NEW ZEALAND GOVERNMENT RAILWAYS

LOCOMOTIVE CORRESPONDENCE COURSE - ENGINEDRIVERS

LESSON NO. 2

As the fuel oil, lubricating oil, and water cooling systems are extremely important to the successful operation of the diesel engine, the Enginedriver is expected to fully understand these systems and the equipment in these systems. Many delays can be caused by an Enginedriver not carrying out the proper precautions when taking fuel, oil, water and not making a complete examination of the systems when preparing and putting away locomotives for any defects. It should be remembered also that frequent checks must be made of these systems whenever an opportunity occurs while on the road.

This lesson will not necessarily cover any particular system on one locomotive but it will name and describe all equipment that will be found in the various systems. It is the Enginedrivers duty to study and understand the type of locomotive he is working on. In later lesson each locomotive will be covered in turn.

Fuel System:

This system must be such that the cylinders are supplied with clean fuel in sufficient amounts to be able to operate the engine at its correct rating.

The equipment in this system consists of the following -

Fuel Tank which, depending on the locomotive, may be placed under the locomotive or as in most shunting locomotives under the superstructure above the engine level. On locomotives fitted with the fuel tank above the engine the flow of fuel is by gravity but on locomotives where the fuel tank is below the engine a fuel pump is required to lift the fuel. A filter is often placed in the fuel tank connected to the fuel outlet pipe. Filling apertures are fitted into the tank on either side which have strainers fitted into them which must not be removed. Gauges are fitted to the tank to show the level of the fuel. Pipes in the fuel systems are painted lino brown.

Fuel Transfer Pump:

This pump is for the purpose of lifting the fuel from the tank by suction and then forcing it through the filters. The fuel pump can be driven by an electric motor through a flexible drive or driven mechanically from the engine. The pump generally is a gear type pump and in some cases has a built-in by-pass valve which is a safety valve. If for any reason the pressure on the discharge side of the pump reaches a dangerous pressure this valve will open and by-pass fuel back to the suction side of the pump and thus relieve the pressure.

Filters:

There are several types of filters in use, the ones placed between the fuel tank and fuel pump are called suction filters and often have a metal gauze element. Those placed after

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the fuel pump are called discharge filters and consist of a paper or fabric element or a sintered bronze filter. They are for the purpose of ensuring the fuel is clean before it is passed on to the fuel injection pumps.

Air Separator and Relief Valve:

This ensures that any air or excess pressure is returned to the fuel tank and it also ensures that the fuel pressure is always constant. If pressure exceeds the pressure for which the relief valve is set, this valve opens and allows the excess pressure and any air to return to the fuel tank until the pressure again drops to normal and then the relief valve closes. The separator consists of a body formed into a chamber which acts as a volume chamber. Bolted to the top of the chamber is the head which contains a spring loaded ball valve. Fuel enters the top of the chamber but the outlet is taken from the bottom of the chamber. Any air or gases entering the chamber rise to the top and when the relief valve opens through excess pressure, is carried away back to the fuel tank with fuel by a return pipe.

Fuel Injection Pump:

This pump though very simple in principle must necessarily be a piece of precision engineering. It must, however, be regarded in the same light as any other piece of precision equipment and its repair, when it does need attention, is definitely beyond the skill of any but specially trained workmen. The fuel injection pump therefore should not be interfered with by Enginedrivers.

The fuel injection pump controls the amount of fuel supplied to the cylinder and the precise time during which it is supplied. In fact the pump has three duties which are : the metering of the fuel, raising of its pressure, and controlling the timing and period of its injection. Since the quantity to be metered is in any case small and the pressure high, and since it is most important that in any set operating conditions, the quantity, pressure, timing and duration of injection shall not materially vary from cycle to cycle and from cylinder to cylinder, the fuel pump must be in effect a precision instrument. Generally, each cylinder is provided with a fuel injection pump which is positively driven from the engine itself; thus for a six cylinder engine there would be six fuel injection pumps, On the smaller type of engines fitted to the shunting locomotives these injection pumps are all mounted together in a monobloc casing complete with its own camshaft and driving gear, or individual pumps for each cylinder may be mounted adjacent to the cylinder and are operated individually from the main engine camshaft. When the pumps are grouped together they are frequently referred to as unit construction pumps, whilst those for individual mounting are commonly referred to as flange mounted pumps.

Whatever the design, the pump comprises a steel barrel in which operates a plunger which is lapped to a perfect fit. These two parts comprise what is referred to as a pump element. The barrel of the element is fitted with ports for the suction of the fuel and the spill of the fuel during that portion of the plungers stroke when it is not actually injecting. The plunger is so

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arranged that it may cover these ports at a predetermined point in its motion whereupon the fuel is trapped in the pump and forced through a spring loaded valve to the fuel nozzle. At a further predetermined point in the plunger's motion one of the ports in the barrel is again uncovered and fuel then takes the easier path, spilling back to suction rather than passing through the delivery valve under pressure. The motion of the plunger is caused by its being pushed outwards by a cam and returned by a heavy spring. To control the amount of fuel the pump plunger is provided with a vertical slot and a helical cutaway portion or recess near the top of the plunger. The pump barrel is clamped rigidly into the fuel pump body and is prevented from turning by the means of a locking pin. Surrounding the lower part of the pump barrel is a control sleeve which cannot move up or down but can be rotated by means of a fuel rack. The fuel rack is cut in the form of a toothed rack and it engages a toothed quadrant which is clamped round the control sleeve. The bottom end of the control sleeve is slotted and working in the slots are projecting lugs formed integrally with the fuel pump plunger. Thus, while the fuel pump plunger is moving up and down in the barrel, by the means of the lugs it can also be caused to rotate if the fuel rack mounted in the fuel pump housing be moved endwise. When the plunger is at the bottom of its stroke, fuel which surrounds the pump barrel under pressure flows through the ports in the barrel on to the top of the plunger. When the plunger moves up, fuel oil is pushed back through the ports into the suction chamber until the plunger reaches the position where the top of the plunger seals off the ports in the barrel. There is now no way for the fuel to escape from the interior of the barrel except through the delivery valve at the top of the pump element and thus to the fuel nozzle. Further upward movement of the pump plunger continues to deliver fuel to the engine until the plunger reaches the position where the lower edge of the control helix has uncovered a port in the barrel, thus allowing fuel to pass down from the top of the plunger by the way of the slot and cutaway helical portion and escape through the port back into the suction chamber. When this occurs the pressure in the delivery pipe falls and the delivery valve in the fuel pump shuts under the action of its closing spring. The stroke of the plunger is always the same, being controlled by the fixed cam, but the amount of fuel delivered is varied according to the amount required by the engine for the load it has to carry by rotating the plunger in the barrel by the movement of a control shaft either from a governor or by manual control which moves the fuel rack. This alters the position of the helical control cutaway part of the plunger relative to the port. In this way fuel is controlled; if the plunger is fully rotated the helical cutaway will not open a port until the plunger has moved its full stroke, thus all fuel on top of the plunger is delivered to the engine and this is the full fuel position. If the plunger is rotated to the position where the vertical slot is in line with a port, no fuel is delivered to the engine because as the plunger moves up and down in the barrel the fuel is merely displaced to and from the suction chamber, and the engine will stop. The amount of fuel delivered therefore depends on when the helical cutaway opens a port and this is controlled by rotating the plunger in the barrel.

The plungers are lubricated by fuel oil, but the cams and other operating gear are either lubricated from the engine pressure system or by a sump formed in the fuel injection body; this is

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generally found on the unit construction pumps. Fuel is supplied to the pumps by a fuel line and is always in excess of the amount that is required for the pump. A relief valve is placed in the system which will open at a set pressure and return the excess fuel to the tank. In this way it ensures that there is always a constant supply of fuel under pressure at the pump.

Fuel Injectors:

The fuel injection pump controls the amount of fuel supplied to the cylinder and the time during which it is supplied but the pressure at which the fuel enters the cylinder is controlled by the fuel injection valve, which may also be called the fuel injector nozzle or atomizer. The nozzles differ depending on the type of engine that they are fitted to but they generally work on the same principle. They consist of a body or nozzle holder and a nozzle held in place by a capnut. The nozzle itself consists of a steel body, bored to receive the nozzle valve, which is a very close fit in the nozzle body. Fuel is delivered to the atomiser body via the fuel injection pipe. The fuel then passes through drilled holes in the nozzle holder body and a further drilled hole in the nozzle body itself to a space below the plunger portion of the nozzle valve. This plunger portion of the nozzle valve is larger in diameter than the seat portion of the nozzle valve so that the fuel delivered under pressure from the injection pump, acting on the difference in area between the nozzle-valve plunger portion and the nozzle valve seat tries to lift the nozzle valve in the nozzle body. This tendency to lift is resisted by a spindle held down by a powerful spring. The plunger portion of the nozzle valve is so good a fit in the nozzle that leakage is negligible, but even so some exceedingly slight leakage does take place and is needed in order to lubricate the plunger portion of the nozzle valve. Any leakage passes up the centre of the nozzle holder body and is taken away by a leak off pipe connected to the nozzle holder body. The pressure at which the nozzle valve will lift from its seat is termed the nozzle opening pressure and will vary according to the design of the engine to which the nozzle is fitted. Usually pressures vary from 1500 lb to 3000 lb per square inch. When the nozzle valve lifts, fuel oil is sprayed into the combustion chamber in a very fine spray. When the pressure drops on the nozzle valve plunger portion, the spring will return the nozzle valve plunger to its seat with a snap action, This is assisted by an anti-dribble device incorporated in the delivery valve portion of the fuel injection pump. High pressure pipes connect the fuel injection pumps to the injector nozzles. On some types of diesel engines the injection pumps and nozzles are made as one unit. The fuel may be sprayed through one hole or several holes in the nozzles and are termed "pintle" or "hole" type nozzles. Another type that is often used is called the "long stem" nozzle; this enables the end of the nozzle to be made of a smaller diameter.

To sum up, the requirements for an efficient fuel system are :-

1. A tank to contain fuel.
2. Means to supply the fuel at a reasonably constant pressure to the injection pump.

3. Means to keep fuel clean before it reaches the injection pump.
4. An injection pump capable of measuring and supplying small quantities of fuel at high pressures at precise times,
5. Means of supplying the small quantities of fuel in the correct manner into the combustion chamber of the engine.
6. The system must not be affected by external dirt or moisture.
7. The system must not be affected by appreciable changes in temperature conditions.

On some systems means are provided so that the fuel system can be primed or the system cleared of air locks. On engines fitted with unit construction pumps such as the shunting locomotives, a small vent screw is fitted into the fuel chamber of the injection pump block and a small manually operated pump is provided. To clear the system this screw must be loosened off and then the hand pump operated until a solid flow of fuel free of bubbles appears at the vent screw, and screw must then be tightened and the manual pump locked. On larger engines bleed screws are fitted into the end of the fuel lines or bus rails as they are called. To prime this system these screws must be loosened with the fuel transfer pump running and when a solid flow of fuel clear of bubbles appears at the bleed screws they may be tightened. Always ensure that they are secure and not leaking. Bleed screws will be found also on fuel filters, injection pumps and nozzles.

It is imperative to exercise the greatest cleanliness when carrying out any work connected with the fuel system as the slightest amount of grit or dust can ruin a fuel pump in a very short time.

When taking fuel always take the following precautions:

1. Do not smoke or allow naked lights near the fuelling bay.
2. Strainers in fuel tanks must not be removed.
3. Fuel must not be spilt or fuel tanks allowed to overflow.
4. Fuel tank caps must be replaced and properly secured.
5. Ensure that all fuel nozzles are clean before using.
6. Do not use waste to wipe nozzles clean.
7. Do not let the nozzle touch the ground.
8. When it is necessary to refuel from drums, ensure the top of the drum is clean and free of water before removing cap.

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Lubricating System:

All diesel engines are pressure lubricated, that is to say, the lubricating oil is fed to the main bearings of the crankshaft and various other parts of the engine from a mechanically driven oil pump. In the case of the large engines two oil pumps are used. Pipes in the lubricating oil system are painted salmon pink. A complete lubricating system would consist of :-

Sump or Oil Pan:

This is fitted to the bottom of the engine bedplate and is used to carry sufficient oil to lubricate the engine. Fitted in the sump is a dipstick which is marked with a "full" mark, an "add" oil mark and a "low" mark to indicate the amount of oil that is carried in the sump. It is the Enginedriver's duty to check the oil level whenever he takes a locomotive into service, when putting away and at intervals on the road. The oil must never be allowed to drop below the "low" mark and should be topped up when the level falls to the "add" oil mark.

Oil Pumps:

The oil pumps are usually located near the bottom of the oil sump as low down on the engine as can conveniently be arranged, in order that oil may flow to the pump suction with as little resistance as possible. The oil pumps may be driven by chain or spur gears from the engine crankshaft, and if so they will be mounted with their spindles parallel to the engine crankshaft. Very frequently, however, the pumps are mounted with their spindles vertical and are driven by bevel or spiral gearing and a vertical shaft from the crankshaft. The pumps generally consist of a spindle driving an oil pump gear which meshes with a similar gear free to rotate on a spindle. The pump gears are enclosed in a housing which has an oil inlet and an oil outlet connection coupled to it. The rotating of the gears causes the oil to be drawn in on the suction side and be carried round by the gears to the pressure side and thus passed out through the outlet connection. The pressure that can be developed by this type of pump depends on the engine speed, the clearance between the gears and the body, and the viscosity of the oil. When two oil pumps are provided one is called the scavenge pump which picks up the oil from the sump and delivers it to the pressure pump which in turn delivers it to the points of lubrication which are the crankshaft, camshaft, big end, little end bearings and also to timing gears or chain, valve gear and other auxiliaries depending on the type of engine. On the smaller type of engines only one oil pump is provided. On some engines a hand pump is provided so that oil pressure can be pumped up by hand to enable easier starting of the engine.

Strainers and Filters:

Oil must be clean and free from impurities, however small. Since the bearing clearances on the engine are at the most only a few thousandths of an inch, very little grit or dirt would soon cause severe scoring, excessive wear and possible seizure. On the suction side between the sump and pump is

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generally placed a gauze type of strainer so that the oil drawn from the sump to the pump is strained of the worst of its impurities. This suction filter must not be too fine in mesh as otherwise it might rapidly clog and starve the pump of oil. The main filtration is therefore carried out on the delivery side of the oil pump and is done by filters of different makes depending on the type of engine. These are commonly made of a renewable fabric element.. Other filters are fitted with a by-pass which allows lubrication of the engine to continue even when a filter becomes choked up. On some engines a magnetic filter is fitted. The purpose of this filter is to remove any metallic particles that may be in the oil system by the use of a magnet fitted in the filter.

Oil Cooler:

As some parts of the diesel engine such as big ends, crankshaft, little end bearings and pistons are cooled by the lubricating oil, it is necessary to keep the lubricating oil at a safe working temperature. To do this an oil cooler is supplied on the locomotive and oil after leaving the sump is passed through it, generally after leaving the scavenge pump. The cooler is often referred to as the heat exchanger. These coolers are made in different forms. One type is made up of tubes fitted with fins and the oil passes through these tubes and cooling air is blown round them thus the heat is transferred from the oil to the air. These are called oil cooling radiators. Another type takes the form of metal tubes made into the form of a radiator and placed in the cooling header tank. In this case the water flows around the outside of the tubes and oil through the tubes, thus heat from the oil is passed out to the water. Other coolers take the form of pipes with U bends on the end and coupled together and are placed in a position where a cooling draught of air will pass round the pipes.

Relief Valves and Differential Valves:

This type of valve consists of a spring loaded valve or piston and is provided so that any excess pressure can be relieved from the oil system, thus maintaining a constant pressure. They are placed in different parts of the system; one is often placed between the scavenge pump and the oil cooler. This valve is referred to on some types of engines as the differential valve. When an engine is started up from cold the oil is thick and thus oil pressure is high, so that if this pressure exceeds a predetermined pressure the relief or differential valve will open and by-pass the oil past the cooling system and then on to the pressure pump. This protects the heat exchanger from damage and also drops the pressure as resistance to the oil flow will drop. On some types of engines the oil also by-passes the oil filter and a sight glass is provided to show that the oil is being by-passed, which could indicate cold oil or a blocked filter. Relief valves are also placed after the pressure pump but these valves, when they operate, allow a certain amount of the oil to pass to the engine for lubrication and the rest to return to the sump; thus by decreasing the volume of oil that is flowing the pressure will drop.

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Starting Valve:

On some engines that depend on the lubricating oil pressure to set the fuel racks a starting valve is fitted.

This valve also is a spring loaded valve and when the engine is being rotated for starting purposes it remains closed. When closed it only allows a certain amount of oil to pass to the engine for lubrication and the rest is supplied to the engine governor to ensure there is sufficient pressure to set the fuel racks. When the engine fires and runs the oil pressure builds up and the starting valve is then forced open removing all restriction in the oil flow to the engine.

Reducing Valve:

This valve is placed in the pressure oil line to the valve and rocker gear; its purpose is to reduce the pressure of the oil and thus the flow to the valve and rocker equipment. If too much oil is supplied to this equipment oil waste will occur as oil can pass down the valve guides and burn. This will also increase the carbon deposits on the pistons and cylinder heads. When the engine is stopped this valve is held open by a spring but when the engine is started the oil flows through the valve to the valve and rocker gear but, at the same time, acts against the face of the valve and when the pressure exceeds the spring pressure, the valve will close. As the pressure will now drop against the valve face the spring will overcome the oil pressure and the valve will again open. By this method the oil pressure to the valve and rocker gear never exceeds the spring pressure of the reducing valve.

Pressure Gauges:

These are fitted to give the operator a visual reading of the oil pressure. A constant check should be kept on this gauge by Enginedrivers and Locomotive Assistants.

Warning Alarms:

These are fitted to give the Enginedriver a warning that oil pressure has dropped to a dangerous level. They may be in the form of a warning light or a warning sound such as a bell. In some cases an automatic shut down device will stop the engine when oil pressure reaches a dangerous level.

Precautions when filling oil system:

1. Ensure that the correct grade of oil is added to the different sumps.
2. Do not remove strainers.
3. Do not spill oil.
4. Take every care to ensure that only clean oil is used.
5. Do not overfill sumps.
6. Book the amount taken on the correct sheet.
7. Always wipe the dipstick clean before testing the oil so that a proper reading is obtained.

Fuel Dilution:

This can occur when fuel leaks take place around or on top of the cylinder heads. Fuel oil can pass down valve guides and other places and find its way into the lubricating oil sump. When this occurs the oil will become very thin and oil pressure will drop. By keeping a check on the oil level in the sump fuel dilution can be detected by the increase of oil shown on the dip-stick. If fuel dilution is suspected it should be booked in the repair book so that a test can be made.

Cooling System:

It is not only important that a diesel engine be adequately cooled but that the cooling be evenly spread over and through the hot surfaces to limit any heat stresses and to ensure that pistons, valves and other moving parts are able to get rid of excessive heat. Pipes in the cooling system are painted field green. The cooling system can consist of the following :-

Water Pump:

This is a circulating pump which must circulate water rapidly through the engine so as to scour all the interior surfaces of the jackets to prevent dead pockets, and carry out all impurities. As a general rule the temperature of the circulating water should not be more than 20°F higher on leaving the engine than on entering. The most commonly used type of water pump is of the centrifugal design. The main parts of the pump are - impeller for circulating the water, impeller housing, drive shaft, drive shaft housing, bearing, water seal, and drive gear. The pump is driven generally by gears from the free end of the crank-shaft.

Radiators:

These are made so that water can pass through tubes fitted with fins and cooling air can be forced round the tubes to cool the water. The radiator can be placed anywhere on the locomotive such as on the side, front or roof. It is most important that outside of the tubes and fins are kept clean of dirt, oil or any other material as this will affect the cooling of the water and cause overheating.

Cooling Fan:

Engines arranged for cooling by radiators are fitted with fans driven indirectly by the engines themselves. This fan on the smaller types of engine is belt driven but on the larger types is driven from an extension from the main crankshaft. The drive is taken through a fan drive gearbox or speed increaser which it is often called, and the drive shaft is fitted with flexible couplings. The gears in the gearbox change the angle of the drive and are lubricated by an oil pump placed in a sump which houses the gears. The housing contains a filling aperture and a sight glass or dip stick. A clutch is provided on the drive after it leaves the gearbox which may be of the centrifugal

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type or operated by air. Oil seals are fitted to the drive shafts. The clutch is provided so that any excessively rapid changes in fan speed are prevented. On some locomotives the clutch does not engage to allow the fan to start rotating until the water temperature has reached a certain temperature. The fan can either force or draw the air through the radiators. On some types of locomotives the fan is driven by a fluid coupling.

Header Tanks:

These are placed generally above the engine level but on the smaller types of engines are incorporated in the radiator. They are provided to give an extra supply of water to the cooling system to allow for a certain amount of loss of water without the system becoming low in water to a dangerous level.

They are provided with filler pipes or caps and overflow pipes. On some engines the cooling water circulates through the header tanks before it returns to the engine, but on others it only circulates through the engine and radiator; in this case, which is called a closed circuit, the water in the header tank is only used to replace any water in the system that may be lost.

Diverter Valve:

This valve has several names and although they may be made differently, they all operate under the same principle. They are a thermostatic by-pass valve and are worked by the temperature of the cooling water. When the engine is cold the valve opens ports to allow the cooling water to pass from the engine to the water pump and back to the engine thus by-passing the radiators. When the engine cooling water reaches a certain temperature, this valve will begin to open another port and start to close one of the former ones. This allows some of the water to pass through the radiators to be cooled and some to pass direct back to the engine. As the temperature of the water rises more water passes through the radiators until at a certain degree of temperature all water passes through the radiators to be cooled. Under this system the engine is allowed to warm up quickly and then is kept at its correct operating temperature. This valve on some locomotives can be manually operated.

On other types of locomotives a shutter system is used to do the work of the diverter valve. When the engine is started and water cold the fan does not operate and shutters block the cooling air off from the radiators. When the temperature rises the fan begins to operate and if the temperature still increases, shutters open to allow more cooling air to the radiator coils.

Warning Alarms:

These alarms are fitted so as to give the Enginedriver a warning that the engine has either overheated or the cooling water level in the header tank has reached a dangerously low level. The alarm is given either by a warning light or a warning light and bell.

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Temperature Gauge:

As most diesel engines are not allowed to be put under load or the engine speed increased until the engine has warmed up and a certain temperature has been reached, a temperature gauge is fitted so that a check can be made of the temperature of the cooling water. It also allows a check to be made when a temperature warning alarm operates.

Precautions to take when taking water:

1. Do not remove radiator caps off hot engines without first taking precautions or allowing the engine to cool down.
2. A radiator fitted with a pressure cap "that is a spring loaded valve fitted to the underneath of the cap to form the seat" must be treated with respect and great care must be taken when removing this kind of cap to prevent being scalded by the hot water.
3. Ensure if necessary that engine temperature is below 140°F as adding cold water to a hot engine could cause damage.
4. Open the overflow valve if fitted.
5. Couple up the hose and add water slowly to the system.
6. Ensure that the system is not overfilled.
7. Do not allow the system to overflow.
8. Book the amount of water taken in inches.
9. Use only clean water.

Checking for leaks:

It is the Enginedriver's duty when preparing and putting away and while on the road to check the fuel, oil, water and lubricating oil systems for leaks and defects. Any defects or leaks that cannot be rectified must be entered in the repair book.

Corrosion:

As the engine is generally made of a metal that can corrode, it is important that safeguards against corrosion in the water channels that are formed in the engine crankcase, cylinder liners and cylinder heads are taken. If corrosion is allowed to take place it could cause a restriction in the water channels thus affecting the cooling of the engine. To assist in preventing corrosion and scale deposits in the engine the Enginedriver must always ensure that clean fresh water is used and when water is added he must book in the repair book the amount taken in inches. This is to give a guide to the repair staff so that they can add to the system the amount of inhibitor required to prevent corrosion and scale. When filling header tanks it is advisable to avoid overfilling of the cooling system to prevent diluting any inhibitor in the system.

When dirty water is used this can also cause the blocking of the tubes in the radiator.

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Fire Precautions:

It must be remembered that where fuel oils or lubricating oils are used there is always a danger of fire.

Suitable fire extinguishers are placed on the locomotives and around the depots. These must not be interfered with unless they are to be used for the purpose they are provided for. If used the Enginedriver must report their use so that they can be recharged.

No naked lights or smoking is allowed around fuelling bays or in the engine rooms of locomotives.

Cotton waste or other inflammable material must not be left around where it is likely to constitute a fire risk.

Fuel oil or lubricating oil must not be spilt and all filling hoses must be replaced and valves closed.

Any fuel or oil around engine rooms and locomotives must be cleaned up and any fuel or oil leaks must be rectified or reported and booked for attention.

Locomotives must not be taken near live fires or over pits with live coals in them.

Use sand or the correct extinguisher for oil fires, not water; water will spread an oil fire.

All caps on fuel tanks and filler pipes must be replaced.

Staff must remember that absolute cleanliness is the best way to prevent fires.

Air Intake:

Air that is taken into the engine cylinders must be clean cool air. The reason for this should be easy to realise; if dirty air is taken in, the inside of the engine could be very rapidly worn out. Special precautions must be taken to exclude dust from the air. On four stroke engines a filter is generally fitted to the end of a pipe which extends the whole length of the engine and is called the intake manifold. All air that enters this pipe must pass through the filter. Taken off this pipe are separate connections for each cylinder so that the cylinders can draw from the intake manifold clean filtered air. By arranging the air supply in this manner the manifold tends to smooth out the pulses, so giving a quieter intake.

It is the Enginedriver's duty to check the air intake to the engine and report any defects. He should be on the lookout for any fault that may allow air into the intake manifold without being filtered.

On two stroke engines air is taken in through filters and forced into an airbox which surrounds the cylinder liners.

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Filtered air from this box enters the cylinders when the piston is at the bottom of its stroke through ports made in the liner walls. The air in this box must be above atmospheric pressure as the piston does not act as a pump. The air box is the area surrounding the liners formed by the cylinder banks and enclosed by the crankcase end plates and side panels.

Release of exhaust gases:

When the exhaust valve opens on a cylinder at least 30 per cent of the total energy of the fuel is released through the exhaust. This energy must be disposed of rapidly and in a controlled manner, otherwise back pressure will be set up inside the engine cylinder and the whole of the exhaust gases will not be scavenged. This is effected by discharging the gases into an exhaust manifold which consists of a chamber of large capacity which runs the length of the engine and has separate connections to each cylinder head. The gases from the cylinder can rapidly enter this chamber and expand before being discharged to the atmosphere. This not only allows the quick release of exhaust gases but it also helps to silence the noise of the exhaust.

Water Manifolds:

The pipes that carry the cooling water to and from the engine are also referred to as exhaust or inlet water manifolds.

LIST OF QUESTIONS

1. Describe the operation of the fuel injection pump.

2. What are the three duties performed by the fuel injection pump?

3. How does the fuel injection pump control the amount of fuel delivered to the cylinder?

4. Why is the air separator and relief valve fitted into a fuel system and what does it consist of?

5. State fully how you would clear air locks from the fuel system.

6. What precautions must be taken when taking fuel?

7. Describe the types of oil coolers used on a diesel engine.

8. Why is it that on some diesel engines a starting valve is fitted into the lubricating oil system?

9. State the precautions necessary when filling lubricating oil systems.

10. When should the Enginedriver check the oil level in the sump?

11. What is fuel dilution and how can it be detected?

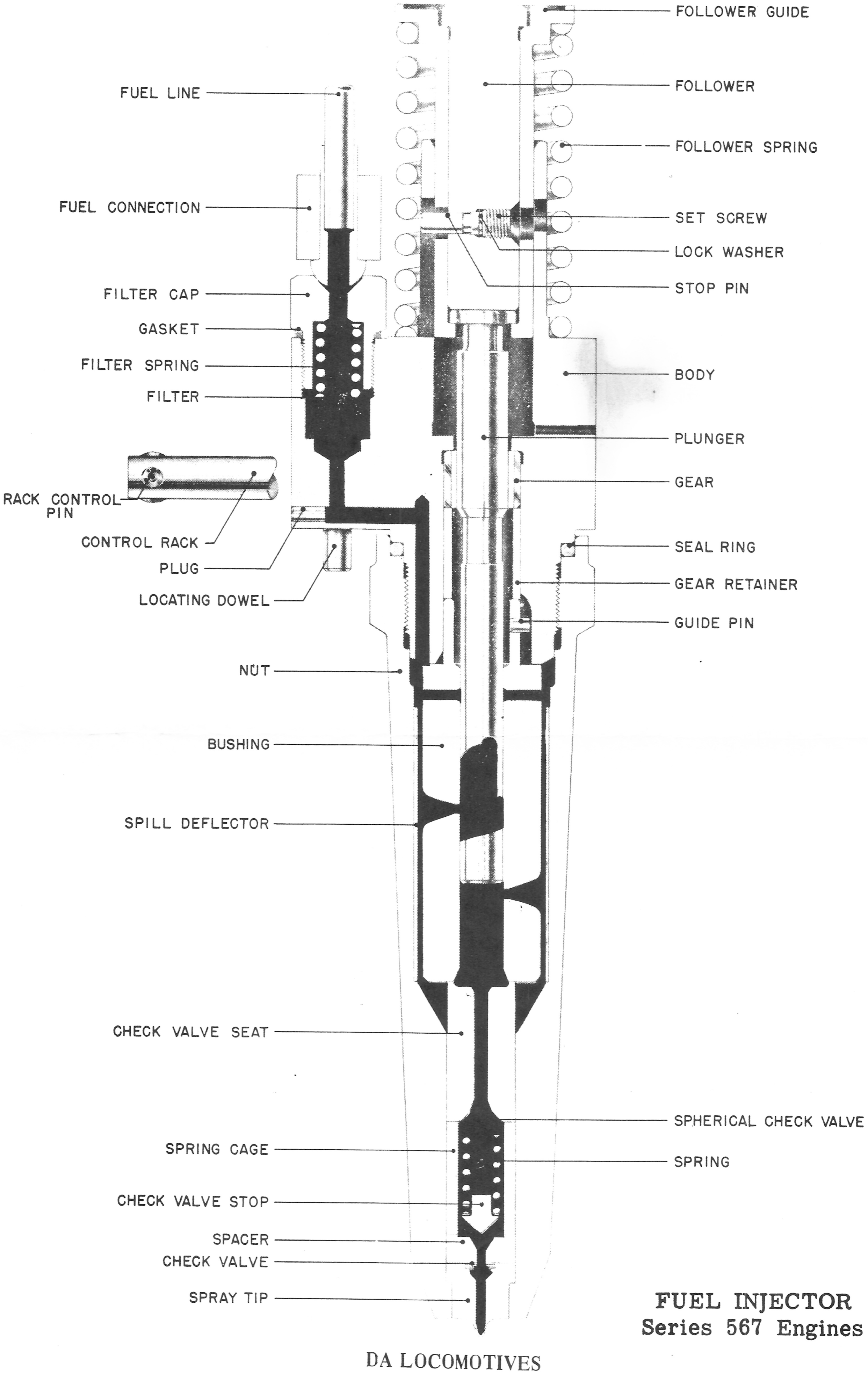
12. What precautions must be taken when filling the cooling system?

13. What are the Enginedriver's duties regarding fuel, oil, water, and lubricating oil leaks?

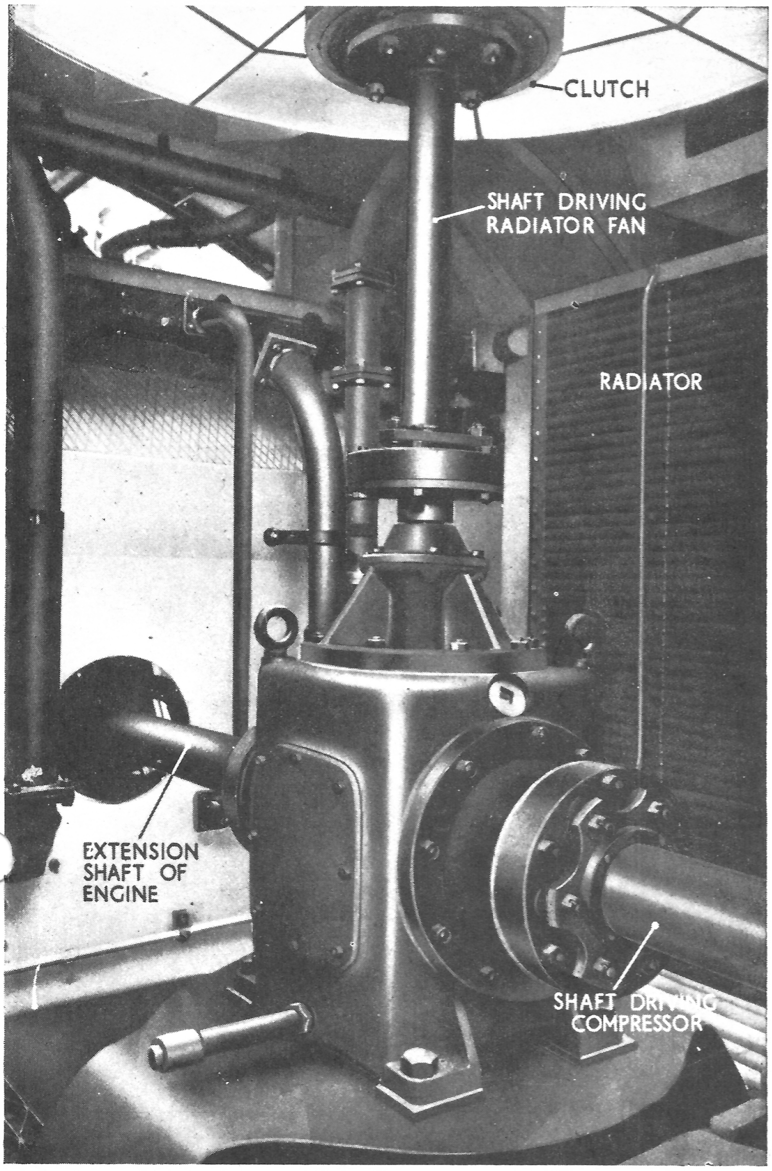
14. What precautions must be taken to prevent an outbreak of fire?

15. What are the Enginedriver's duties regarding the air intake manifold on a diesel engine?

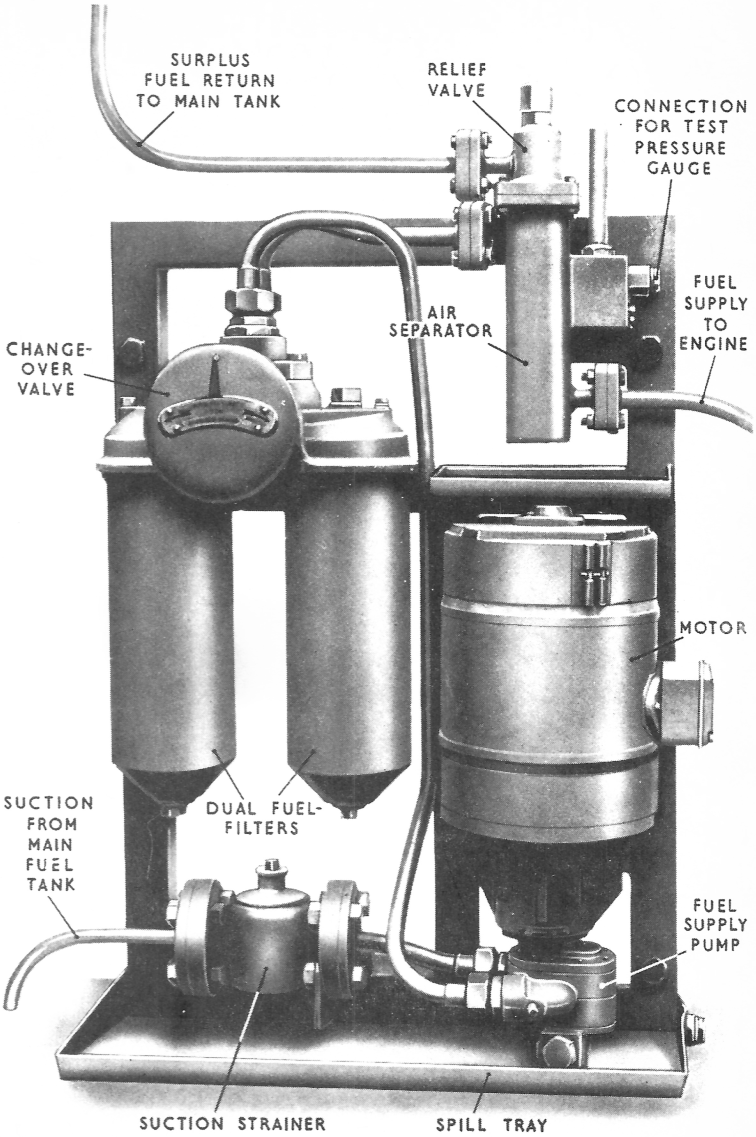
16. What colour are the pipes painted in the fuel system, lubricating oil systems, and the engine cooling systems?



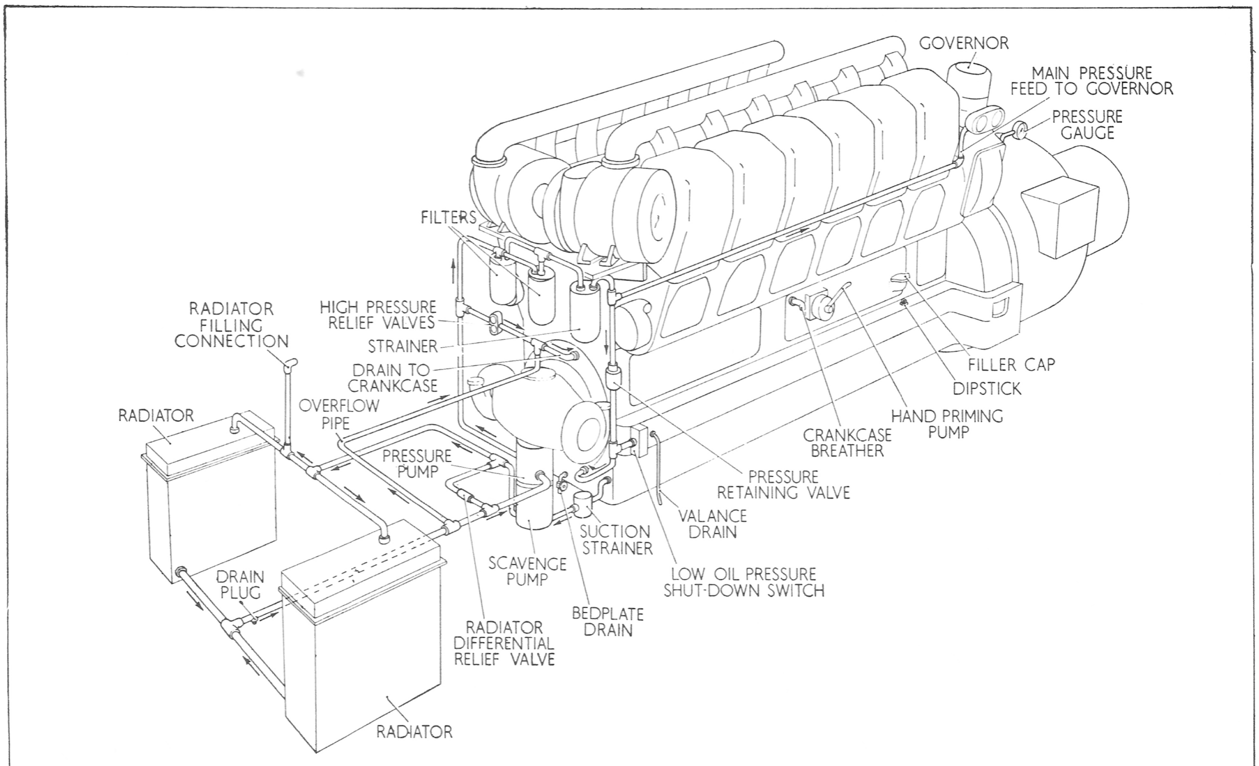
FUEL INJECTOR
Series 567 Engines

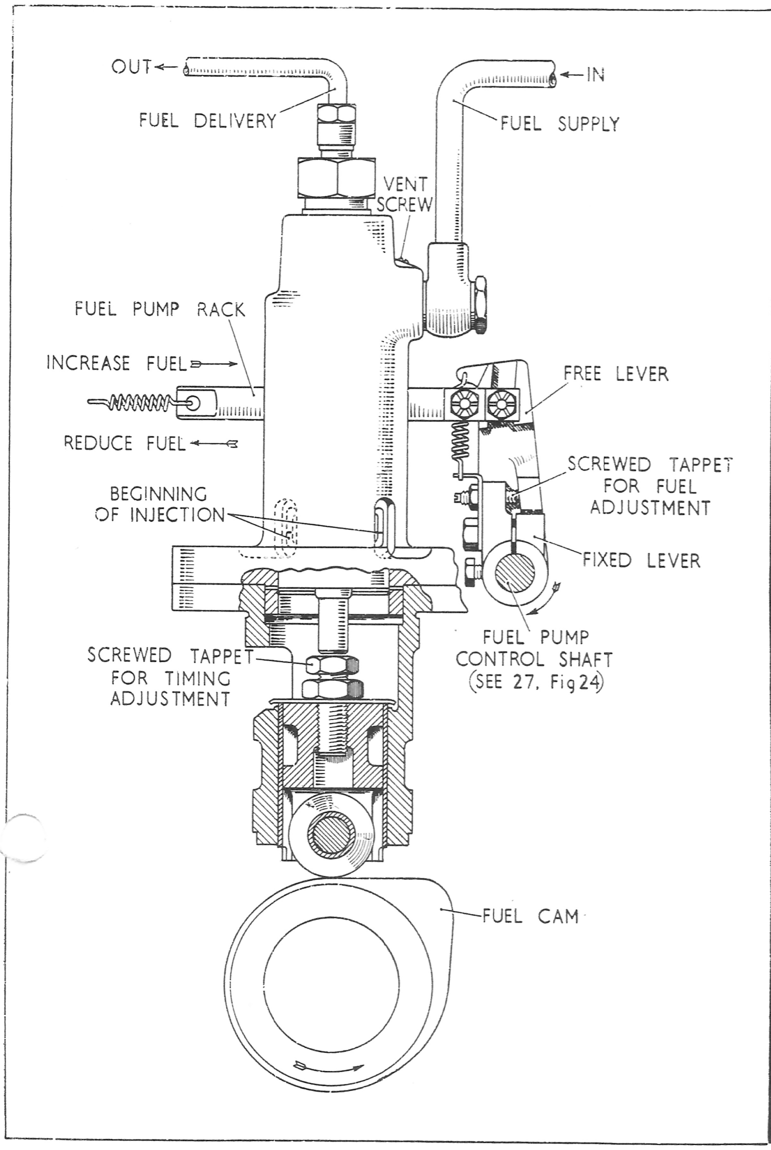


Mechanical drive for compressor and radiator fan

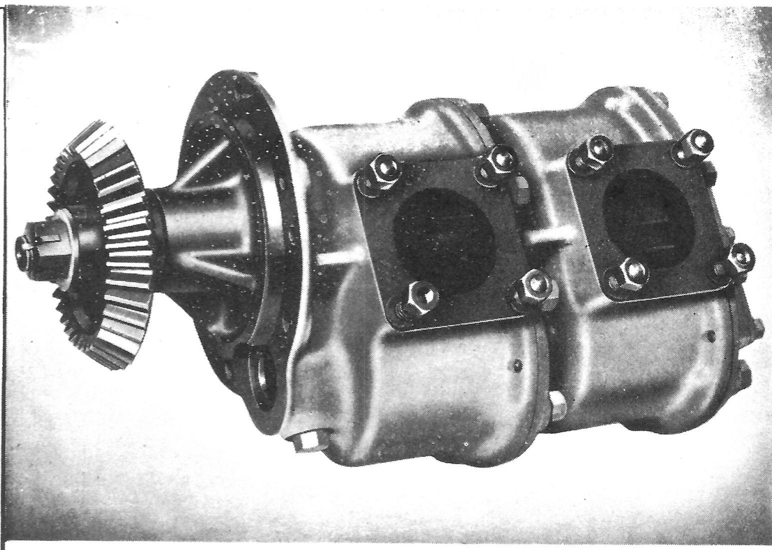


Fuel supply unit

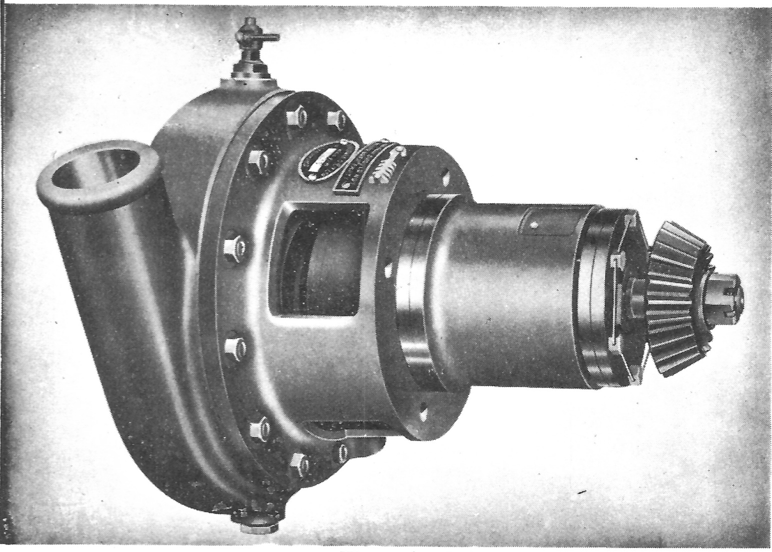




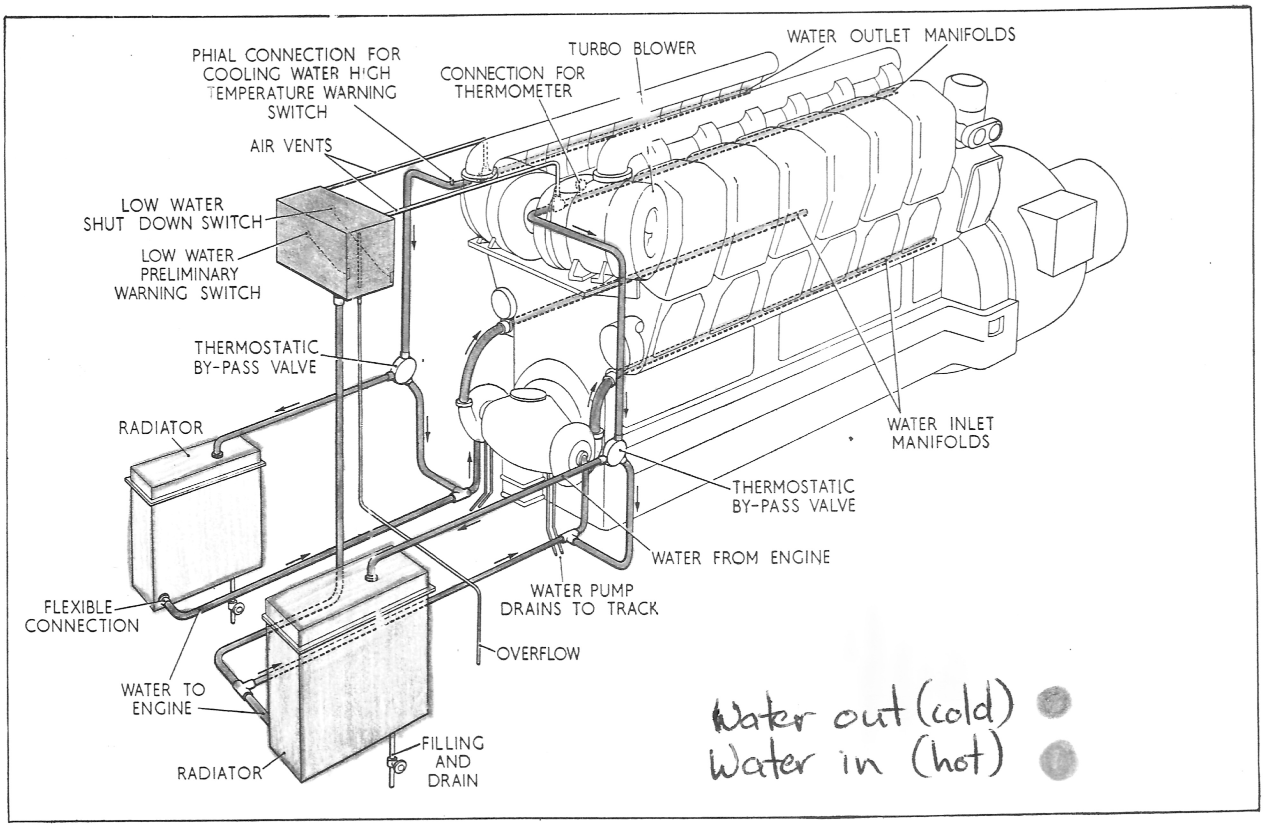
Fuel Injection Pump



Lubricating oil pumps

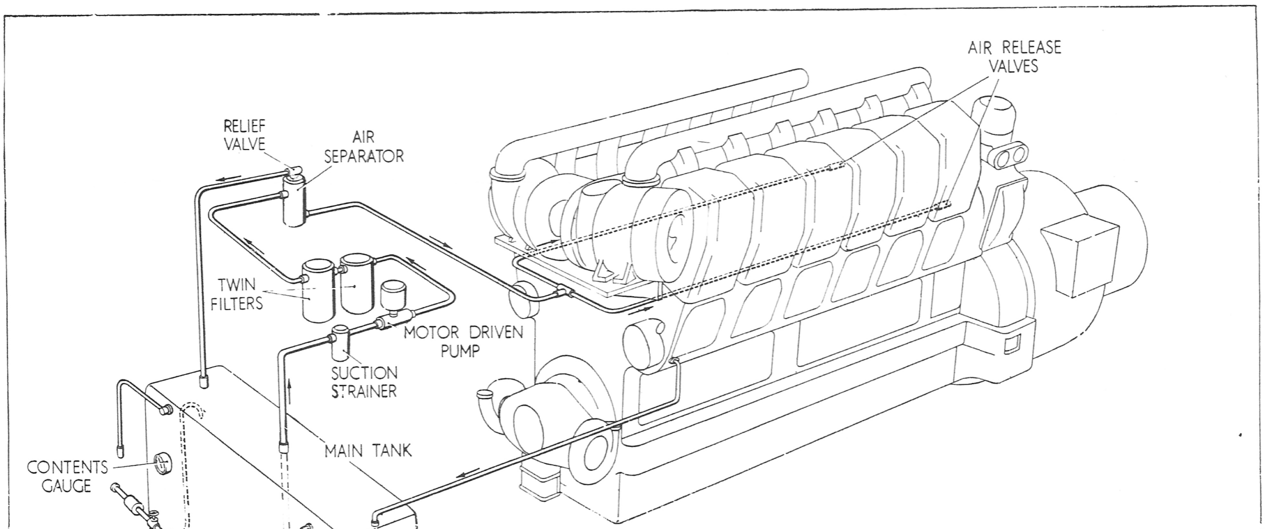


Water circulating pump



Water out (cold) ●
Water in (hot) ●

Schematic external water cooling system



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Schematic external fuel system

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FUEL INJECTION SYSTEM

Chart showing internal construction and principle of operation.

101	Pump Housing.
101a	Closing Plug.
101b	Dipstick.
101c	Plug inlet closing.
101g	Inlet connection.
101i	Inspection Cover Plate.
101k	Screw, Cover Plate.
101l	Screw, barrel locking.
101m	Stop Control Rod.
101n	Stop nut.
101p	Dust Cap.
101q	Split pin.
102	Camshaft.
102a	Cam.
102b	Bearing.
104	Pin, roller.
104c	Roller, tappet.
105	Pump element complete.
105a	Pump Plunger.
105b	Pump barrel.
105c	Spring plate, upper.
105d	Spring, plunger.
105e	Spring plate, lower.
106	Delivery valve and seating.
106a	Seating, delivery valve.
106b	Delivery valve.
106c	Spring, delivery valve.
106d	Holder, delivery valve.
106e	Packing washer.
106f	Nut, delivery union.
107a	Control sleeve.
107b	Regulating toothed quadrant.
107d	Control Rod.
108a	Half Coupling, pump side.
108b	Fibre disc.
108c	Half Coupling, engine side.
110a	Governor Housing.
110c	Lubricator.
110d	Governor Spring, outer.
110f	,, ,, inner.
110g	Bell crank lever.
110h	Flyweights.
110i	Fixing sleeve.
110k	Nut, spring adjusting.
110l	Eccentric Shaft.
110p	Control lever.
110q	Screw, lever fixing.
110r	Floating lever.
110s	Link pin.
110t	Outer link fork.
110u	Inner ,, ,,
110x	Spring plate upper.
110y	Crosshead pin.
111	Nozzle Holder body.
111b	Nozzle cap nut.
111c	Spring plate upper.
111d	Leak off stud.
111f	Spindle.
111h	Valve spring.
111k	Compression screw.
111m	Protecting cap.
111n	High pressure pipe.
112	Filter housing.
112b	Cover, filter.
112c	Cap nut.
112f	Inlet pipe.
112g	Outlet pipe.
112i	Filter element.
112t	Filter gauze.
112w	Centre tube
113a	Nozzle body.
113b	Nozzle valve.
113c	Vertical channel.
113e	Spray hole.
114	Relief valve.
114a	Feed pump.
114b	Hand Priming Device.
114c	Preliminary Filter.
114d	Retaining case.
114e	Drain plug.

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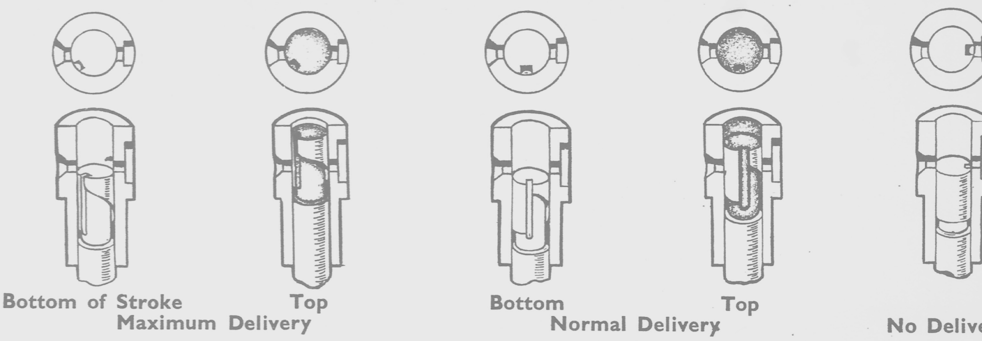
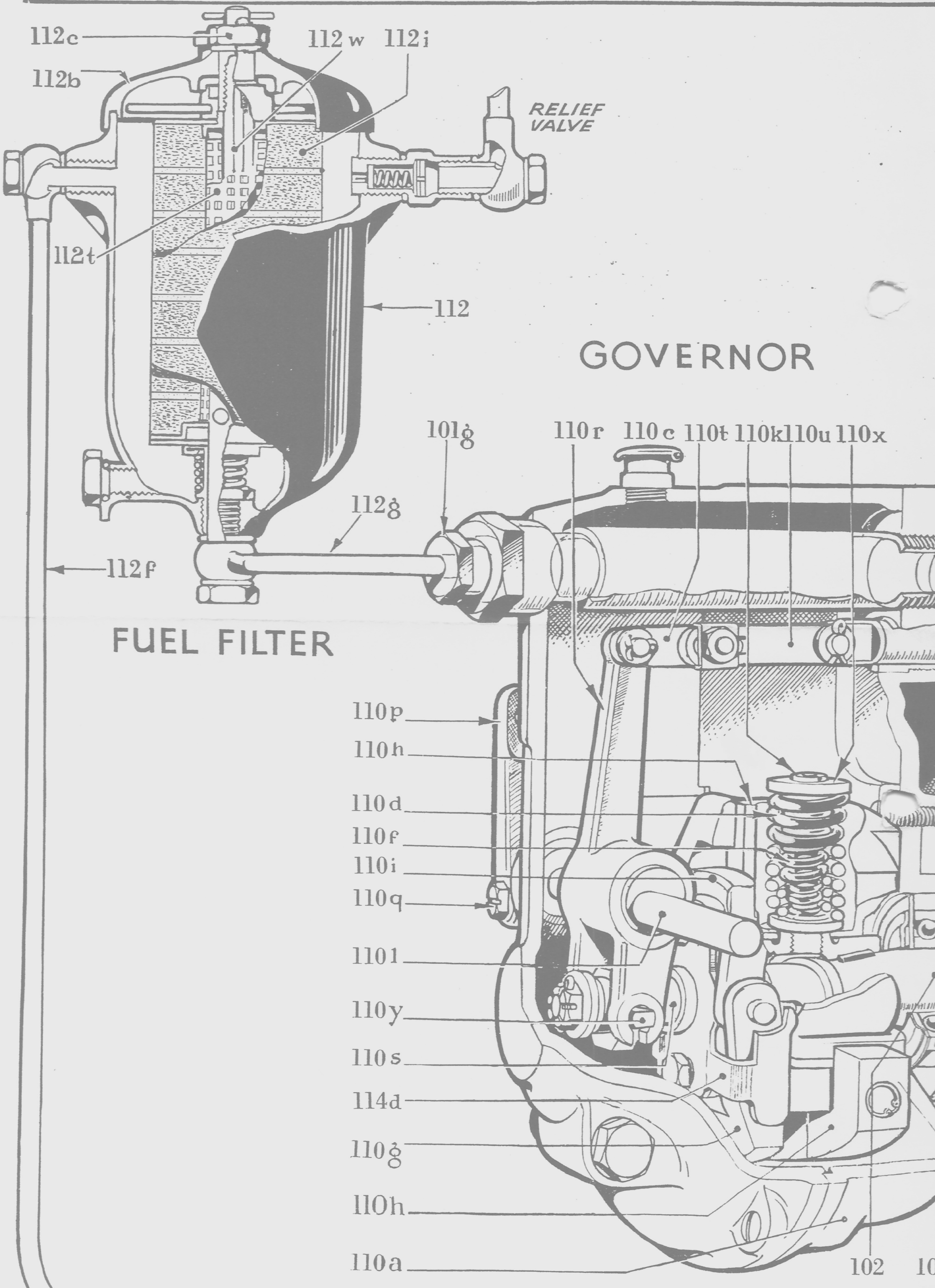
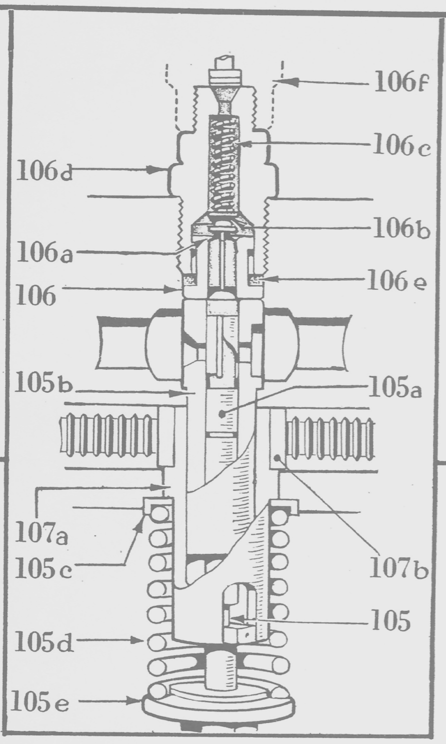
PRINCIPLE OF FUEL METERING





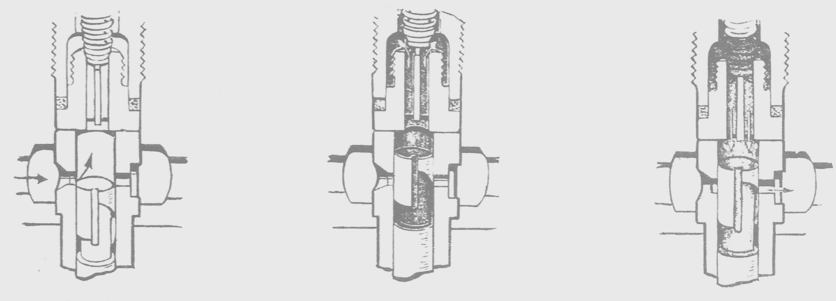
FUEL FILTER

GOVERNOR



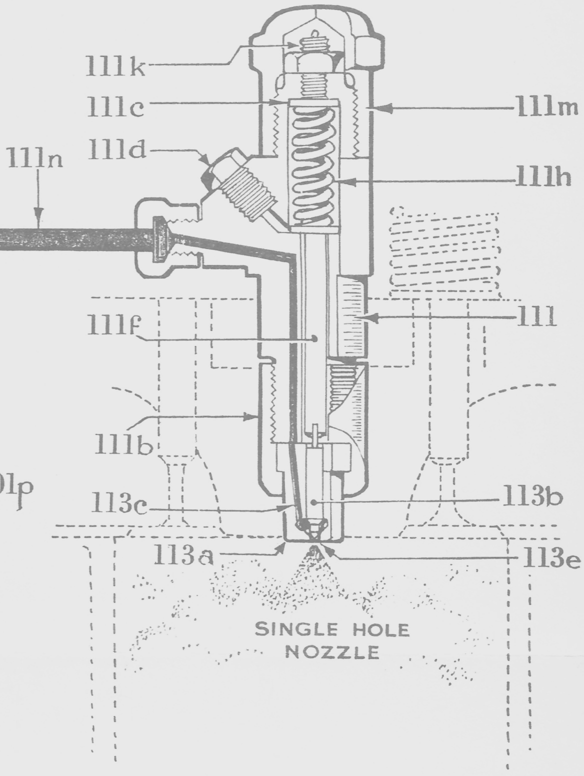
ENLARGED SECTION of PUMP ELEMENT.

PRINCIPLE OF OPERATION

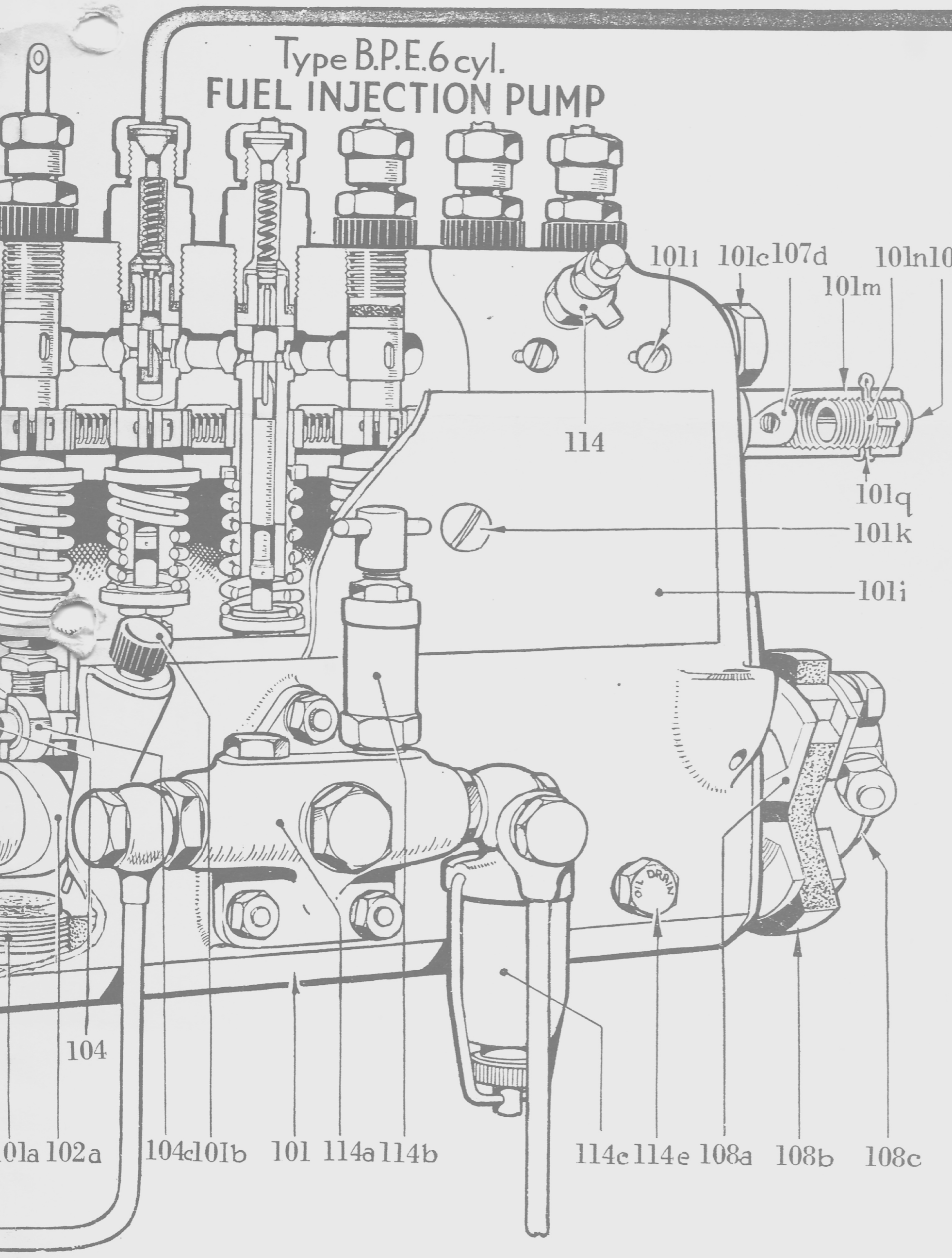


Intake Injection By-Pass

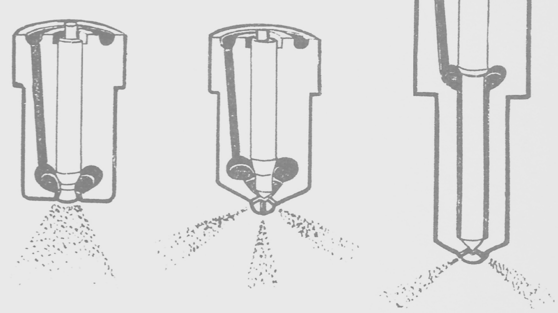
NOZZLE HOLDER & NOZZLE



Type B.P.E.6 cyl.
FUEL INJECTION PUMP



NOZZLE TYPES



PINTLE MULTI-HOLE LONG STEM

☐ FUEL OIL SUPPLY PRESSURE
▨ FUEL OIL UNDER HIGH PRESSURE
☐ LUBRICATING OIL
☐ SHOWING PARTS IN SECTION.

CHART No 2. 2nd Edition