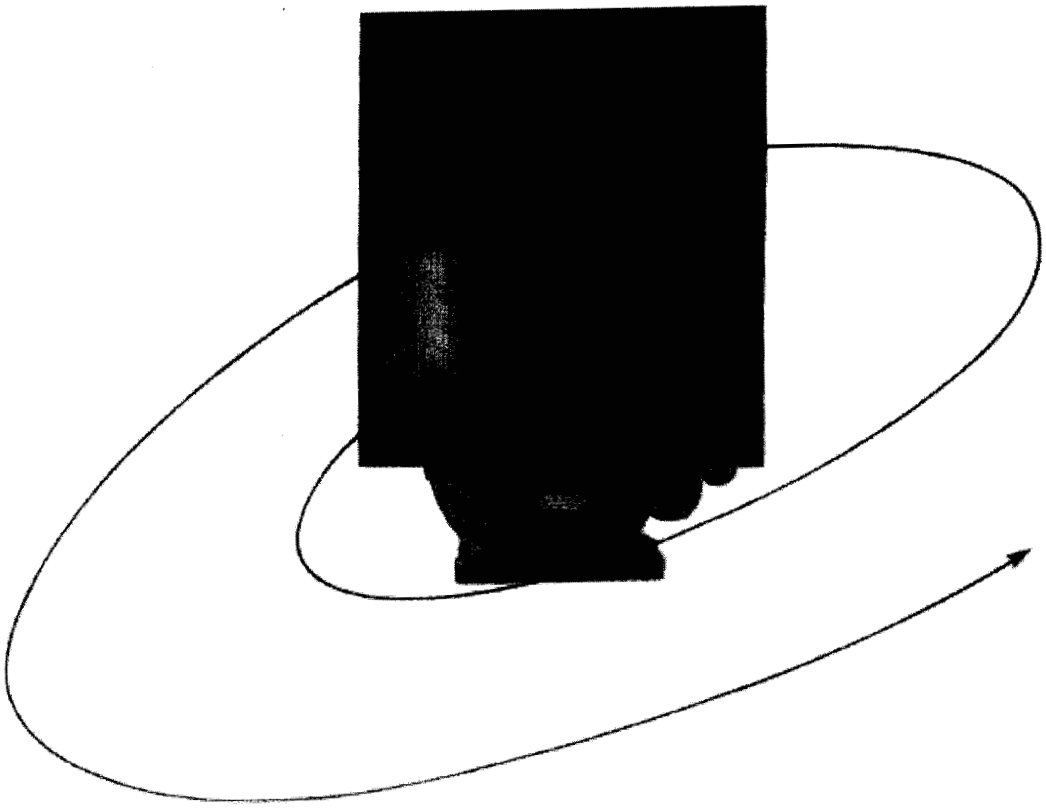
42p.



REPAIR MANUAL

DIESEL ENGINE

15 A/B/D
18 A/B/C/D
29 C/32 A

Lampertheim
Farymann Diesel
Germany

32L80 104

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CONTENTS

PREFACE

This Manual is for workshop use only and intended for use by experienced mechanics.

Only the standard type of engine models 15B/D 18B/D 29C/32A are illustrated and dealt with.
Because there are, however, many different type variants which can differ to a greater or lesser degree from the standard type described, this Manual can and should be used only as a quideline. Because some work is very complicated, **we recommend that the Manual be completely read before starting repairs.**

The repair of **FARYMANN DIESEL** engines requires some special tools in addition to standart ones. Their use is strongly recommended.

All safety precautions are to be strictly observed, because otherwise:

- **death or injury to the user or third parties can occur;**
- **the machine or other material assets of the user may be impaired;**
- **efficient operation of the machine may be jeopardized.**

Every person in the user`s business who is tasked with the installation, commissioning, operation, servicing or repair of engine must have read and understood the „Safety" chapter of the Operating Instructions.

The engine may be serviced only by trained personnel. Any work procedure which impairs the saety of the engine is to be forbidden.
Modifications or changes to the engine or the use of non-original replacement parts without proper authority is not allowed on safety grounds and invalidates the liability of the **FARYMANN DIESEL COMPANY.**

This Workshop Manual is technically up-to-date at the time of poing to press. Every care was taken in its compilation to avoid errors.
We are, however, not responible for any errors in illustrations or descriptions or for any omissions. There may also be changes due to technical developments.
We reserve the right to make changes without prior notice

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I.1. Introduction to Diesel Engines

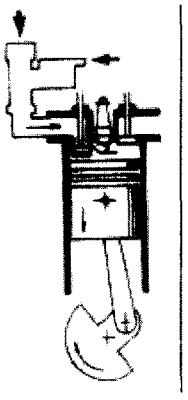
Nowadays diesel engines are well known and quite common in all kinds of machinery and equipement as an alternative to the well established gasoline engine.

Most people who are fully familiar with gasoline engines are reluctant to deal with a Diesel. This is without any reason, in fact, **you already know more about a Diesel** than you may have thought. If you are already familiar with the gasoline 4-stroke engine, study the comparison below. It will show the differences between a 4-stroke Diesel and a 4-stroke gasoline engine.

Gasoline

I. Intake stroke

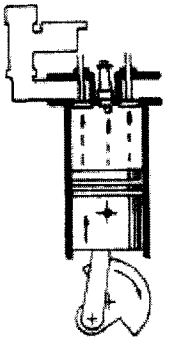
The downwards movement of the piston draws a mixture of gaseous fuel and air through the open inlet valve into the cylinder.



II. Compression stroke

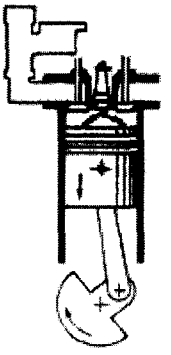
The upwards movement of the piston compresses the fuel/air mixture. The temperature rises through the compression stays below the self-ignition point of the fuel.

Diesel

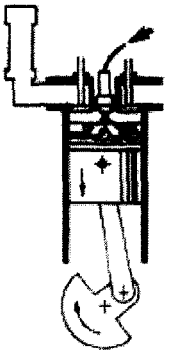


III. Power stroke

A spark created by a spark plug ignites the fuel. The resulting expansion of the combustion gases forces the piston down.

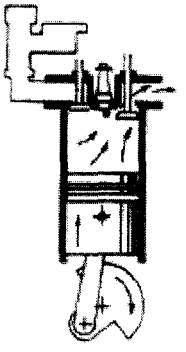


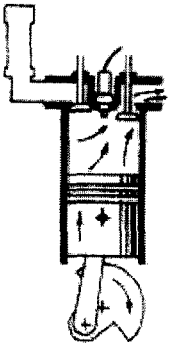
Fuel in a fine mist is sprayed into the cylinder and self ignites in the hot air. The resulting expansion of the combustion gases forces the piston down.



IV. Exhaust stroke

The upwards movement of the piston forces the exhaust gases through the open exhaust valve. This stroke is identical on both engines.

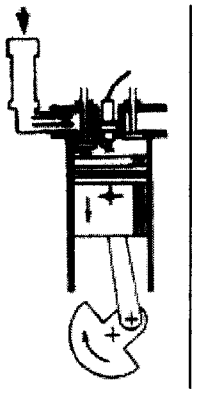




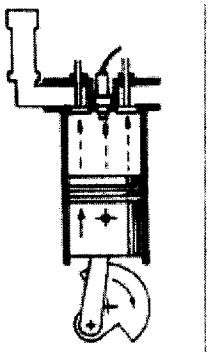
Both engines are of the internal combustion design because they burn fuel within the engine.
Both engines require fuel, air and a method of igniting the fuel.
Both engines can be of 2 - or 4 cycle design.
Both engines can be aircooled or watercooled.
The basic differences are:
The gasoline engine has an external mixture (carburator) of the fuel and combustione air. It needs an electric source (spark plug) to ignite the fuel.
The diesel engine draws in only air. It has an internal mixture of fuel and combustion air. The fuel is self-ignited by the high temperature of the compressed air.

To ensure that the air temperature is high enough to ignite the fuel, a diesel engine has a very high compression ratio compared to a gasoline engine. The diesel engine does not need an ignition system, due to the self-ignition of the fuel. Needed are a injection pump, fuel lines and a fuel injector. The injector is often called the heart of the diesel engine. It is a precision manufactured assembly, built to rigid specifications and clearances. It performs almost the same duties as a carburator. An injection pump delivers fuel to the injector where it is sprayed into the cylinder. Another difference between diesel and gasoline engines is that a diesel engine does not use a throttle valve. The governing is done by varing the amount of fuel injected into the cylinder.
Whereever sturdiness, reliablity, fuel economy and long service life are required, the diesel engine is the right choice.

The downwards movement of the piston draws only air through the open inlet valve into the cylinder.



The upwards movement of the piston compresses the air, which causes the temperature to rise above 500 C (932 F).



I.2. Farymann Diesel engine

All **Farymann Diesel** engines are 4 stroke, direct injection diesel engines. They are built as single cylinder engines in vertical and horizontal cylinder configuration.The direct injection guarantees an outstanding efficiency with low fuel consumption and excellent cold starting abilities. Robert Bosch fuel injection equipments are used on all engines. A high precision centrifugal governor totally enclosed in the crankcase links to the fuel injector pump and to the speed contol lever.
The flywheel fan cools the engine, eliminating troublesome V-belts. Air is drawn into the flywheel fan and routed through shouding to the cooling fins of the cylinder head.

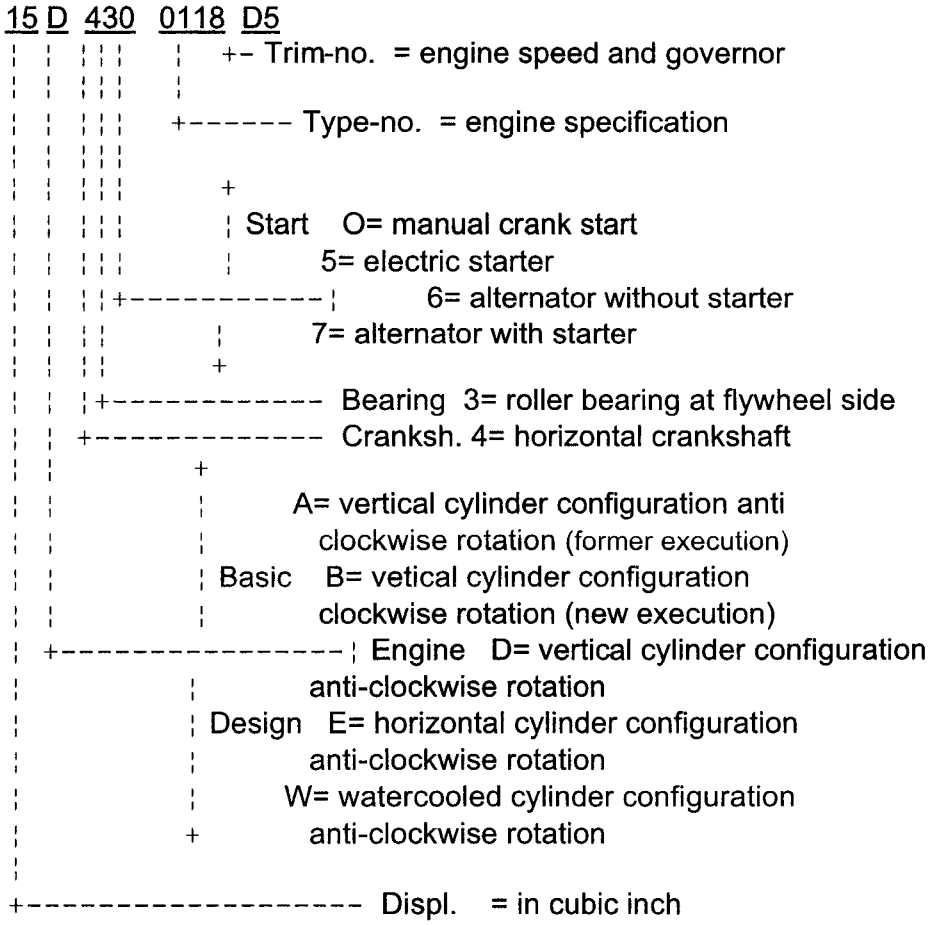
I.3. Engine identification

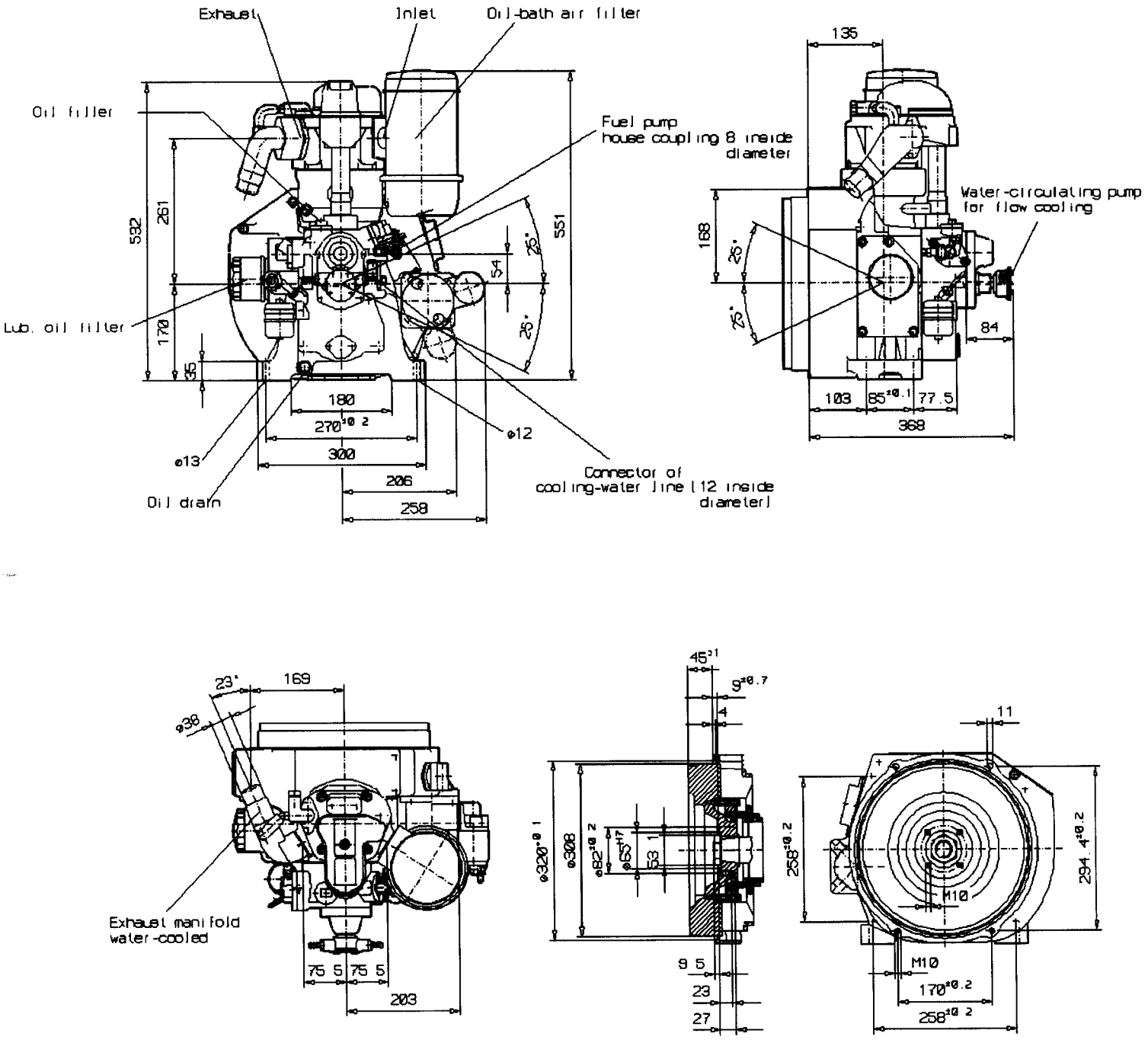
Until July 1982 the engine nomination system consisted of a 10 figure code.
For example: **35K54 0715 F**

35 = code figure for the year of manufacture
K54 = engine type
0715 = serial number
F = code figure for month of manufacture

Effective July 1982 the new system consists of a 12 figure code system in addition to the serial number (see engine name plate).

For example: 15D430 0118 D5
86 03 20 manufactoring date

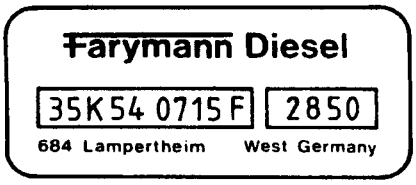


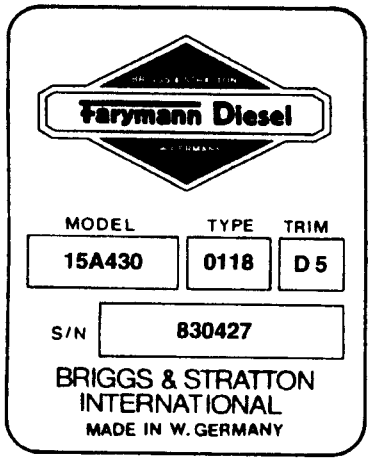

Exhaust
Inlet
Oil-bath air filter
Oil filler
Fuel pump
house coupling 8 inside
diameter
Water-circulating pump
for flow cooling
Lub. oil filter
Oil drain
Connector of
cooling-water line (12 inside
diameter)
Exhaust manifold
water-cooled
532
261
170
35
551
54
25°
180
270±0.2
300
206
258
ø13
ø12
135
168
84
103
85±0.1
77.5
368
23°
169
ø38
75.5
75.5
203
45±1
9±0.7
4
ø320-0.1
ø308
ø82±0.2
ø65H7
53.1
9.5
23
27
11
258±0.2
294.4±0.2
M10
M10
170±0.2
258±0.2

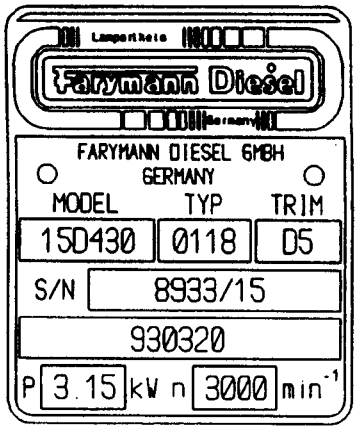
738 210 4

I.3. Engine identification

An engine name plate is affixed to every engine. In addition to the name plate the engine order number and, effective July 1985, the running engine number are also stamped on the crankcase.







The complete engine code must be quoted when ordering spare parts in order to supply the correct parts for the engine.

I.4. Cross reference old - new engine type

up to 1982	since 1982
K54/15A	model range 15D
K55	model range 15B
K64/18A/C	model range 18D
K65	model range 18B
K34	model range 15W/18W
K10	model range 29C

II.1. General engine data

Specifications/engine type		15B/D	18B/D	29C	32A
Number of cylinders			one, vertical		
Combustion			direct injection, 4 stroke		
Bore/Stroke	mm(inch)	75/55	82/55	90/74	95/74
Total displacement	cm3(inch)	242	290	470	524
Compression ratio		1:20	1:20	1:19	1:20

Direction of rotation A+C+D: counter clockwise when viewed flywheel
B : clockwise when viewed flywheel

Performance data (ful 1 load)

Working speed, max.	min^{-1}		3600		
Idle speed, min.	min^{-1}		900-1000		
Output „A" DIN 6270	kW (Hp)	3.5 (4.8)	4.2 (5.7)	6.6 (9)	7.1 (9.7)
„B" DIN 6270	kW (Hp)	3.9 (5.3)	4.7 (6.4)	7.35(10)	7.9 (10.7)
„F" DIN 70020	kW (Hp)	4.3 (5.8)	5.1 (6.9)	8.1 (11)	8.7 (11.8)
Mean piston speed	m/sec.	6.6	6.6	8.88	8.88
Torque („F" output) (Nm /	min^{-1})	12.5/2400	15.2/2500	24.5/2400	27.5/2400
Lub. oil pressure max. (at 100°C (220°F) oil temp.)	bar	4.0	4.0	5.0	5.0
Lub. oil pressure min. (at 100°C (220°F) oil temp.)	bar	1.8	1.8	2.0	2.0
Fuel consumption	g/kWh	330	310	295	300
Lub. oil consumption	g/kWh	1.0	1.0	1.0	1.0
Exhaust back pressure max.	kPa	5.0	5.0	5.0	5.0
Intake underpressure max.	kPa	2.0	2.0	2.0	2.0

Operation temparatures

Lub. oil max.	°C (°F)	130 (317)	130 (317)	130 (317)	130 (317)
Exhaust gas in manifold max.	°C (°F)	580 (1,415)	580	580	580
Entering cool. air max.	°C (°F)	50 (122)	50	50	50
Δt cooling air (at outlet cyl.-head)	°C (°F)	50 (122)	50	50	50

Capacity

Lub. oil	dm^3 (gal)	1.o (0.264)	1.0	1.6	1.6
Fuel tank	dm^3 (gal)	4.0 (1.056)	4.0	6.8	6.8

Weight

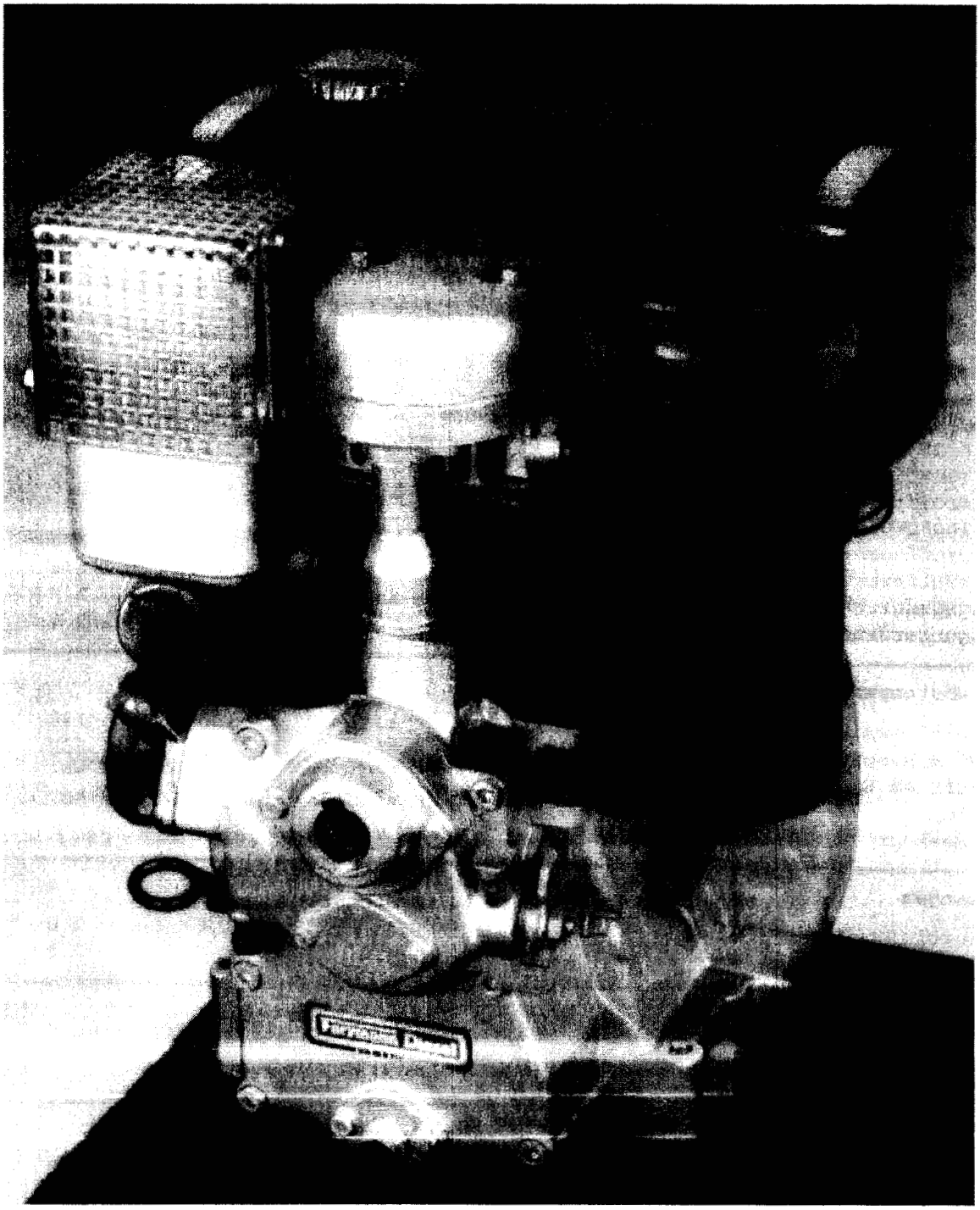
Engine (dry, standart, flywheel)	kg (lb)	39.5 (87)	41.0 (90)	70.0 (154)	72.0 (158)

Setting data

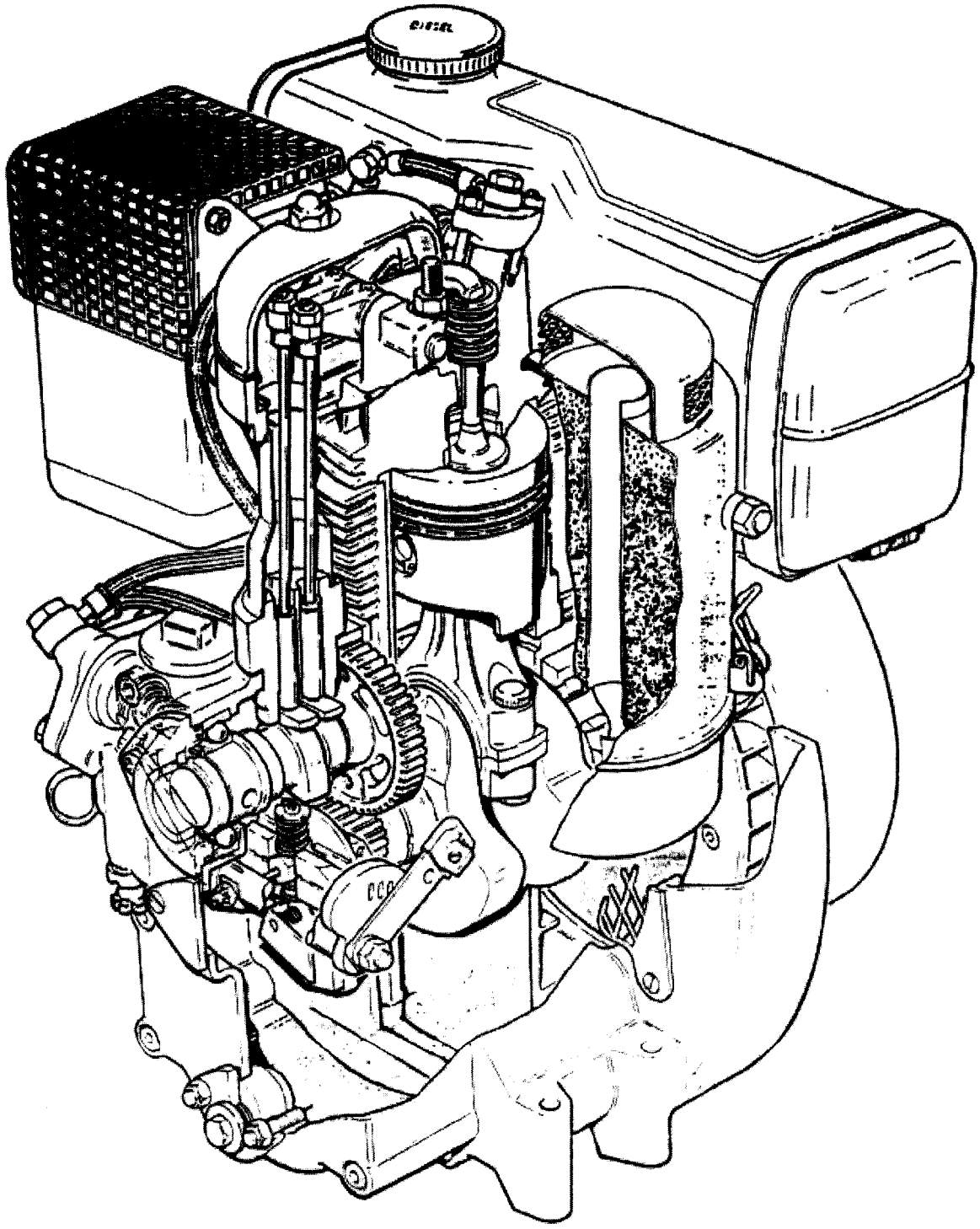
Valve clearance cold engine	mm (inch)	0.1 (0.004)	0.1	0.1	0.1
injection pressure	bar	200	200	175	175

Working angle (standart oilpan)

lengthwise	deg.	25	25	25	25
crosswise	deg.	25	25	25	25

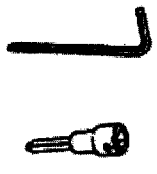
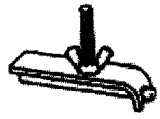
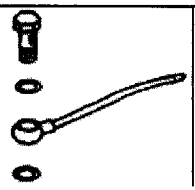
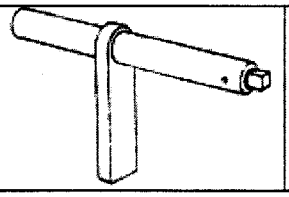
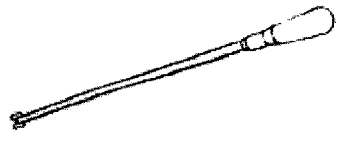


II. TECHNICAL DATA

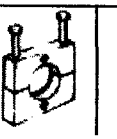
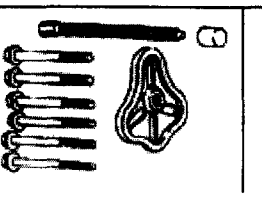
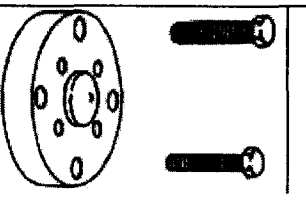
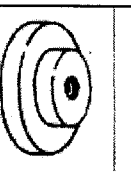
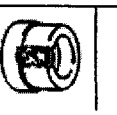
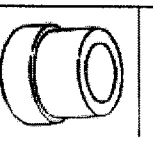
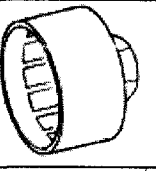


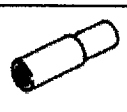
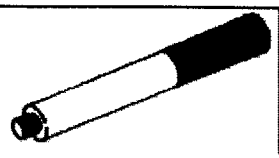
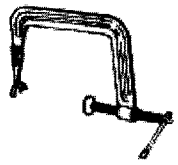
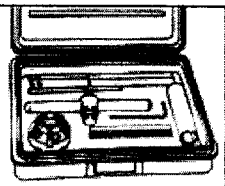
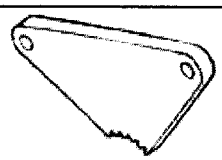
II.4. Special Tool List

It is assumes that authorized **Farymann Diesel** Dealers have all of the common tools needed to service diesel engines i.e. metric open end and ring spanners, sockets, torque wrench, mtric caliper and depth gauge as well as piston ring pliers, piston ring compressor, etc.
All "drivers" should be used with a hydraulic or arbor press.

Part No.	Description	Use	
748.092.2 748.093.2 748.094.2 748.116.6	Pin Allen Wrench 4mm Pin Allen Wrench 5mm Pin Allen Wrench 6mm Pin Allen Wrench 6mm	To remove pin type allen head screws (only for old models of K5/K6 engines)	
748.115.6	Fuel line camp	To clamp fuel supply lines	
748.117.6	Drip tube assembly	To check injection timing	
748.171.4	Hexagon Socket 14mm	For gorvernor screw	
748.170.4	Deep tube Socket 13mm	For cylinder head nuts	
748.130.2	¾" Drive Socket 36mm	For flywheel nut	
748.128.4	¾" Drive Sticker	For use with socket	
748.108.5	Governor spring tool	To adjust governor spring tension	

II. TECHNICAL DATA

748.132.6	Cranksh. Race Puller	Use with puller to remove crankshaft roller bearing race	
748.137.2	Crankshaft Gear Puller	Use with puller to remove crankshaft gear wheel	
748.136.2	Puller	For parts 148.132.6 and 748.137.2	
748.122.6	Flywheel Puller	To remove flywheel from crankshaft tapper	
748.119.4	Bearing driver	To install crankshaft roller bearing outer race and radial oil sealing ring	
748.120.4	Bearing Driver	To remove and install crankshaft bearing bushing and to remove camshaft roller bearing	
748.121.4	Bearing Driver	To remove and install camshaft	
748.124.4	Bearing Driver	To remove crankshaft roller bearing outer race and to install camshaft roller bearing	
748.173.2	Oilfilter Socket	To remove oilfilter	
748.172.4	Bearing Driver	To remove and install conrod bearing bushing	

748.129.4	Bearing Driver	To remove and install regulation shaft bushing	
748.123.4	Bearing Driver Handle	Treated handle for various bearing drives	
748.125.4	Valve Guide Driver	To remove and install valve gides	
748.131.5	Valve Sring Compr.	To remove and install valves	
748.135.2	Retaining Ring Pliers	To remove retining rings	
748.126.2	Oil Pressure Gauge	To check engine oil pressure	
748.127.4	Gauge Adaptor	To connect oil pressure gauge at crankcase	
748.138.2	Valve reface kit	43 cutter to reface valve seats	
748.174.4	Hilding device	To tighten and remove governor of partly assembled engine	

III.1. ENGINE DISASSEMBLY

Prior to dismantling the engine clean off engine exterior thoroughly.Dismantling will be greatlyfacilitated by location withgood lighting and freedom ofmovement, away from dirt andmetal chips.The work to be carried out isdescribed and illustrated step by step in the following.Please do take the trouble to read the description of thework involved prior to startingso that the scope will beappreciated right from the start.

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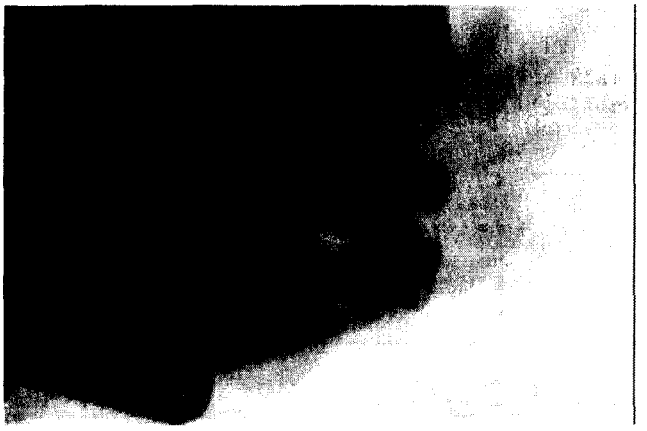
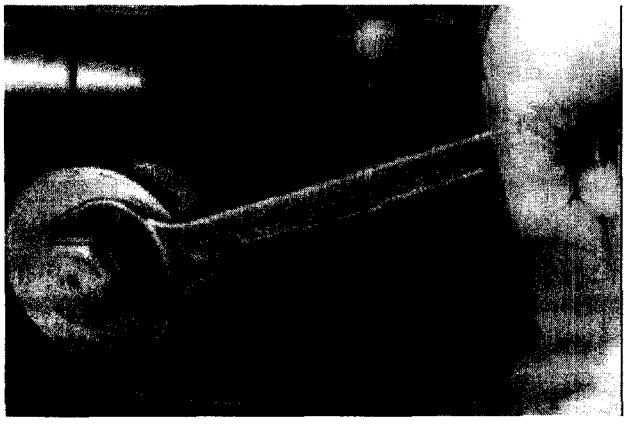


1. Drain lubrication oil

Place suitable container under the drain hole. Remove oval flange of oil drain, remove oilfilter. Wait until oil has fully trained, if necessary, tip over engine.
(Figures 1 and 1a)

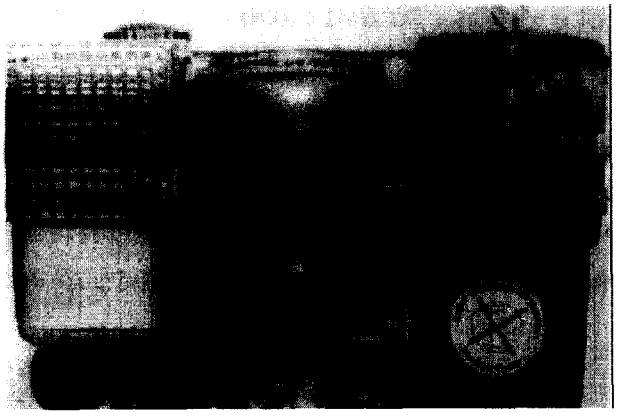


2.Air cleaner

Remove the two aircleaner selflocking nuts. Pull off the air cleaner and discard gasked.

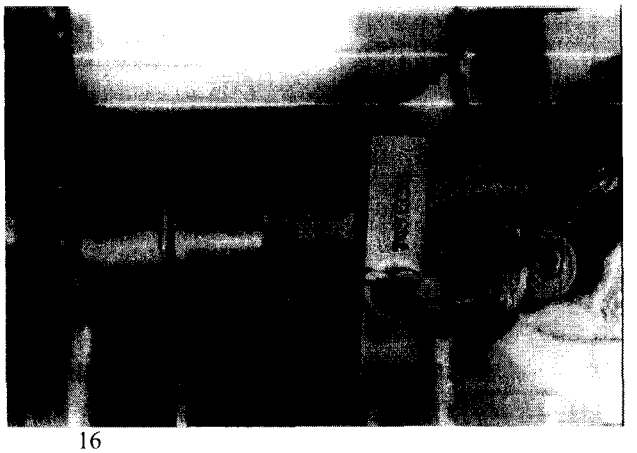
3. Muffler

Unscrew the two M8 hex nuts of the muffler and the M6 hex nut of the muffler screen. Pull of the screen, muffler and discard gasket.
(Figure 2)



4. Fuel tank

Place clamp, close to the injector pump on the fuel supply line coming from the tank. Next, remove the banjo bolts and their copper washers from the fuel injector and the fuel injection pump. Close ports of injector and pump again with banjo bolts to preventdirt from entering. Next,remove the locknut holding the fuel supply line clamp. Finally, loosen the fuel tank straps and slide them off the ends of the tank. The fuel tank and the line may now be removed.
(Figure 3)

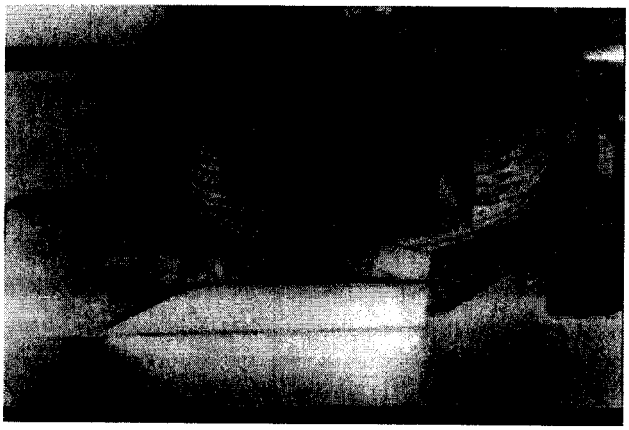


5. Fuel tank support brackets

Pull off the fuel tank upport brackets as well as the intake and the exhaust manifold gaskets.
Figure 4)

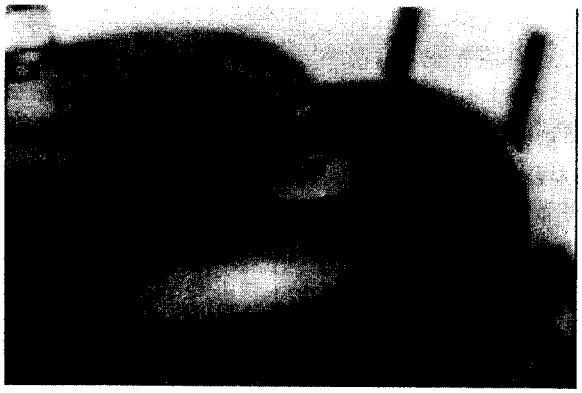
6. Air deflectors

Remove the two screws and lockwashers holding the air deflector shields on top of the crankcase.
(Figure 5)



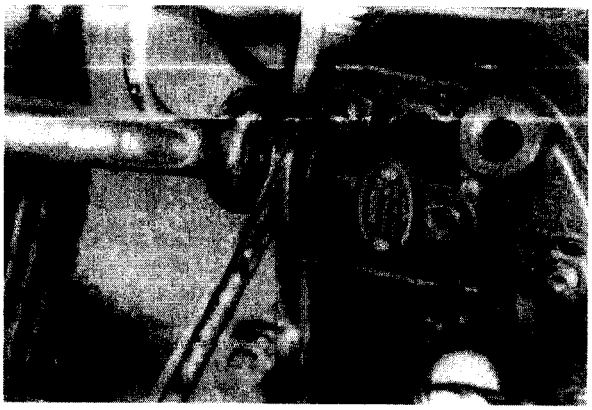
7. Valve cover

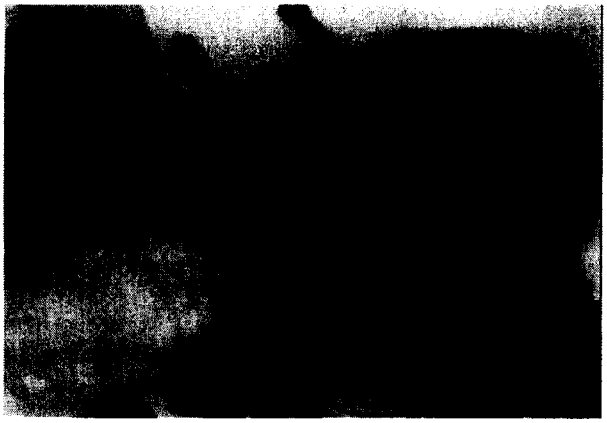
Remove the valve cover and the gasket by removing the two nuts and plastic washers on top of the valve cover. If necessary, tap lightly on the side of the valve cover with a soft faced hammer to loosen it.
(Figure 6)

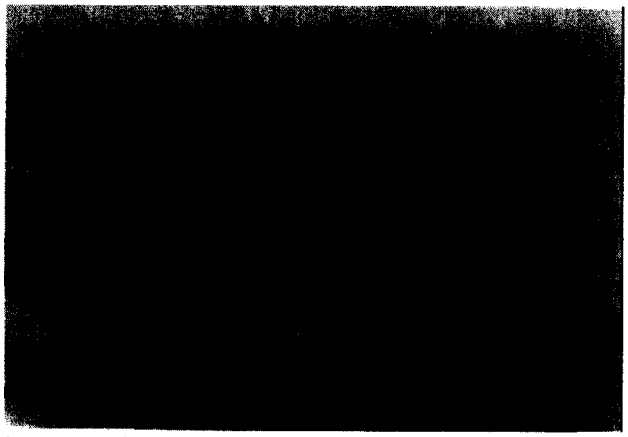


8. High pressure fuel line

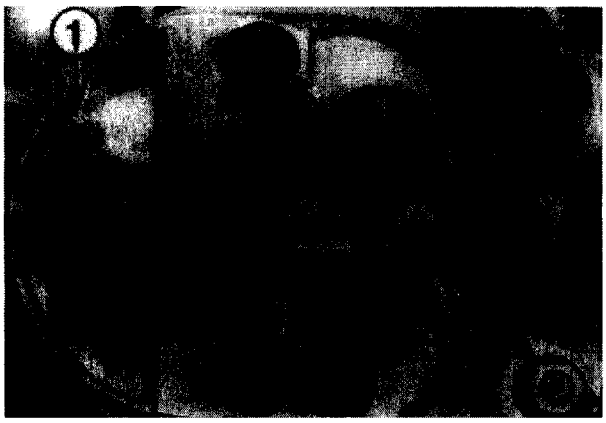
Loosen the high pressure fuel line by holding a 14 mm wrench on the delivery valve holder while unscrewing the
fuel line fitting with a 17 mm wrench.
(Figure 7)







Loosen the high pressure line at the injector in the same way.
(Figure 8)



9. Fuel injector

Remove the two hex nuts and their lockwashers from thr injector clamp. and pull out the injector. If the injector sticks in the hand, use a soft faced hammer and tap slightly on the injector. Do not use too much force, as this may damage the injector.

Attention: Undder the injector a special packing washer is located which must also be removed.

10. Cylinder head

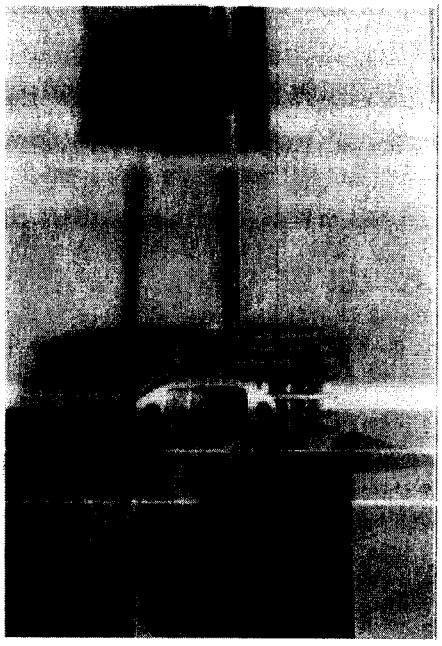
Remove the two locknuts and washers (1) holding the protection tubr retaining spring. Next loosen the four cylinder head nuts (2).
(Figure 10)

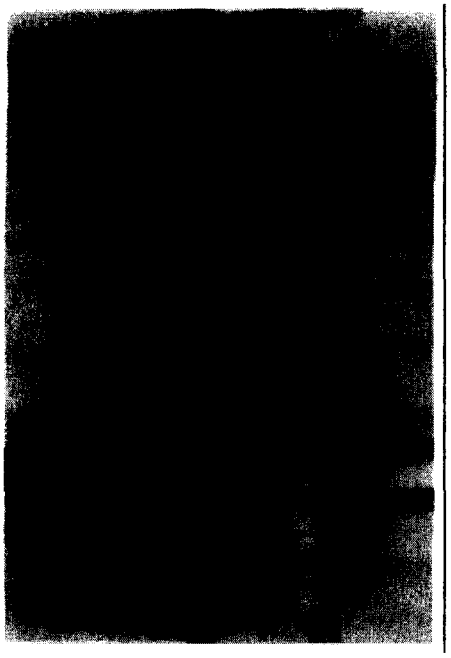
Drive out the rocker arm bolt with a drift pin and a hammer. Remove the rocker arms and push rods.(Figure 11)

Remove the cylinder head nuts and the cylinder head.
(Figure 12)

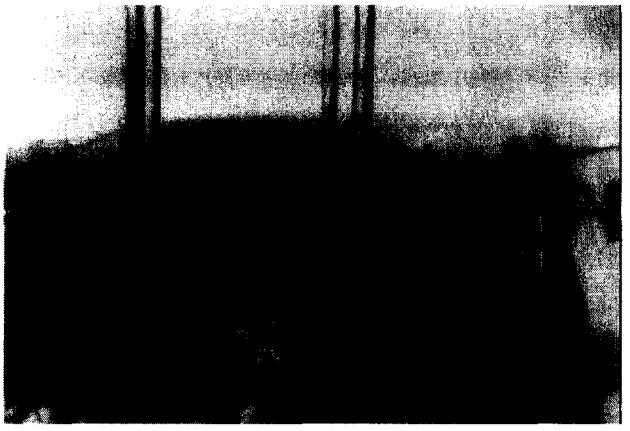
For dismantling valves use special tool. Watch out for the two thin steel washers under the inlet valve spring.
(Figure 13)

If the valve guides need replacement (for wear and tear measurements refer to section III.2.),use driver to press old guides out.
(Figure 14)



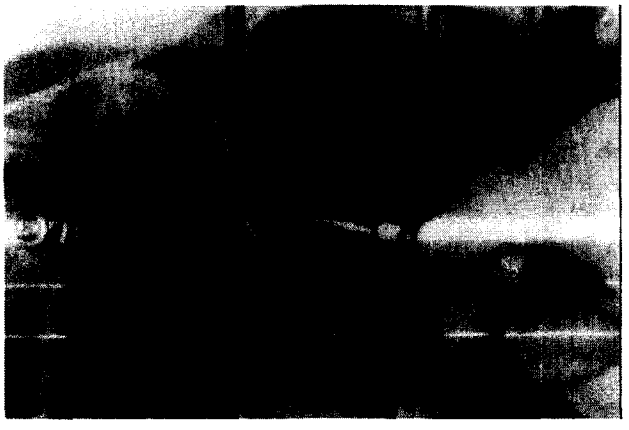


Shout the valve seat be damaged to the point that grinding of valves is not sufficient, the seat can be resurfaced with tool (for wear and tear limits and detailed instructions for use of tool refer to section III.2. resp. III.7.)
(Figure 15)

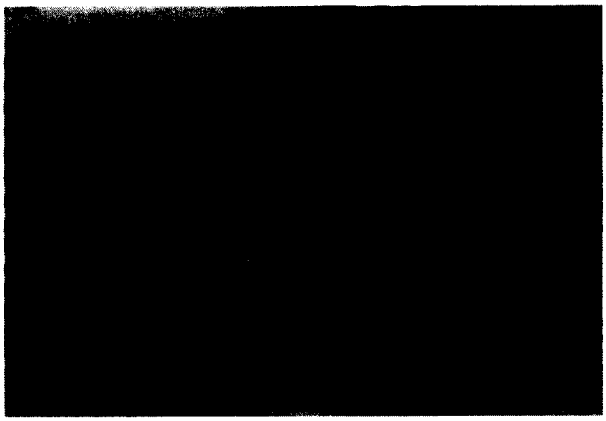


11. Cylinder shields

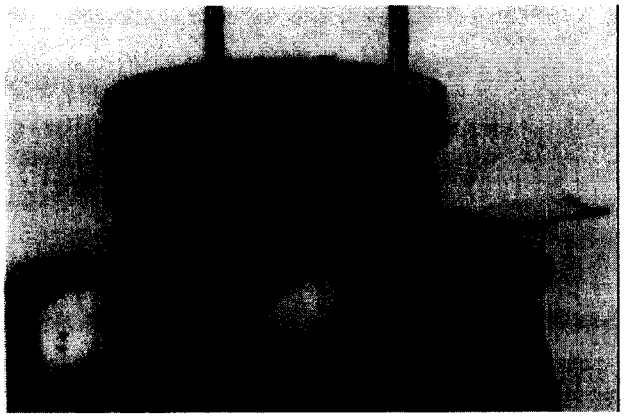
Remove the bolt holding the two cylinder air deflector shields together using a screwdriver and needle nose pliers or a seven mm wrench.
(Figure 16)



Next, unscrew the two head screws and remove the shields from the crankcase.
(Figure 17)



Compression release
After removing its screws, pull the compression release out of the gearcase.
(Figure 18)

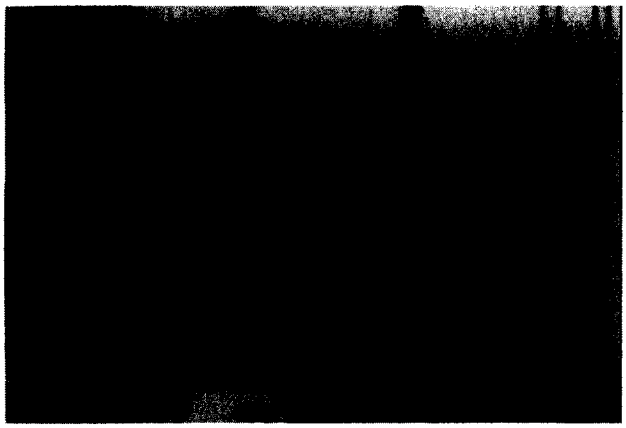


13. Cylinder

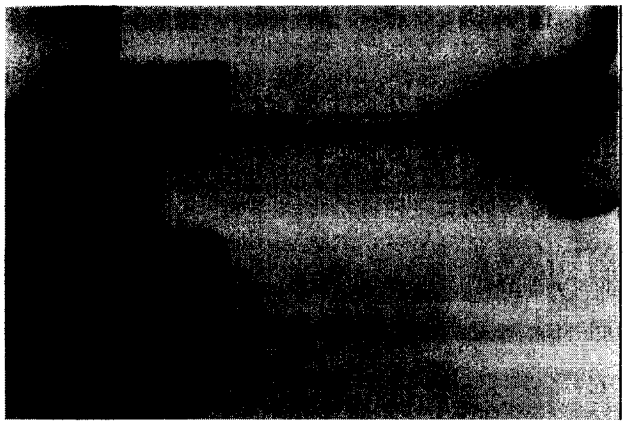
Rotate the flywheel until the piston reaches the bottom of its stroke. Carefully slide the cylinder up off the studs.
Attention: If the repair does not require the renewal of piston and liner, leave the liner on the piston. Pull up the liner only so far that piston pin bore is free and continue with step 14.
(Figure 19)

14. Piston

Slowly rotate the flywheel until the piston reaches the top of its stroke. With a needle nose pliers, remove the piston pin retainer from groove in piston at the gear train side of the engine.
(Figure 20)

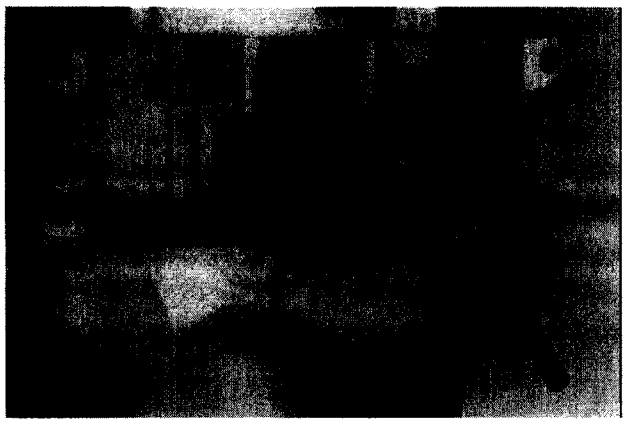


With a drift pin gently hammer piston pin out of the piston from flywheel side.
Attention: If piston pin sticks in piston, remove piston compete with connecting rod (step 15 and hammer out piston pin after the assembly has been removed from engine.
(Figure 25)



15. Connecting rod

Turn the flywheel until piston reaches the bottom of his stroke (BCD).
Lay engine on to its flywheel side. Remove the crankcase inspection cover by unscrewing the six head screws. If these srews are very tight, tapping on them with a hammer and drift pin or flat-faced punch may help loosen them.
(Figure 22)



When re-using the conrod bearings again, mark the bearing shell halves and the corresponding parts of the conrod. This ensures that the bearing runs in the same position again after the reinstallation.

Using a 13 mm socket, remove the two conrod hex nuts. Pull out the conrod cap downwards and the conrod upwards.
(Figure 24)

16. Crank handle guide

Remove the two crank handle guide screws. Pull off the guide in a twisting motion.
(Figure 24)

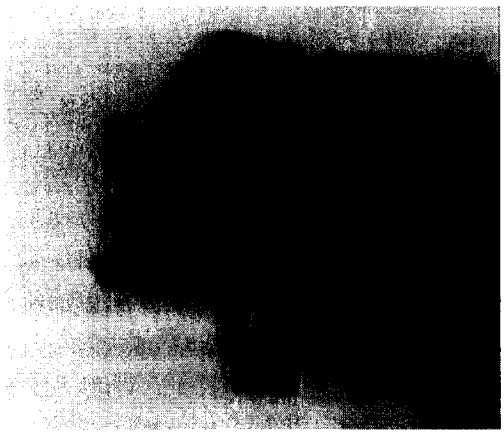
17. Gear cover

Remove the six allen screws and pull off the gear cover. If nenecessary, tap at the gear cover with a soft faced hammer to loosen it.If, when removing, the cover should catch on the governor beneath, turning the flywheel slightly will free it.
(Figure 25)

Do not dismantle the gear cover any further,if there is no need for (to check wear and tear limits of cramshaft, speed regulation shaft and camfollower refer to section III.2.). In case the need for dismantling arises, proceed as follows:

17.1. Injection pump

Remove the two injection pump hex nuts. Pull the injection pump from the gear cover. Leaving the injection pump gasket and shims on the gear cover, reinstall the hex nut and lockwashers on their studs.
(Figure 26)

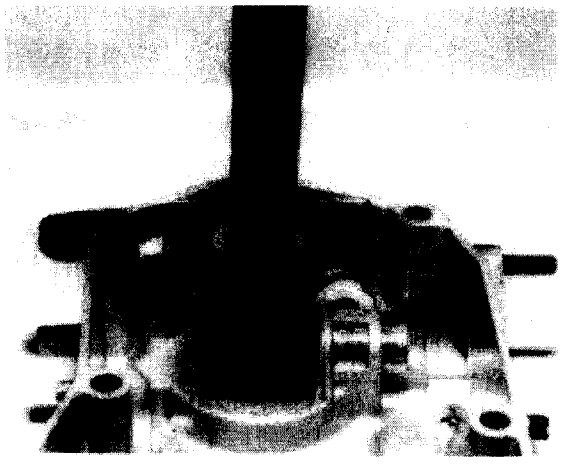


To remove the injection pump camfollower, unscrew fixing screw (arrow) through oil filling bore.
(Figure 27)

17.2. Cramshaft

Remove the snap ring holding the cramshaft in the gear cover. Press out the cramshaft using the driver.
(Figure 28)

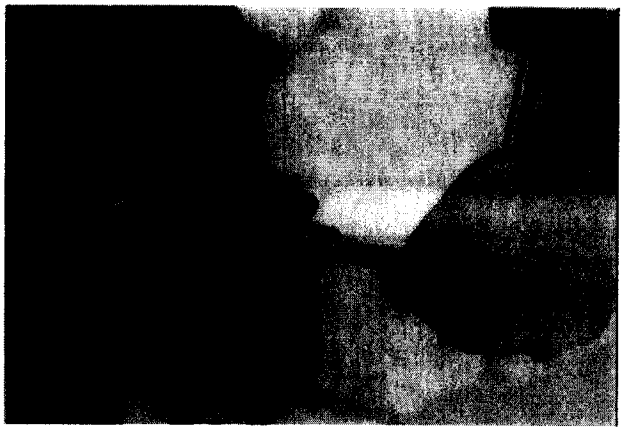
To pull off the camshaft gear wheel, use puller or press out the camshaft.
(Figure 29)



After the camshaft is removed, the roller bearing can be pressed out from the inside of the cover using driver.
(Figure 30)

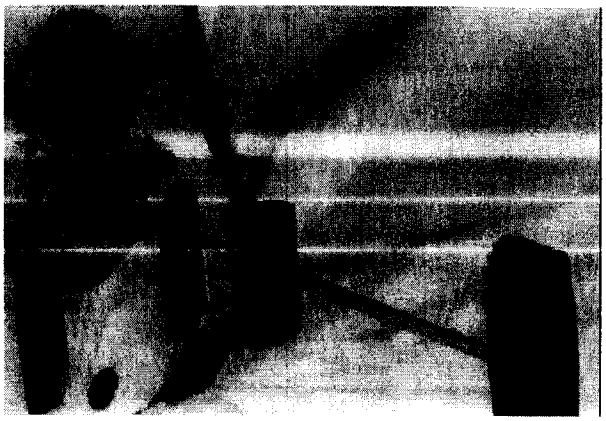
17.3. Speed regulation assembly

Lay the gear cover down on the work bench. Remove the retaining ring from the regulation shaft with a pliers.Pull the shaft outwards till the ratchet plate is free from the pin.Unhook the outer torsion spring from the boss(use a pliers and watch out for your fingers).Hold the inner control lever and twist the acceleration lever down below the-normally - stop position till the inner torsion spring is without tension (approx. horizontal position of the acceleration lever) and then pull eccentric shaft out of control lever and bearing bush.
(Figure 31)



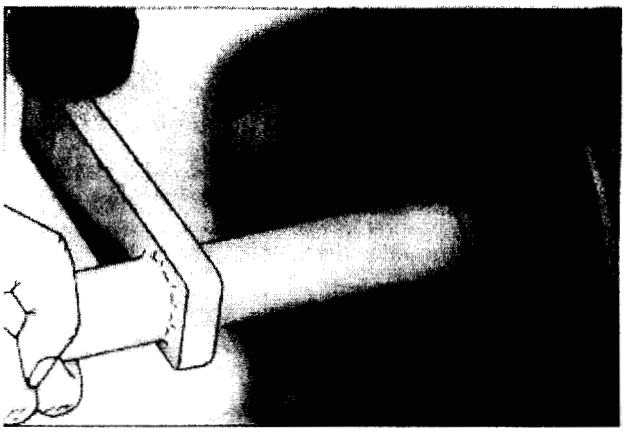
18. Governor

Install holding device remove governor pin from governor. Spread flywheights with a breakerbar and use hexagon socket to unscrew governor.
Attension: Since governor has left hand thread, unscrew governor in a clockwise direction.
(Figure 32)



19. Oil pump

Remove the oil pump by unscrewing the 3 oil pump screws.
(Figures 33)



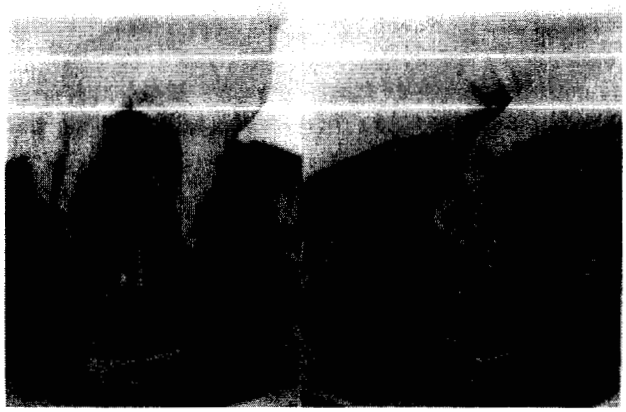
20. Flywheel

Using socket on stricker and a hammer, loosen the flywheel nut by two turns.
Attention:If the flywheel has to be removed from an engine without dismantling the governor/regulation linkage, it is necessary to place the acceleration lever at full load position. Otherwise damage may occure to the regulation linkage.
(Figure 35)

Leave the flywheel nut on the shaft. Install the flywheel puller and turn the screws until the flywheel breaks loose from the crankshaft tapper. Remove the flywheel nut and flywheel.
(Figure 35)

21. Main bearing cover

Remove the four main bearing cover nuts and washers. Next install two screws M6x30 (if not available use allen screws M6x30 from oilpump) into the threaded holes and screw them in until the cover breaks loose.
(Figure 36)



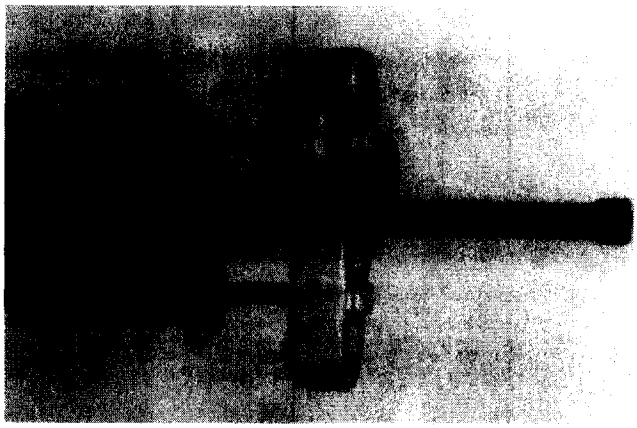
Remove the key, belleville washers, angle ring, o-ring and thrust washer.
(Figure 37)

22. Crankshaft

Remove the crankshaft from the crankcase, being careful not to drag the crankshaft gear on the main bearing bushing.
To pull off the crankshaft gear wheel,use puller.
(Figure 38)

22.1.

In case the roller bearing needs replacement, replace also the inner race,which is shrunk fit on to the crankshaft.Use race puller, pull off the inner race.
(Figure 39)



The engine is now completely stripped down. Clean all parts in diesel fuel or another cleaning solution.
When the parts are dry, check for damage and / or wear and tear. In case of doubt, change the part.

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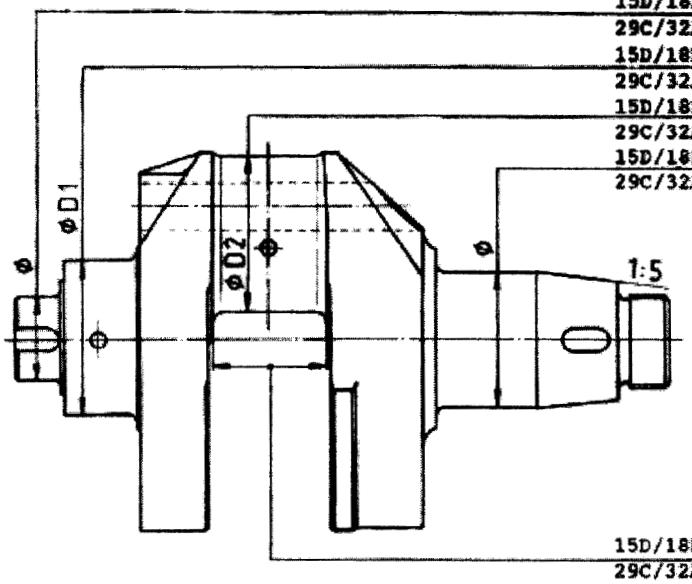
III. 2. DIMENSION TABLE - WEARING PARTS

Part. Description		Dimension Original max. mm	Original min. mm	max. Limit mm
III.2.1 Crankcase	15D/18D	45.971	45.955	45.985
	29C/32A	46.016	46.000	46.030
		22.020	21.990	22.990
	15D/18D	95.035	95.000	
	29c/32A	104.100	104.100	
	15D/18D	75.050	74.950	74.900
	29C/32A	92.050	91.950	91.900
	15D/18D	100.004	99.982	
	29C/32A	128.004	127.979	
III.2.2 Main bearing bush	15D/18D	46.105	46.065	
	29C/32A	46.075	46.035	
		inner diameter not fixed can only be checked when bush is pressed into crankcase via the bearing play, radial play:		
	15D/18D	0.02	0.06	0.09
	29C/32A	0.02	0.06	0.09
		Bearing bush will have to be replaced when galvanically applied Layer "R" wears off (recognisable on shiny gold bronze color) and/or when scoring appears around circumference. The inner diameter should not be used to determinate wear, only the radial bearing play is important.		

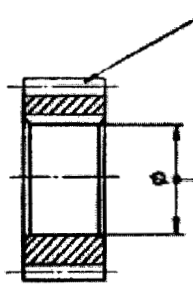
Part. Description		Dimension Original max. mm	Original min. mm	max. Limit mm
III.2.5 Crankshaft				
	15D/18D	22.029	22.008	*
	29C/32A	22.029	22.008	*
	15D/18D	40.080	40.060	*
	29C/32A	41.010	39.990	*
	15D/18D	40.030	40.020	*
	29C/32A	47.960	47.940	*
	15D/18D	35.023	35.015	*
	29C/32A	45.020	45.009	*
	15D/18D	30.200	30.130	30.300
	29C/32A	30.250	30.180	30.350
Radial Bearing play D1	15D/18D	0.020	0.050	0.080
Radial Bearing play D1	29C/32A	0.020	0.060	0.090
Radial Bearing play D2	15D/18D	0,030	0.060	0.110
Radial Bearing play D2	29C/32A	0.030	0.060	0.120

* allowable wear to be determinated by radial bearing play.

Regrind Stages
The crank pin and journal can be reground in 2 steps of 0.25 mm each and fitted with under size bearings

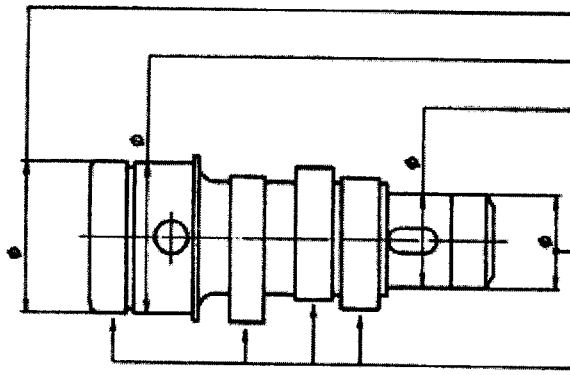
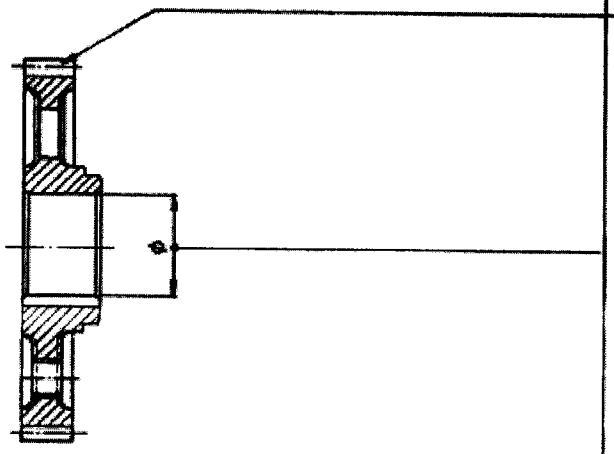
	ø D1	ø D2	D1 corresponding bearing	D2 corresponding bearing	
1	39.830 39.810	39.780 39.770	775.033.4	470.009.4	15D/18D
2	39.580 39.560	39.530 39.520	775.034.4	470.012.4	
1	40.985 39.740	47.710 47.460	775.035.4	470.019.4	29C/32A
2	40.735 39.490	47.690 47.440	775.036.4	470.020.4	

III.2.4 Gearwheel Crankshaft

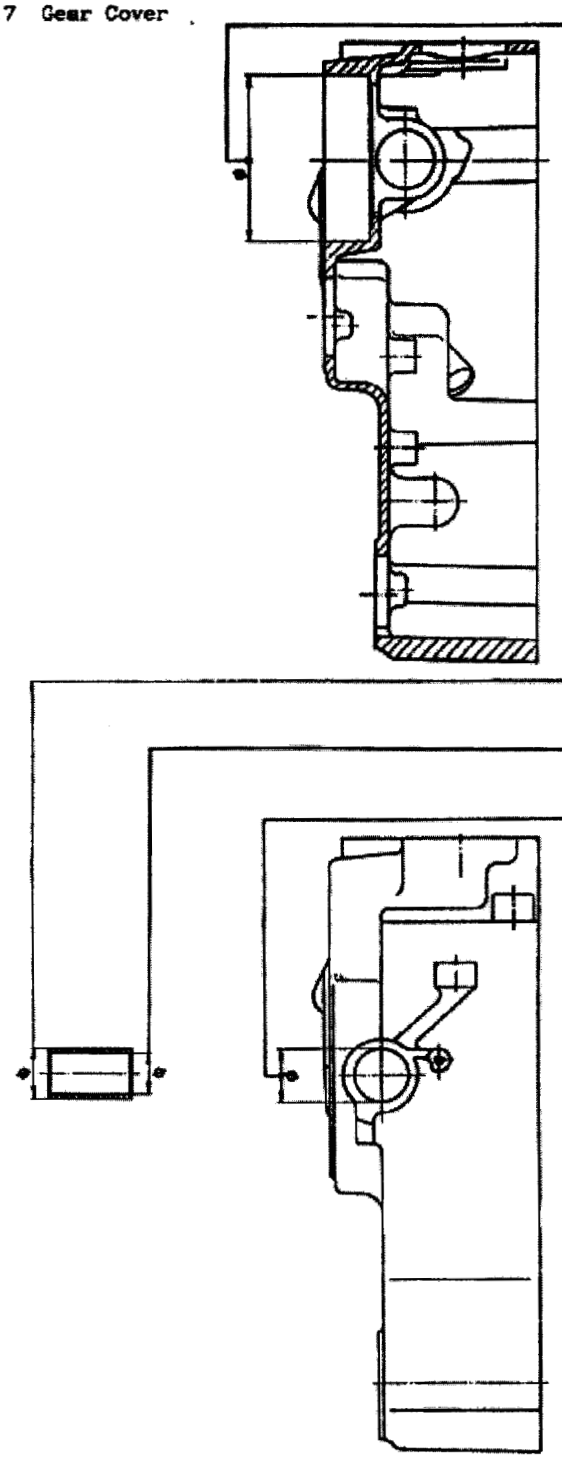


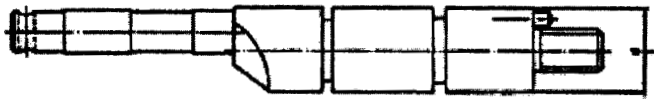
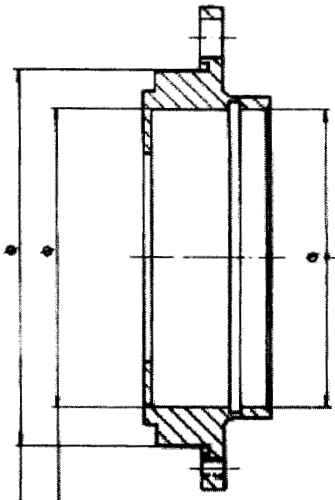
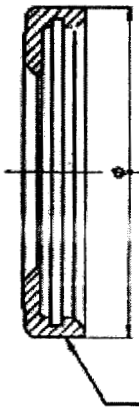
	22.000	19.970	Tooth edges smooth, no scoring and wear.

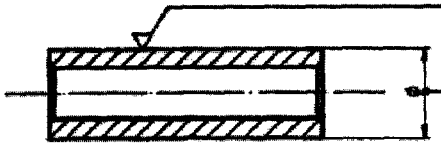
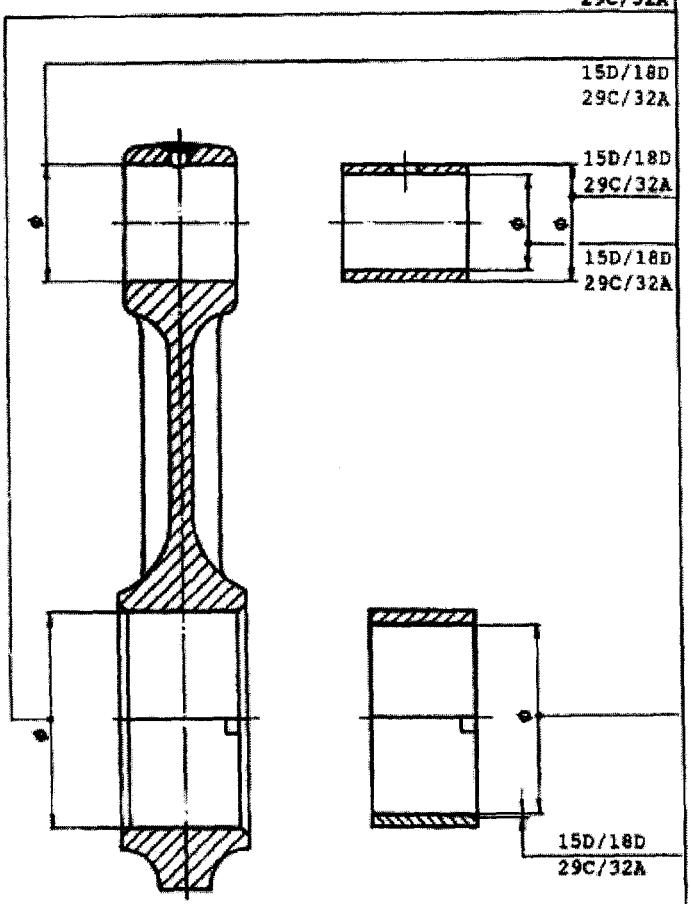
Heat gear to 90-100°C to obtain shrink-fit.

Part. Description	Dimension		
	Original max. mm	Original min. mm	max. Limit mm
III.2.5 Camshaft			
	34.850	34.800	34.750
	35.018	35.002	
	22.031	22.022	
	21.930	21.910	21.860
			renew if scored
III.2.6 Gearwheel Camshaft			
			Tooth edges smooth, no scoring and wear.
	22.000	21.980	
			Heat gear to 90-100°C to obtain shrink-fit.

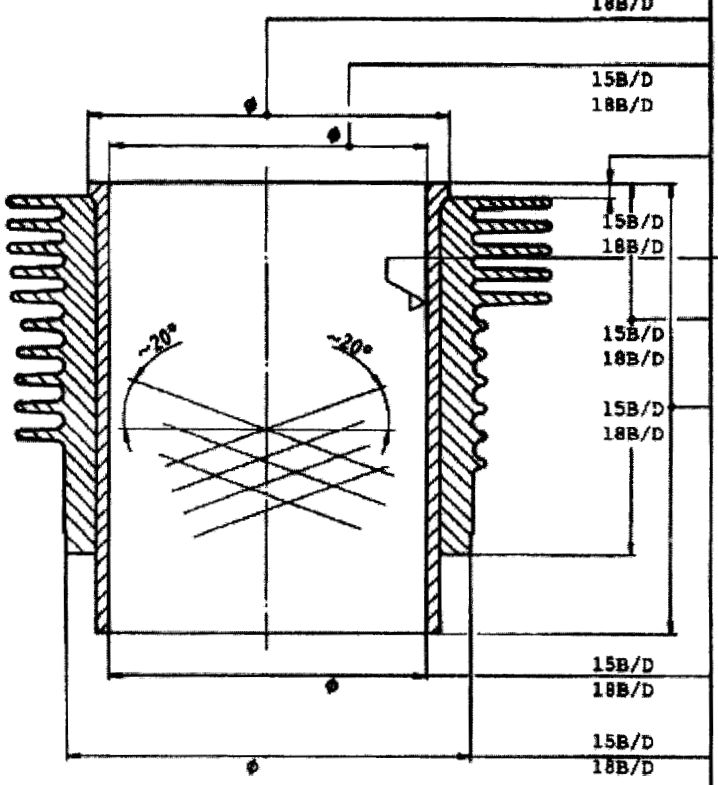
Part. Description	Dimension Original max. mm	Original min. mm	max. Limit mm
III.2.7 Gear Cover	61.991	61.961	
	20.074	20.054	
	16.142	16.092	
	when pressed into gearcover		
	16.100	16.080	16.150
	20.020	20.010	



Part. Description	Dimension		
	Original max. mm	Original min. mm	max. Limit mm
III.2.8 Excentric Shaft 	16.056	16.045	16.000
III.2.9 Main Roller Bearing Housing 			
15D/18D 29C/32A	15D/18D 29C/32A	80.046 99.982	80.000 99.967
15D/18D 29C/32A	79.986 99.982	79.967 99.967	
15D/18D 29C/32A	100.035 128.027	100.013 128.008	100.010 128.000
III.2.10 Angle Ring 			
15D/18D 29C/32A	60.000 65.000	59.810 64.810	
			renew if scored

Part. Description	Dimension Original max. mm	min. mm	max. Limit mm
III.2.11 Piston Pin			
 15D/18D	22.000	21.996	renew if scored
29C/32A	26.000	25.996	
III.2.12 Connecting Rod with Bearings			
15D/18D	43.666	43.650	
29C/32A	51.619	51.600	
15D/18D	24.986	24.974	
29C/32A	29.013	29.000	
15D/18D	25.075	25.035	
29C/32A	29.075	29.035	
15D/18D	22.050	22.030	renew if scored
29C/32A	26.109	26.045	
 15D/18D 29C/32A	inner diameter only to be checked via radial bearing play: 0.030 0.060 0.110 0,030 0,060 0.120 Both bearing shells will have to be renewed when the galvanically applied layer "R" wears off (recognisable on shiny gold-bronze color) and/or when scoring appears around circumference.		

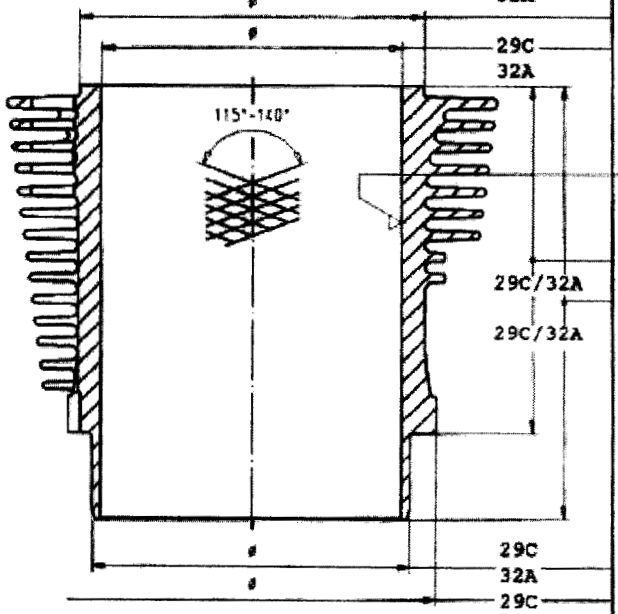
III.2.13 Cylinder 15B/D / 18B/D



Part. Description		Dimension Original max. mm	Original min. mm	max. Limit mm
	15B/D	85.000	84.950	
	18B/D	92.000	91.950	
	15B/D	74.930	74.910	75.030
	18B/D	81900	81.880	82.000
	15B/D	3.300	3.200	
	18B/D			renew if scored
	15B/D	88.150	88.125	88.075
	18B/D	86.700	86.675	86.625
	15B/D	107.350	107.250	
	18B/D	104.900	104.800	
	15B/D	75.030	75.010	75.130
	18B/D	82.030	82.010	82.130
	15B/D	94.900	94.850	
	18B/D	94.900	94.850	

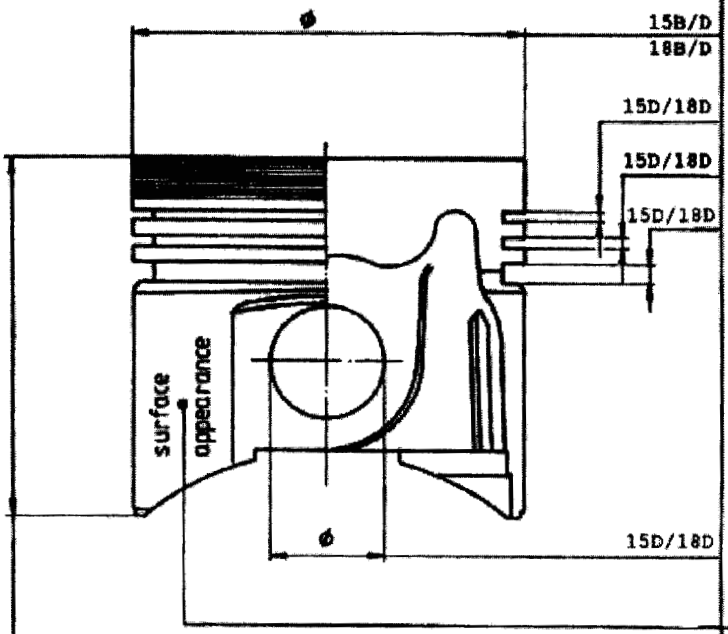
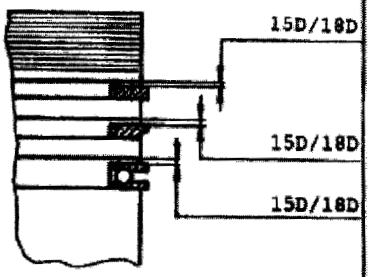
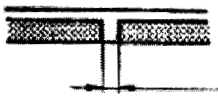
Attention: It is not possible to rehone the liner, due to conical shape.
We recommend always to exchange cylinder liner together with piston and rings.

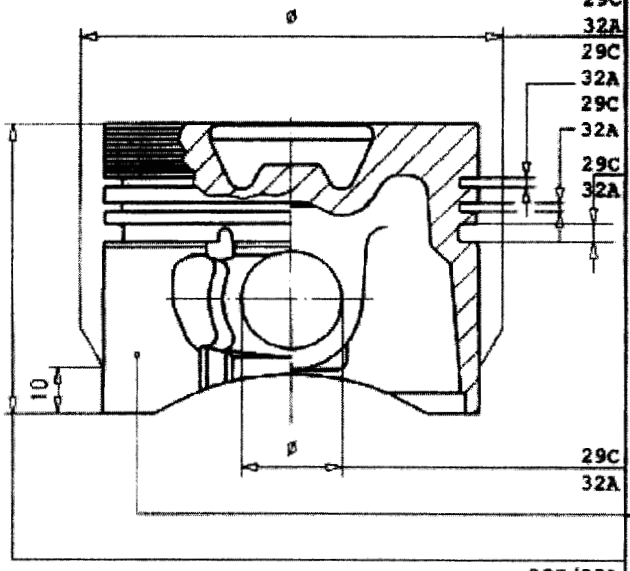
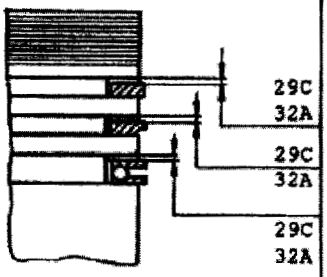
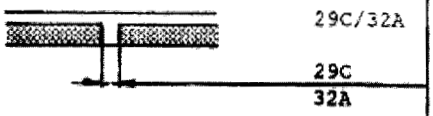
III.2.14 Cylinder 29C /32A

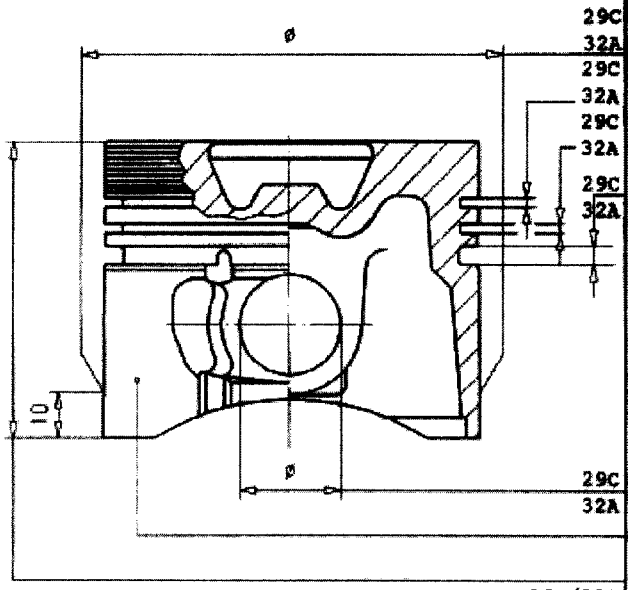
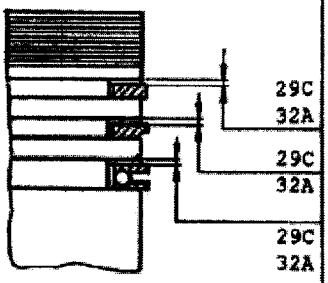


Part. Description		Dimension Original max. mm	Original min. mm	max. Limit mm
	29C	100.000	99.950	
	32A	108.995	108.990	
	29C	90.030	90.010	90.130
	32A	95.050	95.030	95.150
				renew if scored
	29C/32A	111.215	111.175	111.125
	29C/32A	138.500	137.900	
	29C	93.900	93.800	
	32A	100.400	100.300	
	29C	103.900	103.850	
	32A	116.900	111.850	

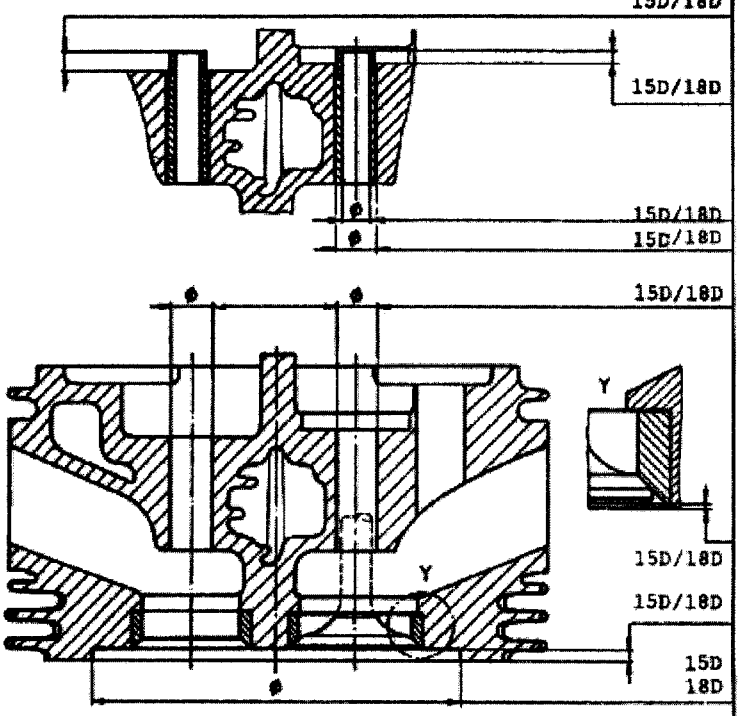
Attention: It is not possible to rehone the liner, due to conical shape.
We recommend always to exchange cylinder liner together with piston and rings.

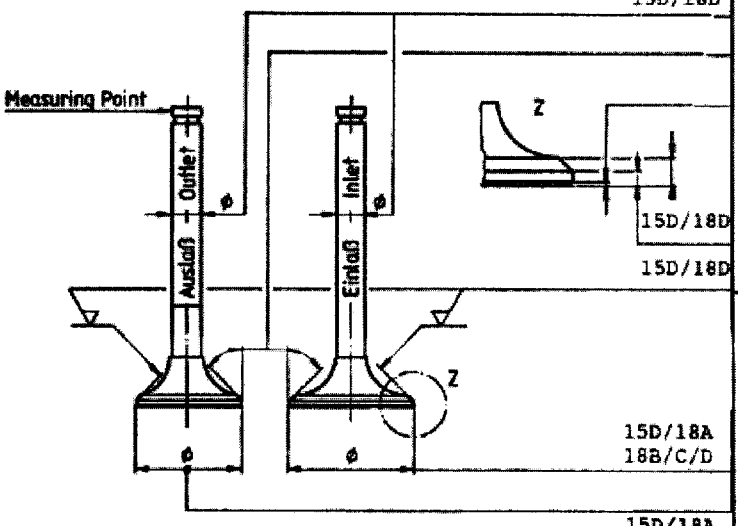
Part. Description		Dimension Original max. mm	Original min. mm	max. Limit mm
III.2.15 Piston 15B/D / 18B/D				
	15B/D	74.967	74.953	
	18B/D	81.967	81.953	
	15D/18D	2.120	2.100	
	15D/18D	2.070	2.050	
	15D/18D	4.040	4.020	
	15D/18D	22.010	22.004	renew if longitudinally scored
	15D/18D	64.200	64.800	
Ring set 	15D/18D	0.145	0.110	0.17
	15D/18D	0.092	0.060	0.14
	15D/18D	0.065	0.030	0.11
 Butt clearance for 2 top rings		0.500	0.300	1.0
for oil scrapper ring		0.500	0.250	1.0
Butt clearance are caused by piston ring wear and wear of cylinder liner surface. We recommend always to exchange cylinder liner, piston and rings together.				

Part. Description		Dimension Original max. mm	Original min. mm	max. Limit mm
III.2.16 Piston 29C / 32A				
	29C	89.968	89.952	
	32A	94.947	94.933	
	29C	2.130	2.110	
	32A	2.100	2.080	
	29C	2.070	2.050	
	32A	2.060	2.040	
	29C	4.070	4.050	
	32A	4.060	4.040	
	29C	24.009	24.004	
	32A	26.008	26.003	renew if longitudinally scored
	29C/32A	79.250	78.795	
Ring set 	29C	0,145	0,110	0.14
	32A	0.125	0.090	0.15
	29C	0.092	0.060	0.14
	32A	0.085	0.050	0.13
	29C	0.095	0.060	0.14
	32A	0.085	0.050	0.13
Butt clearance for 2 top rings 	29C/32A	0.650	0.400	1.1
	29C	0.600	0.300	1.0
	32A	0.450	0.250	1.1
for oil scrapper ring		Butt clearance are caused by piston ring wear and wear of cylinder liner surface. We recommend always to exchange cylinder liner, piston and rings together.		

Part. Description		Dimension Original max. mm	Original min. mm	max. Limit mm
III.2.16 Piston 29C / 32A				
	29C	89.968	89.952	
	32A	94.947	94.933	
	29C	2.130	2.110	
	32A	2.100	2.080	
	29C	2.070	2.050	
	32A	2.060	2.040	
	29C	4.070	4.050	
	32A	4.060	4.040	
	29C	24.009	24.004	
	32A	26.008	26.003	renew if longitudinally scored
	29C/32A	79.250	78.795	
Ring set 	29C	0,145	0,110	0.14
	32A	0.125	0.090	0.15
	29C	0.092	0.060	0.14
	32A	0.085	0.050	0.13
	29C	0.095	0.060	0.14
	32A	0.085	0.050	0.13
Butt clearance for 2 top rings 	29C/32A	0.650	0.400	1.1
	29C	0.600	0.300	1.0
	32A	0.450	0.250	1.1
for oil scrapper ring				
Butt clearance are caused by piston ring wear and wear of cylinder liner surface. We recommend always to exchange cylinder liner, piston and rings together.				

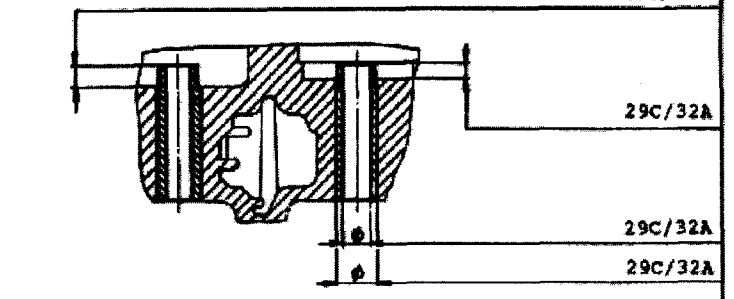
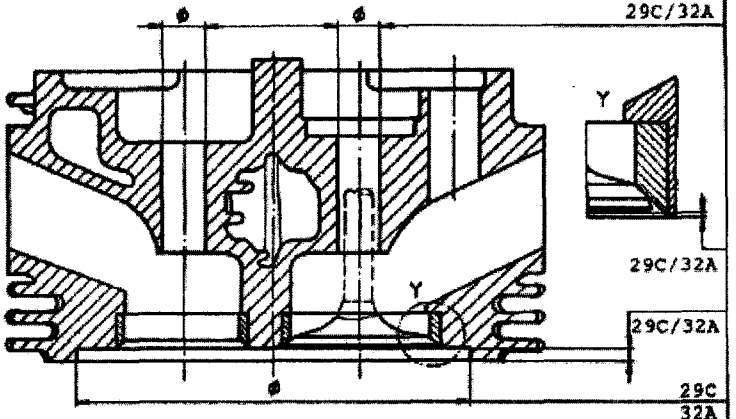
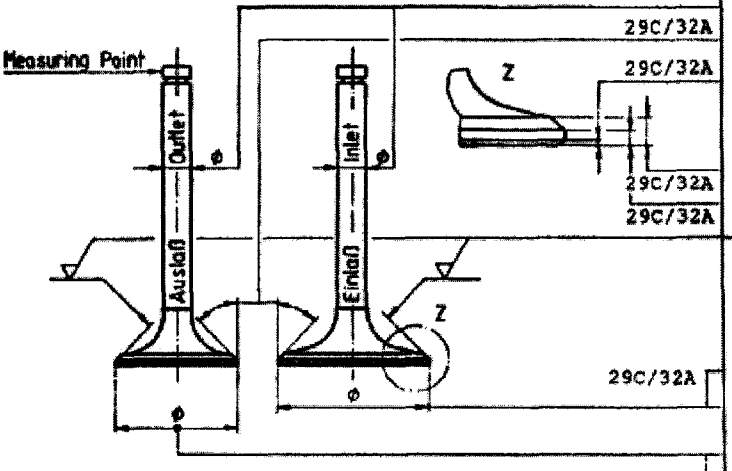
III.2.17 Cylinderhead 15B/D / 18B/D



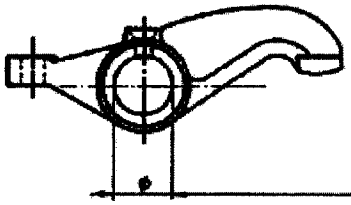
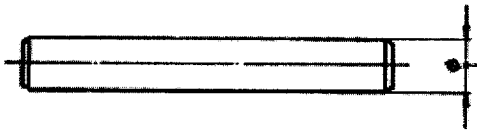
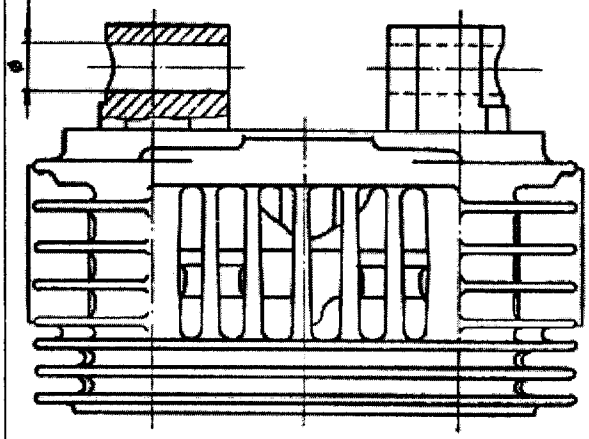


Part. Description		Dimension Original max. mm	Original min. mm	max. Limit mm
	15D/18D	6.2	press guide in till lower edge is flush with wall inside channels	
	15D/18D	5.7		
	15D/18D	7.014	7.005	see note
	15D/18D	10.019	10.010	
	15D/18D	9.988	9.979	
	15D/18D	0.200	0.100	0.600
	15D/18D	2.600	2.500	
	15D	85.050	85.000	
	18D	92.050	92.000	
	15D/18D	6.980	6.965	see note
		45°		
		0.2 x 45°		
	15D/18D	2.600	2.500	
	15D/18D	1.000	0.850	renew if scored
	15D/18A	29.150	28.850	
	18B/C/D	36.150	35.850	
	15D/18A	26.150	25.850	
	18B/C/D	29.150	28.850	

Note: To check wear of valve shaft and valve guide, insert valve guide and put dial gauge to "measuring point". Move valve lateral. If movement is more than 0.15 mm replace both parts.

Part. Description		Dimension Original max. mm	Original min. mm	max. Limit mm
III.2.18 Cylinder Head 29C / 32A				
	29C/32A	6.2		
		Press guide in till lower edge is flush with wall inside channels.		
	29C/32A	5.7		
	29C/32A	7.014	7.005	see note
	29C/32A	10.019	10.010	
	29C/32A	9.988	9.975	
	29C/32A	0.200	0.100	0.600
	29C/32A	2.600	2.500	
	29C	100.500	100.000	
	32A	109.050	109.000	
	29C/32A	6.980	6.965	see note
	29C/32A	45°		
	29C/32A	0.2 x 45°		
	29C/32A	3.150	2.850	
	29C/32A	1.000	0.850	renew if scored
	29C/32A	36.150	35.850	
	29C/32A	36.150	35.850	

Note: To check wear of valve shaft and valve guide, insert valve into guide and put dial gauge to "measuring point". Move valve lateral. If movement is more than 0.15 mm replace both parts.

Part. Description	Dimension		
	Original max. mm	Original min. mm	max. Limit mm
III.2.19 Rocker arm and shaft 15B/D 18B/D 29C 32A			
	12.018	12.000	12.060
	11.984	11.966	11.962
	12.018	12.000	12.060
			

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III. 3. ENGINE REASSEMBLY

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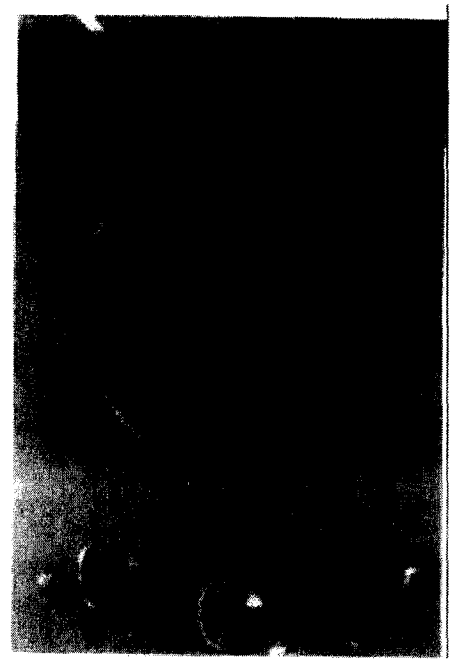
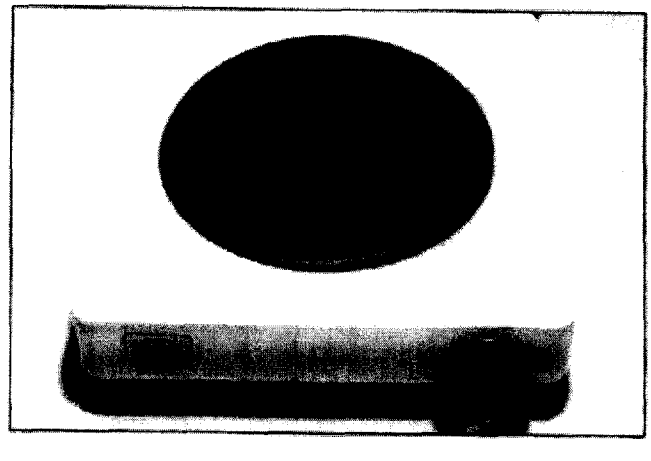
1. Crankcase

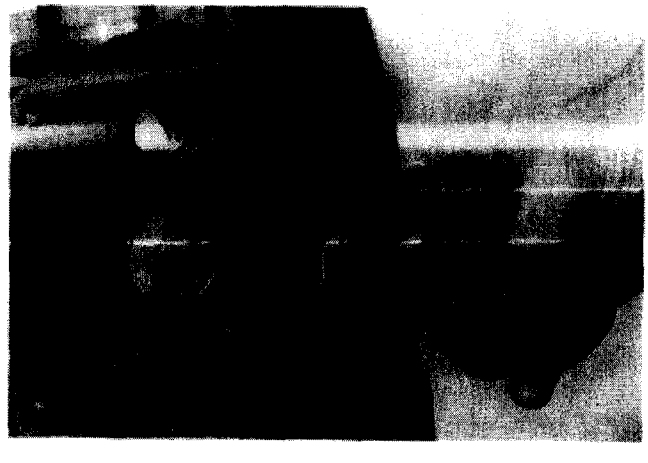
Press the bearing bush with driver. Take care that the joining line of the bearing bush is located as shown and that the oil holes in the bushing and the crankcase are properly lined up.
(Figure 1)



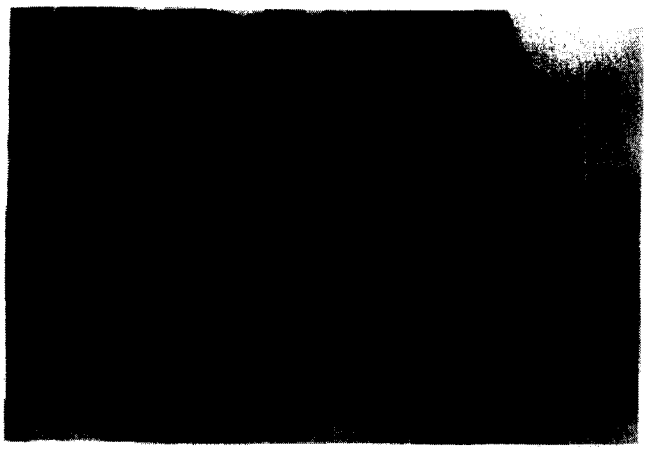
2. Crankshaft

To install the crankshaft gear wheel and the inner race of the roller bearing, heat the parts in an oil bath or on an electric heater plate to a temperature of 90 - 100°C (195 - 210°F). Thrust them down on the shaft using a suitable length of pipe and a hydraulic press.
(Figure 2)



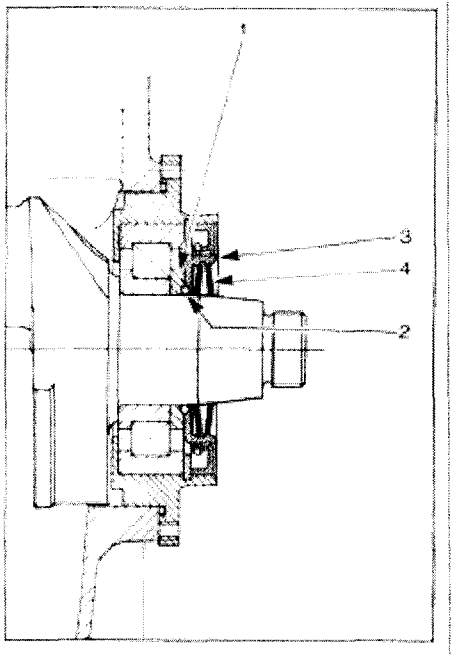


Oil the bearing bush and slide the crankshaft into the housing. Take care not to damage the bearing bush with the gear teeth.
(Figure 3)



3. Main bearing cover

Press the outer race of the driver into the bearing cover. Insert the retaining ring with pliers. Press the oil sealing ring into the cover with driver. Before assembling oil crankshaft journal and the sealing ring lip, do not use grease. Insert o-ring in the bearing cover and put bearing cover onto stud.
Attention: Bearing cover can only be fitted in one position. Tap lightly with a soft faced hammer to seat the cover. Torque down the fastening nuts crosswise.
(Figure 4)



Assemble the thrust washer (1) and o-ring (2), followed by the angle ring (3) and the two belleville washers (4) exactly as shown.
(Figure 5)

4. Flywheel

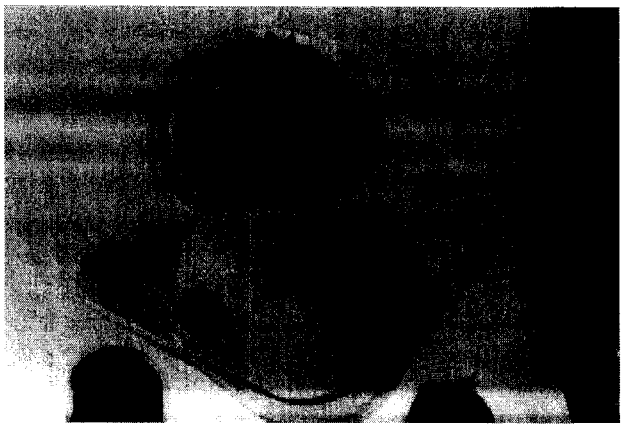
Clean crankshaft and flywheel tapper free of oil or grease. Insert the flywheel key and slide the flywheel onto the crankshaft tapper. Assemble flywheel retaining nut and tighten to the specified torque.
(Figure 6)

5. Oil pump

Reassemble oil pump with thin covering plate (only for securing bolts) and gasket. Before tightening the screws to the specified torque, pull the pump downwards. The clearance in the srew holes of the pump allows a sufficient backlash between the crankshaft gear and the pump gear.
(Figure 7)
Attention: Engines with clockwise (B) and counter-clockwise (D) rotation have different pumps.

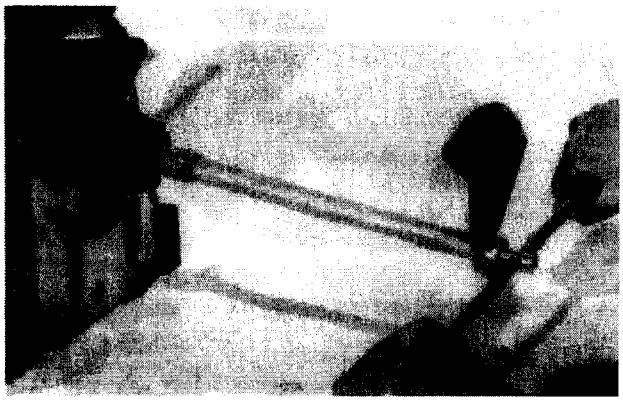
B: Pump gears are located on the left hand side, a yellow dot is visible on the front of the base plate on the right side.
(Figure 8)

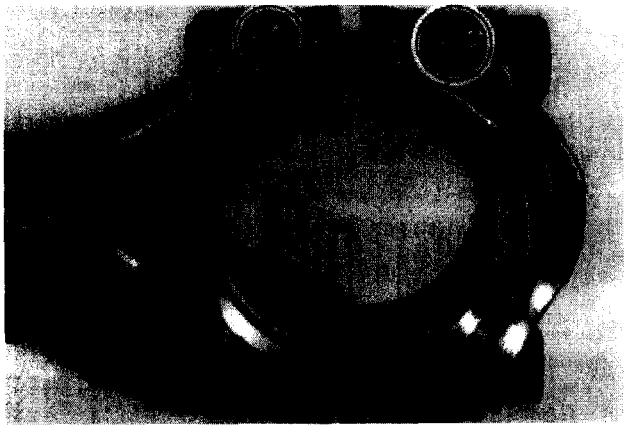
D: Pump gears are located on the right hand side, a „R" is visible on the front of the base plate on the left side.
(Figure 8a)
The lefthand pump can easily be modified into a righthand pump:Punch out the straight pins, turn the base plate and reassemle the pump.

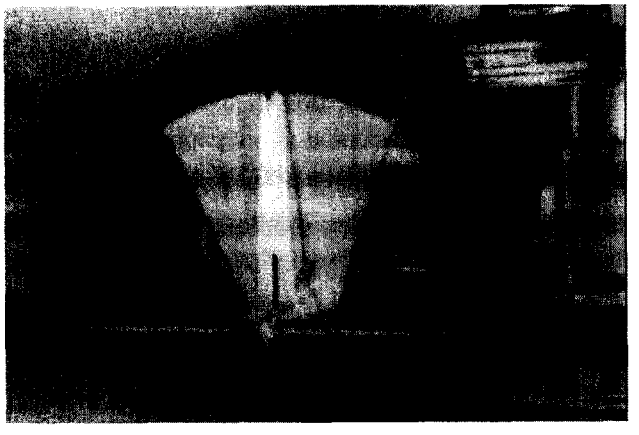


6. Governor

Install holding device so that all teeth fit exactly onto cranksaft. Make sure the governor and the crankshaft threads are free of oil and grease.Apply a couple of drops of Loctite No. 270 (or similar) on the governor threads. Torque the governor down according to engine specification.
Attention:The governor has a lefthand thread. While torquing, the socket must completely cover the governor screw head. Therefore spread flyweights.
Remove holding device after assembly. For exact governor adjustment refer to section III.6.
(Figure 9)







7. Connecting rod

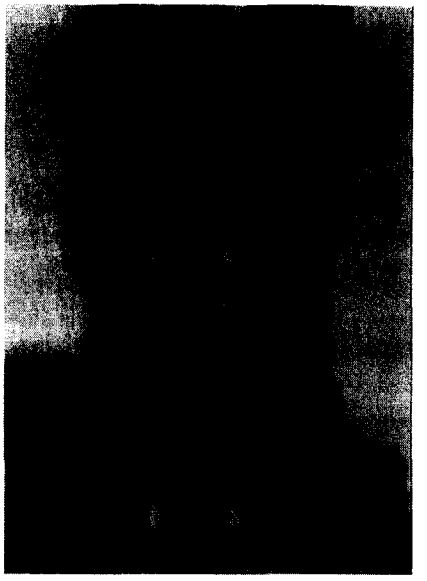
To install new bearing shells, take a shell half and lay it to approx. ¾ into the cap. Now press with your thumb the bearing in a sliding movement onto ist seat. The bearing lip must fit into the grove in the cap. The connection rod side shell half is installed the same way. (Figure 10)

Notice the numbers stamped onto one side of the conrod. These are matching marks i.e. identical numbers must be on rod and cap.
(Figure 11)

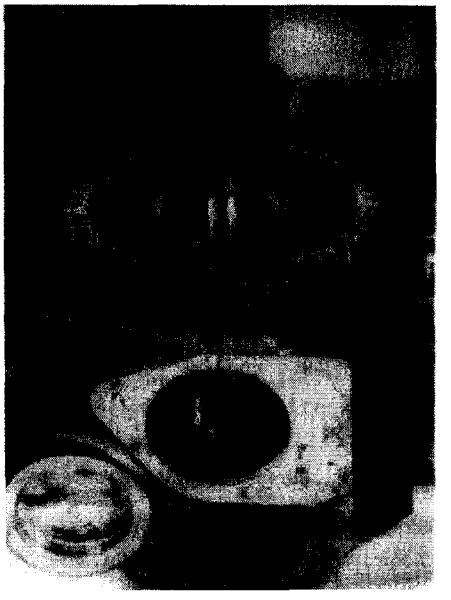
Oil the bearing shells and install conrod into the crankcase until it seats on the crank pin. Insert the conrod cap through the inspection cover.
Attention: The stamped numbers must be aligned on the same side of the rod but it is not important which engine side the numbers face. Tighten the conrod nuts to the specified torque and reinstall the crankcase cover.
(Figure 12)

8. Camshaft
Heat the camshaft gear wheel in an oil bath or an electric heater plate to 90-100°C (195-210°F). Thrust gear down onto the camshaft using a suitable length of pipe and a hydraulic press.
Attention: The chisel mark for the timing must face towards cam side of assembly.
(Figure 13)

Using a driver press the camshaft bearing into the gear cover.
(Figure 14)

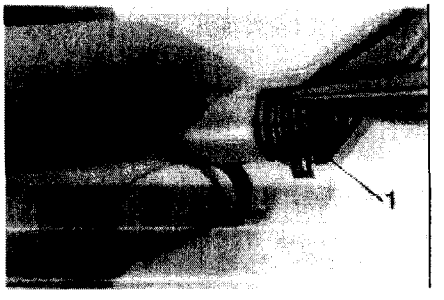


Now press the camshaft with driver into the bearing using a driver as a counter pressure piece for the bearing. Make sure that the bearing seats fully against the bearing seat flange. Insert the retaining ring. Install the camfollower for the injection pump and tighten its fixing screw. Do not forget to install a new o-ring on the camshaft prior to pressing the camshaft into the bearing.
(Figure 15)

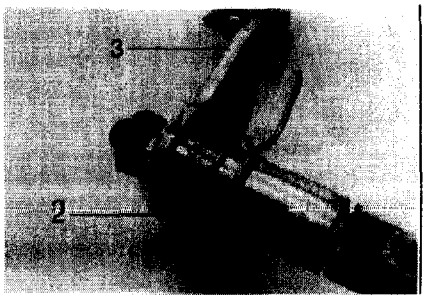


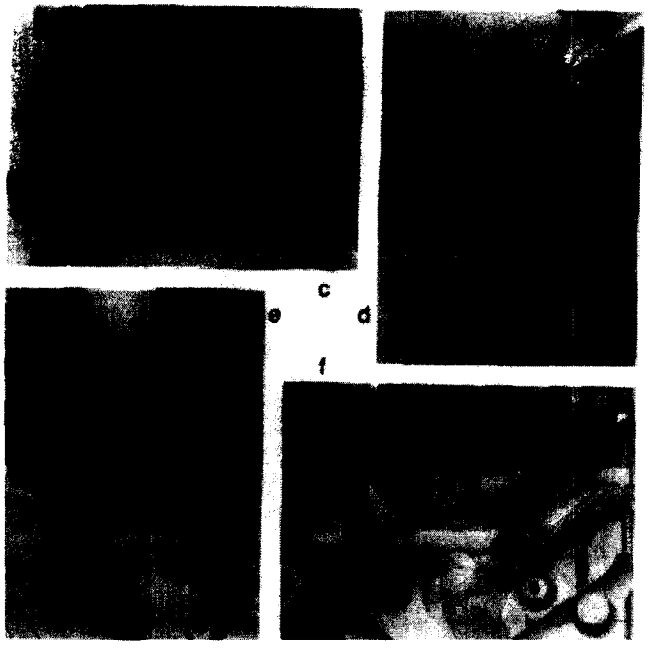
9. Governor control/speed Regulation Linkage

Insert ratchet pin and its spring into its hole in the gear housing and lay housing on work bench. Put the return spring into small hole of the control lever.
(Figure 16a)



Move the torsion spring over the eccentric shaft and hook spring leg in the space in the middle of the ratched plate.
(Figure 16b)





Slide the eccentric shaft through the bearing bush in the housing and into the control lever. Turn the acceleration lever downwards („stop"-position) until spring leg of the return spring can be managed to get into the notch of the eccentric shaft.
(Figure 16c)

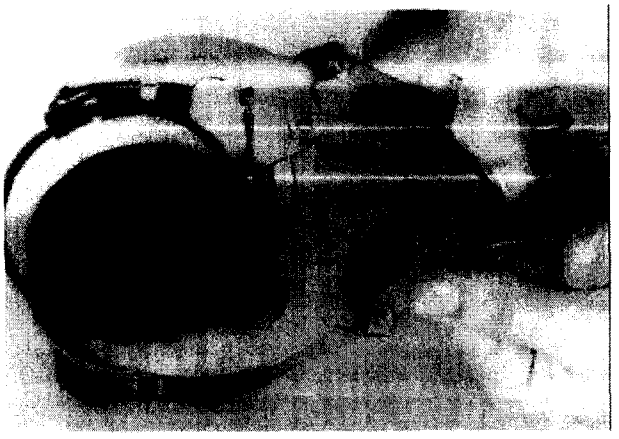
Use a wire loop to move and hook torsion spring leg to the boss of the gear housing.
(Figure 16d)

Push eccentric shaft further in and push ring spring into the notch of the eccentric shaft.
(Figure 16e)
Attention:Initiate performance test.

The tension of the return spring must be acting against the pressure onto the binding screw.
(Figure 16f)

Regulation - Stationary
The outer torsion spring pulls the acceleration lever from the stop - position back into the idle position.

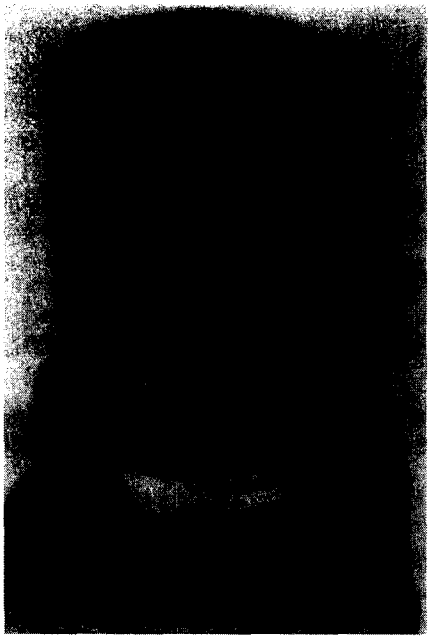
Regulation -
Vehicle/Bowden Cable
The outer torsion spring pulls the acceleration lever in the stop - position.
Attention:The spring tension may be altered by hooking the spring leg into one of the neighboured notches.
(Figure 17)



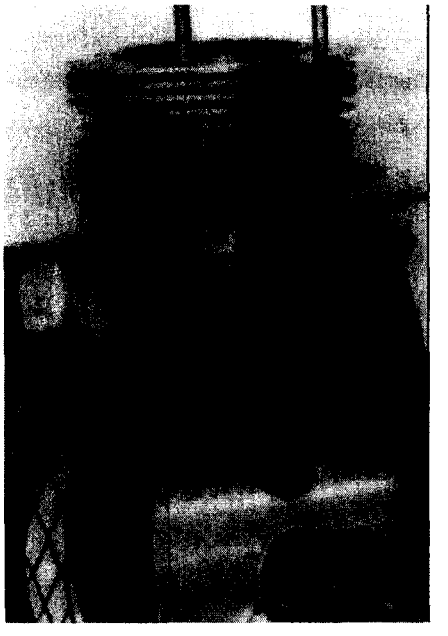
10. Piston

Install the piston rings using a ring expander so that the imprinted „R" is on top.
(Figure 18)

Oil the ring and piston skirts. Check that piston ring gaps are 120 degrees offset. Compress rings with ring compressor. Lay the cylinder down on the bench with the bottom facing up. Install the piston into the cylinder from the bottom. Never tap on the piston crown.
Attention: Never try to install piston through top of cylinder liner as liner is slightly tappered. Push in the piston so far that the piston pin bore is slightly above edge of cylinder.
(Figure 19)

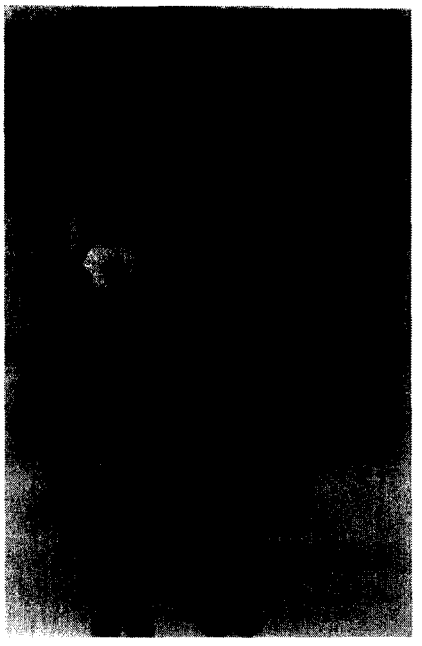


Slide the piston and cylinder over the studs with the crescent shaped sparing in the cylinder fins facing the gear side of the engine.
For 18B/D engines only:
The arrow stamped on the piston top must point towards the flywheel.
Align the piston and connecting rod bores. Push the piston pin in and insert the retaining ring. Push the cylinder down until it seats firmly onto the engine block.
(Figure 20)

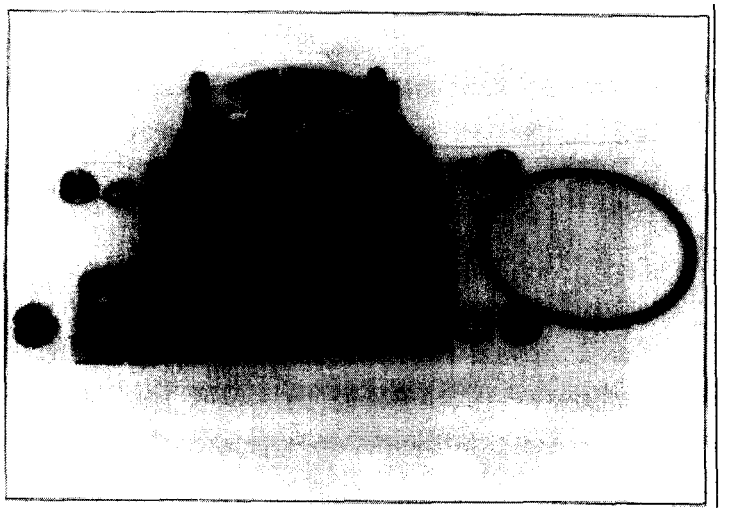


11. Cylinder head

Press the valve guides into the cylinder head using driver (for protrusion dimension see III.2.17/
18). Special care is necessary to ensure that the guide is exactly vertical before pressing in.
Attention: Before pressing in exhaust valve guide, assemble the two small washers and retainer ring (the exhaust valve has the larger counterbore when viewed from top but the smaller valve diameter when viewed from the bottom.
(Figure 21)



Grind in the valves. The rotocap and the conical shaped spring belong to the exhaust valve. The two thin steel washers must be under the cylindrical spring of the inlet valve. Fit new sealing cap onto the inlet valve guide. Before fitting the rotocap check for proper function: Spin the cap, if rattling sound or hard movement replace it.
(Figure 22)



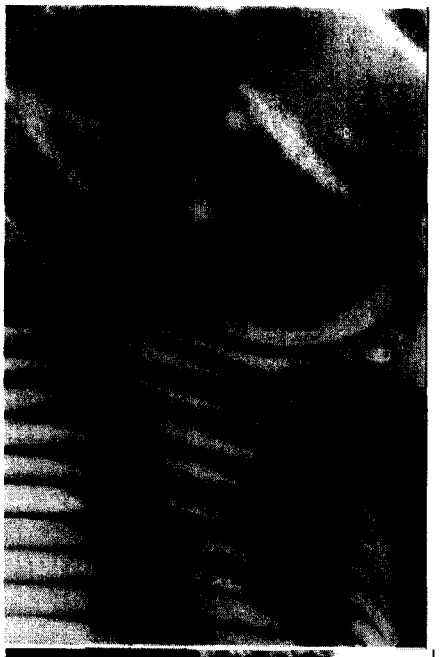
Fit cylinder head gasket and slide cylinder head down onto the cylinder. Fit spring washers and cylinder head nuts. On the shorter stud bolt - intake side -fit the tote bracket and the cylinder head nut without spring washer.
(Figure 23)

Attention: Models 15B/D do not have any cylinder head gaskets.
At this stage do not torque down the cylinder head nuts as the rocker arms and push rods still have to be fitted at a later stage.

12. Gear cover

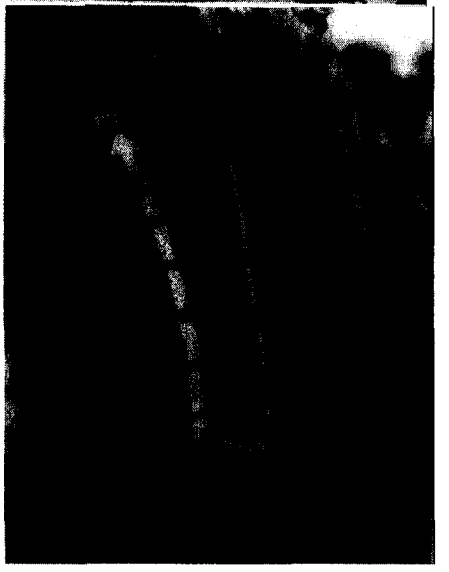
To install the gear cover, first bring the piston to TDC (Top dead center) by aligning the flywheel timing mark with the TDC mark stamped on the crankcase at the 3 o`clock position.
(Figure 24)

Insert the governor pin into the bore in the governor. Use grease to keep the pin in place. Line up the timing mark on the camshaftgear with the mark on the gear cover. (marks „A" and „B"). Install the gear cover (remember to place the gaskets) onto the crankcase being careful not to move the camshaft gear. After the cover is installed, check the timing mark on the flywheel. If the crankcase and flywheel timing marks are within ± 2mm (± 0.0787) of lining up, the timing is correct (for governor adjustment refer to section III.6.)
(Figure 25)

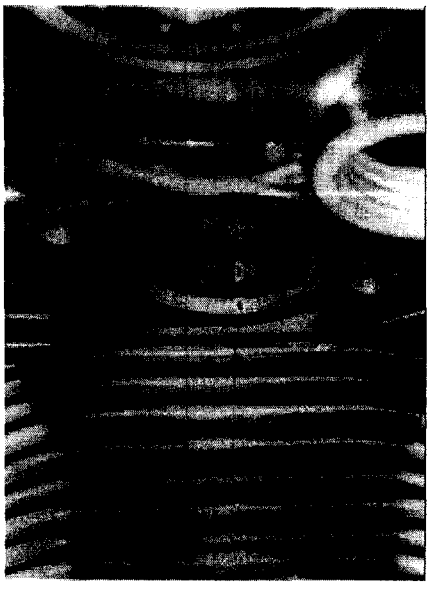


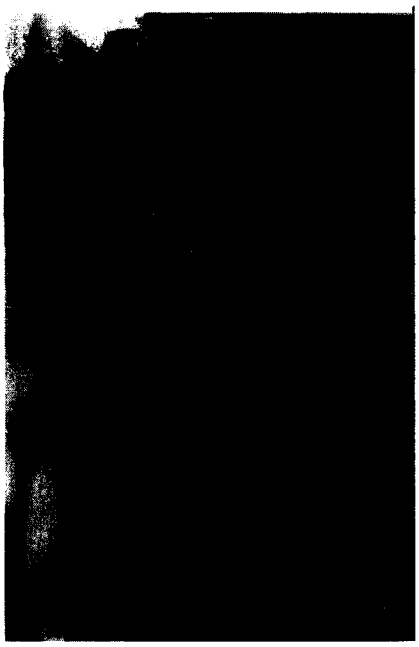
Occasionally, however, the governor will tighten onto the crankshaft in a position that makes it difficult to install the gear cover. If this happens, use the following procedure to install the cover:

- Turn the flywheel until its timing mark aligns with the treaded hole in the crankcase at approximately the 1 o`clock position.
(Figure 26)



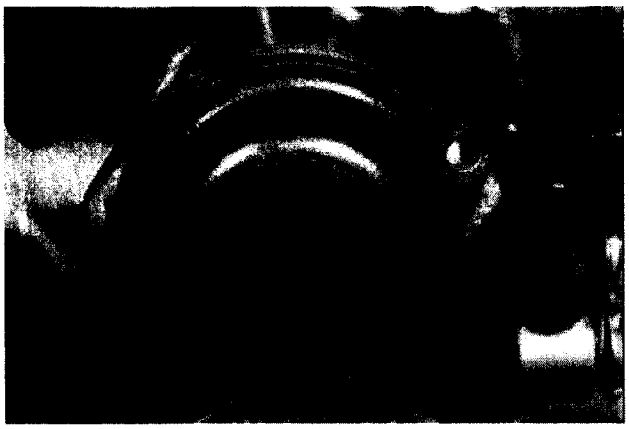
- Move the timing mark on the camshaft gear exactly 3 teeth to the left.
(Figure 27)



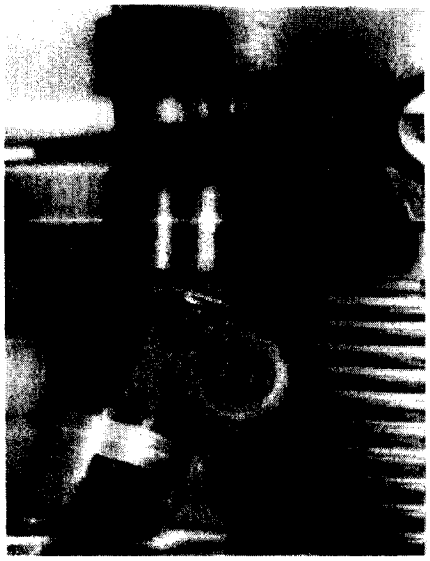


- Install the cover. Align the camshaft gear and gear cover timing marks. Now check the flywheel and crankcase timing marks. The timing is acceptable, if they are within ± 2 mm (± 0.0787) of each other.

When installing the gear cover screws, note that the top two and bottom left screw are longer than the other three. (Figure 28)



Place new o-ring in the flute of the support starting handle. Lubricate the camshaft and the sealing lips of the oil sealing ring. Do not push the guide straight onto the gear cover. Instead use a light twisting motion until the guide seats itself. Tighten the two guide screws to the specified torque. (Figure 29)



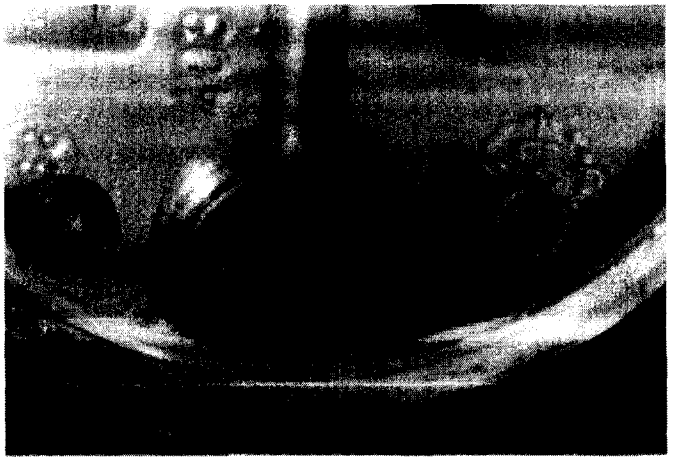
13. Compression release device

Slide the protection tube up into its hole in the cylinder head as far as possible. Remember to install a new o-ring in the cylinder head. Assemble the decompression device with new o-ring and gasket.
Attention: Before reinstal-ling the decompression device check if retaining pin for the shaft (arrow) is still in place.
(Figure 30)

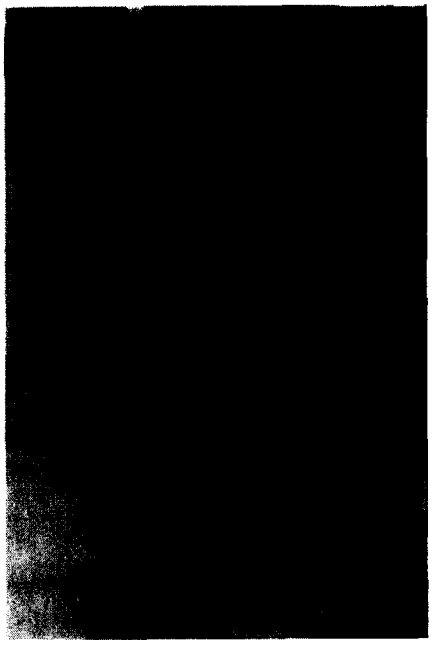
When a new decompression device is installed the correct function must be checked. To do so install the decompression device with the 0.4 mm (0.0157") thick gasket, continue with step 14, 15 and 16. Turn the piston approx. 1/8 revolution before TDC and measure with a depth gauge the distance between bracket for rocker arm shaft and spring collar of the inlet valve. Next, activate the decompression device and measure the distance again. There must be a difference between the two measurements of o.7 - 0.9 mm (0.0236-0.384"). If it is less than 0.7 mm disassemble the decompression divice and replace the 0.4 mm (0.0157") gasket with two 0.3 mm (0.0118") gaskets (in extreme cases use one 0.4 mm and one 0.3 mm gasket). Carry out the two measurements again.
If the tolerance is more than 1.0 mm replace the 0.4 mm gasket with the 0.3 mm. Carry out the two measurements.
(Figure 31)

14. Push rods and protection tube

Slide the protection tube down onto the decompression device. Assemble the retaining spring in the top of cylinder head exactly as shown but do not tighten the nuts yet.
(Figure 32)



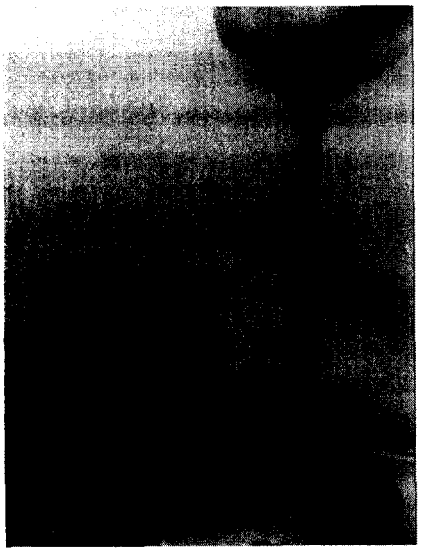
Insert the push rods through the protection tube into top of the decompression device. Both push rods are alike. The intake push rod goes into the hole in decompression device closest to cylinder.



15. Rocker arms

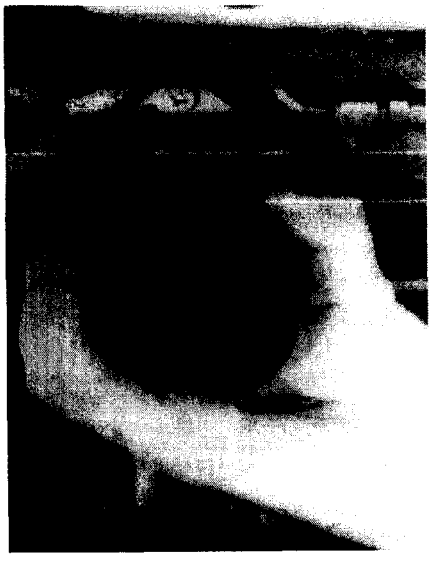
Place piston to TDC position. Line up rocker arms and push rods and oil the rocker arm bolt before installing it into the support.
Attention: To prevent damage of push rods while torquing the cylinder head nuts, ensure sufficient clearence between setting screw and push rods.Tighten the cylinder head nuts crosswise, in 3 steps, to the specified torque.
(Figure 33)

Tighten down the nuts for the retaining spring.
(Figure 32, page 51)



16. Valve adjustment

Check that the decompression device is not activated (pin is on 9 o`clock position). Set the piston on TCD compression stroke (see step 15). Loosen the locknuts of valve setting screws, insert a 0.1 mm (0.004") feeler gauge between the valve stem and rocker arm and adjust the clearence until a slight drag is felt on the gauge when pulled out. Tighten the locknut while holding the setting screw with a screwdriver. When finished recheck the clearance.
(Figure 34)

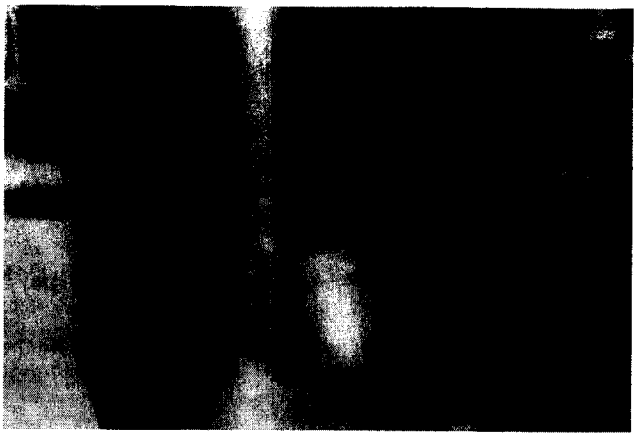


17. Oilfilter

Oil the rubber gasket of oilfilter and screw on oilfilter.
Attention: Hand-tighten oilfilter only.
Install oval flange of oil drain with gasket and screw plug. Fill the engine with new oil up to the upper dipstick mark.
(Figure 35)

18. Cylinder shields and air guides

Install both halves of cylinder shields and the clamping bolt. Do not overtighten the bolt. It is sufficient when the bold protrudes about 1-2 mm (0.0394"-0.0787") out of the locknut. Install the two air guides on top of the crankcase.
(Figure 36)

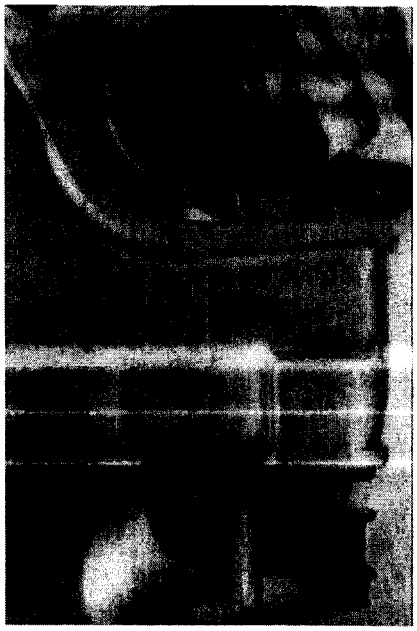


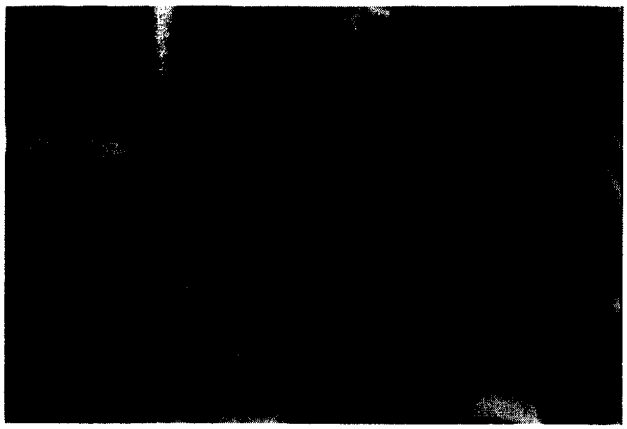
19. Fuel injector

Replace the special washer located in the cylinder head fuel injector seat.
Attention: Use one gasket only, make sure that the old one has been taken out. Install the injector and the clamp. Torque the two nuts as specified.
(Figure 37)

20. Injection pump

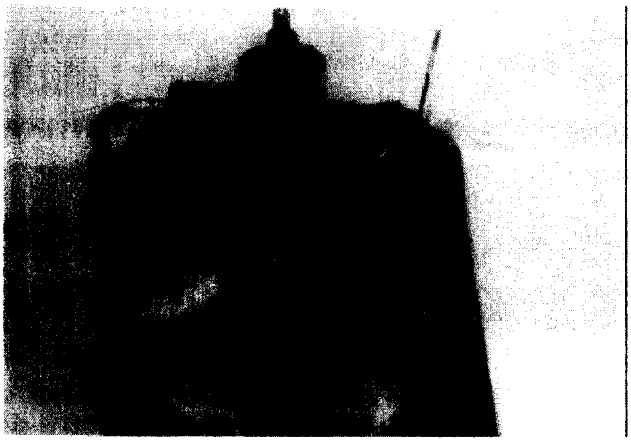
Place acceleration lever in full load position and pull excess fuel button. The internal spring pushes the control lever against the housing. Place rod of the „fuel injection". When sliding in the pump the pin of the rod directly grips into the yoke of the control lever. Reinstall the injection pump by using the same number and types of shims as were on the engine before (see III.5 for complete injection timing info.)
Attention: First install the paper gasket, then the shims onto the stud. Shims should not be in direct contact with the housing due to insufficient sealing function.
(Figure 38)





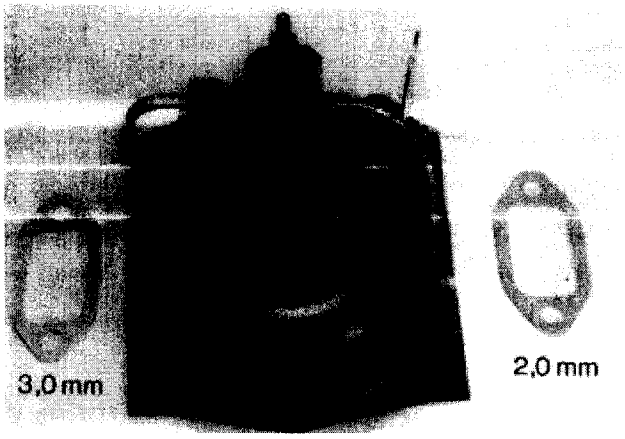
21. High pressure fuel pipe

Install the high pressure fuel pipe and tighten the union nuts on injector and pump. While tightening nut on pump and injector maintain counter parts with a 14 mm wrench.
(Figure 39)



22. Valve cover

Install the valve cover gasket and the valve cover, making certain the gasket is properly seated on the cylinder head. Insert new plastic washers under the nuts and tighten to specified torque.
(Figure 40)

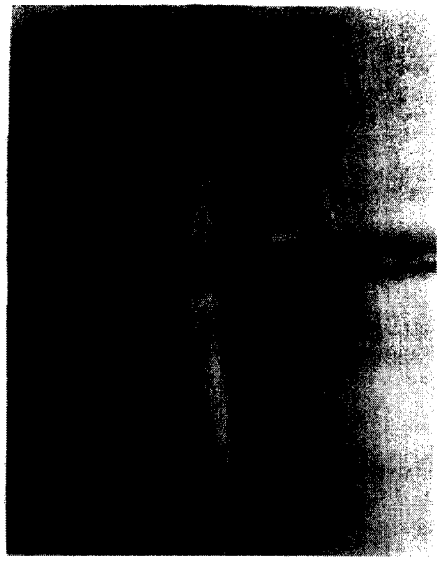


23. Fuel tank brackets

Reinstall the two brackets. Fit new gaskets on both sides of each bracket.
Attention: The exhaust and air filter gaskets are different. You need two gaskets for each bracket.
(Figure 41)

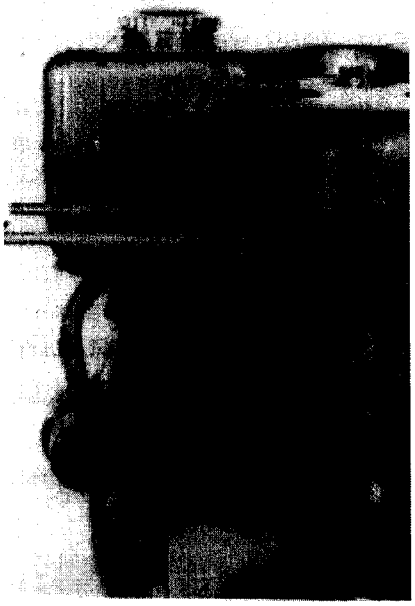
24. Fuel tank

Place the fuel tank on the tank brackets. Slide both tank straps over the tank and brackets. Do not forget to reinstall the two tank seam protectors. Tighten the straps.
(Figure 42)



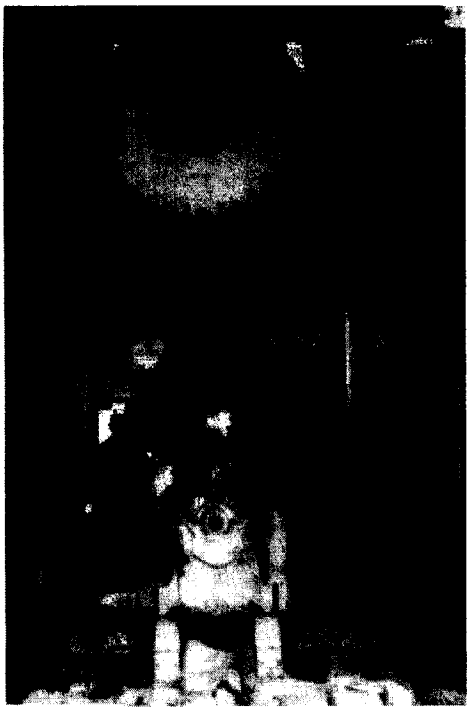
25. Fuel leak-off and supply line

Install banjo bolts on the fuel leak-off/supply line at the fuel tank and fuel injector. Remember to replace both copper washers on each banjo bolt. Route the fuel line as shown.
Attention: On the injector end the thicker copper washer is located between the injector and the end piece of the leak-off pipe.
(Figure 43)



26. Air filter/Muffler

Using a new gasket and two new self locking nuts, install the air filter.
Install the muffler and muffler screen.
Attention: Fit the two flat washers each bolt. One in front and one behind the muffler screen.
(Figure 44)



27. Test run

The engine is now completely reassembled. Install engine on a test bench and carry out a test run. The engine does not require a long time running-in program. After a short run according to below specifications the engine is ready for normal operation. Also the use of special break-in oils or lub. oil additives are **not** recommended.
(Figure 46)

Running-in instruction:

10 min. idle speed, no load
10 min. half speed, half load
20 min. fuel speed, full load
2 min. idle speed, (for cooling down)

During the test run, check for proper function, unusual noise and leakages. Low and high idle speed, full load speed, exhaust gas temperature, lub. oil temperature and lub. oil pressure should be recorded. After the test run change the lub.oil.

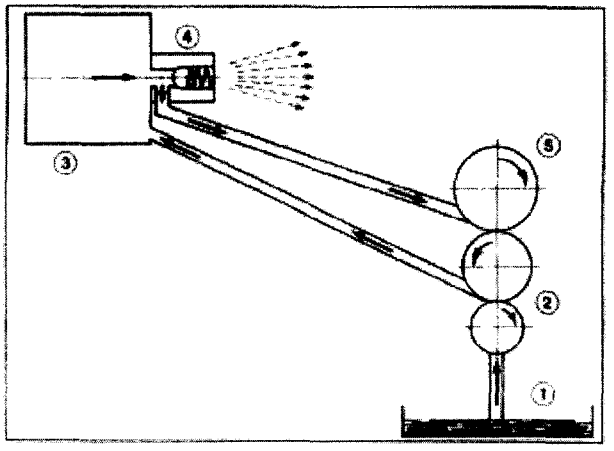


Figure 1

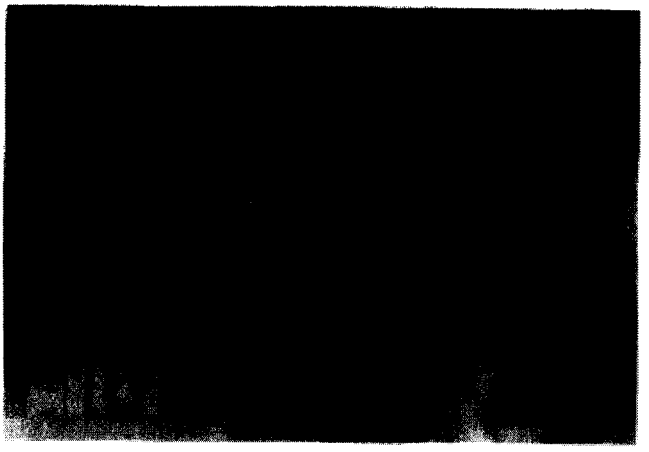


Figure 2

A gear pump (2) sucks the oil from the oil sump (1) and pumps it through the oilfilter (3) to the main bearing (5) and to the conrod bearing.
Piston, piston pin, cylinder liner and rocker arms are splash lubricated. When oil pressure rise above 4,5 bar (63 PSI) the oil pressure relief valve (4) opens and the oil flows back into the oil sump partly.

All **Farymann** engines require heavy duty lubrication oils of at least CC, preferably CD quality (API service classification).
For correct viscosity and oil change intervalls refer to operation manual. At least once a year crankcase should be flushed to remove all dirt and abrasions that may be in the crankcase.

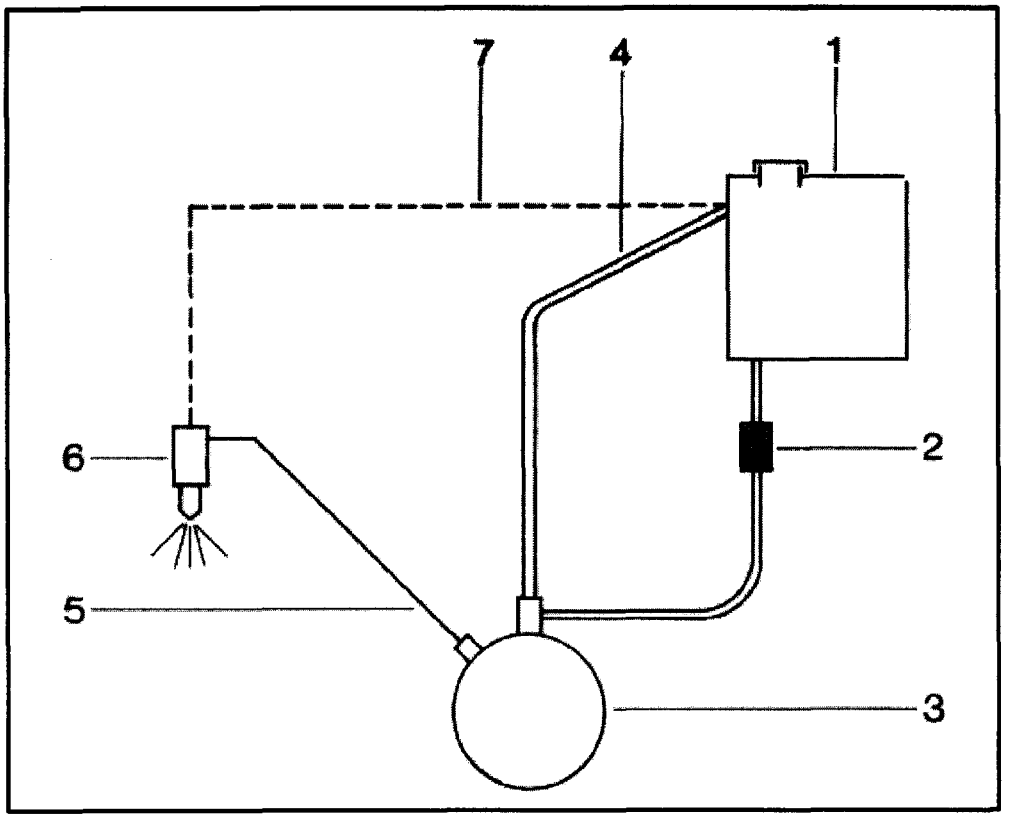
Oil pressure testing

The oil pressure depends mostly on the bearing play (see section III.2). Before oil presure make sure that oil level is topped up and correct viscosity is used.

Remove the oil channel plug screw (Figure 2) and connect gauge adaptor and oil pressure gauge.

The oil pressure at idle speed should be at least 0.5 bar (7 PSI). At full load (2850 rpm and 100°C/220°F oil temperature) it should be at least 1.8. bar (23 PSI).

If oil pressure is too low, check first if the oil has the correct viscosity (according to the ambient temperature) and if the pressure relief valve is working before further dismantling of the engine.



The fuel flows from the tank (1) through the filter (2) to the injector pump (3). As the quality supplied is higher than required for the injection, most of it goes back to the tank via the return pipe (4), simultaneously carrying heat away from the pump.

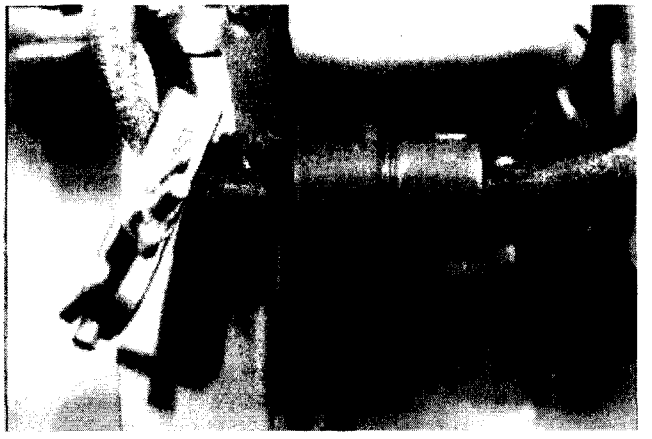
Also the return pipe ensures a constant bleed of the fuel system.

From the injection pump fuel is fed through the high pressure pipe (5) to the injector (6) and, in a fine mist, sprayed into the combustion space shortly before TDC of the compression stroke. A return pipe (7) carries back any leakage to the tank.

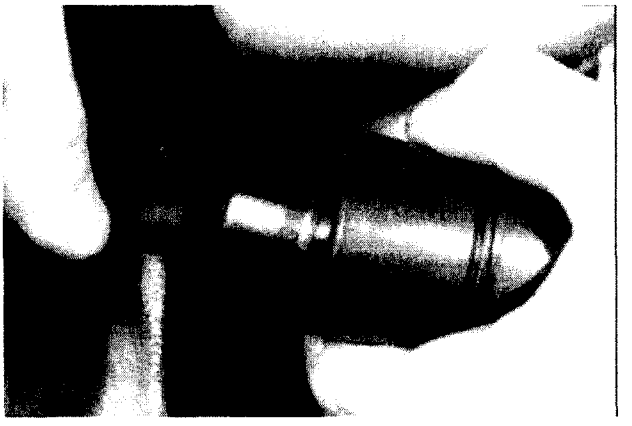
III.5.1. Fuel System

The fuel filter prevents the entry of dirt into the injection pump. The normal lifespan of the filter is approx. 2000 operation hrs., however, it depends on the purity of the fuel used.

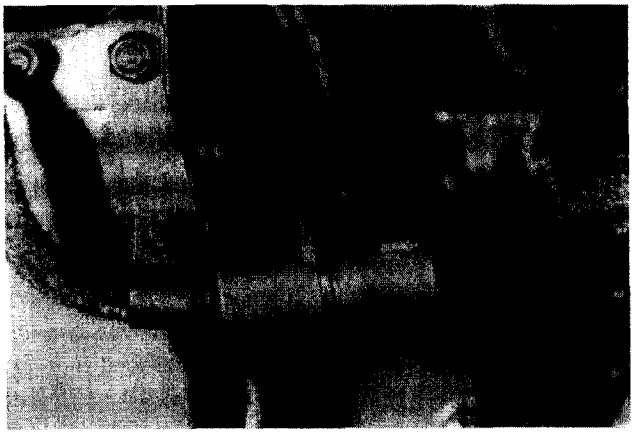
Prior to changing fuel filter, clean the fuel pipe from dirt with a rag and close off the line between tank and filter with clamp.
(Figure 21)



Pull the inlet and outlet lines from the filter.
(Figure 3)



Take care that no dirt enters the pipes. Discard the used filter. Do not try to clean it! Push the pipes as far as possible onto the connection nipples of the filter.
Attention: Watch out for the correct direction of flow (arrow on filter housing)!
(Figure 4)

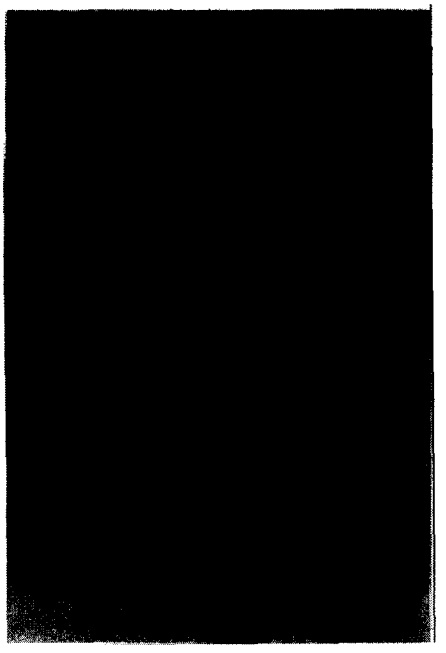


III.5.2. Injection nozzle

The injector nozzle injects the fuel in a fine mist and under a high pressure into the combustion space. Due to the high mechanical and thermal stress, the nozzle requires regular maintenance.

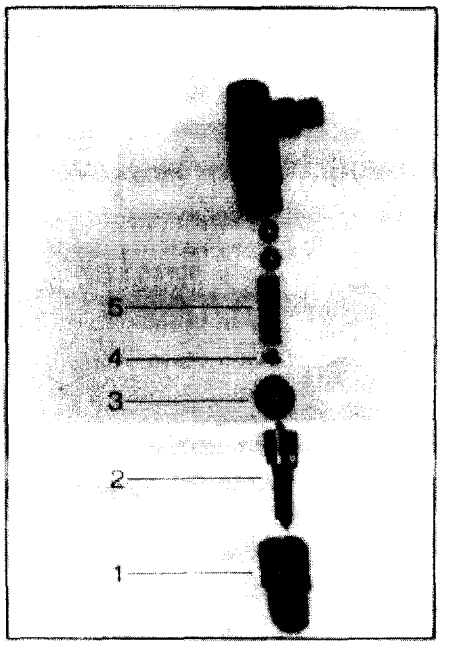
Carbon resuides on the nozzle tip are removed with a brass wire brush.

The spray holes can be cleaned with a special needle (Bosch tool)
(Figure 5)



To check the injection pressure, connect the complete injector valve to a nozzle tester.
Pump with the hand lever till the nozzle ejects.The fuel must be ejected evently atomized without drippling at the specified pressure.
(Figure 6)

Caution:
Keep hands away from nozzle spray!
The spray from a nozzle can penetrate deep into the flesh of the fingers or hand and destroy the tissues. Diesel oil entering the bood stream can cause blood poisoning.

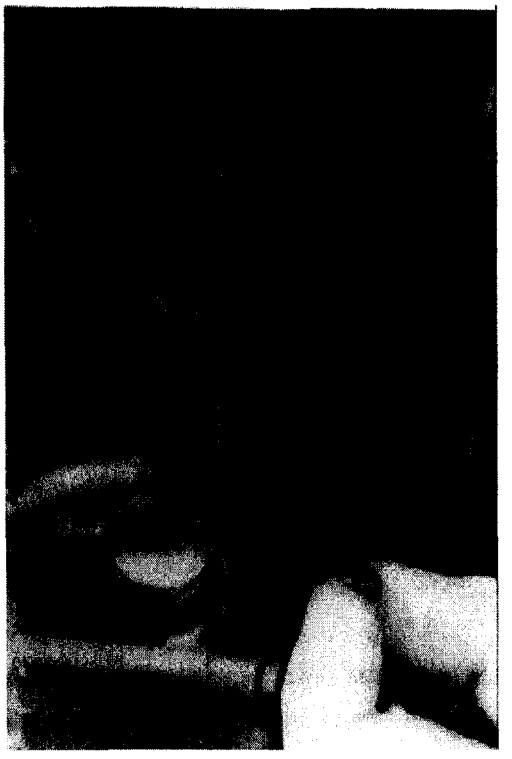


If injection pressure is too high or too low, it must be corrected by replacing shims in the injector valve.
To do so dismantle the injector valve: Unscrew the sleeve nut (1), take of the nozzle (2), pressure piece (3), valve cone (4) and pressure spring (5).
(Figure 7)

Replace adjustment shims.
Thicker shims= higher pressure
Thinner shims= lower pressure
An alteration of 0.1 mm(.004") will bring a change of approx. 10 bar (145 PSI)
When reassembling take care that the pins on the pressure piece are correctly located in nozzle body and nozzle holder.
If the nozzle leaks,dribbs or does not atomize properly, change the complete nozzle. Lapping of the nozzle needle is not recommended.

III.5.3. Excess starting fuel button

For ease of starting all engines are fitted with an excess startingfuel pull button.
(Figure 8)

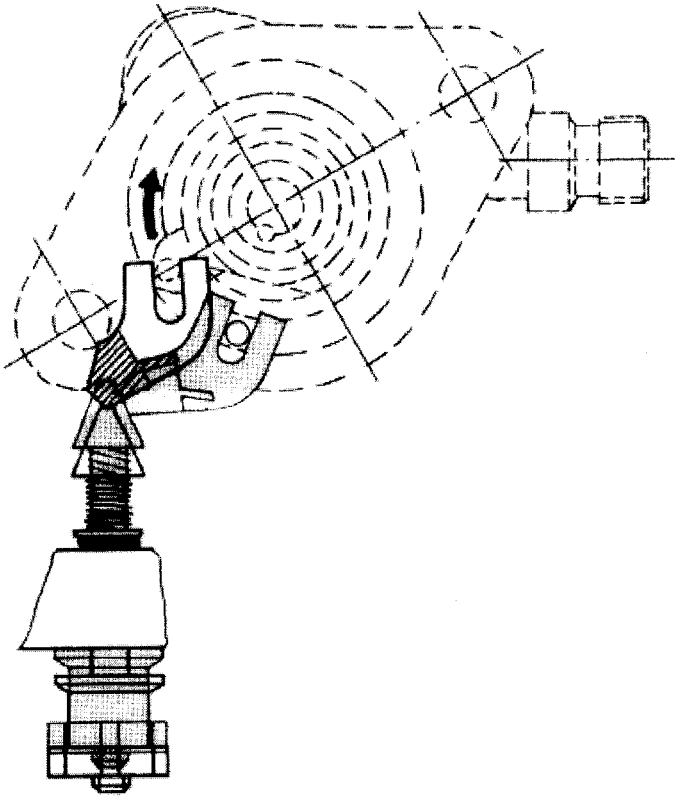


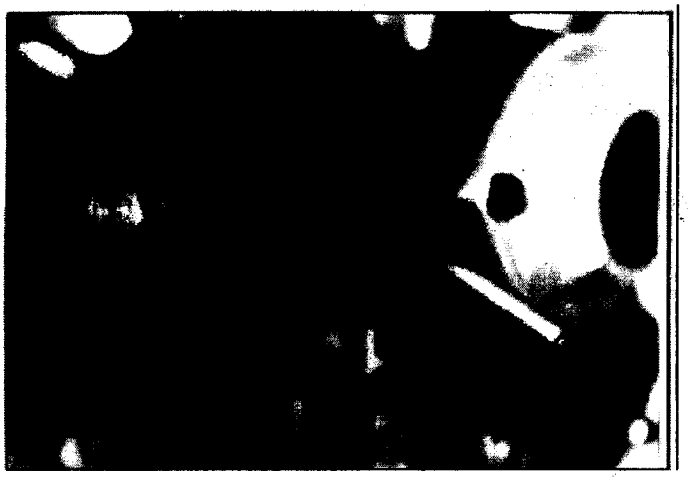
A cone limits the travel of the injector pump fuel rack. When the starting fuel button is pulled down prior to start, the cone allows the fuel rack to travel a longer way.
(Figure 9)

As soon as the engine reaches its high idle speed the governor pushes the fuel rack towards stop, the starting fuel button disengages and returns to its normal position.

Therefore it is necessary to start the engine without load in order to reach maximum rpm. Otherwise the starting fuel button will not disengage and continously overload the engine.

Also the engine output is adjusted via the con of the starting fuel button. Depending in the installation depth of the cone the fuel rack travel is shorter (=less output) or longer (=higher output).
This output adjustment is done at the factory´s test bench. Under no circumstance this setting should be altered.
If the excess staring fuel button or the complete gearcover was renewed, the engine output must be readjusted on a testbench.





III.5.4. Adjustment of fuel injection timing

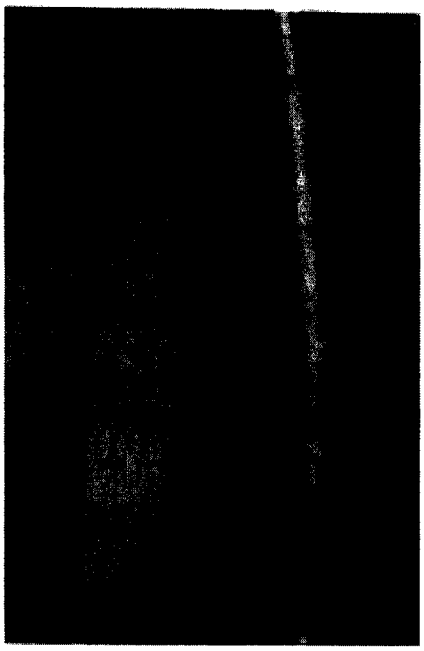
The correct setting of the commencement of delivery is a basic requirement for a troublefree function of the engine. As the injection timing is fixed, a check and respectively readjustment is only necessary when the engine speed was altered, a new injection pump was installed or the camshaft/camshaft gear was renewed.

Engines of model 15 and 18 are set at „delivery cur off point".

First crank the engine in rotation direction to compression stroke till TDC mark on the flywheel is approx. at the 5 o`clock position. Remove the allen head screw from injector pump head and the sealing washer under it and fit drip tube. (Figure 10)
Attention:Fuel will flow out of the pump as soon as the screw is loosened.

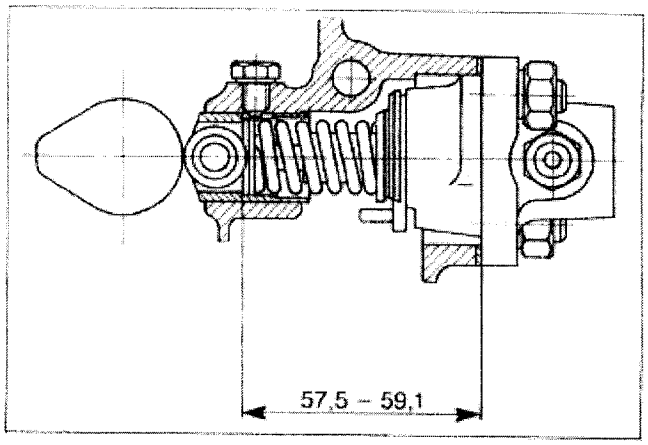
Set acceleration lever at half load.
Attention: Excess starting fuel buttom must not be pulled.
Slowly crank the engine rotationwise and observe the drip tube. First the fuel flows free out of it, drips, stops and starts to drip again. The delivery cut-off point is reached when approx. 1 drop per second comes out of the tube.
(Figure 11)

Use a flexible ruler and measure the distance between TDC marks on the flywheel and housing.
(Figure 12)



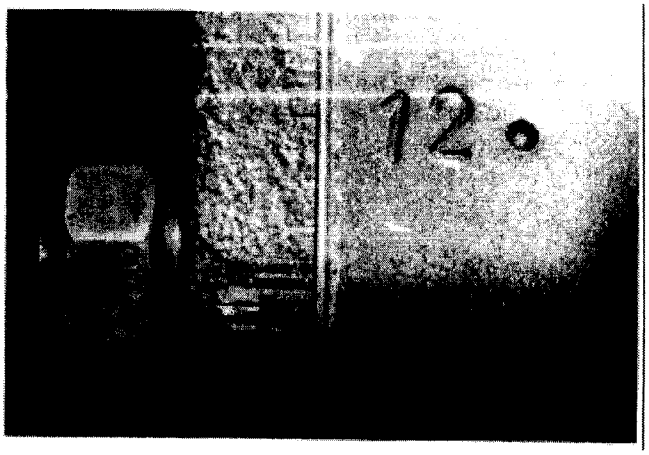
Compare the measurement with the valves at the table III.8 observing the correct flywheel diameter and engine speed. If the measured value is out of tolerance, readjust the commencement of delivery, either by adding or removing shims under the injection pump. Adding shims shortens the distance (=delayed injection), removing shims increases (=advanced injection) the distance between the TCD marks.

If shims have been added respectively removed, or a new injection pump ishas been fitted, the installation deepth must be checked.
Measure from the mounting flange down to the **edge** in the roller tappet (**not down to the roller**). This measurement plus the thickness of the shims should be between 57.5 mm (2.263") and 59.1 mm (2.327").
(Figure 13)



If it is not possible to set the injection timing via the shims, then most probably the alignment of the camshaft gear is not correct (see III.3.12) or the TDC mark is wrong.
Attention: The thickness of the shims fitted under the pump is stamped on the mounting flange of the injector pump in 1/10 mm.

e.g. 12 = 1.2. mm. This value, however, refers only to the originally fitted pump. When a pump has been changed or the injection timing was altered, the new corrected thickness should be stamped on.
(Figure 14)



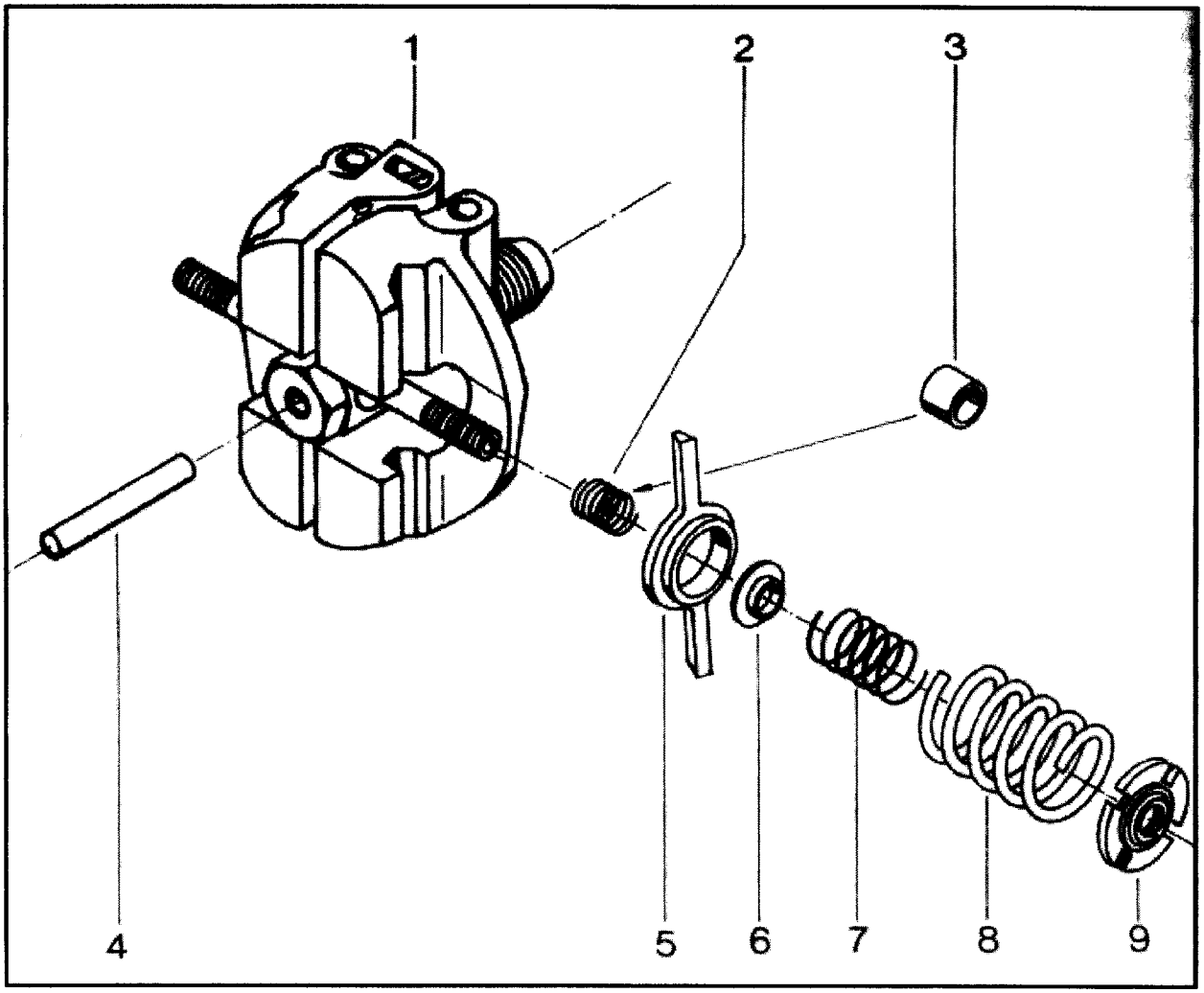


Figure 15

1. Governor body.
2. Midrange spring.
3. Spacer (instead of 2 for generator application).
4. Governor pin.
5. Bridge.
6. Support.
7. Full load spring.
8. Idle speed spring.
9. Cross slotted nut.

The purpose of governor is to maintain constantly the specified speed of the engine. Therefore, centrifugal and resilient spring forces are used to monitor the amount of fuel injected by the injection pump.
According to the utilization of the engine, there are several types of governor:

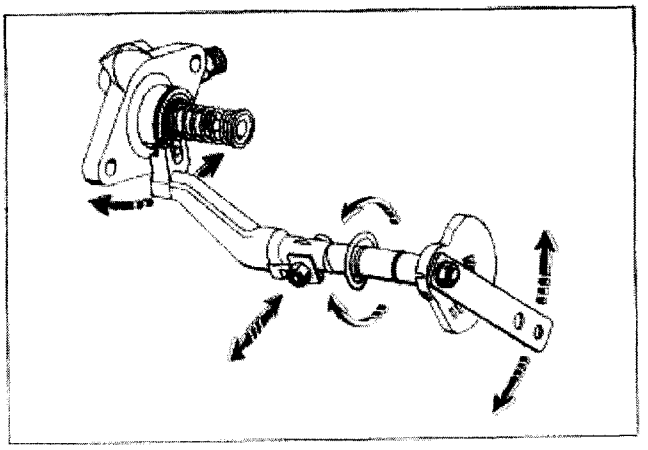
1. Fixed full speed governor.
Only one speed (full load) is governed. For applications with constant speed operations such as generating sets.

2. Idle and full speed governor (2- stage governor.)
Besides the full load speed the idling speed is also governed. For applications with constant speed operation and idle speed relief such as compressors, freezer units.

3. All speed governor (variable speed governor).
Governs the complete range of speeds from idle up to full speed. For applications with variable speed operation such as industrial engines, vehicle applications.

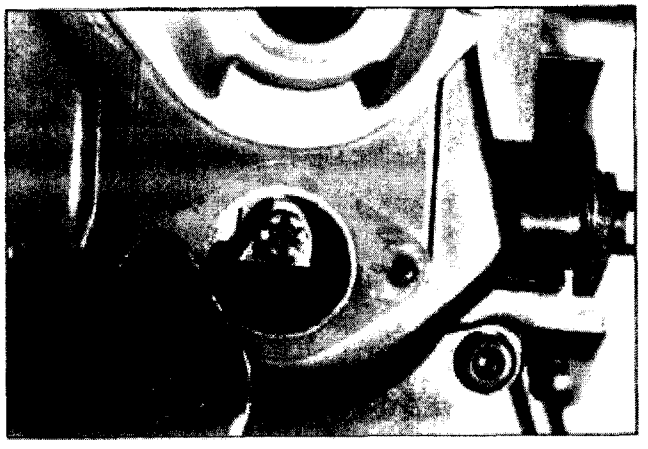
III.6.1. Construction and function of governor

The governor consists mainly of two flyweights and a set of springs which counteract the centrifugal force exerted by flyweights.
(Figure 15)
The governor being assembled onto the crankshaft, its speed is synchron with the engine speed. Its rotation drives the flyweights outwards and pushes a pin via a lever transmission against the adjustable tappet bolt of the control lever. Through this lever the injection pump fuel rack is pushed towards idle position. The control lever pivots on the eccentric regulation shaft.



Due to the control lever pivoting on the eccentric regulation shaft the distance between tappet bolt and governor pin increases when the acceleration lever is moved towards full load position. Thus enabling the small tension spring to push the control lever and the connected injection pump fuel load. More fuel means higher speed, i.e. the governor pin is being pushed out further and pressed again the tappet bolt, resulting in a movement of the control lever/fuel rack towards the idle position.Less fuel is injec-ted the speed drops , governor pin moves back leaving a gap between tappet bolt and pin - and the complete governing loop starts again. Consequently the speed of the engine undergoes permannt oscilla-tions, but these are so slight that only a very sensitive revolution meter would detect them.
(Figure 16)

III.6.2. Governor setting



Each time the governor has been repaired and/or the gear cover or speed regulation assembly removed and reassembled, the governor must be reset, proceeding as follows:
Remove the governor cover plate.
(Figure 17)

Crank the engine until the governor flyweights stand in a vertical position. Put the acceleration lever in full load position. Open the lock plate and loosen the castle nut. Screw in tappelt bolt completely till tappet rests on control lever. Insert a screwdriver between the flyweights and force them apart to maximum opening.
(Figure 18)

Now screw in the tappet bolt until it just comes in contact with the governor pin (no play to be felt when pushing onto the lever with your fingers.) Release the flyweights and screw in the tappet bolt half a turn further.

Maintain the screw in this position and tighten the castle nut, bend the lock plate and reassemble the cover plate. The correct setting of the clearance between tappet bolt and governor pin is essential for the proper function of the engine. If the clearance is too wide the engine can overspeed, is it too small the engine will not reach its full speed.

Speed adjustments in the range of ± 50 rpm are possible by altering the position of the cross slotted nuts.
(Figure 19)

To increase speed - tighten the cross slotted nut.
To reduce speed - loosen the cross slotted nut.

Attention: The cross slotted nut must be at least flat with the end of the stud bold. Otherwise the self securing effect of the nut is not working. Normally the stud bold should protude out of the cross slotted nut.

For larger speed variations the governor springs must be replaced. Replace the cross slottered nuts whenever a nut has been unscrewed. Every change in speed setting should be controlled on a test bench, or at least with a revolution counter.

III.6.3. Acceleration lever

The acceleration lever is fixed in its position on the excentric shaft with a pin. The rachet plate located behind the lever is not fixed and only kept in place by the M8 nut. As the ratched plate is used as a buffer for the engine shut down, the correct position between plate and lever is important. The lower edge of the lever should leave one and a half notches visible.
(Figure 20)

If more notches are visible the shut down of the engine may be hampered; if no notch is visible, damages (denting) on the control/eccentric shaft lever may occur.
To relocate the rachet plate loosen M8 nut, hold the lever and move the plate till correct position is reached. Tighten the M8 nut while holding the lever, as otherwise the regulation linkage may be dented.

III.7. Resurfacing valve seats

The cylinder head is fitted with valve seat rings made of wear resistant steel. Should a resurfacing be necessary,use valve seat cutter. Simply insert guide pin (o.6.98 mm) into valve guide. Slide cutter over the guide and, while applying light pressure only, rotate the cutter with the T-handle.
(Figure 21)

Do not cut too deep. Observe the maximum permissible valves recess.After cutting the seat with fine grinding compound. To check the valve sealing, insert the valve and fill a small amount od diesel oil through the inlet resp. outlet channel. The sealing is ok when at a maximum 2 drops per minute leak out of closed valve.

This section is a guide to be possible location of the faults that may occure on an engine. Information of possible causes and suggested remedies are also given. But please note that this list can never be compete.

III.8. Adjustment – Injection pump – begin of delivery

Engine type	Flywheel- Part-No.:	dia-meter mm	Begin of delivery (mm) BTDC - Toleranz +-2mm engine speed (mm^{-1})							
			1500	1800	2000	2500	2800	3000	3300	3600
15B/D	738.146.4	258								
	738.149.4									
	738.158.4									
15B	738.160.4									
15B 15D	738.174.4									
	738.181.4									
	738.185.4				*			36	*	39
	738.219.4									
15D	738.223.4									
15B/D	738.237.4									
	738.254.4									
	738.255.4									
15B 15D	738.201.4	280								
	738.225.4				*			39	*	42
	738.305.4									
	738.221.4	285			*			40		43
18B 18D	738.181.4	258								
	738.185.4									
	738.208.4									
	738.226.4									
	738.236.4									
	738.238.4									
	738.244.4				*			36	*	39
	738.254.4									
	738.255.4									
	738.257.4									
	738.259.4									
	738.218.4	298			*			42	*	45
29C 32A	738.304.4	280	*41/38*		*			57/55	*	66/66
	738.270.4	304	*44/41*		*			62/59	*	72/72
	738.298.4									
	738.210.4	308	*45/42*		*			63/60	*	73/73
	738.291.4									
	738.284.4	350	*51/48*		*			72/68	*	83/83

III.8.1 Adjustment - Injection pump - begin of delivery

Engine type	*Flywheel-* Part-No.:	*dia-meter mm*	*End of delivery (mm) BTDC - Toleranz +-2mm engine speed (mm^{-1})*							
			1500	1800	2000	2500	2800	3000	3300	3600
15B/D	738.146.4	258	*	18		21			27	
	738.149.4									
	738.158.4									
15B	738.160.4									
15B 15D	738.174.4									
	738.181.4									
	738.185.4									
	738.219.4									
15D	738.223.4									
15B/D	738.237.4									
	738.254.4									
	738.255.4									
15B 15D	738.201.4	280	*	20		23			29	
	738.225.4									
	738.305.4									
	738.221.4	285	*	20		23			30	
18B 18D	738.181.4	258	*	18		21			27	
	738.185.4									
	738.208.4									
	738.226.4									
	738.236.4									
	738.238.4									
	738.244.4									
	738.254.4									
	738.255.4									
	738.257.4									
	738.259.4	258	*	*		*			20	
	738.218.4	298	*	21		24			31	
29C 32A	738.304.4	280	25			29	33	36		42
	738.270.4	304	28			32	36	40		46
	738.298.4									
	738.210.4	308								
	738.291.4									
	738.284.4	350	32			36	41	45	*	*

III.9 Torque specifications

	15B/15D/18B/18D			29C/32A		
	Spanner size (mm)	Tightening tourque (Nm) min	max	Spanner size (mm)	Tightening tourque (Nm) min	max
Cylinder head nuts	13	30	33	17	52	56
Connecting road nuts	13	30	33	14	52	56
Valve cover nuts	13	8	12	13	8	12
Main bearing plate nuts	13	30	33	13	30	33
Fuel pump nuts	13	30	33	13	30	33
Delivery valve holder – fuel pump	14	34	39	14	34	39
High pressure fuel pipe nut – fuel pump	17	18	22	17	18	22
High pressure fuel pipe nut – injector	17	25	30	17	25	30
Injector clamp nuts	10	8	12	13	20	23
Governor on crankshaft	14	55	60	14	55	60
Flywheel nut	36	216	226	46	390	410
Gear end cover screws	6	34	38	6	34	38
Tapped guide screws	4	8	10	4	8	10
Crank handle guide screws	10	8	12	10	8	12
Oil pump screws	5	16	20	5	16	20
Sump plate screws	Cross-slotted	9	11	Cross-slotted	9	11
Banjo bold on fuel pump	17	25	35	17	25	35
Plastic nipple on injector	10	6	8	*	*	*
Banjo bold on injector	*	*	*	11	8	10
Banjo bold on tank	12	8	10	12	8	10
Ölfilter	Hand-tighten!					

IV.1. TROUBLE SHOOTING

This section is a guide to be possible location of the faults that may occure on an engine. Information of possible causes and suggested remedies are also given. But please note that this list can never be compete.

IV.2. Engine will not start

Reason	Causes	Remedy
If squeak cannot be heard	No fuel in tank	Fill tank only
	Acceleration lever at stop	Set lever to full load
	Vent bore in tank cap plugged	Renew cap
	Fuel line blocked	Check system,remove blockage
Fuel supply failure -check by cranking the engine and listen for the characteristic squeak in the injector.	Fuel filter clogged	Renew filter
	Broken fuel line or leaking connection	Renew pipe/tighten connections
	Vapor lock (fuel too hot)	Cool the fuel
	Fuel too thick (no.2 in winter)	Drain and flush system, fill with proper fuel
	Faulty injector nozzle	Check/repair/renew nozzle
	Faulty injector pump	Check/repair/renew pump
If squeak can be heard	Starting fuel button not pulled	Pull button
	Gasoline instead of diesel in tank	Drain gasoline,flush system, fill with diesel
	Air intake blocked	Check system for blockage
Poor compression	Decompression device defect	Check/renew decompression device
	Incorrect valve clearance	Adjust valve clearance
	Valve not sealing properly	Check/repair/renew valves
	Valves sticking	Free valves
	Cylinder head loose	Tighten head nuts
	Piston rings stuck in grooves	Check rings and clean the piston
	Worn cylinder and piston	Overhaul the engine
Difficult to crank engine	Starting load too high	Reduce load
	Lub oil too thick	Change to correct viscosity
	Bearings seized	Overhaul engine
	Piston seized	Overhaul engine

IV. 3. Engine starts but fires intermittently or soon stop

Faulty fuel supply	Fuel filter choked Fuel line choked Leaking fuel lines or conncetions Water in fuel Faulty injector nozzle Faulty injector pump	Renew filter Check lines for blockage/restriction Check lines, tighten connections Drain fuel, fill with clean fuel Check/renew nozzle Check/repair/renew pump
Faulty compression	Incorrect valve clearance Worn valves Valves sticking Piston ring stuck in grooves Worn cylinder and piston	Adjust valve clearance Overhaul cylinder head Free valves Check rings and clean piston Overhaul engine
Faulty exhaust and intake	Restricted/blocked exhaust Restricted/blocked intake	Check/clean exhaust system Check/clean intake system

IV. 4. Engine lacks power and /or smokes black

Operation conditions	Engine overloaded- Power reduction due to altitude and ambient temperature has not been observed	Reduce load
Faulty fuel supply	Gasket under injector missing or too many installed Fuel filter blocked Fuel injector nozzle Faulty injector pump	Correct number of gasket Renew filter Check/renew nozzle Check/repair/renew pump
Out of adjustment	Incorrect valve clearance Incorrect injection timing Complete timing incorrect Piston installed wrongly (18A/C only)	Adjust valve clearance Adjust injection timing Adjust engine timing correctly Correct piston installation
Dirty engine	Blocked air intake Excessive carbon on piston and cylinder head	Clean/renew filter Decarbonize
Engine condition	Faulty piston rings Worn out piston and cylinder Worn out bearings	Check/renew ring set Overhaul engine Overhaul engine

IV. 5. Faulty running

Overheating	Engine overloaded Cooling fins clogged, flywheel air restricted Short circuit of cooling air Lub oil level too high Faulty injector nozzle	Reduce load Clean air passages, remove restrictions Improve cooling air flow (redesign application) Drain to proper level Check/repair/renew nozzle
Knocking	Carbon on piston crown Injector needle sticking Fuel timing too far advanced Broken piston ring Worn piston Worn bearings Loose flywheel	Decarbonize Fit new nozzle Adjust timing Fit new ring set Renew piston and liner Renew bearings Tighten flywheel nut
Speed is hunting	Overheating Air in fuel pipes Governor sticking Fuel filter choked	See above Check the system for leaking connections Free the governor Renew filter
Sudden stop	Empty fuel tank Vent bore in fuel tank cap plugged Vapor lock (fuel too hot) Choked injector Fuel pipe broken Seized piston Seized crankshaft	Fill tank Renew tank cap Cool fuel Renew nozzle Renew pipe Renew piston and liner Repair/ renew crank-shaft and bearings

Blue smoke	Oil level in oil bath air filter too high Breather valve choked Oil seal at intake valve defect Worn valves/ valve guides Worn piston/ cylinder	Fill to proper level Renew breather Renew seal Renew valves and guides Renew piston and cylinder
White smoke	Fuel timing too late Injector nozzle worn out	Adjust timing Renew nozzle
Oil pressure warning lamp on	Oil pressure warning lamp is defect Oil level is too low	Exchange warning lamp Measure oil level, if necessary top up oil
Oil pressure is too low	Pressure valve is defect, ball place in the pressure valve is dirty. Oil filter is restricted lub oil pump is defect.	Check/clean if necessary renew