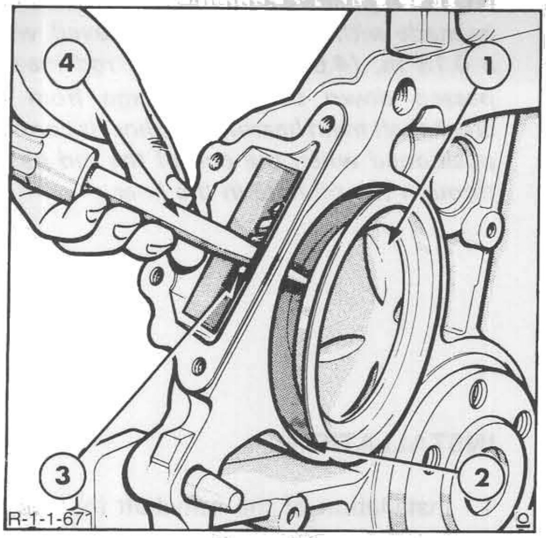


Figure 68
Camshaft Rear Cover Plate Removal

1. Rear Cover Plate
2. Sealant
3. Hydraulic Pump Drive Gear
4. Punch

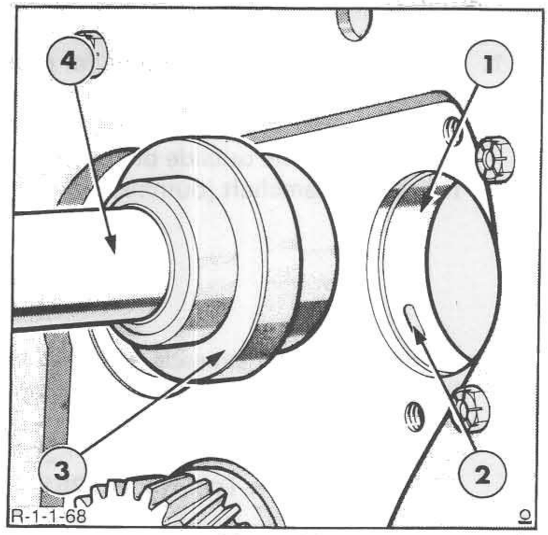


Figure 69
Camshaft Bearing Removal and Installation

1. Bearing
2. Oil Hole
3. Tool No. FT 6203 or 1255
4. Tool No. N 6261-A or 1443

6. Withdraw the bolts and lockwashers and remove the camshaft thrust plate.

7. For engines without a gear on the rear end of the camshaft, the camshaft can be withdrawn from the front of the engine. If the camshaft is equipped with a gear, the flywheel and rear cover plate must be removed and the camshaft rear cover driven out with a punch, Figure 68. Remove the key and spacer from the front of the camshaft and carefully withdraw the camshaft from the rear of the engine.

8. Lift out the tappets and place in a numbered rack to facilitate re-assembly.

INSPECTION AND REPAIR

1. Inspect the camshaft journals and lobes for damage, pitting or heat discolouration. If any of these conditions exist, install a new camshaft.

2. Inspect the oil pump drive gear on the camshaft for broken or worn teeth. Check the mating gear on the oil pump drive shaft. If any damage is apparent, install a new camshaft and/or oil pump drive gear.

3. Check each tappet for signs of chipping or other damage. Measure the diameter and renew tappets if worn beyond the limits specified see "Specifications" – Chapter 4.

4. Measure the diameter and out-of-round of the bearing journals. If the journals exceed the specified limits, see "Specifications" – Chapter 4, install a new camshaft.

Camshaft Bearings

1. Inspect the camshaft bearings for pitting or scoring. Measure the clearance between the internal diameter of the bearings and the outside diameter of the respective camshaft journals.

   If the clearance exceeds the specified limit, see "Specifications" – Chapter 4, remove and install new bearings, using Remover/Replacer Tool No. FT 6203 or 1255 and Handle, Tool No. N 6261-A or 1443, Figure 68.

2. Camshaft Bearing Removal:

   - Position Tool No. FT 6203 or 1255 against the camshaft bearing to be removed and attach Tool No. N 6261-A or 1443, Figure 69.
   - Drive the camshaft bearing from the bearing bore.

3. Camshaft Bearing Installation:

   - Align the oil holes of the new camshaft bearing with the oil holes in the engine block then drive the new bearing into place using Tool No. FT 6203 or 1255 and Handle, Tool No. N 6261-A or 1443.

NOTE: *A positive alignment check can only be made with the crankshaft removed, when a 0.18 in. (4.6 mm) diameter rod may be passed down the oil passage from the crankshaft main bearing. The liner is correctly positioned when the end of the rod passes through the oil hole in the liner.*

INSTALLATION

1. Installation of the camshaft follows the removal procedure in reverse. On installation observe the following requirements:

   - Apply petroleum jelly to each tappet foot and coat the tappet body with oil. Install the tappets in the bores from which they were removed.
   - Oil the camshaft journals and apply petroleum jelly to the cam lobes before carefully installing the camshaft into the engine.
   - Install the spacer and a new key on the front of the camshaft.
   - Align the camshaft drive gear timing mark and re-check the camshaft end-play.
   - Apply sealant ESE-M2G-114A to the sealing flange of a new camshaft cover plate when installing.

PART 1

ENGINE SYSTEMS

Chapter 3
COOLING SYSTEM

A. COOLING SYSTEM – 3-CYLINDER ENGINE DESCRIPTION AND OPERATION

The 3-cylinder engine cooling system is of the recirculating by-pass type with full length waterjackets for each cylinder. The coolant is drawn from the bottom tank of the radiator by the water pump which passes the coolant to the cylinder block. The coolant flows through cored passages to cool the cylinder walls. Passages in the head gasket allow coolant to flow from the cylinder block into the cylinder head. Cored passages conduct the coolant to fuel injector nozzle locations before reaching the thermostat.

The thermostat is located in the front of the cylinder head. When the thermostat is closed, a recirculating by-pass is provided to allow a percentage of the coolant to recirculate from the head to the block to effect a faster warm-up.

Cooling occurs as the coolant passes down through the radiator cores which are exposed to air sucked through the radiator by the fan.

The purpose of the thermostat is to maintain sufficiently high operating temperature to provide a maximum combustion and engine efficiency.

A faulty thermostat may cause the engine to operate at too hot or too cold an operating temperature resulting in improper engine performance.

NOTE: *Do not operate an engine without a thermostat. Do not use pure water only in the cooling systems. Ford New Holland recommends that a solution of 50% clean water and 50% antifreeze, no matter what degree of freeze protection is required be premixed with 5% inhibitor.*

The cooling system incorporates a drain cock on the right-hand side of the cylinder block and at the lower left-hand side of the radiator.

B. COOLING SYSTEM – 4-CYLINDER ENGINE DESCRIPTION AND OPERATION

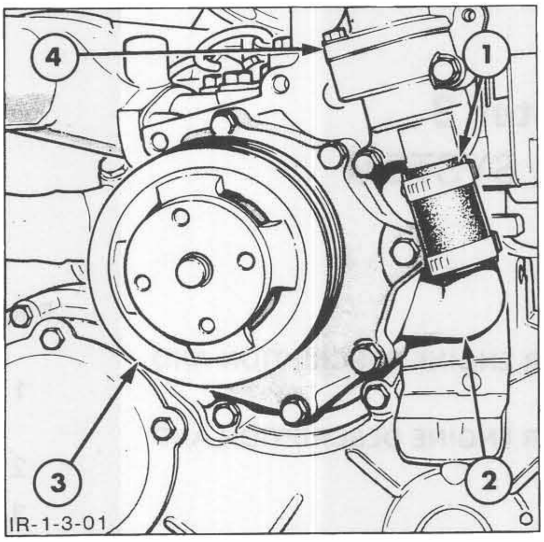


Figure 1
Water Pump and Thermostat Housing

1. By-Pass Hose
2. Water Pump By-Pass Inlet
3. Water Pump Pulley
4. Thermostat Housing

The 4 cylinder engine cooling system is of the full flow by-pass type with full length water jackets for each cylinder. The coolant is drawn from the bottom tank of the radiator by the water pump which passes the coolant to the cylinder block. The coolant flows through cored passages to cool the cylinder walls. Passages in the head gasket allow coolant to flow from the cylinder block into the cylinder head. Cored passages conduct the coolant to ful injector nozzle locations before reaching the thermostat.

The thermostat housing is situated above the rubber by-pass hose, Figure 1. When the thermostat is closed, a full flow by-pass is provided to allow the coolant to recirculate from the head, via an enternal rubber hose, to the water pump and back to the block to effect a controlled engine warm-up.

This system, in effect, will reduce any tendency for cylinder head distortion and consequent cylinder head gasket leaks.

Cooling occurs as the coolant passes down through the radiator cores which are exposed to air sucked through the radiator by the fan.

The purpose of the thermostat is to maintain sufficiently high operating temperature to provide a maximum combustion and engine efficiency.

A faulty thermostat may cause the engine to operte at too hot or too cold an operating temperature resulting in improper engine performance.

NOTE: *Do not operate an engine without a thermostat. Do not use pure water only in the cooling systems. Ford New Holland recommends that a solution of 50% clean water and 50% antifreeze, no matter what degree of freeze protection is required be premixed with 5% inhibitor.*

The Ford 655C and units with a turbocharger have an engine oil cooler (heat exchanger) in the bottom tank of the radiator to effect engine oil cooling.

The cooling system incorporates a drain cock on the right-hand side of the cylinder block and at the lower left-hand side of the radiator.

C. COOLING SYSTEM – OVERHAUL

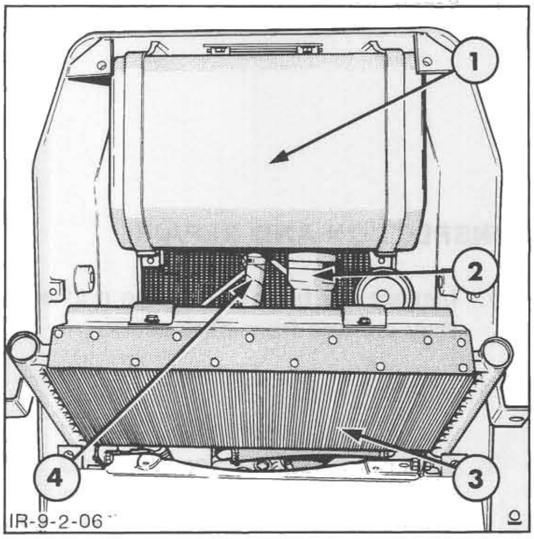


Figure 2
Hydraulic Reservoir and Hoses

1. Reservoir
2. Outlet Hose
3. Oil Cooler
4. Return Line

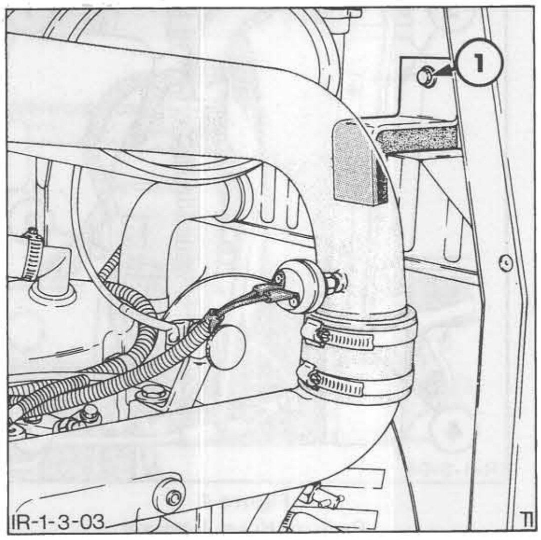


Figure 3
Radiator Upper Support Bracket

1. Support Bracket

RADIATOR

REMOVAL

1. Remove the right and left hand engine side panels.

2. Remove the vertical exhaust pipe and air intake cap assembly.

3. Remove the engine hood assembly and fan belt pulley guard, where fitted.

4. Open the drain cocks and drain the coolant. If the engine is hot carefully unscrew the radiator cap to speed up draining.

5. Drain the hydraulic oil by removing the hydraulic filter and depressing the anti-syphon valve, see Part 7, 'Hydraulic Systems, Controls and Frame'.

6. Remove the oil cooler to radiator shell retaining bolts and pivot the cooler forward to gain access to the hydraulic reservoir hoses, Figure 2.

7. Disconnect the oil return line from the cooler, Figure 2, at the reservoir.

8. Disconnect the oil outlet hose from the hydraulic reservoir, Figure 2.

9. Remove the radiator upper support bracket, Figure 3.

10. Disconnect the horn wiring at the front of the main wiring harness.

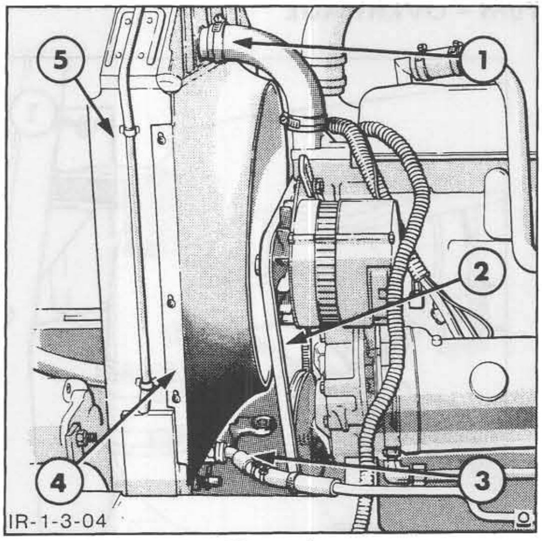


Figure 4
Radiator Hoses Removal

1. Top Hose
2. Drive Belt
3. Engine Oil Cooler Tube
4. Fan Shroud
5. Radiator

11. Disconnect the radiator and hydraulic filler flap release cable and knob at the intake manifold and secure to the radiator shell assembly.

12. Support the radiator shell with the oil reservoir tank and reove the lower radiator shell base retaining bolts.

13. Remove the radiator shell and reservoir as a unit.

14. Remove the upper and lower radiator hoses.

15. Disconnect the two engine cooler oil lines at the radiator lower coolant tank, where fitted.

16. Remove the radiator and fan shroud as an assembly.

INSPECTION AND REPAIR

1. Inspect the fins for damage and ensure they are free from obstruction.

2. Check the radiator for leaks and, if the lower tank has an engine oil heat exchanger tube installed, check the tube for leaks. If the lower tank or heat exchanger tubes leak, install a new lower tank.

INSTALLATION

1. Installation of the radiator follows the removal procedures in reverse. On installation observe the following requirements:

- Tighten all bolts and clips to the specified torque see "Specifications" – Chapter 4.
- Ensure the correct grade and quantity of water, antifreeze and chemical inhibitor is added to the cooling system, see the relevant Operator's manual for details.
- Start and run the engine for several minutes and check all connections for leaks.

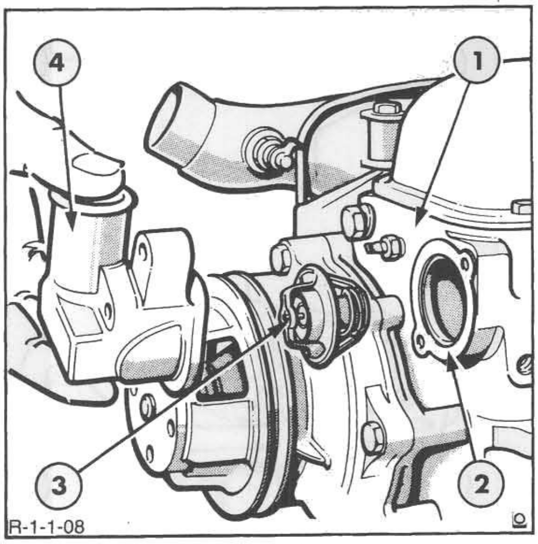


Figure 5
Coolant Outlet and Thermostat Removal
3 Cylinder Engine

1. Cylinder Head
2. Gasket
3. Thermostat
4. Coolant Outlet Connection

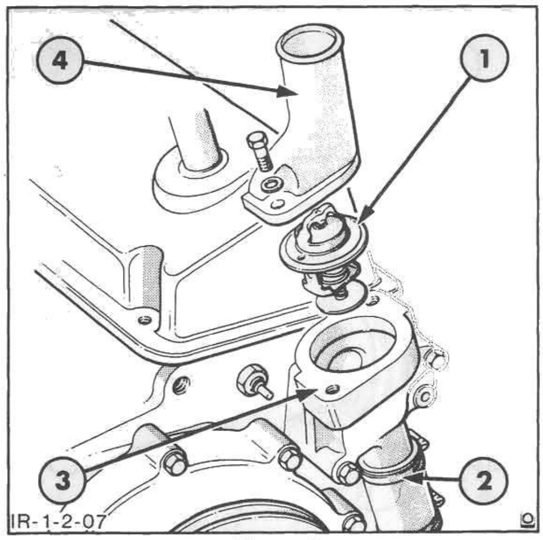


Figure 6
Thermostat Removal 4 Cylinder Engine

1. Thermostat
2. By-Pass Hose
3. Thermostat Housing
4. Coolant Outlet Connection

THERMOSTAT

REMOVAL

1. Drain the cooling system to below the level of the coolant outlet connection.

2. Remove the coolant outlet connection retaining bolts and slide the connection with the hose attached to one side.

3. Remove the thermostat and gasket, Figure 5 for 3 cylinder engines, Figure 6 for 4 cylinder engines.

INSPECTION AND REPAIR

1. Place the thermostat in a container of water and heat the water. If the thermostat valve does not open at or near the specified temperature, or fails to close, install a new thermostat. For opening temperature, see 'Specifications' – Chapter 4.

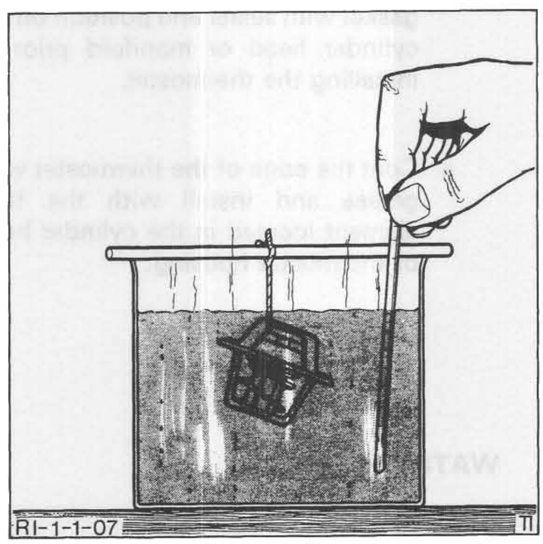


Figure 7
Checking Thermostat Opening Temperature

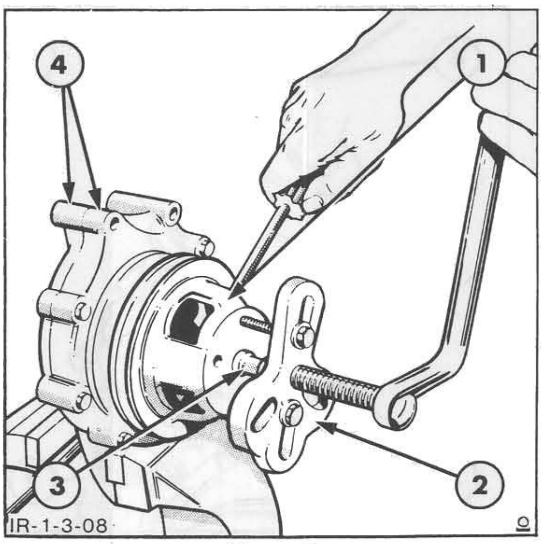


Figure 8
Water Pump Pulley Removal

1. Pulley
2. Pulley Tool No. 1001 or 9196
3. Sleeve
4. Pump Covers

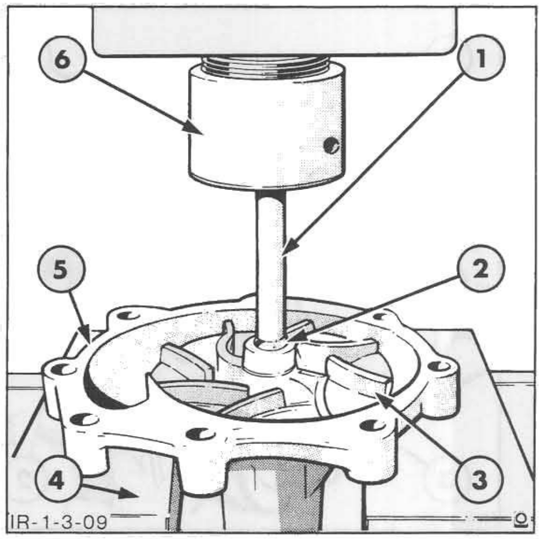


Figure 9
Water Pump Shaft and Bearing Assembly Removal

1. Adaptor
2. Shaft and Bearing Assembly
3. Impeller
4. Support
5. Front Housing
6. Press

INSTALLATION

1. Installation of the thermostat follows the removal procedure in reverse. On installation observe the following requirements:

   - Coat a new coolant outlet connection gasket with sealer and position on the cylinder head or manifold prior to installing the thermostat.

   - Coat the edge of the thermostat with grease and install with the heat element located in the cylinder head or thermostat housing.

WATER PUMP

REMOVAL

1. Drain the cooling system.
2. Remove the radiator as detailed previously in this Chapter.
3. Remove the alternator drive belt.
4. Ford 555C and 655C disconnect the by-pass hose at the outlet connection.
5. Withdraw the four bolts which pass through the water pump into the block and remove the pump.

DISASSEMBLY

1. Withdraw the attaching bolts and remove the fan from the pump pulley.
2. Use Puller Tool No. 1001 or 9196 and a sleeve slightly smaller in diameter than the pulley shaft to remove the pump pulley, Figure 8.
3. Remove the retaining bolts then separate the pump covers and discard the gasket.

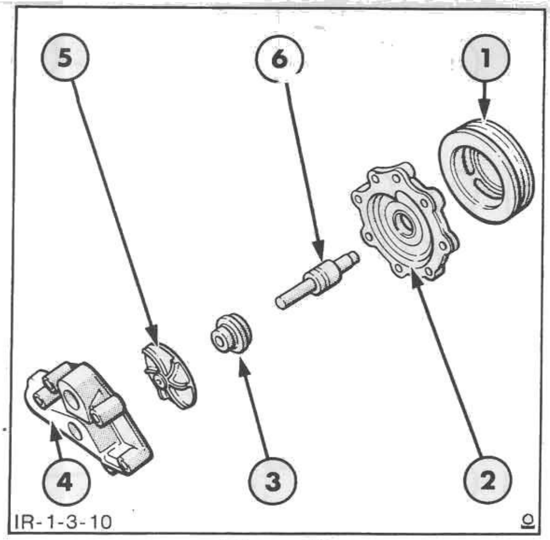


Figure 10
Water Pump Components

1. Pulley
2. Front Cover
3. Seal Assembly
4. Rear Cover
5. Impeller
6. Bearing Shaft Assembly

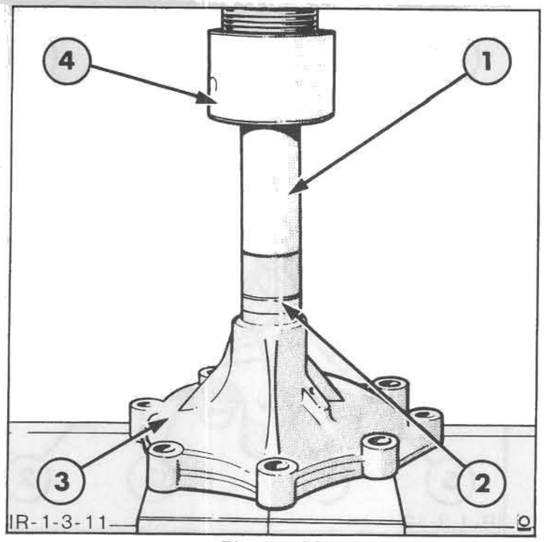


Figure 11
Water Pump Shaft and Bearing Assembly Installation

1. Sleeve
2. Shaft and Bearing Assembly
3. Front Cover
4. Press

4. Using a press and an adaptor with a diameter slightly smaller than the bearing shaft, press the bearing assembly out of the pump housing. Figure 9. Discard the bearing.

5. Use a suitable sleeve and press the seal assembly out of the impeller side of the pump housing. Discard the seal assembly.

INSPECTION AND REPAIR

1. Check the impeller for worn or damaged vanes. Install a new impeller if the vanes are damaged.

2. Check both parts of the pump housing for cracks or signs of leakage. Renew any defective parts.

RE-ASSEMBLY

1. Use a sleeve, which passes over the shaft and rests on the outside diameter of the bearing, to press the bearing and shaft assembly into the housing until the bearing is flush with the face of the housing, Figure 11. Use a straight edge to check the final position.

2. Turn the pump housing over and position in a press with the seal bore facing upwards.

3. Coat the outer diameter of the seal flange with a thin application of thread sealer and position the seal assembly over the shaft in the centre bore of the housing.

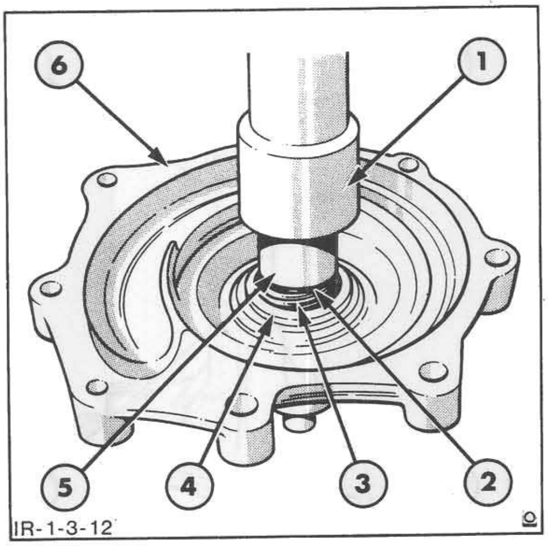


Figure 12
Water Pump Seal Assembly Installed

1. Press
2. Seal
3. Spring
4. Seal Retainer
5. Tool No. FT6209 or 4672
6. Front Cover

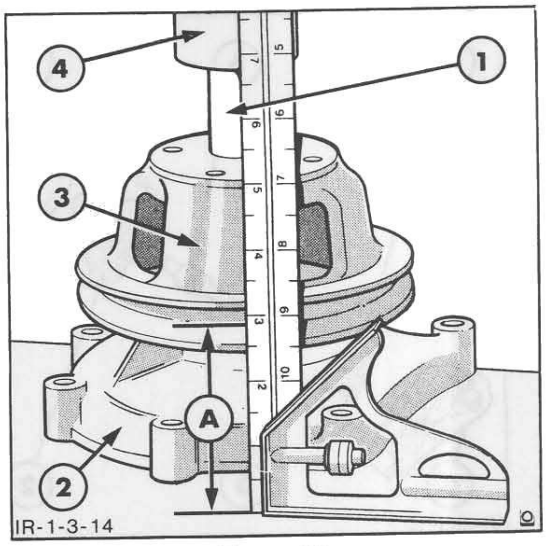


Figure 14
Water Pump Pulley Installation

A. 2.48 in. (63 mm)
1. Sleeve
2. Front Cover
3. Pulley
4. Press

4. Place Tool No. FT6209 or 4672 over the shaft and onto the seal assembly. Press the seal into the bore until the flange is flush with the top of the housing, Figure 12.

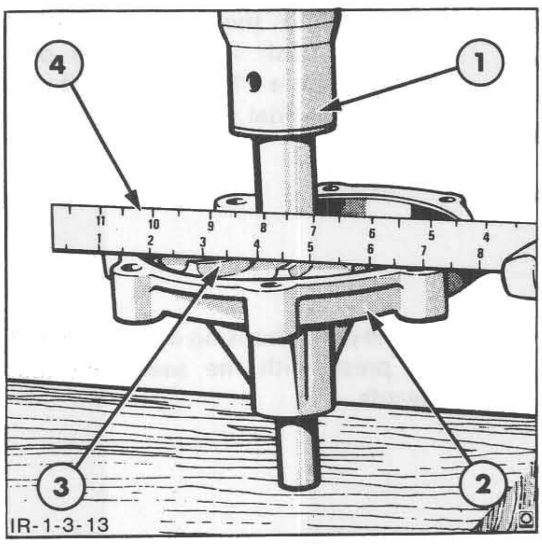


Figure 13
Water Pump Impeller Installation

1. Press
2. Front Cover
3. Impeller
4. Straight Edge

5. Support the shaft on a block of wood and use a length of pipe of suitable internal diameter to press the impeller onto the shaft and flush with the rear face of the housing. Check the final position with a straight edge, Figure 13.

6. Support the shaft on a block of wood and press the pulley onto the shaft, to the dimension shown in Figure 14. This dimension is from the rear face of the front cover to the centre of the pulley V-groove. After installation, ensure the pulley runs true on the shaft.

7. Install a new gasket and assemble the front and rear halves of the pump together and tighten the bolts to the specified torque, see 'Specifications' – Chapter 4.

8. Install the fan on the pulley and tighten the bolts to the specified torque, see 'Specifications' – Chapter 4.

INSTALLATION

1. Installation of the water pump follows the removal procedure in reverse. On installation observe the following requirements.:

   - Install a new pump gasket.
   - Adjust the alternator drive belt tension, see PART 3, 'Electrical Systems'.
   - After installation of the radiator, fill the cooling system and run the engine to check for leaks.

PART 1

ENGINE SYSTEMS

Chapter 4

TROUBLE SHOOTING, SPECIFICATION AND SPECIAL TOOLS

A. TROUBLE SHOOTING

IMPORTANT: *When effecting a repair the cause of the problem must be investigated and corrected to avoid repeat failures.*

The following table lists problems and their possible causes with recommended remedial action.

PROBLEM	POSSIBLE CAUSES	REMEDY
Engine does not develop full power—	1. Clogged air cleaner	1. Clean or renew element
	2. Fuel line obstructed	2. Clean
	3. Faulty injectors	3. Clean and reset
	4. Incorrect valve lash adjustment	4. Check and reset
	5. Burnt, worn or sticking valves	5. Renew valves and/or guides
	6. Blown head gasket	6. Check head flatness and fit new gasket
	7. Incorrect fuel delivery	7. Check injectors and pump
	8. Low cylinder compression	8. Renew piston rings or re-bore/re-sleeve as necessary

PROBLEM	POSSIBLE CAUSES	REMEDY
Engine Knocks	1. Diluted or thin oil	1. Drain and refill with specified oil and renew filter. Ascertain cause of dilution
	2. Insufficient oil supply	2. Check oil level and top up as necessary. Overhaul or renew pump as necessary Check pump filter not clogged
	3. Low oil pressure	3. Overhaul pump or relief valve as necessary
	4. Excessive crankshaft end play	4. Install new thrust bearing liner
	5. Flywheel or ring gear run-out excessive	5. Skim flywheel or fit new ring gear
	6. Excessive connecting rod or main bearing clearance	6. Install new bearing inserts and/or re-grind crankshaft
	7. Bent or twisted connecting rods	7. Renew connecting rods
	8. Crankshaft journals out-of-round	8. Re-grind crankshaft and fit undersize bearing inserts
	9. Excessive piston-to-cylinder bore clearance	9. Re-bore/re-sleeve block and fit new pistons
	10. Excessive piston ring clearance	10. Fit new pistons and rings
	11. Broken rings	11. Fit new rings. Check bore/pistons for damage
	12. Excessive piston pin clearance	12. Fit new piston pin and bush
	13. Piston pin retainer loose or missing	13. Install new retainer. Check bore/pistons for damage
	14. Excessive camshaft end play	14. Install new thrust plate
	15. Imperfections on timing gear teeth	15. Renew timing gear
	16. Excessive timing gear backlash	16. Renew timing gear

PROBLEM	POSSIBLE CAUSES	REMEDY
Engine overheats	1. Hose connection leaking or collapsed	1. Tighten hose connection. Renew hose if damaged
	2. Radiator cap defective or not sealing	2. Renew radiator cap
	3. Radiator leakage	3. Repair/renew radiator
	4. Improper fan belt adjustment	4. Re-adjust fan belt
	5. Radiator fins restricted	5. Clean with compressed air
	6. Faulty thermostat	6. Renew thermostat
	7. Internal engine leakage	7. Check for source of leakage Renew gasket or defective parts
	8. Water pump faulty	8. Overhaul water pump
	9. Exhaust gas leakage into cooling system	9. Renew cylinder head gasket. Check head for damage or distortion
	10. Coolant aeration	10. Tighten all connections and check coolant level is correct. Ensure cylinder head gasket has not blown
	11. Cylinder head gasket improperly installed	11. Renew cylinder head gasket
	12. Hot spot due to rust and scale or clogged water jackets	12. Reverse flush entire cooling system
	13. Obstruction to radiator air flow	13. Remove the obstruction
	14. Extended engine idling	14. Do not allow engine to idle for long periods
	15. Oil cooler tube blocked	15. Clean
	16. Radiator core tubes blocked	16. Check free flow

PROBLEM	POSSIBLE CAUSES	REMEDY
Low oil pressure	1. Engine oil level low	1. Top up, as necessary
	2. Wrong grade of oil	2. Drain and refill with correct grade of oil
	3. Blocked oil pump sump screen	3. Clean pump screen
	4. Oil pressure relief valve faulty	4. Fit new relief valve
	5. Oil pump drive shaft worn	5. Renew drive shaft
	6. Excessive oil pump rotor and shaft assembly clearance	6. Overhaul pump
	7. Excessive main or connecting rod bearing clearances	7. Install new bearing inserts and/or re-grind crankshaft
Excessive oil consumption	1. Engine oil level too high	1. Reduce oil level
	2. External oil leaks from engine	2. Renew gaskets/seals, where necessary. Check mating surfaces for damage or distortion
	3. Worn valves, valve guides or seals	3. Renew
	4. Renew gasket. Check head for damage or distortion	4. Renew gasket. Check head for damage or distortion
	5. Oil loss past the pistons and rings	5. Renew rings and/or re-bore/re-sleeve block as necessary
	6. Oil cooler leak (if fitted)	6. Repair/renew oil cooler assembly
Engine tends to keep firing after fuel is shut off	1. Air cleaner dirty or restricted	1. Clean or renew element
	2. Oil leak on compressor side of turbocharger where fitted	2. Overhaul turbocharger

PROBLEM	POSSIBLE CAUSES	REMEDY
Oil pressure warning light fails to operate	1. Bulb burnt out	1. Renew bulb
	2. Warning light pressure switch faulty	2. Renew pressure switch
	3. Warning light circuit faulty	3. Check and renew wiring
Excessive exhaust smoke	1. Oil leak on compressor or turbine side of turbocharger, where fitted	1. Overhaul turbocharger
	2. Exhaust leak on exhaust manifold side of turbocharger, where fitted	2. Fit new gasket
	3. Air cleaner dirty or restricted	3. Clean
	4. Excessive fuel delivery	4. Overhaul injection pump/ injectors
Water temperature gauge fails to reach normal operating temperature	1. Faulty temperature sender switch	1. Renew sender switch
	2. Incorrect or faulty thermostat	2. Renew thermostat
	3. Faulty water temperature gauge	3. Renew temperature gauge

B. SPECIFICATIONS

GENERAL SPECIFICATIONS

Model	Ford 455C	Ford 555C	Ford 655C	Ford 555C & 655C Turbocharged
No. of Cylinders (T=Turbocharged)	3	4	4	4T
Displacement: in³ cm³	201 3294	256 4195	268 4393	256 4195
Bore: in mm	4.4 111.8	4.4 111.8	4.4 111.8	4.4 111.8
Stroke: in mm	4.4 111.8	4.2 106.7	4.4 111.8	4.2 106.7
Compression ratio	16.3:1	16.3:1	16.3:1	15.6:1
Firing Order	1-2-3	1-3-4-2	1-3-4-2-	1-3-4-2
Rated Engine Speed (rev/min)	2200	2200	2200	2200
Idle Speed (rev/min)	600-850	600-850	600-850	700-800
Maximum No Load Speed (rev/min)	2350-2400	2350-2400	2350-2400	2350-2400

CYLINDER BLOCK

Taper of Cylinder Bore	0.001 in (0.025 mm) Repair limit 0.005 in (0.127 mm) Wear limit
Cylinder Bore Out-of-round	0.0015 in (0.03 mm) Repair limit 0.005 in (0.127 mm) Wear limit
Cylinder Bore Diameters	4.4007-4.4032 in (111.778-111.841 mm)
Rear Oil Seal Bore Diameter	5.542-5.546 in (140.77-140.87 mm)
Block to Head Surface Flatness	0.003 in (0.08 mm) in any 6 in (152 mm) or 0.006 in (0.15 mm) overall limit

RETAINING COMPOUND

Cylinder Sleeve to Cylinder Block	Ford Part No. ESW M2G 160A

CYLINDER HEAD

Valve Guide Bore Diameter	0.3728-0.3735 in (9.469-9.487 mm)
Head to Block Surface Flatness	0.003 in (0.08 mm) in any 6 in (152 mm) or 0.006 in (0.15 mm) overall limit.

EXHAUST VALVES

Face Angle	44°15′-44°30′ Relative to Head of Valve
Stem Diameter	Std: 0.3701-0.3708 (9.401-9.418 mm) 0.003 in. (0.076 mm) Oversize: 0.3731-0.3738 in. (9.477-9.495 mm) 0.015 in. (0.38 mm) Oversize: 0.3851-0.3858 (9.781-9.799 mm) 0.030 in. (0.76 mm) Oversize 0.4001-0.4008 in. (10.163-10.180 mm)
Head Diameter	
Ford 455C and 555C	1.495-1.505 in. (37.97-38.23 mm)
Ford 655C	1.505-1.515 in. (38.23-38.48 mm)
Stem-to-Guide Clearance	0.0020-0.0037 in. (0.051-0.094 mm)
Lash Clearance (Cold)	0.017-0.021 in. (0.43-0.53 mm)

INTAKE VALVES

Face Angle	
Ford 455C	44°15′–44°30′ Relative to Head of Valve
Ford 555C and 655C	29°15′–29°30′ Relative to Head of Valve
Stem Diameter	Std: 0.3711–0.3718 in. (9.426–9.444 mm) 0.003 in. (0.076 mm) Oversize: 0.3741–0.3748 in. (9.502–9.520 mm) 0.015 in. (0.381 mm) Oversize: 0.3861–0.3868 in. (9.807–9.825 mm) 0.030 in. (0.762 mm) Oversize: 0.4011–0.4018 in. (10.188–10.206 mm)
Head Diameter	
Ford 455C	1.800–1.810 in (45.72–45.97 mm)
Ford 555C and 655C	1.832–1.842 in (46.48–46.77 mm)
Stem-to-Guide Clearance	0.0010–0.0027 in. (0.025–0.069 mm)
Lash Clearance (Cold	0.014–0.018 in. (0.36–0.46 mm)

VALVE SPRINGS

Number per Valve	1
Free Length	2.15 in. (54.6 mm)
Load at 1.74 in. Length (44.20 mm)	61.69 lb (27.7–31.3 Kg)
Load at 1.32 in. Length (33.53 mm)	125–139 lb (57.8–63.1 Kg)

VALVE TIMING

	Ford 455C	Ford 555C and 655C	
Intake Opening	14°	12°	Before Top Dead Centre
Intake Closing	38°	38°	After Bottom Dead Centre
Exhaust Opening	41°	54°	Before Bottom Dead Centre
Exhaust Closing	11°	12°	After Top Dead Centre

VALVE INSERTS

Insert Oversize	Exhaust Valve Insert	Intake Valve Seat Insert
	Counterbore Diameter in Cylinder Head	Counterbore Diameter in Cylinder Head
0.010 in (0.254 mm)	1.607–1.608 in (40.82–40.84 mm)	1.907–1.908 in (43.44–43.46 mm)
0.020 in (0.508 mm)	1.617–1.618 in (41.07–41.10 mm)	1.917–1.918 in (43.69–43.72 mm)
0.030 in (0.762 mm)	1.627–1.628 in (41.33–41.36 mm)	1.927–1.928 in. (43.95–43.97 mm)

VALVE SEATS

Exhaust Valve Seat Angle	45°00′–45°30′
Intake Valve Seat Angle–	
Ford 455C	45°00′–45°30′
Ford 555C and 655C	30°00′–30°30′
Interference Angle Valve Face to Valve Seat	0°30′–1°15′
Seat Run Out	0.0015 in (0.038 mm) Total Indicator Reading Max.
Seat Width	
Exhaust	0.084–0.106 in. (2.13–2.69 mm)
Intake	0.080–0.102 in. (2.03–2.59 mm)

CAMSHAFT DRIVE GEAR

Number of Teeth	47
End Play	0.001–0.011 in (0.25–0.28 mm)
Bushing Inside Diameter	2.005–2.0015 in (50.813 –50.838 mm)
Adaptor Outside Diameter	1.9985–1.9990 in (50.762–50.775 mm)
Backlash with Crankshaft Gear	0.001–0.009 (0.025–0.23 mm)
Backlash with Camshaft Gear	0.001–0.009 in (0.025–0.23 mm)
Backlash with Fuel Injection Pump Drive	0.001–0.012 in (0.025–0.30 mm)

CAMSHAFT GEAR

Number of Teeth	52
Timing Gear Backlash	0.003–0.008 in (0.08–0.20 mm)

ROCKER ARM SHAFT

Shaft Diameter	1.000–1.001 in (25.40–25.43 mm)
Support Diameter (Internal diameter)	1.002–1.004 in (25.45–25.20 mm)

ROCKER ARM

Inside Diameter	1.003–1.004 in (25.48 – 25.50 mm)

TAPPETS

Clearance to Bore	0.0006–0.0021 in (0.015–0.053 mm)
Tappet Diameter	0.9889–0.9894 in (25.118–25.130 mm)
Tappet Bore Diameter	0.9900–0.9910 in (25.15–25.17 mm)

CAMSHAFT

Bearing Journal Diameter	2.3895–2.3905 in (60.696–60.719 mm)
Bearing Clearance	0.0010–0.0030 in (0.025–0.076 mm)
End Play	0.0010–0.0070 in (0.025–0.18 mm)

CONNECTING RODS

Small End Bushing (Internal Diameter)	
Normally Aspirated	1.5003–1.5006 in (38.108–38.115 mm)
Turbocharged	1.6253–1.6256 in (41.283–41.290 mm)
Clearance Bushing-to-Piston-Pin	0.0005–0.0007 in (0.013–0.018 mm)
Side Float	0.0070–0.0130 in (0.18–0.33 mm)
Maximum Twist	0.0120 in (0.30 mm)
Maximum Bend	0.0040 in (0.10 mm)

PISTON PIN

Outside Diameter	
Normally Aspirated Engine	1.4997–1.5000 in (38.092–38.100 mm)
Turbocharged Engine	1.6247–1. 6250 in (41.267–41.275 mm)

PISTONS

Skirt-to-Cylinder Clearance	
Ford 555C	0.0075–0.0085 in. (0.191–0.216 mm)
Ford 455C and 655C	0.0080–0.0090 in. (0.203–0.229 mm)
Taper (Out-of-Round)	0.0025–0.0050 in. (0.063–0.127 mm)
Grading Diameter (at Right Angles to Piston Pin)	
Ford 555C	4.1927–4.1952 in. (106.40–106.56 mm)
Ford 455C and 655C	4.3922–4.3927 in. (111.56–111.62 mm) in increments of 0.0005 in. (0.0127 mm)
Piston Pin Clearance	0.0003–0.0005 in. (0.0076–0.0127 mm) at 70°F (21°C)
Piston Crown to Block Face	
Normally Aspirated Engine	0.011.0.023 in. (0.28–0.58 mm) above
Turbocharged Engine	0–0.012 in. (0–0.3 mm) above

PISTON RINGS

Oil Control:	
Number and Location	1–Directly above Piston Pin
Type	Slotted with Expander
Gap Width	0.015–0.038 in. (0.38–0.97 mm)
Side Clearance	0.0024–0.0041 in. (0.061–0.104 mm)
Compression:	
Number and Location	1–Top and 2–Intermediate above Piston Pin
Type – Normally Aspirated Engine	
Top	Parallel Sides – Inner Chamfer or No Chamfer
Intermediate (2nd Compression)	Straight Face – Inner Step
Intermediate (3rd Compression)	Straight Face – Inner Step or Chamfer
– Turbocharged Engine	
Top	Keystone Tapered
Intermediate (2nd Compression)	Straight Face – Inner Step
Intermediate (3rd Compression)	Straight Face – Outer Step

PISTON RINGS (Cont'd)

Side Clearance	
Top Compression	0.0044–0.0061 in. (0.112–0.115 mm)
2nd Compression	0.0039–0.0056 in. (0.099–0.142 mm)
3rd Compression	0.0039–0.0056 in. (0.099–0.142 mm)
Gap Width	
Top	0.015–0.030 in. (0.38–0.76 mm)
Intermediate	0.013–0.028 in. (0.33–0.71 mm)

CRANKSHAFT

Main Journal Diameter – Blue	3.3713–3.3718 in (85.631–85.644 mm)
– Red	3.3718–3.3723 in. (85.644–85.656 mm)
Main Journal Length	1.455–1.465 in (36.96–37.21 mm)
Main Journal Wear Limits	0.005 in (0.127 mm) Maxmimum
Main and Crankpin Fillet Radius	0.12–0.14 (3.048–3.556 mm)
Thrust Bearing Journal Length	1.459–1.461 in (37.06–37.11 mm)
Intermediate Bearing Journal Length	1.455–1.465 in (36.96–37.21 mm)
Rear Bearing Journal Length	1.495–1.515 in (37.97–38.48 mm)
Crackpin Journal Length	1.678–1.682 in (42.62–42.72 mm)
Crackpin Diameter – Blue	2.749–2.7500 in (69.840–69.850 mm)
– Red	2.7500–2.7504 in (69.850–69.860 mm)
End Play	0.004–0.008 in (0.10–0.20 mm)
Crankpin Out-of-Round	0.0002 in (0.005 mm) total Indicator Reading
Taper-surface Parallel to Centre Line of Main Journal	0.0002 in (0.005 mm)
Crankshaft Rear Oil Seal Journal Diameter	4.808–4.814 in (122.12–122.28 mm)
Crankshaft Pulley Journal Diameter	1.750–1.751 in (44.45–44.48 mm)
Crankshaft Timing Gear Journal Diameter	1.820–1.821 in (46.23–46.25 mm)
Crankshaft Flange Runout	0.0015 in (0.038 mm) Max

CRANKSHAFT DRIVE GEAR

Number of Teeth 26

MAIN BEARING

Liner Length (except thrust liner) 1.10–1.11 in (27.94–28.19 mm)

Liner Length (thrust liner) 1.453–1,455 in (39.91–36.96 mm)

Liner Identification

Identifying Mark	Colour Code	Material	Wall Thickness	Specified Clearance
PV or G	Red	Copper Lead	0.1245–0.1250 in (3.162–3.175 mm)	0.0022–0.0045 in (0.056–0.114 mm)
PV or G	Blue	Copper Lead	0.1249–0.1254 in (3.172–3.185 mm)	0.0022–0.0045 in (0.056–0.114 mm)
G and AL	Red	Aluminium Tin Alloy	0.1245–0.1250 in (3.162–3.175 mm)	0.0022–0.0045 in (0.056–0.114 mm)
G and AL	Blue	Alluminium Tin Alloy	0.1249–0.1254 in (3.172–3.185 mm)	0.0022–0.0045 in (0.056–0.114 mm)

CRANKPIN BEARINGS

Liner Length 1.40–1.41 in (35.56–35.81 mm)

Liner Identification

Identifying Mark	Colour Code	Material	Wall Thickness	Specified Clearance
PV or G	Red	Copper Lead	0.0943–0.0948 in (2.395–2.408 mm)	0.0017–0.0038 in (0.043–0.096 mm)
PV or G	Blue	Copper Lead	0.0947–0.0952 in (2.405–2.418 mm)	0.0017–0.0038 in (0.043–0.096 mm)
G and AL	Red	Aluminium Tin Alloy	0.0941–0.0946 in (2.390–2.403 mm)	0.0021–0.0042 in (0.053–0.107 mm)
G and AL	Blue	Alluminium Tin Alloy	0.0945–0.0950 in (2.400–2.413 mm)	0.0021–0.0042 in (0.053–0.107 mm)

CRANKSHAFT RE-GRINDING

When re-grinding a crankshaft, the main and crankpin journal diameters should be reduced the same amount as the undersize bearings used. The following dimensions apply. The rear end of the crankshaft should be located on the 60° chamfer of the pilot bearing bore.

Undersize Bearing Available	Main Journal Diameters
0.002 in (0.051 mm)	3.3693-3.3698 in (85.580-85.593 mm)
0.010 in (0.254 mm)	3.3618-3.3623 in (85.390-85.402 mm)
0.020 in (0.508 mm)	3.3518-3.3523 in (85.136-85.148 mm)
0.030 in (0.762 mm)	3.3418-3.3423 in (84.882-84.894 mm)
0.040 in (1.016 mm)	3.3318-3.3323 in (84.628-84.640 mm)

Crankpin Journal Diameters	
0.002 in (0.051 mm)	2.7476-2.7480 in (69.789-69.799 mm)
0.010 in (0.254 mm)	2.7400-2.7404 in (69.956-69.606 mm)
0.020 in (0.508 mm)	2.7300-2.7304 in (69.342-69.352 mm)
0.030 in (0.762 mm)	2.7200-2.7204 in (69.088-69.098 mm)
0.040 in (1.016 mm)	2.7100-2.7104 in (68.834-68.844 mm)

CRANKSHAFT BALANCER – FORD 555C and 655C

Gear Backlash	0.002-0.010 in (0.05-0.25 mm)
Shaft-to-Bushing Clearance	0.0002-0.008 in (0.005-0.020 mm)
Shaft Diameter	0.9895-1.000 in (25.133-25.400 mm)
Backlash between Balancer and Crankshaft Gear	0.002-0.008 in (0.05-0.20 mm)
End Float, Balancer Gear to-Support	0.008-0.020 in (0.20-0.51 mm)

FLYWHEEL

Runout of Clutch Face (Between Outer Edge of Friction Surface and Mounting Bolt Holes)	0.005 in (0.127 mm)
Ring Gear Runout	0.025 in (0.64 mm)

OIL PUMP

Rotor Clearance	0.001-0.006 in (0.025-0.15 mm)
Rotor-to-Pump Housing Clearance	0.006-0.011 in (0.15-0.28 mm)
Rotor End Play	0.001-0.0035 in (0.025-0.089 mm)
Relief Valve Pressure	60-70 lbf/in² (4.1-4.8 bar) (4.2-4.9 kg/cm²) at 2000 rev/min
Relief Valve Spring Tension	1.07 in (27.2 mm) under 10.7-11.9 lb (4.85-5.4 kg) load

Temperature	Oil Viscosity and Type	API Classification	Engine Oil & Filter Change Period (hours)	
			Ford 455C, 555C, 655C	Ford 555C 655C Turbocharged
Below −12°C (10°F)	Low Ash, SAE 5W	CC	150	75
	Supplement 1 or Low Ash SAE 5W/20 Supplement 1	CC	150	75
	or SAE 10W-30	CD	150	75
−12°C to 4°C (10°F to 40°F)	Low Ash, SAE 10W	CD	300	150
	Series 3 or SAE 10W-30	CD	300	150
0°C to 32°C (32°F to 90°F)	Low Ash, SAE 20	CD	300	150
	Series 3 or SAE 10W-30	CD	300	150
Above 24°C (75°F)	Low Ash, SAE 30 Series 3	CD	300	150

NOTE: *When using diesel fuel with a sulphur content below 1.0% Series 3 diesel engine oil with an A.P.I. classification of CC may be used instead of CD oil, but the oil and filter change interval must be reduced to 150 hours.*

When using diesel fuel with sulphur content between 1% and 1.3% use only oils listed above but reduce the oil and filter change period to every 50 hours.

ENGINE OIL CAPACITIES (Less Oil Filter)

Model	Imp. pts.	U.S. pts.	Litres
Ford 455C	10	12	5.65
Ford 555C and 655C	13.2	16	7.6

ENGINE OIL CAPACITIES (With Oil Filter)

Model	Imp. pts.	U.S. pts.	Litres
Ford 455C	11.7	14	6.6
Ford 555C and 655C	15	18	8.5

THERMOSTAT

Opening Temperature	168°F (76°C)

WATER PUMP

Type	Centrifugal
Drive	V-Belt
Deflection	0.5-0.75 in (12-19 mm) Midway between pulleys.

COOLING SYSTEM CAPACITIES

Model	Imp. pts.	U.S. pts.	Litres
Ford 455C	18.3	22.0	10.4
Ford 555C and 655C	26,75	32.1	15.2

The following general nut and bolt installation torque requirements (lubricated) apply to any operation not previously listed.

TORQUE VALUES	lb ft	Nm	Kgm
INCH SERIES			
1/4-20	8	11	1.1
1/4-28	8	11	1.1
5/16-18	14	19	1.9
5/16-24	17	23	2.3
3/8-16	23	31	3.2
3/8-24	33	45	4.6
7/16-14	48	65	6.6
7/16-20	55	75	7.6
1/2-13	65	88	8.9
1/2-20	75	102	10.4
9/16-18	90	122	12.4
5/8-18	138	187	19

TORQUE VALUES	lb ft	Nm	Kgf m
Main Bearing Bolts	145	197	20
Connecting Rod Nuts	80	109	11
Cylinder Head Bolts (with Engine Cold)	160	217	22
Intake Manifold-to-Cylinder Head	26	35	3.5
Exhaust Manifold-to-Cylinder head	28	38	3.9
Exhaust Pipe-to-Flange	23	31	3.2
Flywheel-to-Crankshaft	145	197	20
Oil Pan Drain Plug	30	41	4.2
Valve Rocker Cover Bolts	18	24	2.4
Crankshaft Pulley-to-Crankshaft	210	224	23
Self-Locking Screw – Valve Rocker Arm	18	24	2.4
Injector Attachment Bolts	17	23	2.3
Oil Pump to Block	36	49	5
Water Pump-to-Cylinder Block	48	35	3.6
Water Pump Cover-to-Pump	20	27	2.8
Water Pump-By-Pass Hose Clamps	18	24	2.4
Oil Pan-to-Cylinder Block (Cast)	28	38	3.9
Injector Line Nuts	18	24	2.4
Leak-off Tube Banjo Fitting Bolts	8	11	1.1
Injection Pump-to-Front Adaptor Plate	18	24	2.4
Camshaft Drive Gear-to-Block	175	237	24
Front Adaptor Plate-to-Cylinder Block	14	19	1.9
Thermostat Housing Bolts	18	24	2.4
Camshaft Gear Bolt	43	58	5.9
Camshaft Gear Plate Bolts	28	38	3.9
Oil Filter Retaining Bolt	48	65	6.6
Oil Filter Mounting Bolt Insert	25	34	3.5
Starting Motor-to-Rear Adaptor Plate	23	31	3.2
Dynamic Balancer – Cylinder Block	65	88	9
Injection Pump-to-Gear Bolts (3 cyl.)	22	30	3.1
Injection Pump-to-Gear Nut (4 cyl.)	38	51	5.2
Oil Pressure Switch Assembly	23	31	3.2
Turbocharger-to-Exhaust Manifold	33	44	4.5
Fan to Pulley Bolts	21	27	2.8
Crankshaft Rear Oil Seal Retainer –			
Initial Tightening	8	11	1.1
Final Tightening	15	20	2

C. SPECIAL TOOLS

(Prior Tool Numbers, where applicable, shown in brackets)

DESCRIPTION	V.L. CHURCHILL TOOL NO.	NUDAY TOOL NO.
Adjustable Bridge Puller	518	9539 (518)
Shaft Protectors	625-A	9212 (625-A)
Step Plate Adaptors	630-S	9210 (630-S)
Bushing Kit	818	9514 (818)
Crankshaft Gear – Remover Replacer	CPT 6040-B CT 6069-A	2134 (SW501)
Replacer Adaptor/Insert	CT 6069-A	1237 (SW.501-1)
Valve Guide Reamer Kit	FT.6202 (SW.502)	2136 (SW.502)
Camshaft Bearings – Remover/Installer Handle	FT.6203 N6261-A	1255 (SW.506) 1442 (N6261-A)
Crankshaft Oil Seal Installer	FT.6204	1301 (SW.520)
Water Pump Seal Replacer	FT.6209	4672

PART 2

FUEL SYSTEMS

Chapter 1

FUEL SYSTEM – GENERAL

Chapter 2

FUEL INJECTION PUMP – DPA DISTRIBUTOR TYPE

Chapter 3

FUEL INJECTION PUMP – DPS DISTRIBUTOR TYPE

Chapter 4

INJECTORS FORD 455C

Chapter 5

INJECTORS FORD 555C and 655C

Chapter 6

AIR CLEANERS

Chapter 7

TURBOCHARGER

Chapter 8

TROUBLE SHOOTING, SPECIFICATIONS, TEST PLANS AND SPECIAL TOOLS

PART 2

FUEL SYSTEMS

Chapter 1

FUEL SYSTEM – GENERAL

A. FUEL SYSTEM – DESCRIPTION AND OPERATION

FUEL SYSTEM

The diesel fuel systems, Figures 1 and 2, consist of a fuel tank, fuel filter/sediment separator, fuel injection pump, fuel injectors and inter-connecting fuel lines. A dry type air cleaner removes dirt and contaminants from the air intake.

The fuel injection pump is either of the DPA distributor type or DPS distributor type dependent on model and engine size.

Ford 455C models are equipped with a DPA distributor type fuel injection which is gravity fed from the fuel tank to the fuel filter/ sediment separator. The fuel is then drawn from the fuel injection pump inlet by means of the vacuum created by the transfer pump which forms an integral part of the fuel injection pump.

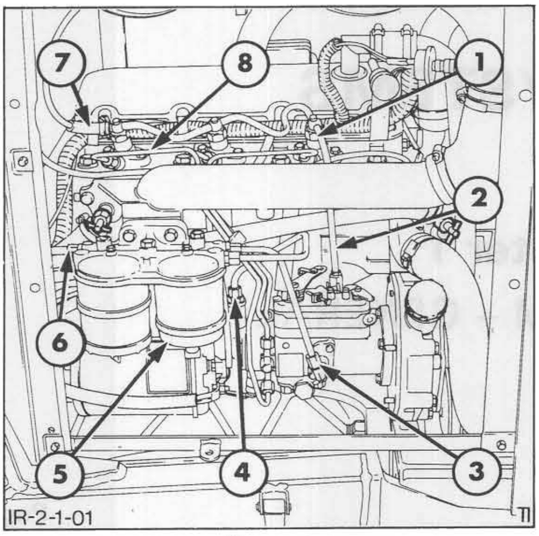


Figure 1
Fuel System Ford 455C

1. Injector
2. Injector Leak-Off Line
3. Return Line to Fuel Filter
4. Fuel Injection Pump Inlet
5. Fuel Filter/Sediment Separator
6. Fuel Filter Inlet
7. Fuel Tank Return Line
8. Injector High Pressure Line

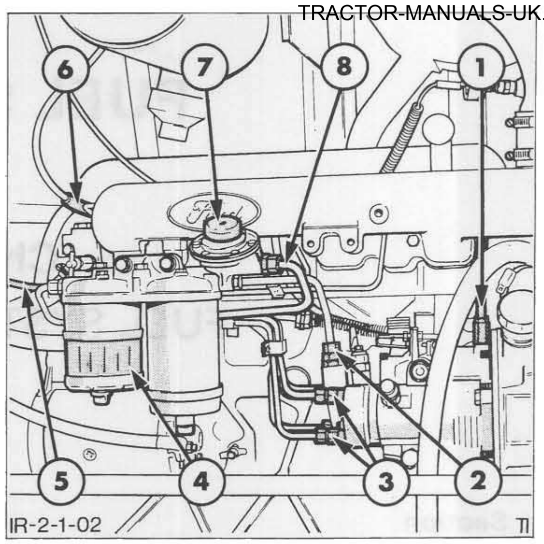


Figure 2
Fuel System Ford 555C and 655C

1. Injector Leak-Off Line
2. Fuel Injection Pump Inlet
3. Injector High Pressure Lines
4. Fuel Filter/Sediment Separator
5. Fuel Filter Inlet
6. Fuel Tank Return Line
7. Hand Primer
8. Inlet to Hand Primer

The transfer pump delivers fuel to the injection pump to supply fuel at high pressure to each injector and also provides extra fuel which lubricates and cools the injection pump. This extra fuel is re-circulated via a fitting on the fuel injection pump governor control housing to the return feed port of the fuel filter/sediment separator.

The transfer pump delivers fuel to the injection pump to supply fuel at high pressure to each injector and also provides extra fuel which lubricates and cools the injection pump. This extra fuel is re-circulated via a fitting on the fuel injection pump governor control housing to the fuel tank by means of the injector leak-off line.

Ford 555C and 655C models are equipped with a DPS distributor type fuel injection pump which is gravity fed from the fuel tank to the sediment separator. The fuel is then drawn from the sediment separator to the fuel injection pump inlet via the hand primer and fuel filter by means of the vacuum created by the transfer pump which forms an integral part of the fuel injection pump.

On all models the excess fuel that leaks past the needle valve of the injectors is directed back into the fuel tank at the filler neck by means of the injection leak-off line.

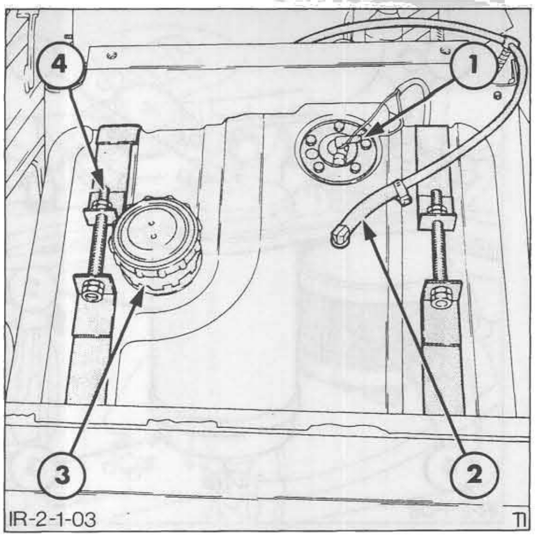


Figure 3
Fuel Tank Assembly

1. Fuel Tank Sender
2. Injector Leak-Off Line
3. Fuel Filler
4. Retaining Strap and Bolt

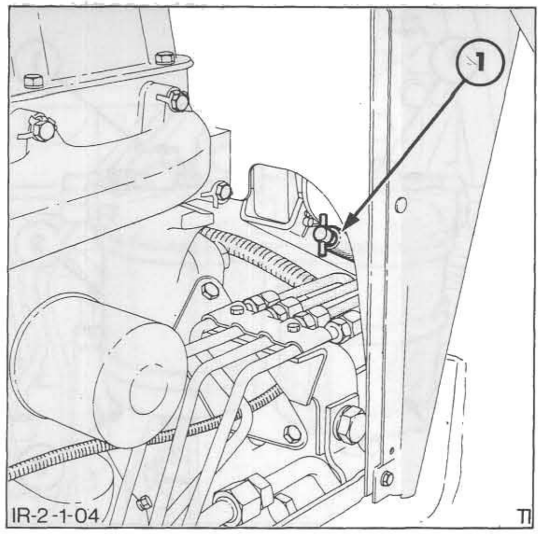


Figure 4
Fuel Shut-Off Valve

1. Shut-Off Valve

MAIN FUEL TANK

Ford 455C, 555C and 655C models have a moulded medium density polyethylene fuel tank located above and to the rear of the engine, Figure 3, secured with two wrap-around straps to the transmission housing. The tank is vented through the filler cap, which may be lockable as an option and fuel from the injectors is returned through the top of the tank via the injector leak-off line connector.

The fuel shut-off valve is an integral part of the fuel outlet assembly which is located on the front left-hand side of the tank, Figure 4. A fine mesh filter screen is located within the outlet assembly to provide initial filtering of the fuel.

FUEL FILTER/SEDIMENT SEPARATOR

FORD 455C:

Positioned between the fuel tank and the fuel injector pump inlet is the fuel filter/sediment separator assembly, Figure 5. The assembly consists of a cast head which is bolted to the engine, a glass sediment separator and a filter element with removable bowls.

The fuel is drawn from the fuel tank and passes into the sediment separator side of the head to be directed down and around the edges of the sediment separator cone, the larger particles of dirt and water (which are heavier than fuel oil) are separated out and sink to the collecting bowl.

The cleaned fuel then flows up the centre tube of the unit through the head and into the filter side of the head where it is directed down through the filter paper into the base chamber. The filtered fuel then flows up the centre tube of the element to the filter head outlet and on to the injection pump.

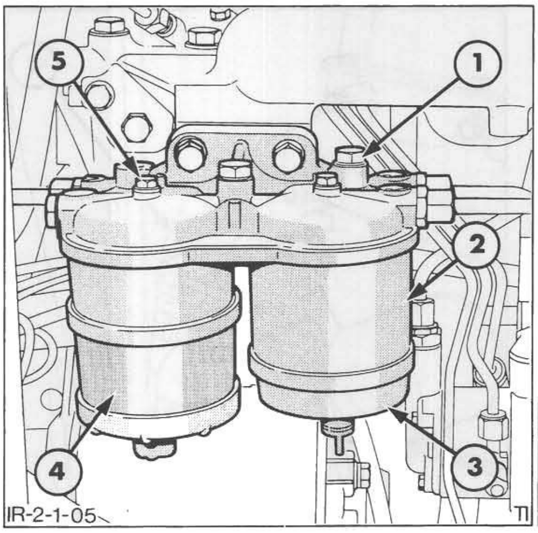


Figure 5
Fuel Filter/Sediment Separator Ford 455C

1. Filter Retaining Bolt
2. Filter Element
3. Filter Bowl
4. Sediment Separator Bowl
5. Sediment Separator Retaining Bolt

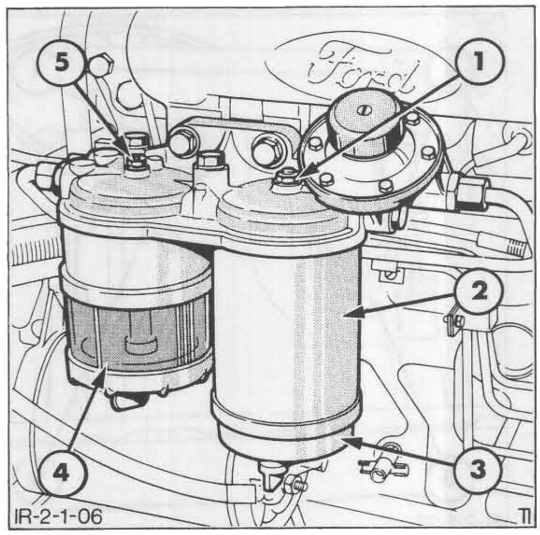


Figure 6
Fuel Filter/Sediment Separator Ford 555C and 655C

1. Filter Retaining Bolt
2. Filter Element
3. Filter Bowl
4. Sediment Separator Bowl
5. Sediment Separator Retaining Bolt

FORD 555C and 655C:

Positioned between the fuel tank and the fuel injection pump inlet is the fuel filter/ sediment separator and hand primer assembly, Figure 6. The assembly consists of a cast head which is bolted to the engine, a glass sediment separator and a filter element with removable bowls, and a hand primer screwed into the cast head.

The fuel is drawn from the fuel tank and passes into the sediment separator side of the head to be directed down and around the edges of the sediment separator cone, the larger particles of dirt and water (which are heavier than fuel oil) are separated out and sink to the collecting bowl.

The cleaned fuel then flows up the centre tube of the unit to the sediment separator head outlet and onto the hand primer. The fuel is then drawn through the hand primer and passes into the filter side of the head to be directed down through the filter paper into the base chamber. The filtered fuel then flows up the centre tube of the element to the filter head outlet and flows onto the injection pump.

The hand primer is normally only used when servicing or repairing the fuel injection system, or in cases where the vehicle has run out of fuel.

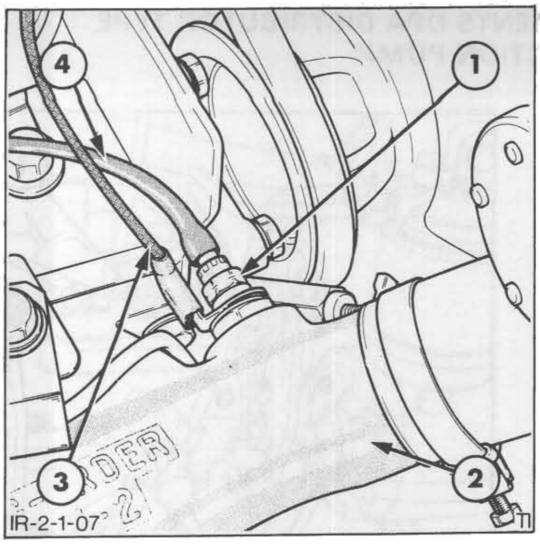


Figure 7
Thermostart Installed

1. Thermostart (Glow Plug)
2. Intake Manifold
3. Thermostart Wire
4. Fuel Feed Line

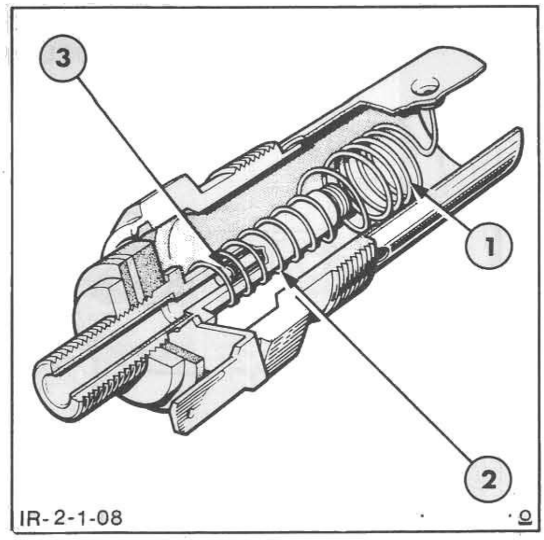


Figure 8
Thermostart Assembly

1. Igniter Coil
2. Heater Coil
3. Check (Ball) Valve

THERMOSTART

To aid engine starting in cold weather conditions, a thermostart cold start device, incorporating an integral reservoir system, is fitted as standard equipment on all models, Figure 7.

The thermostart cold start device comprises a plug assembly screwed into the intake manifold, a fuel line connected to the injector leak-off tube and an electrical circuit, connected to the ignition switch.

The plug assembly, Figure 8, consists of a check valve and electrically heated element.

Fuel is gravity fed to the plug assembly and when an electrical current is applied, by operating the key start/stop switch and the thermostart switch, the heater and 'igniter' coils are both energised. The 'heater' coil opens a check valve which allows diesel fuel to flow through the thermostart. The fuel is ignited by the 'igniter' coil in the manifold, heating indrawn air prior to it entering the combustion chamber.

When the thermostart switch is released to the off position the electrical current is disconnected from the thermostart and the check valve closes.

B. FUEL SYSTEM – ADJUSTMENTS DPA DISTRIBUTOR TYPE FUEL INJECTION PUMP

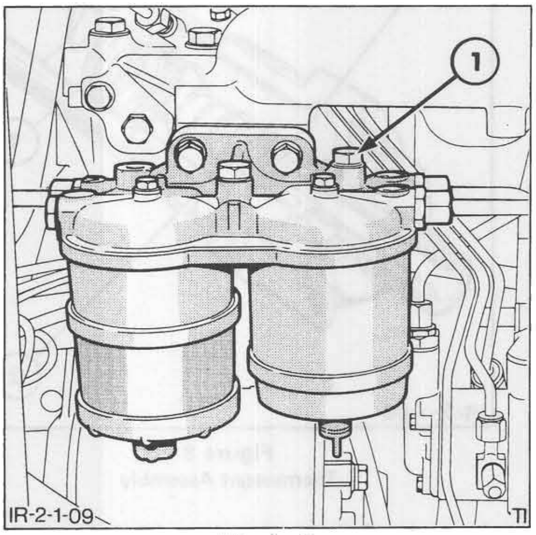


Figure 9
Fuel Filter/Sedimentor Bleed Screw

1. Bleed Screw

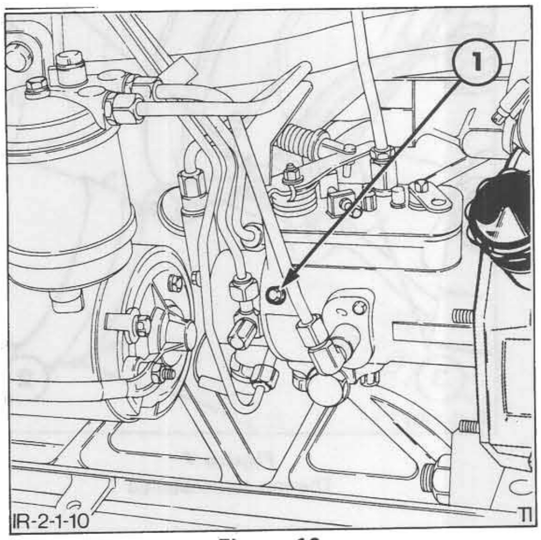


Figure 10
Injection Pump Bleed Screw

1. Bleed Screw

BLEEDING THE FUEL SYSTEM

NOTE: *The fuel system should be bled whenever fuel system components are removed, disconnected or renewed, in order to expel any air in the system.*

1. Ensure there is sufficient fuel in the tank and all connections are tight. Ensure the fuel shut-off valve is open.

2. Loosen the bleed screw on top of the fuel filter/sediment separator, Figure 9, and allow fuel to flow until it is free from air bubbles. Re-tighten the bleed screw.

3. Loosen the bleed screw on the injection pump, Figure 10. With the throttle in the fully open position, crank the engine until fuel free from air bubbles is discharged from the bleed screw. Re-tighten the bleed screw.

4. Loosen the injector line connections, Figure 11. Continue to crank the engine until air-free fuel is discharged from the connections. Tighten each connection in turn whilst the engine is still cranking.

5. Run the engine and check for leaks.

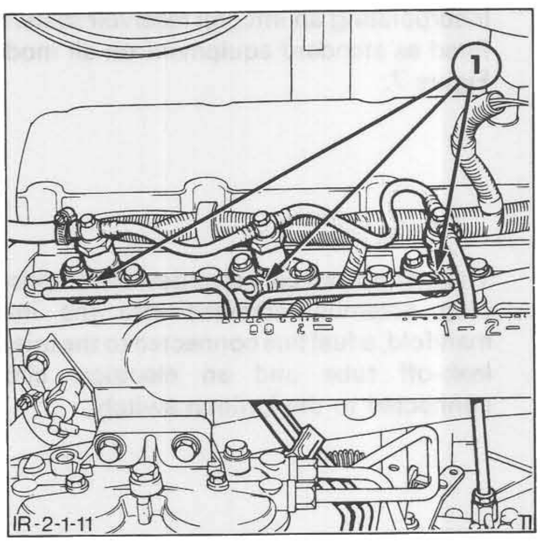


Figure 11
Fuel Injector Line Connections

1. Injector Connections

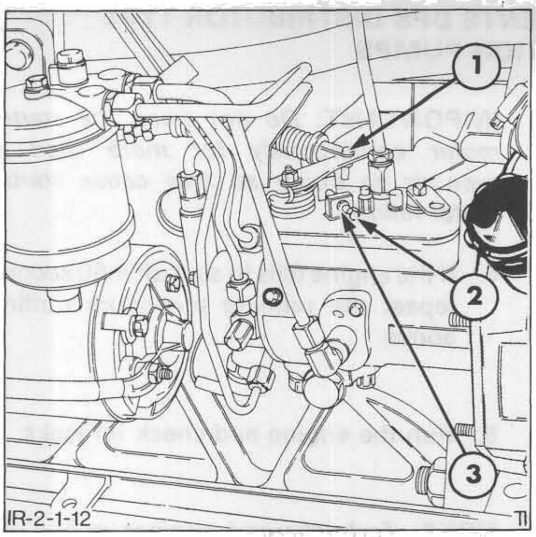


Figure 12
Injection Pump Adjustment Screws

1. Throttle Cable Connection
2. Idle Speed Adjustment Screw
3. Idle Speed Adjustment Screw Locknut

IDLE SPEED ADJUSTMENT

1. With the engine running and at normal operating temperature, disconnect the throttle linkage at the injection pump, Figure 12.

2. Loosen the locknut and adjust the idle speed stop screw until the specified idle speed is obtained, see "Specifications" – Chapter 8, and reconnect the throttle linkage.

3. Operate the throttle several times and check that the idle speed obtained corresponds with the reading in step 2.

MAXIMUM NO-LOAD SPEED ADJUSTMENT

IMPORTANT: *The maximum no-load speed screw is adjusted and sealed at the factor for correct fuel delivery and maximum no-load speed. If the maximum no-load speed is above or below the specified range, see "Specifications" – Chapter 8, then adjustment may be made as follows:-*

1. With the engine running and at normal operating temperature, disconnect the throttle linkage at the fuel injection pump, Figure 12.

2. Cut and remove the maximum no-load speed stop screw sealing wire and remove the locking sleeve.

3. Set the throttle lever at the injection pump to the maximum no-load speed position then loosen the locknut and adjust the screw until the specified maximum no-load speed is obtained. Tighten the locknut to the specified torque, see "Specifications" – Chapter 8, and secure the adjustment with a new sealing wire and locking sleeve.

4. Ensure the throttle linkage can be reconnected to the injection pump and adjust the linkage length, if necessary.

5. Reconnect the throttle linkage and re-check the maximum no-load and idle speeds can be obtained using the hand and foot throttles.

The throttle linkage adjustment procedure for the Ford 455C models follows the same procedure described for the Ford 555C and 655C models in Section C of this Chapter.

C. FUEL SYSTEM – ADJUSTMENTS DPS DISTRIBUTOR TYPE FUEL INJECTION PUMPS

PRIMING THE FUEL SYSTEM

NOTE: *The fuel system should be primed whenever fuel system components are removed, disconnected or renewed, in order to expel any air in the system.*

1. Ensure there is sufficient fuel in the tank and all connections are tight. Ensure the fuel shut-off valve is open.

2. Operate the hand primer, Figure 13, on the fuel filter/sediment separator to pump fuel into the filter assembly. Continue to pump the hand primer until resistance is felt, indicating that the system is pressurised (primed).

3. With the throttle in the maximum no-load speed position operate the starting motor to crank the engine. The fuel injection pump is self-venting and does not require bleeding.

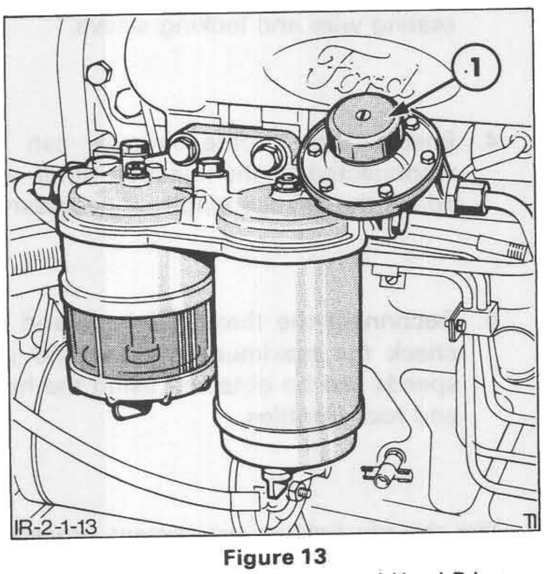


Figure 13
Fuel Filter/Sediment Separator and Hand Primer

1. Hand Primer

IMPORTANT: *Do not crank the starting motor continuously for more than 60 seconds as doing so may cause starting motor failure.*

4. If the engine fails to start after 60 seconds repeat the priming procedure outlined above.

5. Run the engine and check for leaks.

NOTE: *Turbocharged engines only – The high operating speed of the turbocharger makes it essential that adequate lubrication is assured when the engine is started. Therefore idle the engine at 1000 rev/min for approximately one minute before driving the tractor.*

IDLE SPEED ADJUSTMENT

1. With the engine running and at normal temperature, disconnect the throttle cable at the injection pump, Figure 14.

2. Loosen the locknut and adjust the idle speed stop screw until the specified idle speed is obtained, see "Specifications" – Chapter 8. Tighten the locknut to the specified torque, see "Specifications" – Chapter 8, and reconnect the throttle cable.

3. Operate the throttle lever several times and check that the idle speed obtained corresponds with the reading in Step 2. If excessive free play is felt in either the foot or hand throttle after adjustment proceed to THROTTLE LINKAGE ADJUSTMENT in this Section.

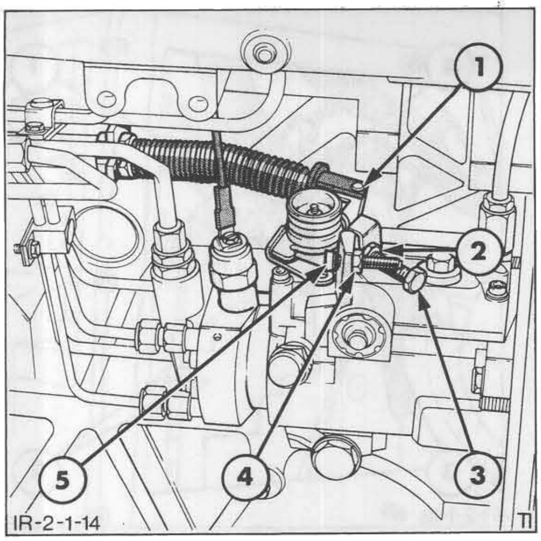


Figure 14
Injection Pump Adjustment Screws

1. Throttle Cable Clevis Pin
2. Idle Screw Locknut
3. Idle Speed Adjustment Screw
4. Maximum No-Load Screw Locknut
5. Maximum No-Load Speed Adjustment Screw

MAXIMUM NO-LOAD SPEED ADJUSTMENT

IMPORTANT: *The maximum no-load speed screw is adjusted and sealed at the factory for correct fuel delivery and maximum no-load speed. If the maximum no-load speed is above or below the specified range, see "Specifications" – Chapter 8, then adjustment may be made as follows:-*

1. With the engine running and at normal operating temperature, disconnect the throttle cable at the injection pump, Figure 14.

2. Cut and remove the maximum no-load speed stop screw sealing wire and remove the locking sleeve.

3. Set the throttle lever at the injection pump in the maximum no-load speed position then loosen the locknut and adjust the screw until the specified maximum no-load speed is obtained. Tighten the locknut to the specified torque, see "Specifications" – Chapter 8, and secure the adjustment with a new sealing wire and locking sleeve.

4. Ensure the throttle cable can be reconnected to the injection pump and adjust the cable length if necessary, see THROTTLE LINKAGE ADJUSTMENTS in this Section.

5. Reconnect the throttle cable and re-check the maximum no-load and idle speeds can be obtained using the hand and foot throttles. If the maximum no-load or idle speeds cannot be obtained, proceed to THROTTLE LINKAGE ADJUSTMENTS in this Section.

THROTTLE LINKAGE ADJUSTMENTS

NOTE: *If the throttle cables have been removed from the tractor during a repair operation it is necessary to install and adjust the hand throttle cable prior to the installation of the foot throttle cable. The following procedures assume that the fuel injection pump idle and maximum no-load speeds are correctly adjusted.*

1. Disconnect the throttle cable from the fuel injection pump lever and loosen the cable locknuts at the engine bracket, Figure 15.

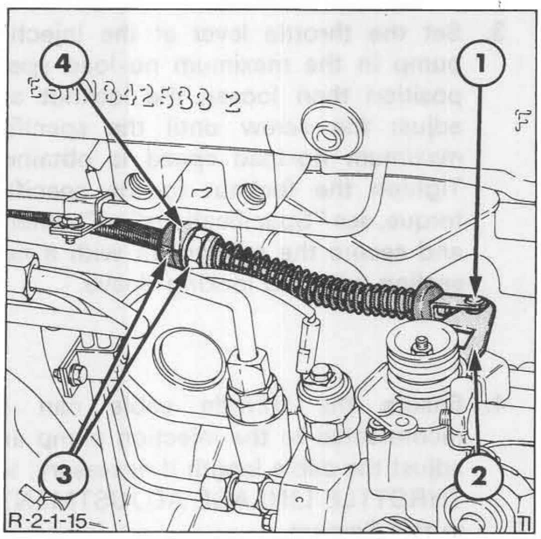


Figure 15
Throttle Connection at Injection Pump

1. Clevis Pin
2. Throttle Lever-Injection Pump
3. Cable Locknuts
4. Cable Retaining Bracket

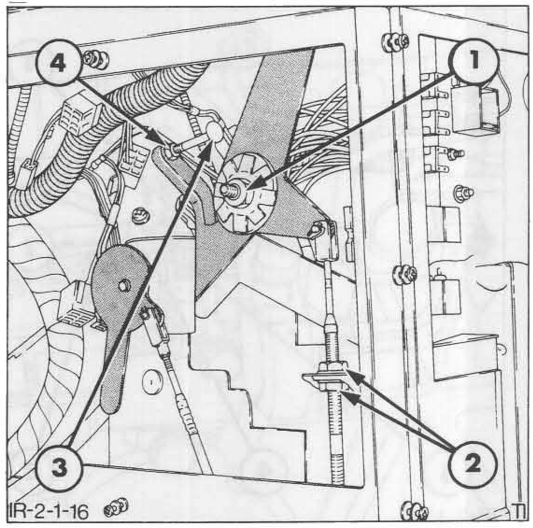


Figure 16
Throttle Connection at Hand Throttle Lever

1. Throttle Lever Retaining Nut
2. Cable Retaining Nuts
3. Throttle Lever Stop Bolt
4. Stop Bolt Lock Nut

2. Loosen the cable locknuts at the hand throttle bracket, Figure 16.

3. Set the hand throttle lever into the idle positions by placing a 6mm diameter rod between the lever and the rear of the lever slot.

4. Adjust the cable locknuts at the hand throttle bracket to position the cable barrel in bracket whilst holding the hand throttle lever in the idle position against the rod.

5. Tighten the locknuts to the specified torque, see "Specifications" – Chapter 8.

6. Connect the throttle cable to the fuel injection pump lever and adjust the barrel locknuts to position the barrel in the engine bracket with the pump lever in the idle position, Figure 15.

7. Check the adjustment of the cable by depressing the foot throttle pedal. The pedal should have a minimum clearance of 6mm between the pedal pad and the cab floor when the fuel injection pump lever is in contact with the maximum no-load speed stop screw. Ensure the pump lever is not travelling into the 'breakaway' motion.

8. Tighten the cable locknuts at the engine bracket to the specified torque, see "Specifications" – Chapter 8.

9. Position the hand throttle lever against the lever stop bolt, Figure 16. Ensure the fuel injection pump lever is on the maximum no-load stop screw.

10. Adjustment of the hand throttle stop screw is required if the lever fails to abut the stop when the pump lever abuts the maximum no-load speed stop screw, or if the injection pump lever moves into the 'breakaway' motion.

11. Tighten the lever stop bolt locknut to the specified torque, see "Specifications" – Chapter 8, after adjustments are complete.

12. Check the effort required to move the hand throttle lever from idle to maximum no-load speed position using a spring balance. Attach the spring balance to the lever and, whilst keeping the spring balance at 90° to the lever, pull on the balance. Compare the effort recorded with the specified figures, see "Specifications" – Chapter 8. Adjust the lever retaining nut, Figure 16, to obtain the specified effort.

D. FUEL SYSTEM – FUEL TANKS, FILTERS AND FUEL LINES OVERHAUL

FUEL TANK REMOVAL

NOTE: *Prior to removing the fuel tank from the tractor, first determine the quantity of fuel left in the tank. It may be necessary to drain the tank of fuel if suitable lifting equipment is not available. It is not possible, however, to drain the tank completely whilst in situ on the tractor.*

1. Disconnect the battery.

2. Remove the engine side panels.

3. Loosen the retaining clamp and remove the muffler extension pipe.

4. Withdraw the retaining screws and remove the engine top hood panel.

5. Withdraw the retaining bolts and remove the rear engine hood panel.

6. Close the fuel shut-off valve on the fuel tank and then disconnect the fuel line to the filter/sediment separator. Plug the exposed pipe to prevent contamination.

7. Disconnect the fuel injector leak-off line at the fuel tank, Figure 17, and plug the exposed openings to prevent contamination.

8. Disconnect the wires from the fuel gauge sender unit.

9. Withdraw the retaining bolts from the two retaining straps, Figure 17, then carefully withdraw the fuel tank.

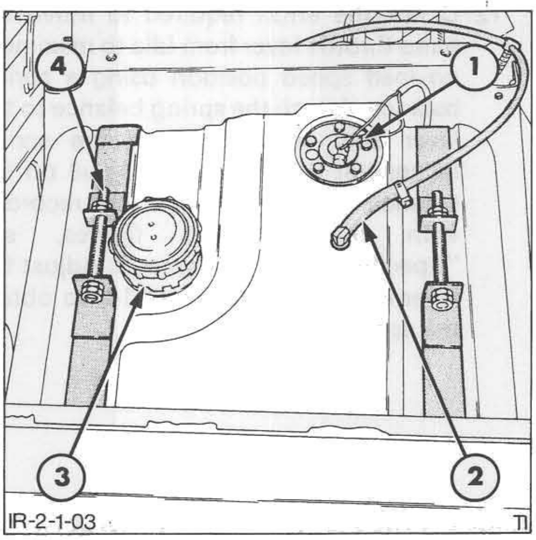


Figure 17
Fuel Tank Assembly

1. Fuel Tank Sender
2. Injector Leak-Off Line
3. Fuel Filler
4. Retaining Strap and Bolt

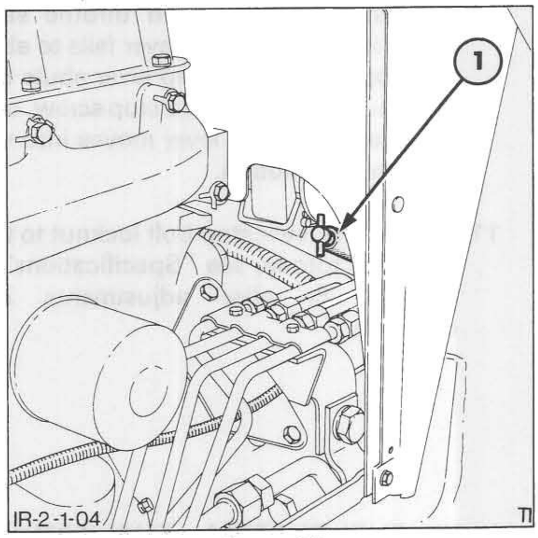


Figure 18
Fuel Shut-Off Valve

1. Shut-Off Valve

DISASSEMBLY

1. Withdraw the retaining bolts from the fuel gauge sender unit and then remove the unit.

2. Withdraw the fuel shut-off valve from the base of the fuel tank.

3. Withdraw the injector leak-off line elbow from the top of the fuel tank.

RE-ASSEMBLY

1. Re-assembly of the fuel tank follows the disassembly procedure in reverse. On re-assembly, observe the following requirements:

   - Apply sealer to the fuel shut-off valve threads prior to assembly, see "Specifications" – Chapter 8.
   - Tighten the fuel shut-off valve to the specified torque, see "Specifications" – Chapter 8, and then continue to tighten until the valve outlet is in the correct radial position, Figure 18.
   - Apply sealant to the injector leak-off line elbow prior to assembly, see "Specifications" – Chapter 8.
   - Tighten the injector leak-off line elbow to the specified torque, see "Specifications" – Chapter 8, and then continue to tighten until the elbow is in the correct radial position, Figure 17.

IMPORTANT: *The fuel shut-off valve and leak-off line elbow must not be unscrewed to obtain the correct radial position.*

   - Install a new gasket to the fuel gauge sender unit and tighten the retaining bolts to the specified torque, see "Specifications" – Chapter 8.

INSTALLATION

1. Installation of the fuel tank follows the removal procedure in reverse. On installation, observe the following requirements:

- Tighten the retaining strap bolts to the specified torque, see "Specifications" – Chapter 8.
- Tighten the engine hood panel bolts to the specified torque, see "Specifications" – Chapter 8.
- Tighten the muffler retaining clamp to the specified torque, see "Specifications" – Chapter 8.
- Assemble the connectors into the fuel shut-off valve and fuel filter assemblies and ensure that the 'O' ring seal is correctly positioned. Tighten the connectors until the stop is reached (metal to metal contact).
- Assemble the fuel pipe to the fuel shut-off valve and fuel filter connectors and tighten the nuts until the stop is reached (metal to metal contact).
- Open the fuel shut-off valve, reconnect the battery and bleed the system as previously described in Sections B and C of this Chapter.

FUEL FILTER/SEDIMENT SEPARATOR

REMOVAL

1. Close the fuel shut-off valve and drain the filter and sediment separator of fuel.
2. Disconnect and remove the fuel lines from the head of the filter/sediment separator assembly and plug the exposed openings to prevent contamination.
3. Withdraw the retaining bolts then remove the assembly from the tractor.

DISASSEMBLY

1. Withdraw the centre retaining bolts and separate the filter components.
2. Using clean fuel, wash out the filter bowl and the glass bowl on the sediment separator.

RE-ASSEMBLY

Re-assembly of the fuel filter/sediment separator follows the disassembly procedure in reverse. On re-assembly, observe the following requirements:

- Install a new filter element and sealing rings. Ensure the sealing rings are correctly positioned.
- Tighten the centre retaining bolts to the specified torque, see "Specifications" – Chapter 8.

INSTALLATION

Installation of the fuel filter/sediment separator assembly follows the removal procedure in reverse. On installation, observe the following requirements:

- Tighten the retaining bolts to the specified torque, see "Specifications" – Chapter 8.

- Assemble the fuel pipes to the connectors in the head and tighten the nuts until the stop is reached (metal to metal contact).

- Open the fuel shut-off valve and bleed the fuel system as previously described in Sections B and C of this Chapter.

FUEL LINES

REMOVAL

1. Close the fuel shut-off valve at the fuel tank.
2. Unscrew the retaining nuts at both ends of the fuel line then remove the fuel line.
3. Withdraw the fuel line connectors.

INSTALLATION

1. Install the connectors and tighten until the stop is reached (metal to metal contact). Ensure the 'O' ring seal is correctly positioned.
2. Position the fuel line and tighten the retaining nuts until the stop is reached (metal to metal contact).
3. Open the fuel shut-off valve and bleed the fuel system as previously described in Sections B and C of this Chapter.

PART 2
FUEL SYSTEMS

Chapter 2
FUEL INJECTION PUMP – DPA DISTRIBUTOR TYPE

A. FUEL INJECTION PUMP – DESCRIPTION AND OPERATION

The DPA distributor type fuel injection pump consists of a pumping and distributing rotor driven directly from the pump drive shaft. The rotor revolves within the hydraulic head and has a vane type fuel transfer pump connected to its end. The fuel injection pump is shown sectioned in Figure 1.

Ford 455C Industrial Tractors are fitted with a double element injection pump, each element containing two opposed plungers, the four plungers operating simultaneously. The plungers are operated by contact with cam lobes on an internal cam ring and the high pressure charges from the pumping element are distributed to the injectors at the required timing intervals through ports in the rotor and hydraulic head.

Fuel entering the pump inlet passes through the nylon filter and the kidney shaped, upper fuel passage to the inlet side (top) of the sliding vane type transfer pump, Figure 2. The transfer pump increases the pressure of the fuel and passes it at transfer pressure to the metering valve which, actuated by the governor, regulates the amount of fuel delivered to the pumping plungers.

The transfer pump pressure is related to engine speed and a direct relationship between pressure and speed is maintained by the regulating valve.

As transfer pressure increases with rising engine speed fuel at transfer pressure acts on the underside of the regulating piston, Figure 3, and tends to force the piston upwards, this is resisted by the regulating spring. As the piston is forced upwards and the regulating spring is compressed the piston uncovers the regulating port, which allows excess fuel pressure to return to the inlet side of the pump so maintaining a predetermined pressure.

When priming, the fuel cannot pass the transfer pump into the hydraulic head, but the fuel acting on the top face of the regulating piston moves it to the lower end of the regulating sleeve uncovering the fuel priming passage and allowing fuel to flow into the hydraulic head.

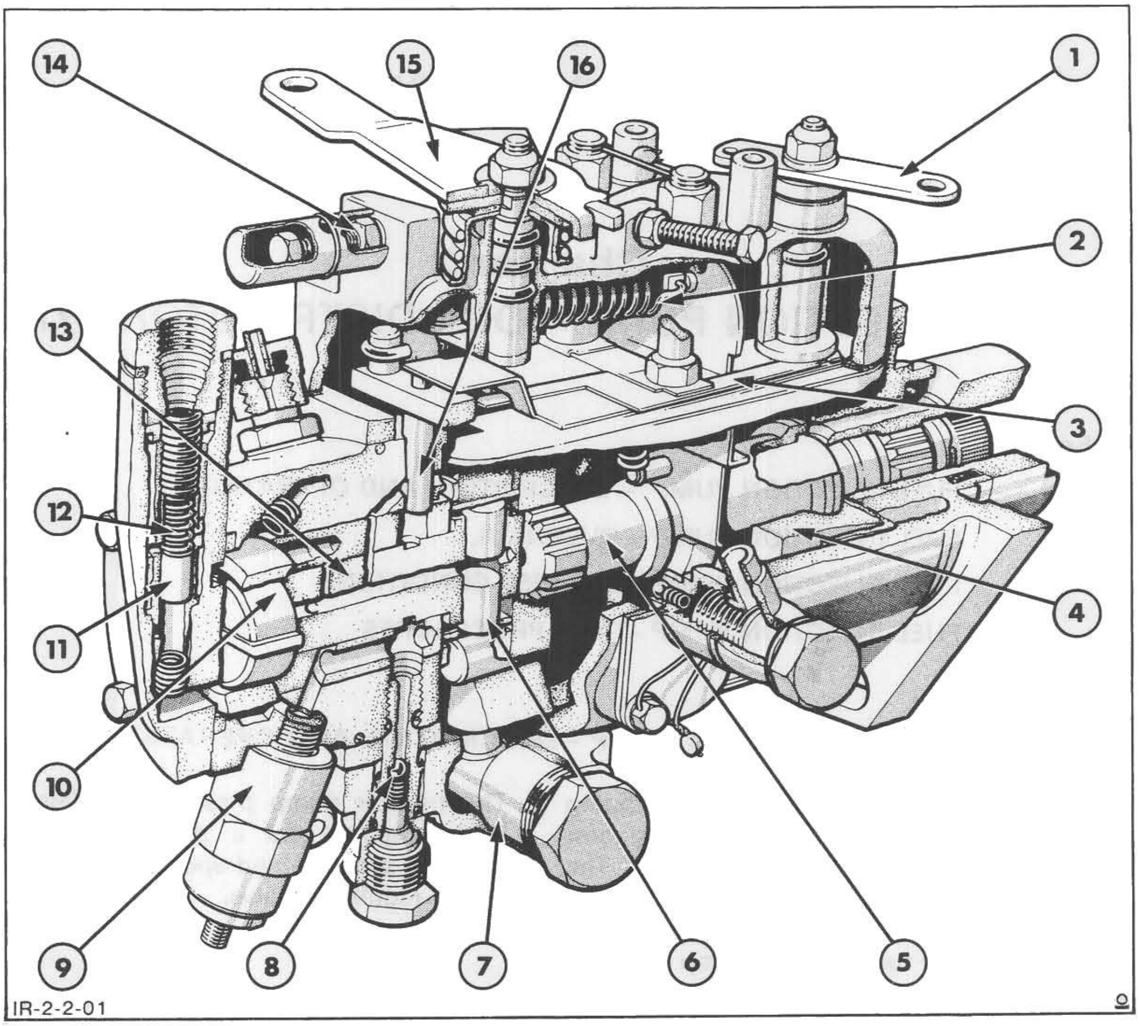


Figure 1
Sectional View of DPA Distributor Type Fuel Injection Pump

1. Fuel Shut-off Lever
2. Governor Spring
3. Fuel Shut-off Bar
4. Governor Weight Assembly
5. Drive Shaft
6. Pumping Plunger
7. Advance Device Piston
8. Advance Device Non-return Valve
9. Shut-off Solenoid
10. Transfer Pump Liner
11. Regulating Valve Piston
12. Regulating Valve Spring
13. Distributing Rotor
14. Maximum Speed Adjustment Screw
15. Throttle Lever
16. Metering Valve

The operating principle of the hydraulic head and rotor is shown in Figure 4. Fuel enters the central drilling of the rotor via the metering valve and moves the plungers outwards to a distance controlled by the volume of fuel, this is the inlet stroke. As the rotor turns the inlet port is closed and the distributor port in the rotor aligns with the appropriate outlet hole in the hydraulic head.

At the same time the plunger rollers contact the cam lobes on the cam ring forcing the plunger inwards, causing the fuel to pass under high pressure out through the distributor port to the injector, this is the injection stroke.

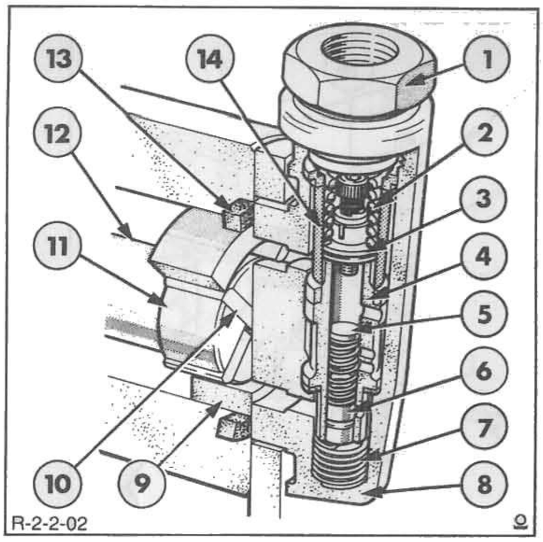


Figure 2
Cut-Away of Regulating Valve and Transfer Pump Assembly

1. Fuel Inlet Connection
2. Regulating Spring
3. Transfer Pressure Adjuster
4. Regulating Sleeve
5. Peg and Spring
6. Regulating Piston
7. Priming Spring
8. End Plate
9. Eccentric Liner
10. Blades
11. Transfer Pump Rotor
12. Distributor Rotor
13. Rubber Sealing Ring
14. Filter

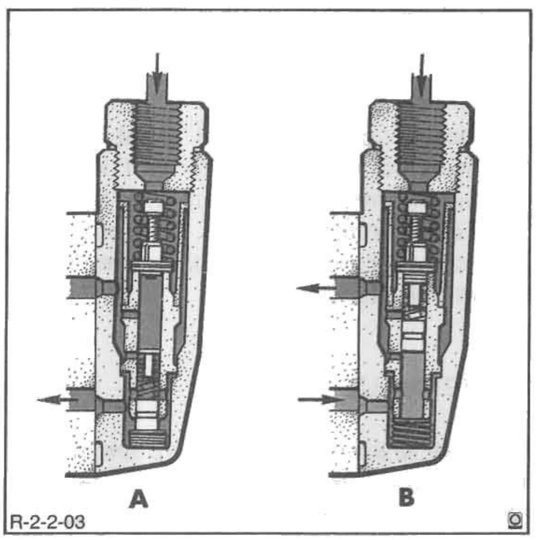


Figure 3
Operation of Regulating Valve

Feed Pressure   Transfer Pressure

A Priming   B Regulating

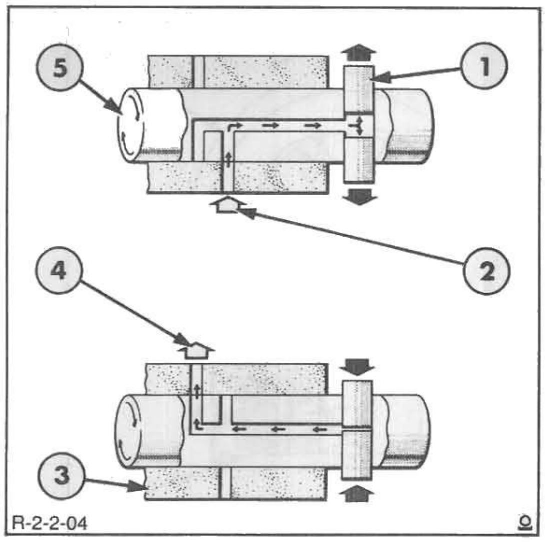


Figure 4
Distributing Head Operation

1. Pump Plungers
2. Fuel Inlet Port
3. Hydraulic Head
4. Fuel Outlet Port
5. Rotor

The maximum fuel setting is controlled by limiting the outward travel of the plungers and this is effected by two pump rotor adjusting plates. These plates have eccentric slots into which engage the lugs on the pump plunger roller shoes. Rotation of the plates controls the travel of the plungers and thus the maximum fuel injected.

An advance device, Figure 5 is provided to automatically advance injection pump timing with increased engine speed. This is effected by fuel at transfer pressure acting on the face of the advance piston so moving the piston and cam ring against the resistance of the advance springs. As transfer pressure increases with engine speed an increasing movement of the cam ring is effected up to a fully advanced position just before maximum engine speed.

The fuel injection pump contains a mechanical governor which controls the metering valve allowing a constant engine speed to be maintained regardless of engine loading.

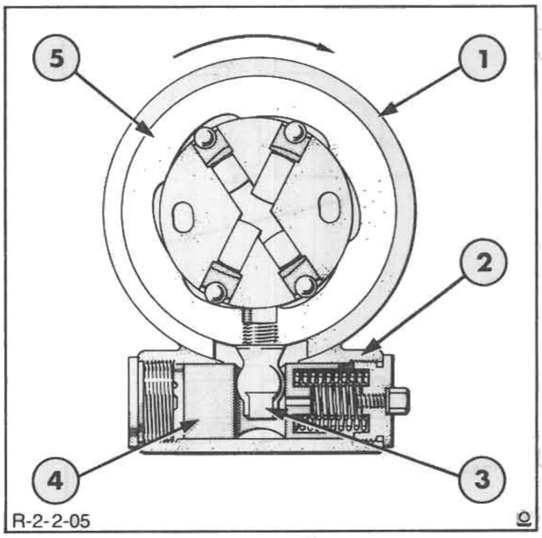


Figure 5
Advance Device

1. Pump Housing
2. Advance Device Housing
3. Cam Advance Screw
4. Piston
5. Cam Ring

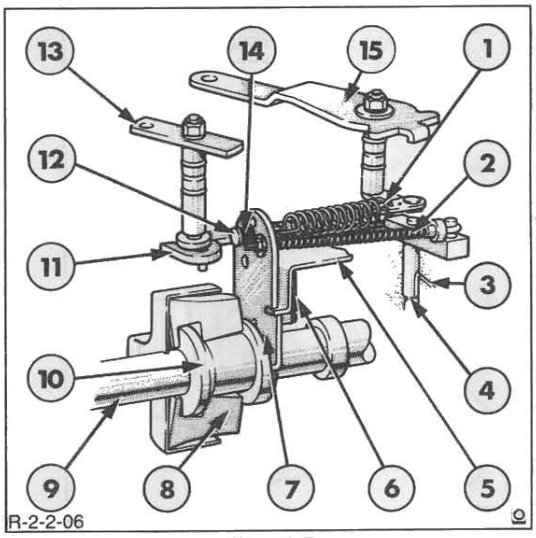


Figure 6
Control Linkage

1. Governor Sping
2. Control Rod and Spring
3. Metering Port
4. Metering Valve
5. Governor Bracket
6. Retaining spring
7. Governor Control Arm
8. Governor Weights
9. Drive Shaft
10. Thrust Sleeve
11. Shut-off Bar
12. Idling Spring Guide
13. Shut-off Lever
14. Idling Spring
15. Throttle Lever

As engine speed is increased governor weights held in a carrier mounted on the pump drive shaft, Figure 6, are thrown outwards by centrifugal force. The outward action moves the governor sleeve along the drive shaft, and through the connecting linkage, moves the metering valve so producing a change in fuel supply.

Engine speed is controlled by movement of the throttle lever which tensions the main governor spring. The spring tension is transmitted through the control linkage to the governor weights and provides the resistance to the movement of the weights necessary to give accurate speed control.

An electrically operated fuel shut-off solenoid screwed into the bottom of the hydraulic head controls the fuel supply to the input side of the metering valve. This provides the operator with an "ignition key" engine start and stop.

B. FUEL INJECTION PUMP – OVERHAUL

REMOVAL

NOTE: *If the pump is not to be internally timed, then prior to removal, make a written note of the position of the scribed line on the pump flange relative to the scale on the engine front plate, Figure 7. Alternatively, mark the plate with a centre punch to align with the pump flange scribed line.*

This mark may be used as a reference point to which the original, re-conditioned or new pump should be set on installation.

1. Shut off the fuel supply. Remove all fuel lines from the injection pump and cap all openings. Disconnect the electrical solenoid wire and throttle control rod or cable.

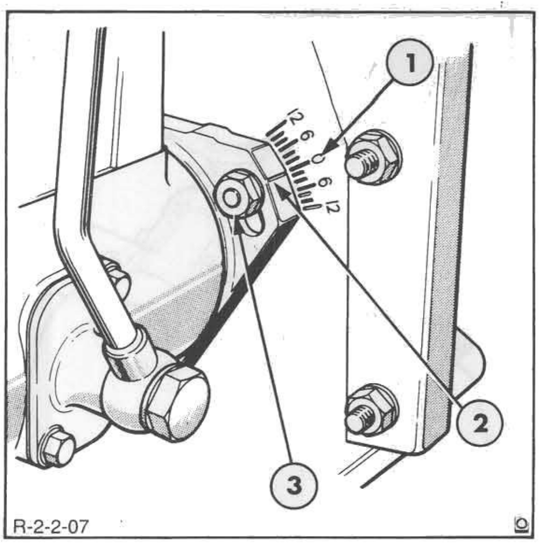


Figure 7
Pump to Engine Timing Mark Adjustment

1. Zero Degree Mark
2. Scribed Line
3. Pump Retaining Bolt

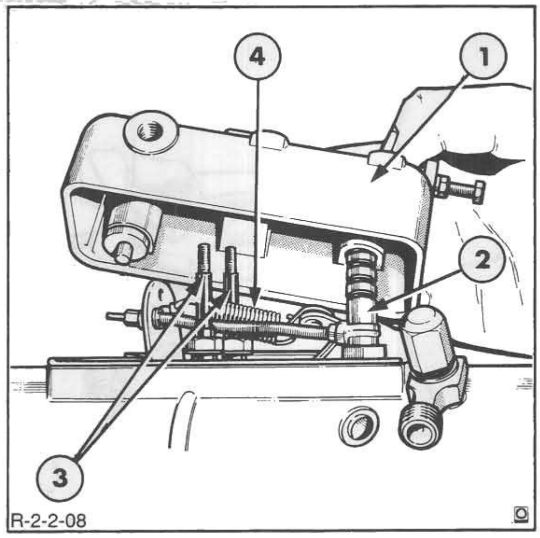


Figure 8
Removing Governor Control Housing

1. Governor Control Housing
2. Throttle Shaft
3. Housing Securing Studs
4. Governor Spring

2. Remove the pump timing cover from the engine front cover and remove the three bolts attaching the pump drive to the timing gear.

3. Remove the three pump-to-engine front plate mounting bolts and withdraw the pump.

DISASSEMBLY

1. Mount the pump on a suitable fixture with the governor control housing uppermost, and remove the throttle lever assembly and shut-off lever from the control shaft.

2. Remove the two domed nuts securing the governor control housing and remove the housing, withdrawing the throttle shaft, Figure 8.

NOTE: *Check in which holes the governor spring is connected into and compare with the position detailed in "Specifications" – Chapter 8. Disconnect the governor spring and remove.*

3. Remove the shut-off bar, Figure 9, the two housing securing studs and the small bolt securing the governor bracket. Remove the governor control linkage together with the metering valve, Figure 10.

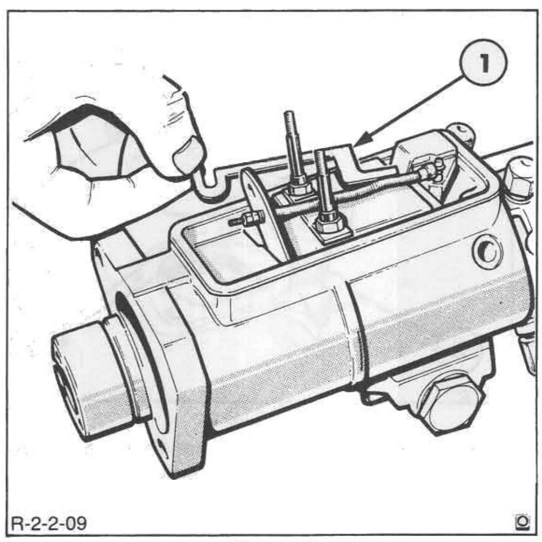


Figure 9
Removing the Shut-off Bar

1. Shut-off Bar

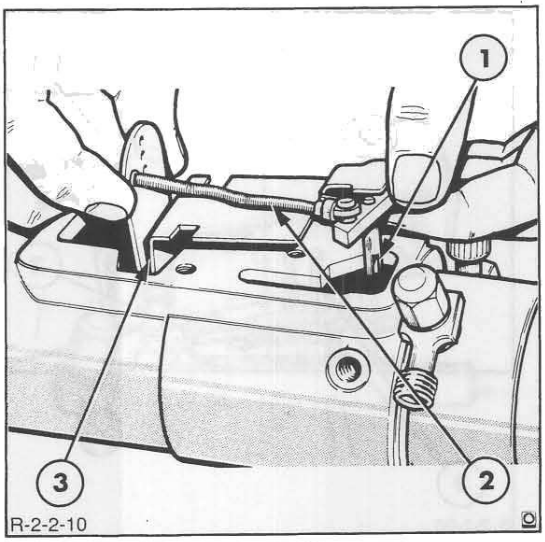


Figure 10
Removing the Governor Control Arm and Metering Valve

1. Metering Valve
2. Control Rod and Spring
3. Governor Control Arm

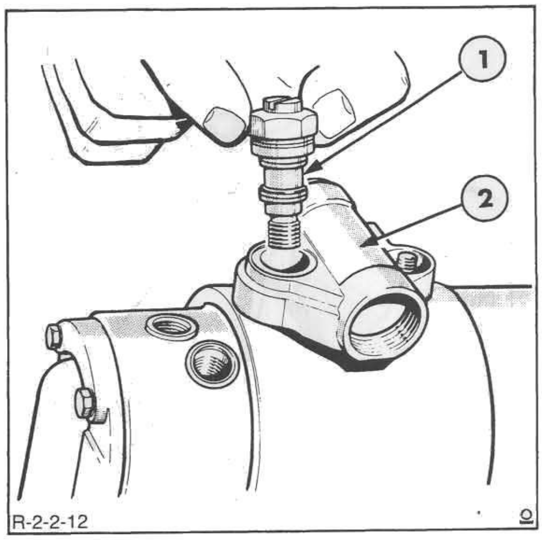


Figure 12
Removing the Advance Device Head Locating Fitting

1. Head Locating Fitting
2. Advance Device Housing

4. Remove the side inspection plate and gasket.

5. Invert the pump on the fixture and remove the electrical solenoid fuel shut-off.

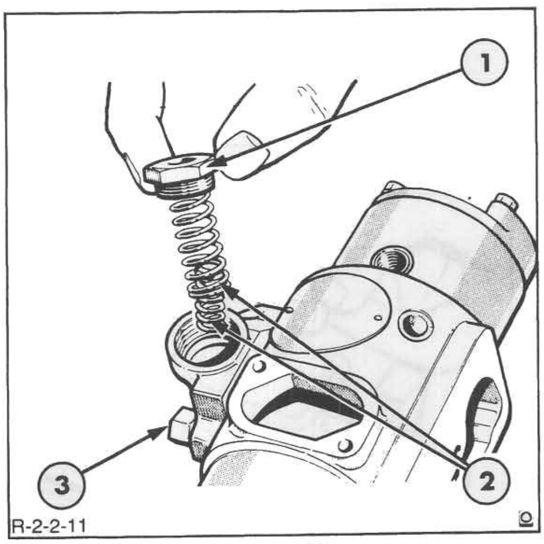


Figure 11
Removing the Advance Device Spring End Cap and Advance Springs

1. Spring End Cap
2. Advance Springs
3. Cap Nut

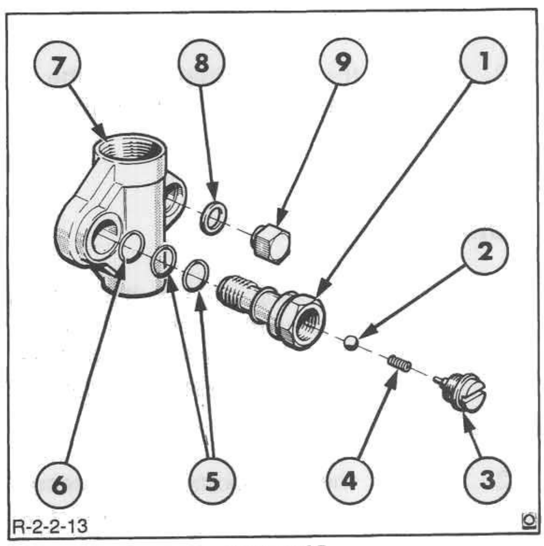


Figure 13
Advance Device Housing Head Locating Fitting Components

1. Head Locating Fitting
2. Non-return Valve
3. End Nut
4. Spring
5. 'O' Rings
6. Washer
7. Housing
8. Sealing Washer
9. Cap Nut

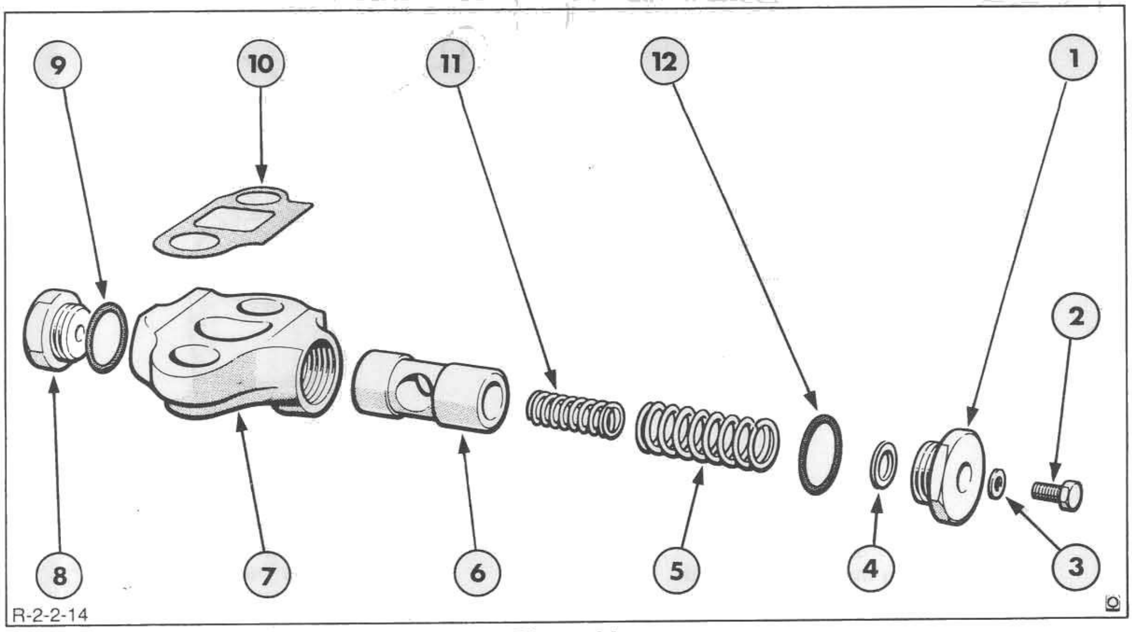


Figure 14
Advance Device Components

1. Spring End Cap
2. End Cap Plug
3. Washer
4. Shims
5. Advance Spring – Outer
6. Piston
7. Advance Device Housing
8. Piston End Cap
9. 'O' Ring Seal
10. Gasket
11. Advance Spring – Inner
12. 'O' Ring Seal

6. Disassemble the automatic advance device as follows:
   (i) Remove the end cap plug and slacken off the two end caps.

   (ii) Remove the spring and cap and withdraw the advance springs, Figure 11. Remove the cap nut and washer.

   (iii) Remove the head locating fitting, Figure 12 and remove the advance device. Disassemble the head locating fitting, Figure 13.

   (iv) Remove the piston end cap and withdraw the piston from the advance device housing. An exploded view of the advance device is shown in Figure 14.

7. With tool No. 7244-125B and a suitable socket wrench remove the cam advance screw, Figure 15.

8. Loosen the fuel inlet connection in the end plate, do not remove. Remove the fuel outlet connections.

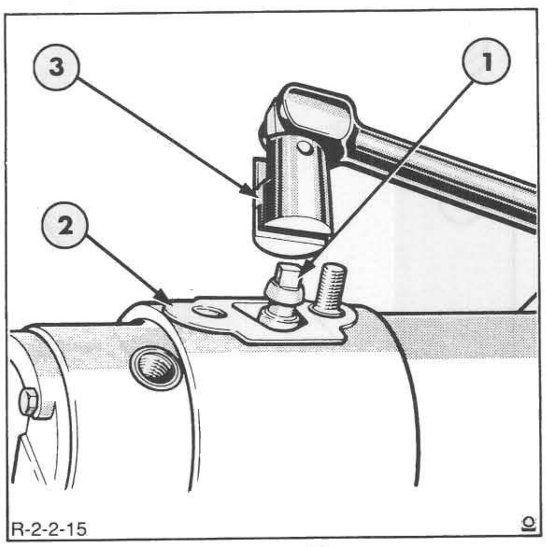


Figure 15
Cam Advance Screw

1. Cam Advance Screw
2. Advance Device Housing Gasket
3. Tool No. 7244-125B

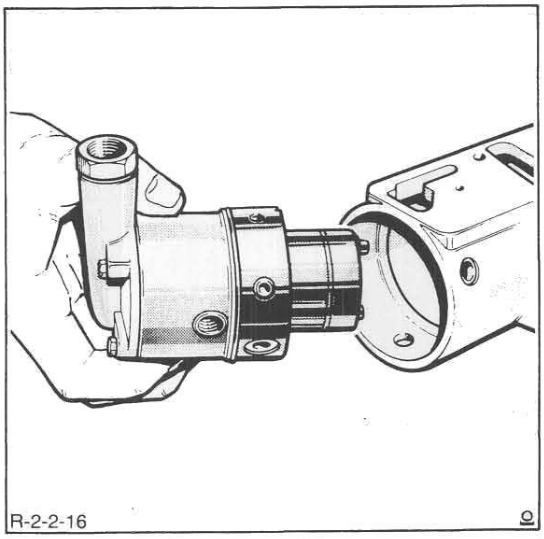


Figure 16
Removing the Hydraulic Head

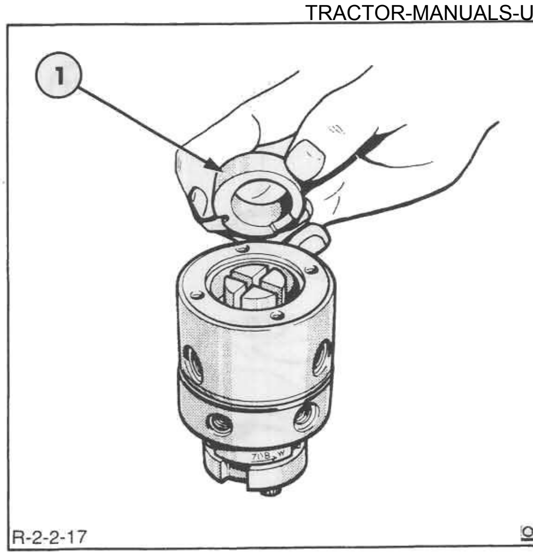


Figure 17
Removing the Transfer Pump Liner

1. Transfer Pump Liner

9. Remove the two hydraulic head locating bolts and withdraw the head assembly, Figure 16.

10. Remove the end plate from the hydraulic head. Remove the rubber sealing ring and the transfer pump vanes. Remove the transfer pump liner, Figure 17.

11. Remove the fuel inlet connection and disassemble the valve. An exploded view is shown in Figure 18.

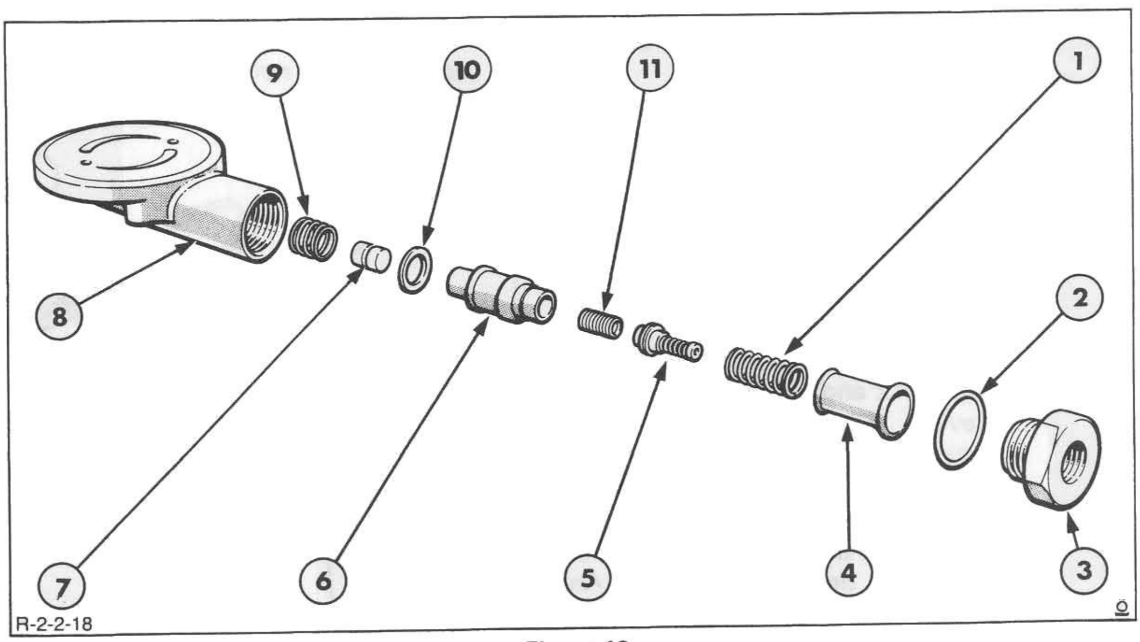


Figure 18
End Plate Components

1. Retaining Spring
2. Copper Washer
3. Fuel Inlet Connector
4. Filter
5. Transfer Pressure Adjuster
6. Valve Sleeve
7. Piston
8. End Plate
9. Priming Spring
10. Sealing Washer
11. Regulating Spring and Peg

12. Hold the drive plate with tool No. 7144-744 and unscrew the transfer pump rotor using tool No. 7044-889, Figure 19. Remove the rotor.

NOTE: *When dismantling the adjusting plates, rollers and shoes from the rotor, it is essential that shoes and rollers are kept together. The shoes and rollers are matched and should be replaced as a unit. In addition, it is highly recommended that each roller and shoe assembly is reassembled in the same roller slot.*

13. Remove the drive plate screws and the drive plate. Lift off the top adjusting plate and the four roller shoe assemblies. An exploded view of the hydraulic head assembly is shown in Figure 20.

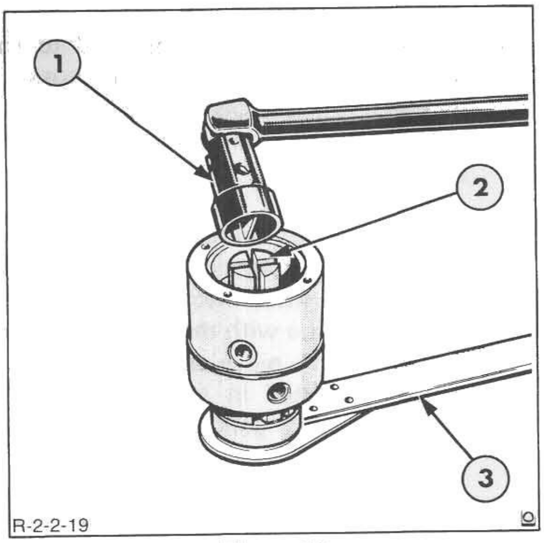


Figure 19
Removing the Transfer Pump Rotor

1. Tool No. 7044-889
2. Rotor
3. Tool No. 7144-744

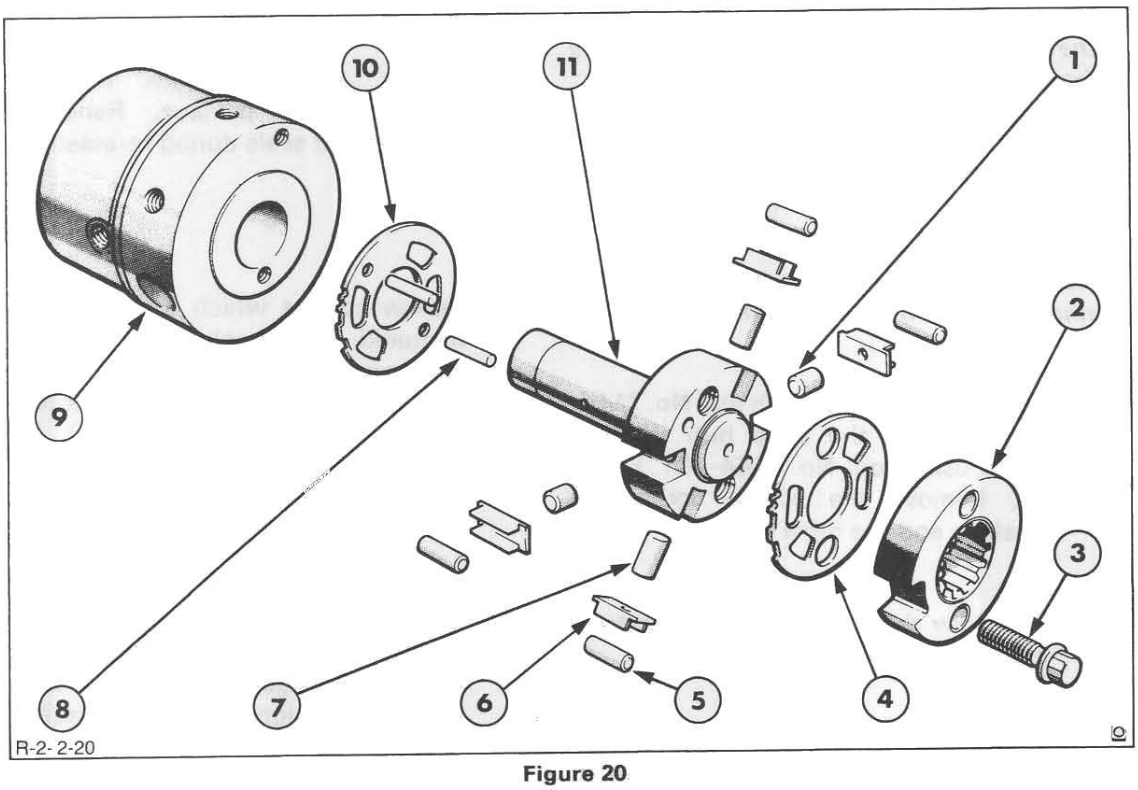


Figure 20
Hydraulic Head Components

1. Plunger (Short)
2. Drive Plate
3. Drive Plate Screw
4. Too Adjusting Plate
5. Roller
6. Roller Shoe
7. Plunger (Long)
8. Dowel Pins
9. Hydraulic Head
10. Bottom Adjusting Plate
11. Rotor

14. The four plungers are matched to the rotor bores and to prevent possible incorrect re-assembly should be retained in the bores after checking that they are free to move.

    The two sets of plungers are of different lengths; it is essential that the longest plungers are fitted into the plunger bore which is in line with the distributor rotor outlet port. A piece of cork or rubber should be fitted in each rotor slot to prevent the plungers from falling out.

15. Remove the bottom adjusting plate by lifting the rotor out of the hydraulic head. The two locating dowels can be removed by light prodding if necessary.

NOTE: *Re-assemble the rotor in the bore in the hydraulic head to protect the surfaces from damage.*

16. Remove the cam ring and remove the snap ring from within the pump body.

IMPORTANT: *Note the location of the snap ring gap for correct re-assembly.*

17. Retain the drive hub with tool No. 7144-733 unscrew the drive hub securing screw using tool No. 7144-261, Figure 21. Remove the screw, spring flat washers and the drive hub.

18. Withdraw the drive shaft and governor assembly from the pump body.

19. Remove the 'O' ring from the shaft and separate the governor weight assembly and shaft. Disassemble the governor assembly.

20. Remove the drive hub oil seal.

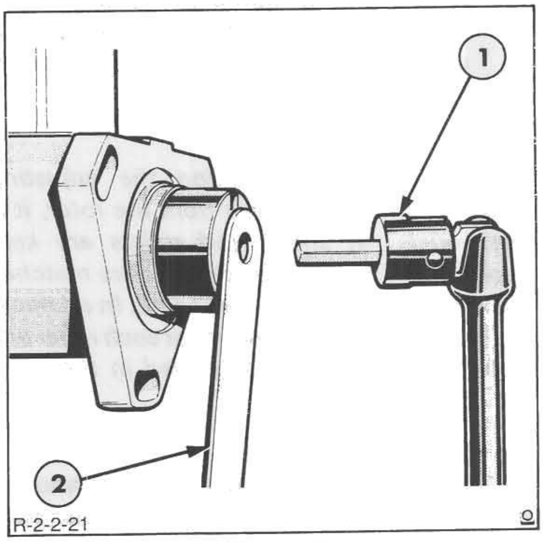


Figure 21
Positioning Drive Hub Screw Removal Tools

1. Tool No. 7144-261 2. Tool No. 7144-773

INSPECTION

1. Inspect all components for wear, corrosion and damage. Renew all 'O' rings and seals during re-assembly.

2. Renew springs which are distorted or fractured and machined components with worn or damaged surfaces. Ensure that the rollers are free to rotate in the shoes and are not damaged.

3. Check the transfer pump blades for wear and chips and renew if necessary. Renew governor linkages, shafts and pivot pins which show signs of wear or scoring.

4. Renew all damaged threaded components.

RE-ASSEMBLY

1. Install a new drive hub oil seal. Re-assemble the governor components as follows:

   (i) Place the weight carrier on a bench with the pockets upwards and insert the weights with their slots uppermost.

   (ii) Lower the thrust washer and sleeve into the slots in the weights, Figure 22, and exert downward pressure on the sleeve to snap the weights into the carrier.

   (iii) Insert the drive shaft through the sleeve, Figure 23, and slide the assembly up the shaft. Install a new 'O' ring in the groove on the shaft.

2. Insert the drive hub through the oil seal in the pump body and slide the drive shaft and governor assembly into the pump body. Ensure the drive shaft and hub splines engage.

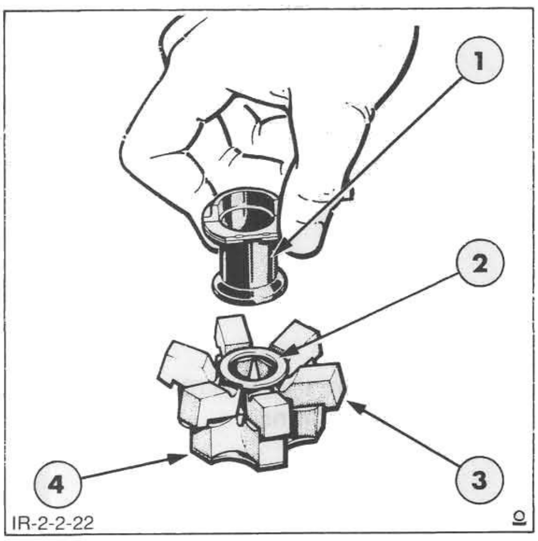


Figure 22
Inserting the Governor Thrust Sleeve and Washer into the Governor Weights

1. Thrust Sleeve
2. Thrust Washer
3. Governor Weights
4. Weight Carrier

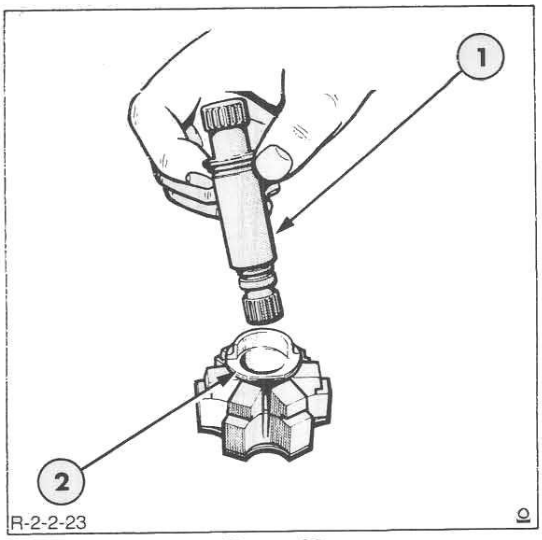


Figure 23
Inserting the Drive Shaft into the Thrust Sleeve

1. Drive Shaft
2. Governor Thrust Sleeve

3. Install the flat and springwashers into the bore of the drive hub and secure the hub to the drive shaft with the securing screw. Tighten the screw to the specified torque, see 'Specifications' – Chapter 8, using tools Nos. 71443-773 and 7144-261, Figure 24. This bolt should be slackened and retorqued 3 times to ensure that the spring washer sets correctly.

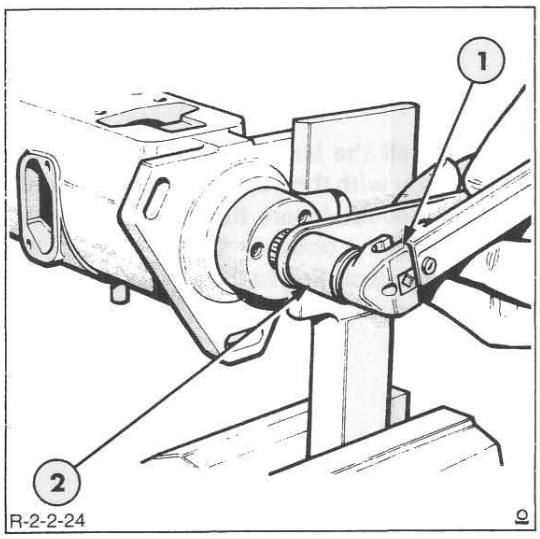


Figure 24
Torquing up the Drive Hub Screw

1. Tool No. 7144-773
2. Tool No. 7144-261

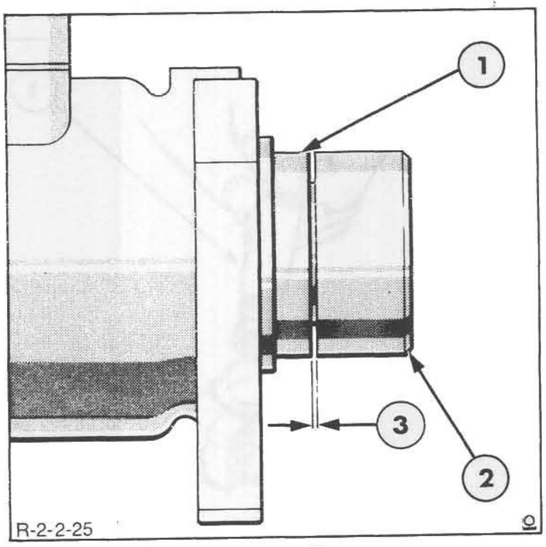


Figure 25
Checking Drive Shaft End Float

1. Pump Body
2. Hub
3. Drive Shaft End Float

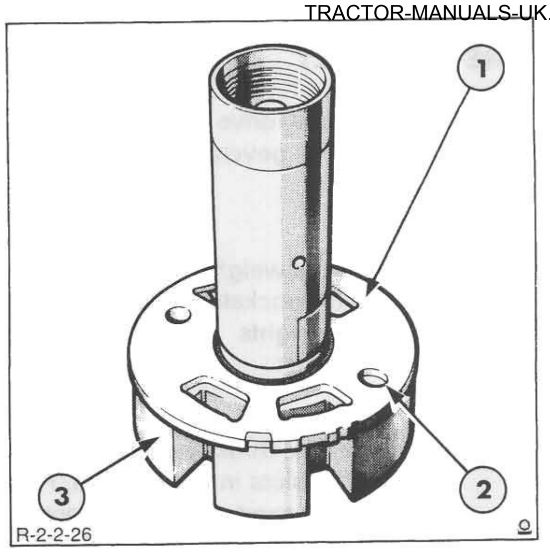


Figure 26
Bottom Adjusting Plate Positioned on Rotor

1. Bottom Adjusting Plate
2. Dowel Hole
3. Rotor

4. Check the drive shaft end float. This should not exceed 0.010 in. (0.25 mm) measured between the rear face of the hub and the pump body as indicated in Figure 25. If this dimension is exceeded, the weight retainer or pump body must be renewed and the end float re-checked.

5. Install the large snap ring in the pump body with the gap in the same position as removed. Insert the cam ring into the pump body with the arrow corresponding to the direction of rotation (marked on the pump nameplate).

6. Install the cam advance screw into the cam ring and tighten to the specified torque using tool No. 7244-125B. Ensure that the cam ring is free to rotate in the body.

7. Re-assembly of the rotor and adjusting plates should be undertaken in the following sequence:

   (i) Install the bottom adjusting plate, which has the two dowel holes, Figure 26, over the shank of the rotor. Ensure that the fuel adjustment slots in the adjusting plate lie within in the cutaway section of the rotor head, Figure 26.

   (ii) Invert the assembly and insert the dowel pins.

   (iii) Insert the rollers and shoes to the rotor assembly.

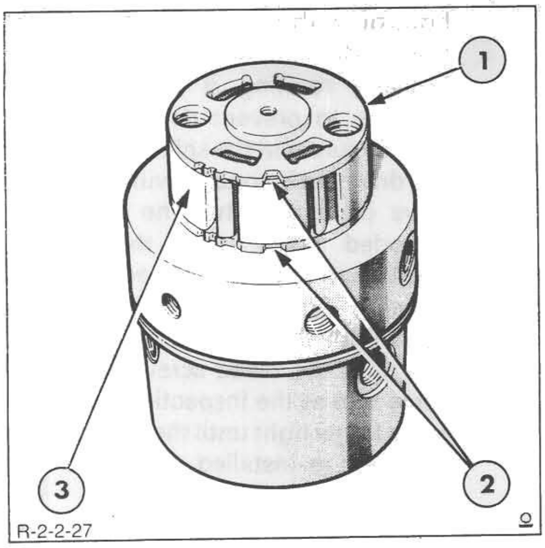


Figure 27
Top Adjusting Plate Positioned on Rotor

1. Top Adjusting Plate
2. Fuel Adjustment Slots
3. Rotor

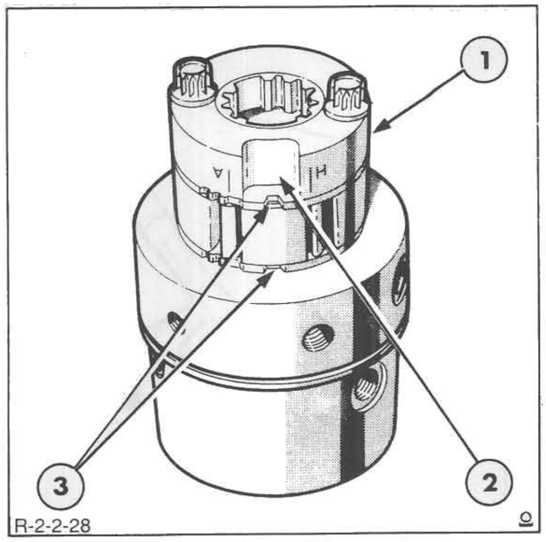


Figure 28
Drive Plate Positioned on Rotor

1. Drive Plate
2. Cut-out
3. Fuel Adjustment Slots

(iv) Install the top adjusting plate, into position, Figure 27. The holes are offset and correct assembly of the adjusting plate is possible only when the fuel adjustment slots are in line with the corresponding fuel adjustment slots on the bottom adjusting plate, Figure 27.

(v) Slide the roller into the hydraulic head and finger tighten the transfer pump rotor.

(vi) Install the drive plate, Figure 28, and tighten the securing screws to:

Direct torque 28 Nm (250 lbf in.)
Indirect torque 20 Nm (180 lbf in.)

NOTE: *Indirect torque is applied when using a torque wrench, setting adaptor 7144-482, and spanner 7144-511A with a 5.0 in (127.0 mm) setting distance.*

Slacken the screws off and retighten to the torque setting first used.

8. Tighten the transfer pump rotor to the specified torque, see 'Specifications' – Chapter 8.

9. Connect tool No. 7144-262 to the fuel outlet specified in the Test Plan, Chapter 8, connecting directly into the pump body. Connect the other end of the tool to an injector testing machine. Operate the injector testing machine until fuel flows from the pressure relief valve on tool No. 7144-262 indicating that the correct pressure is being produced at the pump rotor. Turn the pump rotor until the plungers and rollers are forced to their maximum fuel position.

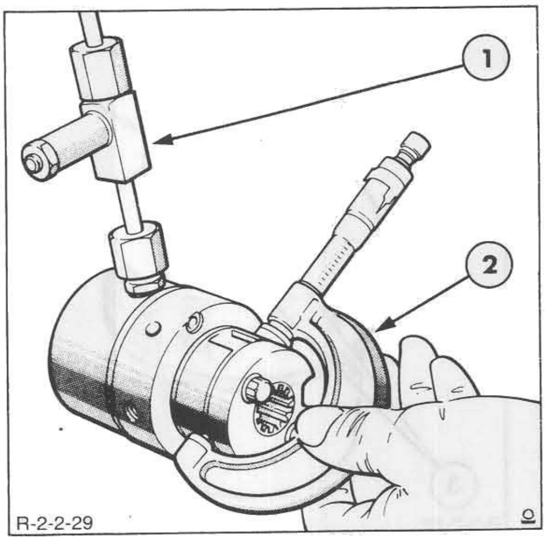


Figure 29
Setting the Roller to Roller Dimension

1. Tool No. 7144-262 2. Micrometer

10. Measure the roller to roller dimension across both pairs of rollers and obtain an average dimension, Figure 29. If necessary, adjustment can be made by rotating the top adjusting plate until the dimension is to specification. If the correct dimension cannot be obtained by adjustment of the top plate, then the top plate and/or the bottom plate must be changed to the next highest or lowest adjusting plate. The following instructions must be adhered to when changing adjusting plates. Tighten the drive plate screws to prevent movement of the adjusting plate and remove tool No. 7144-262 from the hydraulic head.

11. Holding the drive plate with tool No. 7144-744 tighten the drive plate screws using tool No. 7144-482 and a torque wrench to the specified torque, see 'Specifications' – Chapter 8. In use the tool No. 7144-482 and torque wrench must form a straight line with the torque wrench extending away from the tool.

12. Position the 'O' ring around the hydraulic head and lubricate the portion of the hydraulic head that fits into the pump housing with clean calibrating oil. Slide the hydraulic head into the pump housing rotating it as it enters the housing to prevent damage to the 'O' ring. Ensure that the splines on the end of the drive shaft engage with those on the drive plate and that the larger of the threaded holes is in the lowermost position to align with the advance device housing fitting. Secure the hydraulic head with the two locking screws, the one with the bleed screw being on the same side as the inspection aperture and leave finger tight until the advance device has been re-installed.

13. Holding the drive hub with tool No. 7144-773 tighten the transfer pump rotor to the specified torque, see 'Specifications' – Chapter 8, using tool No. 7044-889 and a suitable torque wrench, Figure 30.

14. Install the transfer pump liner, recess inwards, into the bore of the hydraulic head. Install the pump vanes into the slots in the rotor and rotate the liner to ensure that the vanes do not bind.

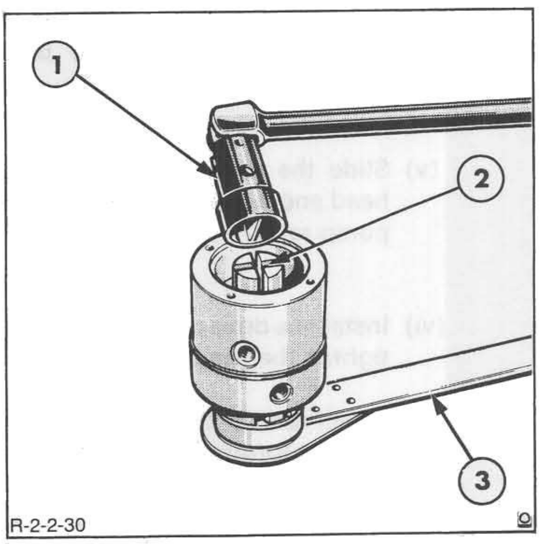


Figure 30
Tightening the Transfer Pump Rotor

1. Tool No. 7044-889 3. Tool No. 7144-744
2. Rotor

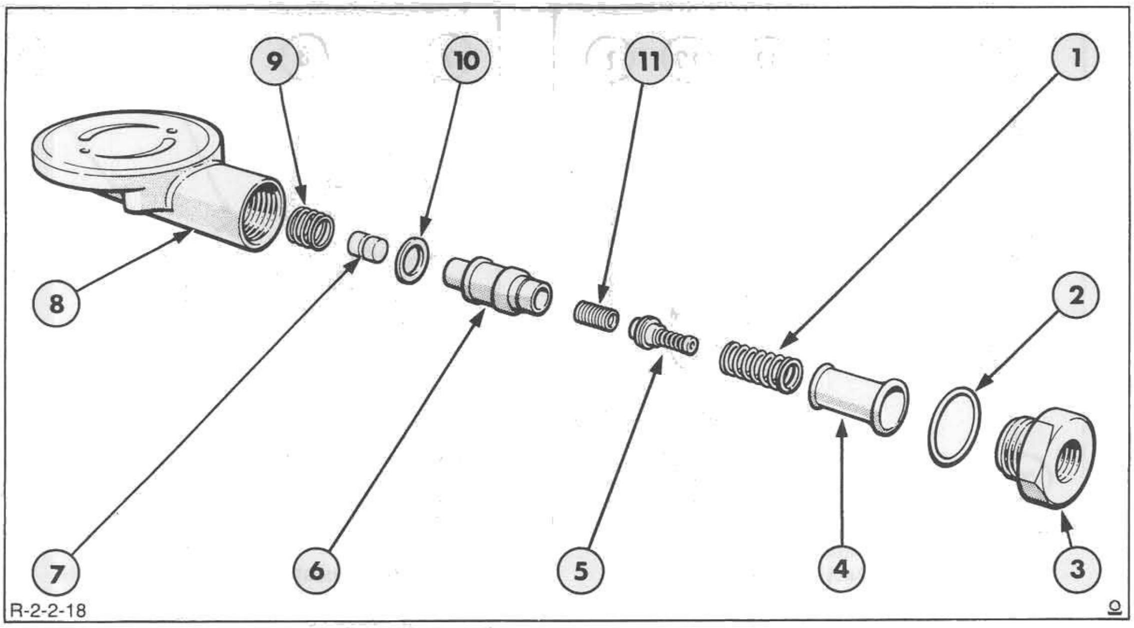


Figure 31
End Plate Components

1. Retaining Spring
2. Copper Washer
3. Fuel Inlet Connector
4. Filter
5. Transfer Pressure Adjuster
6. Valve Sleeve
7. Piston
8. End Plate
9. Priming Spring
10. Sealing Washer
11. Regulating Spring and Peg

15. Re-assemble the end plate as follows, referring to Figure 31 for component identification.

(i) Insert the priming spring into the bore of the valve chamber.

(ii) Install a new sealing washer to the valve sleeve and the piston into the bore of the valve sleeve.

(iii) Hold the valve sleeve vertically with the larger diameter uppermost and the piston retained in the bore of the sleeve. Insert the regulating spring and peg into the bore above the piston with the peg end uppermost. Position the transfer pressure adjusting screw assembly on top of the regulating valve screen.

(iv) Re-assemble the nylon filter onto the valve sleeve and insert the retaining spring into the filter locating it onto the adjusting screw assembly.

(v) Install a new washer onto the inlet connection and place it on top of the filter.

(vi) Invert the assembly standing it on the fuel inlet connection. Pass the end plate over the assembly and retain it by tightening the inlet connection.

16. Install a new rubber sealing ring in the groove around the transfer pump liner. Re-assemble the end plate onto the hydraulic head ensuring that the dowel in the end plate engages in the slot in the transfer pump liner and the fuel inlet connection will be uppermost when the pump is reinstalled on the engine. Secure the end plate to the hydraulic head with the four screws, tightening diagonally to the specified torque, see 'Specifications' – Chapter 8. Tighten the fuel inlet connection to the specified torque, see 'Specifications' – Chapter 8.

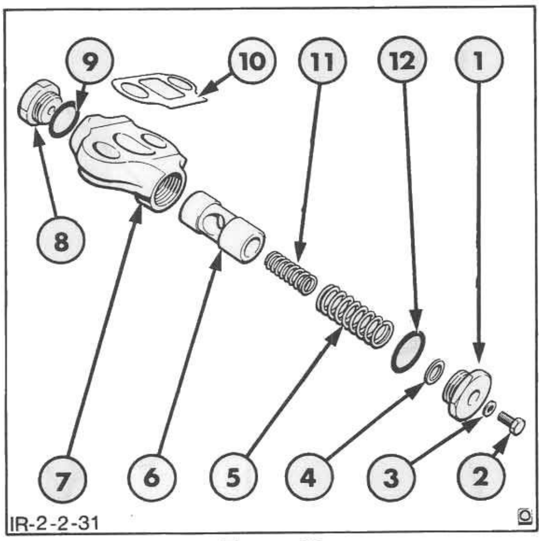


Figure 32
Advance Device Components

1. Spring End Cap
2. End Cap Plug
3. Washer
4. Shims
5. Outer Advance Spring
6. Piston
7. Advance Device Housing
8. Piston End Cap
9. 'O' Ring
10. Gasket
11. Inner Advance Spring
12. 'O' Ring

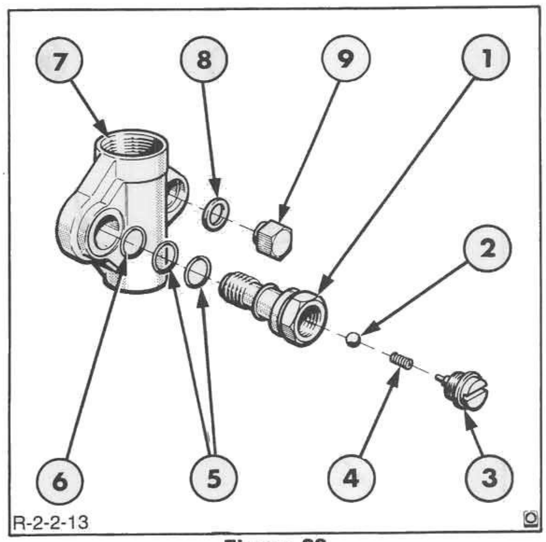


Figure 33
Head Locating Fitting Components

1. Head Locating Fitting
2. Non-Return Valve
3. End Nut
4. Spring
5. 'O' Rings
6. Washer
7. Housing
8. Sealing Washer
9. Cap Nut

17. Re-assemble the advance device as follows, referring to Figures 32 and 33 for component identification.

(i) Install a new 'O' ring onto the piston and spring caps using protection cap tool No. 7044-898. Insert the piston cap into the housing at the end of which the fuel inlet drilling enters the bore.

(ii) Insert the piston in the bore of the housing with the hollow end outwards and ensure it is free to slide in the bore.

(iii) Install the non-return valve spring and ball into the head locating fitting and retain with the end cap. Install a new upper 'O' ring onto the head locating fitting using protection cap tool No. 7044-898. Position the fitting in the advance device housing and install a new second 'O' ring using protection cap tool No. 7144-18, and the steel washer.

(iv) Invert the pump housing on the fixture and place the advance device gasket on the housing with the flat side of the gasket centre hole towards the drive end of the pump.

(v) Position the advance device on the pump housing ensuring that the cam advance screw engages into the piston. Screw the head locating fitting into the hydraulic head, Figure 34, and the cap nut and washer onto the advance device housing stud. Tighten the nut and fitting to the specified torque. Tighten the two head locking screws to the specified torque, see 'Specifications' – Chapter 8. Ensure that the drive hub rotates freely; if not, disassemble to find the cause.

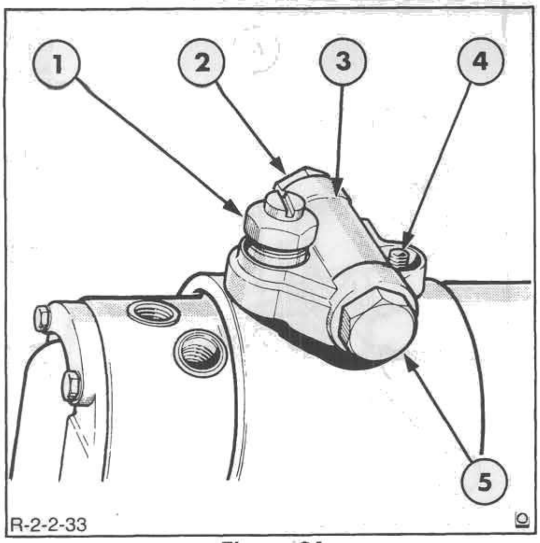


Figure 34
Installing Head Locating Fitting

1. Head Locating Fitting
2. Spring End Cap
3. Auto Advance Housing
4. Advance Housing Stud
5. Piston End Cap

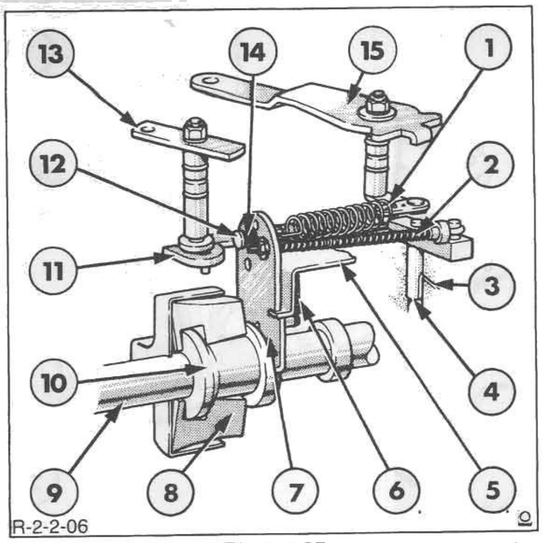


Figure 35
Control Linkage

1. Governor Spring
2. Control Rod and Spring
3. Metering Port
4. Metering Valve
5. Governor Bracket
6. Retaining Spring
7. Governor Control Arm
8. Governor Weights
9. Drive Shaft
10. Thrust Sleeve
11. Shut-off Bar
12. Idling Spring Guide
13. Shut-off Lever
14. Idling Spring
15. Throttle Lever

(vi) Ensure that the piston is free to move in the bore of the housing and install the springs into the bore of the piston. Install the spring cap, end cap plug and copper washer. A 1.0 mm Shim must be fitted in the spring cap at all times. Tighten the two end caps to the specified torque, see 'Specifications' – Chapter 8.

18. Install the electrical solenoid fuel shut-off into the pump housing.

19. Re-assemble the governor linkage as follows; referring to Figure 35 for component identification.

(i) Re-assemble the governor control arm and the control bracket securing with the small retaining spring. Install the upper and lower 'O' rings onto the throttle and shut-off shafts using protective cap tool No. 7144-458B.

NOTE: *Fill the groove in the shafts between the 'O' rings with a suitable lithium based grease.*

(ii) Install the idling spring onto the idling spring guide and pass the guide through the correct hole in the governor arm, see 'Specifications' – Chapter 8, and secure by fitting the governor main control spring to the guide.

(iii) Assemble the spacing collar, large diameter towards the hooked end, and spring onto the hooked rod. Pass the threaded end of the rod through the governor control arm, fit the nylon cone washer and secure with the nut and self locking nut. Assemble the hooked end of the lever to the metering valve.

(iv) Connect the free end of the governor main control spring to the correct hole, see 'Specifications' – Chapter 8, in the swivel link of the throttle shaft.

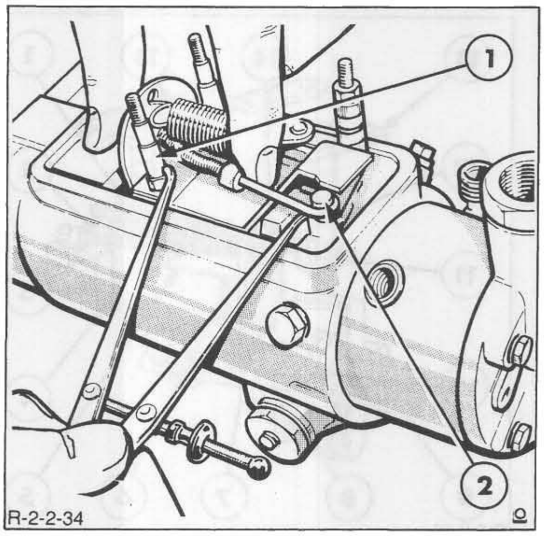


Figure 36
Setting the Governor Control Link Dimension

1. Governor Housing Stud
2. Metering Valve Lever Pin

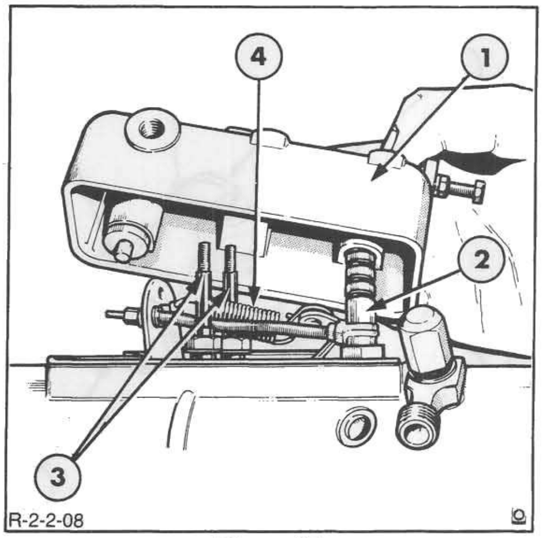


Figure 37
Installing Governor Control Housing

1. Governor Control Housing
2. Throttle Shaft
3. Housing Securing Studs
4. Governor Spring

20. Position the assembled governor linkage on the pump housing, engaging the control arm with the governor thrust sleeve and inserting the metering valve in its bore in the hydraulic head.

21. Locate the keep plate on the governor control bracket. Install new lock tabs on the governor cover studs and screw the studs into the pump housing, securing the keep plate and governor control bracket. Tighten the studs and lock by bending up the tab washers.

22. Insert and secure the tab washer and screw in the end of the governor bracket adjacent to the metering valve. Position the shut-off bar on the governor control bracket so that the peg on the shut-off shaft will engage in the cut out in the bar when the governor housing is installed.

23. Set the internal dimension between the metering valve lever pin and the large shoulder above the hexagon head of the adjacent governor housing stud to the dimension quoted in the Test Plan, Chapter 8. Light pressure should be applied to the governor control arm to hold the metering valve in fully open position and the measuring gauge held parallel to the pump body, Figure 36. Adjustment is made by screwing or unscrewing the nut on the end of the hooked lever.

24. Position a new governor housing gasket on the pump housing.

25. Press the shut-off shaft through the governor housing, Figure 37, and turn the shaft so that the peg which engages in the slot of the shut-off bar is next to the housing.

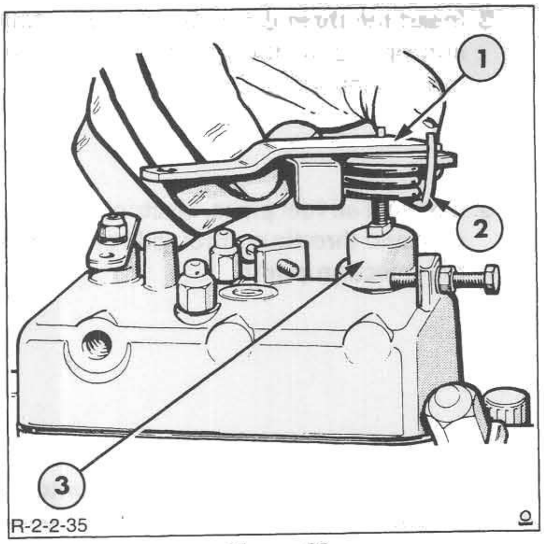


Figure 38
Installing Throttle Control Lever

1. Throttle Control Lever
2. Spring
3. Spring Guide

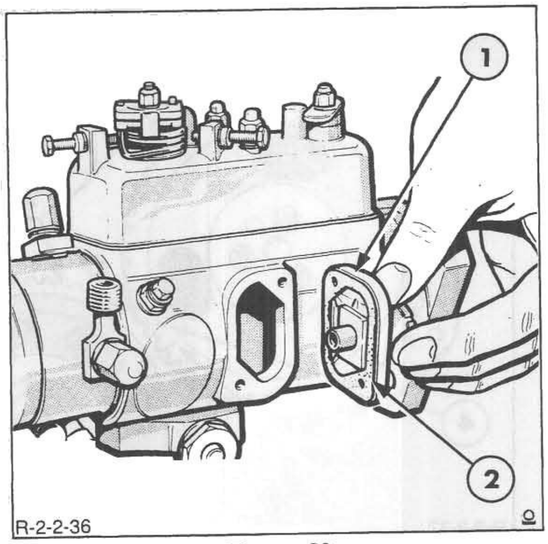


Figure 39
Installing the Side Inspection Cover

1. Inspection Cover
2. Gasket

26. Pull the throttle shaft through the governor housing using tool No. 7144-459A and lower the housing over the securing studs. Before securing with the domed nuts and fibre washers ensure that the peg on the shut-off shaft locates in the cut out of the shut-off bar. Tighten the nut to the specified torque, see 'Specifications' – Chapter 8.

27. Position the shut-off lever onto the shut-off shaft and secure with the nut and washer.

28. Fit the throttle lever to the throttle shaft by initially placing the spring guide over the hub on the governor control housing, Figure 38, and then placing the lever onto the shaft, securing with the washer and locknut tightened to the specified torque, see 'Specifications' – Chapter 8.

29. Locate the pump body inspection cover and gasket and secure with the retaining screws, Figure 39.

INSTALLATION

1. Place a new 'O' ring on the pump mounting flange.

2. If the pump timing cover is in position on the engine front cover, it should be removed.

3. Ensure that the injection pump drive gear is correctly meshed with the camshaft drive gear so that the timing marks are aligned, Figure 40.

NOTE: *All engines with a distributor type fuel injection pump have a common fuel injection pump drive gear. This gear features two timing marks identified by numerals '3' and '4' for 3 and 4-cylinder engines respectively.*

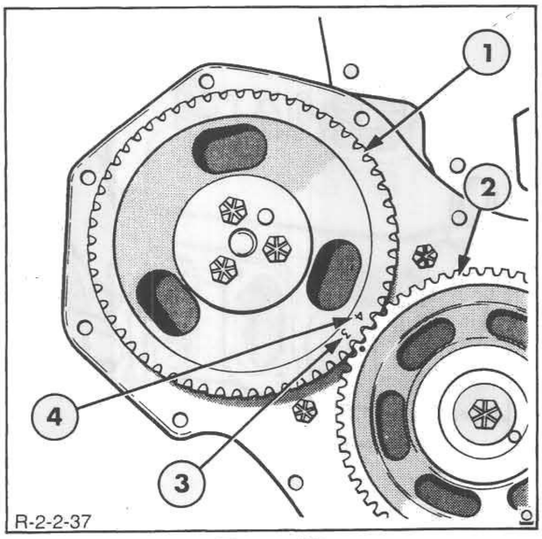


Figure 40
Injection Pump Drive Gear Timing

1. Pump Drive Gear
2. Camshaft Drive Gear
3. 3-Cylinder Timing Mark
4. 4-Cylinder Timing Mark

4. Install the injection pump, ensuring that the drive hub dowel pin engages with the hole in the drive gear – turn pump drive shaft as necessary, then secure pump loosely to the engine front plate with the three securing bolts.

5. If the pump has been internally timed, rotate the pump clockwise, as viewed from the rear end, ½ a division relative to the zero degree mark on the rear of the engine front plate.

6. If the pump has not been internally timed, align the scribed line on the pump flange with the centre punch reference mark previously made on the rear of the engine front plate.

7. Tighten the mounting bolts to the specified torque, see 'Specifications' – Chapter 8.

8. Insert the three drive gear securing bolts and tighten to the specified torque, see 'Specifications' – Chapter 8.

9. Connect all fuel pipes, electrical solenoid wire and throttle control rods or cables to the injection pump.

10. Install the pump timing cover onto the engine front cover, using a new gasket, and secure with the retaining screws tightened to the specified torque, see 'Specification' – Chapter 8.

11. Bleed the fuel system as follows:

(i) Ensure there is sufficient fuel in the tank and all connections are tight.

(ii) Remove the bleed screw from the top of the filter and allow the fuel to flow until it is free from air bubbles. Install the bleed screw and tighten.

(iii) Loosen the bleed screw on the injector pump and crank the engine until the fuel flowing is free from air bubbles. Tighten the bleed screw.

(iv) Loosen the injector line connectors at the injectors and crank the engine with maximum throttle until fuel free from air bubbles flows. Tighten the connectors.

C. FUEL INJECTION PUMP – ISO TEST CONDITIONS

INTRODUCTION: THE NEED FOR ISO

As Government legislation on power, smoke and noise emissions becomes ever more stringent, manufacturers of fuel injection equipment are faced with the necessity of more accurate measurements and tests for their products.

With the additional objectives of reducing discrepancies between test machines of different manufacturers and improving the correlation between test machine results and engine performance, the International Standards Organisation (ISO) has drawn up new standards for pump test conditions.

The ISO Committee is made up of members from the standards organisation of each country concerned, plus representatives from interested companies including Lucas CAV Limited.

The most noticeable change is the adoption of a test fluid of a lower viscosity, nearer in characteristics to diesel fuel and conforming to ISO Standard 4113. Further ISO standards relate to the high pressure pipes, test injectors, delivery measurement system, test bench drive and coupling, anti-backlash requirements and various other conditions.

Although these standards are not a legal obligation, they may be adopted into the legislation of any country where they are practised.

The accompanying Explanatory Notes for 'DPA' distributor pumps are typical of those which will be issued for use with all fuel injection pumps manufactured by Lucas CAV Limited. The Notes have been written in accordance with the conditions set down by the International Standards Organisation.

Copies of relevant ISO Standards are available from the National Standards Body of each individual concerned.

EXPLANATORY NOTES (ISO TEST CONDITIONS) FOR 'DPA' DISTRIBUTOR PUMPS

Fuel Pump Test Plans should be used in conjunction with the appropriate Ford Tractor Repair Manual.

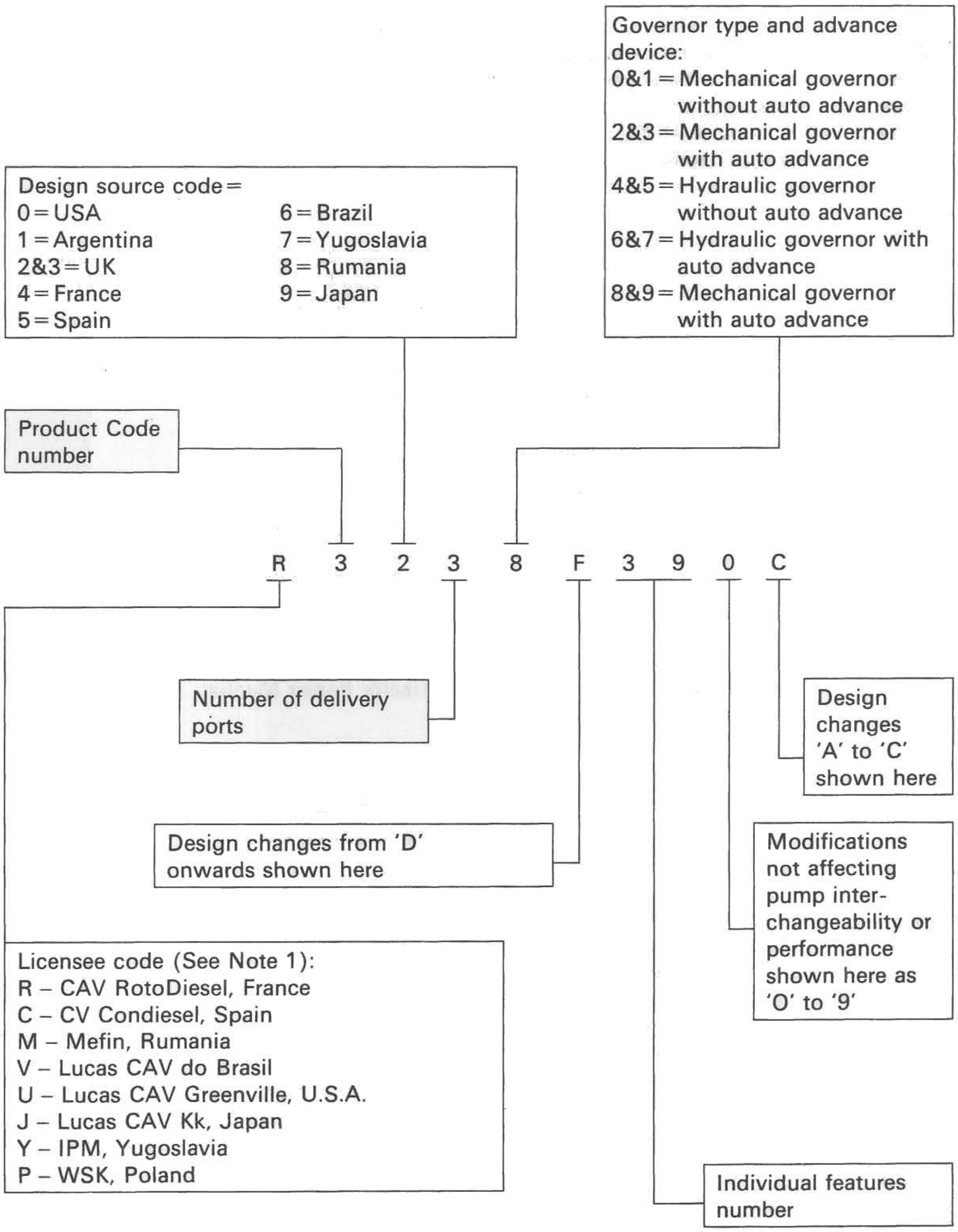
When Test Plans are superseded, the revised information will be distributed under a new issue Service Bulletin.

Test Plans are NOT specification information and must not be used as such.

Test Plans are issued for every pump specification except when two or more pumps form a group applicable to one engine and the pump detail variations do not create any change in the test figures. Related pumps of this type may all be covered by one Test Plan.

NOTE: *Successive Design Changes may also be covered by a single Test Plan if they conform to the above rule.*

DPA – DESPATCH NUMBER SIGNIFICANCE



NOTE 1: Lucas CAV, Medway, U.K. pumps do not have a code letter.

TEST MACHINE SPECIFICATION

Test Injectors

Two different types of test injector will be required for testing fuel injection pumps fitted to the Ford Tractor range.

1. Injectors fitted with the ISO 4010 delay pintle type nozzle, principally for high speed, indirect injection engine applications, are required for testing in-line pumps.

2. Injectors fitted with orifice plates (ISO 7440*), principally for direct injection engine applications, are required for testing distributor pumps.

   Use only the nozzle type specified in the individual Test Plan, together with the appropriate nozzle holder.
   "Pending ISO confirmation

Test injectors are available from Leslie Hartridge Limited, Tingewick Road, Buckingham, MK18 1EF, England, in sets of 4, 6, 8 or 12. The appropriate part number is dependent on the test nozzle required and the test machine type.

These injectors are essential for accurate pump calibration and are manufactured to a standard which will ensure minimum line to line scatter, consistent results between sets and accurate maximum fuel setting. ENSURE THAT TEST NOZZLE TYPE AND OPENING PRESSURE ARE AS SPECIFIED IN THE INDIVIDUAL TEST PLAN, e.g. delay pintle type ISO 4010 at 172-0+3 bar opening pressure (identified by ISO 4010 marked on their shank).

The use of the ISO nozzle means that test injectors can be serviced in the workshop by changing the nozzles only. Test nozzles are available from Leslie Hartridge in sets of 6 or 8.

NOTE: *Test injectors should be checked as follows:-*

Weekly or every 100 pumps – Check and reset open pressure. Check seat leakage, nozzle backleakage and replace nozzle where appropriate.

Every 1,000 pumps – Replace the test nozzle.

High Pressure Pipes:

Refer to the individual pump test plan.

Pipes to conform to the requirements of ISO 4093, viz:

1. "The pipes may be of any ferrous material, usually cold-drawn mild steel, and shall have a smooth internal bore, free from any cracks or other structural weaknesses and from corrosion or other matter likely to cause damage to the fuel injection system.

2. After making the end connections, any closing-in of the pipe shall be removed by inserting a reamer of the nominal internal diameter of the pipe to a depth of at least twice that of the length of the deformed end of the pipe. Any closing-in of the ends after extended use shall also be eliminated in a similar manner.

3. The radius of any bend subsequently made in fabricating the pipes shall be not less than 16 mm for 6 mm pipes, measured from the centre line of the pipe.

4. Pipes shall be washed out internally after the making of ends and bending in order to remove extraneous matter.

   For storage, the ends shall be sealed to prevent inlet of air in order to avoid internal corrosion."

Reproduced from ISO 4093 by kind permission of ISO, Geneva.

Dimensions

The standard dimensions of high pressure pipes are:-

ISO Identification	Internal Diameter	External Diameter	Length
ISO 4093.1	2±0.025	6	600±5
ISO 4093.2	2±0.025	6	845±5

Refer to the individual pump test plan for high pressure pipe requirement.

Fuel delivery can be seriously affected by restrictions in the bore or length of pipe. Regular checks should be made to ensure that no closure of the bore occurs in use and that bore ends are maintained at not less than 0.025mm below the nominal size. Shortening of the pipe (to reform a nipple) is only permissible if pipe length remains within the tolerance of the specified length.

Pump Outlet Connections

All tests are to be made using high pressure outlet connections as originally fitted to the pump unless stated otherwise on the Test Plan.

Measuring Glasses

Fuel readings are to be taken in accordance with the test bench manufacturers recommendations (see delivery values). Glasses should be cleaned regularly to ensure accurate and consistent readings.

On some older models of test machine, the graduations may be marked in cc's. On the newer test machines, the equivalent units of ml or cm^3 will be found.

Calibration Fluid (Test Oil)

Refer to the Test Plan for test oil requirement.

A PUMP SPECIFICATION WITH A TEST PLAN DEVISED ON ISO 4113 CALIBRATION FLUID MUST NOT BE TESTED ON A TRADITIONAL THICK FLUID WITH A VISCOSITY OF 6.5 TO 7.1 cSt AT 21C.

The following oils conform to ISO 4113 and also meet an oxidation requirement to improve shelf life of fuel injection equipment.

Brugarolas (Spain) Califluid 2
Castrol Diesel Calibration Oil 4113
Dalton (U.K.) Viscor 1487
Shell (International) S.9365
Shell (France) Normafluid BR

These oils are not necessarily available in all countries and where difficulty is experienced you should contact your normal supplier, quoting the following specification. A sample MUST be submitted for approval by Lucas CAV Ltd. before commencing tests.

Description

A refined, deodorised mineral oil with anti-foaming additives and other additives to improve resistance to wear, ageing and corrosion.

Physical Properties

Property	Unit	Requirement	Test Procedure
Colour	—	3 max	ISO 2049
Specific Gravity at 15°C	—	0,820–0,830	ISO 3675
Pour point	°C	–18 max	1P15
Cloud point	°C	–10 max	ISO 3015
Flash point	°C	75 min	ISO 2719
Total acidity	mg KOH/g	0,1 max	1P1
Sulphur active	—	Class 1 max	ISO 2160
Water content	% vol	0,05 max	1P74
Distillation	% vol	5 max @ 210°C	ISO 3405
	% vol	95 min @ 360°C	ISO 3405
Kinematic viscosity			
a) at 40°C	cSt	2,45-2,75	ISO 3104
b) $10^6 sec^{-1}$ shear at −12°C	cSt	30 max	1P71
Choking tendency Vx	Litres	454 min	7-2-66*
	Gallons	100 min	7-2-66*
Corrosion resistance at 60°C	—	Pass 24 hours	ASTM-D665A
Rust protection 50h with polished panels	—	Must pass 5 out of 6 faces of three panels	ASTM-D1748
Ageing test residue	mg/100ml	1,0 max	ASTM-D2274
Oxidation stability-acidity	mg KOH/9	0,3 max	7-2-68*
Oxidation stability sludge	% wt	Less than 0.05	7-2-68*
Foaming tendency	ml	50 max	(ASTM-D892, (Seq 1 only
Foaming stability	ml	nil	(in each case.
Aromatic components, CA value	%	11 max	(40-25-50* (ASTM-D2140

* Lucas Standards

General

Test oil, when in use in a test machine, will not retain its physical properties indefinitely. It can become contaminated with fuel oil and due to evaporation of the light fractions its viscosity will increase, thus giving inaccurate results.

To reduce such contamination as much as possible, pumps which have been removed from an engine and not dismantled should be drained of fuel oil BEFORE being put on the test machine. Ideally, the viscosity should be physically checked periodically and the oil changed when it varies from the limits quoted in the preceding specification.

NOTE: *In the absence of a viscosity check, it is recommended that the test oil should be changed at least every two months or after testing 150 pumps, whichever occurs sooner – more frequently where ambient temperature is high. Filters should be renewed at the same time.*

Test Oil Supply

To avoid fuel starvation and irregular pump behaviour the test machine should be able to support calibration fluid at 40°C, at a rate not less than 1,000 cm^3 per minute for a maximum feed pressure of 0.1 bar (1.5 lbf/in^2). It is an ISO requirement that the test machine should be capable of supplying at least the equivalent of two and a half times the delivery of the pump under test.

For the purpose of testing the Ford range of DPA pumps the supply pressure should be 0.1 bar (1.5 lbf/in^2) unless otherwise stated on the Test Plan.

Temperature of Test Oil

Values given in Test Plans are correct when the oil in the test machine supply connection is at a temperature of 38-42°C. It is recommended that a temperature control unit is fitted to maintain the temperature.

Storage of Test Oil

"Calibration fluid conforming to an ISO standard shall be obtained in sealed metal drums bearing two identification marks:

a) The manufacturer's (or supplier's) name which shall vouch for conformity with the relevant ISO standard.

b) The ISO standard number to which the fluid purports to conform.

Calibration fluid shall be retained, in its sealed original identifiable container, under cover, until required for use.

Fluid shall be protected from severe frost (−10°C) at all times."

Reproduced from ISO 4008, by kind permission of ISO, Geneva.

Test Machines

CAV DPA distributor pumps must be tested on machines which conform to the dynamic (drive system) and static (fuel measuring system) requirements as laid down in ISO 4008 Parts 1 and 2 respectively. The maximum power specified to drive any distributor pump under test is 1.4 KW at a specified peak injection pressure of 625 bar.

Hartridge 2500 and 1150 test machines are recommended, as they meet the above requirements and are capable of testing the whole range of distributor pumps. Additionally, Hartridge 1100 and 875 test machines are suitable for testing pumps to be fitted to the Ford Tractor range.

Fuel Pump Drive

Fuel delivery can be substantially affected by the backlash and/or stiffness of the test machine drive system. It is, therefore, important to limit these effects to ensure accurate fuel settings and reduce line-to-line scatter.

The drive couplings should have zero backlash and exhibit a torsional stiffness which allows less than 0.1° deflection under peak injection torque for the pump under test. Coupling manufacturers quote figures for coupling stiffness and corresponding maximum fuel delivery in mm^3/stroke, according to ISO standard 4008/1.

The corresponding maximum fuel delivery in mm^3/stroke should not be exceeded for any pump under test. If doubt exists about a coupling's performance contact either the coupling manufacturer or CAV Parts and Service.

It is recommended that an anti-backlash coupling (Hartridge Kit HF 533) is used. On no account may flexible rubber or fibre disc type Oldham couplings be used as part of the drive system.

DELIVERY VALUES

To conform with the requirements of ISO 4008/2, all critical fuel delivery values are quoted in mm^3/stroke (not cm^2 per 200 strokes) on the Test Plan or on the pump nameplate. Using a simple conversion chart, supplied by the test machine manufacturer, critical fuel deliveries can be related to the minimum filling requirements of the test machine graduates necessary to ensure accurate readings. This is introduced to minimise the errors due to the variations in the graduate capacities of different machines, count errors and glass drainage requirements. The appropriate number of strokes in these cases should be determined in accordance with the test machine manufacturer's instructions. Where NOT specified by the test machine manufacturer, the number of strokes taken should give at least a 50% fill of the graduates. All other fuel readings are taken over 200 strokes unless stated otherwise on the Test Plan.

When using Hartridge 1150, 1100 and 875 test machines, the number of strokes chosen should give at least a 40% fill of the graduate with a SINGLE operation of the trip mechanism. Allow 30 seconds glasss drainage time and let the test oil settle for 15 seconds before taking readings (unless the test machine is equipped with a piston-in-graduate measurement system, which enables readings to be taken directly). The bottom of the meniscus must always be used when taking fuel readings.

For Hartridge machines, conversion charts are included at the end of Chapter 8. These give directly the minimum number of strokes and corresponding cm^3 value for each mm^3/stroke value. However, critical fuel values can be determined as shown in the following examples:

Example for Hartridge 1100 Mark II

Method to determine the minimum number of strokes for a Test Plan critical fuel value of 25 mm^3/stroke using a Hartridge 1100 test machine with 30 cm^3 graduates.

Delivery for 100 strokes in

$$cm^3 = \frac{25 \times 100}{1000} = 2.5\ cm^3.$$

Hartridge 1100 should give at least a 40% fill of graduates,i.e. 40% of 30 cm^3 = 12 cm^3.

Therefore, to achieve at least this fill it will be necessary to use 500 strokes giving a delivery of 12.5 cm^3, with a SINGLE operation of the trip mechanism.

5×2.5 cm^3/100 strokes = 12.5 cm^3/500 strokes.

Similarly 60 mm^3/stroke requires 200 strokes giving 12 cm^3 and 30 mm^3/stroke requires 500 strokes giving 15 cm^3.

Example of Hartridge 2500:

Method to determine minimum number of strokes for a Test Plan critical fuel value of 30 mm^3/stroke using a Hartridge 2500 test machine with 60 cm^3 graduates:

Delivery for 100 strokes in

$$cm^3 = \frac{30 \times 100}{1000} = 3cm^3.$$

Hartridge 2500 should give at least a 25% fill of graduates, i.e. 25% of 60 $cm^3 = 15$ cm^3. Therefore, to achieve at least this fill, it will be necessary to use 500 strokes, giving a delivery of 15 cm^3.

Before commencing tests, unscrew the maximum stop screw and the idling stop screw to allow full movement of the throttle arm.

The throttle lever is to be fully open and the stop lever and solenoid stop valve in the "run" condition unless otherwise stated.

Do NOT run the pump for long periods with the shut-off lever closed, particularly at high speed.

Roller to Roller Dimension

The setting given on the Test Plan is approximate and is for use when assembling the pump. Final adjustment of maximum fuel must be carried out on the test machine. If a substantial alteration is required, then the pump cannot be functioning correctly, e.g, plungers sticking, incorrect governor link setting etc.

Transfer Pressure Adjustment

Various end plate transfer pressure adjusting assemblies or sleeve plugs of different thickness can be used to vary the load on the regulating spring. Where this is applicable, it is stated on the Test Plan.

Governor Link Setting

Refer to "Overhaul – Section B" for the method of setting governor link length.

The link length is specified to satisfy two main factors for governor performance:

1. Fuel cut-off at maximum speed.

2. Non-interference with fuel delivery at the maximum fuel setting.

Whilst most governors will operate satisfactorily with the nominal link length, some units fail for the above reasons and can be corrected by an alteration to the link length. The following procedure should, therefore, be adopted:

a) Set to nominal link length before commencing test.

b) If unit fails for 'no cut-off at maximum governed speed,' reduce link length.

c) If unit fails for maximum fuel interference, increase link length.

Note, however, that incorrectly machined, worn or wrongly assembled parts can produce the same faults and alteration to link length, which may already be correct, will not necessarily effect a solution. Should adjustment to the link length fail to correct the fault, then this should be reset to the nominal length and the trouble looked for elsewhere.

When adjustment to the governor link length has been made, the sequence of governor setting tests must be repeated and the test requirements satisfied. Adjustment must NOT be made beyond the specified tolerance.

Automatic Advance Devices

1. Before commencement of test ensure the correct thickness of shims is fitted to the advance assembly as stated in the relevant Test Plan. The minimum thickness of shims must not be removed, and shims may be added as stated in the Test Plan.

2. Tests are carried out strictly in the order specified on the relevant Test Plan.

3. The maximum amount of shimming allowed is not exceeded.

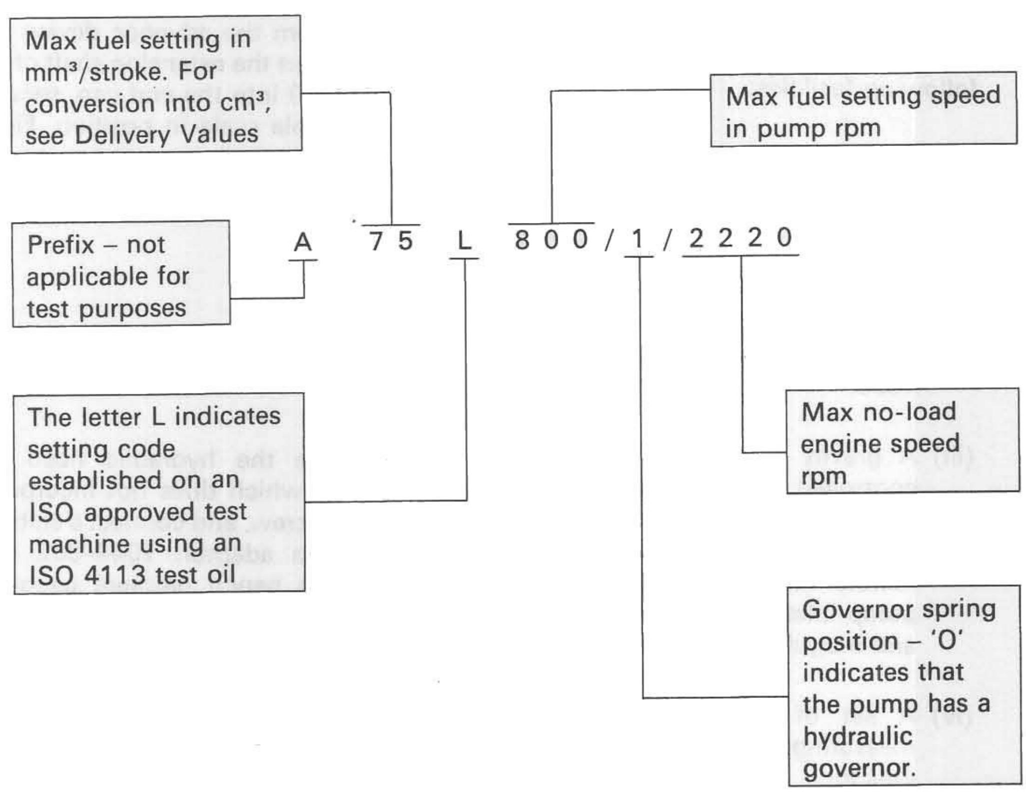
TEST PLANS FOR PUMPS WITH SETTING CODE ON NAMEPLATE

The following test data is not given on the Test Plan for coded pumps and must be obtained from the setting code on the pump nameplates:

Maximum fuel setting, maximum fuel setting pump speed, governor spring position on all-speed mechanically governed pumps and maximum no-load engine speed.

For pumps produced before the introduction of ISO Standards, the setting code on the nameplate (unlettered code or 'E' code) applies *only* to thick test fluid *not* conforming to ISO 4113. In these cases, when testing with a thin fluid conforming to ISO 4113, the setting code must be disregarded and all necessary information extracted from the relevant ISO Test Plan or CAV dealer or Ford Test Plan (ISO) if available or issued!

Example of Setting Code



D. FUEL INJECTION PUMP – TEST PROCEDURES

1. Prior to installing the pump on the test bench, check the pump for external leaks as follows:

   (i) Connect a compressed air supply to the leak-off connection and plug the return from the governor cover.

   (ii) Completely immerse the pump in a bath of clean fuel oil and subject the assembly to a pressure of 2 lbf/in² (0.14 bar) for a period of one minute.

   (iii) Repeat using 10 lbf/in² (0.70 bar). Rotate drive hub slowly during test.

NOTE: *Pressures greater than 20 lbf/in² (1.40 bar) will damage the pump seals.*

   (iv) Leaks will be indicated by air bubbles emerging from the pump and these should be rectified before further pump testing commences.

2. The calibrating machine must conform to ISO 4008 Parts 1 and 2 and have the following facilities:

   (i) A speed range of 100 to 1500 rev/min.

   (ii) Matched set of ISO 7440 nozzles set at 207 to 210 bar opening pressure connected to high pressure pipes 6mm × 2mm by 845mm long to ISO 4093.

   (iii) A gravity feed fuel supply, or a controlled pressurised feed of 2.0 lbf/in² (0.14 bar). In either case a minimum flow of 1000/cc per minute must be available at the pump inlet to avoid fuel starvation and irregular pump behaviour.

   (iv) A set of graduated glasses for measuring the output from each injector.

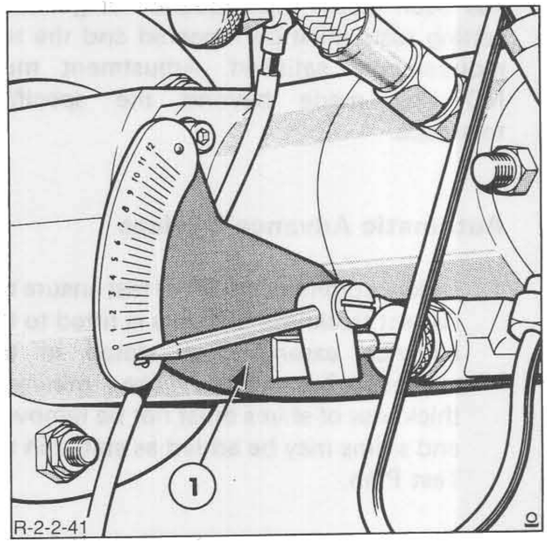


Figure 41
Advance Device Measuring Scale

1. Tool No. 7244-59

3. Mount the pump on the test bench using a suitable bracket and install a quill shaft between the pump drive hub and the test bench drive shaft. Remove the end cap plug from the advance device end cap and insert the extension shaft of tool No. 7244-59 into the end cap, securing the adjustable scale in position, Figure 41. Adjust the scale to set the pointer at zero.

4. Remove the hydraulic head locating screw, which does not incorporate the bleed screw, and connect a suitable high pressure adaptor: 7044-892. Connect the test bench pressure gauge to this adaptor. The gauge should be marked in increments of 2.0 lbf/in² (0.1 bar) and be capable of 100 lbf/in² (7.0 bar). Connect the back leakage gauge feed pipe to the pump outlet port, located in the pump body inspection cover.

5. Connect the high pressure pipes to the high pressure connections. The original high pressure connections on the pump must be used.

6. Connect the pressure gauge and bleed-off pipe to the connection in the top of the governor control housing. Ensure that the banjo bolt bleed return orifice is of the correct size, i.e. 0.5 mm. Connect the fuel supply line to the inlet in the end plate of the pump.

TESTING PROCEDURE

Injection pump testing should be carried out as outlined under 'Test Plan' in Specifications, Chapter 8 in conjunction with the following procedure.

The throttle and stop control levers must be fully open except where otherwise stated.

The pump must be completely free from leaks while running and stationary. A negligible leak from the extension shaft of tool No. 7244-59 is unavoidable.

All fuel delivery quantities are given in mm^3/stroke except where otherwise stated.

IMPORTANT: *Do not run the pump for long periods with the shut-off lever closed. Do not run the pump for long periods at high speed with small delivery.*

Observe the points in the test procedure where priming and venting are required. To prime the pump:

(i) Slacken the bleed screw on the pump body.

(ii) Slacken the unions at the injector ends of the high pressure lines.

(iii) Run the pump at 100 rev/min, close the bleed screw and tighten the high pressure line unions when fuel free from air issues from each location.

Transfer pump vacuum is checked at the specified pump speed by turning the two way tap on the fuel feed line to cut off the fuel supply and connect the line to the vacuum gauge, and required vacuum must be reached within the specified time.

NOTE: *Reprime the pump after the completion of this test.*

Transfer pump pressure is noted at certain pump speeds and must be as specified.

Speed advance is checked at the given pump speeds, the amount of advance should be as specified. If incorrect adjust the transfer pressure to ensure correct advance travel at the two check points.

IMPORTANT: *A 1.0 mm (0.04 in) shim is installed in the end plug on assembly. This must not be removed.*

NOTE: *Re-prime the pump after any adjustment has been made.*

Maximum fuel delivery is checked at a given pump speed and should be between the limits given in the test-plan.

If the setting is incorrect, adjust as follows:

(i) Turn off the fuel supply and remove the pump body inspection cover.

(ii) Slacken the rotor drive plate bolts using adaptor tool No. 7144-482 and suitable stock wrench. Slacken the drive plate bolt farthest from the adjusting notch first. When re-torquing, tighten the drive plate bolt nearest the adjusting notch first.

(iii) Enter the hooked end of tool No. 7144-875 through the inspection aperture and engage with the notch in the periphery of the top adjusting plate, Figure 42.

(iv) The necessary adjustment can be made by tapping the end of the tool with a suitable hammer. If the correct fuel level cannot be obtained by adjustment of the top plate, then the top plate and/or the bottom plate must be changed to the next highest or lowest adjusting plate, the following instructions must be adhered to when changing plates.

(v) Tighten the drive plate securing screws using the adaptor tool No. 7144-482 and a suitable torque wrench. The torque specified for the adaptor should be applied with the adaptor and torque spanner in line, as this will ensure the correct torque being applied to the drive plate securing bolts.

The governor setting should be carried out at the specified pump speed and the maximum speed screw adjusted until the specified output is obtained.

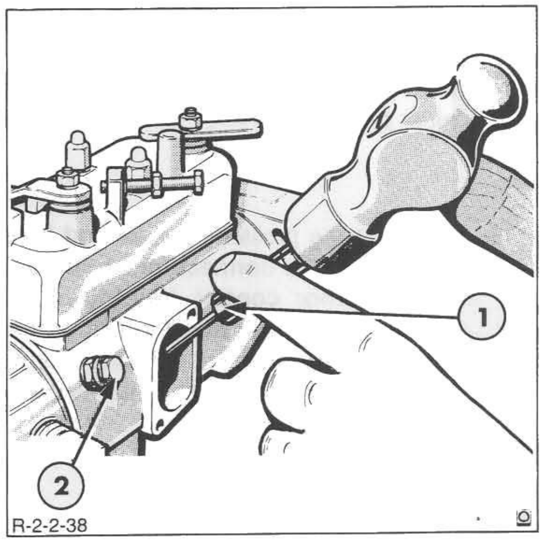


Figure 42
Adjusting Maximum Fuel Setting

1. Tool No. 7144-875
2. Bleed Screw

With a given pump speed increase delivery must not exceed the specified amount and with the given pump speed reduction the delivery must increase to a volume within the specified limits of the maximum fuel delivery.

Pump timing must be carried out after the pump has been removed from the test bench and the fuel drained from the pump body.

The pump drive hub has a master spline and slot which is positively located by the peg on the engine pump drive gear. Accurate timing of the injection pump to the engine is ensured by scribing a line on the pump mouting flange, relative to the master spline. This scribed line is relative to a fixed mark on the engine front mounting plate.

It is therefore possible to install a new injection pump and maintain correct timing of pump to engine by engaging the master peg and slot and aligning the mark on the pump body with zero mark on the engine.

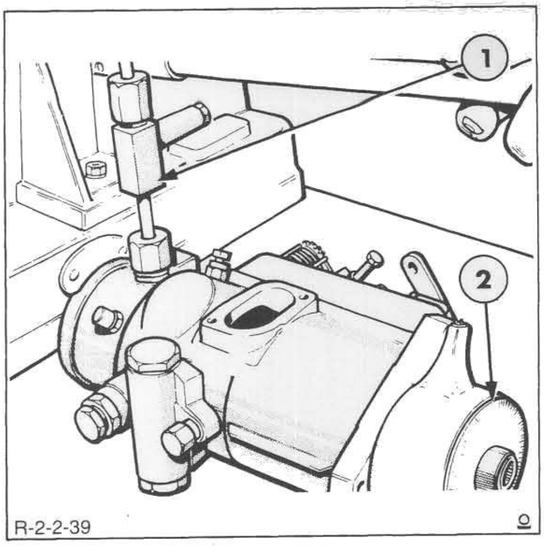


Figure 43
Setting the Pump Timing Mark

1. Tool No. 7144-262
2. Tool No. 7244-26

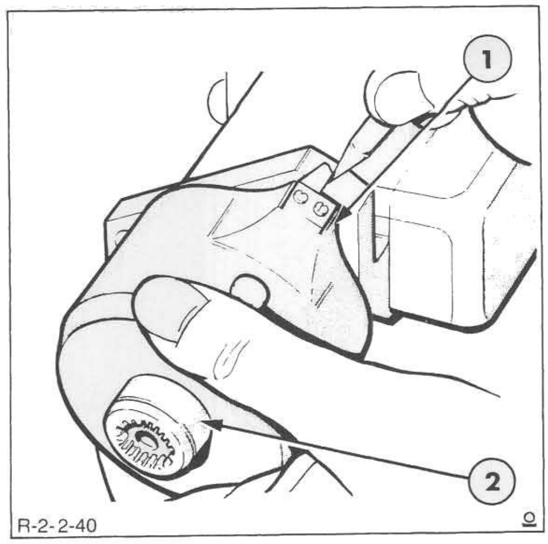


Figure 44
Scribing the Pump Timing Mark

1. Tool No. 7244-26
2. Quill Shaft

To set the pump timing, after testing proceed as follows:

(i) Remove the non-return valve from the specified outlet see Test Plan, Specifications, Chapter 8 of the hydraulic head and connect the adaptor pipe of tool No. 7144-262 directly to the outlet of the hydraulic head.

(ii) Connect the outer end of the adaptor pipe to an injector tester and pump the tester until fuel flows from the pressure relief valve in the pipe indicating that the required pressure has been obtained.

(iii) Set the pump flange marking gauge tool No. 7244-26 to the specified indexing figure see Test Plan Specification, Chapter 8 and using a suitable quill shaft install it onto the pump drive hub.

(iv) Turn the gauge and hub in the direction of pump rotation, the fuel pressure will cause the plungers and rollers to move to their outermost position. When the rollers contact the cam lobes, resistance to further rotation is encountered, this being the setting point for the pump, Figure 43.

(v) With the pump held in this position a line should be scribed on the pump flange along the guide on the gauge, Figure 44.

INJECTION PUMP STORAGE

If after overhaul, an injection pump is being stored the body should be left filled with substitute oil and all connections sealed with dust plugs and caps.

If the pump is stored for a period of six months or more it is recommended that the unit be tested to the Test Plan again before putting the pump into service.

PART 2
FUEL SYSTEMS

Chapter 3
FUEL INJECTION PUMP – DPS DISTRIBUTOR TYPE

A. FUEL INJECTION PUMP – DESCRIPTION AND OPERATION

General Description

The DPS distributor type fuel injection pump, Figure 1, is installed on all diesel engine Ford 555C and 655C Tractors.

The pump is flange mounted at the front right-hand side of the engine being driven by a gear timed to the camshaft drive gear, see "ENGINE SYSTEMS" – Part 1. It is oil tight, having a double lip type seal, preventing engine oil entering the pump body and also fuel oil entering the engine lubrication system.

During operation all moving parts are lubricated by fuel oil under pressure preventing the ingress of dust, water and other foreign matter.

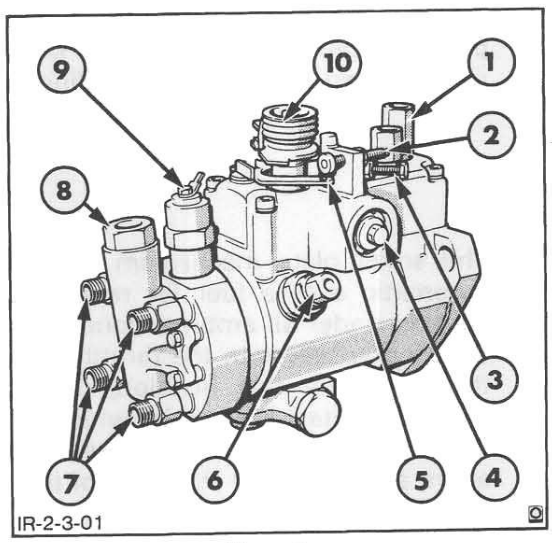


Figure 1
Fuel Injection Pump

1. Leak-off Connector
2. Maximum No Load Speed Adjuster
3. Idle Speed Adjuster
4. Excess Fuel Device
5. Stop Control
6. Latch Valve
7. Outlets to Injectors
8. Fuel Inlet Connector
9. Fuel Shut-Off Solenoid
10. Throttle Lever

The DPS distributor type fuel injection pump consists of a pumping and distributing rotor driven directly from the pump drive shaft. The rotor revolves within the hydraulic head and has a vane type fuel transfer pump connected to the end.

A regulating valve controls transfer pressure to the metering valve, which is operated by the throttle lever, and regulates the flow of fuel to the filling ports of the rotor. The distributor rotor carries two pairs of opposed high pressure pumping plungers which, under the action of fuel at filling pressure, push the rollers into contact with the internal lobes of the cam ring.

Maximum fuelling is pre-set by a sealed external adjuster which controls a pair of scroll plates located concentrically with and either side of the cam ring. These act as check plates, limiting the outward movement of the rollers in contact with the pumping plungers and can be partially rotated to adjust maximum fuelling.

The scroll plate mechanism also gives automatic excess fuel for rapid engine starting under all ambient conditions. At cranking speed, with the throttle lever in the maximum fuel position, the scroll plates are rotated to a point which allows the pumping plungers to move further apart, admitting fuel in excess of the normal maximum.

As soon as the engine self-sustains excess fuel is terminated as fuel pressure, supplied via the latch valve, acts on the piston in the excess fuel device moving the scroll plates into the maximum fuel position. At this point action of the governor on the metering valve reduces the fuel level to the maximum no-load requirements.

In addition to excess fuelling during engine cranking, the advance and start retard unit automatically adjusts the cam ring to retard injection timing. When the engine self-sustains the cam ring is partially rotated in the opposite direction to pump rotation to advance the timing as the pump speed increases.

At engine cranking speed, the latch valve located in the pump housing ensures that transfer pressure does not reach either the auto-advance unit or excess fuel device until the engine has self-sustained. When the engine self-sustains transfer pressure opens the latch valve diverting the fuel under pressure to the advance and excess fuel devices.

A variable speed mechanical governor controls the metering valve allowing a constant engine speed to be maintained regardless of engine loading. The governor is fitted with a "cush drive" weight retainer with 6 weights.

An electrically operated fuel shut-off solenoid screwed into the top of the hydraulic head controls the fuel supply to the input side of the metering valve. This provides the operator with an "ignition key" engine start and stop.

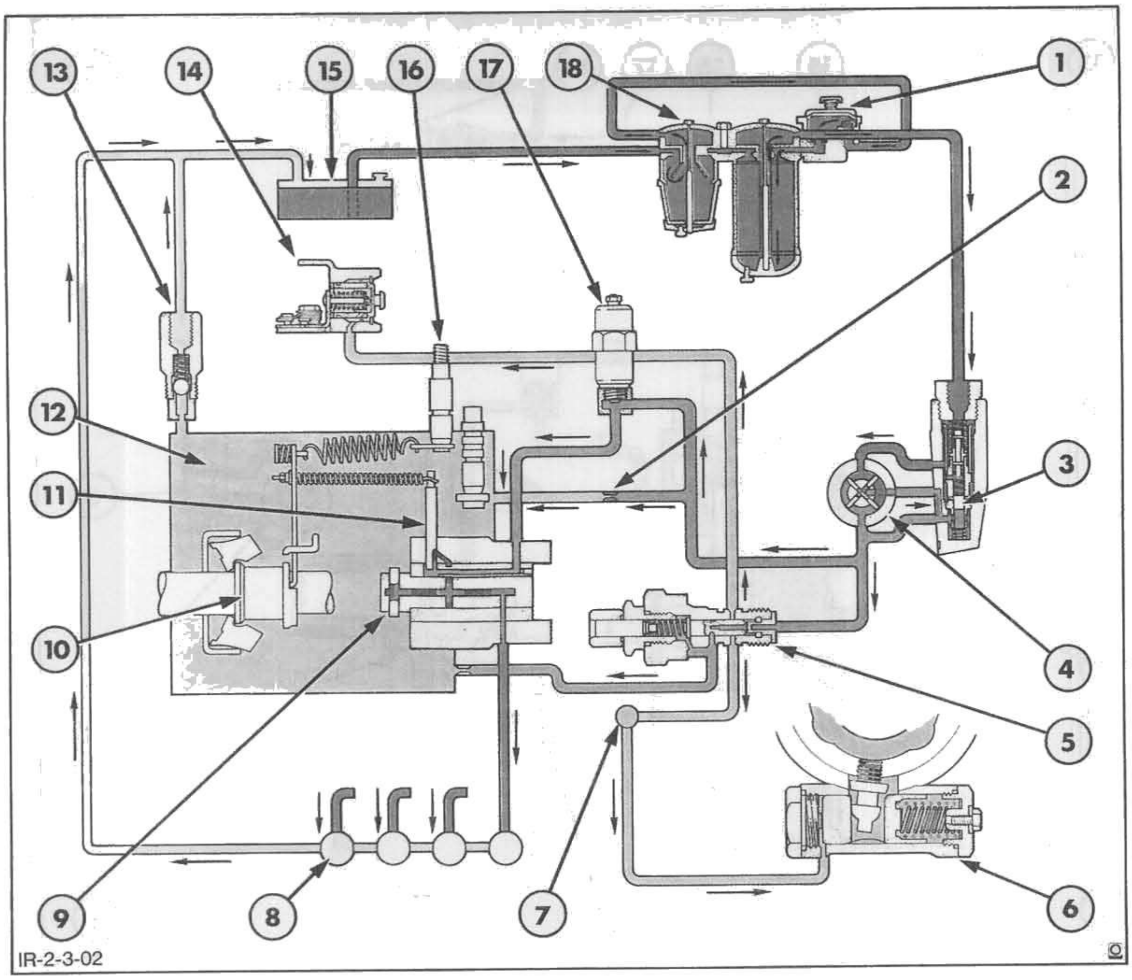


Figure 2
Fuel System Schematic - Engine Cranking

A Feed Pressure	B Transfer Pressure	C Injection Pressure
D Cam Box Pressure	E Back Leakage Fuel	F Metering Pressure
G Differential Pressure		

1. Hand Primer
2. Vent Orifice
3. Regulating Valve
4. Transfer Pump
5. Latch Valve
6. Automatic Advance and Start Retard Unit
7. Head Locating Fitting
8. Injector
9. Hydraulic Head and Rotor
10. Variable Speed Governor
11. Metering Valve
12. Cam Box
13. Pressurising Valve
14. Excess Fuel Device
15. Fuel Tank
16. Throttle Shaft
17. Fuel Shut-off Solenoid
18. Sedimenter - Filter

Fuel Pump Operation

With reference to Figures 2 and 3.

Fuel is drawn by the transfer pump from the fuel tank through the sedimenter, hand primer and on through the filter assembly. Fuel, at feed pressure (A), passes into the transfer pump which raises the pressure with increasing engine speed to an intermediate value termed transfer pressure controlled by the regulating valve.

In operation, the regulating valve maintains a pre-determined relationship between transfer pressure and the speed of rotation by returning part of the fuel to the inlet side of the transfer pump.

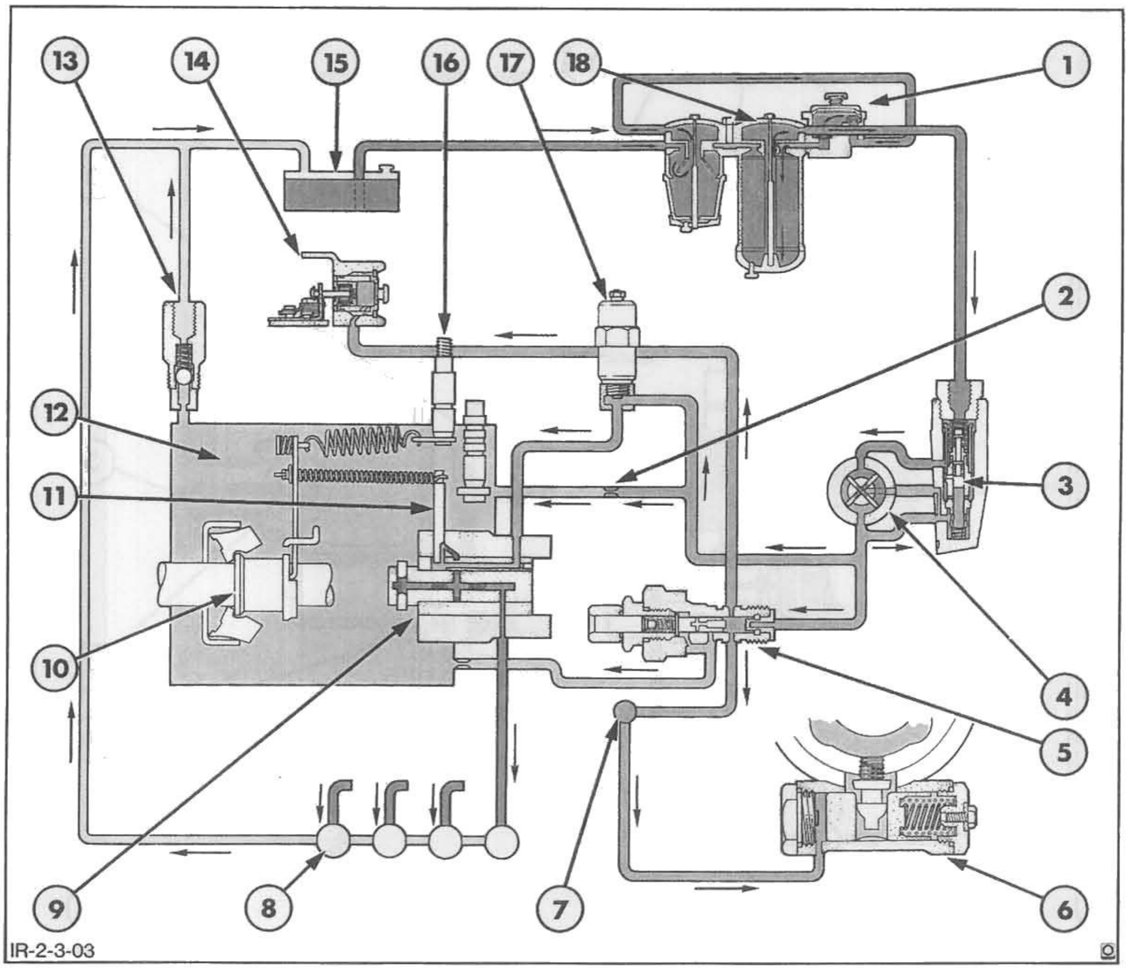


Figure 3
Fuel System Schematic - Engine Running

A	Feed Pressure	B	Transfer Pressure	C	Injection Pressure
D	Cam Box Pressure	E	Back Leakage Fuel	F	Metering Pressure

1. Hand Primer
2. Vent Orifice
3. Regulating Valve
4. Transfer Pump
5. Latch Valve
6. Automatic Advance and Start Retard Unit
7. Head Locating Fitting
8. Injector
9. Hydraulic Head and Rotor
10. Variable Speed Governor
11. Metering Valve
12. Cam Box
13. Pressurising Valve
14. Excess Fuel Device
15. Fuel Tank
16. Throttle Shaft
17. Fuel Shut-off Solenoid
18. Sedimenter - Filter

The transfer pump supplies fuel to the pumping plungers and via a separate passage, actuates the latch valve.

To fill the pumping plungers, fuel at transfer pressure (B) flows around annular grooves in the hydraulic head and passes into a drilling in the top of the hydraulic head sleeve. Fuel then flows to the metering valve, which regulates fuel flow through the linkage to the throttle lever or movement of the governor weights.

As fuel passes through the metering valve orifice in the hydraulic head, a pressure drop occurs reducing transfer pressure (B) to a level known as metering pressure (F). Fuel from the metering valve then passes into two oblique filling ports via a circular groove in the sleeve to the rotor charging ports, then through a central drilling in the rotor to two pairs of opposed pumping plungers. These are actuated by an internally lobed cam ring.

The lobes of the cam ring are phased with the drillings in the hydraulic head and rotor which allows alternate filling and injection. The rotor ports first charge the pumping plungers at metered pressure (F), then fuel is pumped from the distributor port at injection pressure (C) to each of the injectors in turn.

A controlled leakage of fuel for lubricating purposes passes between the rotor, hydraulic head, plungers and bore etc., and then to the cam box.

Cam box pressure (D) is maintained by a pressurising valve which unloads excess pressure in the cam box and returns the back leakage fuel (E) to the supply tank. Back leakage from the injectors is also returned to the supply tank.

To actuate the latch valve, fuel at transfer pressure (B), regulated by pump speed, flows into a drilling in the bottom of the hydraulic head sleeve and, via an annular groove in the sleeve, to the latch valve.

At cranking speeds, the latch valve is closed and prevents fuel at transfer pressure (B) flowing, via either the head locating fitting, to the advance unit, which therefore remains in the retarded position or to the excess fuel device. The passages to both the advance unit and excess fuel device remain at cam box pressure (D).

At a pre-determined pressure, i.e., above cranking speed, the latch valve opens to allow fuel at transfer pressure (B) to flow via an annular groove in the hydraulic head sleeve to the head locating fitting and also to the excess fuel device. Fuel flows from the head locating fitting to the pressure side of the piston in the automatic advance and start retard unit.

With an increase in pump speed, transfer pressure (B) acting on the advance piston causes the cam ring to advance the injection timing. Leakage from the advance unit flows back to the cam box.

Two orifices, one situated in the passage between the latch valve and the cam box and the other in the latch valve, are utilised to generate a differential pressure (G). This pressure is only generated at cranking speed when both orifices are open.

When the engine self sustains, transfer pressure exceeds the combined effect of differential pressure and spring force; the latch valve opens, the valve orifice closes and differential pressure is reduced to cam box pressure.

Thus the valve will close at a lower pump speed i.e., when transfer pressure drops below the combined effect of the latch valve spring force and cam box pressure. This is necessary to prevent the pump retarding during rapid engine deceleration.

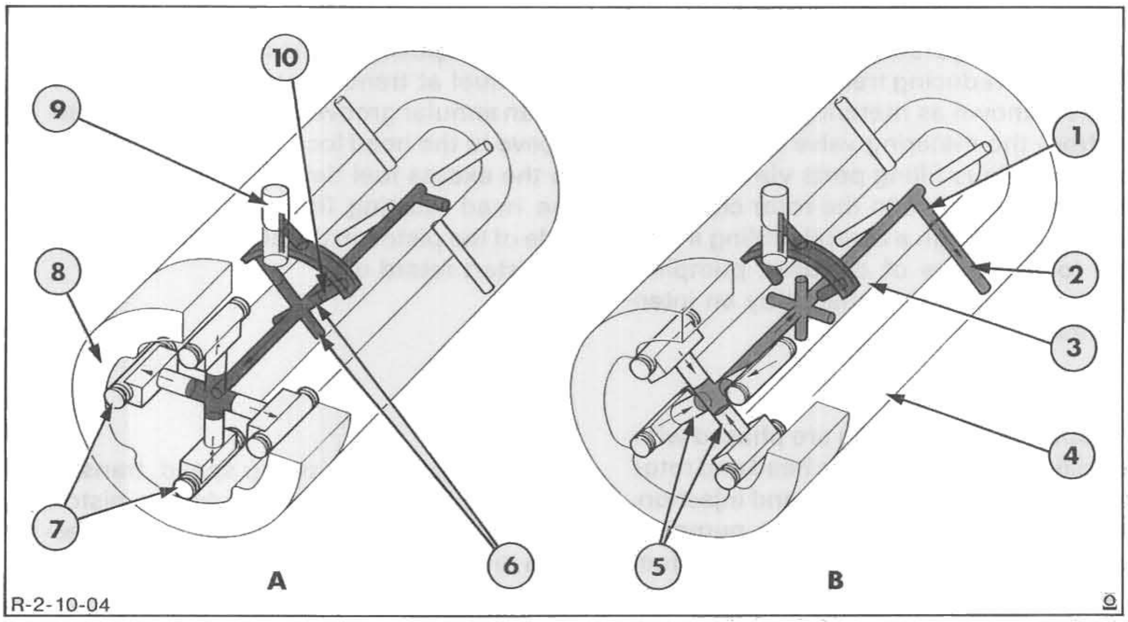


Figure 4
Fuel Charging and Injection Cycles- Schematic

F Metering Pressure

A. Charging Cycle

C Injection Pressure

B. Injection Cycle

1. Single Fuel Delivery Port
2. Outlet Port - Hydraulic Head
3. Rotor
4. Hydraulic Head
5. Pumping Plungers
6. Charging Ports - Rotor
7. Rollers
8. Cam Ring
9. Metering Valve Bore
10. Filling Ports - Hydraulic Head

Metering of Fuel

With reference to Figure 4.

Fuel at feed pressure, entering the pump through the main inlet connection is pressurised by the sliding vane transfer pump carried on the rotor inside the hydraulic head. The fuel, now at transfer pressure, passes through passages in the hydraulic head and then to the metering valve bore.

The metering valve, operated by the throttle control lever and governor, regulates the flow of fuel through the two oblique filling ports in the hydraulic head and into the pumping section of the rotor.

The volume of fuel passing into the pumping elements is thus controlled by three factors. By the position of the metering valve, which is sensitive to throttle lever position or governor weight movement at a given engine speed; the pump transfer pressure and the time during which the rotor filling ports are aligned with the hydraulic head filling ports.

Pumping and Distribution of Fuel

With reference to Figure 4.

As the rotor turns, the two filling ports in the hydraulic head align with the two charging ports in the rotor and fuel at metering pressure flows into the central passage in the rotor and forces the pumping plungers apart. The amount of plunger displacement is determined by the amount of fuel which can flow into the rotor while the ports are aligned.

With continued rotation, the fuel entering the two filling ports in the hydraulic head is cut-off from the charging ports. Then the single fuel delivery port in the rotor, registers with an outlet port in the hydraulic head. At the same time, the pumping plungers are forced inwards by the rollers in contact with the internal lobes of the cam ring and fuel at injection pressure passes through the central passage of the rotor and through the ports to one of the injectors.

With further rotation, the charging and injection cycles are repeated in sequence with the rotor alternately charging through a pair of filling ports and discharging into each successive outlet port. The number of outlet ports in the hydraulic head is equal to the number of cylinders on the engine.

Transfer Pump and Regulating Valve

With reference to Figures 5, 6 and 7.

The regulating valve performs two separate functions. First, it controls fuel pressure by maintaining a definite relationship between transfer pressure and speed of rotation. Second, it provides a means of by-passing the transfer pump when the engine is stationary, so that the fuel passages in the hydraulic head can be primed with the external hand priming pump.

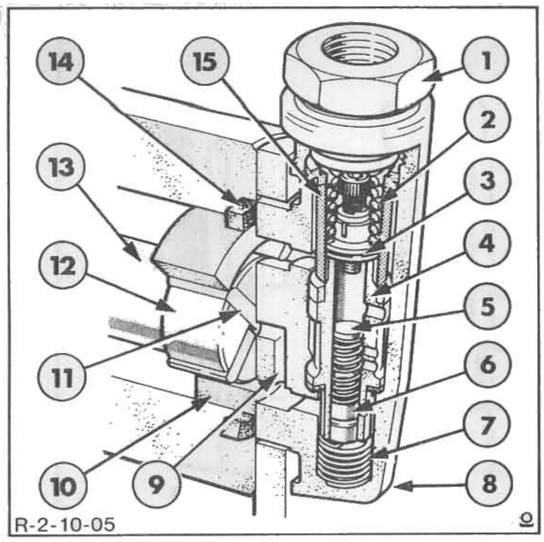


Figure 5
Cut-Away of Regulating Valve
and Transfer Pump Assembly

1. Fuel Inlet Connection
2. Regulating Spring
3. Transfer Pressure Adjuster
4. Regulating Sleeve
5. Peg and Spring
6. Regulating Piston
7. Priming Spring
8. End Plate
9. Drilling to Pump Blades
10. Eccentric Liner
11. Blades
12. Rotor Transfer Pump
13. Distributor Rotor
14. Rubber Sealing Ring
15. Filter

Fuel entering the main inlet connection at feed pressure is raised to transfer pressure by the transfer pump consisting of rotor, sliding blades and eccentric liner.

The rotor is screwed on to the end of the distributor rotor; the direction of the screw thread being opposite to the direction of the rotation of the injection pump so that the rotor tends to tighten when running.

Four rigid blades at 90° to one another are held in contact with, and follow, the internal profile of the eccentric liner by pressure from two springs. As transfer pressure increases fuel is supplied, via the end plate, to force the blades against the internal profile of the liner, hence the blades stay in contact with the liner at all engine speeds.

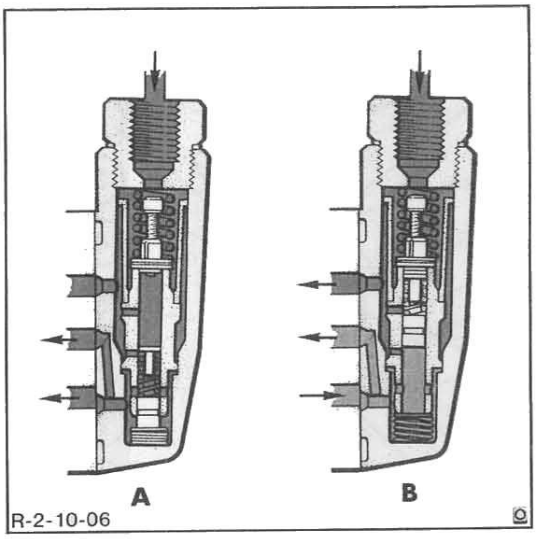


Figure 6
Operation of Regulating Valve

A Feed Pressure B Transfer Pressure

A. Priming B. Regulating

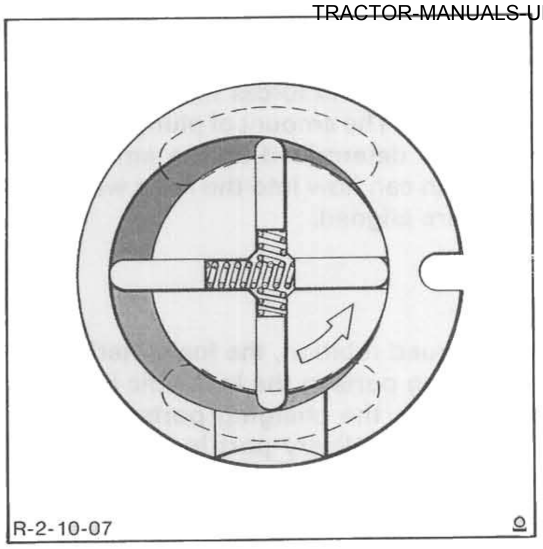


Figure 7
Operation of Transter Pump

A Feed Pressure B Transfer Pressure

Fuel entering the end plate at feed pressure passes to the inlet side of the transfer pump through the nylon filter and upper fuel passage of the end plate.

This fuel in the upper chambers, formed by the transfer pump blades, liner and rotor, is displaced downwards and ejected at a rate in excess of the injection and back leakage requirements of the pump, hence the pressure increases.

This transfer pressure is transmitted to the underside of the regulating piston through the lower fuel passage to force the piston upwards. The force is opposed by the pressure exerted on the upper face of the piston by the regulating spring.

As transfer pressure rises with increasing engine speed, the piston is forced upwards and the regulating spring is compressed.

Such movement of the piston progressively uncovers the regulating port and transfer pressure is controlled by permitting a metered flow of fuel back to the inlet side of the transfer pump. The effective area of the regulating port is thus increased as engine speed is raised.

The maximum lift of the regulating piston is adjusted by a screw in order to control the rate at which transfer pressure rises. This screw, which is referred to as the transfer pressure adjuster, is set during test to suit the application concerned.

When priming the pump from the external hand primer, fuel entering the end plate cannot pass through the transfer pump and into the fuel passages in the hydraulic head in the normal way.

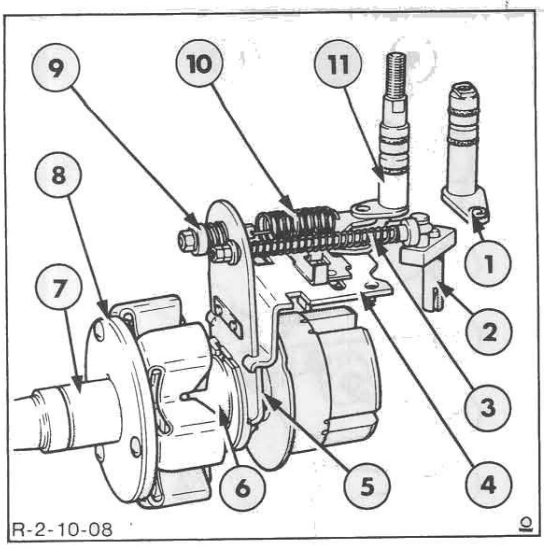


Figure 8
Variable Speed Mechanical Governor

1. Fuel Shut-off Shaft
2. Metering Valve
3. Governor Link Arm and Spring
4. Control Bracket
5. Governor Arm
6. Thrust Sleeve
7. Drive Shaft
8. Governor Flyweight Assembly
9. Idling Spring and Peg
10. Main Governor Spring
11. Throttle Shaft

Fuel at priming pressure enters the regulating sleeve and acts on the upper face of the regulating piston. The piston is forced to the lower end of the sleeve, compressing the priming spring and uncovering the priming ports. Fuel then passes through the priming ports and the lower fuel passage to the outlet side of the transfer pump and into the fuel passages within the hydraulic head.

Variable Speed Governor

The variable speed governor, Figure 8, is of the mechanical fly-weight type giving accurate control of the engine at maximum and intermediate speeds. The governor flyweight assembly is mounted on the drive shaft and is entirely contained within the pump body.

Movement of the governor flyweights, which pivot outwards when under centrifugal force set up by drive shaft rotation, actuates a thrust sleeve. The sleeve, sliding along the drive shaft, causes the governor arm to pivot about a fulcrum on the control bracket and this movement is transmitted by the governor link to the metering valve which rotates to change the quantity of fuel entering the filling ports. Rotating the metering valve changes the flow area between the groove in the valve and the metering port. The amount of fuel that enters the filling ports is therefore changed by varying the effective area of the metering orifice.

The governor link arm and spring are located in the upper part of the pump enclosed by the control cover which houses the throttle shaft and manual fuel shut-off.

The mechanical governor takes control of fuel delivery at maximum and intermediate speeds when the centrifugal force generated by the flywheel balances the force applied to the governor control arm by the tension of the main control spring. Fuel output is varied by governor action as the control arm operates the metering valve through the governor link.

During idle running with the speed control lever in the minimum speed position all tension is removed from the main control spring and the governor force is balanced by the idling spring carried on the spring peg. This provides more sensitive response at low RPM when the governor force is minimal thus ensuring an even engine speed.

The spring tension is dependent on the position of the speed control lever thereby giving variable speed control and enabling the driver to select governed speed according to operating requirements.

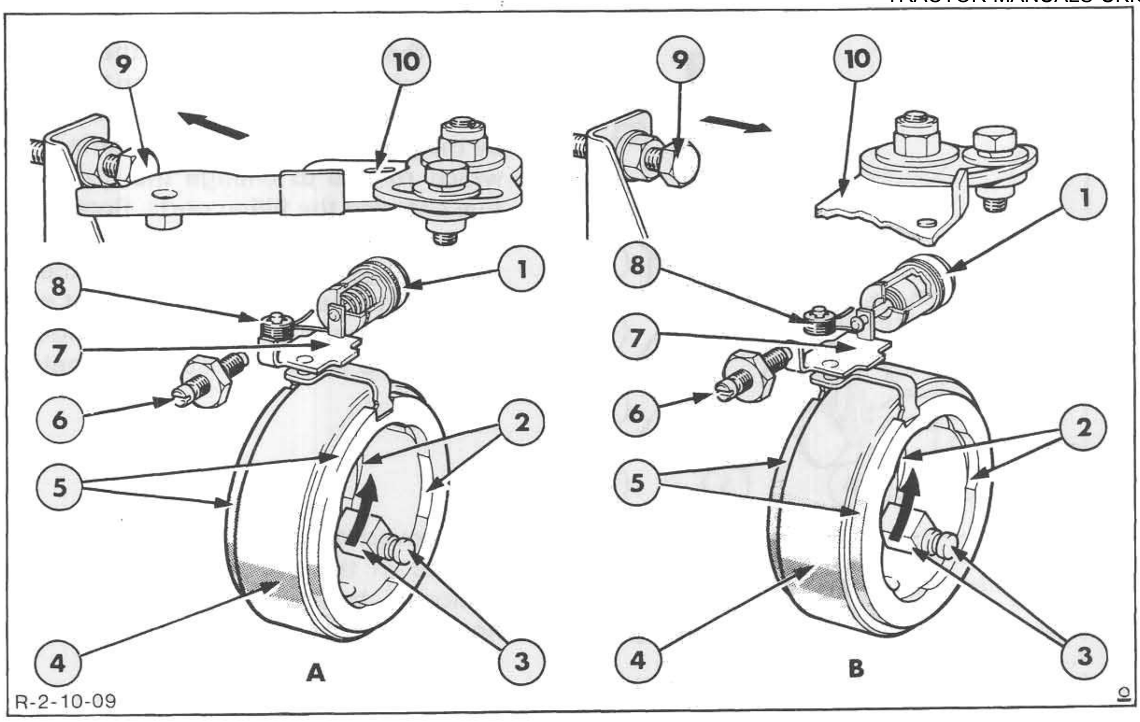


Figure 9
Scroll Plate Operation

A. Scroll Plate in Excess Fuel Position-Throttle Closed

B. Scroll Plate in Maximum Fuel Position-Throttle Open

1. Excess Fuel Device
2. Scroll Plate Profiles
3. Rollers and Shoes
4. Cam Ring
5. Scroll Plates
6. Maximum Fuel Adjuster
7. Link Plate
8. Link Plate Spring
9. Low Idle Stop Screw
10. Throttle Control Arm

Scroll Plates

With reference to Figure 9.

The scroll plates which are located either side of the cam ring perform two functions:-

A. To provide automatic excess fuelling for rapid engine starting at cranking speed under all ambient conditions.

B. To adjust maximum fuelling to a predetermined setting by limiting the outward movement of the pumping plungers.

The scroll plates are each provided with a slot in the outer rim to control their movement through a transversely mounted link plate which slides in a slot in the governor control bracket.

Movement of the link plate is controlled in one direction by the excess fuel device and in the opposite direction, by the maximum fuel adjuster screw.

When automatic excess fuelling is required, the throttle lever is closed against the low idle stop and the inner tongue of the link plate is held by the excess fuel device. In this position the scroll plates are rotated against pump rotation and the scroll profiles on the internal rims of the plates allow the pumping plungers to move further apart admitting fuel in excess of the normal maximum.

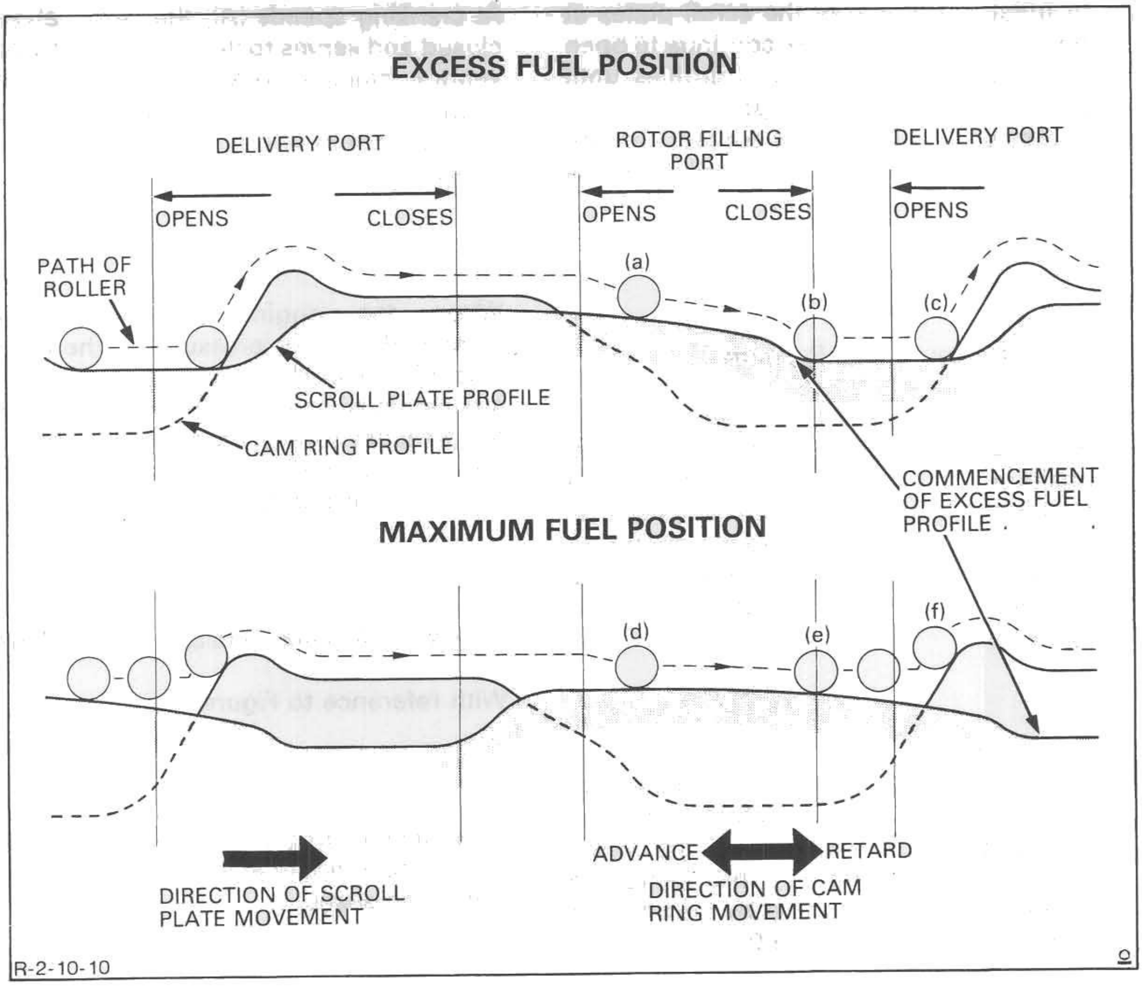


Figure 10
Scroll Plate and Cam Ring Phasing

As soon as the engine self-sustains, excess fuel is terminated. Fuel at transfer pressure, supplied via the latch valve, and acting on the piston in the excess fuel device causes the link plate spring to move the scroll plates transversely in the direction of pump rotation to the maximum fuelling position against the pre-set adjuster screw.

In this position, the profiles on the internal rims of the scroll plates check the outward movement of the rollers and shoes, in contact with the pumping plungers, to the normal maximum fuel level.

Scroll Plate Principle

With reference to Figure 10.

A. In Excess Fuel Position

At cranking speeds with the throttle lever against the low idle screw, the scroll plates are automatically positioned so that the excess fuel profile corresponds with the rotor filling stage. The cam ring is in the fully retarded position.

As the rotor filling port opens, metering pressure forces the cam rollers outwards to meet the profile of the scroll plates at point (a). The cam rollers continue to open outwards against the scroll profiles until the filling port closes at point (b) on the excess profile. The rollers contact the cam ring at point (c) and deliver fuel in excess of the normal maximum.

B. In Maximum Fuel Position

When the throttle is fully open the scroll plates are rotated to the maximum fuel position and the cam ring is rotated to a position determined by transfer pressure. As the rotor filling port opens, metering pressure forces the cam rollers outwards to meet the profile of the scroll plates at point (d).

The cam rollers continue to move outwards, remaining in contact with the retracting scroll profiles until the filling port closes at point (e), this being the maximum fuel position set by the adjuster screw as shown in Figure 9.

With metering pressure to the pumping plungers now terminated by filling port closure, the rollers are free to leave the scroll plate profiles and "float" until contact is made with the cam lobe at point (f). This is the point at which fuel injection commences via the now open delivery port.

Latch Valve

The latch valve, Figure 11, viewed from the drive end, is screwed into the left-hand side of the pump housing and comprises a spring loaded valve with a central drilling fitted in a threaded body which also retains the hydraulic head in the pump housing.

At cranking speeds (A), the latch valve is closed and serves to delay advance by preventing transfer pressure reaching the advance unit and also the excess fuel device, both of which, remain at cam box pressure.

When the engine self-sustains (B) increased transfer pressure on the under side of the latch valve opens the valve against its spring and allows fuel at transfer pressure to flow through a drilling in the valve to the pressure chamber in the advance unit and the excess fuel device.

Automatic Advance and Start Retard Unit

With reference to Figure 12.

This device progressively advances the commencement of injection as the engine speed increases.

The unit incorporates an automatic start retard system that operates at cranking speeds.

Automatic advance is controlled by a piston which slides in the advance housing mounted on the underside of the pump housing. The movement of the piston is transferred via the cam advance screw to the cam ring which rotates freely in the pump housing. The advance spring is located between the piston and the spring cap and serves to limit the travel of the piston, thus balancing the effect of fuel at advance pressure entering the chamber. Fuel at advance pressure enters the chamber through a passage from the head locating fitting which secures the advance device to the pump body.

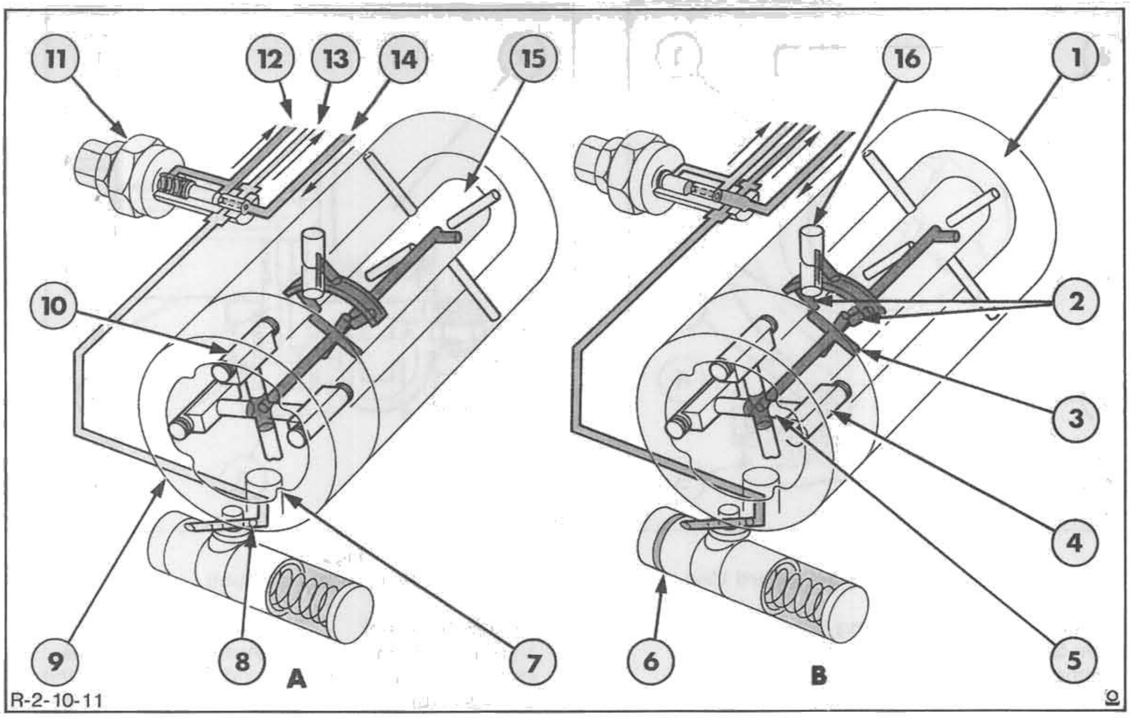


Figure 11
Latch Valve Operation-Schematic

B	Transfer Pressure	D	Cam Box Pressure
F	Metering Pressure	G	Differential Pressure

A. Engine Cranking

B. Engine Self Sustained

1. Hydraulic Head
2. Filling Ports - Hydraulic Head
3. Rotor Inlet Ports
4. Roller and Shoe
5. Plunger
6. Pressure Chamber - Auto Advance
7. Head Locating Fitting
8. Ball Valve
9. Cam Ring
10. Roller and Shoe
11. Latch Valve
12. Return to Cam Box
13. Feed to Excess Fuel Device
14. Inlet from Transfer Pump
15. Distributor Rotor
16. Metering Valve

Start retard is controlled by the 1st stage low rated spring which is located between the hollow end of the piston and the spring cap. When the engine is stopped and the latch valve (see Figure 11) is closed, there is no pressure acting on the piston which, under the pre-compression of the advance spring and 1st stage (retard) spring, rests against the piston plug. The system is therefore in the fully retarded position.

On starting, when transfer pressure from the pump opens the latch valve, pressure in the chamber bearing against the piston compresses the 1st stage (retard) spring and the system reverts to the normal speed advance mode of operation.

As engine speed increases, the transfer pressure acting on the piston moves the piston along the bore and compresses the advance spring. This causes the piston and cam ring to move in the opposite direction to pump rotation and progressively advances the point of injection.

When engine speed is reduced, the transfer pressure drops and the normal leakage of fuel past the piston permits the device to return towards the retard position under the action of the spring.

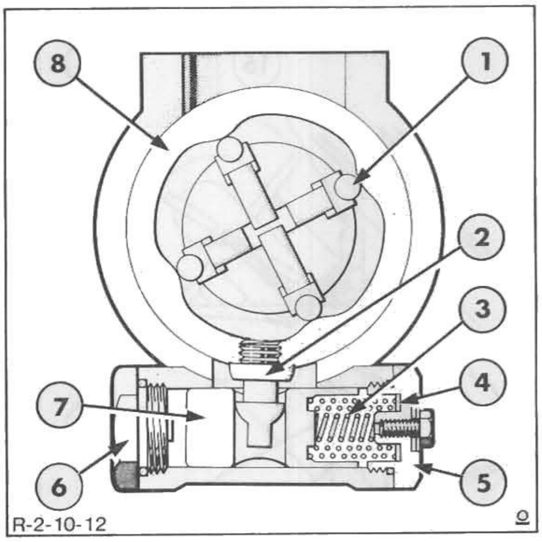


Figure 12
Automatic Advance and Start Retard Unit

1. Roller
2. Cam Screw
3. Spring
4. Shim
5. Spring Cap
6. Piston Plug
7. Advance Piston
8. Cam Ring

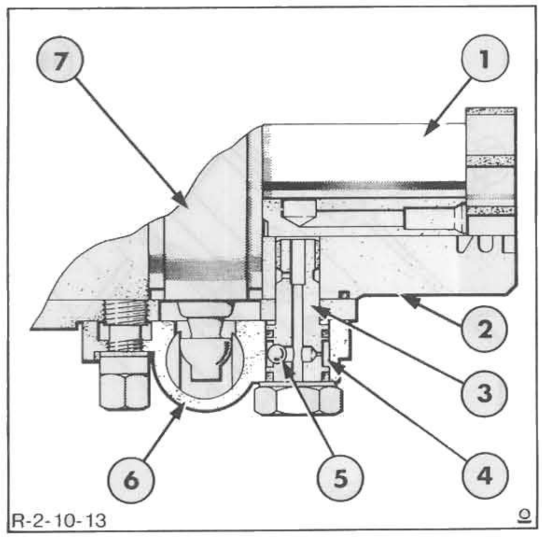


Figure 13
Head Locating Fitting

1. Distributor Rotor
2. Hydraulic Head
3. Head Locating Fitting
4. By-pass Hole
5. Ball Valve
6. Automatic Advance and Start Retard Unit
7. Cam Ring

Head Locating Fitting

The head locating fitting, Figure 13, is screwed into the underside of the pump housing and also correctly positions the hydraulic head relative to the pump hous-
The head locating fitting connects the fuel passages in the hydraulic head with the advance unit.

The hydraulic head comprises a barrel and a sleeve. The hydraulic head outlet ports are equally spaced and positioned radially on the outside diameter and register in turn with the rotor distributor outlet port through passages in the sleeve. The sleeve also contains two inlet ports which register with the rotor filling ports.

The assembly contains a non-return ball valve which serves to balance and reduce the impact effect of the rollers on the cam ring which, during the injection phase, would otherwise tend to turn the cam ring in a retard direction.

The transfer pump is housed within a recess which has been counter bored in the end of the hydraulic head. This recess contains a self-venting orifice which removes air bubbles from the fuel via a drilling to the cambox before fuel flows to the pumping plungers.

Hydraulic Head and Rotor

The hydraulic head and rotor, Figure 14, is a mated assembly which minimises leakage whilst allowing sufficient bearing clearance.

The distributor rotor has two pairs of opposing pumping plungers which pump simultaneously against the lobes of the cam ring.

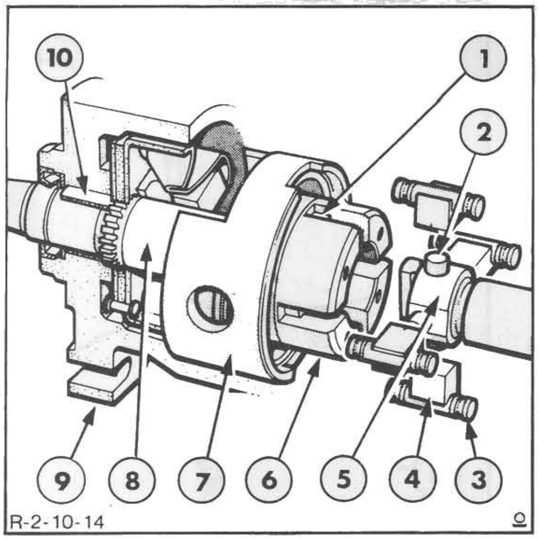


Figure 14
Pump Drive Shaft

1. Spacer
2. Pumping Plunger
3. Roller
4. Shoe
5. Distributor Rotor
6. Drive Shaft Head
7. Rear Bearing
8. Drive Shaft
9. Pump Housing
10. Front Bearing

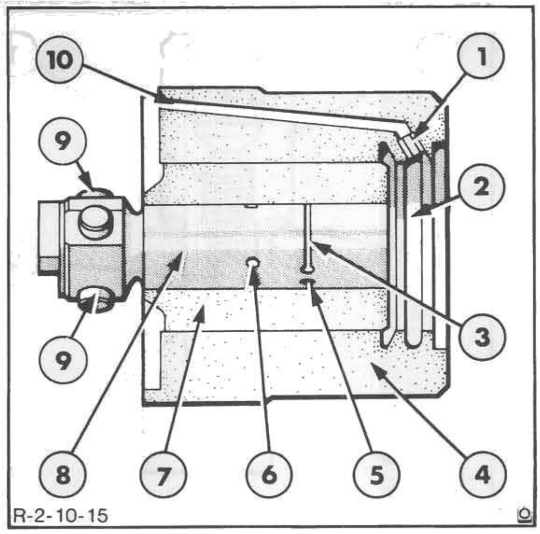


Figure 15
Hydraulic Head with Rotor in Situ

1. Vent Orifice
2. Transfer Pump Recess
3. Equalisation Groove
4. Barrel - Hydraulic Head
5. Distributor Outlet Port
6. Rotor Filling Port
7. Sleeve
8. Distributor Rotor
9. Plunger
10. Drilling to Cam Box

The rotor comprises a number of filling ports and one port distributor as described under "**Pumping and Distribution of Fuel**".

The rotor has an equalisation groove cut around the majority of the circumference of the rotor on the same plane as the distributor outlet port. This achieves a constant residual line pressure in all the lines and improves line to line deliveries, particularly important at idling speeds.

The fuel lines, except the next in line to be charged, are connected by the groove and the residual pressure in the line which has just injected is "balanced out" with the remaining lines.

Pump Drive Shaft

With reference to Figure 14.

The pump drive is a solid one piece shaft carried on two bearings located wide apart at each end of the shaft.

Drive to the distributor rotor is through an inner slot in the driving head which engages with the driven tang on the rotor. Two pairs of opposed pumping plungers within the head of the rotor, contact the shoes and rollers each of which slides radially in the outer slots of the drive shaft. The plungers bring the rollers into contact with the cam ring and the outer ends of the rollers with the scroll plates during excess and maximum fuelling.

Long and short spacers are located, one in each slot of the driving head which allow only one position of engagement for the tang on the rotor. The spacers also act as guides for the roller shoes.

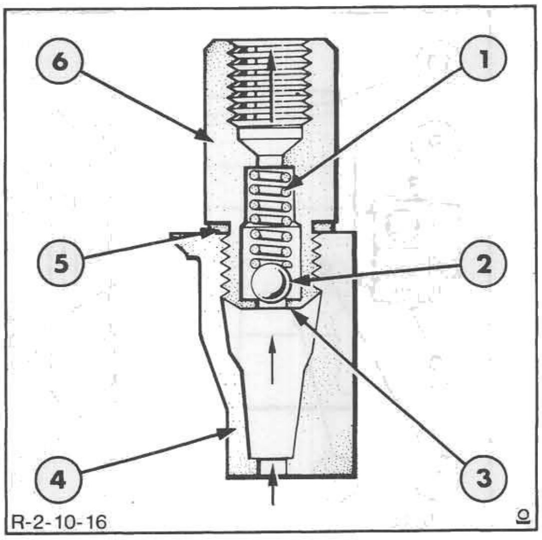


Figure 16
Pressurising Valve Assembly

1. Upper Spring
2. Ball Valve
3. Valve Seat
4. Governor Control Cover
5. Sealing Washer
6. Valve Holder

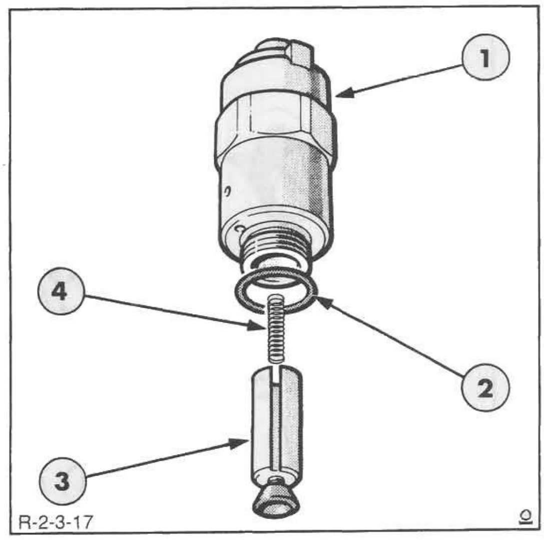


Figure 17
Solenoid Fuel Shut-off Valve

1. Solenoid Valve
2. Rubber 'O' Ring
3. Piston
4. Spring

Pressurising Valve

The pressurising valve, Figure 16, is screwed into the top of the governor control cover and comprises a ball, valve seat and spring.

During running, constant pressure is maintained in the cam box by the spring retaining the ball on its seating. Only when pressure exceeds the loading on the spring at a pre-determined pressure is fuel allowed to lift the valve.

As changes occur in engine speed, with resultant pressure differences in the cam box, the valve reacts by lifting or closing on its seating to allow the back leakage of fuel to return to the supply tank thus controlling the maximum cam box pressure in the pump housing.

Maintaining pressure in the cam box prevents the ingress of dirt into the pump and provides smoother governor run-out characteristics.

Solenoid Shut-off Valve

An electrically operated fuel shut-off valve, Figure 17, is screwed into the top of the hydraulic head. The unit consists of a solenoid assembly which controls a spring loaded piston and is located between the transfer pump outlet and the metering valve.

When the solenoid valve is energised on starting the engine, the solenoid lifts the piston against spring pressure and allows fuel at transfer pressure to pass to the metering valve.

When the solenoid is de-energised, by cutting the electrical supply, the return spring pushes the piston back against its seat and prevents the rotor from filling thereby stopping the engine.

B. FUEL INJECTION PUMP – OVERHAUL

General

Except in the case of complete overhaul, full dismantling is not always necessary. When a pump requires attention, the recommended practice is to set it up on a test machine and check to locate specific faults or maladjustments. Repairs or adjustments can then be undertaken on the basis of the test results.

Dismantling, assembly, testing and adjustment of the DPS pump must be carried out by trained personnel, using specialised tools and test apparatus. The service tools listed in "Special Tools" Section E – must be used to obtain the closest possible approach to factory standards.

Conditions of scrupulous cleanliness must be observed in workshops where pump overhaul is carried out. The following equipment must be available in the workshop when fuel injection equipment is to be serviced:-

1. A bench covered with sheet metal or linoleum, which should preferably be kept for injection equipment only.

2. A divided storage tray of fire retardant material.

3. A vice with soft metal or fibre jaws.

4. A fire proof tank containing clean test oil for large components and a small bath with a lid containing clean test oil which should be kept only for pump plungers and small components.

5. A complete set of special tools, see "Special Tools", Chapter 8.

6. Non-fluffy cloths must be used for drying of hands. Under no circumstances use cotton waste.

Typeplate

The number stamped on the typeplate attached to the pump housing identifies the type and model of the pump. Pumps that are of identical build, but with modified settings for different applications are further identified by the setting code stamped beneath the ordering number. See Section C – "FUEL INJECTION PUMP – ISO TEST CONDITIONS."

Should the typeplate be obscured by paint, care must be taken to ensure that the type details are not defaced when removing the paint.

Overhaul Procedure

If any part in a mated assembly is damaged or worn, the complete assembly must be rejected. Any component showing signs of fretting, wear, damage, corrosion, cracks or distortion must be discarded.

All 'O' rings, gaskets, tab washers, locking and sealing devices must be discarded and new ones fitted.

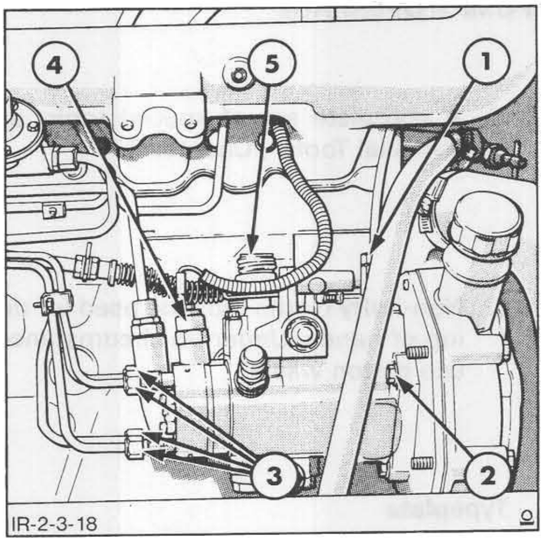


Figure 18
Fuel Injection Pump Removal

1. Fuel Return Line
2. Pump Retaining Bolt
3. Injector Lines
4. Fuel Shut-off Solenoid
5. Throttle Linkage

REMOVAL

1. Clean all dirt from the injection pump and the surrounding parts.

2. Turn the fuel shut-off valve to the 'OFF' position.

3. Drain the cooling system of coolant and remove the bottom radiator hose.

4. Disconnect and remove all fuel lines from the injection pump and cap all openings to prevent entry of dirt.

5. Disconnect the throttle cable and fuel shut-off solenoid wire.

6. If the pump is not to be internally timed, then prior to removal note the setting of the pump relative to the zero degree mark on the rear of the engine front plate. Mark the plate with a centre punch to align with the pump flange scribed line.

7. Remove the engine timing cover from the engine front cover. Withdraw the drive gear retaining nut from the injection pump driveshaft.

8. Fabricate a puller as outlined in "Special tools" – Chapter 8. Install the puller to the drive gear using three bolts and remove the gear.

9. Withdraw the pump mounting bolts then remove the pump from the engine front cover plate. Cap all openings to prevent entry of dirt.

DISASSEMBLY

Before commencing disassembly, remove the surface grime from the exterior of the pump by using a suitable proprietory fluid as a cleansing agent.

Turn the pump on its side, drain plug uppermost. Remove the drain plug from the pump housing, detach the dowty washer and discard. Invert the housing and drain the pump oil into a suitable receptacle.