Section 230

FUEL/AIR OPERATION AND TESTS

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GROUP 00
SPECIFICATIONS AND SPECIAL TOOLS

SPECIFICATIONS

Item	Specification
Air Intake System	
INTAKE MANIFOLD	
Manifold pressure at 2200 rpm (full load)	
6404T	15-17 psi (1.0-1.2 bar) (1.0-1.2 kg/cm²)
6404A	16-20 psi (1.1-1.4 bar) (1.1-1.4 kg/cm²)
6466T	14-16 psi (1.0-1.1 bar) (1.0-1.1 kg/cm²)
6466A	18-23 psi (1.2-1.6 bar) (1.2-1.6 kg/cm²)
Intake manifold-to-cylinder head cap screws	35 ft-lbs (47 Nm) (4.7 kgm)
Diesel Fuel System	
FUEL SUPPLY PUMP	
Normal operating pressure (T and A engines)	20-25 psi (1.4-1.7 bar) (1.4-1.7 kg/cm²)
Normal operating pressure (D engines)	3.5-4.5 psi (0.2-0.3 bar) (0.2-0.3 kg/cm²)
FUEL INJECTION PUMP	
Timing to engine	
Idle speeds and special advance (Roosa Master Pumps)	

	Engine Speeds (RPM)			Deg. Advance (Full Load)	
	Slow Idle	Fast Idle	Full Load	Set	Min. Movement
4270DR (Reg. Governor)	800	2750	2500	4° at 1900	4-1/2° by 2500
4270DF (3-5% Governor)	800	1900	1800	1° at 900	3-1/2° by 1350
6404DR and DF (Reg. Governor)					
(357084-499999)	800	2400	2200	5° at 1700	5-1/2° by 2100
(500000-)	800	2400	2200	—	8-1/2° by 2100
6404DR and DF (3-5% Governor)					
(357084-499999)	800	1900	1800	4° at 1300	5-1/2° by 1650
(500000-)	800	1900	1800	—	8-1/2° by 1500
6404TR-13 and AR-09					
(-357083)	800	2650	2500	5° at 1900	5-1/2° by 2200
6466DR and DF					
Regular Governor	800	2400	2200	—	9° ± 1/2° by 2000
3-5% Governor	800	1900	1800	—	8° ± 1/2° by 1500
6404TR-14 & AR-16					
(357084-445569)	800	2300	2160		
(445570-)	800	2300	2160		
6466TF (Reg. Governor)	800	2400	2200		
6466TF & TR-09 (3-5% Governor)	800	2300	2200		
6466AF (Reg. Governor)	800	2300	2100		
6466AF & AR-03 (3-5% Governor)	800	2200	2100		

Item	Specification
ANEROID ACTIVATOR (T and A engines; if equipped)	
Operating pressure	7-11 psi (0.5-1.0 bar) (0.5-1.0 kg/cm²)
SHUT OFF SOLENOID (D engines)	
Operating voltage	12 volts
RACK PULLER (T and A engines)	
Operating voltage	12 volts

Control Linkage

STARTING FUEL CONTROL LINKAGE

Bell crank bracket pivot pins (center-to-center) .... 1.22 in. (31 mm)
Governor control lever-to-fast idle stop screw clearance .... 0.09-0.11 in. (2.3-2.8 mm); collar locked against swivel
Control rod protrudes from rear collar (late linkage) .... 0.10 in. (2.5 mm)

SPECIAL TOOLS

Injection Pump and Speed Control Linkage

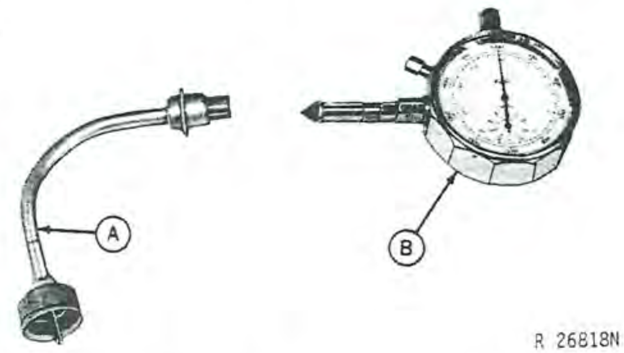

Fig. 1-Tools For Checking Speeds

TOOL	USE
A-JDE-28 Speed Indicator Adapter*	**Obtain accurate engine rpm reading (use with tachometer)**
B—Hand Tachometer	**Checking injection pump and speed control linkage speed adjustments**

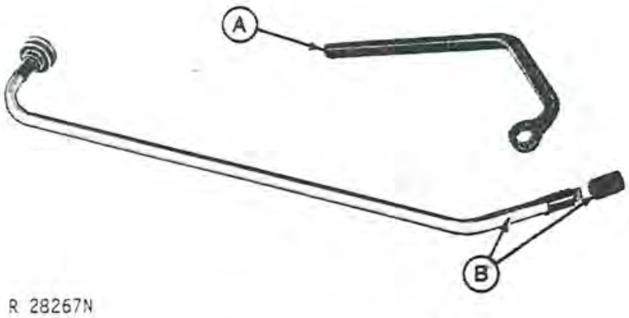

Fig. 2-Tools For Adjusting Pump Fast Idle Stop Screw

TOOL	USE
JDF-9 Fast Idle Stop Screw Wrench Kit* **A—JDF-9-1 Wrench** **B—JDF-9-2 Flexible Screwdriver (Including Screwdriver Bit Socket)**	**Adjusting pump fast idle speed on 6466A engines.**

Intake Manifold

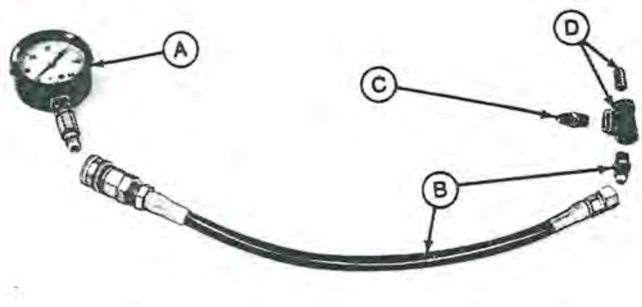

Fig. 3-Pressure Gauge with Hose and Fittings

TOOL	USE
Pressure Gauge (0-60 psi [0-4 bar] [0-4 Kg/cm²]) with Hose and Fittings **A—Pressure Gauge*** **B—Hose and Connector*** **C—Connector (J.D. Part No. R39832)** **D—Pipe Fittings**	**Measuring intake manifold pressure (Group 05) ("T" and "A" engines)**

***Part of D-15027NU Hydraulic Test Kit**

*Order from Service Tools, Box 314, Owatonna, MN 55060.

SPECIAL TOOLS—Continued

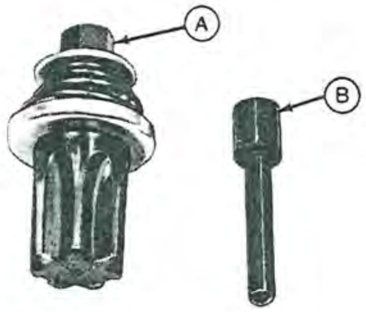

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Fig. 4-Tools Required for Checking Timing

A—JDE-81-1 Engine Rotation Tool* — **Checking injection pump timing on 6-cylinder engines**

B—JDE-81-4 Timing Pin* — **Checking injection pump timing on 6-cylinder engines**

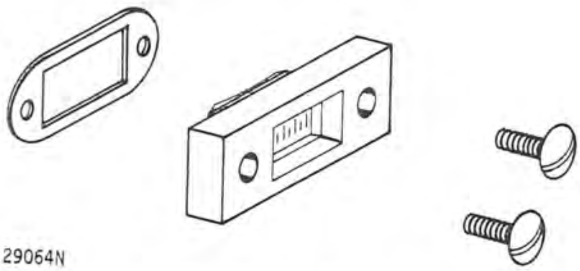

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Fig. 5-Tool For Checking Speed Advance

No. 13366 Timing Window (4270D)* — **Checking degrees of advance on "D" Engines**

No. 19918 Timing Window* (6404D, 6466D)

JDF-21 Gauge* (Not Illustrated)

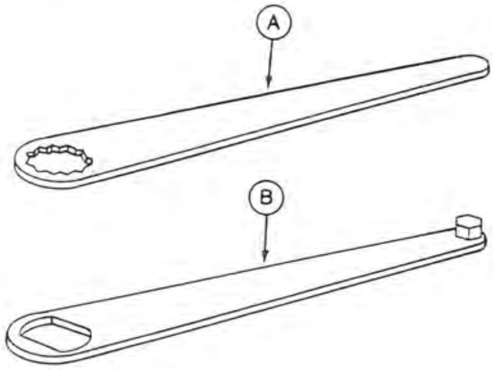

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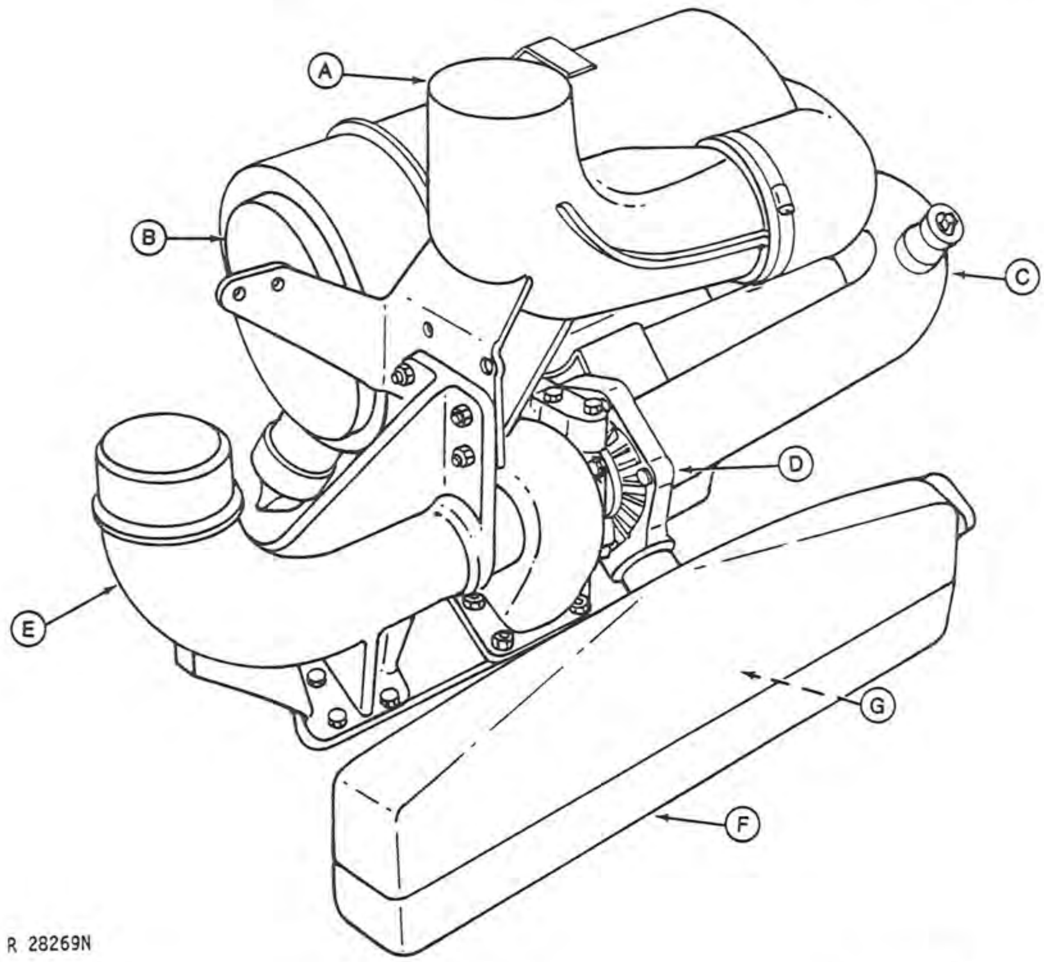
Fig. 6-Speed Advance Adjusting Tools

A—JDF-18-1* — **To adjust speed advance on 6466D Engines**

B—JDF-18-2*

*Order from Service Tools, Box 314, Owatonna, MN 55060.

Group 05
AIR INTAKE SYSTEM



A—Air Stack
B—Air Cleaner

C—Air Intake Hose
D—Turbocharger (T and A only)

E—Exhaust Elbow
F—Intake Manifold
G—Intercooler ("A" engines only)

Fig. 1-Air Intake System (6466A Engine Shown)

Outside air is drawn into the air intake system (Fig. 1) by engine suction.

Dust-laden air enters the system through the air inlet (A) and is filtered in the air cleaner (B). Clean air travels through the air intake hose (C) to the turbocharger (D) ("T" and "A" engines) and intake manifold (F) of the engine.

On "T" and "A" engines, exhaust, as it is expelled out the exhaust elbow (E), drives the turbocharger to deliver a larger quantity of air to meet engine requirements than what could be delivered under naturally aspirated (not turbocharged) conditions.

On "A" engines, intake air which has been compressed (and heated) by the turbocharger, flows around the intercooler (G) before entering the engine cylinders. Lowering the intake air temperature (the air becomes more dense) permits an even greater quantity of air to be made available for combustion.

Increasing the volume of air, and combining with it a proportional increase in the quantity of fuel delivered, enables more power to be produced.

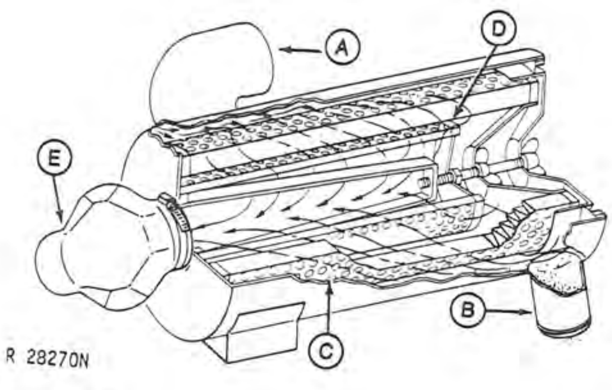
DIAGNOSING SYSTEM MALFUNCTIONS

The following is a guide for diagnosing air intake system malfunctions. For specific diagnosis of air intake system components, refer to the headings which cover complete servicing.

PROBLEM	POSSIBLE CAUSE	SUGGESTED REMEDY
Engine Starts Hard or Won't Start	Air leak on suction side of system	Check connections for tightness; repair as required (Section 30, Group 05)
Erratic Engine Operation	Air leak on suction side of system	Check connections for tightness; repair as required (Section 30, Group 05)
Engine Emits Excessive Black Smoke	Air cleaner element is restricted	Clean or replace elements (Section 30, Group 05)
	Turbocharger defective	Repair (Section 30, Group 05)
	Air leak in manifold	Check connections for tightness; repair as required (Section 30, Group 05)
Engine Idles Poorly	Air leak on suction side of system	Check connections for tightness; repair as required (Section 30, Group 05)
Engine Does Not Develop Fuel Power	Air cleaner is restricted	Clean or replace elements (Section 30, Group 05)
	Air leak on suction side of system	Check connections for tightness; repair as required (Section 30, Group 05)
	Turbocharger defective	Repair (Section 30, Group 05)
	Manifold pressure pipe to aneroid loose or broken	Check connections for tightness; repair as required (Section 30, Group 05)

AIR CLEANER

How The Air Cleaner Works



A—Air Inlet
B—Dust Outlet
C—Primary Element
D—Secondary (Safety) Element
E—Air Outlet

Fig. 2-Air Flow Through Air Cleaner

Dust-laden air enters the air cleaner inlet (A, Fig. 2), and is forced into a high-speed centrifugal motion.

Most of the dust settles out of the air (before it enters the filter elements) and falls to the bottom of the air cleaner body. It is expelled to the outside of the air cleaner through a rubber valve (B), which automatically ejects the dust and keeps it from accumulating inside the air cleaner body.

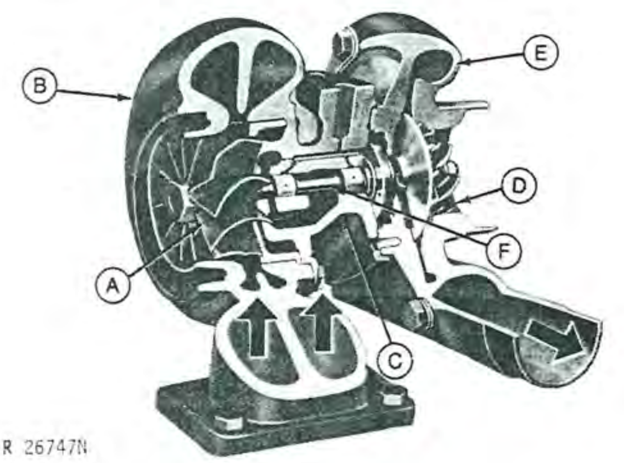
As the intake air is drawn through the primary element (C) and a secondary (safety) element (D), the remaining dust particles are retained in the primary element to permit only clean air to enter the intake manifold.

The safety element retains the dust that would otherwise pass into the engine if the primary element should rupture.

See Section 30, Group 05 for service information.

AIRESEARCH T-04B TURBOCHARGER

How The AiResearch Turbocharger Works



A—Turbine Wheel
B—Turbine Housing
C—Center Housing
D—Compressor Wheel
E—Compressor Housing
F—Shaft

Fig. 5-Air Flow Through AiResearch Turbocharger

Exhaust gases from the engine pass through the turbine housing (B, Fig. 5) causing the turbine wheel and shaft (F) to rotate before the exhaust gas is discharged to the atmosphere.

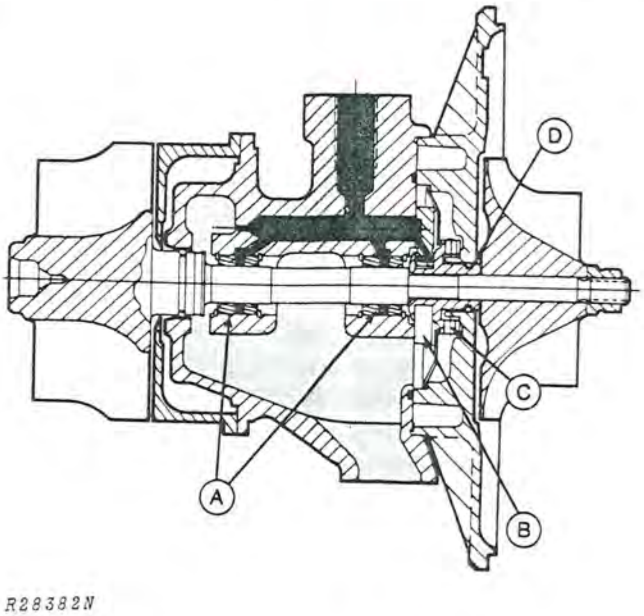
The compressor wheel (D), also mounted on shaft (F), rotates in the compressor housing (E). Inlet air is drawn into the housing, where it is compressed and delivered to engine cylinders.

Engine oil under pressure from the engine lubrication system is pumped through passages (Fig. 6) in the center housing and directed to bearings (A) and thrust washer (B) through passages in the center housing and thrust collar (C). Oil is sealed from the compressor and turbine by a piston ring (D) at both ends of the center housing.

The turbocharger contains two floating bearings that have a clearance between the bearing O.D. and housing wall as well as a clearance between the bearing I.D. and the shaft O.D.

These clearances are lubricated by the oil supply and the bearings are protected by a cushion of oil.

The discharge oil drains by gravity from the center housing to the engine crankcase.

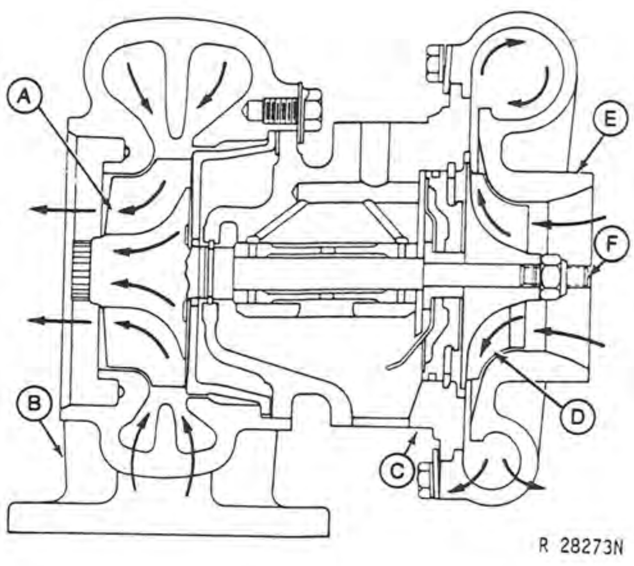


A—Bearings
B—Thrust Washer
C—Thrust Collar
D—Piston Ring
Pressure Oil
Discharge Oil

Fig. 6-AiResearch Turbocharger Lubrication

SCHWITZER 3LM TURBOCHARGER

How The Schwitzer Turbocharger Works



A—Turbine Wheel
B—Turbine Housing
C—Center Housing
D—Compressor Wheel
E—Compressor Housing
F—Shaft

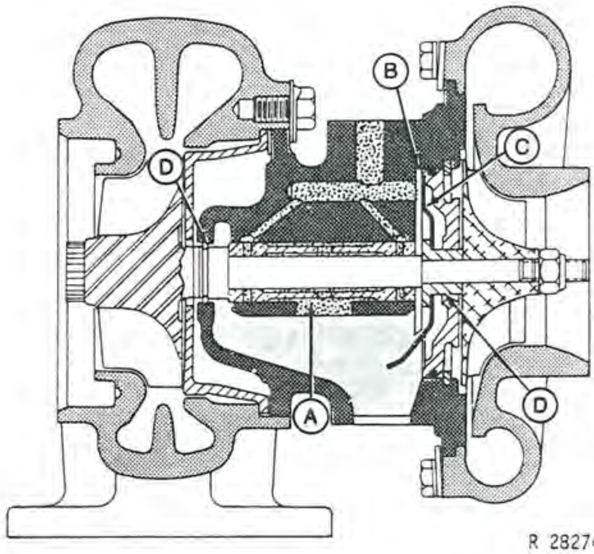
Fig. 7-Air Flow Through Schwitzer Turbocharger

Exhaust gases from the engine pass through the turbine housing (B, Fig. 7) causing the turbine wheel and shaft (F) to rotate before the exhaust gas is discharged to the atmosphere.

The compressor wheel (D), also mounted on shaft (F), rotates in the compressor housing (E). Inlet air is drawn into the housing, where it is compressed and delivered to engine cylinders.

Engine oil under pressure from the engine lubrication system is pumped through passage (Fig. 8) in the bearing housing and directed to the bearing (A), thrust plate (B), and flinger (or thrust) sleeve (C). Oil is sealed from the compressor and turbine by a piston ring (D) at both ends of bearing housing.

The turbocharger contains a single floating bearing that has clearance between the bearing O.D. and the housing wall as well as a clearance between the bearing I.D. and the shaft O.D. These clearances are lubricated by the oil supply and the bearings are protected by a cushion of oil. Discharge oil drains by gravity from the bearing housing to the engine crankcase.



A—Bearing
B—Thrust Plate
C—Flinger (or Thrust) Sleeve
D—Piston Ring
Pressure Oil
Discharge Oil

Fig. 8-Schwitzer Turbocharger Lubrication

DIAGNOSING TURBOCHARGER MALFUNCTIONS

Before replacing the turbocharger, determine what caused the failure of the defective unit, and correct the condition. This will prevent an immediate repeat failure of the replacement unit. Refer to Section 30, Group 05 for turbocharger repair information.

Noise or Vibrations

(Do not confuse the whine heard during rundown with noise which indicates a bearing failure.)

Bearings not lubricated (insufficient oil pressure)
Air leak in engine intake or exhaust manifold
Improper clearance between turbine wheel and turbine housing.
Broken blades (or other wheel failures)

Engine Will Not Deliver Rated Power

Clogged manifold system
Foreign material lodged in compressor, impeller, or turbine.
Excessive dirt build-up in compressor
Leak in engine intake or exhaust manifold
Leak in intake manifold-to-aneroid pipe
Rotating assembly bearing failure

Oil on Compressor Wheel or in Compressor Housing (Oil Being Pushed or Pulled Through Center Housing)

Excessive crankcase pressure
Air intake restriction
Restricted oil return line

Oil in Manifolds or Dripping from Housing

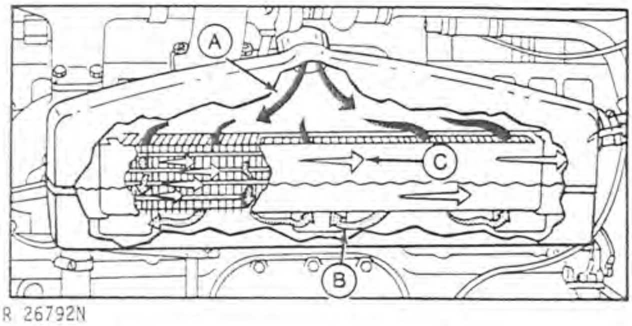
Damaged or worn journal bearings
(a) Unbalance of rotating assembly
Damage to turbine or compressor wheel or blade. Dirt or carbon build-up on wheel or wheels
(b) Bearing wear
Oil starvation or insufficient lubrication
Shaft seals worn
Excessive crankcase pressure

Drag in Turbine Wheel

Carbon build-up behind turbine wheel caused by coked oil or combustion deposits
Dirt build-up behind compressor wheel caused by air intake leaks
Bearing seizure or dirty or worn bearings caused by excessive temperatures, unbalanced wheel, dirty oil, oil starvation, or insufficient lubrication

INTERCOOLER AND INTAKE MANIFOLD ("T" and "A" Engines)

How The Intercooler Works



A—Heated Air
B—Cooled Air
C—Engine Coolant

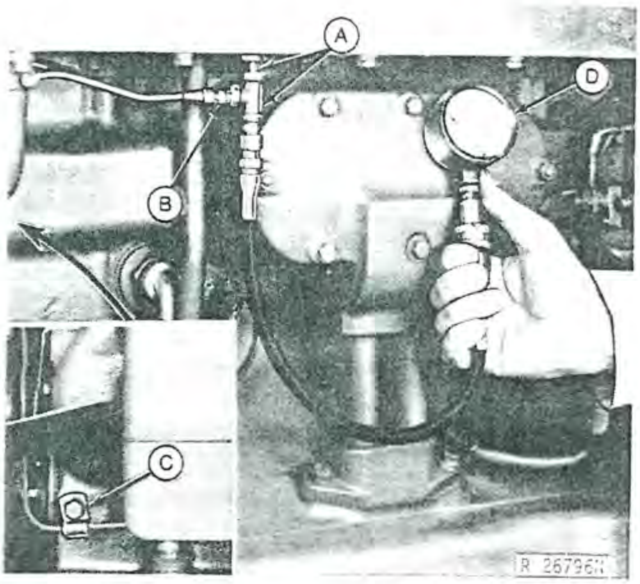
Fig. 9-Air Flow Through Intake Manifold and Coolant Flow Through Intercooler

Air entering the intake manifold (Fig. 9) has been compressed (and heated) by the turbocharger. As this heated, compressed air (A) enters the intake manifold, it flows around the intercooler before going to the engine cylinders.

The intercooler functions as a heat exchanger, lowering the intake air (B) temperature as much as 80°-90°F. (27°-32°C). Lowering the air temperature makes the air more dense, permitting an even greater volume (compared with not having an intercooler) to be delivered to the engine cylinders. This increased volume of air, when combined with a predetermined quantity of additional fuel, enables more power to be produced.

Engine coolant (C) circulating through the intercooler core is the media used for heat exchange. Extreme care must be used to insure that the engine coolant does not leak into the intake manifold, resulting in possible damage to the engine.

Checking Intake Manifold Pressure



A—1/8-in. Nipple and "T"
B—R39832 Connector
C—Aneroid Pipe Clamp Cap Screw
D—Pressure Gauge

Fig. 10-Checking Intake Manifold Pressure

To check the intake manifold pressure (Fig. 10):

1. Install pipe fittings in intake manifold.

   a. Disconnect aneroid pipe and remove elbow fitting from bottom of intake manifold.

   b. Install a 1/8-in. pipe nipple and "T" fitting (A) in manifold.

   c. Install an R39832 fitting (B) in "T".

   d. Loosen aneroid pipe clamp cap screw (C) and connect pipe to R39832 fitting.

2. Connect a hose and an accurate 0-30 psi (0-2 bar) (0-2 kg/cm^2) pressure gauge (D) to "T" fitting.

3. With engine at operating temperature, connect to a dynamometer. Operate engine at full load, rated speed.

4. Observe pressure reading on gauge.

INTAKE MANIFOLD PRESSURE SPECIFICATION

Engine	Pressure
6404T	15-17 psi (1.0-1.2 bar) (1.0-1.2 kg/cm²)
6404A	16-20 psi (1.1-1.4 bar) (1.1-1.4 kg/cm²)
6466T	14-16 psi (1.0-1.1 bar) (1.0-1.1 kg/cm²)
6466A	18-23 psi (1.2-1.6 bar) (1.2-1.6 kg/cm²)

If reading is low, check the following:

(a) Restricted air cleaner (page 30-05-1).

(b) Leak in air intake system between turbocharger and cylinder head.

(c) Defective turbocharger (page 30-05-1 and 30-05-9).

After completing test, remove gauge and test fittings and install plug or pipe.

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HOW THE SYSTEM WORKS — "D" ENGINES

The fuel pump (B, Fig. 1A) draws fuel from the tank (A) and pressurizes it to 3.5 to 4.5 psi (0.2 to 0.3 bar) (0.2 to 0.3 kg/cm²) at idle speed (800 rpm). This pressure permits the fuel to flow through the fuel filter (D) and charge the transfer pump (E) of the injection pump (G).

With the transfer pump charged with fuel by the fuel pump, the injection pump plungers pressurize the fuel to about 6000 psi (412 bar) (422 kg/cm²). Delivery pipes (I) route this high pressure fuel to the injection nozzles (J).

Fuel entering the injection nozzle at 6000 psi (412 bar) (422 kg/cm²) easily overcomes the 3200 to 3600 psi (221 to 248 bar) (232 to 254 kg/cm²) pressure required to open the nozzle valve. When the nozzle valve opens, fuel is forced out through the orifices in the nozzle tip and atomizes as it enters the combustion chamber.

Incorporated into the fuel system is a means of returning excess (or unused) fuel back to the fuel tank. Excess fuel comes from two sources:

(1) Injection pump - A quantity of fuel greater than that required by the engine is supplied to the injection pump.

(2) Injection Nozzles - A small amount of fuel seeps past the nozzle valve for lubrication of the internal nozzle parts.

A return line (K) from the injection pump is connected to the front end of the nozzle leak-off pipe (L). Fuel from both sources is then returned to the tank by a return pipe (M) connected to the front or rear end of the leak-off pipe.

HOW THE SYSTEM WORKS — "T" and "A" ENGINES

The fuel supply pump (C, Fig. 1B) draws fuel from the tank (A) and pressurizes it to 20 to 25 psi (1.4 to 1.7 bar) (1.4 to 1.7 kg/cm²). This pressure permits the fuel to flow through the fuel filters (D) and fill the fuel gallery (F) of the injection pump (G).

With the fuel gallery being kept full by the supply pump, the injection pump plungers (H) pressurize the fuel to about 7500 psi (518 bar) (529 kg/cm²). Delivery pipes (I) route this high pressure fuel to the injection nozzles (J).

Fuel entering the injection nozzle at 7500 psi (518 bar) (529 kg/cm²) easily overcomes the 3800 psi (262 bar) (267 kg/cm²) pressure required to open the nozzle valve. When the nozzle valve opens, fuel is forced out through the orifices in the nozzle tip and atomizes as it enters the combustion chamber.

Incorporated into the fuel system is a means of returning excess (or unused) fuel back to the fuel tank. Excess fuel comes from two sources:

(1) Injection Pump—A quantity of fuel greater than that required by the engine is supplied to the injection pump.

(2) Injection Nozzles—A small amount of fuel seeps past the nozzle valve for lubrication purposes.

A return line (K) from the injection pump is connected to the front end of the nozzle leak-off pipe (L). Fuel from both sources is then returned to the tank by a return pipe (M) connected to the front or rear end of the leak-off pipe.

DIAGNOSING SYSTEM MALFUNCTIONS

The following is a guide for diagnosing fuel system malfunctions. For specific diagnosis of fuel system components, refer to the groups which cover complete servicing.

FUEL SYSTEM DIAGNOSING MALFUNCTIONS CHART

PROBLEM	POSSIBLE CAUSE	SUGGESTED REMEDY
Fuel Not Reaching Injection Nozzles	Fuel filter clogged	Replace fuel filter (this group)
	Fuel line clogged or restricted	Clean lines as required
	Fuel too heavy at low temperatures	Use correct grade of fuel (see machine OM)
	Air in system	Correct problem and bleed fuel system (this group)
	Fuel tank valve shut off	Open fuel tank valve
	Low supply pump pressure	Check fuel lines for restrictions
Engine Starts Hard or Won't Start	Cranking speed too low	Recharge battery
	Fuel too heavy at low temperatures	Use correct grade of fuel (see machine OM)
	Injection nozzles faulty or sticking	Repair (Section 30, Group 10)
	Incorrect timing	Adjust timing (this group)
	Injection pump is faulty	Repair (Section 30, Group 10)
	Water in fuel	Drain water from fuel, Install new filters (this group)
	Fuel filter clogged	Replace fuel filter (this group)
	Injection pump return fuel line or fittings restricted	Clean lines as required
	Low cetane fuel	Use correct grade of fuel (see machine OM)
	Defective injection pump solenoid ("D" engines)	Repair (Section 30, Group 15)
	Broken starting fuel control shaft spring ("T" and "A" engines)	Repair (Section 30, Group 10)
Engine Starts and Stops	Air in system	Correct problem and bleed fuel system (this group)
	Fuel filter clogged	Replace fuel filter (this group)
	Fuel lines clogged or restricted	Clean lines as required
	Water in fuel	Drain water from fuel. Install new filters (this group)
	Injection pump return fuel line or fittings restricted	Clean lines as required
Erratic Engine Operation	Fuel filter clogged	Replace fuel filter (this group)
	Fuel too heavy at low temperatures	Use correct grade of fuel (see machine OM)
	Injection nozzles faulty or sticking	Repair (Section 30, Group 10)
	Fuel lines clogged or restricted	Clean as required
	Incorrect timing	Adjust timing (this group)
	Governor faulty	Repair (Section 30, Group 10)
	Water in fuel	Drain water from fuel, Install new filters (this group)
	Injection pump return fuel line or fittings restricted	Clean lines as required

FUEL SYSTEM
DIAGNOSING MALFUNCTIONS CHART—Continued

PROBLEM	POSSIBLE CAUSE	SUGGESTED REMEDY
Erratic Engine Operation	Low cetane fuel	Use correct grade of fuel (see machine OM)
	Injection nozzle return lines clogged	Clean lines as required
	Speed advance faulty ("D" engines)	Repair (Section 30, Group 10)
Engine Emits Excessive Black Smoke	Injection nozzles faulty or sticking	Repair (Section 30, Group 10)
	Injection pump timing is incorrect	Adjust timing (this group)
	Low cetane fuel	Use correct grade of fuel (see machine OM)
	Over-fueling	Repair and adjust (Section 30, Group 10)
	Aneroid defective ("T" and "A" engines)	Repair and adjust (Section 30, Group 10)
	Speed advance not operating ("D" engines)	Repair and adjust (Section 30, Group 10)
Engine Emits Excessive Blue or White Smoke	Cranking speed too low	Check batteries and electrical system (Section 240)
	Injection pump timing is incorrect	Adjust timing (this group)
	Injection nozzles faulty or sticking	Repair (Section 30, Group 10)
	Excessive wear in liners and/or piston rings stuck	Repair (Section 20)
	Incorrect cetane fuel for ambient temperature	Use correct grade of fuel (See machine OM)
	Engine running too "cold"	Check thermostat (Section 20, Group 30)
Engine Idles Poorly	Injection nozzles faulty or sticking	Repair (Section 30, Group 10)
	Incorrect timing	Adjust timing (this group)
	Pump slow idle speed not correctly adjusted	Adjust slow idle speed (this group)
	Fuel lines clogged or restricted	Clean as required
	Water in fuel	Drain water from fuel. Install new filters (this group)
	Injection pump return lines or fittings restricted	Clean as required
	Injection nozzle return lines clogged	Clean as required
	Low cetane fuel	Use correct grade of fuel (see machine OM)
	Injection pump housing not full of fuel	Restriction or faulty transfer pump
Engine Does Not Develop Full Power	Low cetane fuel	Use correct grade of fuel (see machine OM)
	Incorrect timing	Adjust timing (this group)
	Injection pump or governor faulty	Repair (Section 30, Group 10)
	Fuel filter clogged	Replace fuel filter (this group)
	Injection nozzle return lines clogged	Clean as required
	Injection nozzles faulty or sticking	Repair (Section 30, Group 10)
	Injection pump return fuel line or fittings are restricted	Clean as required
	Water in fuel (or gasoline in fuel)	Drain water or replace with clean fuel. Install new filters (this group)
	Incorrect fast idle speed	Adjust speed (this group)

FUEL SYSTEM
DIAGNOSING MALFUNCTIONS CHART—Continued

PROBLEM	POSSIBLE CAUSE	SUGGESTED REMEDY
Engine Does Not Develop Full Power	Manifold pressure pipe to aneroid loose or broken	Repair as required (Section 30, Group 10)
	Fuel shut-off cable improperly adjusted	Adjust (Section 230, Group 15)

FUEL PUMPS

FUEL PUMP—"D" ENGINES

General Information

Fuel from the fuel tank enters the inlet side of the diaphragm-type pump. This pump increases the fuel pressure to 3-1/2 to 4-1/2 psi (0.25-0.30 bar) (0.25-0.30 kg/cm²) at idle speed, and forces fuel through the filter to the injection pump.

The fuel pump is operated by an eccentric lobe on the engine camshaft. A hand primer is also provided for manual operation.

Diagnosing Malfunctions

Before replacing the pump when fuel does not flow (or only a small amount flows), check the following sources that would limit pump performance:

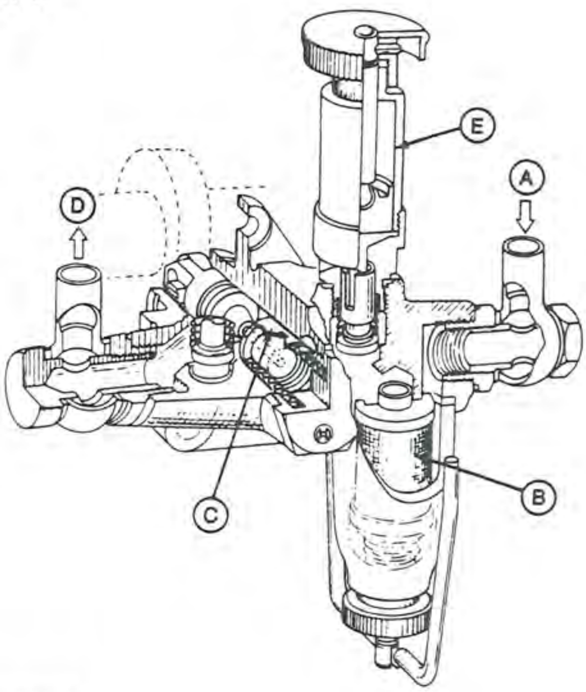
Fuel shut off at tank.
Hand primer left in the upward position.
Clogged fuel line.
Loose or damaged fuel line connections.

If correction of these conditions does not provide a satisfactory flow of fuel, the pump is defective and must be replaced (see Group 10, Section 30).

FUEL SUPPLY PUMP —"T" AND "A" ENGINES

How The Supply Pump Works

The FP/K-Series fuel supply pump (Fig. 2) is a single-acting pump mounted on the side of the injection pump housing, and is driven by the injection pump camshaft. Fuel enters the supply pump at (A), and is filtered by the preliminary filter (B) contained in the glass sediment bowl. After the fuel is pressurized by the plunger (C), it is discharged through the outlet banjo fitting at (D). The hand primer (E) provides manual pump operation.



R28383N

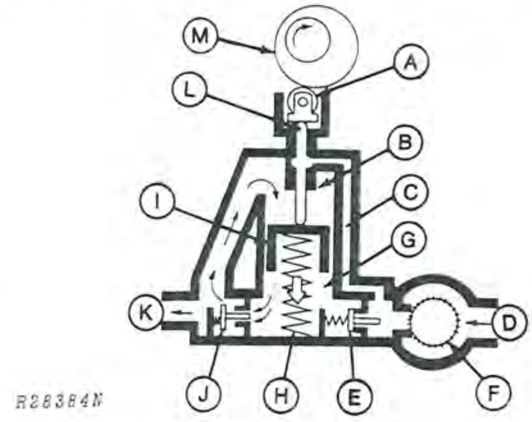
A—Fuel Inlet
B—Preliminary Filter
C—Plunger
D—Fuel Outlet
E—Hand Primer

Fig. 2-FP/K-Series Fuel Supply Pump

As the pump camshaft (M, Fig. 3) rotates towards the "high cam" intermediate stroke position, the roller tappet (A) and pressure spindle (L) cause the plunger (I) to move against the plunger spring (H) and compress it.

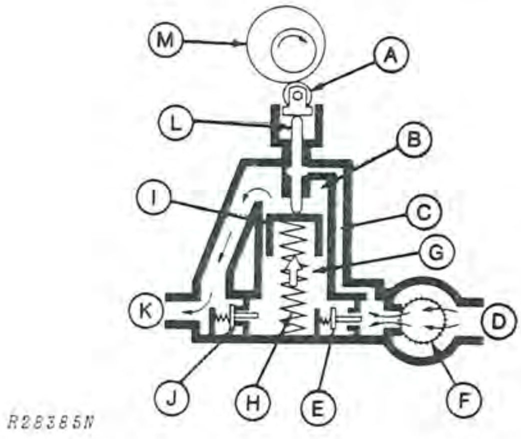
Plunger movement forces the fuel out of the suction chamber (G), through the pressure valve (J), and into the pressure chamber (B). The amount of fuel discharged from the suction chamber is equal to the amount of fuel delivered for each stroke of the plunger.

Towards the end of the intermediate stroke, the spring-loaded pressure valve closes again.



A—Roller Tappet
B—Pressure Chamber
C—Leakage Channel
D—Fuel Inlet
E—Suction Valve
F—Filter
G—Suction Chamber
H—Plunger Spring
I —Plunger
J —Pressure Valve
K—Fuel Outlet
L—Pressure Spindle
M—Camshaft

Fig. 3-Intermediate Stroke Position



A—Roller Tappet
B—Pressure Chamber
C—Leakage Channel
D—Fuel Inlet
E—Suction Valve
F—Filter
G—Suction Chamber
H—Plunger Spring
I —Plunger
J —Pressure Valve
K—Fuel Outlet
L—Pressure Spindle
M—Camshaft

Fig. 4-Suction and Discharge Stroke Position

As the camshaft rotates toward the "low cam" or suction and discharge position (Fig. 4), plunger spring pressure causes the plunger, pressure spindle, and roller tappet to follow the camshaft.

Movement of the plunger pushes the fuel from the pressure chamber, and delivers it to the fuel filters and injection pump. At the same time, plunger suction pressure is permitting fuel to enter the suction chamber through the suction valve (E). With the suction chamber charged with fuel, the pumping cycle begins again.

Fuel is allowed to work its way around the pressure spindle to lubricate the spindle as it moves back and forth in housing. To prevent the fuel from entering the pump crankcase, a rubber O-ring is positioned in the spindle bore of housing at the roller tappet end. Excess fuel is returned through the leakage channel (C) back to the suction chamber.

Unscrewing the knurled knob and pulling upward causes the suction valve to open and fuel to flow into the suction chamber. When the hand plunger is pushed downward, the suction valve closes, and fuel is forced out the pressure valve.

Each stroke of the hand primer delivers approximately six cm^3 (cubic centimeters) of fuel.

Diagnosing Malfunctions

Before replacing the pump when fuel does not flow (or only a small amount flows), check the following sources that would limit pump performance:

Fuel partially restricted at tank

Clogged fuel line or banjo fitting

Loose or damaged fuel line connections

Restricted fuel filters (page 10-8)

Air in system (page 10-9)

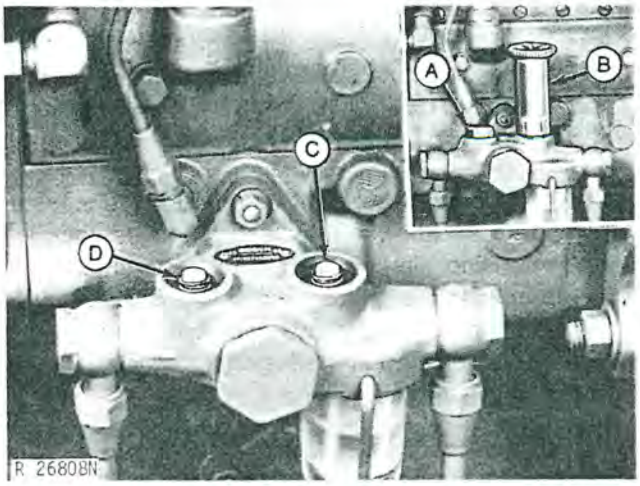
Supply pump filter restricted

If correction of these conditions does not provide a satisfactory flow of fuel, a possible cause for the malfunction may be foreign material under the supply pump valves.

To prevent entry of dirt into fuel system, thoroughly clean the supply pump body and area adjacent to pump before loosening connections.

Close fuel shut-off valve at tank.

FUEL PUMPS—Continued



A—Plug
B—Hand Primer
C—Valve
D—Spring

Fig. 5-Supply Pump Valves and Springs

To gain access to the valves, remove plug (A, Fig. 5) and hand primer (B). Take out valves (C) and springs (D). Inspect valves and valve seats for foreign material, wear, or pitting. Valve springs must not be broken.

Reassemble parts, open tank shut-off valve, and check operation. if the supply pump operation is still not normal, the pump will have to be removed and repaired, or replaced. (See Section 30, Group 10.)

FUEL FILTER

General Information

A fuel filter (Fig. 6) is used to prevent dirty fuel from reaching the injection pump and injection nozzles. Two filters are used on "T" and "A" engines.

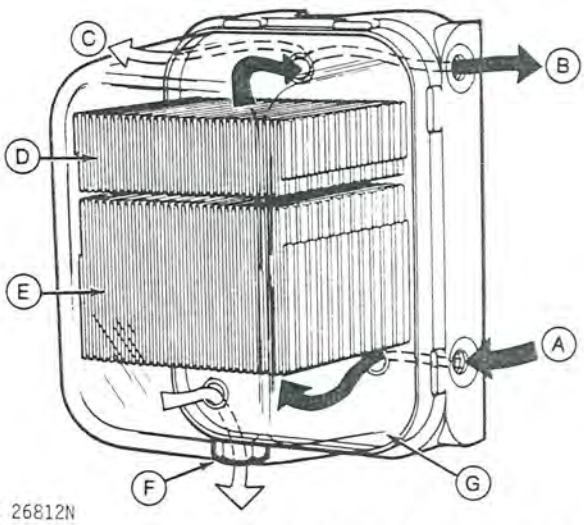
The filter element will require occasional replacement to maintain an adequate flow of fuel to the injection pump. The frequency of this service will vary according to the cleanliness of available fuel and the care used in storage.

Fuel enters the filter at (A, Fig. 6) and flows through a first stage filtering media (E) and a second stage filtering media (D) before flowing through outlet (B) to the injection pump. The filtering media is housed in the glass sediment bowl (G) and expoxied to the bowl as one assembly.

Since water and other contaminants may settle to the bottom of the sediment bowl, a drain plug (F) is provided to permit their removal.

An air vent (C) enables air in the fuel system to be expelled to the outside through filter when bleed plug (A, Fig. 7) is removed.

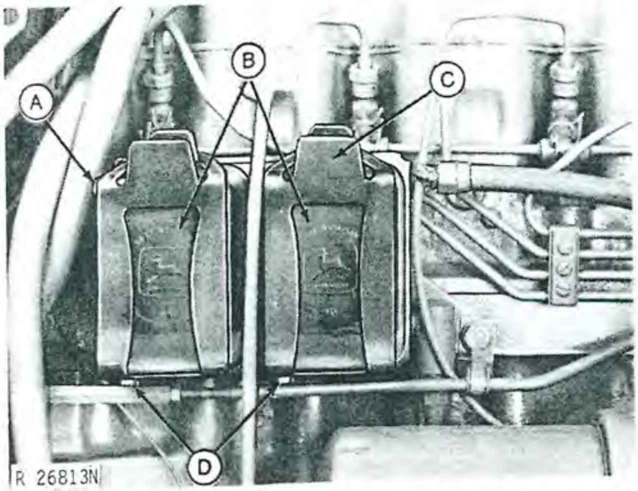
Fow The Fuel Filter Works



A—Inlet
B—Outlet
C—Air Vent
D—Second Stage Filtering Media
E—First Stage Filtering Media
F—Drain
G—Sediment Bowl
C ▇ Supply Pump Pressure

Fig. 6-Fuel Flow Through Filter

Replacing Filter Elements



A—Bleed Plug
B—Filter Elements
C—Retaining Spring
D—Drain Plugs

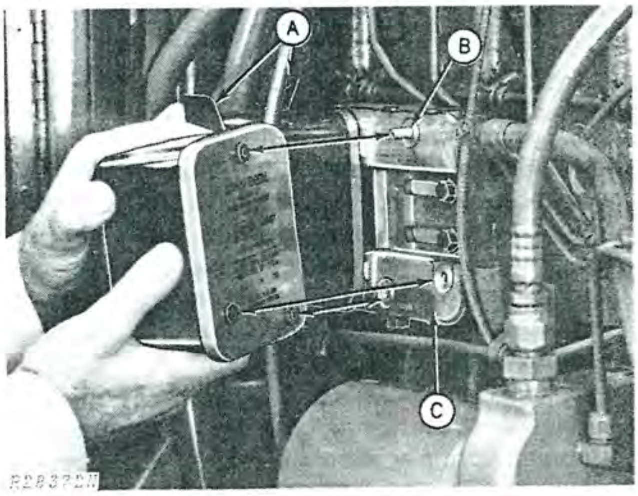
Fig. 7-Fuel Filter

To change the filter elements (B, Fig. 7), close the fuel shut-off valve at fuel tank.

Remove drain plugs (D) and drain filter.

Release the filter element retaining spring (C) and pull off element.

NOTE: The spring may be released by pressing inward on the outside finger tab (A, Fig. 8) until the top hook of the spring can be disengaged. Disengage the top hook by pulling upward on the inside finger tab.



A—Finger Tabs
B—Spring Pin
C—Fuel Filter Body

Fig. 8-Installing Filter Element

Before installing new filter elements, inspect the filter body where elements make contact. These locations must be completely void of dirt or other contaminants. If contaminants are found, clean carefully.

IMPORTANT: Any dirt lodged in the spring pin groove or at the end of the spring pin by cleaning efforts will be washed into the injection system and may result in severe damage to the injection pump or nozzles.

Push new element over the spring pin (B). Hook the bottom end of retaining spring first, then hook the top end.

After changing both elements, install drain plugs in filter body.

Open the fuel shut-off valve and bleed the filters. (See "Bleeding Fuel System" on next page.)

BLEEDING FUEL SYSTEM

CAUTION: Escaping diesel fuel under pressure can have sufficient force to penetrate the skin, causing serious personal injury. Before disconnecting lines be sure to relieve all pressure. Before applying pressure to the system, be sure all connections are tight and that lines, pipes and hoses are not damaged. Fuel escaping from a very small hole can be almost invisible. Use a piece of cardboard or wood, rather than hands, to search for suspected leaks.

If injured by escaping fuel, see a doctor at once. Serious infection or reaction can develop if proper medical treatment is not administered immediately.

Whenever the fuel system has been opened up for service (lines disconnected or filters removed), it will be necessary to bleed the air from system.

"D" Engines

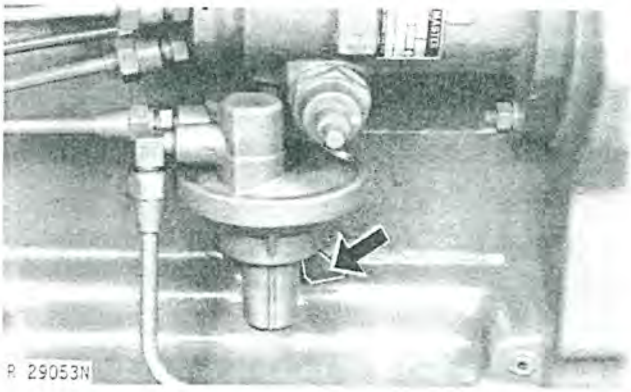


Fig. 9-Hand Primer (6404D Shown)

Loosen bleed plug on fuel filter (A, Fig. 7), and operate hand primer (Fig. 9) on fuel pump until most of the air bubbles are expelled from the filter.

Push hand primer back (toward engine) as far as it will go. Tighten filter bleed plug.

"T" and "A" Engines

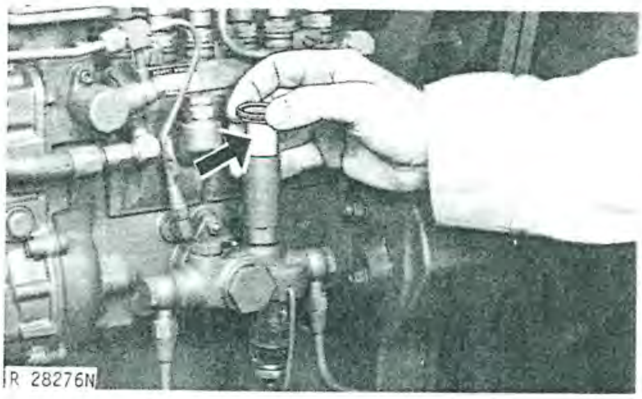


Fig. 10-Hand Primer (6466T Shown)

To bleed the fuel system, loosen bleed plug (A, Fig. 7). Unscrew the hand primer knurled knob (Fig. 10) on the fuel supply pump, and loosen until it can be pulled up by hand. Operate the hand primer until most of the air bubbles are expelled from the glass bowl.

Push hand primer down and tighten. Tighten bleed plug.

NOTE: If the engine will not start, it may be necessary to loosen the fuel pipes at the injection nozzles to bleed the air from system. With the hand throttle in slow idle position on stationary engines, push engine stop button on "D" engines (or do not reset rack puller on "T" and "A" engines). On all other engines, place the hand throttle in slow idle position and push the engine fuel shut-off control knob all the way in. Turn the engine with the starter until fuel without air flows from the loose fuel pipe connections. Tighten the connections.

FUEL INJECTION PUMP — "D" ENGINES

General Information

Roosa-Master fuel injection pumps are used on "D" engines as follows:

Engine	Pump Model
4270D	JDB
6404D (-499999)	DM-2
6404D (500000-)	DM-4
6466D	DM-4

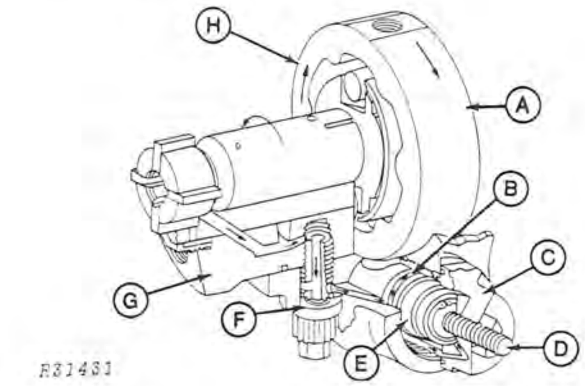
The Model JDB and DM-2 pumps have a single cylinder (two plungers), while the Model DM-4 is a twin cylinder (four plunger) pump. All pumps are distributor-type, with automatic speed advance and an electric fuel shut-off control.

For information on how a JDB pump operates, refer to SM-2045, "Testing and Servicing Fuel Injection Pumps and Nozzles". Information on how the DM-2 and DM-4 pumps operate can be found in TM-1064, "Fuel Injection Equipment - Roosa Master".

Automatic Speed Advance

How The Speed Advance Works

The purpose of the automatic speed advance (Fig. 11) is to insure optimum combustion for maximum power at higher engine speeds. This is done by advancing or retarding the start of fuel delivery in response to changes in engine speed.



A—Cam Ring
B—Annulus
C—Plug
D—Adjusting Screw
E—Advance Piston
F—Head Locating Screw
G—Hydraulic Head
H—Rotor

Fig. 11-Automatic Speed Advance (6404D Shown)

As engine speed increases, the movement of the cam ring (A, Fig. 11) also increases to a maximum of 9 degrees. As engine speed decreases, the cam ring is forced to return to a retarded position.

Movement of the cam ring is accomplished hydraulically, using fuel under pressure from the transfer pump. Fuel is directed to an advance piston (E) which rotates the cam ring against the direction of rotor (H) rotation. Counteracting piston movement is a spring that is preloaded by an adjusting screw (D), called a "trimmer" screw.

NOTE: The illustration and information given above pertains to the advance system used on 6404D engines. The advance system used on 6466D engines is called a Servo-Advance. It is similar in that fuel pressure from the transfer pump is used to move the advance piston, but differs in that a pilot piston (located in advance piston bore) covers or uncovers ports to move the cam ring. Thus, pump timing is advanced or retarded. A trimmer screw is used to provide adjustment of the advance. Trimmer screw is located between pump body and cylinder block.

Adjustments

Speed Advance (4270D; 6404D)

Before adjusting the speed advance, be sure the injection pump is correctly static-timed. See "Installation".

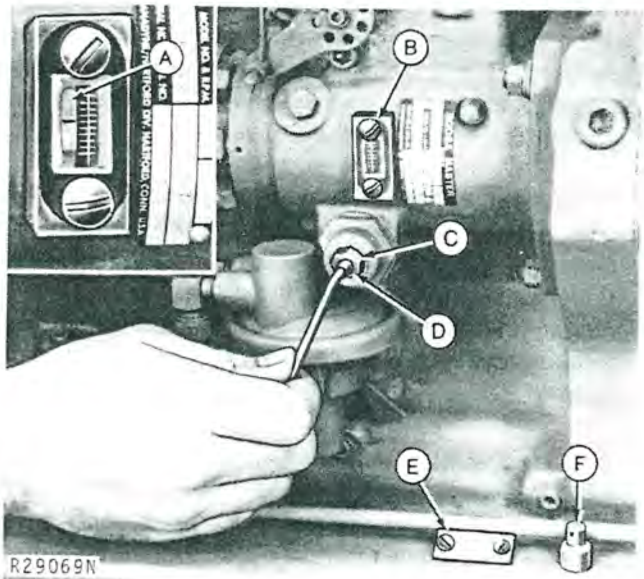
Disconnect the tachometer drive cable from engine and install JDE-28 adapter. Connect an accurate tachometer to the adapter.

Remove the timing hole cover (E), and install No. 13366 (4270D) or No. 19918 (6404D) Timing Window (B, Fig. 12). Refer to "SPECIAL TOOLS".

NOTE: A new speed advance gauge (JDF-21) is available for use on all DB, JDB, JDC, and DM injection pumps. This gauge has 1/4-degree graduations (instead of two-degree marks on timing window) and may be used in place of either the No. 13366 or 19918 timing windows given above. See page 230-00-4.

Start the engine and bring to operating temperature.

Adjustments—Continued



A—Cam Ring
B—Timing Window
C—Lock Nut
D—Adjusting Screw
E—Timing Hole Cover
F—Seal Cap

Fig. 12-Adjusting Speed Advance (6404D Shown)

Remove the sealing wire and seal cap (F, Fig. 12) from side of injection pump. Loosen lock nut and turn the advance adjusting screw (D). On 6404D engines, turn the screw out to retard timing and in to advance timing. On 4270D engines, turn the screw in to retard timing and out to advance timing. Adjust the speed advance to the setting specified below:

Engine	Deg. Advance (Full Load) Set	Min. Movement
4270DR (Reg. Governor)	4° at 1900	4-1/2° by 2500
4270DF (3-5% Governor)	1° at 900	3-1/2° by 1350
6404DR and DF (Reg. Governor)		
(357084-499999)	5° at 1700	5-1/2° by 2100
(500000-)	—	8-1/2° by 2100
6404DR and DF (3-5% Governor)		
(357084-499999)	4° at 1300	5-1/2° by 1650
(500000-)	—	8-1/2° by 1500
6404TR-13 and AR-09		
(-357083)	5° at 1900	5-1/2° by 2200

After adjusting the speed advance, tighten the lock nut, and install seal cap and sealing wire.

Remove timing window, and install timing hole cover.

If the automatic speed advance cannot be adjusted to specifications, remove the pump from engine, and repair (Sect. 30, Group 10).

Speed Advance (6466D)

Before adjusting the speed advance, be sure the injection pump is correctly static-timed. See "Installation", Section 30, Group 10.

Disconnect the tachometer drive cable from engine and install JDE-28 adapter. Connect an accurate tachometer to the adapter.

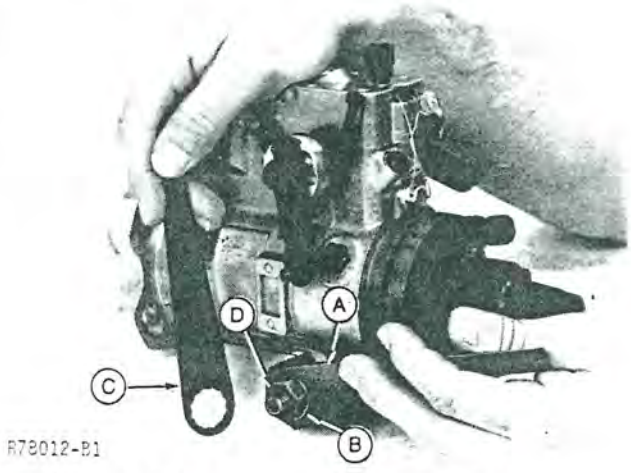
Remove the timing hole cover (E), and install No. 19918 timing window (B, Fig. 12). Refer to "SPECIAL TOOLS", Group 00, this Section.

NOTE: A new speed advance gauge (JDF-21) is available for use on all DB, JDB, JDC, and DM injection pumps. This gauge has 1/4-degree graduations (instead of two-degree marks on timing window) and may be used in place of the No. 19918 Timing Window. See page 230-00-4

Start the engine and bring to operating temperature.

Remove the sealing wire from the side of injection pump.

NOTE: Speed control rod may be removed to facilitate adjustment of speed advance.



A—JDF-18-2 Tool
B—End Plug Lock Nut
C—JDF-18-1 Tool
D—Trimmer Screw Lock Nut

Fig. 13-Loosening Trimmer Screw Lock Nut (6466D Engine) (Pump removed for illustrative purposes)

Place JDF-18-2 Tool (A, Fig. 13) on spring slide lock nut (B). Place JDF-18-1 Tool (C) on trimmer screw lock nut (D). Loosen trimmer screw lock nut, making sure spring slide lock nut does not come loose. Remove both tools.

A—JDF-18-2 Tool B—Trimmer Screw

Fig. 14-Adjusting Speed Advance (6466D Engine) (Pump removed for illustrative purposes)

Place Allen head end of JDF-18-2 Tool (A, Fig. 14) into trimmer screw (B). While holding trimmer screw lock nut with JDF-18-1 Tool, turn trimmer screw out to advance and in to retard. Each mark on the timing window represents 2 degrees. Adjust the speed advance to the specified setting at rpm given in the table below.

Engine	Deg. Advance (Full Load) Set	Min. Movement
6466DR and DF		
Regular Governor	—	9° ± 1/2° by 2100
3-5% Governor	—	8° ± 1/2° by 1500

After adjusting the speed advance, tighten the lock nut, and install seal cap and sealing wire.

Remove timing window, and install timing hole cover.

If the automatic speed advance cannot be adjusted to specifications, remove the pump from engine, and repair.

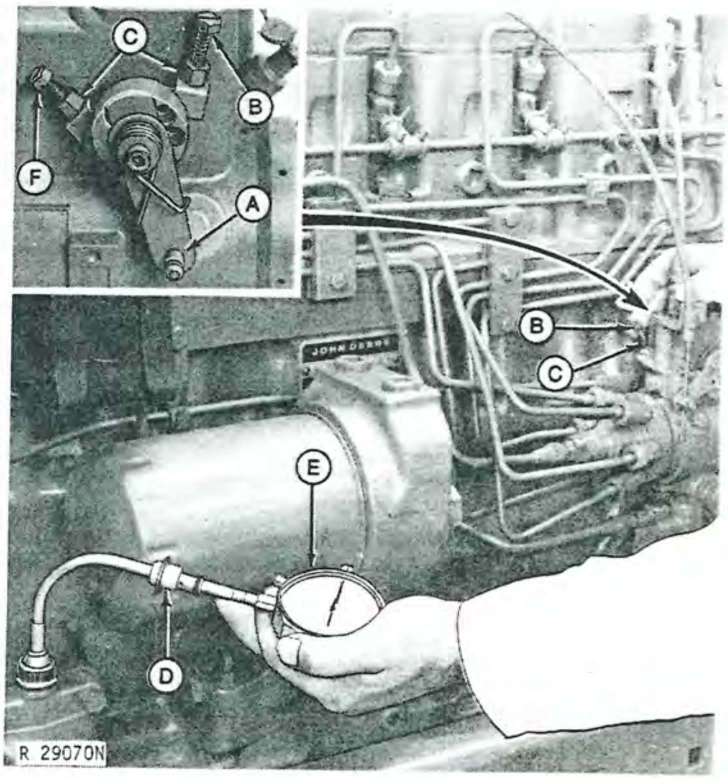
Pump Idle Speeds

Move pump shut-off lever all the way forward against its stop in "run" position. Operate engine until it is thoroughly warmed up.

CAUTION: To avoid possible personal injury, do not make any adjustments while engine is running.

Disconnect throttle cable from injection pump.

Fast Idle Speed



A—Throttle Lever
B—Fast Idle Screw
C—Lock Nut
D—JDE-28 Adapter
E—Hand Tachometer
F—Slow Idle Screw

Fig. 14-Checking Pump Fast Idle Speed

To check the fast idle speed, disconnect the tachometer drive cable and install JDE-28 Speed Adapter (D, Fig. 14).

Adjustments—Continued

With the engine running, move the throttle lever (A) forward so that the fast idle stop screw (B) is against its stop. Use an accurate tachometer similar to D-05011-ST Indicator (E) and JDE-28 Speed Adapter for measuring the fast idle speed.

Read fast idle speed and compare to the following specifications. Always stop engine before making any adjustments.

FAST IDLE SPEED SPECIFICATIONS (Roosa Master)

4270DR (Reg. Governor)	2750 rpm
4270DF (3-5% Governor)	1900 rpm
6404DR & DF (Reg. Governor)	2400 rpm
6404DR & DF (3-5% Governor)	1900 rpm
6404TR-13 and AR-09	2650 rpm
6466DR (Reg. Governor)	2400 rpm
6466DF (3-5% Governor)	1900 rpm

Tighten lock nut (C) securely.

Slow Idle Speed

With the engine running, move the throttle lever (A, Fig. 14) rearward, so that slow idle screw (F) is against its stop. Check slow idle speed using same method as fast idle speed described above.

SLOW IDLE SPEED SPECIFICATION

All engines	800 rpm

Tighten lock nut (C) securely. Connect tachometer drive cable and throttle cable.

Refer to Group 15 of this Section for speed control linkage adjustment information.

FUEL INJECTION PUMP - "T" AND "A" ENGINES

General Information

Robert Bosch fuel injection pumps are used on "T" and "A" engines as follows:

Engine	Pump Model
6404T	A-2000
6404A	A-3000
6466T	A-2000
6466A	P-110

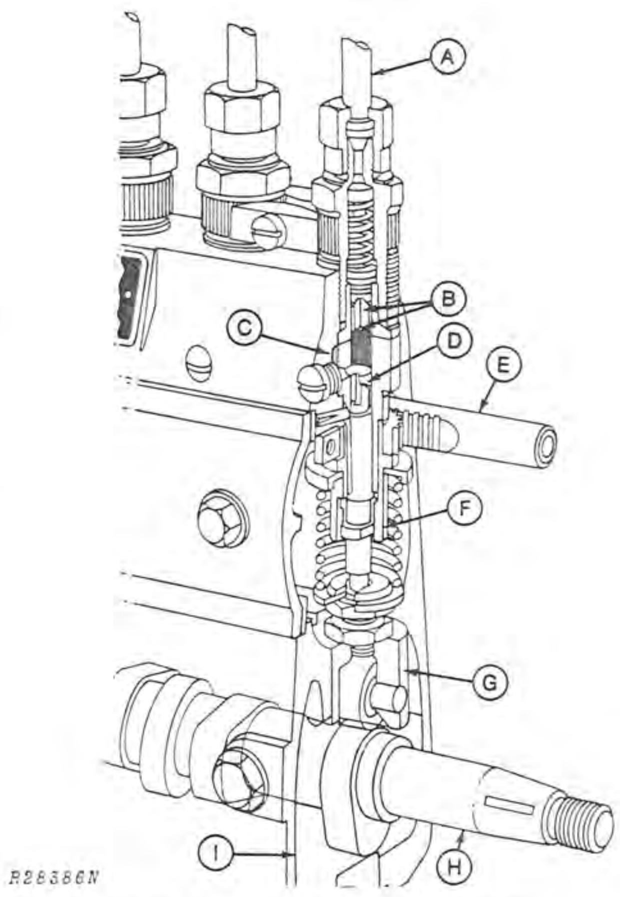
These pumps are a multiple-plunger, in-line type, equipped with a mechanical flyweight governor. An engine-driven gear on the pump camshaft drives the pump at one-half engine speed.

For information on how a Robert Bosch pump operates, refer to TM-1065, "Fuel Injection Equipment - Robert Bosch".

How The Fuel Injection Pump Works

Filtered fuel under pressure by the supply pump fills the injection pump fuel gallery (C, Fig. 15). As the camshaft rotates, roller tappets (G) riding on the camshaft lobes operate the plungers (D) to supply high pressure fuel through the delivery valves (B) to the injection nozzles.

A governor-operated control rack (E) is connected to the control sleeves (F) and plungers to regulate the quantity of fuel delivered to the engine.



A—Fuel Delivery Pipe
B—Delivery Valve
C—Fuel Gallery
D—Barrel and Plunger
E—Control Rack
F—Control Sleeve
G—Roller Tappet
H—Camshaft
I —Housing Crankcase
Injection Pressure
Supply Pump Pressure
Engine Lube Oil

Fig. 15-Section View of Robert Bosch A-Series Injection Pump

Engine lubricating oil is piped to the injection pump crankcase (I) to provide splash lubrication of the working parts. Two drain holes at the front end of the pump determine the level of oil maintained in the crankcase. Excess oil drains out these holes and returns back to the engine through the timing gear housing.

FUEL INJECTION PUMP DIAGNOSING MALFUNCTIONS CHART

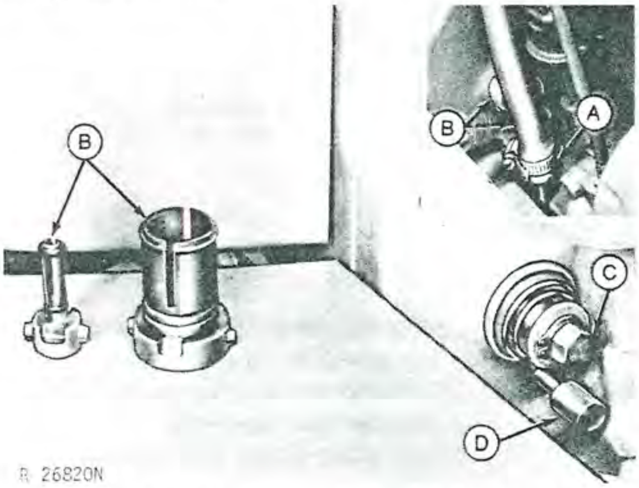
PROBLEM	POSSIBLE CAUSE	SUGGESTED REMEDY
Engine Starts Hard or Won't Start	Injection pump control rack not moving all the way forward.	
	a. Incorrect fuel shut-off lever position	Adjust shut-off cable if required (Section 230, Group 15).
	b. Defective injection pump	Remove pump from engine and repair (Section 30, Group 10).
	Injection pump not correctly timed	Check pump timing (this page).
	Defective injection pump	Remove pump from engine and repair (Section 30, Group 10).
Slow Idle Speed Irregular	Slow idle stop screw improperly adjusted	Recheck stop screw adjustment Section 230, Group 10).
	Supplementary idling spring improperly adjusted	Recheck adjustment (Section 230, Group 10).
	Defective injection pump	Remove pump from engine and repair (Section 30, Group 10).
Engine Horsepower Low	Pump not properly timed	Check timing (this page).
	Defective injection pump	Remove pump from engine and repair (Section 30, Group 10).

Adjustments

Checking Pump Timing

To check pump timing, perform the following steps:

1. Position engine at TDC, with No. 1 piston on the compression stroke.

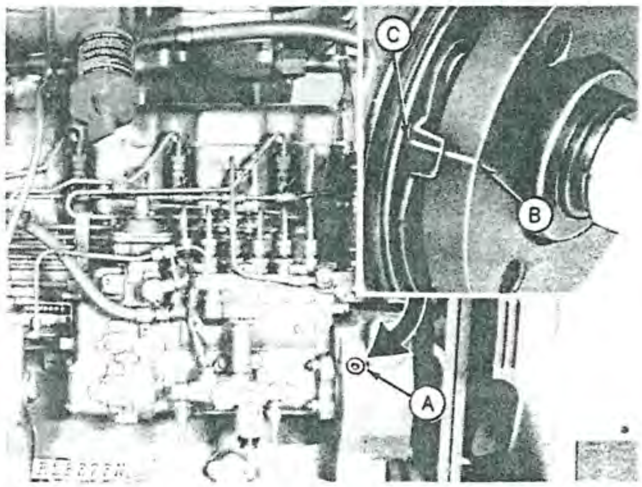


A—Crankcase Vent Hose
B—Plastic Plugs
C—Engine Rotation Tool
D—Timing Pin

Fig. 16-Installing JDE-81-1 Engine Rotation Tool and JDE-81-4 Timing Pin

2. Disconnect the crankcase vent hose (A, Fig. 16) and lower vent tube from engine. Remove two plastic cover plugs (B) from flywheel housing next to oil pressure sending unit.

3. Install JDE-81-1 Engine Rotation Tool (C) in flywheel housing.



A—Timing Hole Plug
B—Drive Hub Mark
C—Pointer Mark

Fig. 17-Injection Pump Timing Marks

4. Remove the timing hole plug (A, Fig. 17), and by looking into hole, observe when the pump drive hub mark (B) comes in alignment with the pointer mark (C) as the engine is turned. At this position, the JDE-81-4 Timing Pin (D, Fig. 16) should enter the hole in flywheel.

NOTE: The normal backlash of gears is enough to throw the pump timing off by several degrees, resulting in poor engine performance. To avoid backlash, always approach the timing mark on the pointer by turning engine in direction of rotation.

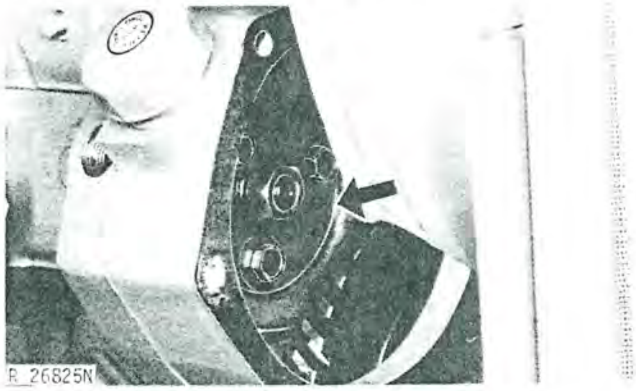


Fig. 18-Injection Pump Drive Gear

5. If the marks are not in line when timing pin enters hole, loosen the pump gear cap screws (Fig. 18), and bring marks into alignment.

Tighten drive gear cap screws and pump mounting stud nuts to 35 ft-lbs (47 Nm) (4.7 kgm) torque.

6. Rotate the engine 1-1/2 revolutions in direction of rotation. Continue to turn the engine until the timing pin drops in flywheel hole for TDC. Recheck alignment of marks, repeating above procedure, if necessary, until marks are aligned.

7. Install gear cover plate and timing hole plug (A, Fig. 17).

Checking Pump Idle Speeds

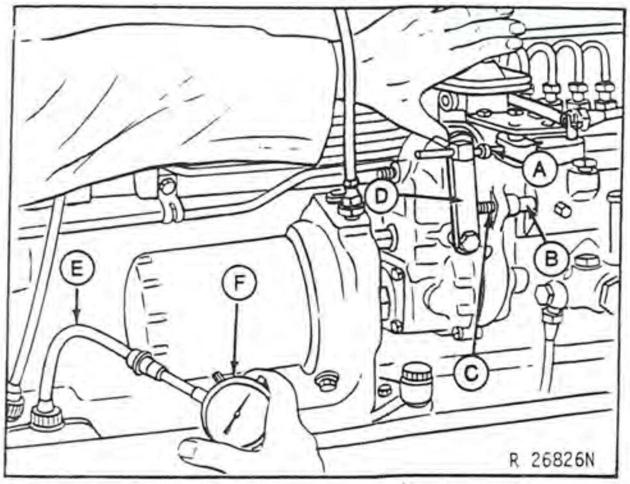
Idle speed adjustment is essentially the same for A-2000, A-3000 and P-110 pumps. Early 6404T (357084-445569) and A (357084-445947) engines equipped with an aneroid are fitted with a mechanical starting fuel control linkage. 6404T and A engines that have an aneroid after these serial numbers use a hydraulic aneroid activator. All 6466T and A engines equipped with an aneroid use the hydraulic aneroid activator.

To check and adjust pump idle speeds:

1. Move pump shut-off lever forward against its stop. Bring engine up to normal operating temperature.

CAUTION: To avoid possible personal injury, do not make any adjustments while the engine is running.

2. Disconnect throttle and rack puller cables at the pump.



A—Stop Collar
B—Sealing Capsule
C—Fast Idle Screw
D—Governor Lever
E—JDE-28 Speed Adapter
F—Hand Tachometer

Fig. 19-Checking Fast Idle Speed (Early 6404 Shown)

3. On early 6404T and A engines, loosen stop collar (A, Fig. 19) to permit free movement of governor control lever (B).

4. Disconnect tachometer drive cable and install JDE-28 Speed Adapter (E).

5. With engine running, move governor lever (D) forward against the fast idle stop screw (C).

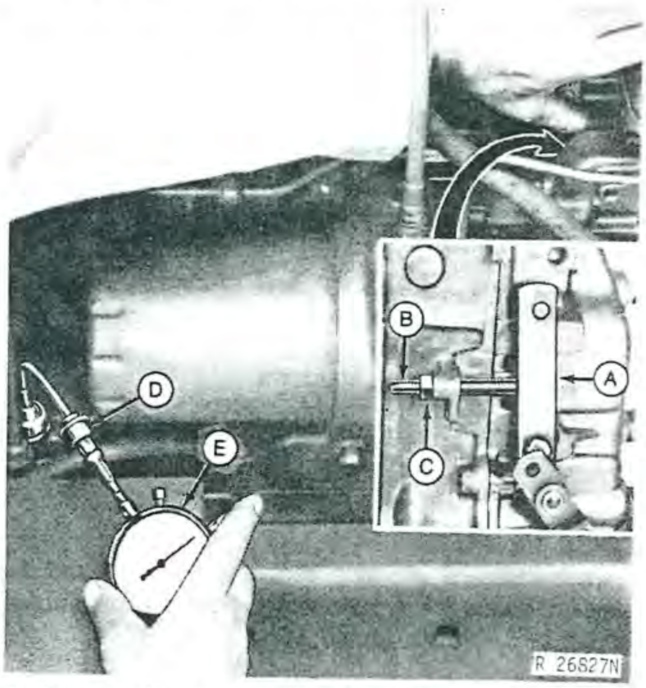
6. Use an accurate tachometer (F) such as D-05011ST Hand Tachometer and JDE-28 Speed Adapter to measure fast idle speed.

FAST IDLE SPEED SPECIFICATION (Robert Bosch)

6404TR-14 & AR-16 (357084-)	2300 rpm
6466TF (Reg. Governor)	2400 rpm
6466TF & TR-09 (3-5% Gov.)	2300 rpm
6466AF (Reg. Governor)	2300 rpm
6466AF & AR-03 (3-5% Gov.)	2200 rpm

7. If the fast idle speed is too low (but not more than 50 rpm below the specified setting), remove the fast idle stop screw sealing capsule (B) by prying it off of the stop screw.

NOTE: On some pumps, the fast idle stop screw is on the side of the pump facing the cylinder block.



A—Governor Lever
B—Fast Idle Screw
C—Lock Nut
D—JDE-28 Adapter
E—Hand Tachometer

Fig. 20-Checking Fast Idle Speed (6466A Shown)

Loosen lock nut (C, Fig. 20). On pumps with fast idle stop screw behind pump, use the special wrench found in JDF-9 Fast Idle Stop Screw Wrench Kit.

Using a screwdriver, or the special screwdriver found in the JDF-9 Kit, back out the fast idle stop screw (B) until speed is correct. Tighten lock nut.

If the fast idle speed is too high (but not more than 50 rpm above the specified setting), back out the supplementary idling spring (F, Fig. 21). Remove sealing capsule (B, Fig. 19) and loosen lock nut. Turn the fast idle screw in (toward governor lever). When correct speed is set, tighten lock nut.

NOTE: If the supplementary idling spring was backed out to make the fast idle adjustment, readjust as directed under "Checking Slow Idle Speed".

Adjustments—Continued

Checking Pump Idle Speeds—Continued

Fast Idle Speed—Continued

If the fast idle speed is more than 50 rpm above or below the specified setting, the pump will have to be removed from the engine and adjusted on the test stand. Refer to TM-1065, "Fuel Injection Equipment - Robert Bosch".

IMPORTANT: Changing the fast idle stop screw adjustment when the fast idle speed is more than 50 rpm above or below the specified setting may significantly alter the governor break-away speed. Break-away speed is the speed obtained when the pump control rack travel just starts to decrease (less fuel) after the full-load speed was reached. To correctly set the break-away speed, the pump must be adjusted on the test stand.

After completing the fast idle speed adjustment, check the slow idle speed.

Slow Idle Speed

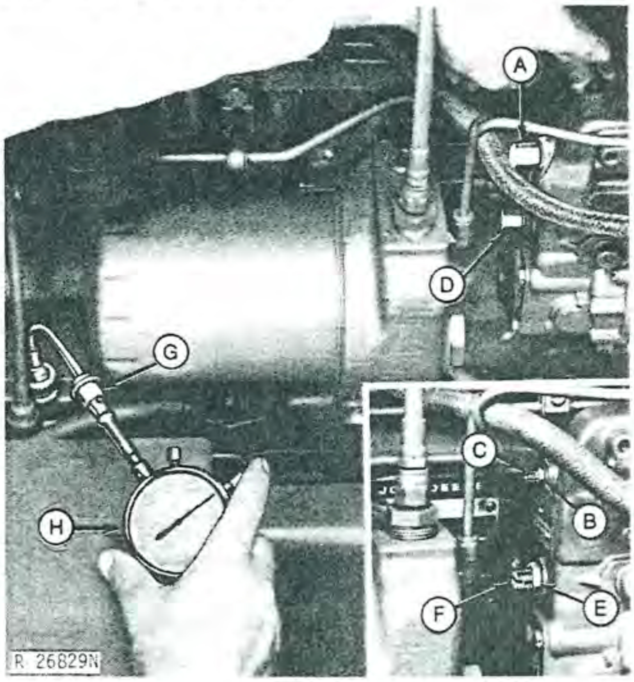
Both the slow idle stop screw (C, Fig. 21) and the supplementary idling spring screw (F) may be used to adjust the slow idle speed.

Minor adjustment of the slow idle speed may be made with the supplementary idling spring screw. However, it should not be used by itself to change engine speed more than 20 rpm, as overspeeding of the engine may result.

IMPORTANT: If slow idle stop screw and supplementary idling spring screw are not adjusted according to instruction, engine damage could result because of overspeeding.

With the engine running, pull the governor control lever rearward to the slow idle speed position, as shown in Fig. 21. The slow idle speed should be 780-820 rpm. Always stop engine before making any adjustments.

Slow Idle Speed—Continued



A—Stop Screw Cover and Washer
B—Lock Nut
C—Slow Idle Stop Screw
D—Supplementary Idling Spring Screw Cover and Washer
E—Lock Nut
F—Supplementary Idling Spring Screw
G—JDE-28 Speed Adapter
H—Hand Tachometer

Fig. 21-Checking Pump Slow Idle Speed

To adjust the slow idle speed:

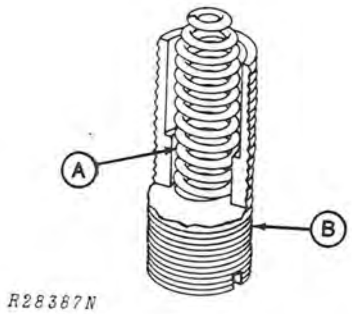
1. Remove the idling spring adjusting screw cover and washer (D, Fig. 21). Loosen lock nut (E), and back out screw (F) three turns.

2. Remove the stop screw cover with washer (A). Loosen lock nut (B) and adjust the slow idle stop screw (C) to obtain an idle speed on the low side of desired slow idle speed setting within 20 rpm.

3. Turn the supplementary idling spring adjusting screw in to increase engine speed a maximum of 20 rpm.

For example, to obtain an 800 rpm slow idle speed, use the slow idle stop screw to set speed at approximately 785 or 790 rpm. Then increase speed to 800 rpm using the supplementary idling spring screw.

NOTE: Increasing the slow idle speed a slight amount above the specified speed range may help to reduce engine surge (or hunting), if this occurs. Use the procedure given above, but do not exceed 850 rpm.



A—Spring **B—Adjusting Screw**

Fig. 22-Supplementary Idling Spring and Adjusting Screw Assembly

If engine continues to surge at slow idle, replace the supplementary idling spring and screw assembly (Fig. 22) with a new one using the procedure outlined above. The idling spring (A) is attached to the adjusting screw (B). Discard any idling spring that is bent inside the screw, as it will not function properly.

When surging or hunting persists, remove the pump from the engine, and repair as instructed in TM-1065 "Fuel Injection Equipment - Robert Bosch".

Again check the fast and slow idle speeds. Readjust, if speeds are not correct.

Check all adjusting screw lock nuts for tightness. Install covers (and copper washers) on slow idle stop screw and supplementary idling spring adjusting screw.

Connect tachometer drive cable, rack puller cable, and throttle cable.

ANEROID

General Information

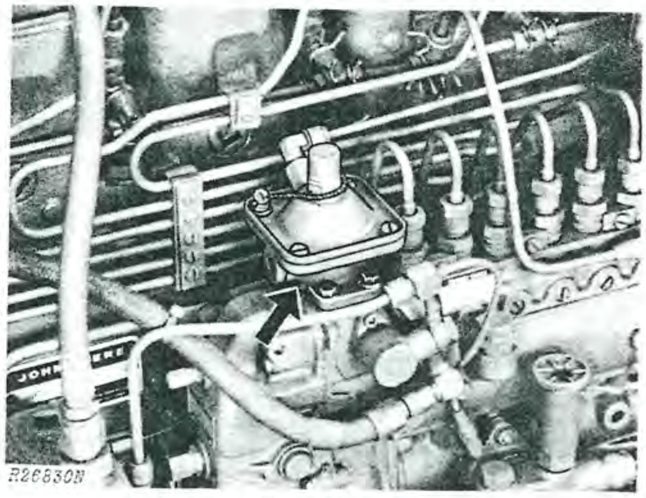


Fig. 23-Aneroid

The aneroid (Fig. 23) is a diaphragm-type control unit that mounts on top of injection pump governor housing.

Its purpose is to limit the black smoke produced during acceleration under two conditions:

(1) When load is moderate to heavy with engine speeds from 800 to approximately 1000 rpm.

(2) When load is light at any engine speed.

How The Aneroid Works

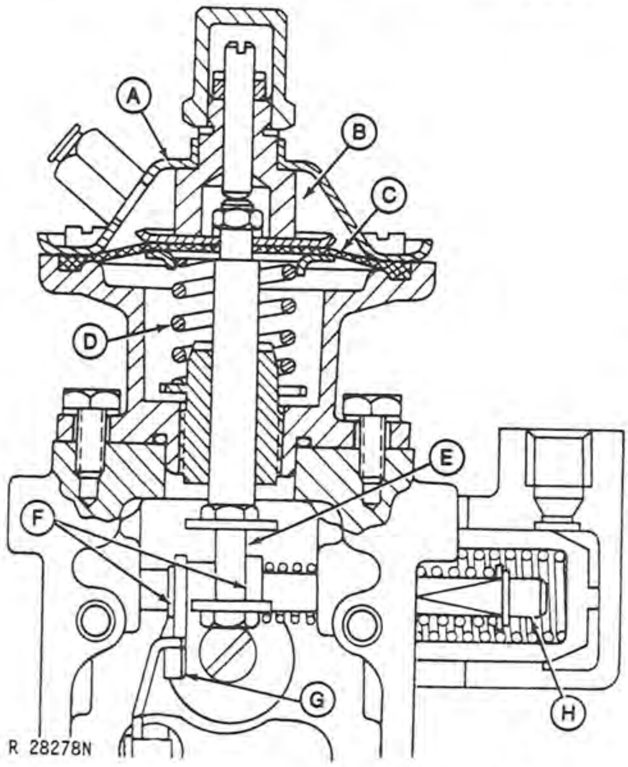
Intake manifold pressure (created by turbocharger) enters aneroid through a fitting on aneroid cover (A, Fig. 24). It is directed to upper side of diaphragm chamber (B) and exerts pressure on diaphragm (C).

When the pressure rises to approximately 10 psi (1 bar) (1 kg/cm^2), or about 1000 engine rpm under moderate to heavy loads, spring pressure (D) is overcome and diaphragm moves the adjusting shaft (E) downward.

Arm (F) has two "legs". One of the legs (outer) bears on the flat surface of adjusting shaft screw (E). The other leg (inner) bears against a shoulder on the control rack link (G).

ANEROID—Continued

How The Aneroid Works—Continued



A—Cover
B—Diaphragm Chamber
C—Diaphragm
D—Spring
E—Adjusting Shaft
F—Arm
G—Control Rack Link
H—Starting Fuel Shaft

Fig. 24-Cutaway View of Aneroid Installation

Downward movement of the adjusting shaft causes arm to rotate on starting fuel control shaft (1) and allows control rack to travel its normal amount.

If the intake manifold pressure is below 10 psi (1 bar) (1 kg/cm^2) because of low engine speed (Condition 1) or light load at higher engine speeds (Condition 2), the aneroid spring pressure is greater than the intake manifold pressure. As a result, the control rack travel is limited (therefore, fuel delivery is limited) by the arm and adjusting shaft.

Aneroid control will be in effect until the manifold pressure is high enough to overcome diaphragm spring pressure.

Diagnosing Malfunctions

Use information contained in the above chart to help diagnose aneroid malfunctions.

Refer to TM-1065 "Fuel Injection Equipment - Robert Bosch", Section 30, Group 10 and 15 for instructions on how to repair and adjust the aneroid.

The aneroid controls fuel delivery when intake manifold pressure is about 10 psi (1 bar) (1 kg/cm^2) or less. Therefore, all final adjustments are to be made on the test stand with aneroid mounted on injection pump.

IMPORTANT: Correct aneroid adjustments are essential for satisfactory engine performance. Whenever the aneroid has been disassembled or the adjustments have been altered, the injection pump (including aneroid) must be calibrated on the test stand before releasing the pump for service.

ANEROID DIAGNOSING MALFUNCTIONS CHART

PROBLEM	POSSIBLE CAUSE	SUGGESTED REMEDY
Slow Engine Acceleration	Loose pipe or broken connection at inlet fitting	Repair as required (Section 30, Group 10)
	Aneroid cover cracked around inlet fitting	Repair as required (Section 30, Group 10)
	Defective diaphragm	Repair (see TM-1065, Section 30, Group 10)
	Aneroid not correctly adjusted	Remove injection pump (Section 30, Group 10) and adjust on test stand.
Excessive Smoke When Accelerating Engine	Aneroid not correctly adjusted	Remove injection pump (Section 30 Group 10) and adjust on test stand

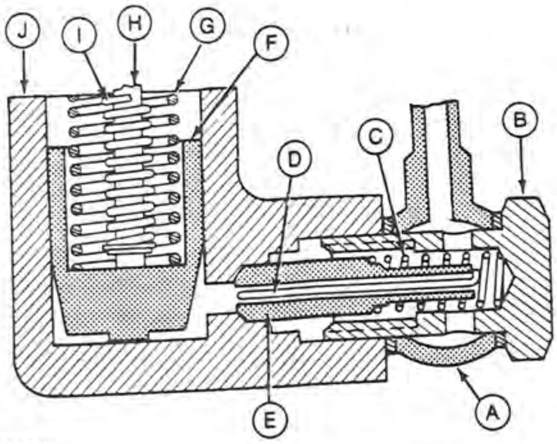
HYDRAULIC ANEROID ACTIVATOR

How The Hydraulic Aneroid Activator Works

Engine oil upon starting the engine is routed to the aneroid activator housing (J, Fig. 25) through a banjo connector (A), special screw (B), and an orifice in the capillary valve (E) to head of piston (F).

Whenever the engine oil pressure is about 9 psi (0.6 bar) or higher, the piston will overcome resistance of piston spring (G) and move the starting fuel control shaft (H) inward to provide aneroid control.

A return spring (I) on the starting fuel control shaft holds the lever arm out of engagement with the control rack link when the oil pressure is lower than the activating pressure.



R 26833N

A—Activator Banjo Connector
B—Special Screw
C—Capillary Valve Spring
D—Restrictor Wire
E—Capillary Valve
F—Piston
G—Piston Spring
H—Starting Fuel Control Shaft
I —Return Spring
J —Activator Housing

Fig. 25-Cross-Sectional View of Hydraulic Aneroid Activator

A restrictor wire (D) is inserted in the capillary valve for two reasons:

(1) To retard engagement of the aneroid when engine is cold.

(2) To help maintain an open passage in the capillary valve (oil pressure action moves the wire enough to prevent orifice from plugging).

The length of time required to achieve aneroid control depends on the ambient air temperature and the viscosity of the motor oil. Warm ambient air temperatures will permit the aneroid to activate in a few seconds. Cold temperatures may delay activation for several minutes.

The following chart gives the approximate ambient temperature-engagement time based on different engine lubricating oil viscosities:

Ambient Temp. °F (°C)	Engine Crankcase Oil	Engagement in Seconds (Approx.)
30(−1)	SAE 30	86
1(−18)	10W-20	255
−20(−29)	5W-20	360

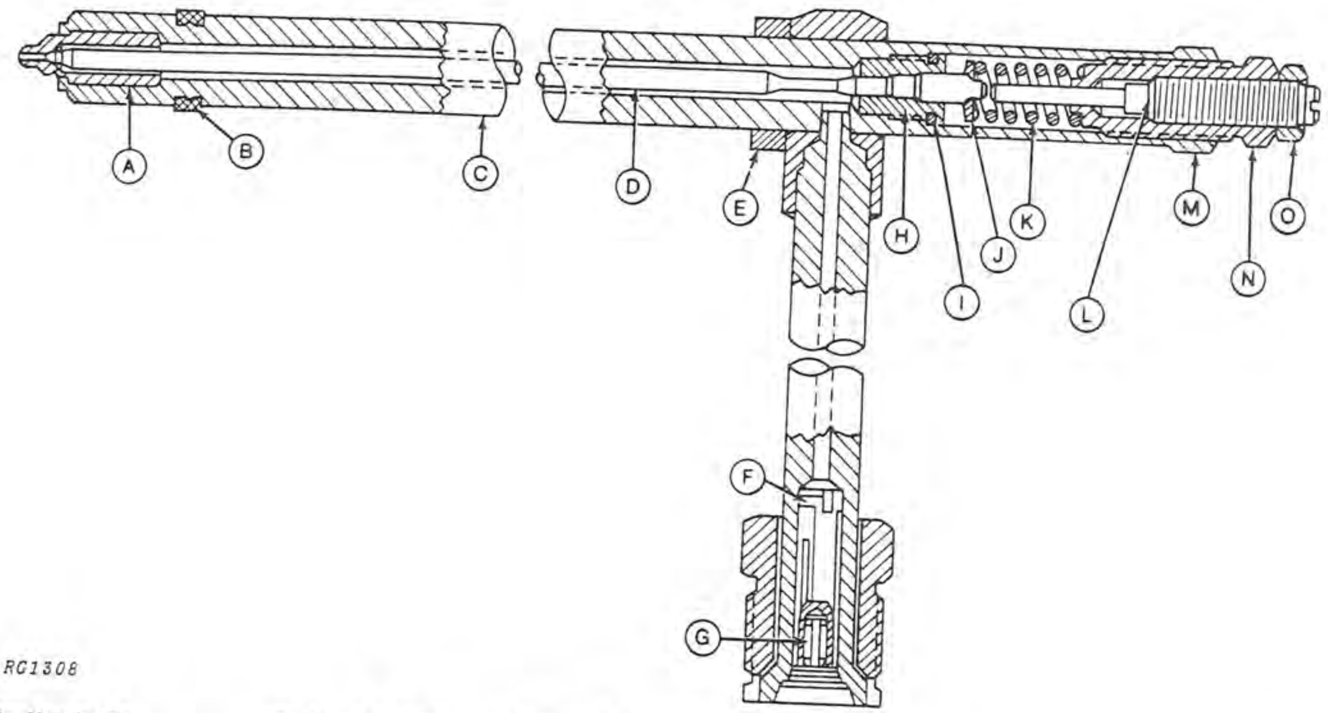
Diagnosing Malfunctions

Use information contained in the chart below to help diagnose hydraulic aneroid activator malfunctions. When repair is required, refer to Section 30, Group 10.

HYDRAULIC ANEROID ACTIVATOR DIAGNOSING MALFUNCTIONS CHART

PROBLEM	POSSIBLE CAUSE	SUGGESTED REMEDY
Engine Starts Hard	Broken return spring on starting fuel control shaft.	Repair (Section 30, Group 10)
	Retaining ring missing from starting fuel control shaft.	Repair (Section 30, Group 10)
Excessive Smoke When Accelerating Engine	Check for restriction in oil supply passages to activator piston.	Disassemble activator (Section 30, Group 10)

9.5 mm FUEL INJECTION NOZZLES



A—Nozzle Tip
B—Carbon Stop Seal
C—Nozzle Body
D—Nozzle Valve
E—Seal Washer
F—Edge Filter
G—Spring Pin
H—Upper Guide
I —Upper Guide Seal
J—Spring Seat
K—Spring
L—Lift Adjusting Screw
M—Lock Nut
N—Pressure Adjusting Screw
O—Lock Nut

Fig. 26-Roosa-Master 9.5 mm Fuel Injection Nozzle

General Information

Roosa-Master 9.5 mm fuel injection nozzles are used on all 4270D engines and on 6404D engines with Engine Serial Number (-49999).

The injection nozzles are located in the cylinder head and are of the spring and valve type. They are hydraulically operated by fuel delivered from the injection pump.

Enclosed in the nozzle body (C, Fig. 26) are the valve (D), valve spring (K) and spring seat (J). The nozzle operating pressure is controlled by the pressure adjusting screw (N) in the upper end of the nozzle body.

Valve lift is controlled by the lift adjusting screw (L) located in the pressure adjusting screw.

The carbon stop seal (B) on the lower end of the nozzle body prevents carbon from collecting around the nozzle in the cylinder head.

The nozzle is held secure in the cylinder head with a locating clamp and cap screw.

How The Fuel Injection Nozzle Works

Metered fuel under high pressure is delivered to the nozzle inlet from the injection pump. This fuel passes the edge filter (F) and fills the area surrounding the nozzle valve.

When fuel reaches nozzle opening pressure, typically about 3200 psi (221 bar) (225 kg/cm²), the valve is forced from its seat against the pressure of the spring.

When the valve lifts from its seat, the measured amount of fuel enters the combustion chamber at high velocity through the orifices in the nozzle tip.

After the fuel has been injected, the spring closes the valve. A small amount of fuel leaks past the valve to lubricate the working parts of the nozzle. This excess fuel is returned to the fuel tank through the fuel leak-off fitting at the top of the nozzle.

DIAGNOSING MALFUNCTIONS CHART

PROBLEM	POSSIBLE CAUSE	SUGGESTED REMEDY
Engine Has Low Horsepower	Nozzle orifices plugged	Clean (Section 30, Group 10)
	Nozzle return lines clogged	Clean (Section 30, Group 10)
	Nozzles faulty or sticking	Repair (Section 30, Group 10)
Engine Emits Too Much Smoke	Nozzles faulty or sticking	Repair (Section 30, Group 10)
	Nozzle orifices plugged	Clean (Section 30, Group 10)

KDL AND KDEL FUEL INJECTION NOZZLES

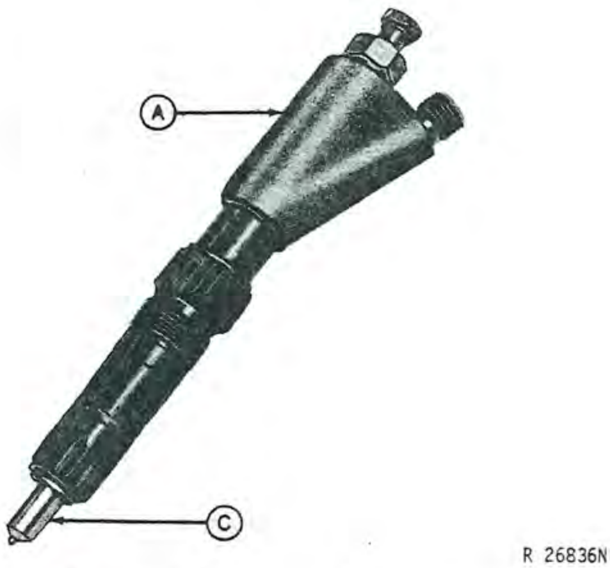
General Information

Two different model Robert Bosch 21 mm injection nozzle holders (Figs. 27 and 28) are used:

Model KDL
6404T, A Engine Serial No. (-445569)

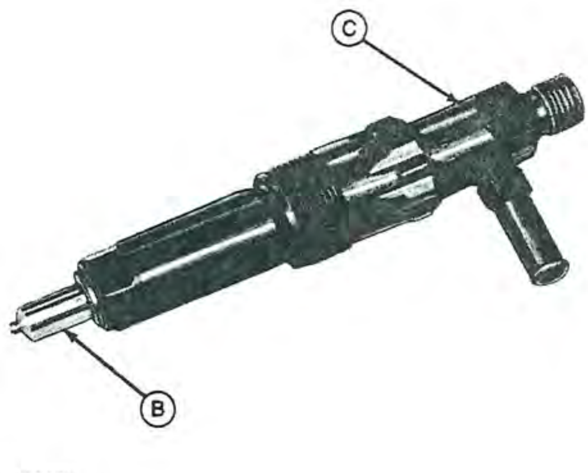
Model KDEL
6404D Engine Serial No. (500000-)
6404T, A (445570-)
6466T, A

Both model nozzle holders use the model DLLA nozzle; a multi-hole type with an inward opening valve. All DLLA nozzles are identical, with the exception of the number and diameter of spray orifices used, which varies with the particular engine model.



A—KDL Nozzle Holder **B—DLLA Nozzle**

Fig. 27-Model KDL 21 mm Fuel Injection Nozzle

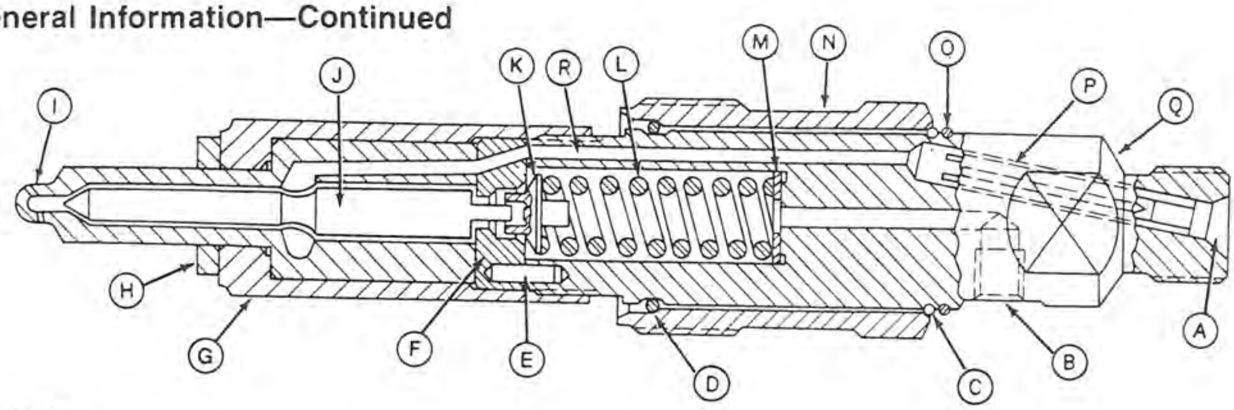


B—DLLA Nozzle **C—KDEL Nozzle Holder**

Fig. 28-Model KDEL 21 mm Fuel Injection Nozzle

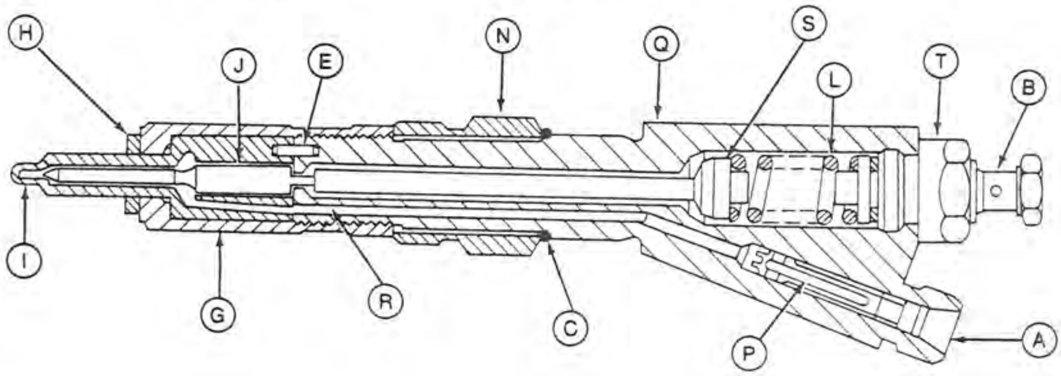
KDL AND KDEL FUEL INJECTION NOZZLES—Continued

General Information—Continued



A—Fuel Inlet
B—Leak-Off Connection
C—O-Ring
D—Snap Ring
E—Dowel Pin
F—Intermediate Plate
G—Nozzle Retaining Nut
H—Washer
I —Nozzle
J —Valve
K—Spring Seat
L—Spring
M—Shims
N—Gland Nut
O—Snap Ring
P—Edge-Type Filter
Q—Nozzle Holder
R—Fuel Passage

Fig. 29-Cross-Sectional View of KDEL—21 mm Injection Nozzle



S—Spindle
T—Screw Plug

Fig. 30-Cross-Sectional View of KDL—21 mm Injection Nozzle

Notice Figures 29 and 30. The nozzle valve (J) is held on its seat by a spindle (S) and spring (L) for KDL holders, or a spring (L) only, for KDEL holders. Shims (M) are used to regulate nozzle opening pressure.

The nozzle (I) and valve are fitted together by precision lapping. These parts are referred to as a nozzle assembly, and are not serviced separately.

Correct alignment of the nozzle assembly with its holder is essential in order that the atomized fuel will be sprayed into the combustion chamber at the angle and location intended by design.

KDL holders have a dowel pin (E) which holds the nozzle assembly in correct alignment with the nozzle holder (Q). KDEL holders use an intermediate plate (F) with dowel pins (E) on both sides to insure alignment.

A retaining nut (G) is used to fasten the nozzle assembly to the holder body. The diameter of the holder body is 21 mm, and from this dimension the fuel injection nozzles are known as 21 mm nozzles.

An edge-type filter (P) is placed in the fuel inlet of nozzle holder. Its purpose is to prevent coarse, foreign particles from damaging the nozzle assembly or plugging the orifices. Finer particles pass through the filter without harm. The filter is not removable.

To provide a seal between the injection nozzle and the engine cylinder head, an aluminum or steel washer (H) is used at the base of the nozzle retaining nut.

The fuel injection nozzle is fastened to the engine cylinder head by a gland nut (N). See Fig. 31. The gland nut also functions as a jack screw to raise the injection nozzle out of cylinder head during removal.

KDL and KDEL injection nozzles will not interchange. Gland nut threads are M24 x 1.5 and M28 x 1.5, respectively.

How The Fuel Injection Nozzle Works

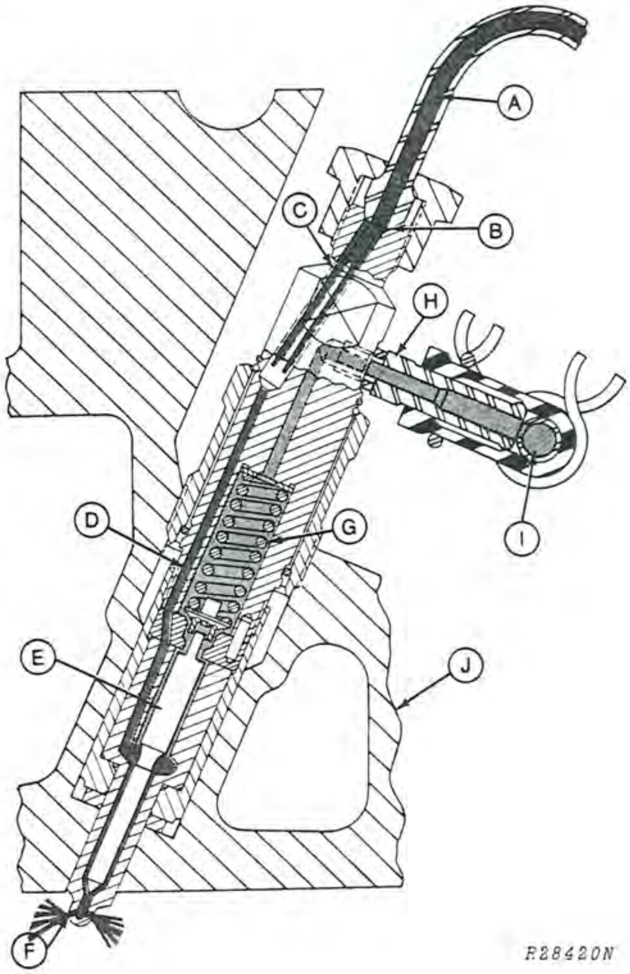
The A-2000 and A-3000 pumps pressurize the fuel to about 7500 psi (518 bar) (529 kg/cm²). The P-110 pump pressurizes fuel to about 10,000 psi (690 bar) (704 kg/cm²). Fuel pipes (A, Fig. 31) deliver the fuel to the injection nozzle.

Fuel enters the injection nozzle inlet (B), and passes through the edge-type filter (C). Coarse foreign particles are retained by the filter.

A passage (D) routes fuel through the nozzle holder to the nozzle valve (E). The nozzle valve is lifted instantly off its seat by the 7500 psi (518 bar) (529 kg/cm²) inlet fuel acting on an annulus in the valve.

NOTE: Since the nozzle valve opening pressure of a used injection nozzle is set to open at 3100 psi (214 bar) (218 kg/cm²) on the KDL, or 3800 psi (262 bar) (267 kg/cm²) on the KDEL, the inlet fuel pressure easily overcomes the resistance of the nozzle valve spring (G).

When the nozzle valve opens, a definite quantity of fuel (determined by the injection pump output for each plunger stroke) is forced out through orifices (F). The fuel becomes finely atomized as it is sprayed into the combustion chamber at high velocity.



A—Fuel Delivery Pipe
B—Fuel Inlet
C—Edge-Type Filter
D—Fuel Passage
E—Nozzle Valve
F—Orifices
G—Nozzle Valve Spring
H—Leak-Off Connector
I—Leak-Off Pipe
J—Engine Cylinder Head
High Pressure Fuel
Return Fuel

Fig. 31-Fuel Flow Through A KDEL Injection Nozzle

FUEL INJECTION NOZZLES—Continued

How The Fuel Injection Nozzle Works—Continued

As soon as the "charge" of fuel has been delivered by the injection pump plunger, the pump delivery valve closes. The nozzle valve then closes instantly to stop fuel delivery and prevent after-dribble. It stays closed until opened at the next delivery stroke.

NOTE: The injection pump delivery valve has a "relief plunger" (or sometimes called a "retraction piston") which is part of the delivery valve. Its function is to provide additional volume in the delivery valve holder for the fuel in the delivery pipe when the delivery valve closes.

The plunger (or piston) volume is as follows:

A-2000 pumps - 35 mm^3
A-3000 pumps - 50 mm^3
P-110 pumps - 70 mm^3

Diagnosing Malfunctions

Fuel injection nozzles are usually removed from the engine when there is a noticeable loss of power or excessive smoking.

Listed on the next page are various malfunctions which may occur on the 21 mm nozzles. Only possible defects related to these nozzles are listed. Failures in other components of the fuel injection system are listed under their respective headings in this group.

This increase in volume available for the fuel causes the pressure within the delivery pipe to drop suddenly to about 50 psi (3 bar) (3 kg/cm^2). When this happens, the nozzle valve closes abruptly because of the heavy spring tension exerted on it.

Operation of the delivery valve is described in more detail in TM-1065 "Fuel Injection Equipment - Robert Bosch".

The nozzle assembly is lubricated by a small amount of fuel which seeps between the lapped surfaces of the nozzle and valve. On the KDL injection nozzle, this leakage accumulates around the spindle and spring (S and L, Fig. 30), and on the KDEL nozzle, it accumulates around the spring (G, Fig. 31).

The leakage fuel is routed out the nozzle holder through a leak-off connector (H) and returned back to the fuel tank by means of a leak-off pipe (I).

FUEL INJECTION NOZZLE DIAGNOSING MALFUNCTIONS CHART

PROBLEM	POSSIBLE CAUSE	SUGGESTED REMEDY
Engine Has Low Horsepower	Nozzle orifices plugged	Repair (Section 30, Group 10)
	Incorrect nozzle valve opening pressure	Adjust (Section 30, Group 10)
	Broken or damaged parts a. Broken nozzle valve spring b. Cracked or split nozzle tip c. Cracked or split nozzle body d. Internal leak	Repair as required (Section 30, Group 10)
	Wrong nozzle and valve in holder	Install correct nozzle assembly (Section 30, Group 10)
	Nozzle loose in cylinder head	Make sure R64840 steel washer is installed on tip end of injection nozzle. Tighten to specified torque (Section 30, Group 00).
Engine Emits Too Much Smoke	Nozzle orifices plugged	Repair (Section 30, Group 10)
	Broken or damaged parts a. Broken nozzle valve spring b. Cracked or split nozzle tip c. Cracked or split nozzle body d. Internal leak	Repair as required (Section 30, Group 10)
	Wrong nozzle and valve in holder	Install correct nozzle assembly (Section 30, Group 10)
	Worn nozzle valve seat	Replace nozzle assembly (Section 30, Group 10)

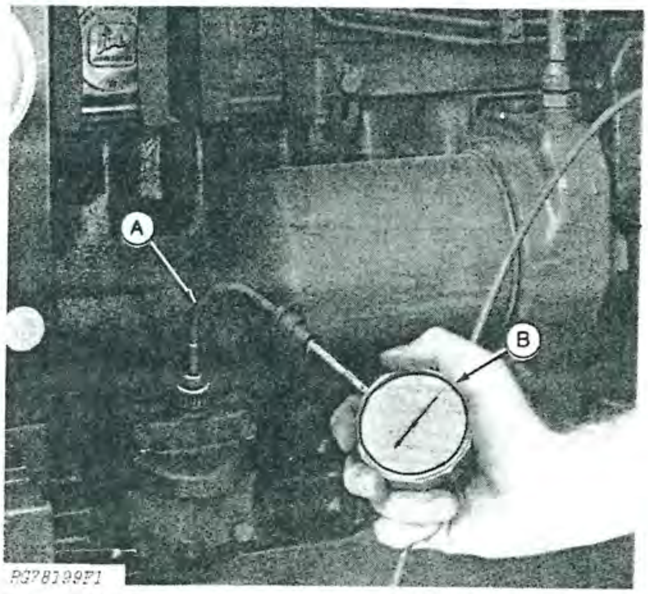
Group 15
CONTROL LINKAGE

THROTTLE CABLE

Adjustments

IMPORTANT: Before adjusting the throttle cable, be sure that the injection pump fast and slow idle speeds are correct. See page 10-13 and 14 for "D" engines and page 10-17, 18 and 19 for "T" and "A" engines for instructions on adjusting the injection pump idle speeds.

Bring engine up to operating temperature. Use the following procedure to adjust the throttle cable:



A—JDE-28 Speed Adapter **B—Hand Tachometer**

Fig. 1-Checking Engine Speeds

Install JDE-28 Speed Adapter (A, Fig. 1).

Disconnect throttle cable at fuel injection pump governor arm.

With throttle handle pushed all the way in, move governor arm back and forth slightly until hand tachometer (B, Fig. 1) indicates 780 to 820 rpm.

Tighten throttle cable clamp on governor arm.

Pull throttle handle all the way out to be sure throttle lever will contact fast idle stop screw.

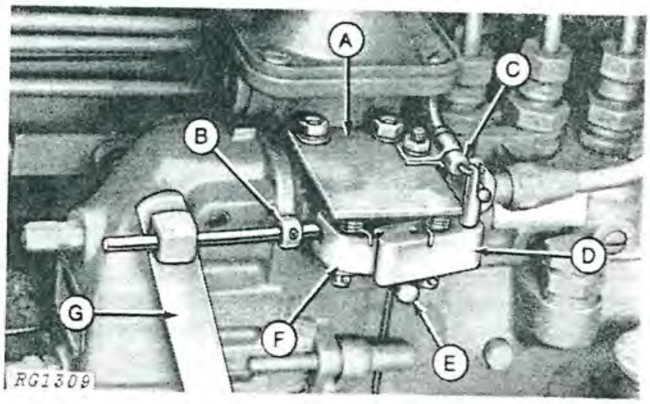
Remove JDE-28 Adapter and connect tachometer drive cable.

STARTING FUEL CONTROL LINKAGE

NOTE: Two different styles of starting fuel control linkage are used on 6404 T and A engines. Refer to page 30-15-01 to determine which type of linkage is used before attempting to adjust the linkage.

Adjustment

Early Linkage



A—Mounting Bracket
B—Collar
C—Starting Fuel Control Cable
D—Bell Crank
E—Control Shaft
F—Latch
G—Governor Control Lever

Fig. 2-Early Linkage Adjustment

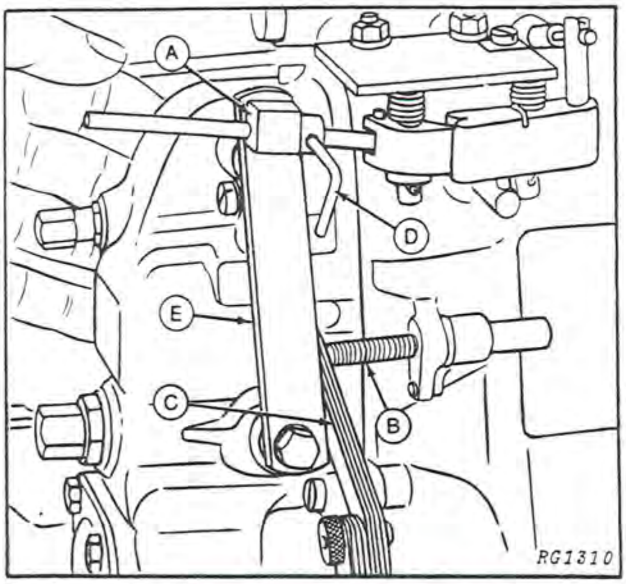
When the injection pump fuel shut-off lever is moved rearward to the engine stop position, the starting fuel control cable (C, Fig. 2) should rotate the bell crank (D) to the latched position as shown.

If bell crank does not latch when the fuel shut-off lever is moved rearward, adjust position of rear cable clamp in slotted hole of guide bracket.

If the starting fuel control shaft (E) did not move fully outward as the bell crank latched, loosen stud nuts on mounting bracket (A) and reposition bracket further away from aneroid. Tighten nuts.

STARTING FUEL CONTROL LINKAGE—Continued

Adjustment—Continued



A—Swivel
B—Fast Idle Stop Screw
C—Feeler Guage
D—Hex. Key Wrench
E—Governor Control Lever

Fig. 3-Adjusting Collar

Insert a 0.10 ± 0.01 in. (2.4 ± 0.25 mm) feeler gauge (C, Fig. 3) between the governor control lever (E) and the fast idle stop screw (B).

Push the governor lever foreard against the feeler gauge. Slide the collar (B, Fig. 2) back against the swivel (A, Fig. 3) and tighten set screw with hex. key wrench (D).

Check linkage adjustment by resetting and then activating the rack puller. Bell crank should latch.

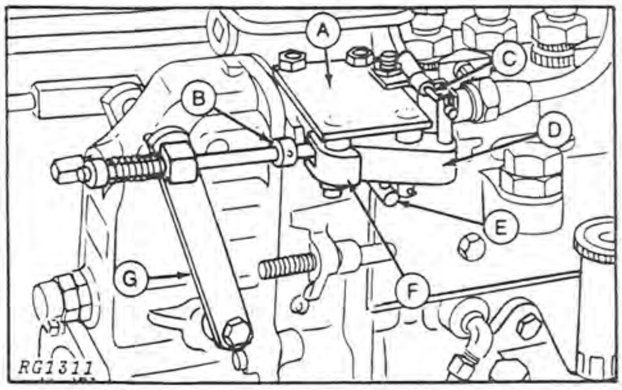
When the rack puller is reset, the bell crank should unlatch.

Recheck adjustment if linkage does not work properly.

Late Linkage

When the injection pump fuel shut-off lever is moved rearward to the engine stop position, the starting fuel control cable (C, Fig. 4) should rotate the bell crank (D) to the latched position as shown.

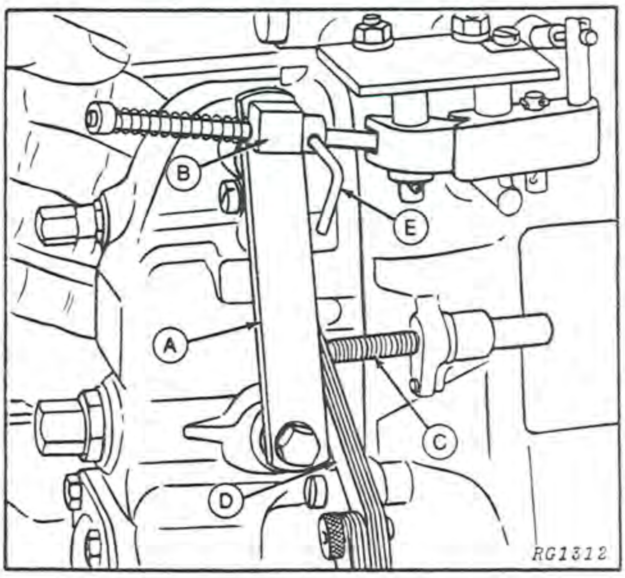
If the bell crank does not latch when the shut-off lever is moved to the rear, adjust position of rear cable clamp in slotted hole of guide bracket.



A—Mounting Bracket
B—Collar
C—Starting Fuel Control Cable
D—Bell Crank
E—Control Shaft
F—Latch
G—Governor Control Lever

Fig. 4-Late Linkage Adjustment

If the starting fuel control shaft (E) did not move fully outward as the bell crank latched, loosen stud nuts on mounting bracket (A) and reposition bracket further away from aneroid. Tighten nuts.



A—Governor Control Lever
B—Swivel
C—Stop Screw
D—Feeler Gauge
E—Hex. Key Wrench

Fig. 5-Positioning Collar

Insert a 0.10 ± 0.01 in. (2.4 ± 0.25 mm) feeler gauge (D, Fig. 5) between the governor control lever (A) and the fast idle stop screw (C).

Push the governor control lever forward against the feeler gauge. Slide front collar against swivel (B) and tighten set screw with hex. key wrench (E).

Check linkage adjustment by resetting and then activating the rack puller. Bell crank should latch.

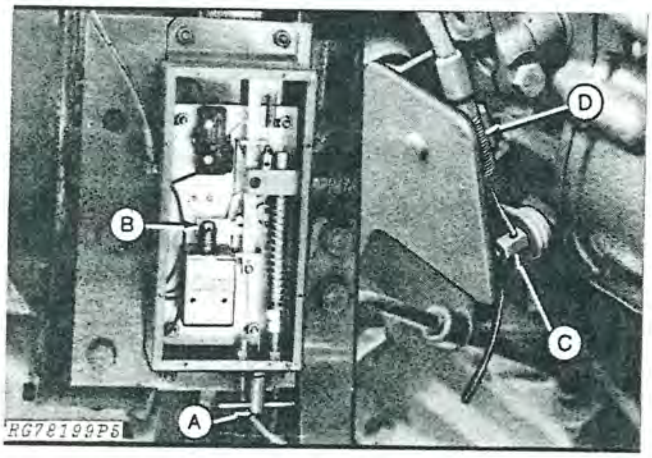
When the rack puller is reset, the bell crank should unlatch.

Recheck adjustment if linkage does not work properly.

RACK PULLER (Fuel Shut-Off Control)

"T" and "A" Stationary Engines

RP-20 Rack Puller



A—Reset Handle
B—Reset Arm
C—Cable Clamp
D—Do Not Loosen This Clamp

Fig. 6-Adjusting Rack Puller Cable

To adjust rack puller:

1. Remove cover from rack puller.

2. Reset rack puller by pulling down on reset handle (A, Fig. 6) until mechanism locks.

3. Start engine.

4. Press down on reset arm (B) to release rack puller.

5. Engine should stop. If not, loosen cable clamp (C) on injection pump shut-off arm. Move arm until engine stops. Tighten cable clamp.

6. Install cover.

RP-75 Rack Puller

1. Start engine as directed on page 10-05-6. If engine will not start, loosen cable clamp (C, Fig. 6). Have an assistant push in the rack puller knob. With knob depressed, move injection pump shut-off arm to the run position. Tighten cable clamp.

2. Stop engine. If engine will not stop, loosen cable clamp and move shut-off arm to stop position. Tighten cable clamp.

3. Recheck start and stop operation.