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## MC-9 MAINTENANCE MANUAL

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# SECTION 6

# COOLING SYSTEM

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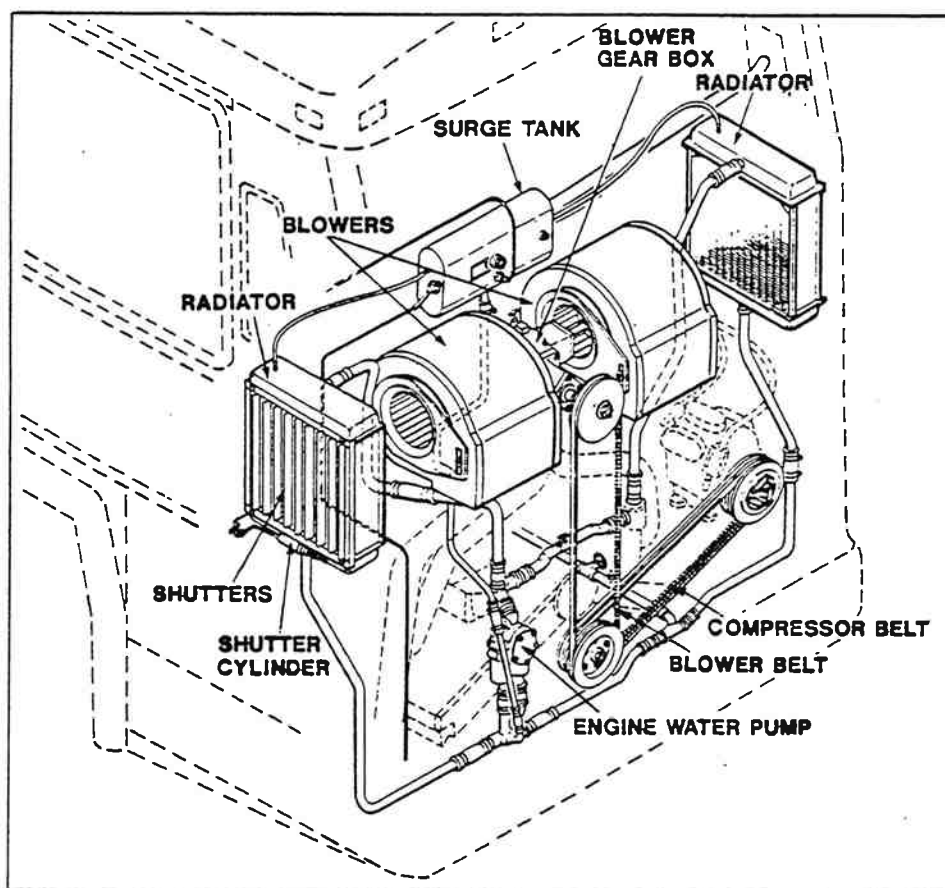


Figure 6-1. Cooling System Components.

## COOLING SYSTEM

One radiator is mounted on each side of the coach above the engine. Cores are of fin and tube construction. Dual centrifugal blowers are belt driven from the engine crankshaft through a gear box. They pull outside air through the radiators into a sealed, insulated blower compartment when the air operated, thermostatically controlled shutters are open.

When engine coolant is below normal operating temperature the shutters are automatically closed. With shutters closed, no air is pulled across the radiators and horsepower required to drive the centrifugal blower becomes significantly reduced.

The blower gear box includes a sight gauge for checking lubricant level and an easily accessible oil filler tube. Belt tension is maintained through an automatic, air controlled belt tightener.

The surge tank is mounted in the upper blower compartment. The coolant filler neck and pressure release valve are mounted behind the access door on the right rear side of the coach. A coolant level check can be done rapidly by means of a sight glass installed on the surge tank. Thermostats and alarms are provided at the front of each cylinder head.

The function of the coolant is to absorb the heat which develops as a result of the combustion process in the engine. In addition, the heat absorbed by the oil is removed by the engine coolant in the oil cooler.

The engine water pump circulates coolant through the engine oil cooler, block, cylinder heads and aftercooler. From the aftercooler it flows through the thermostats to the radiators and down to the water pump completing the cycle. Anything that interferes with this process of heat transfer can cause engine components to overheat, often resulting in serious engine damage. See figure 6-1.

## COOLANT TEMPERATURE

The heat-dissipating capacity of the V-92 Series engine cooling system and related components must be sufficient to prevent the coolant-out temperature from rising above the maximum allowable coolant-out temperature limit of 210°F (98.9°C).

This temperature must not be exceeded under any engine operating conditions, regardless of altitude, type of coolant used, or cooling system condition. Exceeding these limits can result in malfunction or serious engine damage.

## TEMPERATURE CONTROL COMPONENTS

The engine is designed to operate with thermostats which, combined with a radiator, regulate coolant temperature. Radiator shutters, and fans, are used to help control coolant temperature. These "add on" cooling system components

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must operate in proper sequence to prevent coolant temperature instability and/or engine overheating. An improper operating sequence can also have a detrimental effect on the life of the "add on" components as well.

The following chart gives the **nominal** temperature settings for the 180°F (82°C) thermostat and shutterstat controls, along with standard and optional alarmstat settings. These settings should not be exceeded, under any engine operating condition, regardless of operating altitude, type of coolant used, or cooling system condition. Exceeding the settings will unnecessarily increase the engine coolant and lubricating oil temperature.

**NOTE: Coolant temperature instability will result from improper component operating sequence.**

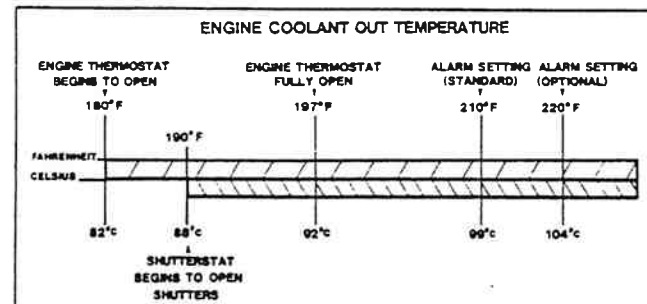


Figure 6-2. Nominal Settings For Coolant Temperature Controls.

The major components of the cooling system are the coolant, radiators, blower gear box and surge tank. These components, as well as the minor ones, are covered in more detail later in this section.

## HOSE INSPECTION

Swollen, cracked or worn out hoses or loose hose connections are frequent causes of cooling system problems.

Serious overheating is often caused by old hose collapsing or from deteriorated rubber shedding from hoses and clogging the coolant passages.

Connections should be inspected periodically and hose clamps tightened. Replace any hose found to be cracked or swollen. When installing a new hose, clean pipe connections and apply a thin layer of a non-hardening sealing compound. Replace worn out clamps or clamps that pinch hoses.

## TESTING ANTIFREEZE SOLUTIONS

Always test solution before adding water or antifreeze. Engine should be warmed to operating temperature. Fill and empty tester several times before using, and ensure that tester is clean inside and out.

If a coolant filter is used, replace the element every 500 hours or 20,000 miles (32,000 km).

Commercial cooling system cleaners of alkaline or acid type may be used. Exercise extreme caution and follow the manufacturer's recommendations when using these types of cleaners.

Problems may develop from leaks and seepage at the engine water pump and thermostat housings hose connections. These may be caused by deformation and rough surfaces on the castings at the hose mounting surfaces. It is recommended that Dow Corning RTV-102 Compound be applied to cast surfaces prior to hose installation.

**CAUTION: Castings should be clean and free of oil and grease before applying compound. No other sealer should be used with RTV compound.**

## COLD WEATHER OPERATIONS

Although not recommended, plain water with an inhibitor may be used as a coolant where temperatures do not reach below 32°F (0°C). In colder regions antifreeze must be used.

Before adding antifreeze the cooling system should be inspected for winter operation. Cylinder head gaskets should be tightened or replaced where necessary to avoid the possibility of coolant leaking into engine and exhaust gases blowing into cooling system.

After antifreeze has been added, the entire system should be inspected regularly to ensure against the development of leaks.

If the cooling system becomes frozen, place the coach in a warm area until the ice is completely thawed. Under no circumstances should the engine be operated when the cooling system is frozen.

## PREVENTIVE MAINTENANCE

A program of maintenance of the cooling system components is essential to ensure maximum system efficiency, and trouble-free operation. Observe the following guidelines:

1. Check, on a daily basis, the coolant level in the surge tank. Keep tank filled with the coolant required for proper operation in the extremes of seasonal temperatures.

2. Every 20,000 miles (32,000 km) perform the following checks:

a. Check belts for condition and tension. Tighten loose belts and replace those frayed or worn.

b. Check water pump operation and installation. A leaking pump will suck air into the cooling system, causing corrosion of engine and cooling system components, and decreasing the efficiency of the coolant. Correct all leaks at once.

c. Check the radiators and all hoses for leaks. Repair leaking components. Clean the radiator cores with low pressure air to remove all dirt and thus provide optimum heat dissipation. Check and tighten radiator mounts as required. Repair all leaks.

d. If a coolant filter is used, replace the element at this interval.

3. The following procedures are necessary every 100,000 miles (161,000 km):

a. Check the strength of the antifreeze with a hydrometer. If too weak, drain a quantity of coolant from the system, and replace with the same quantity of coolant (water/antifreeze mixture) in proper proportion to result in correct overall solution strength.

b. Check the strength of the inhibitor in the coolant. Use a test kit or strip made available by the manufacturer of the inhibitor in use. Follow the instructions of the inhibitor manufacturer. Add inhibitor only in the amount necessary to reach manufacturer's strength recommendations.

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**NOTE: Specific instructions are set forth below concerning coolant requirements, antifreeze, use of water in the system, corrosion inhibitors, silicate gel formation and coolant testing.**

## COOLANT REQUIREMENTS

Coolant solutions must meet the following basic requirements:

1. Provide for adequate heat transfer.
2. Provide a corrosion-resistant environment within the cooling system.
3. Prevent formation of scale or sludge deposits in the cooling system. Figure 6-3 contains water quality data.
4. Be compatible with cooling system hose and seal materials.
5. Provide adequate freeze protection during cold weather operation and boil-over protection in hot weather.

The first four requirements are satisfied by combining a suitable water with reliable inhibitors. When freeze protection is required, a solution of suitable water and an antifreeze containing adequate inhibitors will provide a satisfactory coolant. Ethylene glycol-based antifreeze solutions are recommended for year-round use.

## WATER

Whether of drinking quality or not, any water will produce a corrosive environment in the cooling system, and the mineral content may permit scale deposits to form on internal cooling system surfaces. Therefore, water selected as a coolant must be properly treated with inhibitors to control corrosion and scale deposition.

To determine if a particular water is suitable for use as a coolant when properly inhibited, the following characteristics must be considered: the concentration of chlorides and sulfates, total hardness, and total dissolved solids.

Chlorides and/or sulfates tend to accelerate corrosion, while hardness (percentage of magnesium and calcium salts broadly classified as carbonates) cause deposits of scale. Total dissolved solids may cause scale deposits, sludge deposits, corrosion, or a combination of any of these. Chlorides, sulfates, magnesium and calcium are among the materials which make up dissolved solids. Water within the limits specified in Table 1 (figure 6-3) is satisfactory as an engine coolant when proper inhibitors are added. The procedure for evaluating water intended for use in a coolant solution is shown in Table 2.

	PARTS PER MILLION	GRAINS PER GALLON*
Chloride (Maximum)	40	2.5
Sulfates (Maximum)	100	5.8
Total Dissolved Solids (Maximum)	340	20
Total Hardness (Maximum)	170	10

Refer to Table 2 for evaluation of water intended for use in a coolant solution.  
\* 4.5 liters

Determine The Concentrations Of Chlorides, Sulfates, And Total Dissolved Solids In The Water	
Chlorides Under 40 ppm, And Sulfates Under 100 ppm, And Total Dissolved Solids Under 340 ppm.	Chlorides Under 40 ppm, Or Sulfates Under 100 ppm, Or Total Dissolved Solids Over 340 ppm.
Determine Total Hardness Of The Water	Distill, De-mineralize Or De-ionize The Water.
Total Hardness Under 170 ppm	Water Suitable for Use As Coolant
Total Hardness Over 170 ppm	Plus Inhibitors
Soften The Water	
Water Suitable for Use As Coolant	
Plus Inhibitors	

Figure 6-3. Cooling Fluid Characteristics.

## ANTIFREEZE

When freeze protection is required, use an antifreeze that meets the GM 6038M formulation, which limits silicate to 0.15% maximum, or an equivalent formulation meeting the 0.15% maximum silicate and GM 1899M performance requirements.

Solutions of less than 30% do not provide adequate corrosion protection. Concentrations over 67% adversely affect freeze protection, heat transfer rates, and silicate stability. A 50% antifreeze solution is normally used as factory-fill.

Ethylene glycol base antifreeze is recommended. Methyl alcohol base antifreeze is not recommended because of its effect on the non-metallic components of the cooling system and because of its low boiling point. Methoxy propanol base antifreeze is not recommended due to the presence of fluoro-elastomer seals in the cooling system.

The inhibitors in antifreeze solutions should be replenished with a non-chromate corrosion inhibitor supplement when indicated by testing the coolant. Engine coolant should be checked at approximately 500 hour or 20,000 mile intervals. (See Coolant Testing, below.)

Antifreeze solutions should be used year-round to provide freeze protection in the winter, boil-over protection in the summer, and a stable environment for seals and hoses in the cooling system of the engine. (See figure 6-4.)

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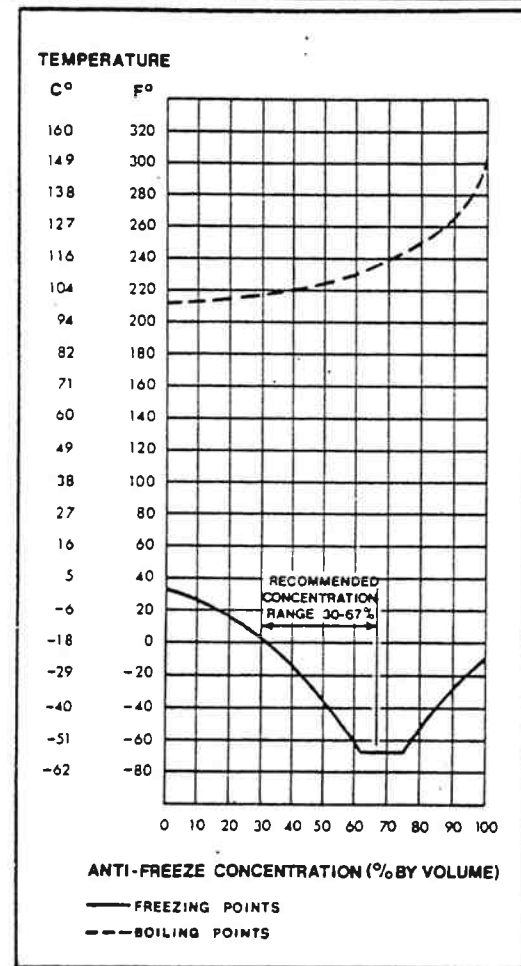


Figure 6-4. Freezing and Boiling Temperatures of Coolant (at sea level).

## CORROSION INHIBITORS

A corrosion inhibitor is a water-soluble chemical compound which protects the metallic surfaces of the cooling system against corrosive attack. Some of the more commonly used corrosion inhibitors are chromates, borates, nitrates, nitrites, and soluble oil. (*Soluble oil is not recommended as a corrosion inhibitor.*) Depletion of all types of inhibitors occurs through normal operation. Therefore, strength levels must be maintained by adding inhibitors as required after testing the coolant.

The importance of a properly inhibited coolant cannot be overstressed. A coolant which has insufficient inhibitors, the wrong inhibitors, or — worse — no inhibitors at all invites the formation of rust and scale deposits within the cooling system. Rust, scale, and mineral deposits can wear out water pump seals and coat the walls of the cylinder block water jackets and the outside walls of the cylinder liners. As these deposits build up, they insulate the metal and reduce the rate of heat transfer. For example, a  $\frac{1}{16}$ " deposit of rust or scale on 1" of cast iron is equivalent to  $\frac{1}{4}$ " of cast iron in heat transferability.

An engine affected in this manner overheats gradually — over a period of weeks or months. Liner scuffing, scoring, piston seizure, and cylinder head cracking are the inevitable results. An improperly inhibited coolant can also become corrosive enough to "eat away" coolant passages and seal ring grooves

and cause coolant leaks to develop. If sufficient coolant accumulates on top of a piston, a hydrostatic lock can occur while the engine is being started. This, in turn, can result in a bent connecting rod.

An improperly inhibited coolant can also contribute to *cavitation erosion*. Cavitation erosion is caused by the collapse of bubbles (vapor pockets) formed at the coolant side of an engine component. The collapse results from a pressure differential in the liquid caused by the vibration of the engine part. As bubbles collapse, they form pin points of very high pressure. Over a period of time, the rapid succession of millions of tiny bursting bubbles can wear away (erode) internal engine surfaces.

Components such as fresh water pump impellers and cylinder liners are especially susceptible to cavitation erosion. In extreme cases their surfaces can become so deeply pitted that they appear to be spongy, and holes can develop completely through them.

**NON-CHROMATES** — Non-chromate inhibitors (borates, nitrates, nitrites, etc.) provide corrosion protection in the cooling system with the basic advantage that they can be used with either a water or water-and-antifreeze solution.

**CHROMATES** — Sodium chromate and potassium dichromate are two of the most commonly used water system corrosion inhibitors. Care should be exercised in handling these materials due to their toxic nature.

Chromate inhibitors *should not be used in antifreeze solutions*. Chromium hydroxide, commonly called "green slime," can result from the use of chromate inhibitors with antifreeze. This material deposits on the cooling system passages, reducing the heat transfer rate and resulting in engine overheating. Engines which have operated with a chromate-inhibited water must be chemically cleaned before the addition of antifreeze. A commercial heavy-duty descaler should be used in accordance with the manufacturer's recommendation for this purpose.

**SOLUBLE OIL** — *Soluble oil is not recommended as a corrosion inhibitor.* It has been used as a corrosion inhibitor for many years. It has, however, required very close attention relative to the concentration level due to adverse effects on heat transfer if the concentration exceeds 1% by volume. For example, 1.25% of soluble oil in the cooling system increases fire deck temperature 6%, and 2.50% concentration raises fire deck temperature up to 15%.

**INHIBITOR SYSTEMS AND ADDITIVES** — An inhibitor system is a combination of chemical compounds which provide corrosion protection, pH control, and water-softening ability. pH control is used to maintain an acid-free solution. The water-softening ability deters formation of mineral deposits. Inhibitor systems are available in various forms, such as coolant filter elements, liquid and dry inhibitor additives, and as integral parts of antifreeze.

Commercially packaged inhibitor systems are available which can be added directly to the engine coolant. Both chromate and non-chromate systems are available, and care should be taken regarding inhibitor compatibility with other coolant constituents.

*Non-chromate inhibitor systems are recommended.* These systems can be used with either water or water-and-antifreeze solutions and provide corrosion protection, pH control, and water softening. Most non-chromate inhibitor systems offer the additional advantage of a simple on-site test to determine protection level. Since they are added directly to the coolant, they

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require no additional hardware or plumbing.

All inhibitors become depleted through normal operation, and additional inhibitor must be added to the coolant as required to maintain original strength levels.

**NOTE: Over-inhibiting antifreeze solutions can cause silicate dropout. Always follow the supplier's recommendations on inhibitor usage and handling.**

## SILICATE DROPOUT

Excessive amounts of chemicals in the engine coolant can cause silicate dropout, which creates a gel-type deposit that reduces heat transfer and coolant flow. Silicate dropout may also occur in coolants using extremely hard water and/or unusually high operating temperatures.

The gel takes on the color of the coolant solution in the wet state but appears as a white powdery deposit when dry. Although silica gel is non-abrasive, it can pick up solid particles in the coolant and become a gritty, abrasive deposit that can cause excessive wear of water pump seals and other cooling system components.

If it is suspected that a coach cooling system has a gelling problem (indicated by engine overheating or coach underheating), first try to remove the gel in its "wet" condition. Use an alkaline cleaner (Nalprep 2001 or equivalent) as directed by the manufacturer, so that the silica-gel is not allowed to dry. If using the cleaner once does not correct it, repeat the procedure. If available, ultrasonics is another process that can be used to remove the gel without damage to cooling system components.

If silica-gel has been allowed to dry inside a cooling system component, removing the gel becomes more difficult. The gel tends to form in low areas of the cooling system, i.e., radiator bottom tank or areas within the engine oil cooler. If gel can be reached for mechanical cleaning (removal of radiator bottom tank or "rodding" out a radiator core), then that method can be used.

Finally, dried silica-gel may be removed from a cooling system component by removing that component from the coach and agitating it in a caustic solution. Extreme care must be taken when handling such caustic solutions. Safety glasses and protective gloves should be worn. **Do not flush engine cooling system with caustic solutions because damage can occur to both metallic and non-metallic components.**

The following recommendations are made to prevent silica-gel formation:

- Use antifreeze that meets GM-6038M formulation which limits the amount of silicate to 0.1% maximum.
- Use antifreeze solutions at the concentration required for freeze protection in your operational area, but **do not** use more than 67% antifreeze or less than 30% antifreeze.
- Never use 100% antifreeze for make-up coolant. Mix the make-up solution at the same concentration as the original fill.
- Use corrosion inhibitor supplements only as required to maintain proper system protection. The system should be tested to determine the need for additional inhibitor. Test kits and test strips are commercially available to check engine coolant for corrosion inhibitor strength level. Coolant should be tested to determine the need for corrosion inhibitor supplements and the amount required. Do not use one manufacturer's test to measure the inhibitor strength level of another manufac-

turer's product. Always follow the manufacturer's recommended test procedures. New additives Nalcool 3000 with stabil-aid and Fleetguard DCA4 have been developed to help prevent silicate dropout and this may be added to the system when need arises.

- As much as possible, avoid using what can be considered "hard" water when mixing with antifreeze.

A list of available antifreeze products that meet GM-6038M is shown below:

Company	Product
Texaco (1)	2055 (was JC-04)
BASF Wyandotte (1)	241-7
International Harvester (1)(5)	I.H. Antifreeze
Old World Trading Co. (1)	Full Force Advance
Northern Petro-Chemical (2)	All Weather (NPC 220)
Dow Chemical Canada(3)	731
Houston Chemical Corp. (4)	Security (701)

- (1) Generally available in U.S.A.  
 (2) Generally available within 750-mile radius of Chicago  
 (3) Generally available in Canada  
 (4) Generally available in northeastern U.S.A.  
 (5) I.H. antifreeze in Canada has high silicate content

## COOLANT FILTERS - GENERAL

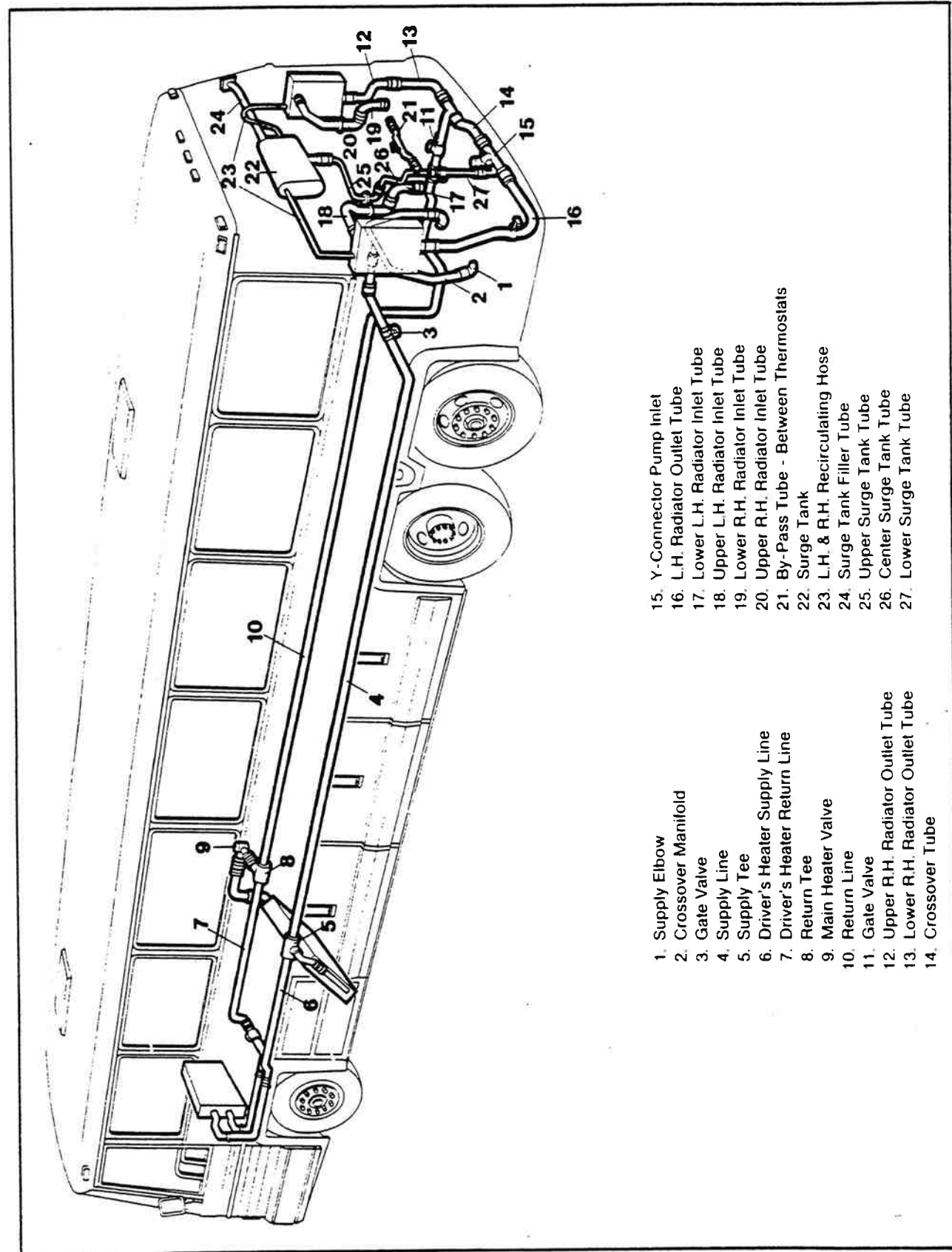
Replaceable elements are available with various chemical inhibitor systems. Compatibility of the element with other ingredients of the coolant solution cannot always be taken for granted.

Problems have developed from the use of the magnesium lower support plate used by some manufacturers in their coolant filters. The magnesium plate will be attacked by solutions which will not be detrimental to other metals in the cooling system. The dissolved magnesium will be deposited in the hottest zones of the engine where heat transfer is most critical. The use of an aluminum or zinc support plate in preference to magnesium is recommended to eliminate the potential of this type of deposit.

High chloride coolants will have a detrimental effect on the water-softening capabilities of systems using ion-exchange resins. Accumulations of calcium and magnesium ions removed from the coolant and held captive by the zeolite resin can be released into the coolant by a regenerative process caused by high chloride-content solutions.



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- |                                     |  |
|-------------------------------------|--|
| 1. Supply Elbow                     | 15. Y-Connector Pump Inlet             |
| 2. Crossover Manifold               | 16. L.H. Radiator Outlet Tube          |
| 3. Gate Valve                       | 17. Lower L.H. Radiator Inlet Tube     |
| 4. Supply Line                      | 18. Upper L.H. Radiator Inlet Tube     |
| 5. Supply Tee                       | 19. Lower R.H. Radiator Inlet Tube     |
| 6. Driver's Heater Supply Line      | 20. Upper R.H. Radiator Inlet Tube     |
| 7. Driver's Heater Return Line      | 21. By-Pass Tube - Between Thermostats |
| 8. Return Tee                       | 22. Surge Tank                         |
| 9. Main Heater Valve                | 23. L.H. & R.H. Recirculating Hose     |
| 10. Return Line                     | 24. Surge Tank Filler Tube             |
| 11. Gate Valve                      | 25. Upper Surge Tank Tube              |
| 12. Upper R.H. Radiator Outlet Tube | 26. Center Surge Tank Tube             |
| 13. Lower R.H. Radiator Outlet Tube | 27. Lower Surge Tank Tube              |
| 14. Crossover Tube                  |  |

Figure 6-5. Coach Cooling System.

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## RAINING COOLING SYSTEM

The cooling system may be completely or partially drained by using the following procedures.

**CAUTION:** After draining the cooling system attach a suitable tag to the steering wheel indicating that the cooling system is dry.

To drain the entire system leave the two gate valves open and proceed with the following: (See figures 6-5, 6-6 and 6-7.)

1. Depress the vent button at the radiator filler cap.
2. Open the filler cap.
3. Remove the drain plug at the radiator return line tee, located below the engine water pump.
4. When the coolant has drained, open the bleeder valve on the driver's heater core.
5. Remove the drain plugs from the suction line, the engine oil cooler, and the air compressor.

To drain only the engine and related components, close the two gate valves and proceed as follows:

1. Depress the vent button on the radiator filler cap.
2. Open the radiator filler cap to allow air into the system as the coolant drains.
3. Remove the drain plug at the radiator return line tee, located below the water pump.

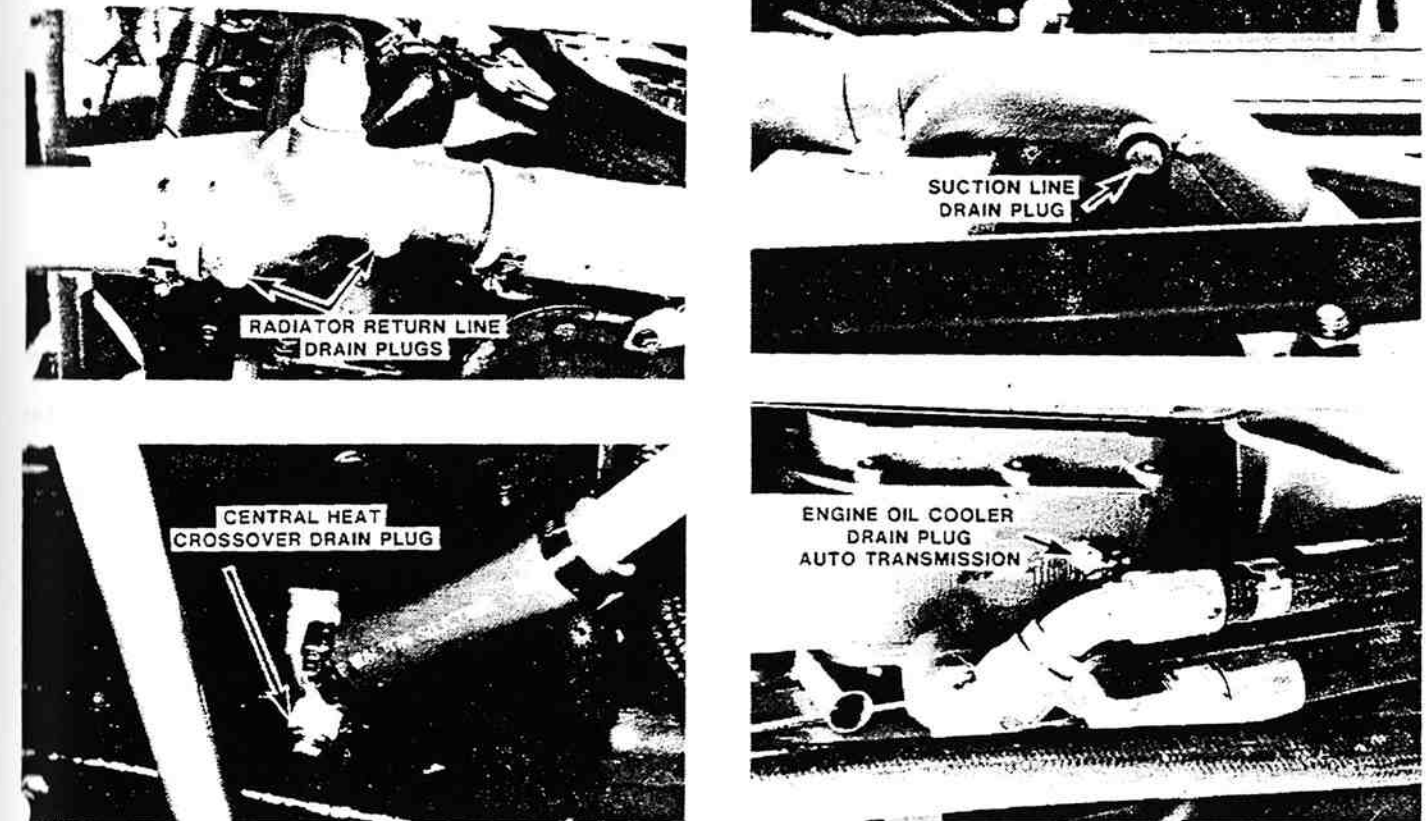


Figure 6-6. Drain Plugs and Coolant Filter.

4. Remove the drain plugs from the central heat crossover line, or on coaches equipped with a coolant filter, open the drain cock on the filter.

5. Remove the drain plugs from the suction line, the engine oil cooler, and the air compressor.

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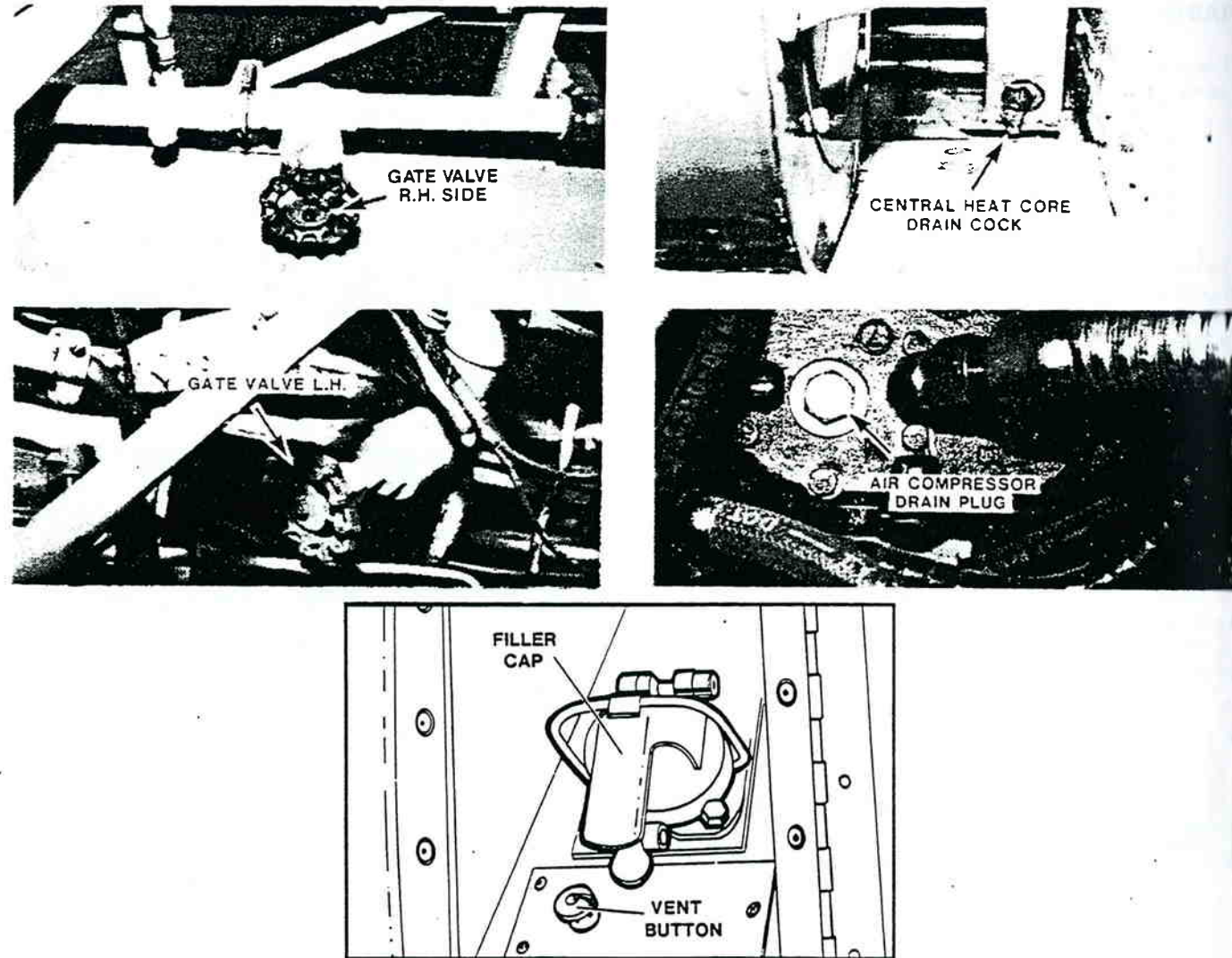


Figure 6-7. Cooling System Drains and Valves.

## REFILLING COOLING SYSTEM

To fill the system, close all drain plugs and cocks, open the gate valves and fill the system halfway with a 50-50 mixture of water and ethylene glycol antifreeze. Start the engine and fill the system completely. The cooling system is completely filled when coolant shows approximately halfway up in the surge tank sight glass. See figure 6-8.

When the cooling system is filled to capacity with cold coolant solution, expansion of the coolant takes place as it heats up. During this initial warm-up period it is possible to lose as much as a gallon and a half of coolant. No further coolant loss should be experienced after this period.

**CAUTION: Never pour cold coolant into a hot engine. The sudden change in temperature may crack the cylinder head or block.**

## COOLANT FILTER

A spin-on coolant filter is available as optional equipment. The filter can be reached through the right hand side engine compartment service door

The element should be replaced every 500 hours, or 20,000 miles (32,000 km). MCI/TMC recommend the use of Perry Filter PFC-22B (MCI/TMC P.N. 6F-8-131) replacement element.

To remove the filter element, close the two shut-off cocks at the filter mounting head and remove the old element.

Clean the area around the mounting head and install the



Figure 6-8. Surge Tank Sight Gauge.

replacement element. Be sure to follow the manufacturer's instructions when installing a new element.

Open the two shut-off cocks at the filter.

For the location of main cooling system components, refer to figure 6-9.

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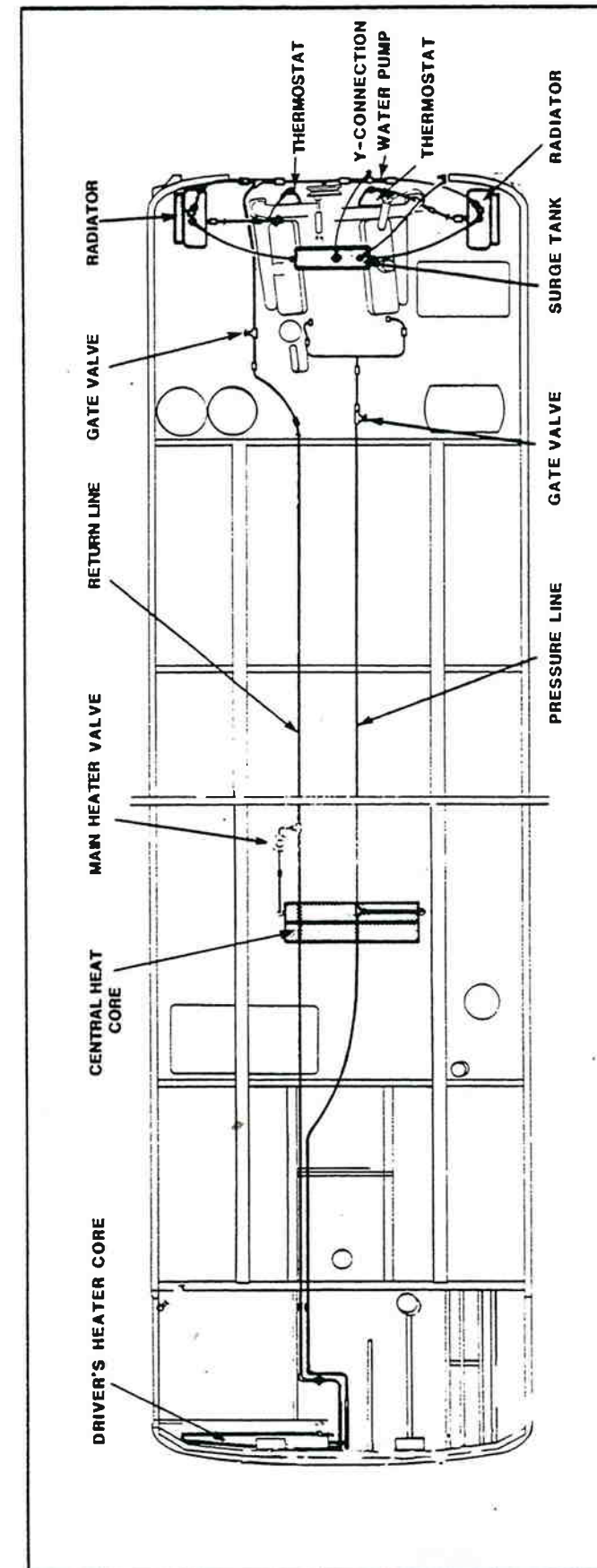


Figure 6-9. Cooling System Component Locations.



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## COOLANT RECOVERY SYSTEM (OPTION)

The automatic coolant recovery system limits the loss of overflow coolant. This is accomplished by a coolant recovery tank with a capacity of six U.S. gallons (22.7 liters). The system also includes a coolant pump with electrical controls (figure 6-10), a tell-tale light on the dash, and a tell-tale light and test switch on the remote control box in the engine compartment. Low coolant sensors in the surge tank are also used, in conjunction with the automatic pump controls.

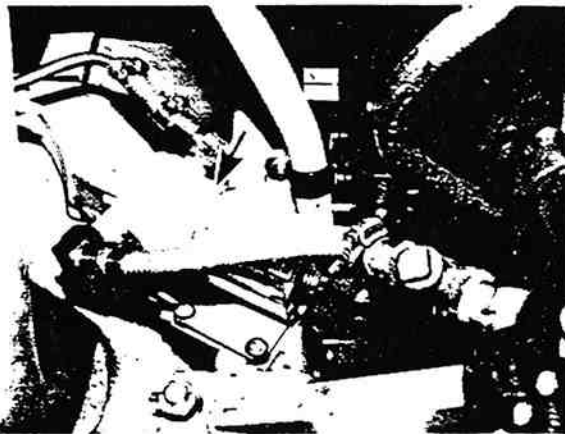


Figure 6-10. Coolant Recovery System Pump.

### OPERATION

When the battery switch is ON and the coolant in the surge tank falls below a certain level, the coolant sensors activate the pump and tell-tale lights. When activated, the pump automatically fills the cooling system from the recovery tank, and shuts off when the system is full. The pump will not operate when the recovery tank is empty.

Filling the cooling system is accomplished through the recovery tank. See figure 6-11. This eliminates the danger of hot, pressurized coolant as the recovery tank is not pressurized. Procedures for draining and filling the cooling system are detailed earlier in this section.



Figure 6-11. Coolant Fill Cap.

### MAINTENANCE

At regular service intervals the operation of the tell-tale lights and pump should be checked.

Push the Fill Bulb Test switch on the remote control box to the BULB TEST position and ensure that both tell-tale lights illuminate.

To check the pump, push the switch to the FILL position and ensure that the pump operates.

During normal coach operation, if the tell-tale lights are on and the pump is not running, the coolant level in the recovery tank is low and should be replenished.

### DRAINING

To drain only the engine and related components close the two gate valves and proceed as follows:

1. Turn the battery switch ON.
2. Remove the drain plugs at the radiator return line tee, located below the engine water pump.
3. As the coolant drains below the sensor in the surge tank, the LOW WATER tell-tale on the remote control box will come on and the pump will start. When the recovery tank is drained, the pump will shut off.
4. Turn the battery switch OFF.
5. Remove the drain plug from the central heat crossover line, or on coaches equipped with a coolant filter, open the drain cock at the filter.
6. Remove the drain plugs from the suction line, the engine oil cooler, and the air compressor.

**NOTE:** Descriptions and locations of cooling system drain points were outlined previously in this section. See figures 6-6 and 6-7.

To drain the entire cooling system the gate valves should be left open and the bleeder valve on the driver's heater core should be opened after the coolant has drained.

**CAUTION:** After draining the cooling system attach a suitable tag to the steering wheel indicating that the cooling system is dry.

### REFILLING

On coaches equipped with the coolant recovery system, the cooling system filler tube is located below the remote control panel in the engine compartment. See figure 6-11.

To fill the system, close all drain cocks and plugs, ensure that the gate valves are open, if filling the entire system, and proceed as follows:

1. Turn the battery switch ON. The LOW WATER tell-tale light on the remote control box will come on. If it does not work, check the light using the Fill Bulb Test switch.
2. Add five gallons (18.9 liters) of coolant to the recovery tank. The pump will begin to operate, pumping coolant into the system.
3. Open the petcock on the water bypass tube between the engine thermostats. This will allow air to bleed as the system fills. When coolant begins to flow, close the petcock.
4. When the recovery tank has drained, the pump will shut off.

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## RADIATORS

Twin radiators are mounted at the rear corners of the coach (in engine compartment) at a height which minimizes the intake of dust and road dirt.

The radiators are designed to reduce the temperature of the coolant under all operating conditions. It is essential that the radiator cores be kept free from corrosion and debris at all times in conjunction with the regular maintenance of the other components of the cooling system.

Radiators with larger capacity are installed on those coaches with 8V-92TA engines. Refer to specifications at the end of this section for the capacities of the cooling system with standard or larger radiators, or with the coolant recovery system.

## RADIATOR SHUTTERS AND SHUTTERSTATS

An air-operated shutter assembly is provided on the intake side of each radiator core. Each shutter assembly is controlled by a separate air cylinder. See figure 6-13. The air supply to the cylinders is controlled by the shutterstat, which is mounted on the right-hand radiator inlet line.

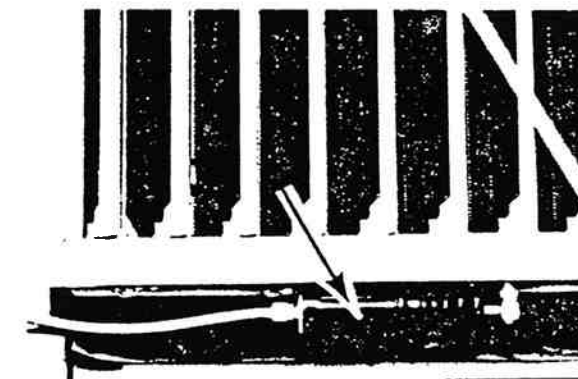


Figure 6-13. Shutter Air Cylinder.

The shutterstat controls the supply of compressed air to the radiator shutter air cylinders. It is mounted on the right-hand radiator inlet line and can be reached for service by opening the rear engine compartment service doors. Refer to figure 6-14.

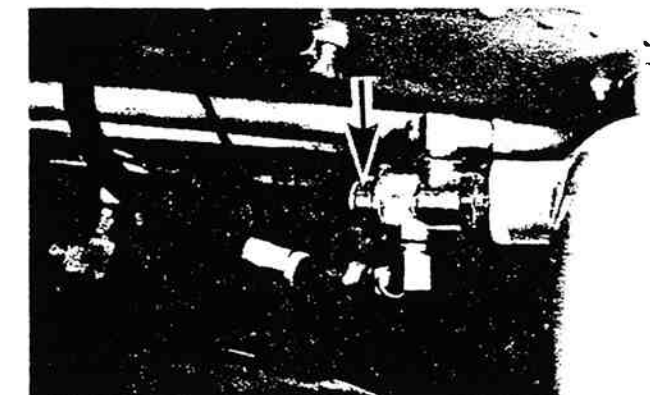


Figure 6-14. Shutterstat.

When the engine coolant reaches the temperature of the shutterstat setting, the shutterstat cuts off the air supply to the radiator shutter air cylinder, and the shutters open. When the coolant temperature is below the setting of the shutterstat, air is allowed to enter the radiator shutter air cylinders, closing the shutters.

5. Continue adding coolant to the recovery tank, five gallons (18.9 liters) at a time, until the pump and tell-tale light shut off. At this point the cooling system is full.

6. Fill the recovery tank until coolant is four to six inches (102-153 mm) from the top of the filler tube. This space will allow the coolant to expand as it warms up, without overflowing.

**CAUTION:** Never pour cold coolant into a hot engine. The sudden change in temperature may crack the cylinder head or block.

## WATER PUMP SEAL

Engines built prior to January 1987 have water pump seals made of a material which tends to harden at high temperatures. As of that date, Detroit Diesel changed the seal to one made of a material which performs better at high temperatures.

The water pump seal should be replaced after it has been in service for 200,000 miles or 6,000 hours.

## ALARMSTATS

Two alarmstats activate the warning light and buzzer that indicate engine overheating. See figure 6-12. Further information on the alarmstats can be found in Section 7 of this manual.

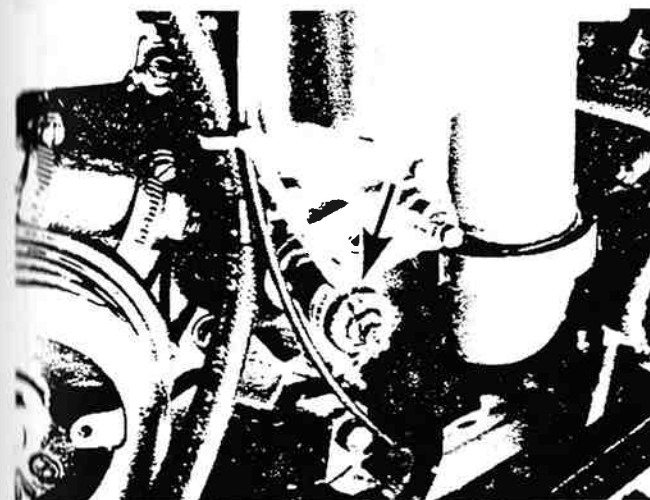


Figure 6-12. Left and Right Side Alarmstats.

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The only maintenance required for the shutterstat is to ensure that the air exhaust holes are kept free of dirt.

## SHUTTERSTAT REMOVAL

Before removing the shutterstat, it is necessary to drain the engine coolant. Refer to Draining Cooling System outlined previously in this section.

1. When the coolant has drained, disconnect the shutterstat air lines and plug or tape them to prevent contamination.
2. Unscrew and remove the shutterstat.
3. The shutterstat is non-serviceable; if it is found to be defective, it should be discarded and replaced.

After replacing the shutterstat, connect the air lines and refill the cooling system. Refer to Refilling Cooling System, outlined previously in this section.

## SHUTTERSTAT AIR FILTER

The shutterstat air filter is mounted on the inside vertical wall of the righthand radiator compartment floor pan (figure 6-15). The filter prevents moisture from entering the air operated components of the blower and shutter air system.

As air enters the filter it strikes the baffle, which diverts any moisture in the air stream to the bottom of the filter housing. The air then passes through two felt filtering elements before flowing to the shutterstat, blower belt adjusting air cylinder.

A periodic check should be made to ensure that there are no air leaks at the filter connections.

The air filter fluid chamber holds approximately one ounce (28 ml) of fluid. Part of the weekly maintenance procedure

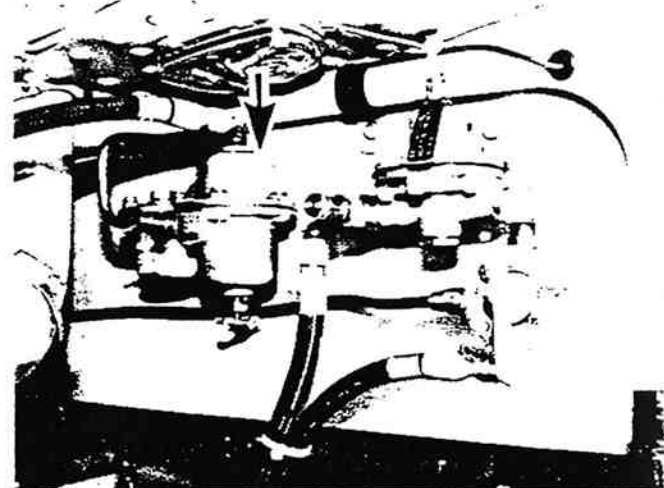


Figure 6-15. Shutterstat Air Filter.

should be to drain the filter by opening the draincock at the bottom of the filter body while the filter is under pressure. During cold weather operation, the filter should be drained daily.

At intervals of 3,000 miles (4,800 km) one ounce (28 ml) of Kysor Air Filter Fluid (P.N. 6-10-33) should be added to the filter. Remove the plug on the top of the filter body, add fluid and replace the plug.

At intervals of 10,000 miles (16,000 km) the air filter should be disassembled and the felts cleaned with commercial solvent or replaced. See figure 6-16. When reassembling the filter, use a new gasket.

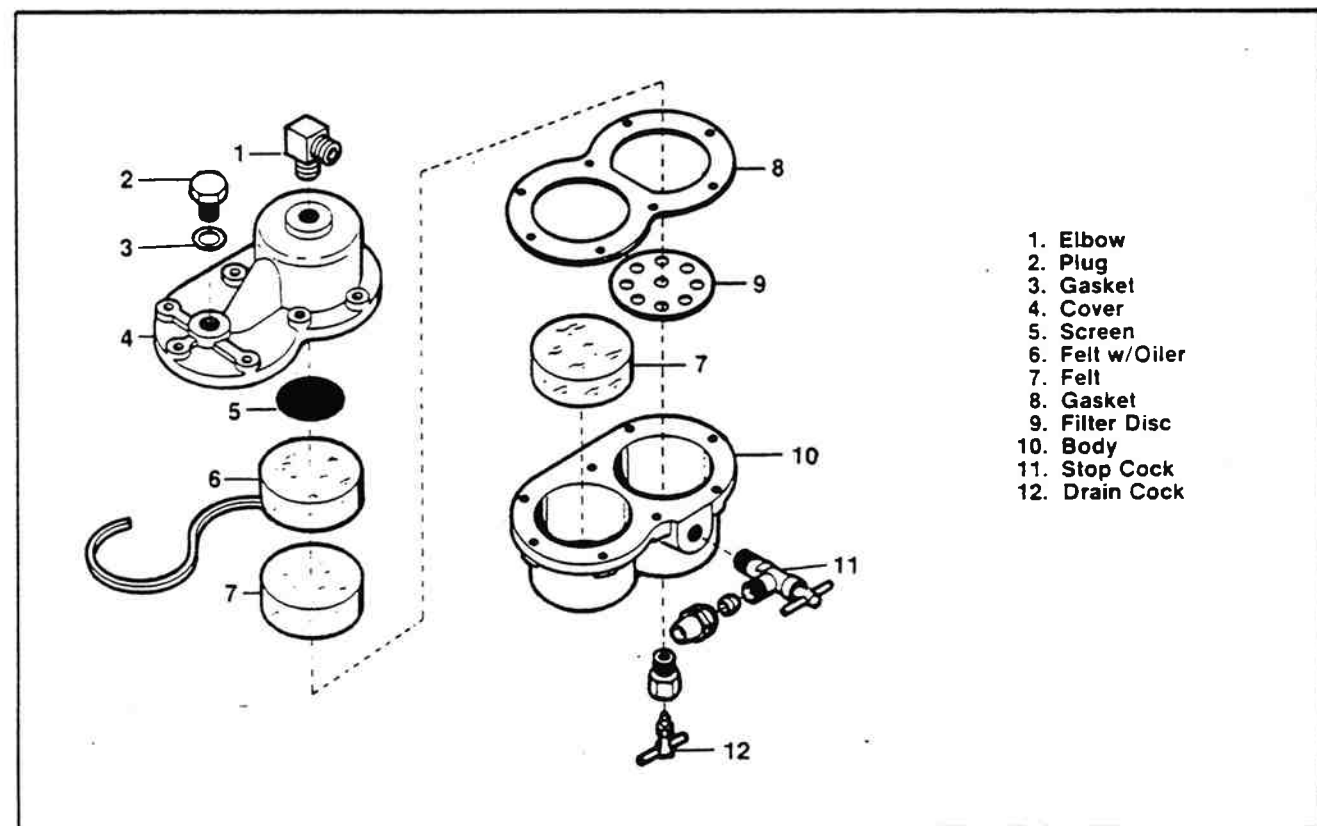


Figure 6-16. Shutterstat Air Filter Parts Breakdown.

1. Elbow
2. Plug
3. Gasket
4. Cover
5. Screen
6. Felt w/Oiler
7. Felt
8. Gasket
9. Filter Disc
10. Body
11. Stop Cock
12. Drain Cock

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## BLOWER GEAR BOX

The engine cooling blowers are located in a separate compartment above the engine. The blower wheels are mounted on a bevel gear box which is driven by means of a V-belt from the engine crankshaft. See figure 6-17. Outside air is drawn in through the radiators and discharged by the blower into the engine compartment.

Maintenance for the blower gear box is minimal; it contains its own oil supply, and part of the daily maintenance procedures should be to inspect the oil level. The correct level is when oil is visible to the halfway point in the sight gauge. Add oil as required in accordance with Section 10 (Lubrication) of this manual.

Make a periodic check of the sealed areas of the gear box to ensure that there is no oil leakage. If any leakage is detected, replace the defective seals or gaskets.

The blower wheels should be checked to ensure that they are tight on the shafts. If necessary tighten the retaining nut until at least one shaft thread is visible through the nut.

The blower wheels are dynamically balanced and care should be taken to prevent the blades from being bent. Any accumulations of grease or dirt, which may cause the wheels to become unbalanced, should be removed.

**CAUTION: Never leave loose objects such as towels or rags in the blower compartment as they may be sucked into the blower wheels causing excessive vibration and ultimate failure.**

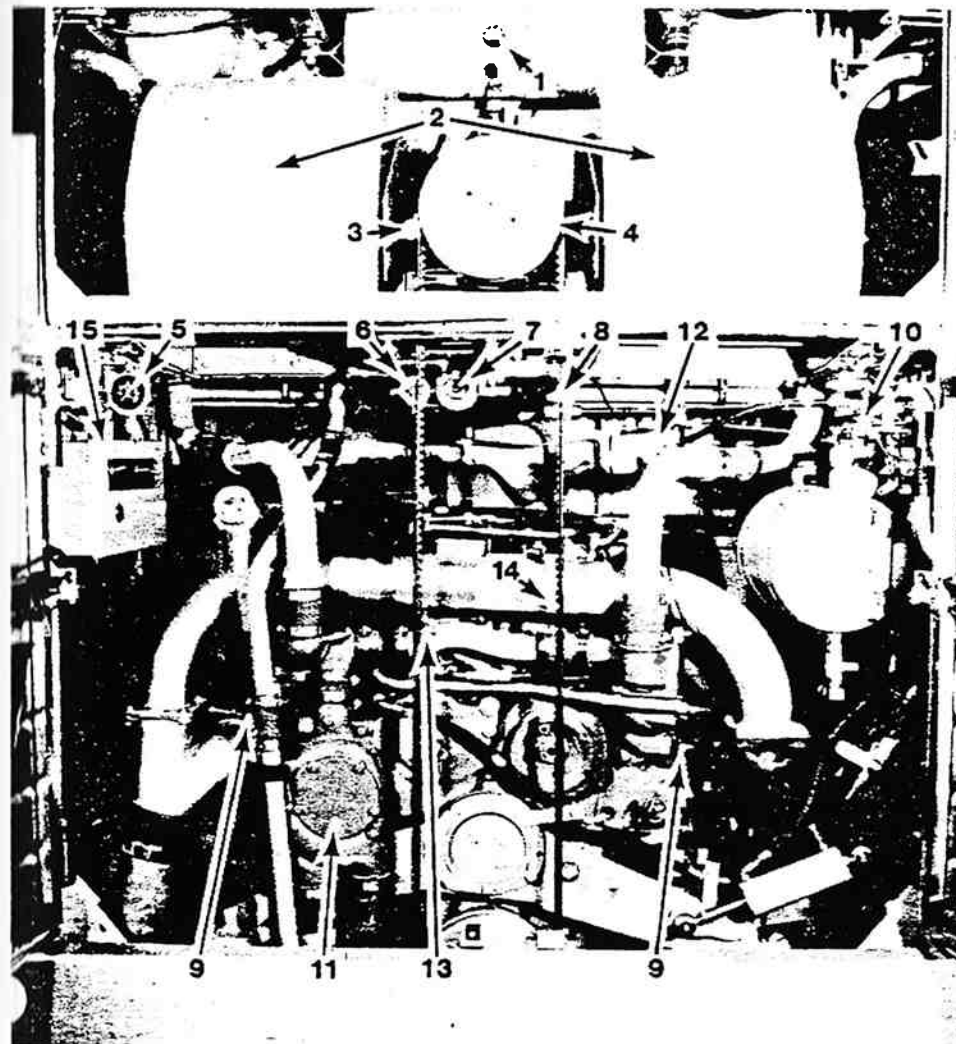


Figure 6-17. Cooling System Components in Engine Compartment.

1. Surge Tank Sight Glass
2. Blower Housings
3. Blower Gear Box Sight Glass
4. Blower Gear Box Pulley
5. Temperature Gauge
6. 2-Way Air Control Valve
7. Blower Belt Cylinder Pressure Regulating Valve
8. Blower Belt Adjusting Air Cylinder
9. Alarmstats
10. Shutterstat Air Filter
11. Engine Water Pump
12. Shutterstat
13. Coolant Bypass Petcock Between Thermostats
14. Blower Gear Box Drive Belt
15. Remote Control Box



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## REMOVAL

The blower gear box and blowers may be removed through the blower compartment door. Remove the drive belt, as outlined under Blower Belt Air Cylinder - Removal, and proceed as follows:

1. Remove the capscrews that secure the blower housings to the blower compartment floor.
2. Remove the capscrews that secure the blower gear box to the blower saddle.

**NOTE: Two shims are used to align the gear box. When removing the gear box and blower housings, take care not to lose the shims.**

3. Remove the gear box and blower housing assembly.

## INSTALLATION OF BLOWER GEAR BOX RUBBER MOUNTS

To properly insert the blower gear box rubber mounts into the blower saddle, only water should be used as a lubricant. Insertion of the rubber mounts using glycerine, or any other lubricant, will result in the tail of the mounts flaring out causing the rubber to rupture.

Using water as a lubricant will allow the tail of the mount to go into compression when the assembly is drawn up tight, giving the proper displacement bulge around the entire rubber mount.

In no case should a lubricant be used which maintains lubricity after assembly and engine start-up.

## DISASSEMBLY

1. Remove four screws holding down top cover and remove cover and gasket.
2. Remove screws and output shaft covers.
3. Remove the capscrews that fasten the bearing carrier to the housing. The bearing carriers, input shaft, bearings and gears will then come out as a unit.

To disassemble input shaft assembly, remove retaining ring from the inner end at the bevel gear. Pull the gear from the shaft. The bearings and spacer can now be removed from the shaft. Using a soft mallet, tap the output shaft out of the housing. The tapered roller bearings and bevel gear will come out with the shaft. Pull or tap off the bearing cones, slide off the spacers and pull or press off the bevel gear.

Reassembly is the reverse of disassembly. When cover gasket is not available, seal the cover and body with Permatex Silicone Sealant.

## REPAIR AND ASSEMBLY

The gears are only supplied in matched, honed sets and must be installed so that the timing marks on the back of the gears are aligned properly.

The back edges of the miter gears must be flush when installed. This can be accomplished by using the proper number of brass shim gaskets under the output shaft bearing caps. Refer to figures 6-19 and 6-20.

The tapered roller bearings must be adjusted by means of brass shim washers so that there is no perceptible play or clearance in them.

Backlash of the spiral bevel gears is also controlled by the use of brass shims between the bearing carrier and the main housing; .003 to .004" (.076 - .101 mm) clearance + .002" (.050 mm) is recommended between gear teeth.

Care must be exercised when installing the shaft seals over the sharp keyways in the shafts. To avoid nicking the inner sealing lip, a thin tapered bushing should be made up to facilitate entry of the shaft in the seal and protect the seal while it is being slid over the keyways.

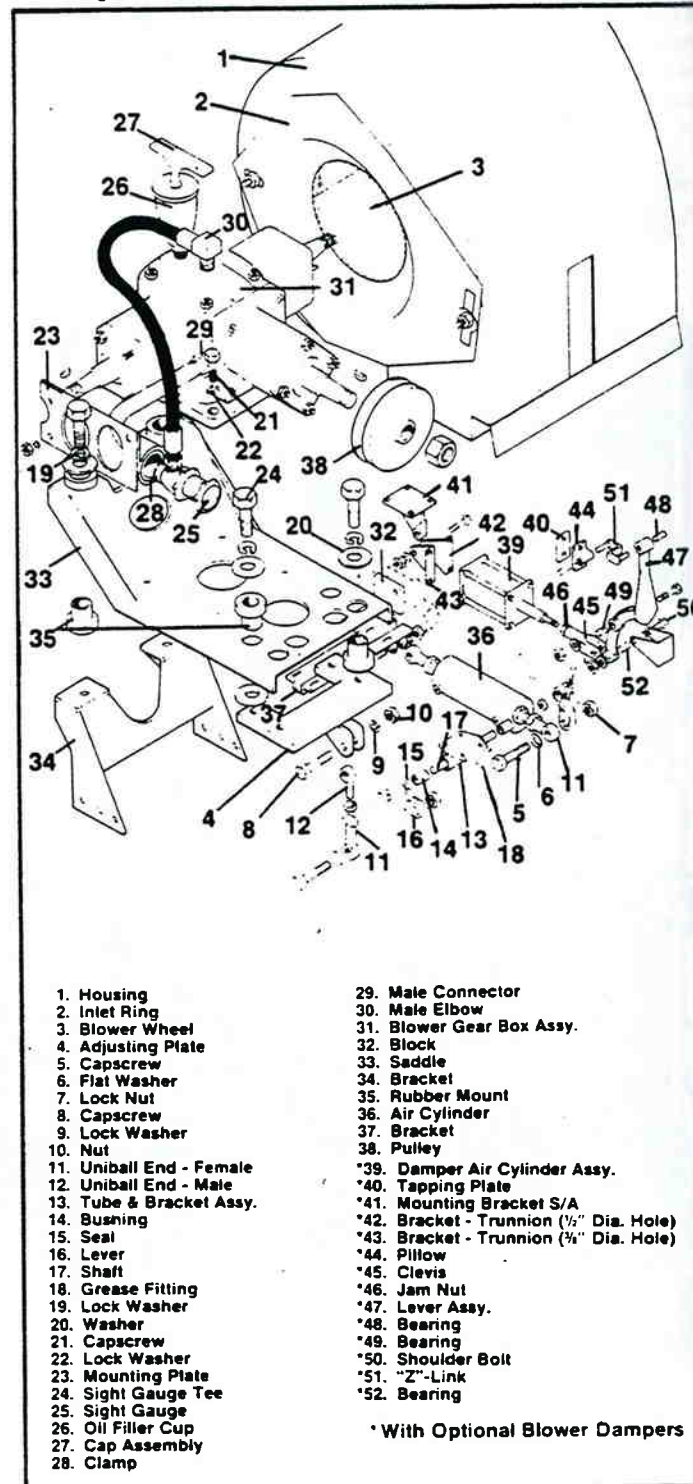


Figure 6-19. Blower Gear Box and Air Cylinder Linkage.

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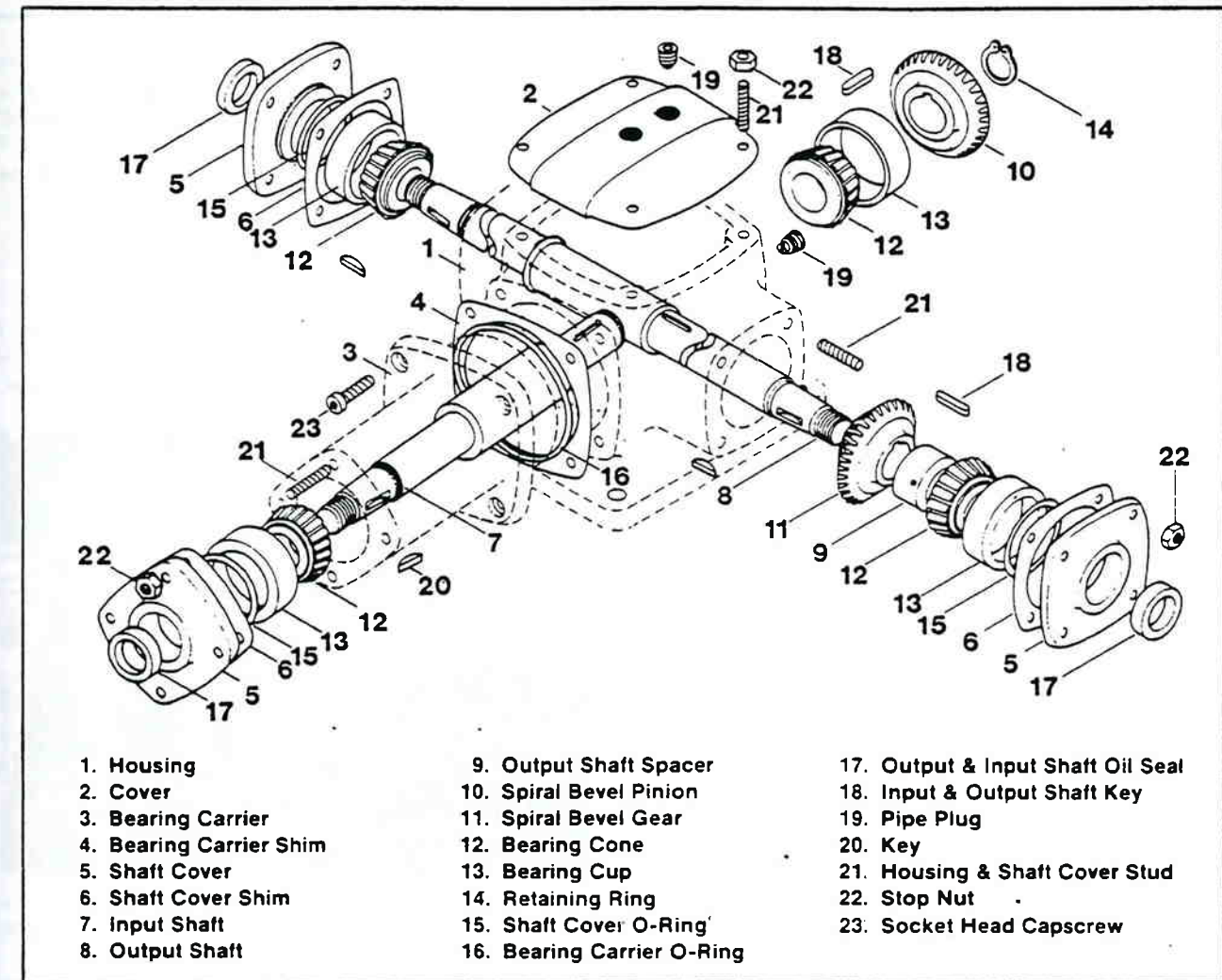


Figure 6-20. Blower Gear Box Component Parts.

## BLOWER BELT AIR CYLINDER

An air operated blower belt adjusting cylinder is installed to ensure the correct tension on the blower gear box drive belt. Access to the air cylinder can be gained through the rear engine compartment service doors. See figure 6-21.

## ADJUSTMENT

To maintain the correct tension on the blower belt, the air cylinder must be properly adjusted. With the air system under normal pressure and the pressure regulating valve set at 21 psi (144.8 kPa), the shaft length must be  $1\frac{1}{4} \pm \frac{1}{8}$ " (31.7 mm  $\pm$  3.1 mm), as shown in figure 6-21.

If the shaft is not within these tolerances, adjust the cylinder as follows:

1. Loosen the jam nut on the shaft end of the cylinder.
2. Rotate the shaft to attain the specified length
3. Tighten the jam nut.

## NEW BELTS

When a new blower drive belt is installed, it may be difficult to

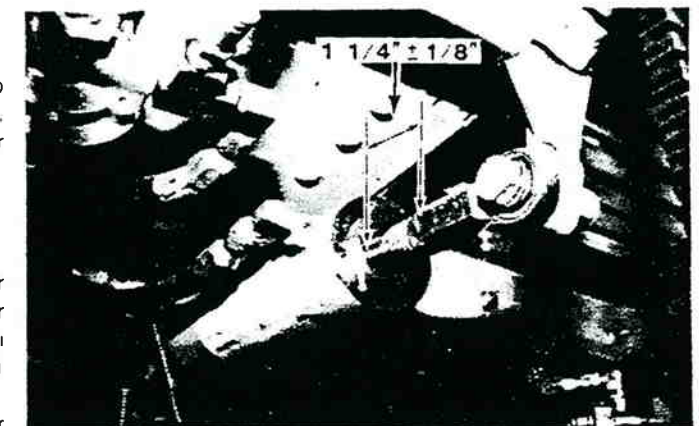


Figure 6-21. Belt Air Cylinder Adjustment.

attain the specified shaft length on the air cylinder. The drive belt stretches with normal wear, and after approximately 500 miles (800 km) the shaft length should return to  $1\frac{1}{4} \pm \frac{1}{8}$ " (31.7 mm  $\pm$  3.1 mm).

At the end of this run-in period the shaft length should be checked and, if necessary, adjusted.



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## MAINTENANCE

It is recommended that the blower belt tension air cylinder be lubricated at regular intervals, approximately every 30,000 miles (48,000 km).

The recommended procedure is as follows:

Remove air feed hose from cylinder and apply a few drops of SAE 30 or 40 engine oil into cylinder hose connector. Reconnect the hose, then reverse the air supply to the cylinder; this will lubricate the other end of the cylinder. Check cylinder for air leaks.

When overhauling cylinder, it is very important to replace all seals, felts, cups and O-rings with new parts for proper operation.

**NOTE:** When overhauling cylinder new parts should be coated with oil before assembly.

## REMOVAL

1. Shut off the air supply to the cylinder by turning the two-way control valve handle (figure 6-22). This will compress the cylinder spring and release the tension on the blower drive belt.
2. Remove the blower drive belt.
3. Remove the capscrew and lock nut that connects the air cylinder rod end to the cross shaft assembly.

**NOTE:** When removing the capscrew from the rod end, it may be necessary to adjust the two-way control valve in order to relieve the pressure on the capscrew.

4. Close the shut-off cock on the shutterstat air filter. This will prevent excessive loss of air when the cylinder is removed.
5. Disconnect the two hoses from the air cylinder.
6. Remove the capscrew and nut from the far end of the cylinder and remove the cylinder from the coach.

**WARNING:** Do not attempt to disassemble the air cylinder while it is in the coach.

## DISASSEMBLY

1. Remove the two rods ends and studs from the cylinder. See figure 6-23.

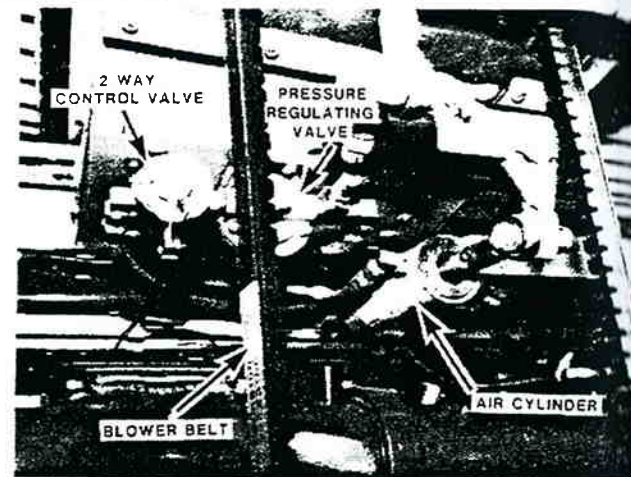
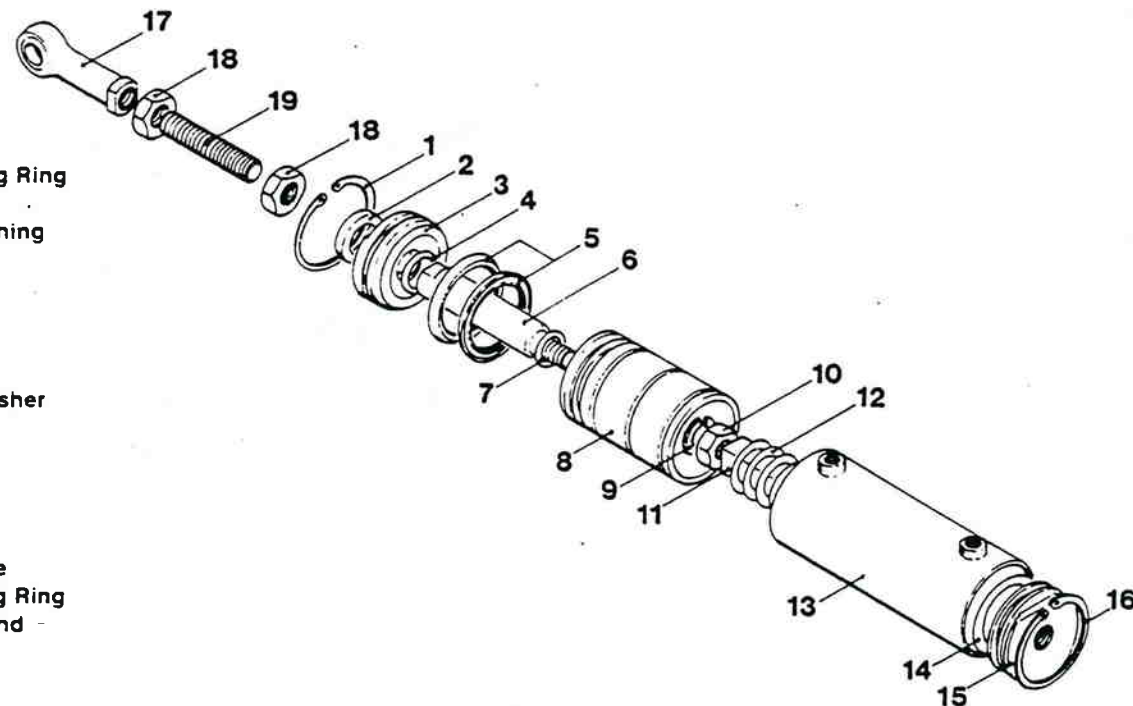


Figure 6-22. Blower Belt Air Cylinder.



1. Retaining Ring
2. Seal
3. End Bushing
4. O-Ring
5. Packing
6. Shaft
7. O-Ring
8. Piston
9. Lock Washer
10. Nut
11. Felt
12. Spring
13. Body
14. O-Ring
15. End Plate
16. Retaining Ring
17. Unibal End
18. Jam Nut
19. Stud

Figure 6-23. Blower Belt Air Cylinder Parts Diagram.

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2. Place the cylinder on the bed of an arbor press, with the piston rod up.
3. Slowly bring the ram of the arbor press down on the piston rod. Depress the piston rod approximately 1/2" (12.7 mm) to relieve the spring pressure on the cylinder end plate.

**NOTE:** Before continuing, lock the arbor press in position or have an assistant maintain the arbor pressure on the piston rod.

4. Release the retaining ring from the cylinder groove using a pair of retaining ring pliers and, if necessary, a small screwdriver.

**WARNING:** The air cylinder end plate is under 50-60 lbs. (22.6-27.2 kg) of internal spring pressure. To avoid personal injury, exercise extreme caution during the disassembly of the cylinder.

5. Slowly release the arbor pressure from the piston rod. This will allow the removal of the cylinder end plate from the cylinder.
6. Once the end plate has been removed, the other internal components of the cylinder may be removed for cleaning and inspection.

## INSPECTION

1. Inspect all O-rings, packings, felts and seals.
2. Inspect the cylinder bore and piston for scoring.
3. Inspect the retaining rings and ensure that they are not bent or otherwise damaged. Replace any parts that are damaged.
4. Check the spring tension to ensure that it is within the tolerances listed under Specifications at the end of this section. If the spring does not meet the specifications, it should be replaced.

## REASSEMBLY

Coat all new parts with SAE 30 or 40 engine oil prior to assembly. Reassemble the internal components in the reverse order of disassembly, and proceed as follows:

1. Place the cylinder on the bed of the arbor press with the piston rod up.
2. Slowly bring the ram of the arbor press down on the piston rod.

**WARNING:** Before applying any force on the piston rod, ensure that the cylinder is firmly positioned on the press. Failure to do so may allow the cylinder to slip from the press.

3. Depress the piston rod until the end plate is approximately 1/16" (1.5 mm) beyond the retaining ring groove. Take care not to damage the oil seal.

**NOTE:** Before continuing, lock the arbor press in position or have an assistant maintain the pressure on the piston rod.

4. Install the retaining ring in the groove. Ensure that it is completely in the groove before removing the cylinder from the press.

## INSTALLATION

1. Install the studs, jam nuts, and rod ends onto the ends of the cylinder.
2. Using the capscrew and nut, connect the rod end, opposite the piston rod, to the lower gear box adjusting bracket.
3. Connect the hoses to the air cylinder.
4. Using the capscrew and nut, connect the rod end, on the piston rod end of the cylinder, to the cross shaft assembly.

**NOTE:** When inserting the capscrew through the rod end, it may be necessary to adjust the two-way control valve to provide the necessary freeplay for installation.

5. Install the blower drive belt.
6. Turn the two-way control valve ON.

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## BLOWER DAMPERS - OPTIONAL

Each blower assembly is provided with an air-operated damper which operates in conjunction with the radiator shutters to prevent the flow of air during engine warm-up. The dampers are located in the outlet ducts of the blowers.

Blower damper linkage adjustment should not be necessary unless the original adjustment is disturbed in disassembly. If an adjustment is to be made, the following method should be followed:

1. Disconnect the air cylinder at damper control lever by removing the clevis pin.
2. Operate the air cylinder so that the ram is fully extended.
3. Hold the damper in the fully closed position, then adjust the clevis until clevis pin holes line up with clevis pin hole in the damper lever.

4. Reconnect the air cylinder to the damper control lever by inserting the clevis pin.

5. Operate the dampers several times to check opening and closing. If dampers are not closing properly, remove clevis pin and unscrew clevis 1/2 turn, reinstall clevis pin and check closing again; repeat as necessary 1/2 turn per time until dampers are closing with a slight pressure.

Worn linkage parts or air cylinders should be replaced.  
Lubricate at pivot points at regular chassis intervals with a rust-preventive oil.

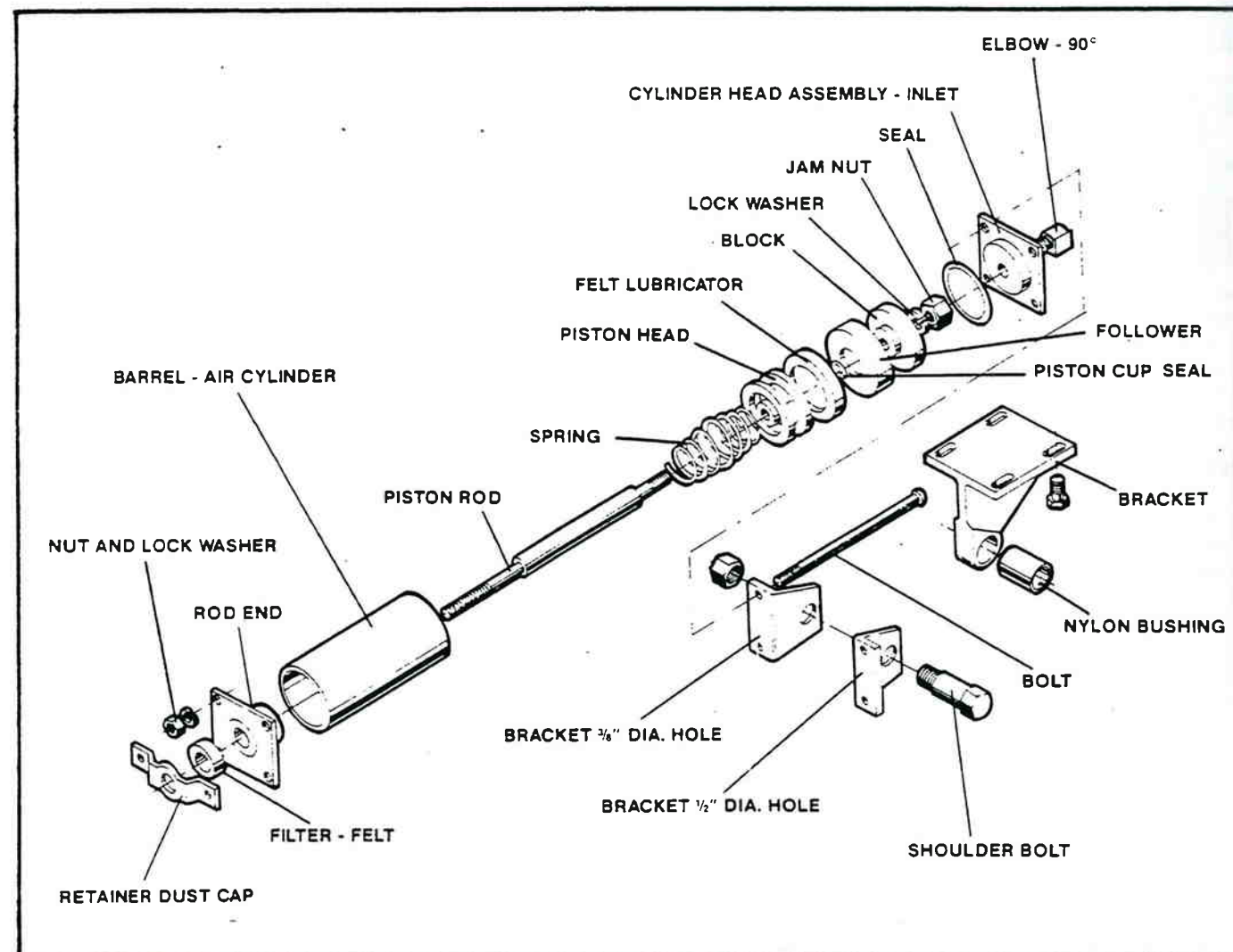


Figure 6-24. Blower Damper Air Cylinder.

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## SPECIFICATIONS

### COOLING SYSTEM CAPACITY WITH:

Standard Radiators	23 U.S. Gallons (87.0 liters)
Larger Radiators	24 U.S. Gallons (92.7 liters)
Coolant Recovery System and Standard Radiators	29 U.S. Gallons (109.7 liters)
Coolant Recovery System and Larger Radiators	30 U.S. Gallons (115.4 liters)

### THERMOSTAT

Quantity	2
Start to Open	180°F (82°C)
Fully Open	195°F (91°C)

### RADIATORS

Manufacturer	Young
Quantity	2
Type	Fin & Tube
Location	Rear, Sides of Coach

### BLOWERS

Gear Box Ratio	1:1
Gears	Spiral Bevel
Bearings	Tapered Roller
Gear Backlash	.003" - .004" (.076 mm - .101 mm)
Backlash Adjustment	Shims
Number of Fan Blades	36
Diameter	11 3/4" (29.8 cm)
Rotation	LH - Clockwise, RH - Counterclockwise
Blower to Housing Side Clearance	1/4" (6.3 mm)
Blower Circumference to Housing Clearance	1 1/8" (28.5 mm)

### SHUTTERSTAT

Manufacturer	Kysor
Shutterstat Needle Travel	.0045" - .005" (.1143 mm - .1270 mm)
Part Number	6G-10-2
Temperature Range	190°F (87°C)

### ALARMSTATS

Manufacturer	Kysor
Part Number	8G-28-7
Points Set to Close At	210°F (99°C)

### OR

Part Number	8G-28-8
Points Set to Close At	220°F (104°C)

### TEMPERATURE GAUGE (in engine compartment)

Manufacturer	Marsh
Part Number	8R-28-2
Operating Range	40° - 240°F (4° - 116°C)

### TEMPERATURE GAUGE (on instrument panel)

Manufacturer	Stewart Warner
Part Number (Domestic Readings)	7K-13-8
(Metric Readings)	7K-13-15
Operating Range	100° - 250°F (38° - 121°C)



