FUEL SYSTEM AND COMPONENTS

The engine employs one "jerk" type fuel injection pump and one injector per cylinder. The injection pump draws filtered fuel from a pressurized fuel circulating system supplied by a circulating pump which has an output throughout the engine speed range, in excess of the engine's fuel requirements. Surplus fuel delivered by the circulating pump is returned to the tank through a pressurizing valve: a constant supply is thus maintained to all injection pumps and the excess fuel prevents the formation of air pockets, as any air is carried away by the scouring action of the fuel.

Circulating System.

The fuel is drawn from the tank, by the engine driven fuel circulating pump. From the pump, fuel flows to twin fuel filters and from the filters through a flexible pipe to the fuel operated hydraulic governor. From the reservoir in the governor casing, the fuel is carried by an external flexible pipe to a junction box mounted on the phasing gear case. From the junction box, the fuel flows through three external pipes to the inlet galleries formed integrally along the three camshaft casings, and into the inlet chambers of the fuel injection pumps through a series of transfer ports.

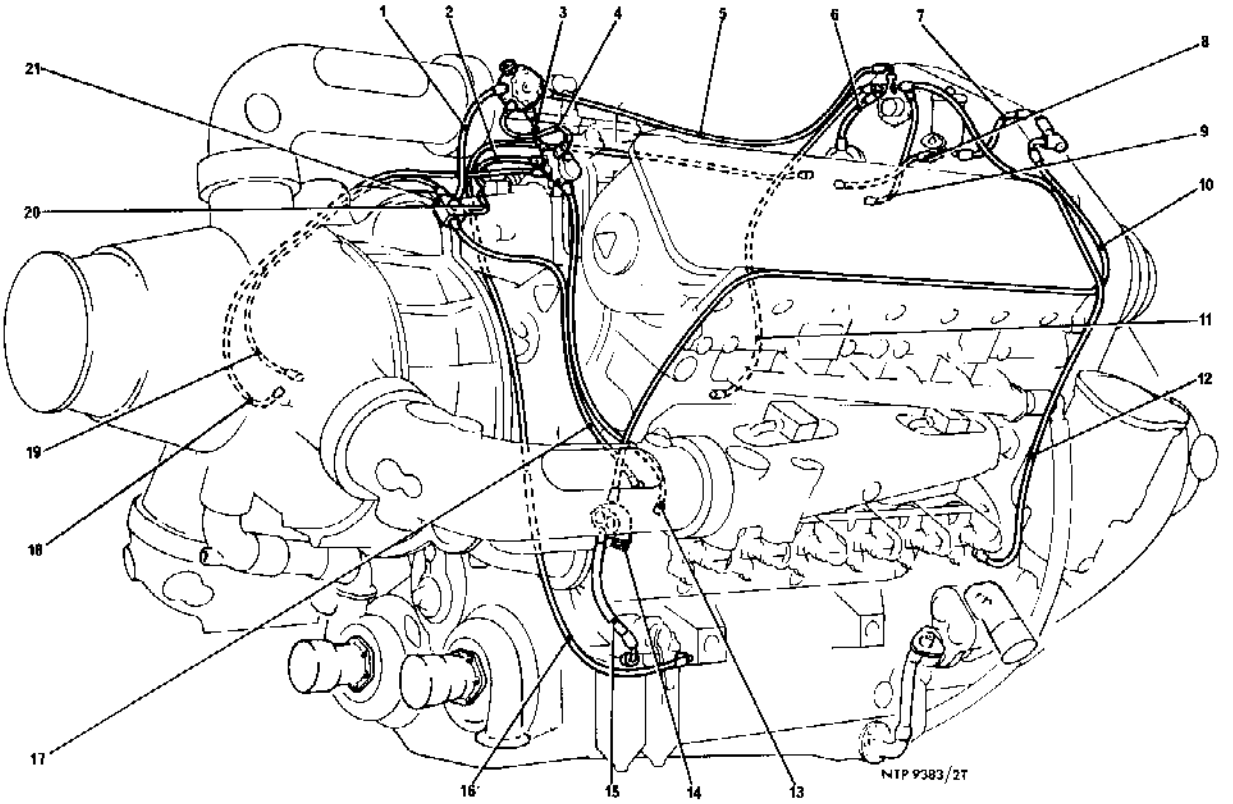
To maintain an adequate fuel supply to the injection pumps at all engine speeds, the flow through the fuel inlet galleries is in excess of requirements, the surplus from the injection pumps being ducted through fuel return galleries formed in each camshaft casing, and through external pipes to the fuel return junction box. The outlet union of the return junction box carries a spring-loaded valve. This pressurizing valve, maintains the necessary pressure in the engine for the satisfactory operation of the injection pumps and of the hydraulic governor. A pipe connects the pressurizing valve outlet with a venting junction box mounted on 'C' side of 'B' exhaust manifold. The venting junction box is connected with the fuel tank.

A manually operated fuel priming pump is fitted to the installation system and is connected by external pipes to a priming valve mounted on the phasing gear case. When the priming pump is operated, fuel is directed to the starting accumulator and to the engine system.

Fuel Circulating Pump.

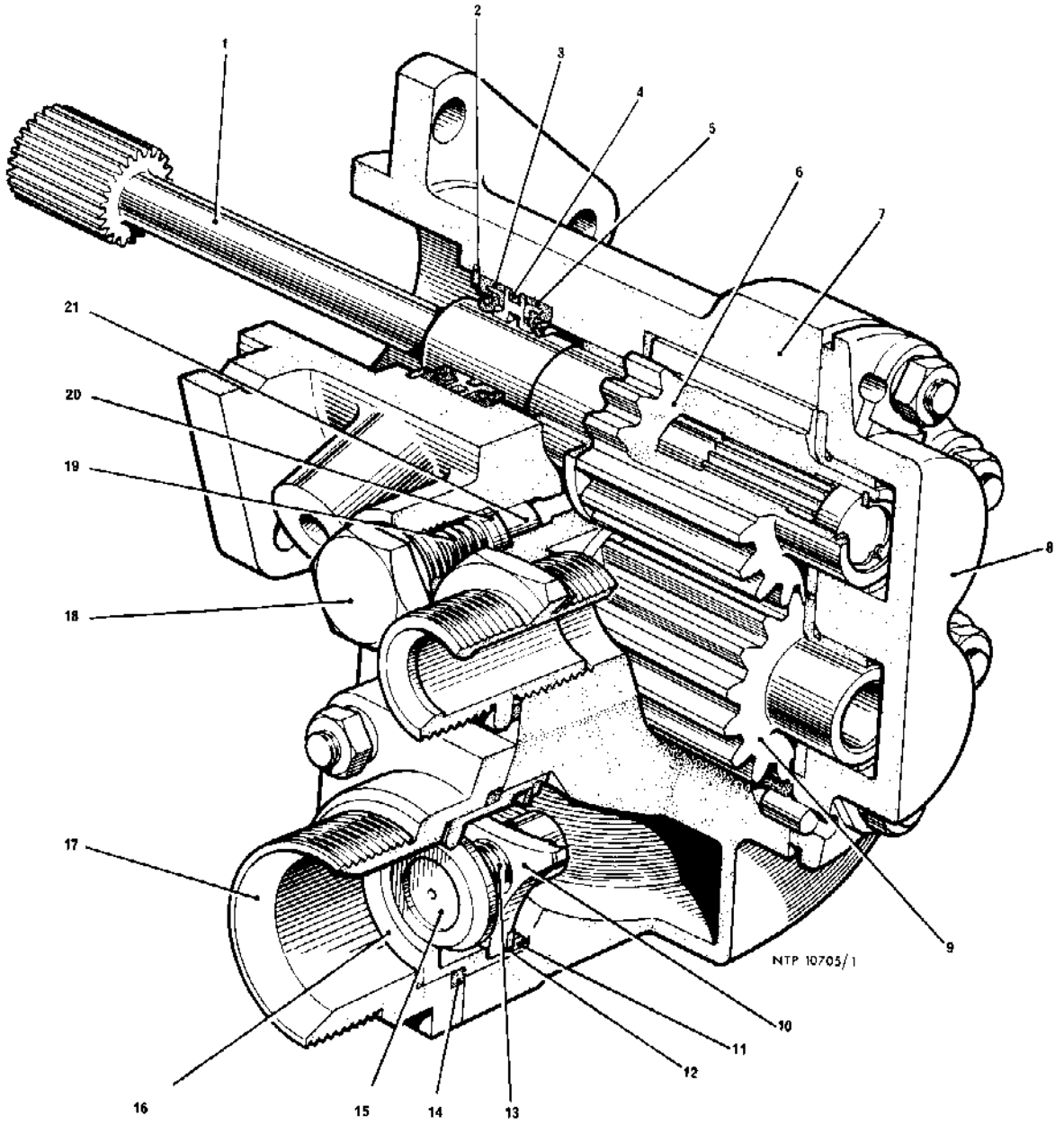
The gear-type fuel circulating pump is mounted on 'C' camshaft casing and is driven, through a quill-shaft by the camshaft.

The pump has two seals suitably positioned on the pump shaft, one to prevent fuel leakage from the pump and the other to prevent ingress of lubricating oil to the pump. A drain duct is provided between the seals to indicate any leakage that may take place from either seal. A non-return valve is positioned in the pump inlet union to maintain fuel in the engine system when the engine is stopped and also when an engine is to be removed from the installation. A by-pass valve housed in a duct formed in the pump casing permits fuel from the hand-operated priming pump to enter the engine system.



1. Pipe four-way connection to venting junction box
2. 'B' camshaft casing to return junction box
3. Fuel return junction box to venting junction box
4. Pressurizing valve to venting junction box
5. Supply junction box to venting junction box
6. Governor to supply junction box
7. Priming connection to accumulator
8. Governor to starting accumulator
9. Supply junction box to 'B' camshaft casing
10. Priming valve to fuel circulating pump
11. Supply junction box to 'A' camshaft casing
12. Supply junction box to 'C' camshaft casing
13. 'C' camshaft casing to return junction box
14. Engine fuel inlet connection
15. Circulating pump to filter
16. Fuel filter to governor
17. 'C' injector spill to four way connection
18. 'A' camshaft casing to return junction box
19. 'A' injector spill to four-way connection
20. 'B' injector spill to four-way connection
21. Four-way connection for injector spill

EXTERNAL FUEL SYSTEM



1. Quill-shaft
2. Circlip
3. Oil seal
4. Backing plate
5. Fuel seal
6. Driving gear
7. Pump body
8. Cover
9. Driven gear
10. Valve guide
11. Circlip
12. Washer
13. Spring
14. Joint ring
15. Non-return valve
16. Valve housing
17. Flanged union
18. Spring guide
19. Spring
20. By-pass valve
21. Valve seat

FUEL CIRCULATING PUMP

Filters.

Each fuel filter consists of a body carrying a cylindrical casing which contains the filter element.

The open end of the filter casing is lipped to form a seal with a joint ring located in the filter body. The casing is fastened to the body by a steel retaining rod which is screwed to the base of the casing and secured to the body by a nut. The corrugated felt-and-gauze element is contained in a cage fitted with end caps and mounted over the steel rod in the filter casing. The filter casing can be drained by unscrewing the drain plug.

Unfiltered fuel is passed by the circulating pump to the inlet union of the filters. The two filters are in parallel and ducts within the head casting direct the fuel to the outside of the filter elements, the fuel passes through the elements from the outside to inside, the filtered fuel returning to a common outlet duct in the head casting and to the outlet union and engine system. The outlet union comprises a non-return valve to prevent drain down of the system when the engine is stationary.

Starting Accumulator

A starting accumulator is incorporated in the fuel system and retains a charge of fuel under pressure which is released to the governor during the starting sequence.

The accumulator is charged with fuel by the governor during normal running and is also connected into the engine priming circuit to ensure that the accumulator is fully charged prior to starting.

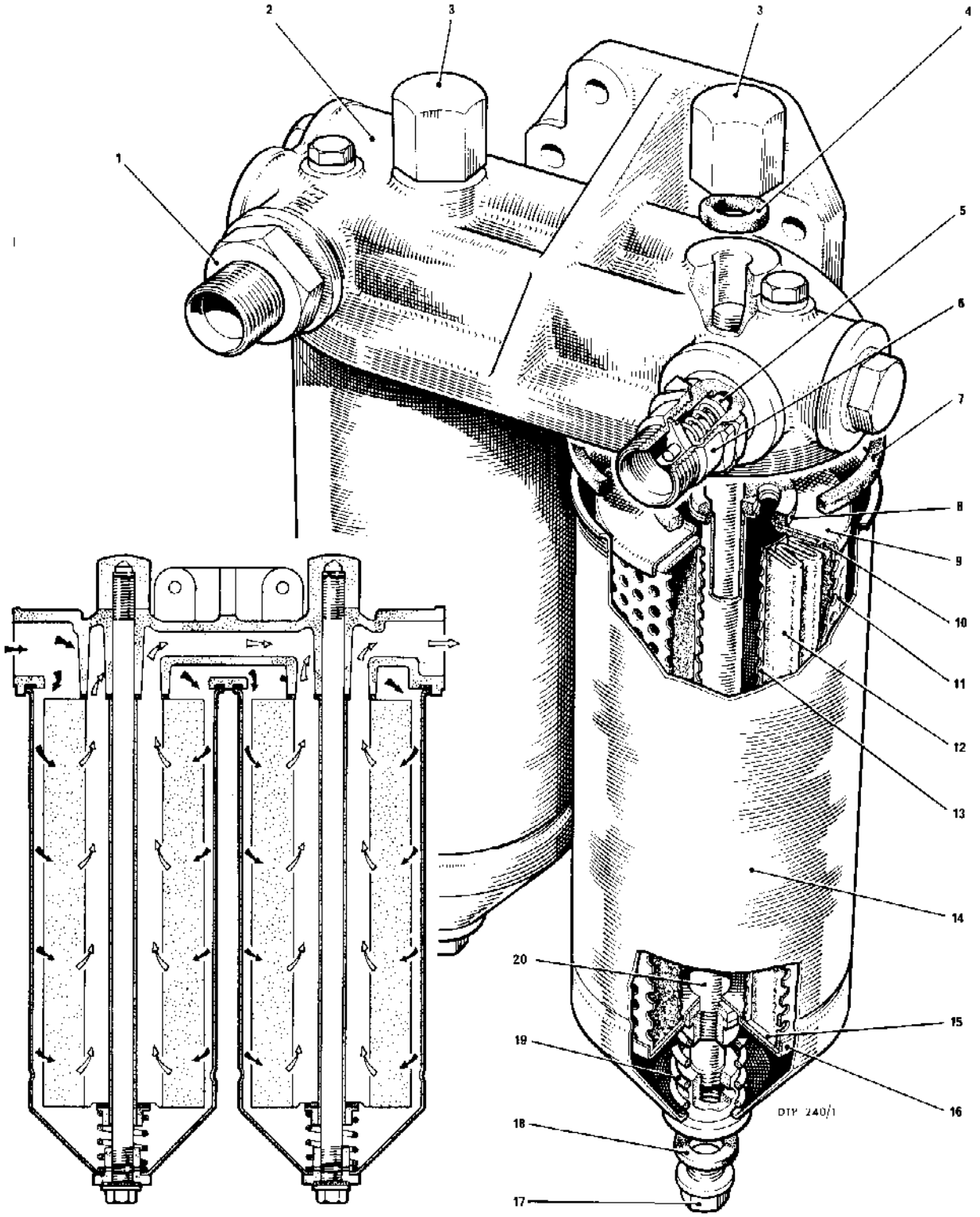
Priming Valve.

The priming valve, mounted on the phasing gear casing top face on 'C' side of the engine, consists of a body having an inlet union and two outlets. One outlet is connected by a flexible pipe to the starting accumulator while the other outlet. which houses a spring-loaded conically seated valve, is connected to the fuel circulating pump by-pass.

Operation of the priming pump causes fuel to be passed direct to the starting accumulator through the wire-wound filter. When the accumulator is fully charged; the pressure exerted by continued operation of the priming pump, lifts the spring-loaded valve off its seat and fuel is permitted to pass to the fuel circulating pump by-pass valve and through to the engine system.

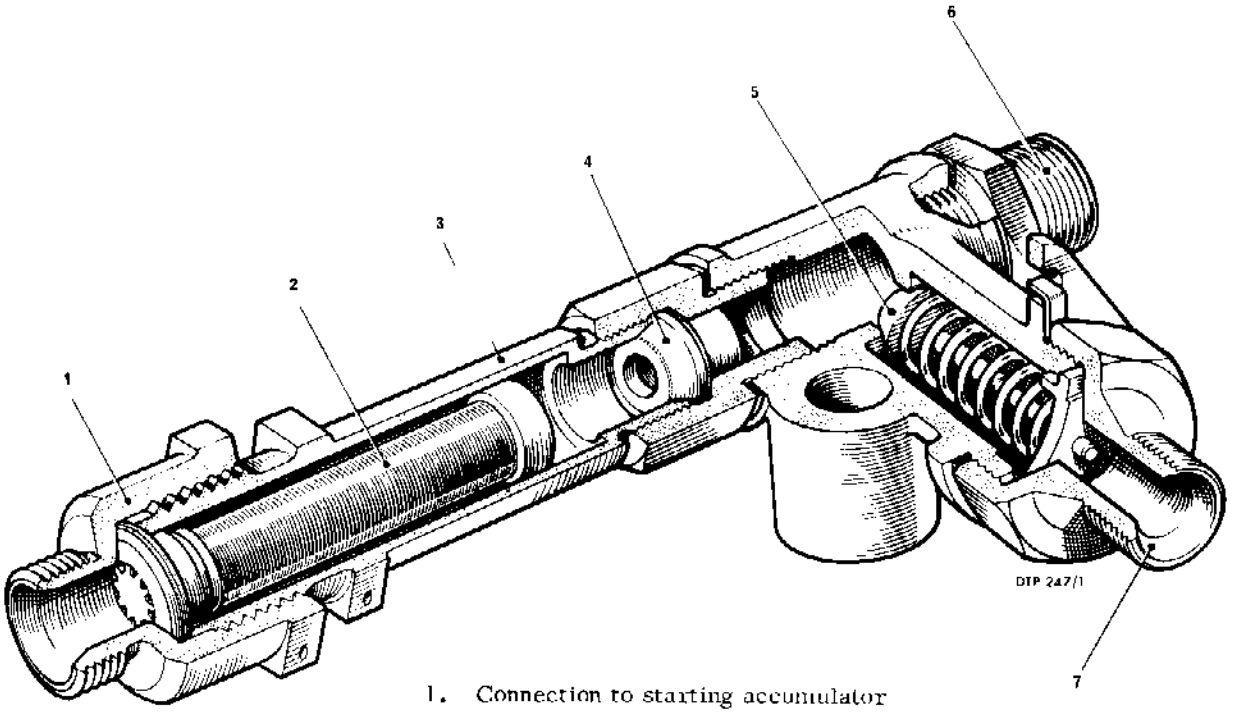
Fuel Pressurizing Valve

The fuel pressurizing valve consists of a spring-loaded check valve mounted in a body which is situated on the fuel pipes return junction box. It maintains the pressure at a nominal 20 lb/ in^2 the fuel circulating system to obviate the possibility of air in the system. This pressure is also required for the correct operation of the hydraulic governor.



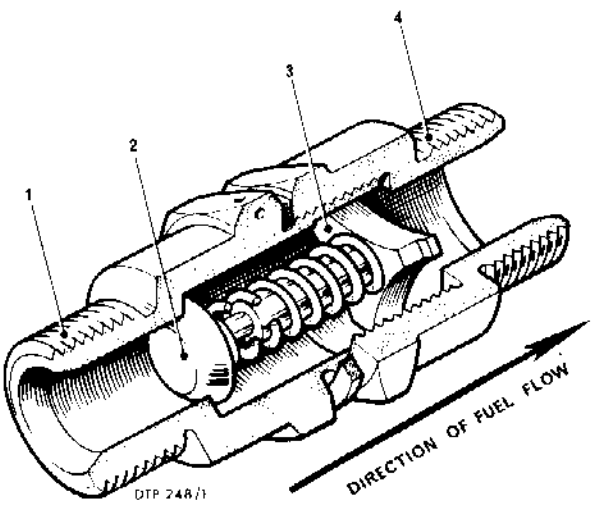
1. Inlet union
2. Filter body
3. Securing nuts
4. Seal ring
5. Non-return valve
6. Outlet union
7. Joint ring
8. Joint ring
9. Top end-cover
10. Top end-pad
11. Element outer cage
12. Filter element
13. Element inner cage
14. Filter casing
15. Bottom end-pad
16. Bottom end-cover
17. Drain plug
18. Seal ring
19. Spring
20. Retaining rod

FUEL FILTERS



1. Connection to starting accumulator
2. Filter
3. Filter body
4. Nipple
5. Valve
6. Inlet connection from priming pump
7. Connection to fuel circulating pump

PRIMING VALVE



1. Union connection to junction box
2. Valve
3. Valve guide
4. Connection to venting junction box

PRESSURISING VALVE.

Venting.

A plug fitted in the filter body enables the filters to be vented during initial installation or after the fuel system has been broken for any reason.

An air release valve is fitted in the filter chamber on each fuel injection pump to enable air to be vented from the pump during fuel priming.

Injection Pump.

The fuel injection pumps are mounted on the camshaft casings, and for control purposes, the pumps are linked together on each bank, the three banks being controlled as a single unit by a system of linkages. The pumps supplying each bank of cylinders are operated by a single camshaft which actuates the pump plungers through spring-loaded tappets, but individual pumps can be removed from the engine without disturbing any other component.

Each pump is assembled into a housing and consists of a pump barrel, a plunger, an unloading delivery valve, a roller tappet shell, and a felt filter pack with an air release valve and a control shaft assembly housed in a bore at right angles to the plunger.

The barrel is located against a machined counter-bore forming a seat in the housing and is prevented from rotating by a barrel locating screw which enters a locating slot cut axially along the outside of the barrel. A fill port and a spill port are drilled in the barrel and are surrounded by an annular chamber which connects with the fuel supply and return galleries in the camshaft casings by two ducts drilled in the mounting flange of the pump housing.

The control sleeve is a running fit on the outside of the barrel and is retained in the housing by the upper spring plate. Helical gear teeth are machined on the outside of the sleeve to engage similar teeth on the control shaft, and a slot is cut in the skirt to engage the actuating arm of the plunger vee dog clutch. Rotary movement of the control rod is thus transmitted, first to the sleeve and then, through the arm and dog clutch, to the plunger.

The camshaft imparts a reciprocating movement to the tappet shell by driving a tappet roller which is supported by needle rollers mounted on a pin: a tappet locating screw prevents the shell from rotating and also retains the tappet assembly in the housing when the injection pump is removed from the engine.

The control shaft assembly of each pump comprises an inner shaft surrounded by an outer shaft carrying an integral gear, the whole assembly being supported at each end by a flanged bush fitted with an oil seal. At one end of the shaft assembly an adjustable coupling piece is splined to the inner shaft in a fixed position and locked by a pinch bolt.

A worm adjustment between the coupling piece and the outer shaft is provided by the adjusting bolt which sets the coupling to the outer shaft in the desired position. Each pump control shaft assembly is connected to the control shafts of the adjacent pumps, by short shafts and axially flexible

discs to form a common control shaft for each bank of fuel pumps and control these as one unit.

A setting pin is provided for locking the control shaft when connecting or disconnecting the controls; the pin is stowed in an adjacent tapped hole when not required.

A spring-loaded delivery valve is retained by a hollow valve stop and a spring which are housed in the outer end of the pump barrel. The barrel is retained in the pump body by a gland nut at the discharge end of the pump; a fuel-tight joint is formed between the gland nut and the barrel by a seal ring.

A short unloading piston is machined below the head of the delivery valve, the unloading piston being a close fit in the valve guide which is formed inside the barrel.

Injection Pump Functioning.

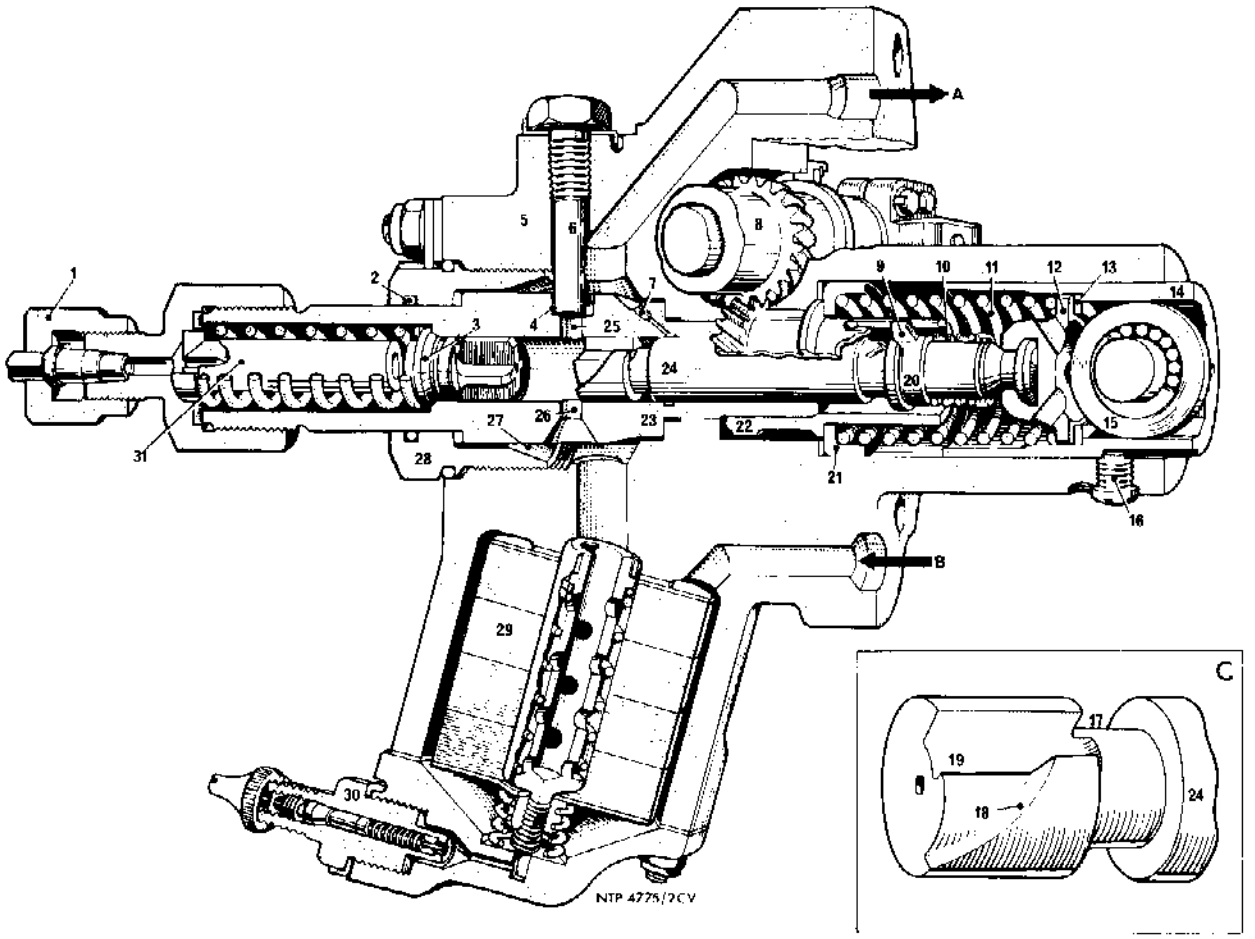
Fuel enters each pump from the pressurized inlet gallery in the camshaft casing and passes through the felt filter pack and feed duct to the annular chamber. With the plunger at the inner end of the stroke, the feed ports are uncovered and fuel enters the space between the head of the plunger and the delivery valve. When the plunger moves outwards the feed ports are closed, the pressure of the fuel trapped in the barrel rises until the delivery valve is forced open and pressure is then applied to the fuel in high-pressure fuel pipe. The increasing pressure in the high-pressure fuel pipe, opens the injector valve and injection takes place until the trailing edge of the piston portion of the plunger uncovers the spill port; the fuel under pressure at the plunger is then released to the fuel return gallery in the camshaft casing by way of the barrel spill port and the return duct in the housing.

The fall in pressure at the plunger allows the delivery valve spring to close the delivery valve and the unloading piston in the valve stem moves into the valve guide. This movement unloads the high-pressure fuel pipe by increasing the volume in the pipe by an amount equal to the volume of the piston; a sharp fall in pressure then occurs and the injection valve closes abruptly, instantly terminating injection.

Fuel Control.

The quantity of fuel delivered by each injection pump is varied by alterations to the effective stroke of the plunger. In response to movement of the governor output lever, the control shaft rotates the injection pump control sleeve which turns the pump plunger by the dog clutch arm and varies the position of the helix relative to the spill port.

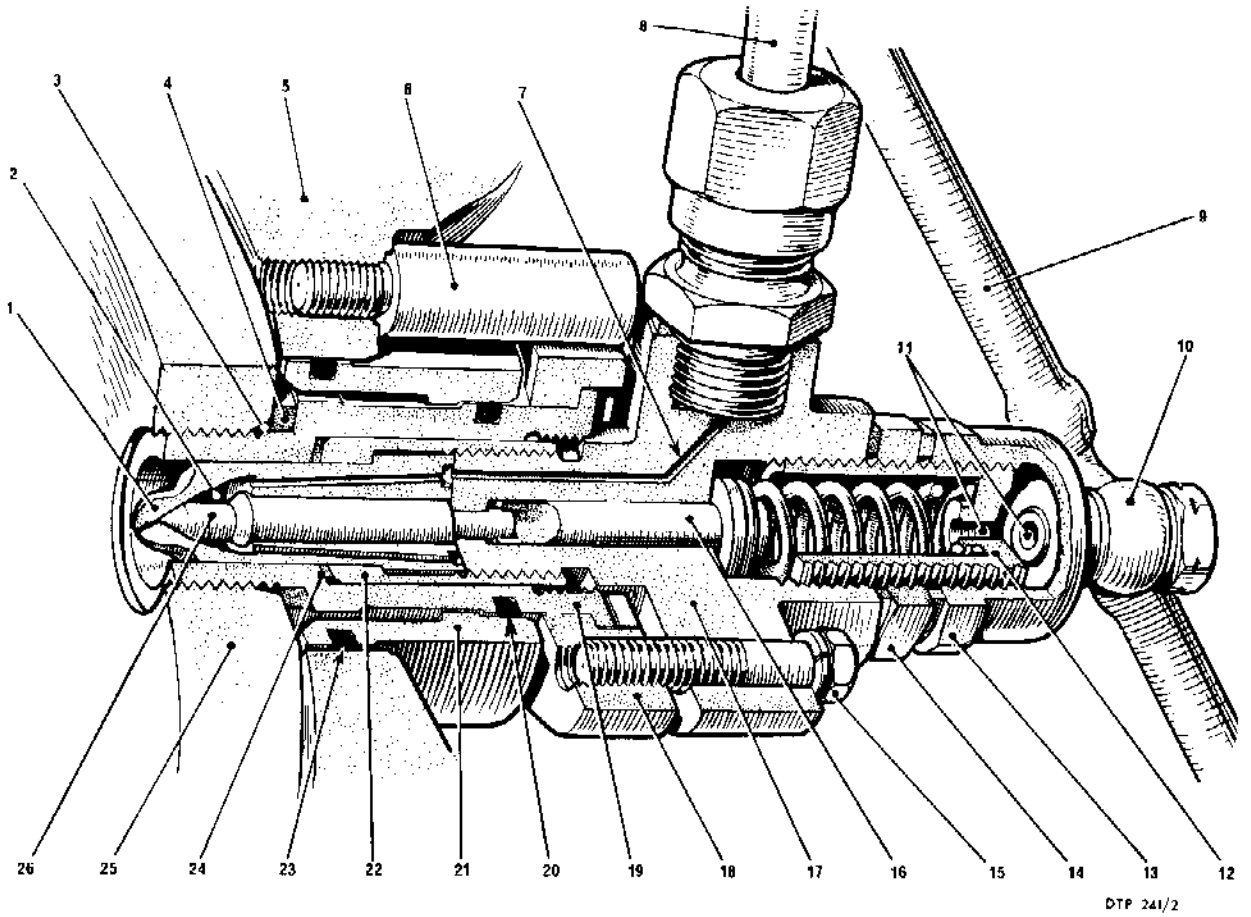
When the engine 'shut-down' mechanism is operated the engine governor causes the fuel injection pumps control shafts to be moved to a 'no fuel' position; the pump plunger is rotated until the axial slot is aligned with the spill port; then, as the plunger moves outward, the fuel is no longer fed to the injectors but is forced through the axial slot and spill port in the return line duct, thereby depriving the engine of fuel and causing it to stop.



1. High pressure fuel pipe and union
2. Seal ring
3. Delivery valve
4. Barrel locating slot
5. Pump housing
6. Barrel locating screw
7. High-pressure vent
8. Control shaft assembly
9. Dog clutch actuating arm
10. Dog clutch spring
11. Tappet return spring
12. Lower spring plate
13. Tappet phasing shim
14. Tappet shell
15. Tappet roller
16. Tappet locating screw
17. Annular groove
18. Timing helix
19. Axial slot
20. Vee dog clutch
21. Upper spring plate
22. Control sleeve
23. Pump barrel
24. Plunger
25. Spill port
26. Fill port
27. Annular chamber
28. Gland nut
29. Felt filter pack
30. Air release valve
31. Hollow valve stop

A. Fuel return
B. Fuel inlet
C. Plunger head

FUEL INJECTION PUMP



1. Nozzle body
2. Sac
3. Capacity filling ring
4. Adapter seating washer
5. Cylinder block
6. Locating peg
7. Supply duct
8. High-pressure fuel pipe
9. Injector spill
10. Union bolt and banjo
11. Spill outlet
12. Spring housing
13. Cap nut
14. Lock nut
15. Injector retaining bolt
16. Spring loaded plunger
17. Injector body
18. Retaining sleeve
19. Injector adapter
20. Seal ring
21. Floating-sleeve
22. Nozzle cap nut
23. Seal ring
24. Copper sealing washer
25. Cylinder liner
26. Needle valve

INJECTOR AND INJECTOR ADAPTER ARRANGEMENT

In the event of plunger seizure, the vee dog clutch prevents jamming of the controls by allowing the driving member to override the seized plunger so permitting free rotation of the control shaft.

Variable Injection Timing.

The inverted timing helix machined on the pump plunger provides the correct degree of injection timing over the full range of speed and load, the commencement of injection varying according to the relative rotational position of the helix to the spill port. This permits the commencement of injection to be retarded for a combination of low speed and low load and advanced gradually as the engine speed or engine speed and load is increased. Thus commencement of injection is variable throughout the whole range of engine speed and load.

Fuel Injector.

The injector consists of the nozzle body needle valve and the spring-loaded plunger housed in the injector body. The needle valve is inserted in the nozzle body which is secured to the injector body by the nozzle cap nut. The spring-loaded plunger is mounted in a bore in the injector body and is retained by the spring located in the housing which is screwed into the injector body and secured by the locknut and cap nut. Fuel flows from the high-pressure pipe through the ducts to the sac inside the nozzle body. Fuel leaking through the bores in the nozzle and injector bodies is returned to the tank through outlets in the spring housing and cap nut and through the common external spill pipe.

Injector Adapter.

The injector adapter passes through an orifice in the wall of the cylinder block and is screwed into a threaded hole in the cylinder liner. A capacity filler at the base of the adapter threads is compressed, during the tightening procedure, to fill the cylinder liner thread counterbore. A seal ring between the liner and the adapter seat, provides a gas and coolant seal.

The adapter is surrounder by a floating-sleeve which is permitted a limited amount of axial movement between a land formed on the outer diameter of the adapter and, the facing on the cylinder liner. A controlled amount of radial movement is permitted between the floating-sleeve and the cylinder block and, between the sleeve and the adapter. Synthetic rubber seal rings carried in grooves in the floating-sleeve and in the adapter, prevent the escape of coolant.

An injector retaining sleeve is carried on the adapter and has two tapped holes for the injector retaining set bolts. A scallop machined in the retaining sleeve, engages with a locating pin secured in the cylinder block. The locating pin ensures the correct angular location of the injector when in position. A copper washer forms a gas tight seal between the injector and the adapter.

Injector Functioning.

Fuel is fed from the injection pump through the high-pressure pipe and

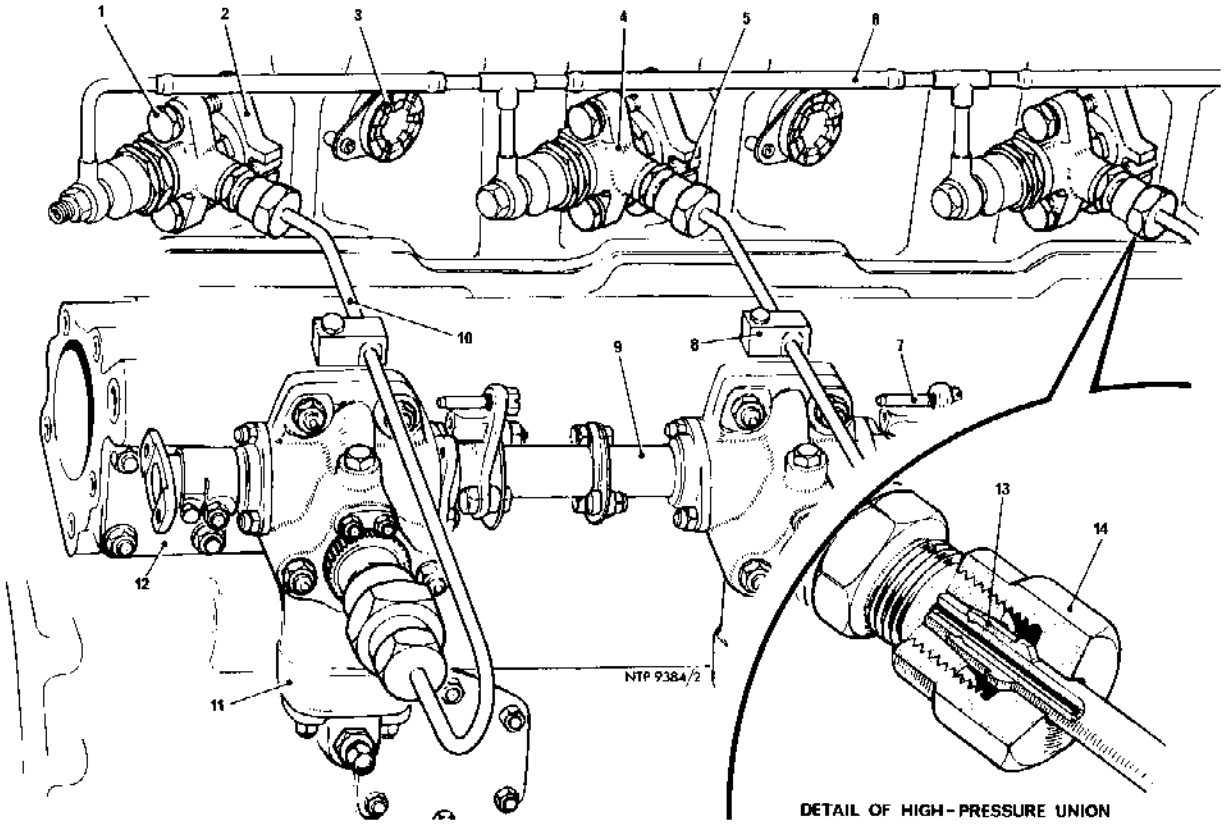
ducts to the sac inside the nozzle body. Pressure built up in the sac forces the needle valve toward the open position against the spring loaded plunger and, as the valve opens, fuel is injected into the combustion space. When injection pump ceases to pass fuel to the injector, the pressure in the sac drops and the spring pressure acting on the plunger closes the needle valve and terminates injection abruptly.

High Pressure Pipes.

The high-pressure pipes connecting the injection pump with the injector are of cold drawn mild steel, tin plated internally and externally. The pressure joints at each end of the pipes are formed by 'Ermeto' couplings.

The pressure coupling consists of a sealing ring and a securing nut. During initial assembly of the coupling, the sealing ring is altered in shape and its leading edge becomes embedded in the pipe; when the joint is subsequently unscrewed, the ring remains permanently attached to the pipe.

The high-pressure pipes are supported on the adjacent camshaft casing by a shroud clip and rubber bush.



1. Injector retaining screws
2. Retaining sleeve
3. Blanking plug
4. Fuel injector
5. Locating peg
6. Injector spill
7. Setting pin
8. Damping shroud
9. Control shaft
10. High-pressure pipe
11. Fuel injection pump
12. Timing segment inspection port
13. Sealing ring
14. Securing nut

HIGH PRESSURE FUEL PIPES AND INJECTOR SPILL PIPE