service bulletin

MerCruiser
STERN DRIVES/INBOARD ENGINES

NUMBER: 82-5
DATE: 6/01/82

CIRCULATE TO:
SERVICE MANAGER
PARTS MANAGER
MECHANICS

# TROUBLESHOOTING THE COOLING SYSTEM ON MERCRUISER 4 CYLINDER 224 CID ENGINES (MCM/MIE 470, MCM 485 and MCM 488)

The following is a general guide to troubleshoot/repair the closed cooling system used on MerCruiser 4 Cylinder 224 CID Engines (470/485/488).

There are several configurations of this cooling system, but the operation is essentially identical. Basically, the system is composed of two separate sub-systems; the seawater circuit and the closed cooling circuit. (Figures 2, 3 and 4) The seawater circuit is similar in function to the fan used in an automobile. The closed cooling circuit is similar in function to the rest of the cooling system in an automobile.

The seawater circuit has one prime cause of trouble: reduced water flow (similar to reduced air flow in an automobile). The most common causes of reduced seawater flow:

- Bad seawater pump impeller
- Kinked or loose hoses
- Impeller blade or debris in drive/transom assembly water passages
- Blockage in heat exchanger (seawater circuit)
- Blocked exhaust elbow
- Improperly repaired heat exchanger
- Hose fitting in exhaust elbow installed too deep

The closed cooling circuit can have trouble from three different causes: 1) loss of coolant, 2) reduced coolant flow and 3) aeration of coolant.

The most common causes of the three different problems in the closed cooling circuit are as follows:

**Loss of Coolant**

- Loose hoses
- Damaged filler cap
- Leaking heat exchanger
- Cracked or warped cylinder head
- Improperly installed gaskets between exhaust manifold and exhaust elbow
- Cracked manifold
- Worn seals on circulating pump
- Cylinder block porosity

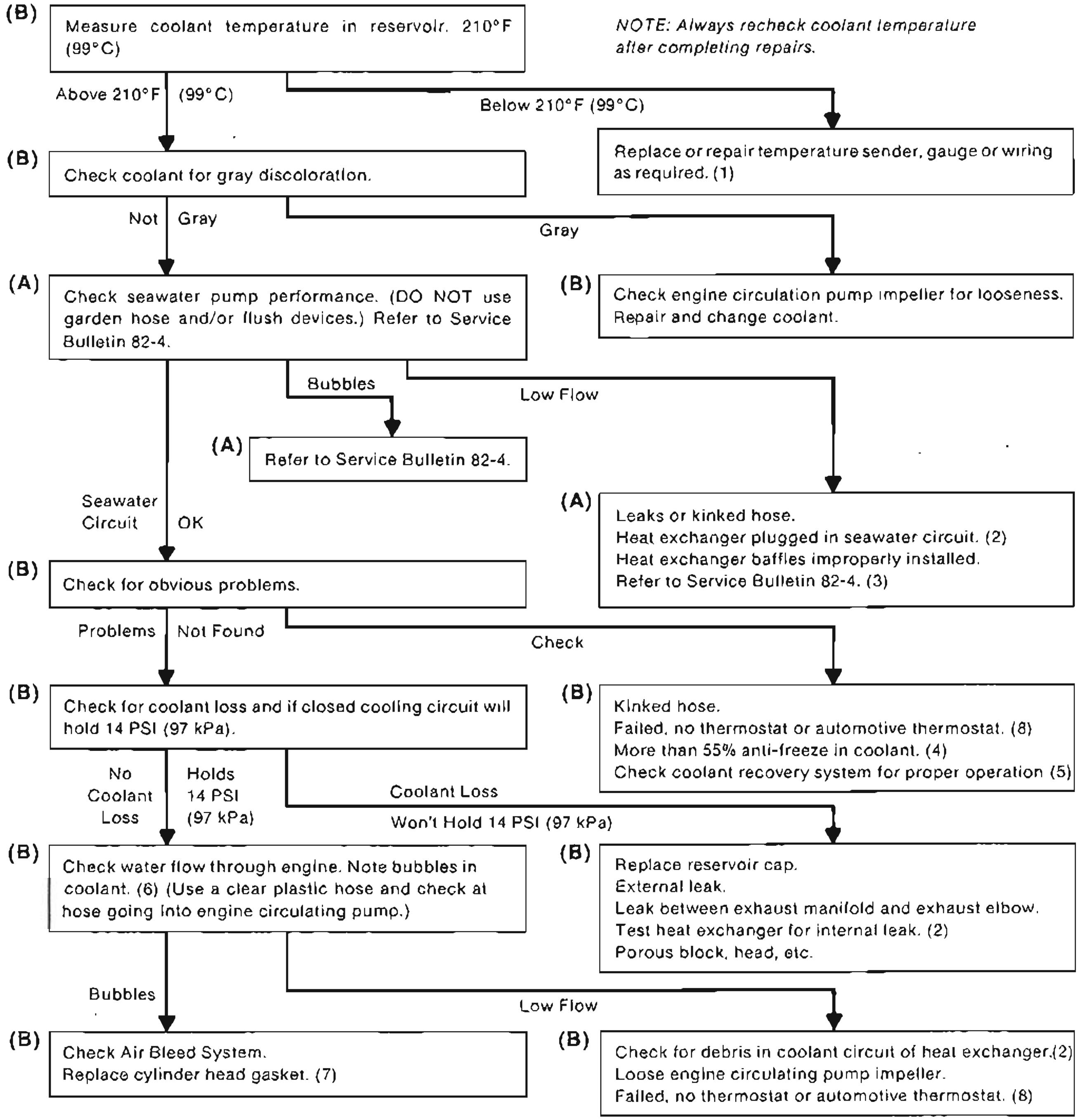
**Reduced flow**

- Thermostat failure or automotive thermostat being used
- Aeration
- Blockage in heat exchanger (closed cooling circuit)
- Loose circulating pump impeller
- Collapsing hoses

**Aeration**

- Improper filling
- Leaking cylinder head gasket

Although the cause of trouble can occur individually, two or three of them usually show up together. All result in an increase in engine temperature. In the following Chart, (A) refers to the seawater circuit and (B) refers to the closed cooling circuit.




*NOTE 1: Normal operating engine temperature taken at the water temperature sender with a direct reading gauge is 165°F (74°C) to 200°F (93°C) at W.O.T. Dual station boats must use a dual station water temperature sender.*

*NOTE 2: Refer to "Testing" Heat Exchanger.*

*NOTE 3: MIE seawater pump flows 30-32 Gal/Min. at 4200 RPM.*

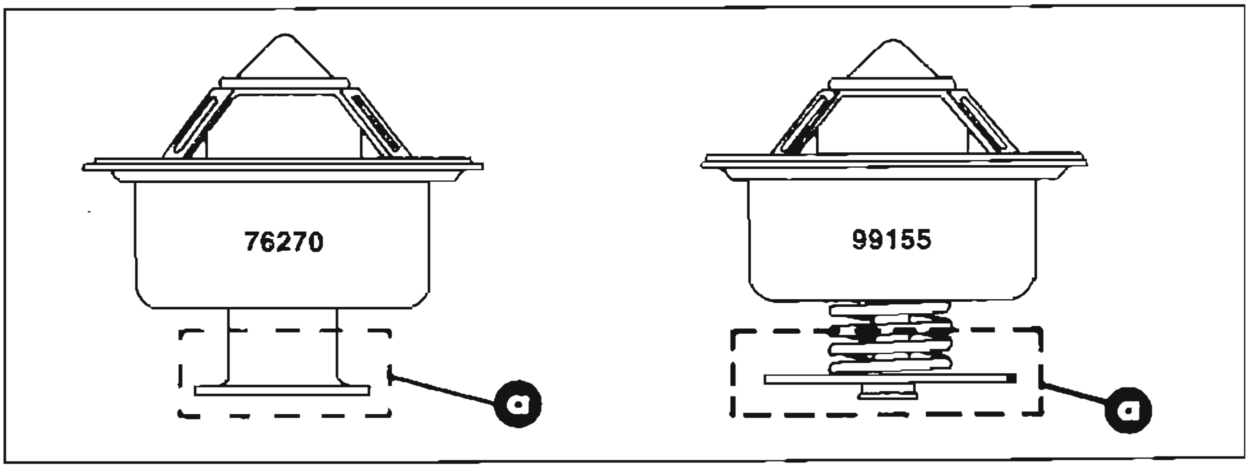
*NOTE 4: % of anti-freeze in coolant can be checked with anti-freeze tester.*

*NOTE 5: Refer to "Coolant Recovery and Air Bleed Systems Operation".*

*NOTE 6: Run in lake for this test.*
*Note coolant color in clear plastic hose and reservoir before starting engine. Coolant is dark in color. Start engine and run at 3500 RPM.*
**Normal:** *Coolant is dark in color (near the color before starting engine) with some air bubbles.*
**Abnormal:** *Coolant becomes very light in color because of many bubbles.*

*NOTE 7: Refer to "Testing for Cylinder Head Gasket Leak".*

*NOTE 8: Automotive thermostats CANNOT BE USED in these engines because they DO NOT direct the coolant flow to the heat exchanger when thermostat is open. (Figure 1)*




a - Umbrella Must Be On Thermostat

**Figure 1. Thermostat**

## FILLING CLOSED COOLING SYSTEM

After draining closed cooling system, refill system with anti-freeze solution as recommended in Service Bulletin 82-3. Start engine and run at fast idle (1000-1500 RPM) (with water running to seawater pump). Fill until coolant level in reservoir remains "full". Normally, there will be air trapped in the coolant. Normal operation will remove the "trapped" air shortly after the thermostat opens. The coolant level must be rechecked in the reservoir after the thermostat has opened.

## COOLANT RECOVERY AND AIR BLEED SYSTEMS OPERATION

**Coolant Recovery System:** This system keeps the reservoir full. Normal coolant overflow into recovery bottle is approximately ½ pint during warm-up. The coolant recovery system draws coolant back into the reservoir from the recovery bottle as the engine cools. As long as there is coolant in the recovery bottle, the reservoir should remain completely full. If not, there's a vacuum leak, usually at the hose leaving the reservoir, or the gasket under the recovery filler cap. The gasket seals against the outer rim of the filler neck.

**Air Bleed System:** This system is designed to reduce or remove aeration which occurs during filling, or slight head gasket leakage. The system operates by producing a small flow through the reservoir which allows coolant/air bubbles to separate and vent the air bubbles off while passing through the reservoir. For the system to operate properly, the small hose and fittings going from the reservoir to the exhaust (or intake manifold) must not be plugged.

## TESTING FOR CYLINDER HEAD GASKET LEAK

A leaking head gasket will cause combustion gas to be forced into the cooling system. The mixture of coolant and tiny air bubbles is a poor heat conductor; and will overheat an engine quickly. Compression tests or cooling system pressure check normally will not detect the leak because the test pressure is far below the combustion pressures which cause the leak. An effective test is as follows:

*NOTE: Run boat in lake for this test. It is best to run the engine at or above cruising speed during this test. Usually a failed head gasket will not cause the engine to overheat below cruising speed.*

1. Install a clear plastic hose between the reservoir and coolant recovery bottle. Use a 2-3 ft. (61-91cm) long hose for this test.
2. Route this hose so a "U" is formed.
3. Put enough coolant into hose to fill the center 4 or 5 inches (10-13cm) of the "U".
4. Observe the "U" while the engine is running.
   a. During idle and warm-up: some coolant and/or air will leave the reservoir.

b. During cruising speed (2500-3500 RPM): coolant and/or air leaving the reservoir should stop after approximately 5 minutes running at a given RPM. A leaking head gasket will produce air bubbling through the "U", going to the coolant recovery bottle. The frequency and size of the bubbles will depend on the size of the leak.
c. At higher speeds (4000+ RPM): Normal operation is the same as described in "b" above. A failed head gasket will cause the bubbles to come faster and may be accompanied by violent, intermittent bursts of coolant leaving the reservoir.

It is important not to confuse normal warm-up expansion with a failed head gasket. Normal warm-up produces an intermittent flow of coolant which will stop within approximately 5 minutes at a given RPM. A head gasket leak will not stop - the one thing that marks a failed head gasket is the continued passage of air, that may be accompanied by violent, intermittent bursts of coolant leaving the reservoir. If coolant continues to flow (not in violent, intermittent bursts) from the reservoir at cruising speed, something else besides the head gasket is causing the engine to overheat.

## TESTING HEAT EXCHANGER

**For Internal Leak:** An internal leak will cause coolant to go into the seawater circuit when pressure is put on the closed cooling circuit.

a. Remove a seawater hose from the exchanger. DO NOT DRAIN the exchanger.
b. Pressurize the closed cooling circuit to 14-20 PSI (97-138kPa) with a radiator tester.
c. If seawater begins to overflow from the nipple (from which hose was removed in "a"), there is a leak.

**For Blockage:**

*NOTE: Seawater flows THROUGH the tubes in the exchanger. Closed cooling coolant flow AROUND the tubes.*

a. Remove end caps and inspect for any blockage in the seawater circuit (broken impeller blades, weeds, etc.).
b. Remove closed cooling circuit hoses and inspect the tubes just inside the nipples. Because the complete exchanger cannot be inspected, the heat exchanger should be replaced if blockage is suspected.

## HEAT EXCHANGER REPAIR

a. Freezing the seawater circuit usually forces the end castings out of the shell. These castings can be cleaned, re-inserted properly and soldered in place by a radiator shop. Refer to Figures 5, 6, 7 or 8 for proper placement of end castings.

**IMPORTANT: The end castings directs the seawater flow through the heat exchanger in Stern Drive (MCM) Engines. If they aren't installed correctly, the water takes a short cut and two-thirds (or more) of the exchanger is not used.**

- **Stern Drive (MCM) Engines with a 3" (8cm) Dia. Heat Exchanger: Seawater passes through exchanger three (3) times before leaving.**
- **Stern Drive (MCM) Engines with a 4" (10cm) Dia. Heat Exchanger: Seawater passes through exchanger five (5) times before leaving.**
- **Inboard (MIE) Model Engines: Seawater passes through exchanger once before leaving.**

b. Internal leaks can be repaired by soldering shut the ends of the leaking tube. This is only a temporary fix because usually another tube will start leaking after a short period of time and this also causes a reduction in cooling capacity. DO NOT close more than 3 tubes.
c. Nipples and drains that have been broken off the heat exchanger can be re-attached by brazing. Care must be taken not to melt other joints during repair.

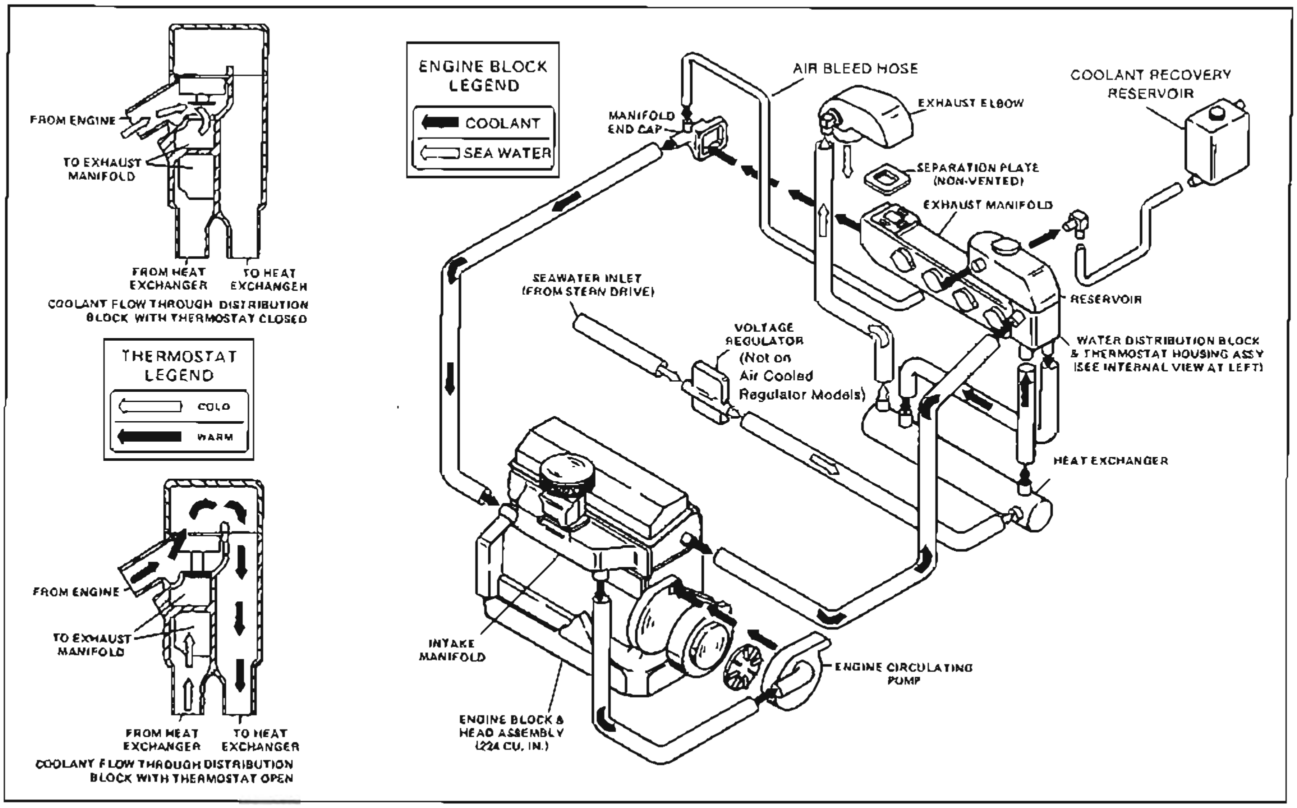



**Figure 2. MCM 470 Water Flow Circuits [With 3" (8cm) Dia. Heat Exchanger]**

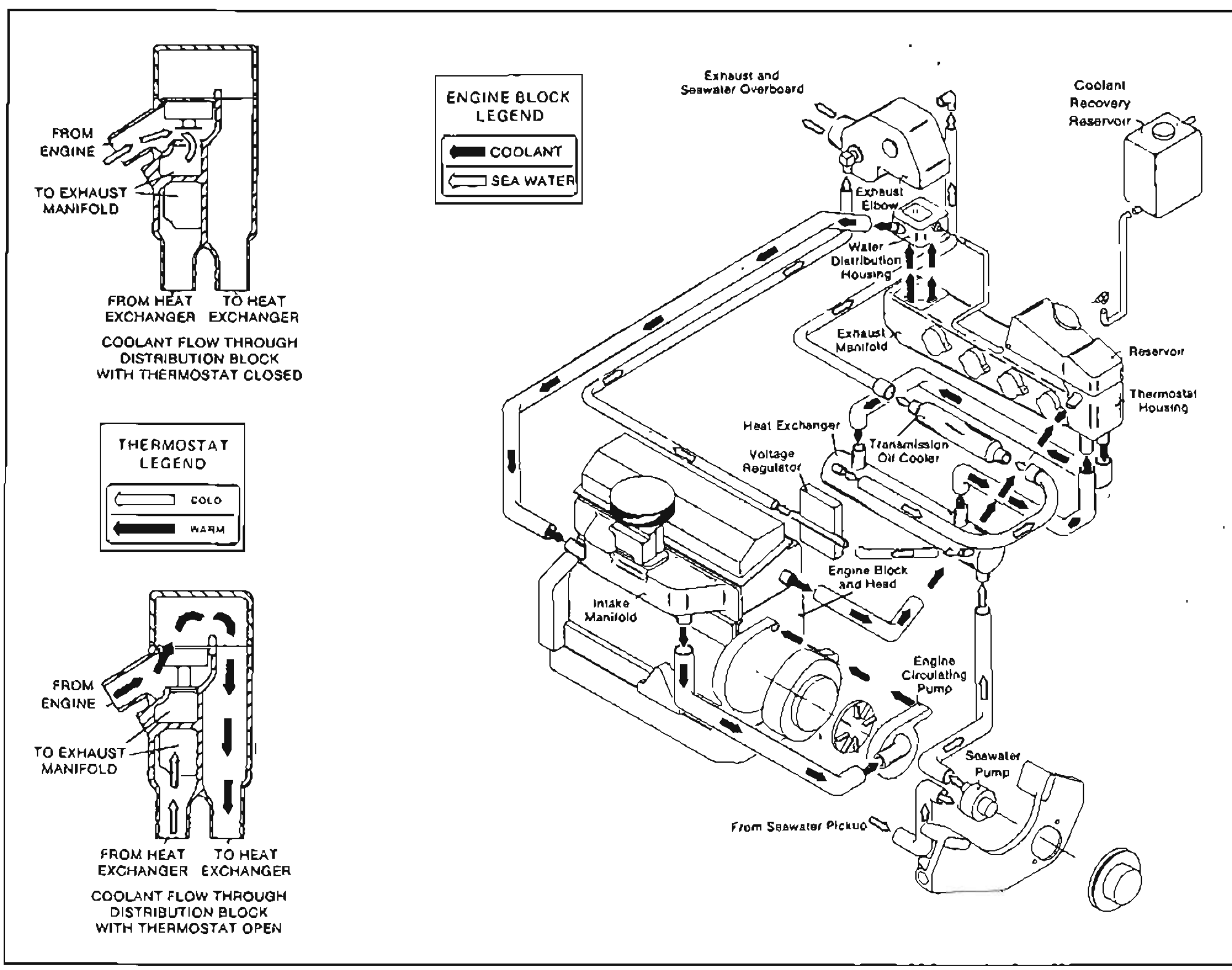



**Figure 3. MIE 470 Water Flow Circuits**

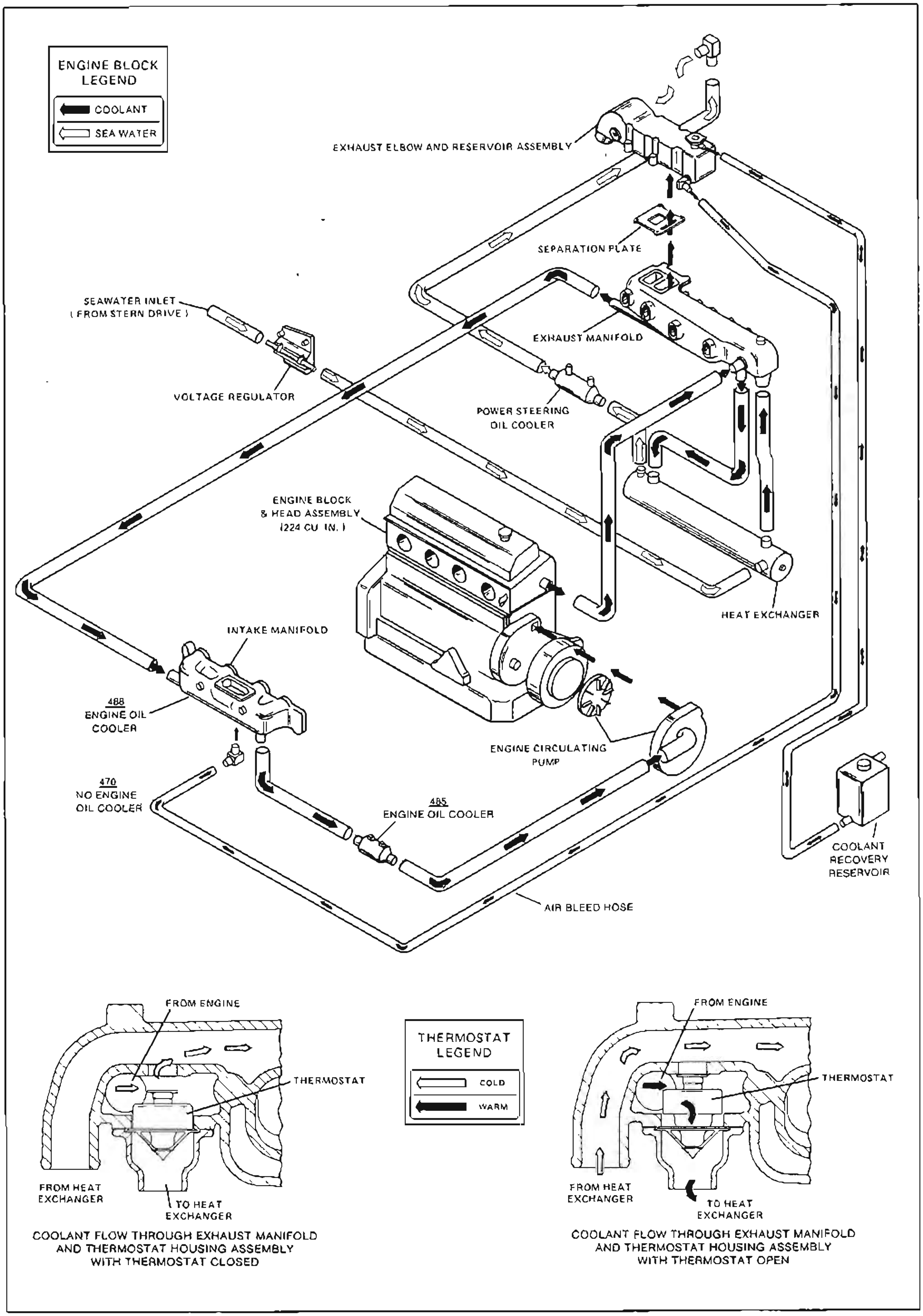
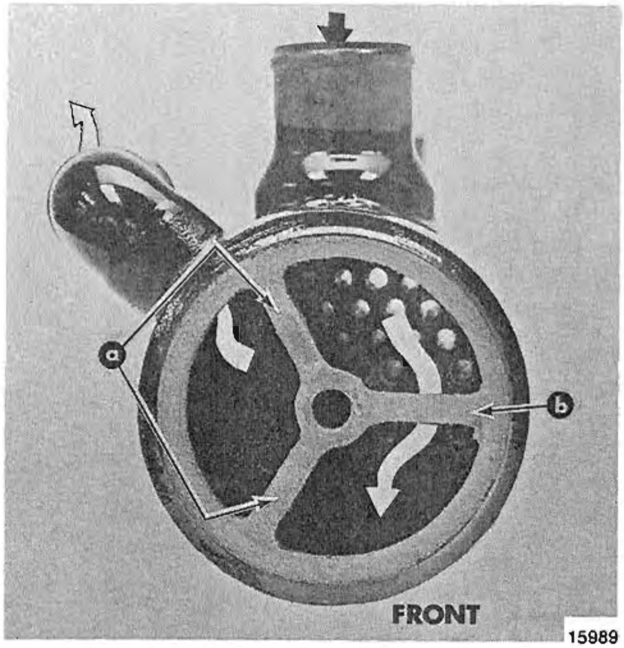
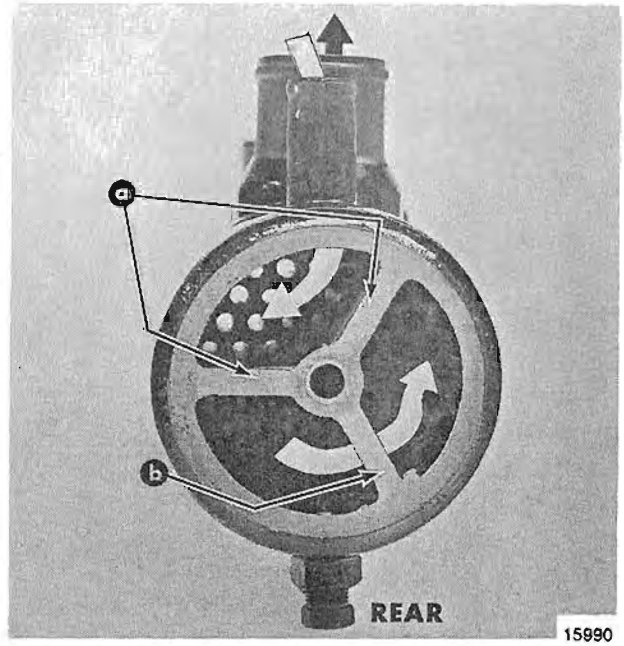



**Figure 4. MCM 485 [3" (8cm) Dia. Heat Exchanger] and MCM 470/488 [4" (10cm) Dia. Heat Exchanger] Water Flow Circuits**



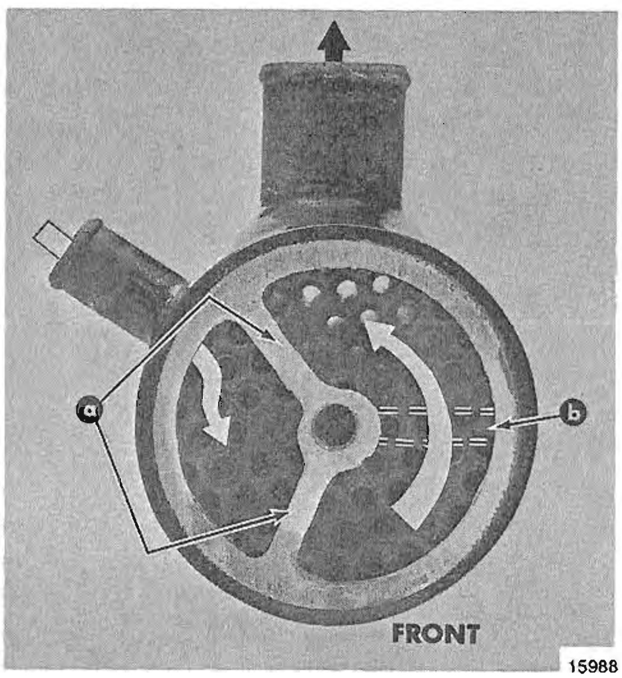



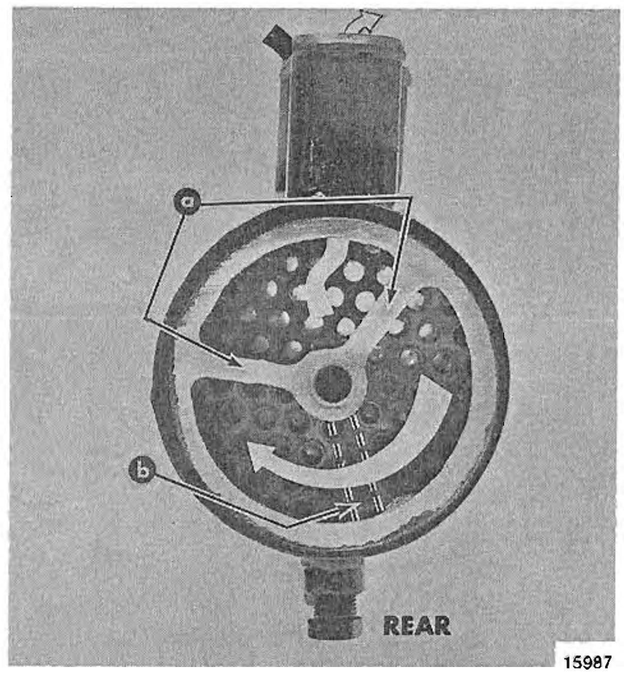

Closed Cooling Coolant Flow

Seawater Flow

a - Solid Ribs
b - Open Rib

**Figure 5. 75959 End Casting Placement [MCM 470 3" (8cm) Dia.]**



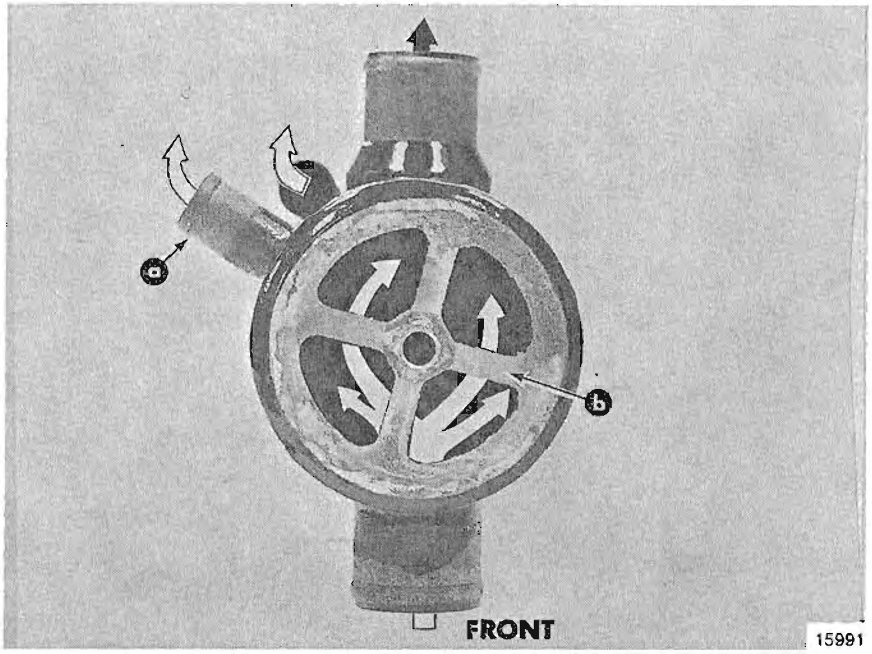




Closed Cooling Coolant Flow

Seawater Flow

a - Solid Ribs
b - Open Rib (If Exchanger Has 3rd Rib At Each End)

**Figure 6. 77319 End Casting Placement [MCM 470/485 3" (8cm) Dia.]**

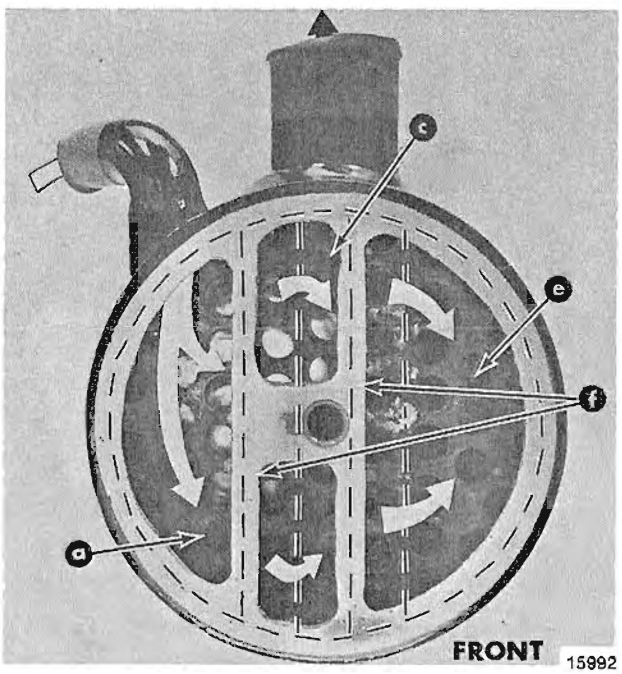


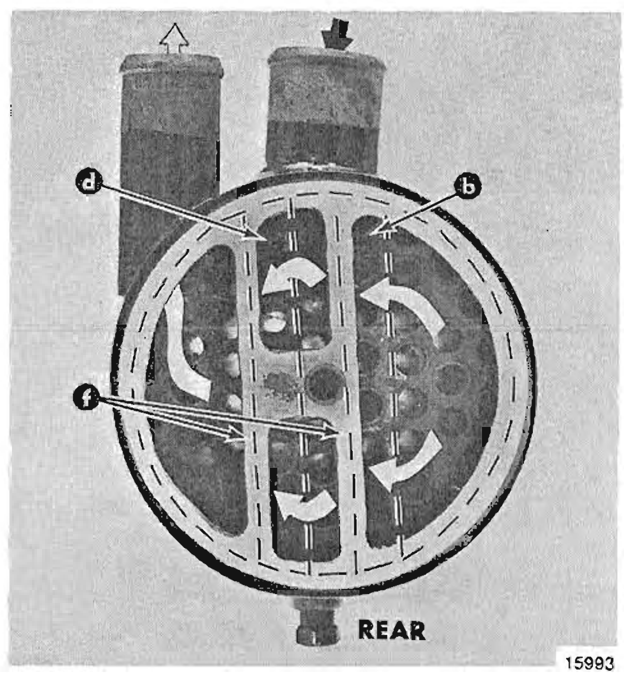

Closed Cooling Coolant Flow

Seawater Flow

a - Small Amount of Seawater to Cool Voltage Regulator
b - All 4 Ribs Are Open

**Figure 7. 78165 End Casting Placement [MIE 470 3" (8cm) Dia.]**




Closed Cooling Coolant Flow

Seawater Flow

a - 17 Tube Flow To Rear
b - 8 Tube Flow To Front
c - 9 Tube Flow To Rear
d - 8 Tube Flow To Front
e - 17 Tube Flow To Rear
f - The Two Ribs On Each End Are Solid

**Figure 8. 98643 End Casting Placement [MCM 470/488 4" (10cm) Dia.]**