Arona 15 hp (1968) marine engine

Lombardini 9LD560
Arona CM 10/B

Index

Sections

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Piston rings Opel 1,5Ltr. "Rekord" (Mot. II. Phase) 3006 ES 80x2,5+2,5+5mm Standard
PASSFORM-RINGSATZ PISTON RINGS-EXPANDER SET

4-stroke direct injection diesel
Piston diameter and stroke = 80 x 85mm
Piston displacement 854cc
Max cylinder ovality 0.2mm
Max cylinder re-boring = 0.7mm
Top piston ring is chromed
Arona piston ring part nos. from top to bottom:-
7390
7391
7391
9690
7392

Replacement consumables and cross-references

Fuel Filter	Crosland 450	FIAAM FA4194/2
Oil filter	FIAAM FA4489	
Piston rings	Opel 1,5Ltr. "Rekord" (Mot. II. Phase) 3006 ES 80x2,5+2,5+5mm Standard PASSFORM-RINGSATZ PISTON RINGS-EXPANDER SET	
Valve guides	Re-machined from a Renault master 2.5 with oil seals.	

Specifications

Manufacturer: - Fausto Arona & sons Voghera Italy
UK Importer E.P. Barrus
4 cycle direct injection 2 cylinder diesel engine
15 hp @ 2500 rpm 12 – 12½ hp @ 2200rpm
Weight 135 Kgs 297 Lbs (=1hp/9Kgs)
Oils Winter SAE 20/20 Summer SAE30
Valve clearance 0.016" cold (0.4mm)
Valve seat angle 120º
Displacement volume 854cc
Piston stroke 85mm
Cylinder diameter 80mm
Max cylinder ovality 0.2mm
Max cylinder re-bore 0.7mm
Injector calibration 2560/2702 Lb/In² (180/190 Kg/cm²)
Injector markings:- Bosch PFR2K05 ut = 82 b = ±0.2
Injector pressure 2560 – 2700 psi
Oil pressure Max. 68psi Min. 25psi

Engine Cycle

(One turn of the starter handle = 2 rotations of the crankshaft)
Cylinder 1 is the cylinder nearest to the flywheel (front end).
Cylinder 2 precedes cylinder 1 by 180º of rotation in the following cycle.
TDC = Top dead centre **BTDC** = Before Top dead centre **ATDC** = After top dead centre

º of cycle	Cylinder 1		Notes
0	Inlet valve opens (8º BTDC) Exhaust valve closes. (8º ATDC) Air drawn in.		= PMS 1
180°	Inlet valve closes (223º) Compression starts.		
330°	Fuel Injection starts (331º) (29º BTDC) = AP Fuel Injection ends (356º) (4º BTDC) 1 Power stroke starts		= PMS 1
540°	Exhaust valve opens (137º ATDC) Exhaust gases purged.		
720°/0°	Inlet valve opens (8ºBTDC) Exhaust valve closes (8º ATDC). Air drawn in.		= PMS 1

Output rotation anticlockwise as viewed from the rear.

Torque settings

Cylinder head bolts (5)	40 Lb/ft	(11½ Lb/ft 5.2Kgf)
Cam shaft bearings	30 Lb/ft	
Injector pump mountings	20 Lb/ft	
Exhaust manifold		

Fuel

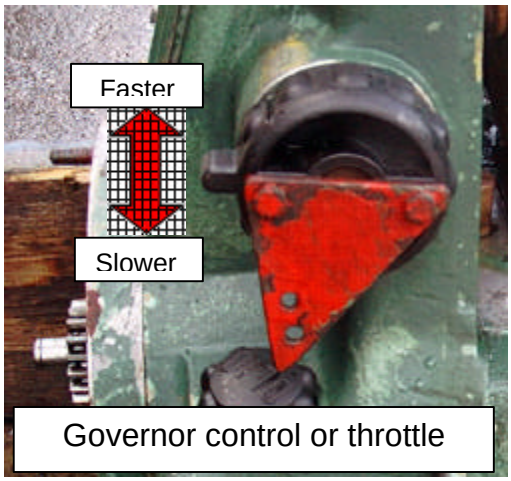
Fuel	Diesel DERV heavy oil (35sec)
Fuel filter	Crosland 450

Operation

Maintenance

Oil Change	Every 90 Hours
Oil filter	every 90 hours
Fuel filter	every 200 hours

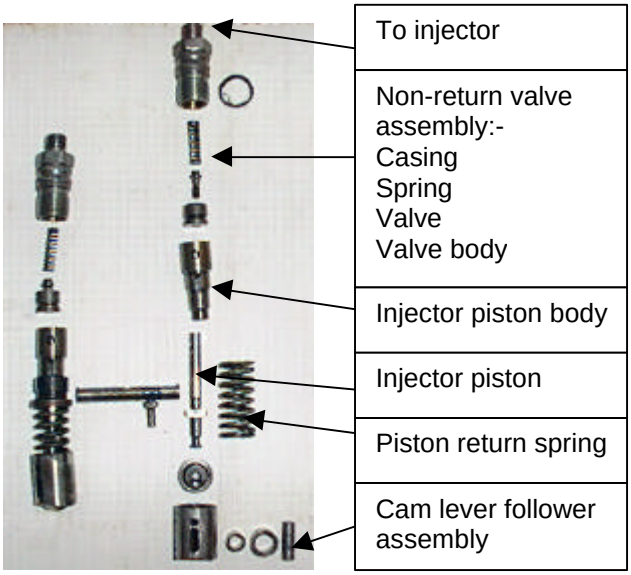
Controls



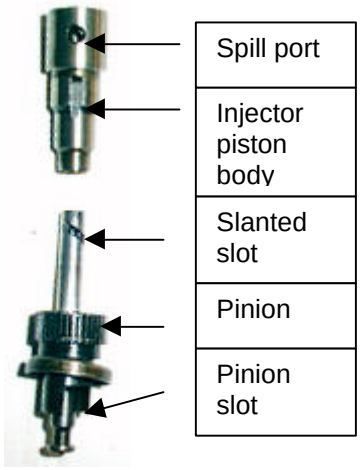
Fuel system

Fuel injector pump

The injector pump comprises of: -
Body
Non-return valve assembly
Piston assembly
Return Springs
Cam lever follower assembly



The **non-return valve** assembly casing has a copper washer which seals to the valve body when the casing is screwed into the injector pump body. This is critical as the further the casing is screwed into the pump body the more it compresses the non-return valve spring which affects the delivery pressure to the injector. The valve body has machined faces top and bottom, which ensure no internal leakage of fuel.



The piston travels up and down inside the piston body. The piston has a slanted slot and a central duct extending from the top to halfway down the piston. The injector piston body has a spill port. As the piston travels upwards the fuel spills out until the slot is no longer over the port. The remainder of the piston travel forces fuel through the non-return valve to the injector. As the piston travels downward a vacuum forms above the piston until the slot is again uncovered by the port, when more fuel is drawn into the piston chamber. The piston is rotated by the governor arm, which moves a rack back and forth. This rack in turn rotates pinions, which have a slot into which the bottom rectangular flange of the piston is located. The rotation of the pistons control the point in the piston stroke at which fuel ceases to spill back through the port thus increasing and increasing the effective delivery stroke of the piston. This in turn dictates the amount of fuel delivered to the injectors in any given stroke.

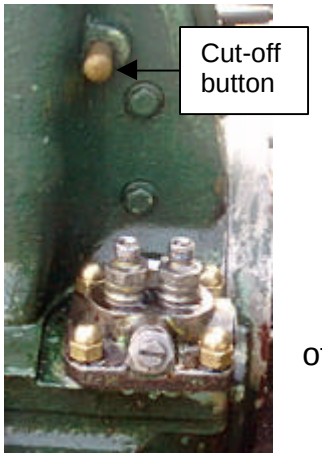
Pump Dismantling

Undo and remove the Non-return valve assembly casing. Inside there is a copper washer, spring, valve and valve body. These should all drop out of the pump casing. The injector piston body will also drop out from this opening.
On the side of the body there are two pins held in place by a spring wire. Withdraw the spring wire. Depress the cam lever followers slightly against pressure from the return springs. This will release the pins, which locate in a slot on the side of the cam follower assembly and prevent the assembly from falling out of the body under pressure from the piston return spring. When removed the cam follower assembly will be partially pushed by the return springs. The follower assembly consists of a gudgeon pin and two concentric rollers set into the follower body. After the follower assembly is removed, slide out the spring, piston foot and piston. The spring retaining washer and pinion can then be removed. Finally the rack can now be slid out.

Pump Reassembly

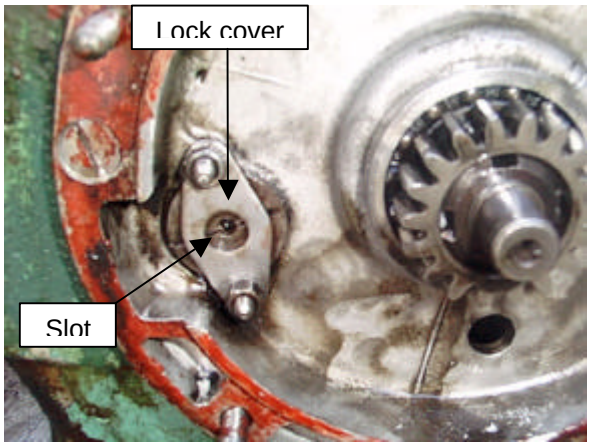
To determine the point of piston rotation at which there is no fuel delivery, carefully slide the piston into the injector piston body fully home. Place a finger over the top of the injector piston body making an airtight seal. As the piston is gently slid back and forth the sound of a quick rush of air into the piston can be heard followed by a tiny puff of air as it is forced out from under the finger. By rotating the piston in small amounts whilst it is being “pumped” the amount of puff can be heard to increase or decrease. Continue this until the

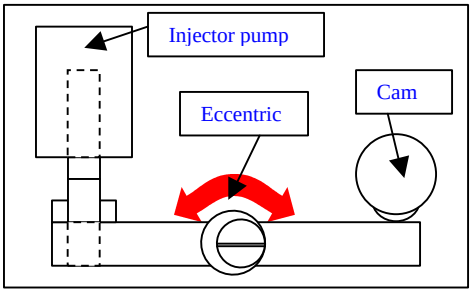
puff gradually decreases and just ceases. It is at this point of rotation that engine cut-off is set. This is also the point at which the governor arm is in line with the locating slot in the cylinder block casing where the pin on the rack drops into the governor control arm. The governor control arm can be set in this position by pushing the brass cut off button located in the side of the cylinder block, just above the injector pump position. There is a locating slot in the injector piston body, which is in line with the spill port. Slide the piston body and piston into the pump body engaging the locating slot with the locating pin inside the pump body, which faces the side of the pump body where the pinions are exposed. Take care not to disturb the cut-off position of the piston. Screw in the re-assembled non-return valve to hold the piston body in position. Mark the orientation of the rectangular locating flange at the bottom of the piston with a felt tip on the bottom face of the injector body. Remove the piston. Insert the rack so that the rack pin is at the cut-off position. Drop the pinion into position so that it engages with the rack and the locating slot is aligned with the cut off rotation marks previously marked with felt tip. The second pinion has a clamping screw. This also acts as a stop. This stop position should also coincide with the cut-off position. When the piston body of the secondary pump is removed, there is sufficient room to disengage the pinion from the rack and then re-engage it so that the stop coincides with the cut-off position. After both pinions are re-engaged the clamping screw can be slackened and the secondary location slot on the pinion aligned with the primary. The clamping screw is then retightened. Both pistons should now be set up so that they cease to deliver fuel when the rack is at the cut-off position. Drop the spring retaining washer into the cam arm follower recess with the washer recess facing up. Drop in the piston return spring. Slide the piston foot over the piston flange and very carefully without using any force slide the piston into the piston body taking care to orientate the piston flange so that it aligns with the pinion recess and that the piston slot is facing towards the spill port i.e. the same side as the pinions are exposed. Slide the follower assembly into the recess and over the spring and piston foot ensuring that the slot aligns with the retaining pinholes. Depress the follower slightly against the return spring and drop the retaining pins through their holes into the follower slots. Slide the pin retaining spring wire across the heads of the pins through the hole in the pump body and into the grooves set into the pinheads.



Injector Pump installation

By slackening off the two nuts on the lock cover the pivot shaft for the cam levers can be rotated. The mounting of the shaft is eccentric, and therefore by rotating the shaft the axis of the cam lever pivot can be raised or lowered. The slot in the face is aligned with eccentric so that if the slot were vertical the pivot axis would be either at it lowest point or its highest point.

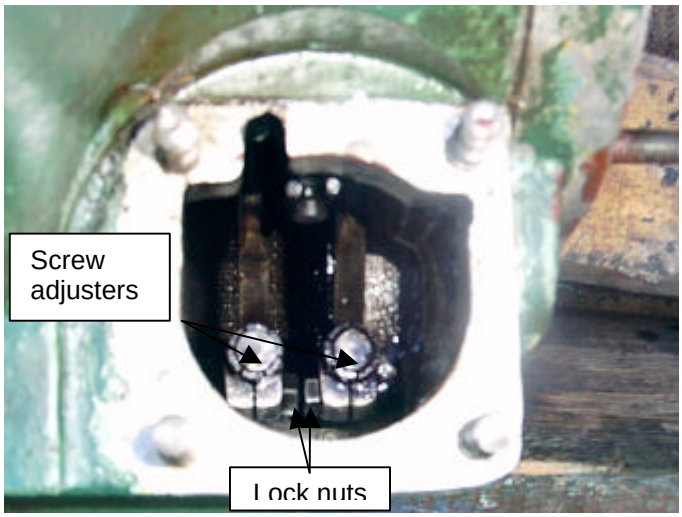




Do not adjust the stroke too high or the injector pump will be damaged.

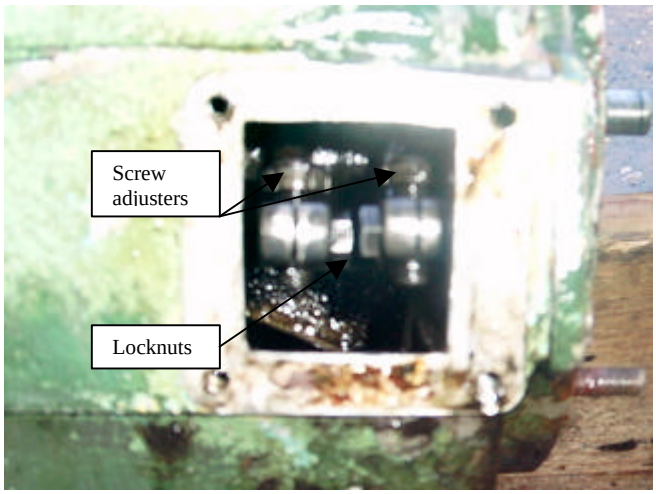
By removing the non-return valve assembly at the injector pump union it is possible to examine whether the injection occurs at the correct point in the engine's cycle. This is the

point marked AP on the front of the flywheel housing. With the removal of the non-return valve assembly fuel will flow through the pump and piston and out of the top of the union until the injector piston is displaced to a point where the spill port is no longer in line with the slanted slot. This is the point when the fuel is compressed in the injector body and fuel injection commences. This should coincide with the AP marking on the flywheel (29º BTDC)



To adjust cam lever setting: -

- Remove the side access cover plate
- Rotate the engine so that the levers are not activating the pump pistons. *(i.e. at their lowest point)*
- Slacken the lock nuts on the pivot shaft locking plate and turn the pivot shaft clockwise so that the levers are just touching the followers on the bottom of the injector pump. *(the eccentric pointing to the pump).*
- Slacken the 2 locknuts on the lever arms and adjust the screw adjusters so that they are just touching the pump followers equally. The followers should touch so that the retaining pins for the cam lever follower assembly are not impacted on the down stroke of the injector pistons and possibly shear.
- Screwing the adjusters up to advance and down to retard the timing can make at this point fine adjustment. The adjusters may only be rotated upwards a maximum of 3 turns to prevent over displacement of the pump pistons and damage to the injector pump.



The cam levers act on each of the two individual injection pistons in the injector pump. Adjust the clearance on the pump followers by slackening off the lock nuts and screwing the adjuster up or down. When adjustments are complete retighten the lock nuts.

View from side with access panel cover removed.

Timing markings

(Note that the flywheel has no woodruff key and may slip)

Timing markings on the flywheel housing.

AP = Injection point (29°BTDC) (Spill point)

PMS = Top dead centre (TDC)

Spill point

The spill point is found by removing the injector pipe couplings at the injectors and rotating the engine. As the engine is rotated and the injector cam rises, fuel will seep from the injector pipe. The spill point is the point during engine rotation when the fuel seepage stops.

Setting injector and valve timing

The injector timing, or spill point and valve timing is critical to the running of the engine.

In making both of these settings it should be noted that serious damage could result in incorrect settings and procedures.

Note that the flywheel is attached to the crankshaft by sliding onto a taper and clamped tight using two locknuts. There is no woodruff key and the flywheel may slip on the crankshaft. It is therefore imperative to confirm TDC every time this procedure is carried out.

This procedure can be applied using either cylinder 1 or 2. Take care not to confuse these during the setting up process.

Always rotate the engine in its normal direction of rotation when setting up the timing positions, as this will ensure any slack in the drive trains for the injector pump and/or camshaft will have been “taken up.”

1. Remove the valve/camshaft cover
2. Remove the injectors
3. Rotate the flywheel by hand until the TDC position can be felt by gently inserting a piece of wire through the open injector port. Mark the TDC position on the flywheel pulley. (Alignment with the PMS marking)
4. Mark the injector pump cam housing for the spill point
5. Remove the injector pump cam housing
6. Remove the valve chain coupling as necessary to realign or confirm alignment of the missing teeth positions. The driving sprocket can be rotated using the starter handle.
7. Rotate the camshaft so that the inlet and exhaust ports for cylinder 1 are rocking. Rotation will be blocked if the piston is at or near TDC.
8. By carefully inserting a length of thin wire in the injector port and rotating the engine slowly, the piston position can be felt and top dead centre (TDC) confirmed. Confirm or mark the TDC positions for cylinders 1 and 2 on the flywheel.
9. Mark the camshaft “rocking” position on a visible part of the sprocket so that this position can be confirmed with the valve cam cover in place.
10. Replace the injector pump cam housing taking care not to disturb any gear positions when re-engaging the gear wheels.
11. Confirm TDC coincides with the valve rocking position for the correct cylinder. The tips of the lobes should be equi-distant from top face of the cylinder head. Fine adjustment of this timing is also made by slackening the three nuts that attach the sprocket to the starter shaft using slotted holes (access through rear access panel) and adjusting its relative position, then retightening the nuts.
12. From the TDC (*PMS*) rotate the flywheel to the AP position.
13. Remove the Injector pump cam housing.
14. Rotate the injector cam so that it is aligned 180º out from the previously marked spill position.
15. Refit the Injector pump cam housing.
16. Confirm that the spill point coincides with the AP position on the flywheel for the correct cylinder.
17. Confirm TDC coincides with the valve rocking position for the correct cylinder.

Removing and refitting the injector pump cam housing

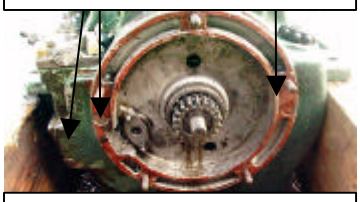
Removing

The injector pump cam housing can be accessed after removal of the gearbox.

Disengage the cam levers from the injector pump by slackening off the 2 nuts on the pivot shaft locking plate and rotating the pivot shaft anticlockwise 90º

Mark the TDC position to aid refitting.

After removal of the 3 mounting screws the cam plate can be withdrawn.



Injector pump cam plate.

Underneath the plate within the governor housing can be seen from top to bottom the governor wheel gear, the crankshaft gear and oil pump gear, Part of the governor arm can also be seen.

The Injector pump cam housing includes a hollow gear with teeth on both the inner and outer face. The inner face is driven by the crankshaft gear and the outer face drives the oil pump and governor wheel gears.

Refitting

The refitting is the reverse of the above. Correct alignment of the gears is essential for injector and valve timing. If this was correct at removal take care not to disturb their positions.

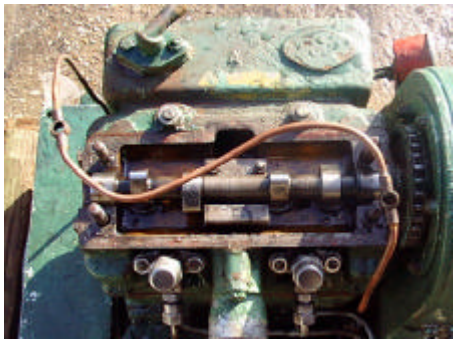
Reset the injector cam pivot shaft by rotating it clockwise until contact with the injector pump resistance is just felt. Turn the shaft a further 1º so that the injector pump pistons bear down on the cam levers and not the piston retaining pins.

It is essential to confirm that the valve timing has not been disturbed.

Injector pump, spill timing should also be confirmed.

Camshaft

The camshaft is driven through a series of gears in the governor housing finally being joined by a chain coupling. The coupling consists of two sprockets positioned face to face and a length of drive chain wrapped around them. The chain has a connector similar to a bicycle chain with a pin, back- plate and clip. The sprockets each have a tooth missing to aid future alignment. The relative positions of the two sprockets to each other affect the valve timing. Valve timing is also made by slackening the three nuts that attach the sprocket to the starter shaft using slotted holes (access through rear access panel) and adjusting its relative position, then retightening the nuts. The TDC position of the piston, indicated by the relative cylinder mark (1 or 2) aligned with the PMS datum on the flywheel housing should coincide with the camshaft lobes "rocking" between the inlet closed and exhaust open position for either cylinder 1 or 2 as appropriate.



Great care should be taken with the valve timing as incorrect timing may result in valves impacting on the piston crowns.

Lubrication is through the camshaft bearing caps at either end of the shaft. Oil is delivered through an external delivery pipe connecting to the hollow rocker cover studs.

Tappets

The tappets are inverted cups with 4 small lubricating holes. They are machine fitted in the cylinder head recess for the double valve springs. On the top of the valve stem is fitted a small machined cap. This cap sits above the valve spring retaining collets. It is by the replacement of this cap with others of various thicknesses that the required valve clearances are achieved.

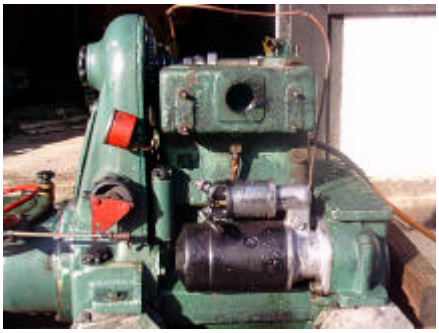
Tip:- It is possible to make up gaps caused by wear by making shim discs of appropriate thicknesses out of a feeler gauge.

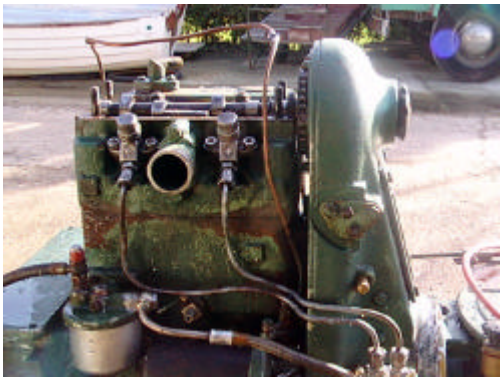
Valve clearance 0.016" cold (0.4mm)

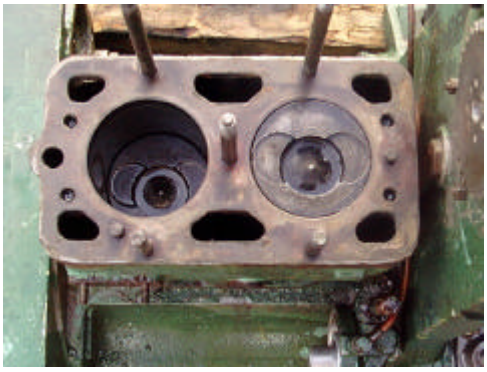
The decompression (valve lifter) system is provided by a flat plate lying across the top edge of the 2 inlet tappets. A cam lever mounted in the rocker cover acts on this plate depressing the plate when the lever is rotated. The plate presses down on the inlet tappets and partially opens the inlet valves. The plate is secured at one edge by two locknuts on each of two studs. The plate floats freely beneath the locknuts, and is held off the tappets by a small spring located on the top of the central cylinder head stud and bolt. The

locknuts are adjust by allowing the plate to rest horizontally on the tappets of the fully closed inlet valves and locked down just touching the plate in this position.

Cylinder head removal



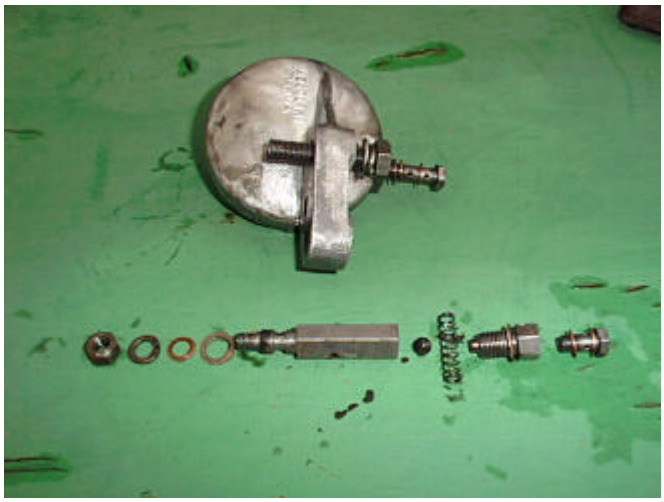




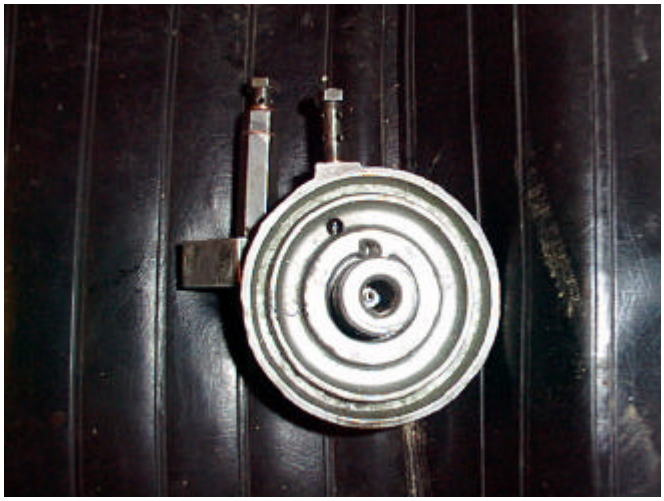
Oil System

Filter head assembly

Note that the non-return valve assembly bolts through the body of the filter head. Care must be taken to remove the filter head casting before removing the NRV assembly as the bolt, lock washer and copper sealing washer will drop into the gallery below the filter head when undone. The NRV serves to prevent the oil draining from the pipes that deliver oil to the camshaft, thus preventing dry running immediately after start up.



The face of the filter head assembly shows the two concentric grooves, inlet and outlet ports and the central threaded recess for the main bolt.



The outer groove takes the filter body seal. The inner groove contains the inlet port, which delivers oil from the pump. The hollow bolt above the inlet port takes two banjo connections: -

1. From the oil pump (within the crankcase.)
2. To the oil pressure gauge.

The banjo connection to the NRV assembly takes oil via a long delivery pipe and a series of banjo connections, to the camshaft and then on to the forward main crankshaft bearing. The connection to the main crankshaft bearing inlet also takes spill oil returning from the camshaft via the exhaust manifold and a large bore pipe which runs from a connection on the underside of the exhaust manifold to the double banjo connection for the forward main crankshaft bearing.

The oil pressure can be set by a screw and locknut arrangement located on the side of the cylinder block.

Cooling System

Exhaust System