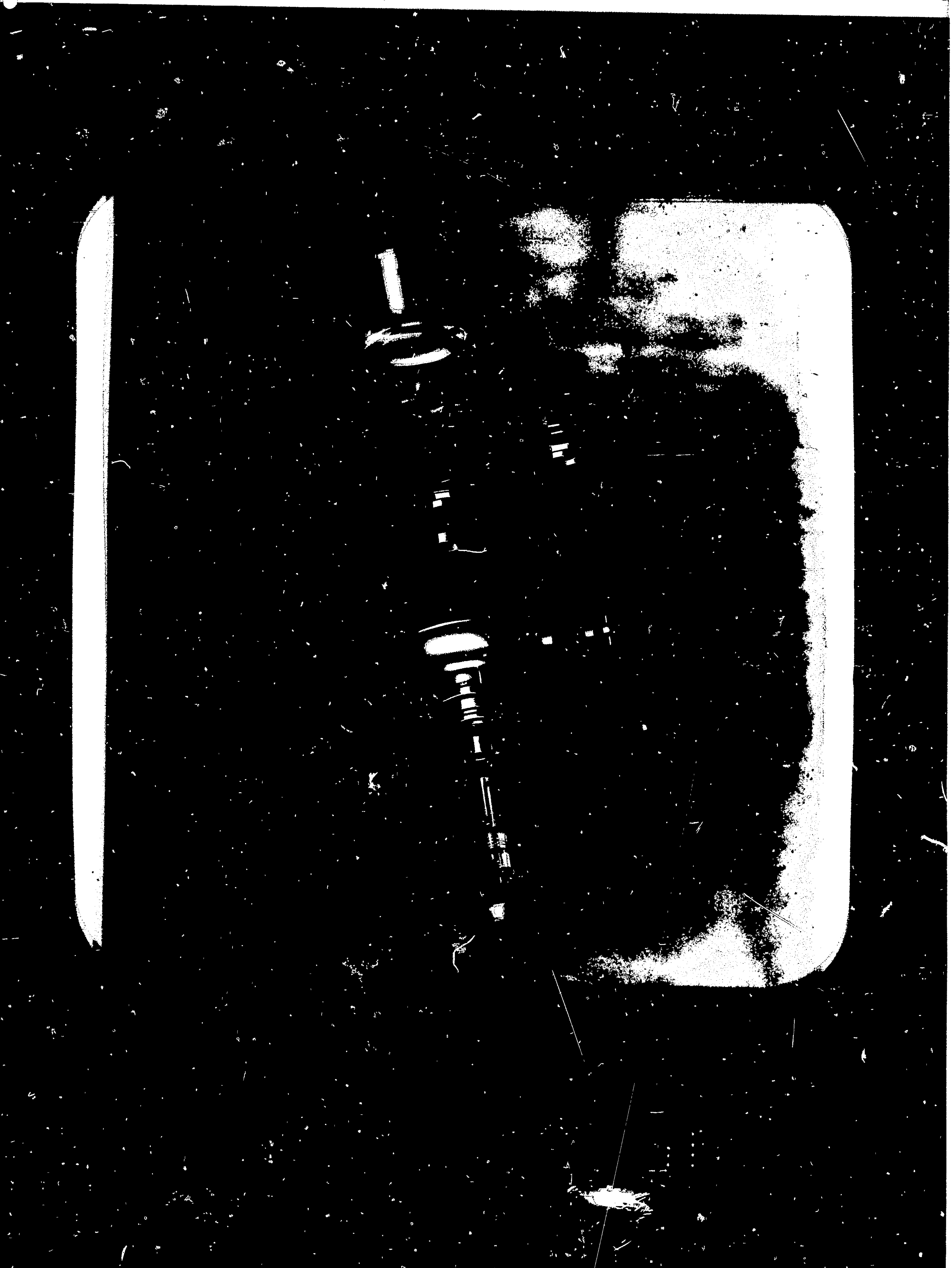
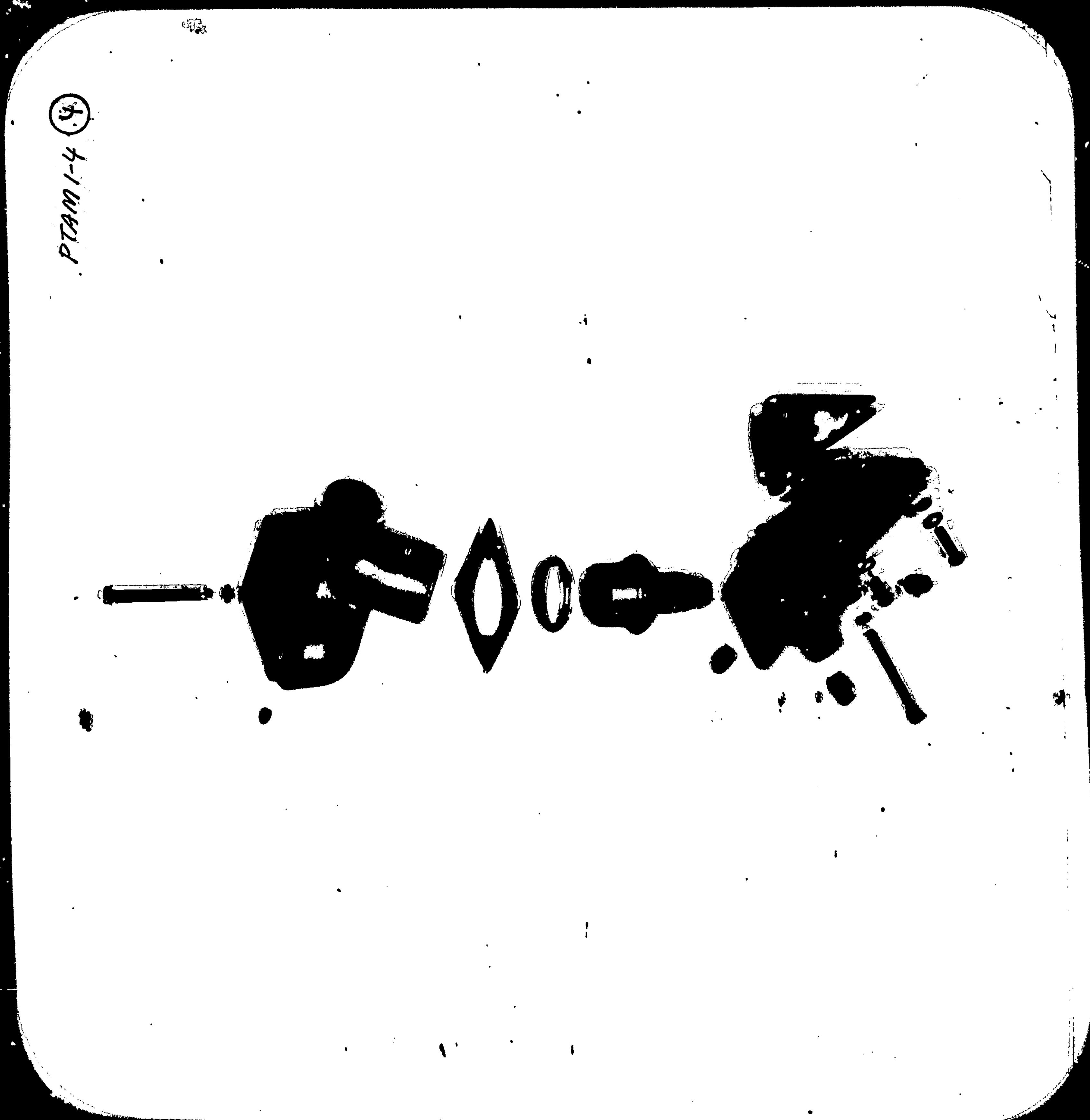
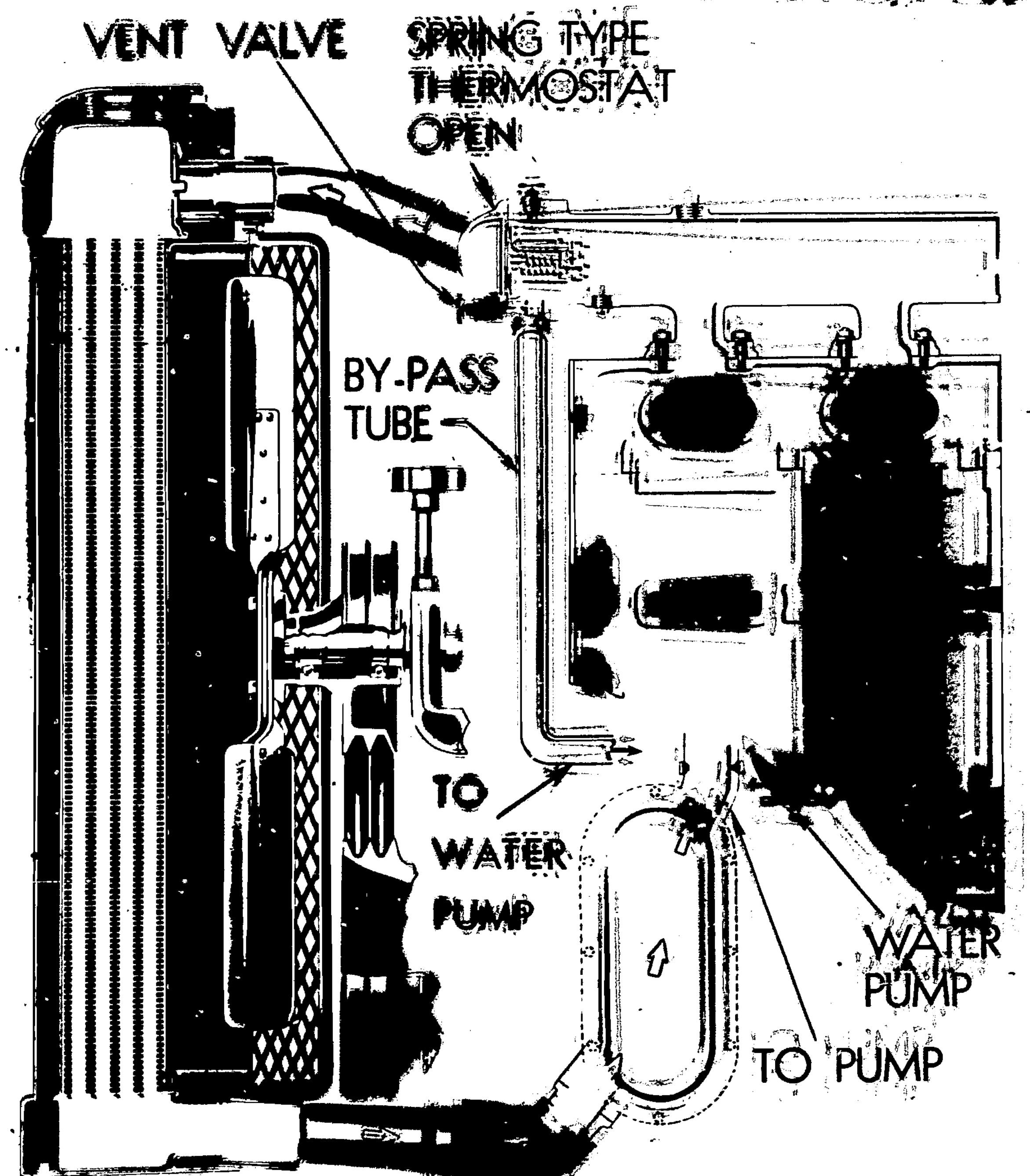
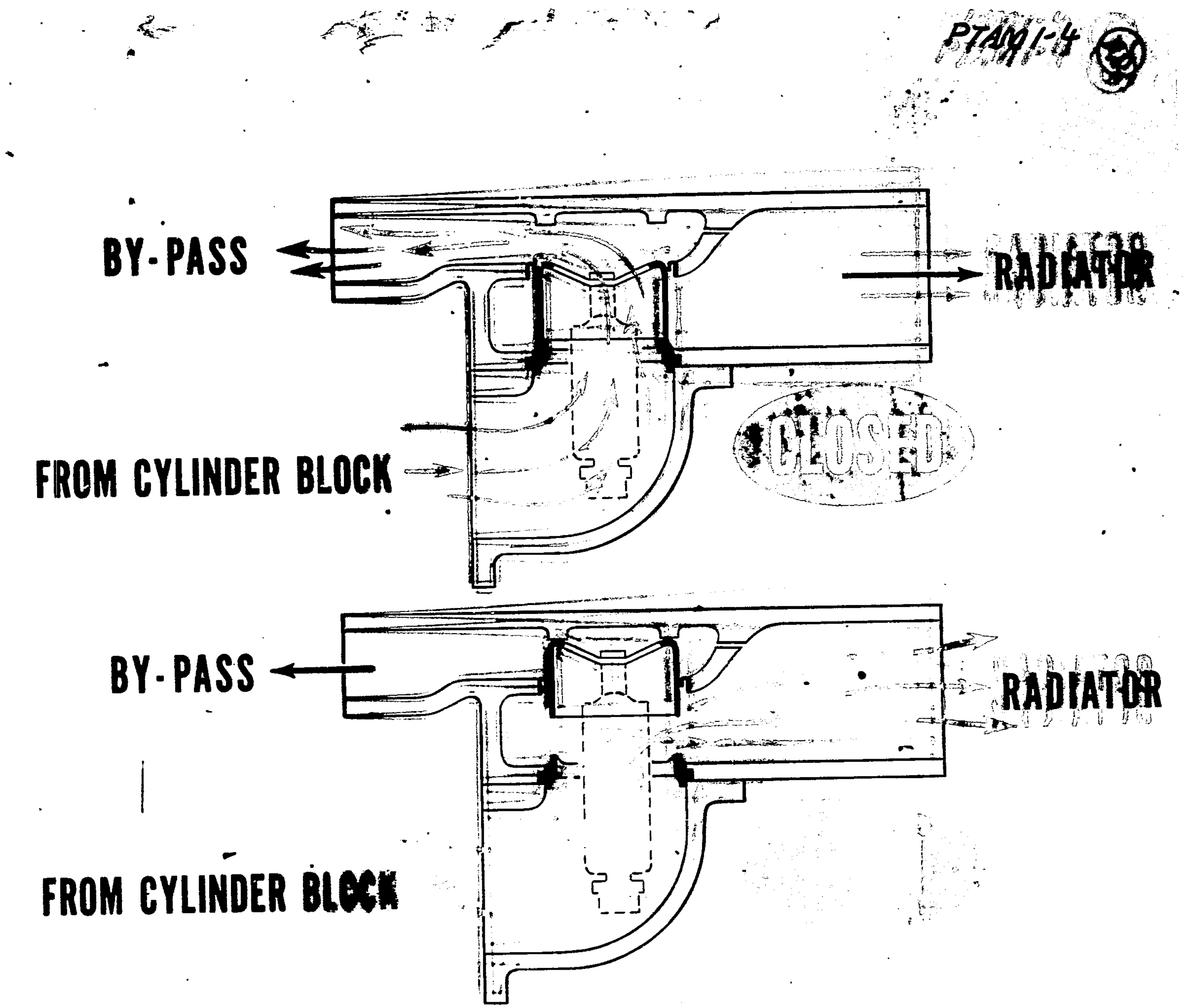



PTAM 1-4 (9)

RADIATOR COOLING SYSTEM

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RADIATOR
CLOSED
FROM CYLINDER BLOCK
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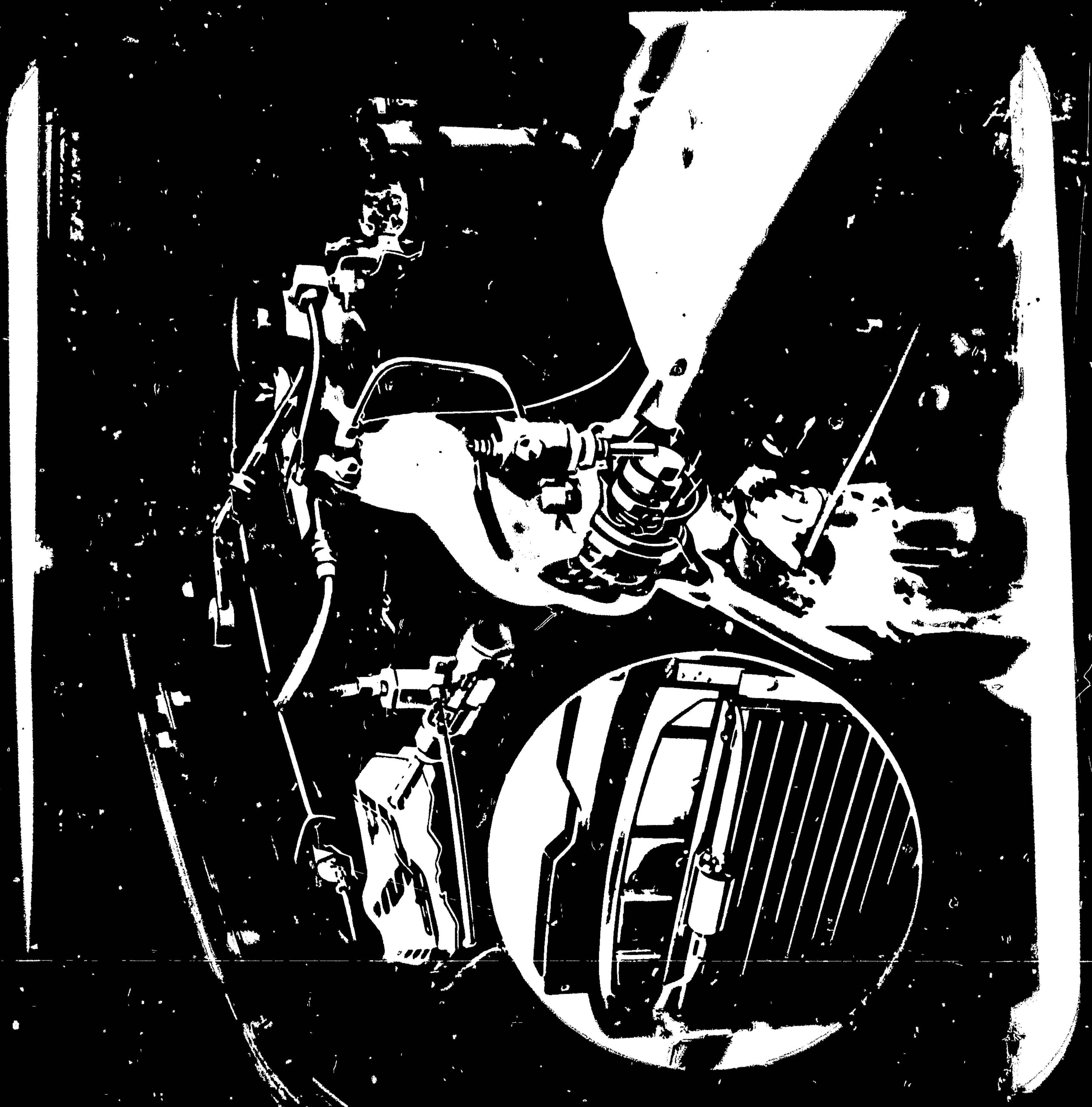

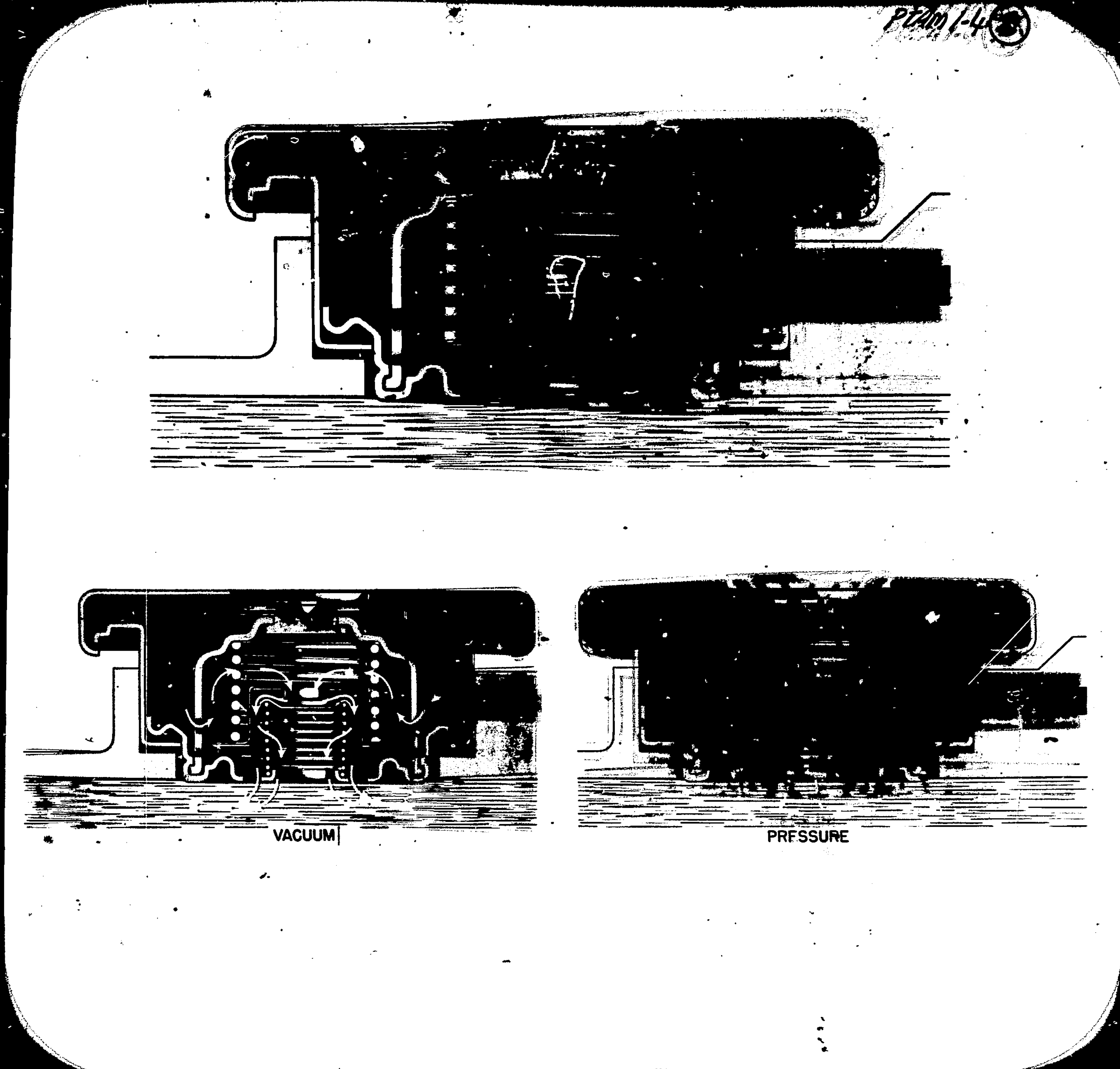
VACUUM
PRESSURE

INSTRUCTOR'S GUIDE

Title: Maintaining the Cooling System -- Detroit Diesel Engines

Code: PTAM 1-4

10/6/65

FIRST: Make sure that each student's questions on the previous tape have been answered.

OBJECTIVES:

1. What the cooling system consists of.
2. How it operates (coolant flow).
3. Cooling system capacities (how to determine them).
4. How to generally maintain the cooling system.
   Including draining and flushing procedures.
   Use of corrosion inhibitors and antifreeze.
5. Various cooling system checks.
6. How to properly maintain the water pump.
   Include lube and inspection.
7. How the thermostat works.
8. How to maintain the thermostat.
9. Proper radiator maintenance.
10. How the pressure control cap works.
11. When to replace the pressure control cap.
12. How to properly maintain and adjust the fan, fan belt, and fan blades.

TRAINING AIDS:

A cutaway water pump, if possible. If not, tear one down in class.

Charts on the Cooling System - GM, Sets TA 301 and TA 302.

Refer to the maintenance manuals for In-line and V-71 engines.

Vue Cells:
PTAM 1-4 (1) (V-71 Cooling System)
PTAM 1-1 (11) (I-71 Cooling System)
PTAM 1-4 (2) (V-71 Water Pump)
PTAM 1-4 (3) (I-71 Water Pump)
PTAM 1-4 (4) (Thermostat Housing)
PTAM 1-4 (5) (Coolant Flow Control - Thermostat)
PTAM 1-4 (6) (Thermostat Operation)
PTAM 1-4 (7) (Radiator-Shutter arrangement)
PTAM 1-4 (8) (Radiator Pressure Control Cap)

Make use of any available components, such as - radiator, fan assembly, fan belts, blades. etc.

You might also show how a Thermostat opens and closes according to water temp.

QUESTIONS:

1. Trace the coolant flow.
2. How is the cooling system capacity determined?
3. How is the system drained?
4. What is the purpose of a corrosion inhibitor?
5. When should they be used?
6. What is the best TYPE of antifreeze to use?
7. How do you decide how much to put in?
8. When is it necessary to flush the system? What is meant by contamination?
9. What care must be taken when using a cooling system cleaner?
10. What do you watch for when checking:
    - the hoses?
    - the thermostat?
    - the pressure cap?
    - for external leakage?
    - the fan belt?
    - the radiator?
    - the fan shroud?
11. How do you lubricate the water pump (in either series)?
12. When do you lubricate the water pump?
13. What do you watch for during inspection of the water pump?
14. How does the thermostat operate?
15. What do you look for when inspecting it?
16. What must be done to properly maintain the radiator?
17. What do you look for when inspecting the radiator?
18. How does the pressure control cap work?
19. When should it be replaced?
20. Do you lubricate the fan?
21. How is the fan belt adjusted?
22. When would you remove or replace the fan blades?