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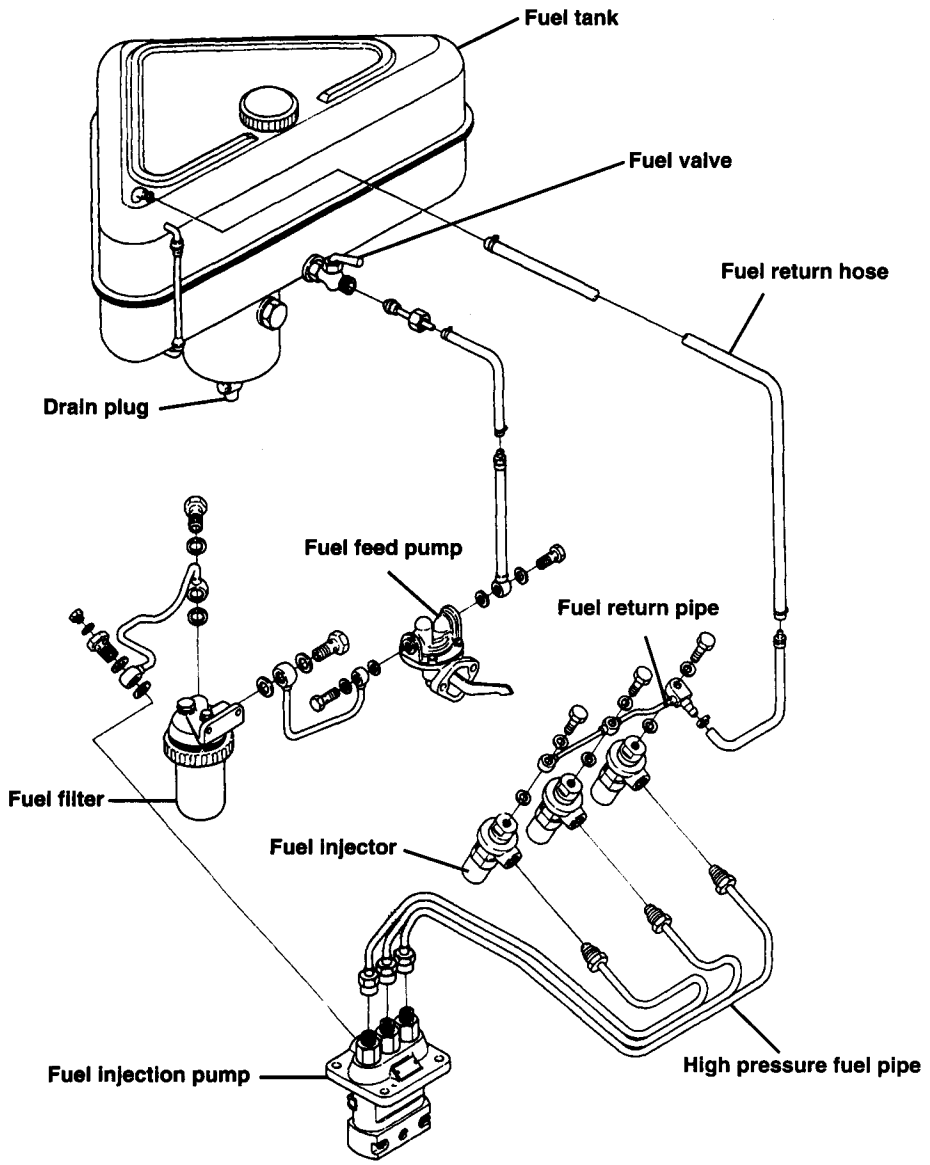
FUEL INJECTION SYSTEM



Individual pumping elements are used on single-cylinder engines as shown in **Figure 4**. Multiple-cylinder engines are equipped with pumping elements combined in a single unit as shown in **Figure 5**.

Fuel injection pumps are precision-built units that require clean fuel to operate properly. The extremely close tolerances and high injection pressure dictate that specialized equipment and experienced technicians are needed to service fuel injection pumps. If properly operated and maintained, a fuel injection pump will provide long-lasting, trouble-free service.

Fuel Injector

A fuel injector (A, **Figure 6**) is required for each cylinder to inject fuel into the combustion chamber. A high-pressure fuel line (B, **Figure 6**) directs fuel from the fuel injection pump to the fuel injector, while a fuel return line (C, **Figure 6**) carries bypass fuel back to the fuel tank. Refer to **Figure 7** for an exploded view of the fuel injector.

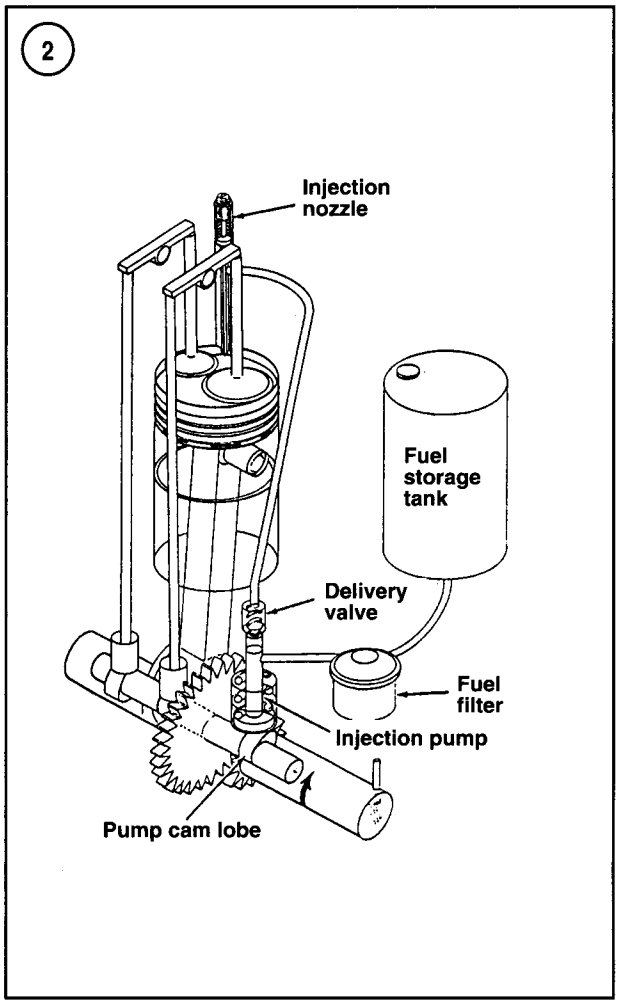
The engines covered in this manual are equipped with an inward opening, throttling-pintle type fuel injector (**Figure 8**). High fuel pressure from the injection pump enters the injection nozzle, surrounds the nozzle valve and forces the valve away from the seat. The pressure exerted by the spring above the nozzle holds the nozzle valve closed until the pressure of the fuel rises higher than spring pressure. The fuel delivered by the pump sprays from the nozzle tip into the combustion chamber when the valve opens. After the fuel is injected, fuel pressure decreases and the spring once again closes the valve.

The injection nozzle atomizes the fuel to help mix fuel with the compressed air in the engine's cylinder. The fuel must be broken into very small particles so that the fuel will quickly absorb heat from the compressed (hot) air, change to a vapor, then ignite. The design of the nozzle tip affects the size and shape of the fuel spray. The throttling pintle reduces the amount of fuel injected for a given orifice and causes a delay in the injection of the principal amount of fuel.

Excess fuel is routed from the injectors back to the fuel tank through a fuel return line.

Fuel and Fuel Filters

Clean, moisture-free fuel is very important to a diesel fuel system. As well as acting as the fuel for combustion, diesel fuel is also a lubricant for many of the internal moving parts in the fuel system. The close tolerances of the injection pump and nozzles are easily damaged by solid particles in the fuel as well as by water in the fuel.



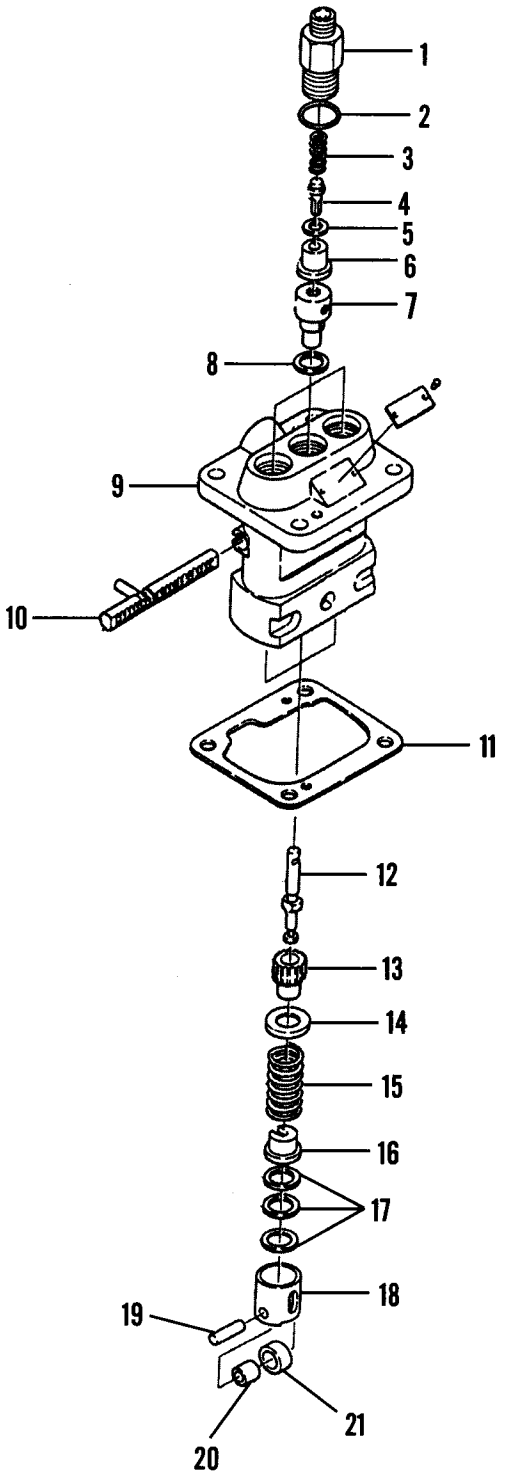
All diesel fuel contains some sulfur, which forms sulfuric acid if water mixes with the sulfur. The sulfuric acid will quickly erode the precision parts of the pump and nozzles. Extra care must be exercised in the storage and handling of diesel fuel to prevent contamination.

Diesel fuel is graded according to the composition of the fuel after passing through the refining process. Common diesel fuel grades are 1D and 2D, with 1D the lighter fuel. The recommended fuel for the Yanmar engines covered by this manual is 2-D diesel fuel.

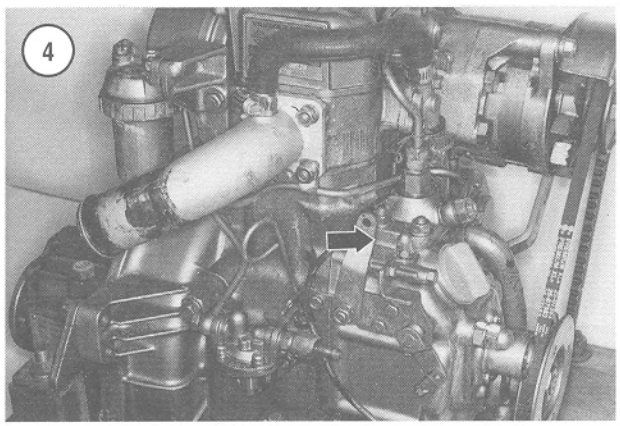
Filters are included within the system to remove solid particles and absorb moisture. In many cases, at least two filtering stages plus a water trap are incorporated to help ensure only clean fuel reaches the fuel injection pump. The primary filter (nearest the fuel tank) removes sediment and water from the fuel. The secondary filter removes very fine particles from the fuel. Both filters must

(3)

INJECTION PUMP



1. Delivery valve holder
2. O-ring
3. Spring
4. Delivery valve
5. Gasket
6. Delivery valve seat
7. Barrel
8. Gasket
9. Pump body
10. Control rack
11. Shims
12. Plunger
13. Control sleeve
14. Washer
15. Spring
16. Spring seat
17. Shims
18. Tappet
19. Pin
20. Bearing
21. Roller



be operating properly to adequately protect the fuel injection system. Failure to maintain fuel filters and use clean fuel can result in engine stoppage and expensive replacement or repair of the injection pump or injectors.

Fuel Transfer Pump

The fuel transfer pump (A, **Figure 9**) moves fuel from the fuel tank to the fuel injection pump. The pump is necessary when the fuel tank is lower than the fuel injection pump. A primer lever on the side of the transfer pump permits manual operation of the fuel pump diaphragm. Priming or bleeding the fuel system requires operation of the primer lever so fuel flows to the injection system with the engine stopped.

FUEL INJECTION SYSTEM BLEEDING

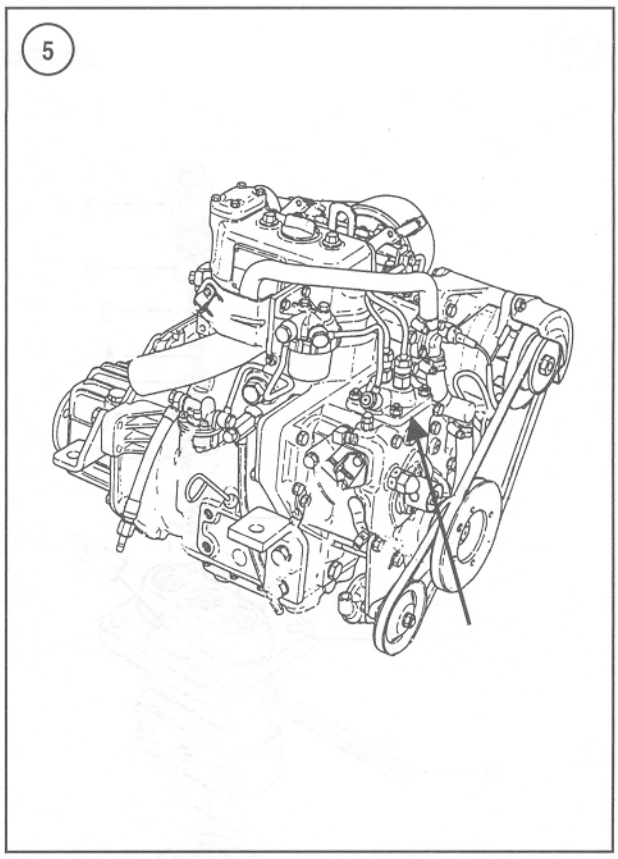
Air in the fuel system can cause rough engine operation or stoppage. Bleeding purges air from the system. Bleed the system anytime fuel line connections are disconnected or fuel components are removed. To ensure all air is removed, perform the complete bleeding procedure described in the following steps:

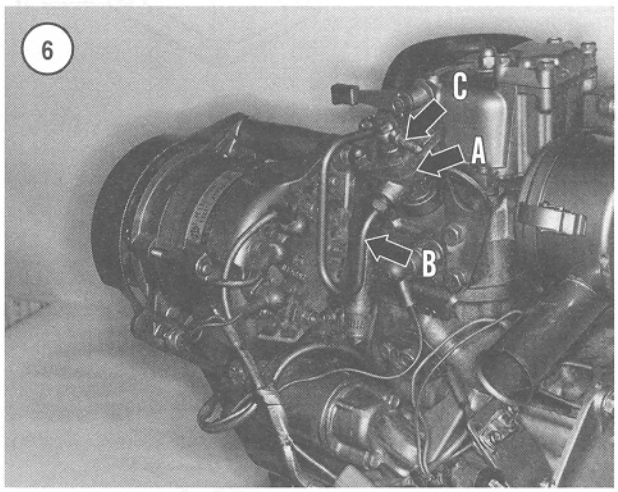
1. Open the bleed screw on the fuel filter (**Figure 10**). Make sure the fuel valve on the fuel tank is open.

NOTE

Be prepared to contain and wipe up expelled fuel.

2. Operate the priming lever (B, **Figure 9**) on the fuel transfer pump while observing the fuel expelled from the bleed screw hole. Continue to operate the priming lever until air-free fuel is expelled, then close the air bleed screw.



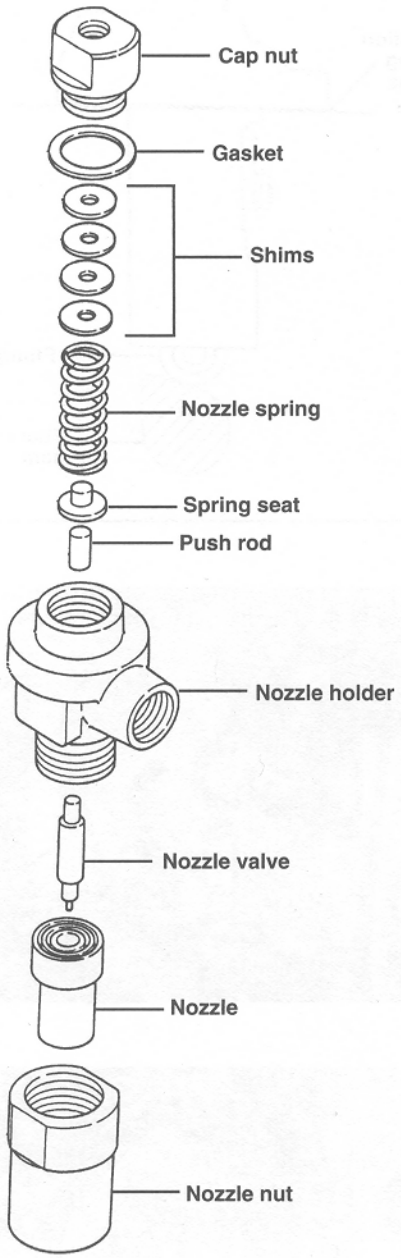


3. Open the air bleed screw (**Figure 11**) on the fuel injection pump.

4. Operate the priming lever (B, **Figure 9**) on the fuel transfer pump while observing the fuel expelled from the bleed screw hole. Continue to operate the priming lever until air-free fuel is expelled, then close the air bleed screw.

7

FUEL INJECTOR



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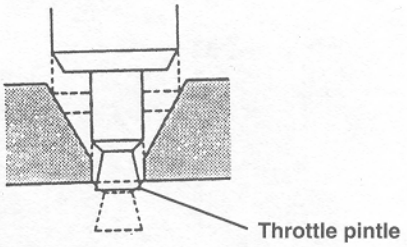

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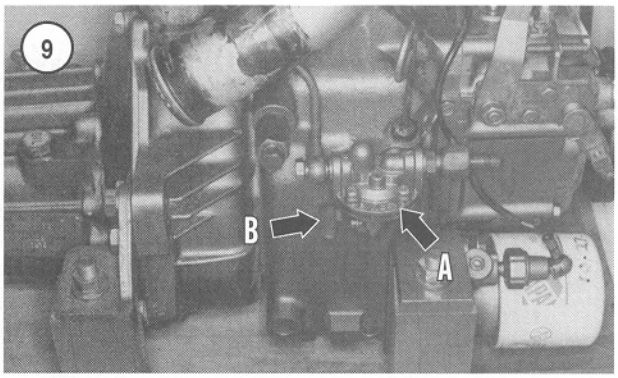

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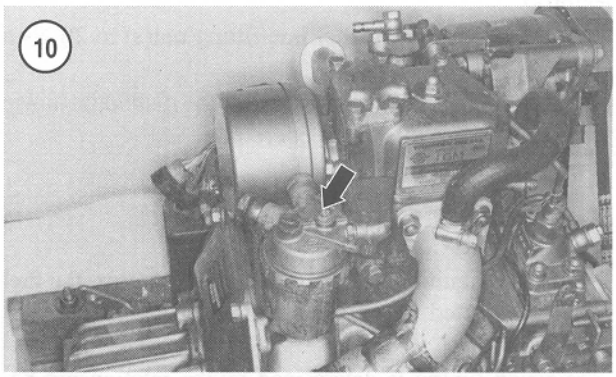

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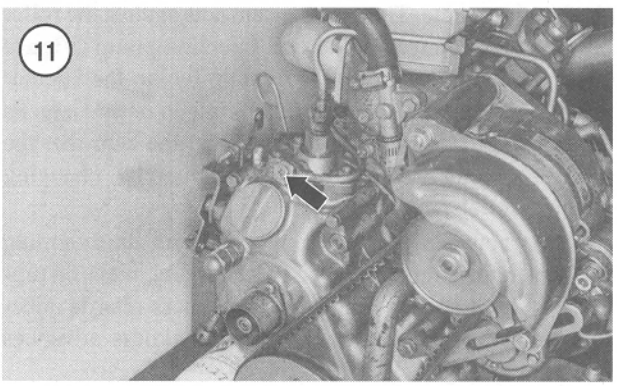

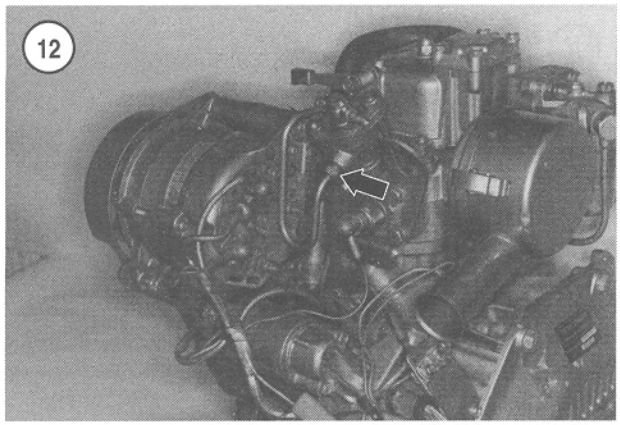

5. Loosen the fitting nut (**Figure 12**) on the injector(s) just enough to expel fuel.
6. Move the engine speed control to the full throttle position.
7. Move the decompression lever to the ON position.

NOTE

Do not operate the starter for more than 30 seconds; otherwise the starter may be damaged due to overheating.

8. Operate the starter until air-free fuel flows from the injector(s).
9. Tighten the injector fuel line fitting nut(s) to 20 N•m (15 ft.-lb.).
10. Operate the starter and listen for the distinctive noise that indicates the injector is operating.

FUEL INJECTION TIMING

Similar to ignition timing on a gasoline engine, the fuel must be injected at the proper time to obtain optimum combustion.

Injection timing is determined by the relationship between the injection pump plunger and the injection camshaft in the engine. The rotating cam acts against the roller on the pump plunger in the fuel injection pump (**Figure 13**) to force up the plunger and pump fuel to the injector nozzle. Moving the fuel injection pump up or down on its mounting surface changes the point on the cam that the plunger begins vertical movement, thereby changing when injection occurs.

Shims between the injection pump and its mounting surface on the engine are used to adjust fuel injection timing (**Figure 13**). Increasing shim thickness retards injection timing, while decreasing shim thickness advances injection timing.