

Fans and Fan Shrouds

Excerpt from the Detroit Diesel Training Manual

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2. FAN RECOMMENDATIONS

Proper fan selection is necessary to insure maximum system efficiency. Parasitic fan losses should be kept to a minimum and should not exceed 6% of basic engine horsepower. The fan can be matched to the radiator by pre-determining the radiator air flow required and ascertaining the total static air pressure which the fan must overcome.

(a) FAN SELECTION

The air flow required to produce the desired amount of cooling in terms of air to water differential is determined by the heat to be dissipated and the coolant flow available. When selecting a fan, a good design point for air flow is characterized by the static pressure point "A" in Figure 22, page 37 which should be in the range of 1 1/2 to 2 inches of water. A small change in static pressure from this point does not mean a large change in air flow. A point which would fall in the shaded portion or stall area of the fan curve should be avoided because unstable flow characteristics occur as evidenced by the wide range of air flow for small changes in static pressure.

(b) FAN PERFORMANCE

Figure 22 on page 37 shows fan performance in the form of flow (CFM), static head (inches of water, gage) and horsepower. Most performance curves are drawn on the basis of theoretical output which is seldom achieved. An additional curve, probable air flow, is often shown also. This usually is 85% of the theoretical and refers to air flow (CFM) only. The theoretical output can be approached with a well formed, close fitting shroud. The fan must be properly located in the shroud and with no more than 1/16" tip clearance. Frequently a close fitting shroud is not practical to use and a compromise to a loose fitting box shroud must be made. Performance with the latter will be 85% of that of a tight fitting shroud.

The above mentioned fan curve also shows performance at various fan speeds. When information at other speeds is required it may be calculated using the standard fan performance laws where:

CFM varies directly with RPM,
Static head varies with RPM^2
Horsepower varies with RPM^3

Other factors influencing actual fan performance are air temperature, atmospheric pressure and humidity. While CFM is not greatly affected by air density it must be remembered that it is the air "mass" flowing across the core that does the cooling and when planning a system for very high altitude operation this factor must be taken into consideration.



DETROIT DIESEL ENGINE DIVISION

GENERAL MOTORS CORPORATION

BDC

RADIATOR - FAN MATCH

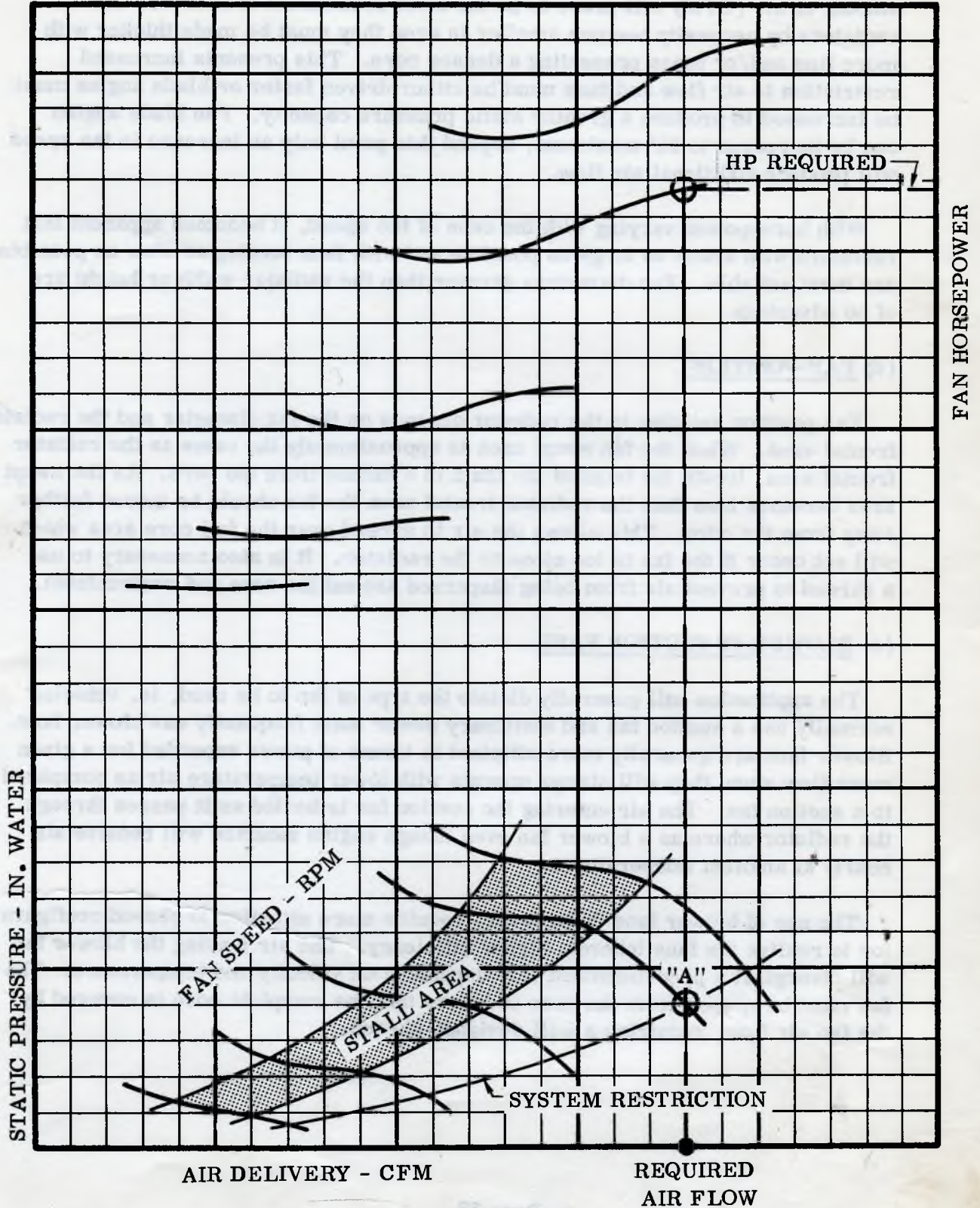


FIGURE 22



(c) FAN SIZE

A study of various fan sizes will indicate that for the most efficient installations the largest diameter fan turning at the lowest speed to deliver the desired amount of air (CFM) will prove to be the most economical to operate. As radiators by necessity become smaller in area they must be made thicker with more fins and/or tubes presenting a denser core. This presents increased restriction to air flow and fans must be either driven faster or blade angles must be increased to produce a greater static pressure capacity. Fan blade angles can be increased to 35° maximum, beyond this point only an increase in fan speed will produce additional air flow.

With horsepower varying with the cube of the speed, it becomes apparent that radiators with areas as large as possible and with fans turning as slow as possible are most suitable. Fan diameters greater than the radiator width or height are of no advantage.

(d) FAN POSITION

Fan position relative to the radiator depends on the fan diameter and the radiator frontal area. When the fan swept area is approximately the same as the radiator frontal area, locate the front of the fan 2 to 4 inches from the core. As the swept area becomes less than the radiator frontal area the fan should be moved further away from the core. This allows the air to spread over the full core area which will not occur if the fan is too close to the radiator. It is also necessary to use a shroud to prevent air from being dispersed around the core and recirculated.

(e) BLOWER VS SUCTION FANS

The application will generally dictate the type of fan to be used, ie. vehicles normally use a suction fan and stationary power units frequently use blower fans. Blower fans are generally more efficient in terms of power expended for a given mass flow since they will always operate with lower temperature air as compared to a suction fan. The air entering the suction fan is heated as it passes through the radiator where as a blower fan even though engine mounted will receive air nearly at ambient temperatures.

The use of blower fans do however, require more attention to shroud configuration to realize the fans inherent higher efficiency. The air leaving the blower fan will diverge at a predetermined rate depending on velocity and temperature. The fan must be spaced from the core to insure that the complete core is covered by the fan air flow, requiring a well designed shroud.

3. FAN SHROUDS

The use of a shroud is very important in achieving an efficient fan installation. A good shroud not only will increase air flow through more efficient usage of core area but will also eliminate recirculation of air.

The shroud attachment to the core must be air tight to prevent recirculation of the air around the radiator core. Radiator guards, grills and other obstructions to flow may also cause air to recirculate. Therefore, the pilot model should be tested to determine if recirculation exists and, if so, it should be corrected as necessary.

(a) TYPES OF SHROUDS

Basically there are three types of shrouds, the well rounded entrance venturi ring, a ring type and box type, see Figures 23, 24 and 25 respectively. The maximum air delivery is obtained with a close fitting, venturi type shroud. This should be used with a fixed fan position and an idler for belt adjustment or an adjustable shroud.

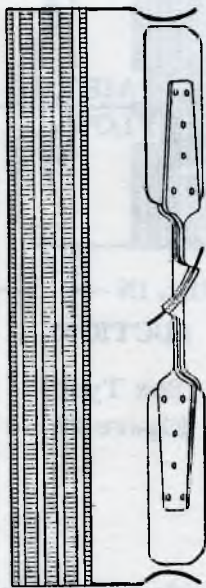


Figure 23

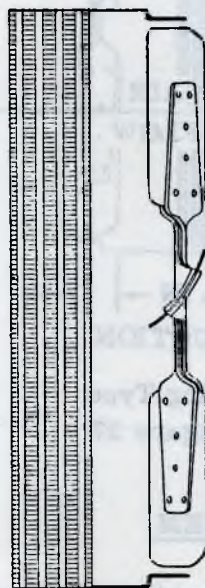


Figure 24

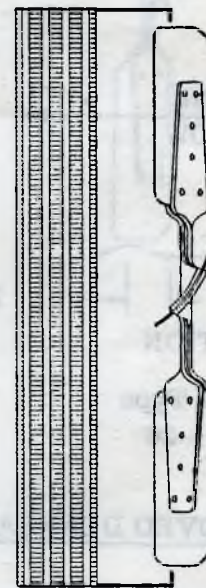
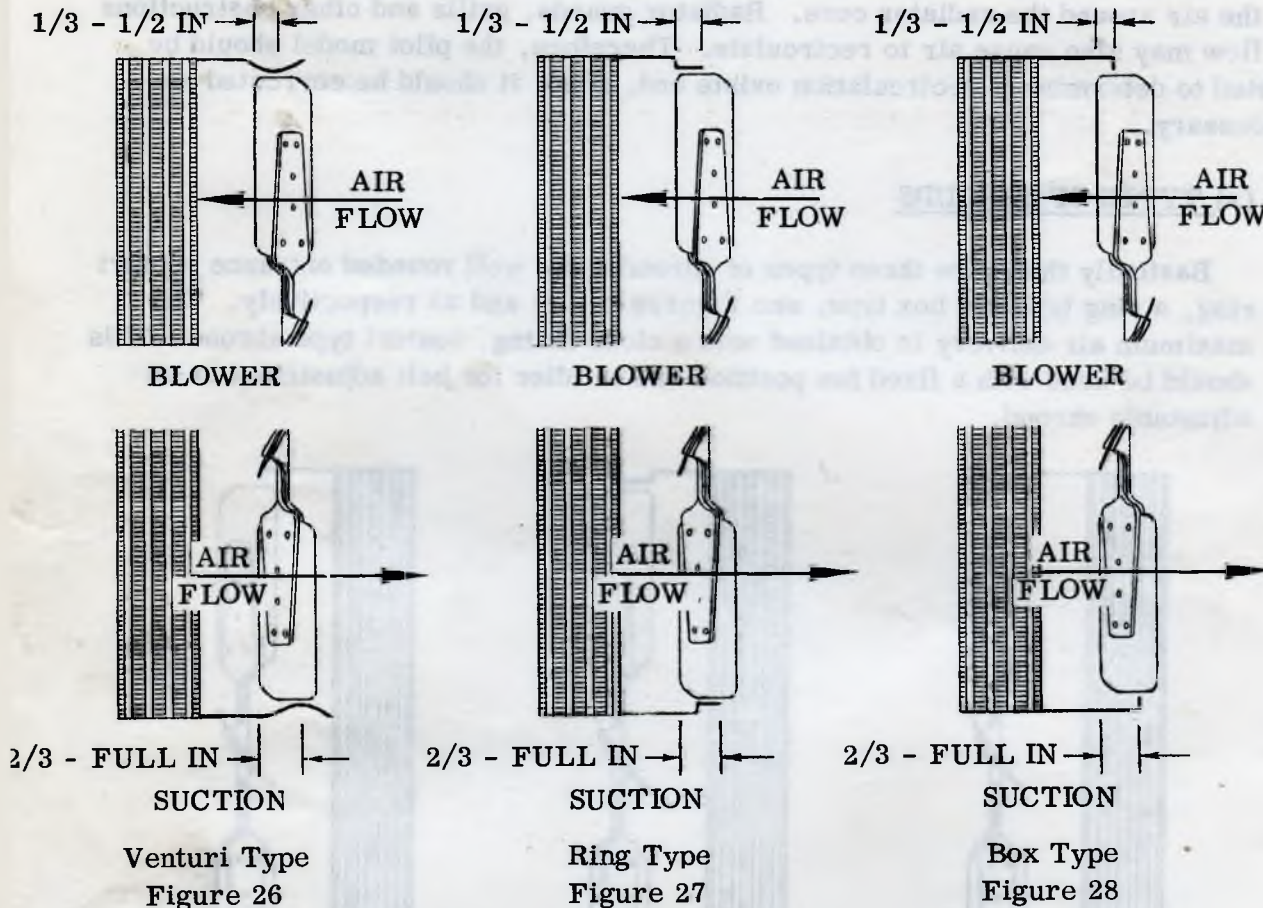


Figure 25

Ring or box type shrouds are most commonly used, but are not as efficient as the venturi type. The tip clearance reduces air flow significantly and should be kept down to a minimum of approximately 1/2 inch or less. Additional clearance must also be provided for fan belt adjustment.

(b) FAN-SHROUD POSITION

Figures 26, 27 and 28 show the generally recommended position of the suction or blower type fans with respect to the shroud. A suction fan extends 2/3 to full projected width into the shroud and a blower fan 1/3 to 1/2 the projected width into the shroud. These positions may vary depending upon air flow restriction.



4. IMPROVED DEAERATION SYSTEM

This system was developed for vehicle applications to provide better air handling ability and closer temperature control than the conventional system.

(a) CONVENTIONAL VS. IMPROVED DEAERATION SYSTEM

Figures 29 and 30 on page 42 show the closed and open thermostat coolant flow through the conventional cooling system. During closed thermostat operation, deaeration is necessary and is accomplished with bleed holes in the thermostat and thermostat housing. This can cause overcooling in low ambient temperature since there is some flow through the radiator at all times.



Figures 31 and 32 on page 43 show the closed and open thermostat coolant flow through the improved cooling system. This system permits coolant flow through the radiator only when the thermostats are open. The closed thermostat deaeration is accomplished through the deaeration line from the engine side of thermostat housing or by-pass side to the radiator top tank. The coolant is then returned to the engine through the supply line without passing through the radiator core and being cooled.

The improved system differs from the conventional system as follows:

Engine changes:

- (1) Eliminates thermostat bleed hole.
- (2) Eliminates holes in thermostat housings which vent coolant and air from the engine to the radiator.
- (3) Suitable engine connections for piping to and from separate surge tank or integral tank must be provided.

On systems with surge tanks, three fittings are required (See Figure 34):

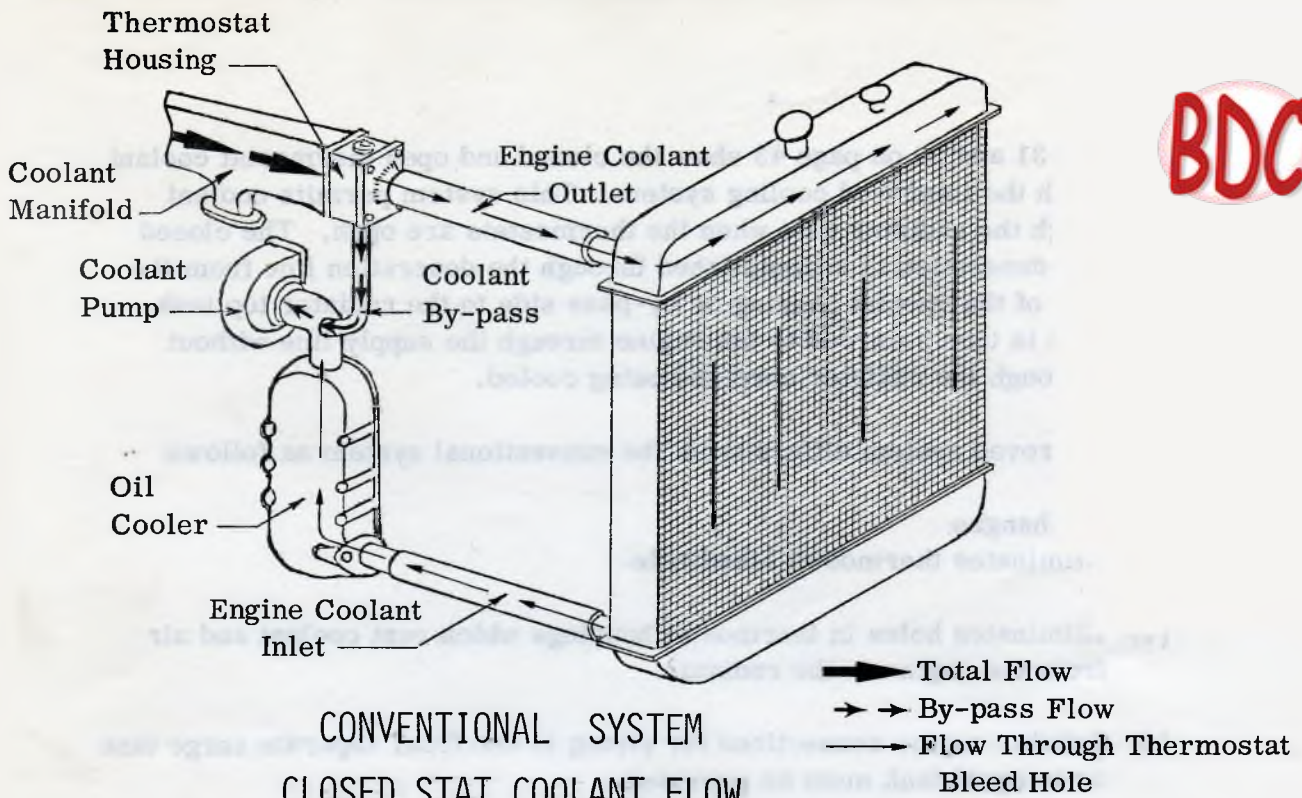
- (1) Low or bottom connection for a deaerating line from engine thermostat housing.
- (2) Bottom connection for a line to the suction side on the engine coolant pump.
- (3) Top connection for a line to the radiator top tank.

On systems with integral top tank (See Figure 33):

- (1) Low or bottom connection for a deaerating line from thermostat housing.
- (2) Bottom connection for a line to the suction side of the coolant pump.
- (3) A standpipe from baffle separating top tank and radiator to above top tank coolant level.

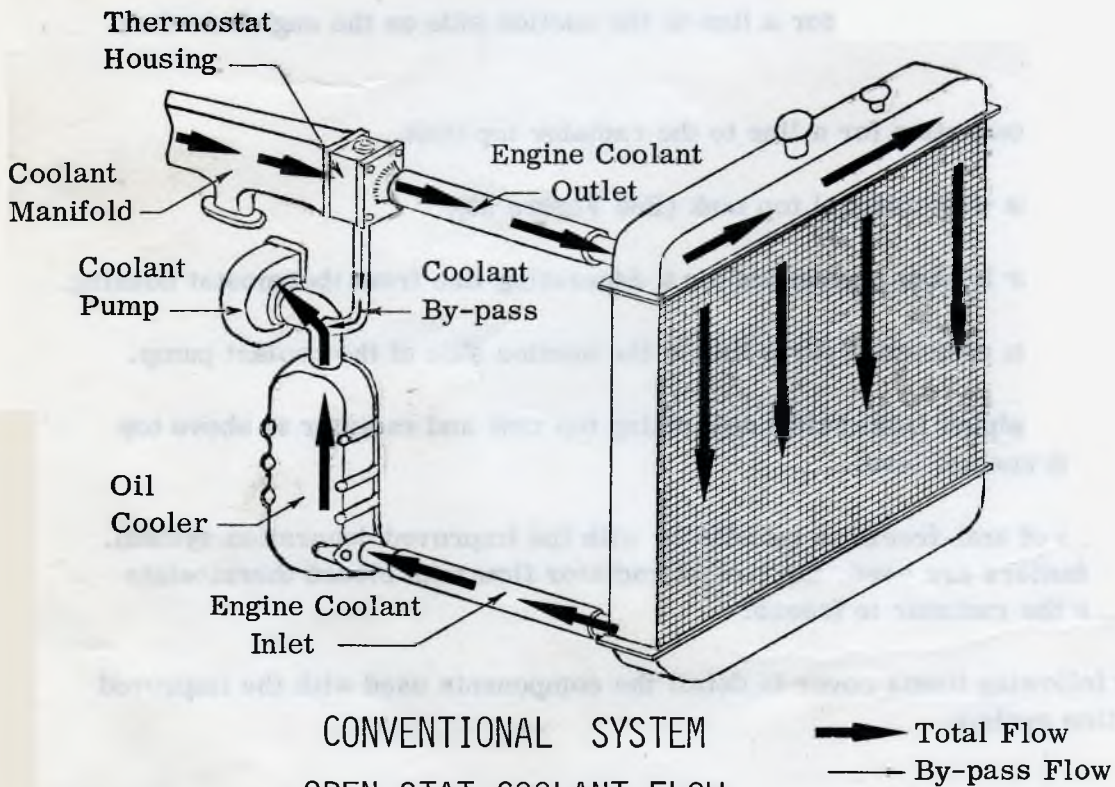
The use of anti-freeze is mandatory with the improved deaeration system. Even if shutters are used, the lack of radiator flow with closed thermostats will allow the radiator to freeze.

The following items cover in detail the components used with the improved deaeration system:



CONVENTIONAL SYSTEM
 CLOSED STAT COOLANT FLOW
 (NON-BLOCKING TYPE STAT)

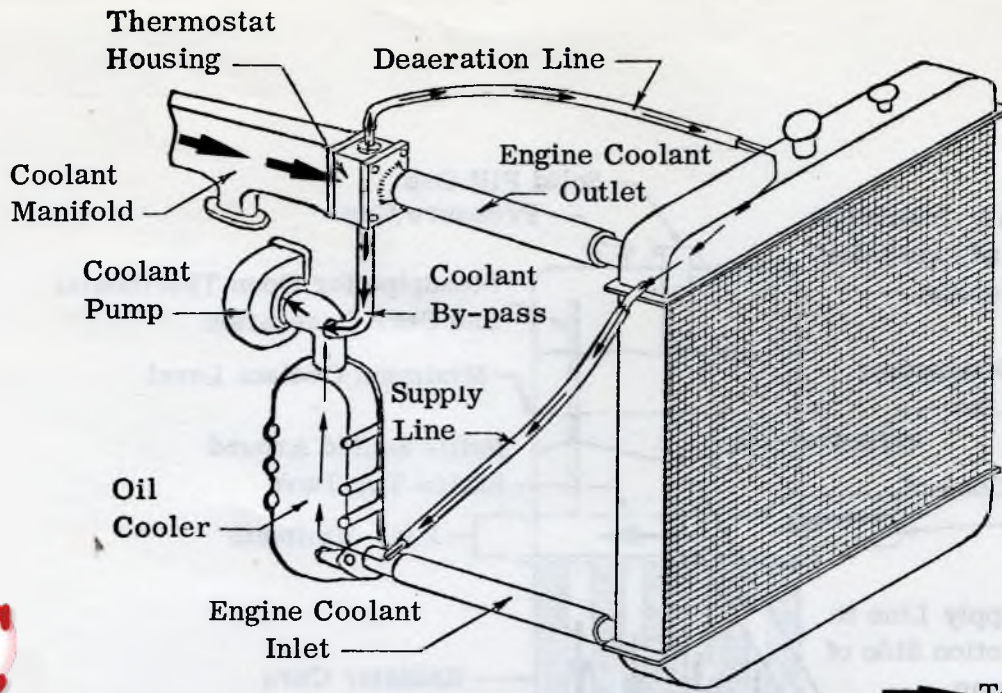
Figure 29






CONVENTIONAL SYSTEM
 OPEN STAT COOLANT FLOW
 (NON-BLOCKING TYPE STAT)

Figure 30
 Page 42

See Figure 33
Page 44 for Top
Tank Detail

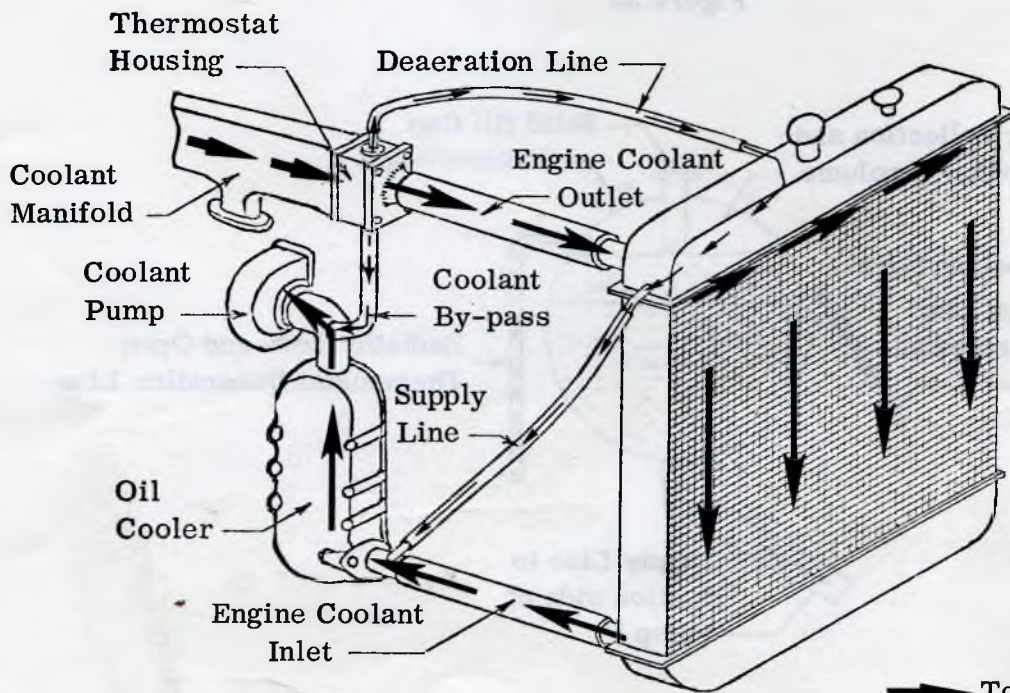






 Total Flow
 By-pass Flow
 Deaeration Flow

IMPROVED SYSTEM
CLOSED STAT COOLANT FLOW

(PARTIAL BLOCKING TYPE STAT)

Figure 31

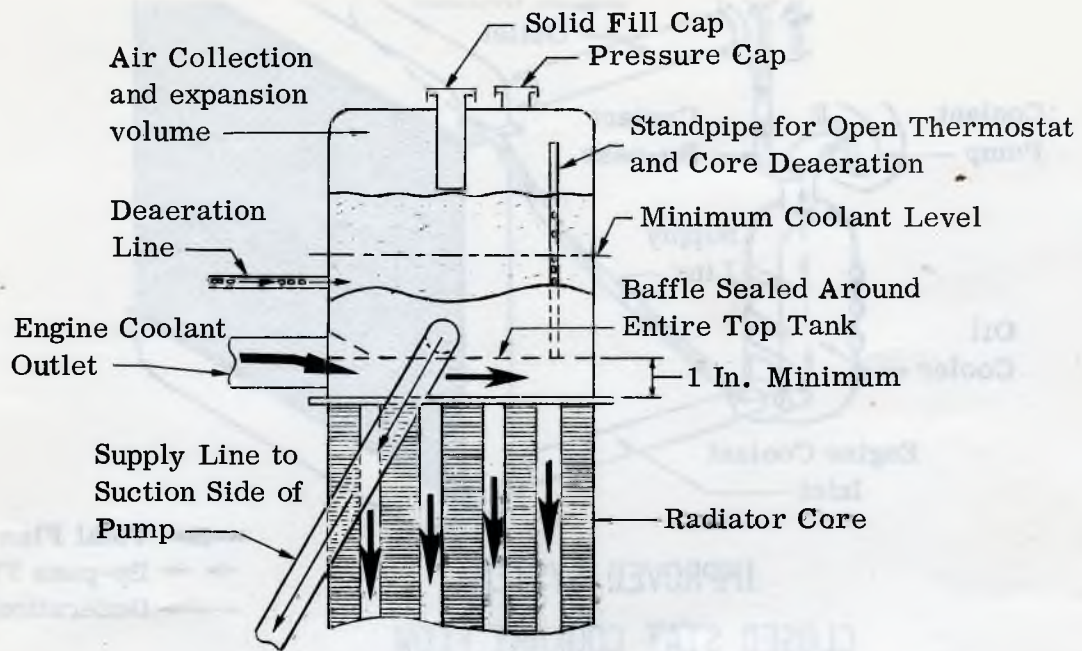


 Total Flow
 Radiator Flow
 By-pass Flow
 Deaeration Flow

IMPROVED SYSTEM
OPEN STAT COOLANT FLOW

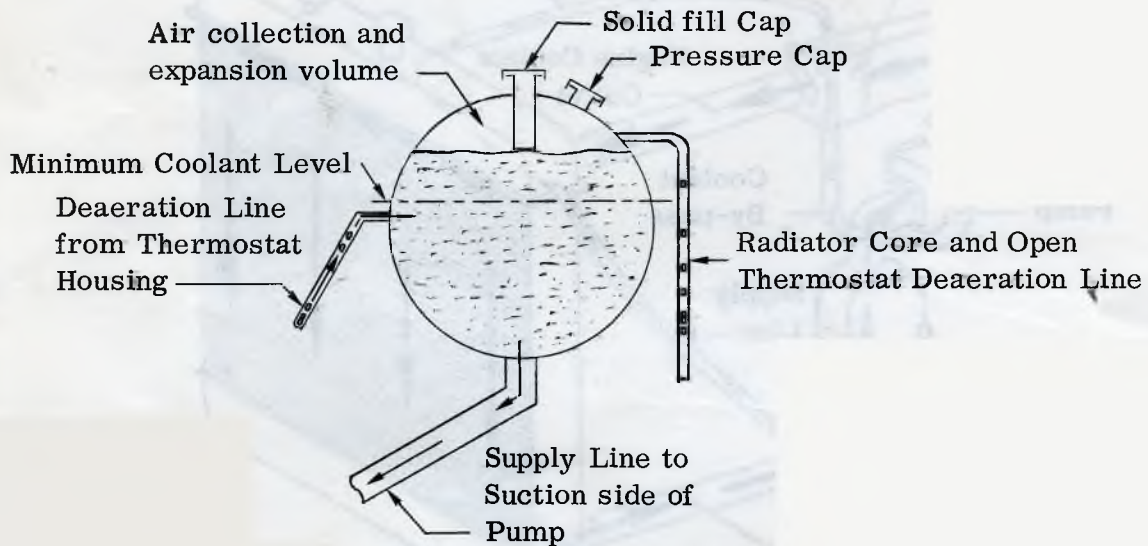
(PARTIAL BLOCKING TYPE STAT)

Figure 32



IMPROVED SYSTEM
RADIATOR TOP TANK

Figure 33



IMPROVED SYSTEM
SURGE TANK

Figure 34

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