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SACHS DIESEL 500

MANUAL No. 522.2E/3

FICHTEL & SACHS AG
SCHWEINFURT

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INDEX

SPECIFICATION

Operating principle:	Two-stroke diesel with swirl chamber
Stroke:	100 mm
Bore:	80 mm
Cylinder capacity:	499 cc
Continuous output:	8 H.P. at 2000 r. p. m.
Intermittent output:	10 H.P.
Direction of rotation:	Anti-clockwise (as viewed from flywheel)
Compression ratio:	18:1, referred to total stroke
Cooling system:	Water cooling by tubular radiator without pump. Radiator capacity approx. 4 litres.
Lubrication:	Forced lubrication by pump SP/G 02/70 R 2
Injection equipment:	Bosch pump PFR 1 A 50/158/11, Delivery pipe 6 x 2 mm dia., Nozzle holder Bosch KBA 38 S 1/13, Bosch pintle nozzle DN 12 SD 12
Injection pressure:	120 atm. (gauge pressure for new nozzle). After a fairly long period of operation the pressure may diminish, but should not drop below 100 atm.
Commencement of injection:	6.4—6.8 mm before T.D.C.
Fuel filter:	Knecht "Mikronik" filter FB 414/1 M with renewable filter cartridge
Air cleaner:	Mann & Hummel oil-bath air cleaner LOZ 1,6—16
Electrical equipment:	Bosch F-AL/EGE 1,3/12 AR 5 inertia gear-drive starter, 12 Volts (optional extra) Bosch KE/GSA 1/2 heater plug
Dynamo output:	Without starter - altern. current 6 V—17 W With starter - direct current 12 V—75 W
Fuel consumption:	0.6—2.0 litres/hour, according to load
Lubricating oil consumption:	Approx. 90 cc/hour at 200 r. p. m.; 50—70 cc/hour an agricultural and haulage duty

INSTALLING OR MOUNTING THE ENGINE

The SACHS Diesel engine is an independent power unit, capable of being used for a great variety of purposes, e.g., for driving tractors, construction machinery, electric generating sets, pumps, etc. If you have purchased a piece of equipment complete with engine, then the conditions of installation applicable to any internal combustion engine will have been duly complied with by the makers of the equipment in question. In a case where a SACHS Diesel 500 engine is being used for a special purpose, however, it is absolutely essential to satisfy the following requirements with regard to installing or mounting the engine:

(1) The cooling air drawn by the fan through the radiator core must be able to flow away freely from the front of the engine, especially if the latter is installed under a protective cowling or bonnet. The cowling should always permit the entry of fresh air and the escape of hot air in sufficient quantities, or else the engine will not be properly cooled.

(2) All the parts of the engine that require periodical servicing, such as oil filler openings, inspection glasses, oil outlets, lubricating points, fuel filter, injection nozzle, etc., as well as all the operating levers and other controls, should be directly accessible for maintenance and observation.

(3) When installed, the engine must not (not even temporarily) be tilted at an angle of more than 15°. If this angle is exceeded, the lubrication conditions in the engine are liable to be adversely affected.

(4) Although the engine is not affected by atmospheric influences, a cover to protect it from rain should be provided, as this will help to keep it in good running condition. In tropical climates the engine should be protected from direct sunlight (by means of awnings, etc.).

(5) The entry of dust into the air cleaner and the engine should be prevented as far as possible by means of protective screens.

(6) If the engine is installed in an enclosed space, good ventilation is essential. In addition, the exhaust gases should be discharged into the open air through the shortest possible pipe (not less than 60 mm dia.), which should be free from sharp bends.

(7) It is necessary to provide sufficient space for operating the starting crank or starter pulley.

(8) The engine should be securely flanged in position or, alternatively, its pedestal should stand on a hard and firm flat base. The frame of the machine or other equipment to which the engine is fixed should be strong enough to preclude any distortion between the engine and the mechanism it drives. The engine shaft and the shaft of the driven machinery should, when coupled directly, be perfectly aligned.

(9) To avoid vibrations, the frame supporting both the engine and the driven machinery should not be in direct contact with the foundation, but should be placed on rubber damping pads.

EFFECT OF LOCATION OF ENGINE ON PERFORMANCE AND ON THE QUANITY OF FUEL INJECTED

1. The **performance** data for the engine relate to an intake air temperature of + 20° C., a relative atmospheric humidity of 60%, and an altitude of about 1000 ft. (300 m) above sea level. Any deviation from the above values will affect the engine performance and tuning. In cases where an engine is used in warm or humid climates, or at high altitudes, the following appromixate rules will enable the effect on the power output to be estimated:

   1.1 For every 330 ft. (100 m) above the standard altitude of 1000 ft. (300 m) the output will be reduced by about 1.4%.

   1.2 For every 10° C. increase in the intake air temperature above 20° C. the output will be reduced by about 4%.

   1.3 For extremely high values of atmospheric humidity (90—100%) and for air temperatures of 40°—50° C. the output will undergo a reduction of about 5%.

Example:

Engine rating 8 H. P., operating at altitude of about 4000 ft. (1200 m) above sea level, air temperature + 30° C., relative atmospheric humidity 100%.

Reduction in output:

1.1 due to difference in altitude of 1200 m—300 = 900 m is 9 x 1.4% = 12.6%;

1.2 due to difference in air temperature of 30°—20° = 10° C. is 1 x 4% = 4%;

1.3 due to higher atmospheric humidity is, say, = 2%

The total reduction in power output is therefore 18.67%, i. e., the output will go down from 8 H. P. to 6.65 H. P.

2. **Reducing the quantity of fuel injected**

If the power output of the engine diminishes in consequence of atmospheric conditions, it is essential to reduce the quantity of fuel injected. To effect the appropriate reduction, the smoke stop (Fig. 3) should, after slackening the counter nut, be given one turn to the right (clockwise) for every 1300 ft. (400 m) increase in altitude. Failure to reduce the quantity injected will cause incomplete combustion (due to unsufficient supply of air to burn up all the fuel), overheating of the engine, dirty exhaust, and excessive clogging of the interior of the engine with carbon deposits which will cause engine trouble.

Example: Engine operates at an altitude of 4900 ft. (1500 m), i. e. 3900 ft. (1200 m) above the reference altitude of 1000 ft. (300 m). Hence the smoke stop should be screwed in (cockwise) three turns (Fig. 3).

PUTTING THE ENGINE INTO OPERATION

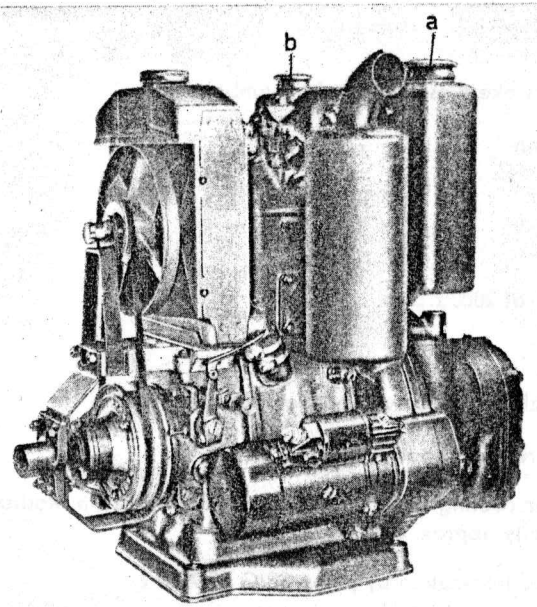

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Fig. 1:
a) Filler cap for fuel tank
b) Filler cap for oil tank

1. GETTING THE ENGINE READY FOR USE

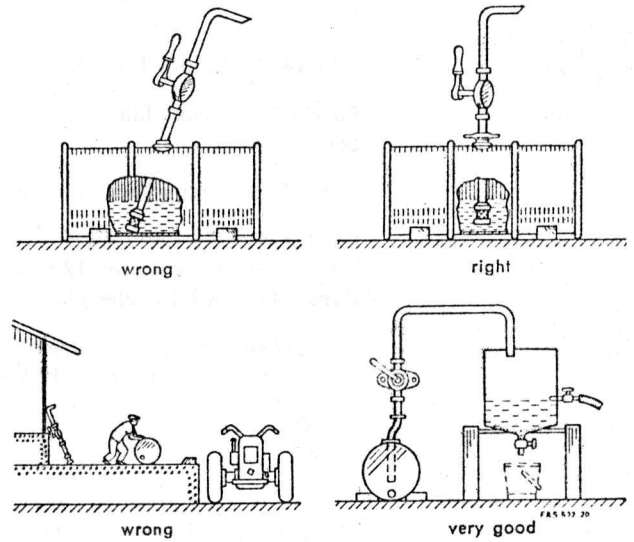
1.1 FILLING THE FUEL TANK

(For filling aperture on stationary engines see Fig. 1). Always use good branded diesel fuel, as this is an essential requirement for trouble-free engine performance. Please follow the instructions given here.

Storing and extracting the fuel (Fig. 2)

Before drawing fuel from them, the drums should always be allowed to stand undisturbed for at least 24 hours in order to give any contaminants in the fuel time to settle out. The inlet pipe of the pump for extracting the fuel should not go right down to the bottom of the drum. Do not agitate the drum while pumping is in progress.

Fig. 2:
The right and the wrong way to handle fuel



Putting the fuel in the tank

The fuel should be poured into the tank through a commercially available diesel oil funnel. Failing this, it should at least be poured through several layers of cloth inserted into an ordinary funnel. This is particularly essential when using the last few inches of fuel from the bottom of the drum, as this fuel has a particulary high content of impurities. Although the fuel filter on the engine intercepts all dirt and impurities and prevents them from reaching such vulnerable parts as the injection pump and the nozzle, the service life and operational reliability of all parts will be considerably increased by always filtering the fuel before putting it into the tank.

Refuelling

The fuel tank should never be allowed to run dry, otherwise air bubbles are liable to occur in the fuel filter, the injection pump and the fuel pipes, and will have to be removed by the time-consuming operation of air-venting. This operation is described in the section "Precautions subsequent to repairs".

Summer and winter fuel

In cold weather, diesel fuel purchased in summer may give trouble in consequence of the precipitation of paraffin wax in the fuel pipes and fuel filter, causing blockage of these components and putting the engine out of operation. As the paraffin content of so-called summer fuel is higher than that of fuel sold in winter, trouble is already liable to occur when the temperature drops below —8° C., whereas winter grade fuel is unaffected by temperatures at least as low as —12° or —14° C. For operating the engine at even lower temperatures, the instructions given in the section "Winter precautions" should be followed.

1.2 FILLING THE LUBRICATING OIL TANK

(For filling aperture on stationary engines see Fig. 1).
Use only a branded H. D. (heavy-duty) diesel grade lubricating oil with the following viscosity ratings:

SAE 40 in summer (April to September)
SAE 20 in winter (October to March)

On no account should SAE 40 oil be used during the winter season, i. e. at temperatures below + 10° C., as this could cause trouble in the lubrication system which would be harmful to the engine.
Never use ordinary petrol-engine lubricating oils not even for short periods), as these are unable to stand up to the severe operating conditions and moreover would desintegrate when being added to HD oil.
The oil level in the lubricating oil tank can at all times be checked by means of the gauge glass. Before starting the engine, **always** make sure that there is enough oil in the tank. As a safety precaution it is advisable to fill up with lubricating oil every time before starting the engine. If the oil tank is not replenished at the proper time, the delivery of lubricating oil to the working parts will fail and the engine will quickly be ruined.

1.3 FILLING THE OIL-BATH AIR CLEANER

Any motor oil of viscosity SAE 20 can be used for the purpose (in summer, however, SAE 40 may alternatively be used). For the sake of simplicity it is best to use the same grade of oil as that put into the lubrication tank. The oil-bath air cleaner should be filled with oil up to the appropriate mark. If the oil is found to have become contaminated with sludge, it should be changed without delay.

1.4 The **radiator** should be filled to overflowing with water having a low lime content or with boiled water. At frosty weather put anti-freeze or drain water every day.

1.5 CHECK OIL IN UNIT HEAD

The oil level glass d (Fig. 3) should be completely filled with oil when the engine is not running. If necessary, add more oil. A branded H. D. oil of viscosity SAE 20 should be used (in summer, however, H. D. SAE 40 may alternatively be used).

1.6 CHECK THE FAN BELT TENSION

(see page 14).

2. STARTING THE ENGINE

2.1 ELECTRIC STARTING

Starting from c o l d :
Place the hand control lever on the engine in the "half open" position; then pull out the starting knob b (Fig. 3) with the forefinger and middle finger. Insert the ignition key and push it until the red control lamp lights up. Apply preliminary heating for about ½—1 minute. Then work the starting device (turn switch, pull switch or press switch).

2.2 STARTING BY HAND

Starting from c o l d :
Screw the fuse holder a (Fig. 4) out of the cylinder head. Pull out the starting knob b (Fig. 3) with the forefinger and middle finger, while at the same time the thumb pushes the control lever a (Fig. 3) to the right until it reaches the "half open" position. Now turn the engine over by means of the starting device until the fuel can be felt pulsing in the fuel delivery pipe when the finger tips are placed on it.
In cold weather the commencement of injection is indicated by white fuel vapour emerging from the fuse hole in the cylinder head. Insert the white end of a starting fuse (supplied by F & S and called "Self-igniting fuses for SACHS-Diesel engines") into the fuse holder a (Fig. 4) and screw the latter into the cylinder head. Give the fuse holder a light tap with a hard object to tighten it. Now start the engine.

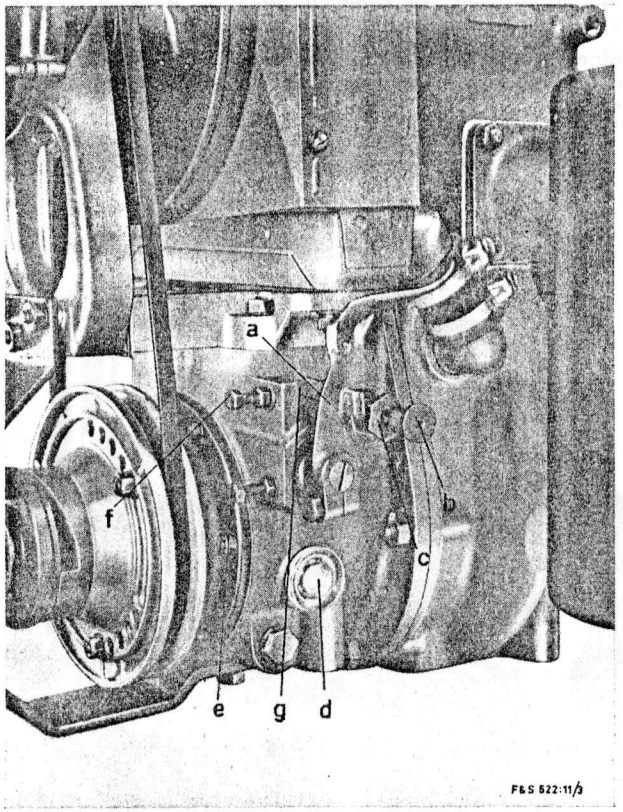


Fig. 3:
Engine controls and adjustments

a) Hand control lever
b) Starting knob
c) Smoke stop
d) Oil level glass
e) Maximum stop (adjusting screw)
f) Idling stop (adjusting screw)
i) Plate spring on hand control lever

a) With starting crank (Fig. 5)

Insert the crank in such a position that when it is pulled **upwards** the resistance due to the compression of the engine can be felt. Let the crankshaft swing back, again turn the starting crank against the compression, let it swing back once more, and then pull it up with a short sharp jerk. Take care that no one is standing within range of the crank should it fly back. The object of swinging the crankshaft to and fro in this way is to enable it to gain enough swing to rotate the engine quickly.

b) With starter pulley (Fig. 6)

Turn the starter pulley by hand in the direction of the arrow until you feel the compression of the engine. Then wind the starter belt around the pulley — about 1½ turns in direction of arrow — and pull the belt, let it swing back, again pull it against the compression, let it swing back once more, and then give it a sharp tug. (Caution: do not wrap the free end of the belt around your hand!). The object of this procedure is to give the crankshaft enough swing to rotate the engine quickly. In very cold weather the lubricating oil is liable to have become so thick and viscous that the necessary swing is not obtained even after several turns of the crankshaft. In that case cranking will have to be continued until the oil becomes more fluid and the engine can be turned easily. If the engine fails to start on being given its first complete revolution by means of the starting crank (or starter pulley), the fuse holder should be unscrewed and a fresh fuse inserted. Before re-inserting the fuse holder into the cylinder head, turn the engine a few times.

I m p o r t a n t ! Always pull out the starting knob before starting the engine. This is essential to ensure automatic adjustment the commencement of delivery by the pump and to prevent the starting crank from kicking back.

Starting the warmed-up engine. In thise case it is not necessary to unscrew the fuse holder, nor to effect preliminary injection of fuel and insert a fuse. Cranking should be done as described above.

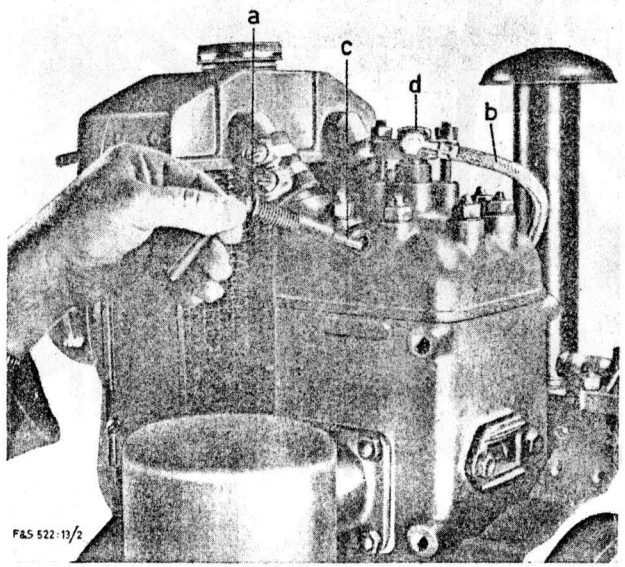


Fig. 4:
Cylinder head and fuse holder
a) Fuse holder
b) Leak-off pipe
c) Fuse
d) Nozzle holder

3. RUNNING THE ENGINE

After the engine has started up, the hand control lever should be moved back to the idling position. When running the engine under load, adjust the position of the control lever as required. Take care not to run the engine at too low a speed (not below 1400 r.p.m.). On haulage work therefore change down to the next lower gear in good time. High engine speeds can do no harm, as the governor will protect the engine from overspeeding.

TO STOP THE ENGINE, push the control lever a (Fig. 3) right back and push it as far as possible to the left against the pressure of the spring i (Fig. 3) (which serves to limit the travel of the lever) until the injection pump stops delivering fuel and the engine comes to a standstill.

RUNNING-IN. While there is no need to be over-cautious during the running-in period, it is essential not to tax the engine to the limit of its capacity in the first twenty hours of service.

SOME IMPORTANT HINTS

To gain the necessary acquaintance with the functioning of the engine and its requirements, it is advisable to read the section "Description of the engine". Furthermore, in the interests of the operational reliability of your engine, make sure that the following requirements are fulfilled (which are dealt with in greater detail in the section "Maintenance of the engine"):

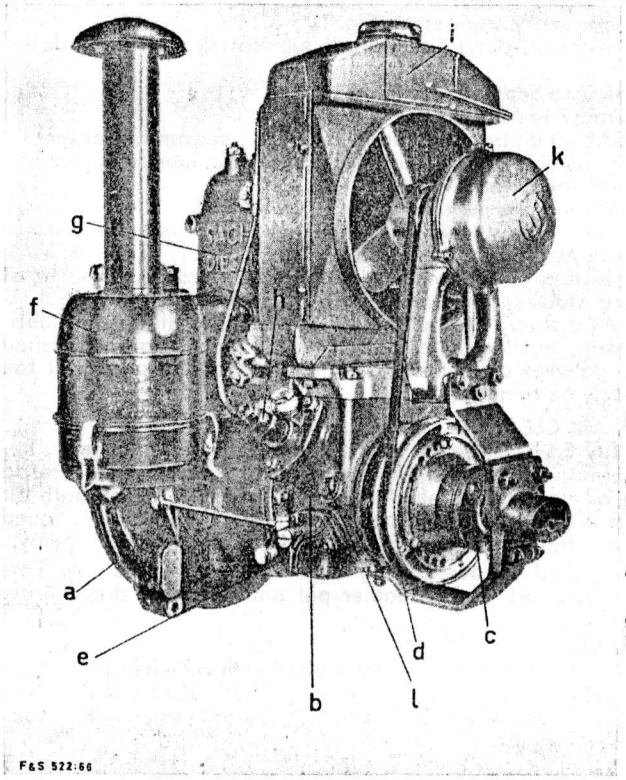


Fig. 5:
Engine viewed from the right
a) Flywheel housing
b) Unit head
c) Starter dog
e) Lubricating oil pump
d) Pulley for fan belt
f) Oil-bath air cleaner
g) Cylinder casing
h) Fuel injection pump
i) Radiator
k) 16-Watt dynamo
l) Oil filler plug for unit head

Before starting

Fuel tank: Use only branded fuels. Pour fuel into tank through diesel oil funnel (or through several layers of cloth). See page 5.

Air cleaner: Under moderately dusty operating conditions, change oil in air cleaner as required. Under very dusty conditions, change it every five hours. For instructions see page 13.

Lubricating oil tank: Fill it with branded H. D. oil SAE 40 in summer (April — September) or branded H. D. oil SAE 20 in winter (November — March).

Radiator: Fill up to overflow with water of low line content or with boiled water.

Every 30 running hours

Air cleaner: Change the oil in the cleaner, if the intake air contains little dust. For instructions see page 13.

V-belt of fan: Check the belt tension. Tighten it if it can be deflected more than 20 mm (about 3/4 in.) by hand. See page 14.

Unit head: Check oil level: when engine is running, oil level glass should be half filled (if necessary add oil: H. D. oil SAE 20 in winter, H. D. oil SAE 40 in summer).

Fan bearing: a (Fig. 9) on engines without dynamo: Fill grease cup with fresh grease (chassis grease or anti-friction bearing grease) and retighten cup.

Every 100 running hours

Battery servicing: On engines fitted with electric starting.

Starting ring and crank: Grease them.

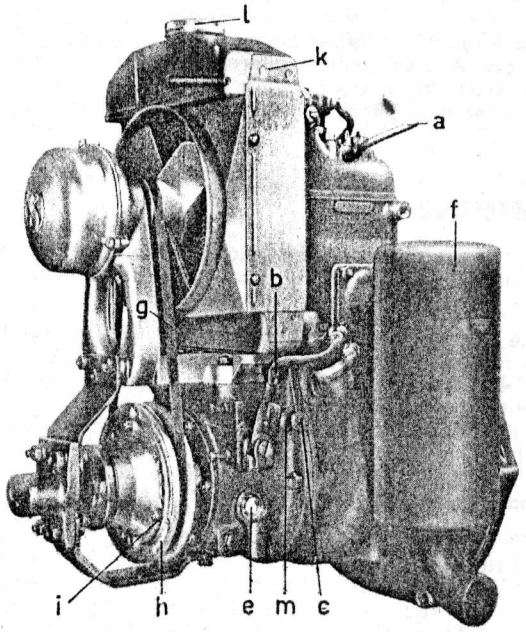


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Fig 6:

Engine viewed from the left

a) Fuse holder
b) Hand control lever
c) Starting knob
e) Oil level glass
f) Silencer
g) V-belt driving fan
h) Front cheek of belt pulley
i) Belt pulley clamping nut
k) Radiator
l) Filler cap
m) Smoke stop

Every 150 running hours

Lubricating oil tank: Drain completely and refill with fresh oil. For oil-change instructions see page 6.

Air cleaner: Clean out the upper part. See page 13.

Fuel filter: Check whether water has been deposited in it. See page 17.

Dynamo: Squeeze in 1/4 tube of speedometer drive grease. See page 14.

Every 1000 running hours

Unit head: Change the oil. Put in 0.5 litre (1 pint) of branded H. D. oil SAE 20 or 40. See page 14.

Nozzle holder and nozzle: Have them checked (SACHS or Bosch service station).

Pipe connections before oil pump: Check for clogging deposits, and clean if necessary.

Fuel filter: Fit a new filter element, See page 17.

As and when necessary

Exhaust silencer: Clean or burn it out at appropriate intervals. This should certainly be done as soon as smoke, oil or sparks issue from the exhaust pipe. If the engine is used for haulage work or generally operates under light loads, it will sooner be necessary to clean the exhaust system than when the engine is operated under heavy loads. Broadly speaking, it should be cleaned at approximately 100-hourly intervals. See page 17.

Cold weather precautions: Check whether water has collected in the lubricating oil tank, oil filter, fuel tank and fuel filter. If so, clean them. Change the oil in the oil tank, unit head and air cleaner to grade SAE 20. See page 10.
Put anti-freeze in radiator.

DESCRIPTION OF ENGINE

The **crankcase and cylinder** of the SACHS Diesel 500 are a monobloc casting, which constitutes the simplest solution for enabling them to withstand the high pressures of the diesel operating cycle.

The supports for the fuel tank and lubricating oil tank can be fixed to the cylinder. At the bottom of the crankcase are robust lugs to which the mounting pedestal is bolted in the stationary version of the engine.

Below the cylinder the crankcase forms a tunnel into which the crankshaft can be inserted endwise. By means of an access cover a (Fig. 7) at the bottom of the crankcase the big-end bearing can be removed and replaced without having do detach the whole engine from the machinery it drives. An oil drain plug c (Fig. 7) is provided at the centre of the access cover.

The **cylinder head** carries the nozzle holder and injection nozzle (d) (Fig. 4). The nozzle sprays the fuel into a spherical swirl chamber which is connected by a passage to the actual cylinder. The fuse holder (a) (Fig. 4) projects into this swirl chamber.

The light-metal **piston** is provided with four compression rings which are secured against rotation; the bottom ring also functions as an oil scraper. The top piston ring has a trapezoidal cross-section and must therefore not be interchanged with the other rings.

The **unit head** b (Fig. 5) carries all the auxiliary equipment of the engine (governor, driving mechanism for fuel injection pump and oil pump). For lubricating these components the unit head is filled with 0.5 litre (1 pint) of oil. This oil is **not** in communication with the lubrication system of the crankcase and the main driving components it contains. Hence the oil in the unit head is hardly used up. The level of the oil can be checked by means of the oil level glass e (Fig. 6) on the left-hand side of the engine. When the engine is running, the oil should be half-way up the glass.

On the unit head is mounted the radiator, while on the right-hand side facing forward (as seen when looking directly at the flywheel) are the fuel injection pump h (Fig. 5) and, below the latter, the lubricating oil pump e (Fig. 5) for the main driving components of the engine. In addition to the driving mechanism for the above-mentioned auxiliary equipment, the governor for regulating the engine speed is accommodated within the unit head. Conveniently positioned on the left-hand side are the hand control lever b (Fig. 6) and the starting knob c (Fig. 6) with the smoke stop m (Fig. 6).

The **tank,** which is divided into two parts for fuel and for lubricating oil respectively, may be mounted either on a pair of supports attached directly to the cylinder or, alternatively, it may be mounted on the driven machinery and at higher level than the engine itself, so that the fuel and lubricating oil are fed to the pumps under a certain amount of pressure. The **silencer** and the **oil-bath air cleaner** are flange-mounted on the left and right of the cylinder respectively.

The **lubrication system** is of the forced-feed type, i. e., when the engine is running, oil is constantly fed to the main driving components in the crankcase and is, for the most part, consumed in the process. Consequently the oil level in the lubricating oil tank will steadily go down while engine is in operation. It is therefore essential to keep a constant check on the oil level in the tank d (Fig. 12, stationary version of engine) by means of the gauge glass i (Fig. 12) so as to ensure that the engine will not all at once be running without lubrication oil.

Oil from the tank flows to the oil pump e (Fig. 5), which is a plunger pump driven through spiral gearing. The delivery rate of the pump is pre-set at the Factory. The pump keeps the two crankshaft bearings supplied with fresh lubricating oil. The oil emerging from these bearings runs into annular channels in the crank webs. These channels communicate with an oilway in the crankpin through which the oil is fed by centrifugal action to the big-end bearing. The oil thrown off the big-end bearing lubricates the cylinder bore.

Cooling system. The engine is water-cooled. The water circulates automatically as long as the radiator k (Fig. 6) is kept filled to the top.

The filler cap l (Fig. 6) should close the radiator so tightly as to enable a certain pressure to build up inside the radiator. If the pressure exceeds a given value, a ball relief valve fitted in the radiator opens automatically and allows the steam to escape.

Fuel injection: From the elevated fuel tank the fuel passes through a filter which intercepts any dirt and contains a filter element a (Fig. 10) which should be renewed every 1000 running hours. From the filter the fuel flows to the Bosch injection pump h (Fig. 5). This pump can function satisfactorily only if the fuel fed to it is free from air bubbles. That is why the fuel tank should never be allowed to run dry, or else the fuel injection system will have to be air-vented.

The **crankshaft,** which is forged in one piece from high-grade steel, is provided at each end with a large parallel roller bearing. The split big-end bearing is of the steel-backed lead-bronze-tin lined type. The rear roller bearing (i. e., on the flywheel side of the engine) is mounted in a grey cast iron housing which is bolted to the flywheel housing. The flywheel housing is designed as a mounting flange by means of which the engine can be attached directly to the machinery it drives. The fuel filter is fitted to the flywheel housing. The front crankshaft bearing is mounted in the back wall of the unit head which closes the front of the crankcase. The crankshaft is provided with air- and oil-tight rubber seals, a single-lipped type at the crankshaft takes the form of a starter dog c (Fig. 5) which carries the pulley d (Fig. 5) for the fan belt and which is engaged by the starting crank.

The **governor** keeps the engine speed constant at any particular value to which it has been set and prevents racing under light loads. It consists of a fixed and a movable cup mounted on the crankshaft and enclosing a number of steel balls which are flung outwards by centrifugal force when the engine is running. The balls tend to displace the movable cup, and the movements of the latter are transmitted, through the medium of the governor fork and a linkage system, to the rack control

rod of the injection pump. The output of the pumps is reduced in proportion as the movable cup of the governor undergoes a greater displacement. The centrifugal force of the steel balls is balanced by a torsion spring to which a load is applied by means of the hand control lever. The farther the control lever is swung over to the right, the greater is the load applied to this spring and the higher is the speed at which the governor responds. The maximum spring load is determined by the setting of the lower adjusting screw e (Fig. 3) on the unit head. **The setting of this screws must on no account be altered in any way.** On the unit head, above this maximum r.p.m. adjusting screw f (Fig. 3), is a second adjusting screw (provided with a lock nut), which serves as a stop for the spring on the control lever. This latter screw determines the idling speed of the engine. The idling speed will be higher according as the screw is turned farther in f (Fig. 3).

A pull-out starting knob b (Fig. 3) is mounted on the unit head beside the hand control lever a (Fig. 3). Its function is to increase the fuel supply to the engine, e. g., when starting up. If, before starting the engine, the control lever is moved over to the right as far as it will go and the starting knob is pulled out, the governor will automatically set the injection pump to maximum delivery. When the engine has started, the governor responds immediately and allows the starting knob to return to its home position.

Important! When the starting knob is pulled out, the injection timing is retarded by an amount corresponding to 9—10° of crank angle in order to reduce the risk of kick-back.

The rod of the starting knob slides in a threaded sleeve which forms the smoke stop c (Fig. 3). At each stroke of the piston the engine can effect the smokeless combustion of only a certain definite quantity of fuel. If fuel is delivered in excess quantities, combustion will be incomplete, and black smoke will issue from the exhaust. Under such conditions carbon is soon deposited on the injection nozzle, in the exhaust port and in the silencer and will adversely affect the running of the engine. The maximum permissible rate of fuel delivery by the injection pump is determined by the setting of the threaded hexagon headed sleeve, which is secured in position by means of a lock nut. Any subsequent alteration to the setting of the smoke stop, after the engine has left the manufacturing works, should be carried out by a SACHS service station. See also "Reducing the quantity of fuel injected", page 4.

MAINTENANCE OF ENGINE

This section describes the correct procedures for complying with the points indicated in the section "Some important hints" on page 10. In addition, some further essential instructions are given.

1. **OIL-BATH AIR CLEANER:** The oil level in the air cleaner b (Fig. 12) should always be kept within the appropriate marks. If necessary, replenish with oil. The oil must be changed from time to time. The frequency with which this should be done will depend on how dusty the conditions are under which the engine is operated. Thus it may be necessary to change the oil after only a few hours. It must in any case be changed when the sludge that forms in the oil bath reaches a depeth of 1 cm (about 3/8 in.). **Oil that has become heavily contaminated with sludge clops up the air cleaner and is liable to cause harm to the engine.**

How to remove the dirt from the air cleaner:

Unscrew the cleaner. Let the oil sludge run out, and thoroughly rinse the lower part of the cleaner with diesel fuel. The upper part of the cleaner is kept clean by the oil bath itself; all the same, it is advisable to rinse out the upper part with diesel fuel about every 150 running hours. Then dry it thoroughly. Check the intake pipe to make sure that no foreign bodies, such as straw, etc. are lodged in it. A bent or badly fitting air cleaner should be replaced by a new one. After cleaning out the air cleaner, fill it with oil up to the mark.

Suitable oil:

A motor oil of viscosity SAE 20 should be used (in summer, SAE 40 may alternatively be used). Furthermore, the old oil drained from the lubricating oil tank when carrying out an oil change may be used in the air cleaner. The contaminated oil from the cleaner itself may be re-used as well, provided that the dust with which it is contaminated is given an opportunity to settle out in a large receptacle.

Constant exposure to dust, vibrations, climatic influences and perfunctory maintenance are liable, in the long run, to cause deterioration of the filter medium. The presence of shreds of disintegrated filter filling in the oil bath is a sign that the air cleaner is due for renewal.

2. **OIL LEVEL IN LUBRICATING OIL TANK** can be constantly supervised by means of the gauge glass i (Fig. 12). Replenish the oil supply in good time — preferably before starting the engine.

3. **OIL LEVEL IN UNIT HEAD** can be constantly supervised by means of the oil level glass e (Fig. 8).

When the engine is not running, the oil should be level with the top of the glass. If it is found to be below this level, oil will have to be added: oil filler plug l (Fig. 5). Use H. D. oil of viscosity SAE 20 (in summer, SAE 40 may alternatively be used). As the oil in the unit head is in an enclosed space isolated from the atmosphere and from the combustion gases, it undergoes hardly any deterioration.

The oil change should therefore be done with the same frequency as the replacement of the filter element a (Fig. 10) in the fuel filter about every 1000 running hours. The old oil in the unit head is drained off by means of the screw plug d (Fig. 8) on the lower part of the unit head and 0.5 litre (1pint) of new motor oil (viscosity SAE 20) is then poured in through the filler plug l (Fig. 5) up to the top of the oil level glass.

4. **ADJUSTING THE FAN V-BELT** (Fig. 8)

The tension of the V-belt (a) should be so adjusted that the belt can be deflected about 10 mm (about 3/8") by pressing it with the thumb. If the belt can be deflected more than about 20—30 mm to 13/16" in this way, it requires retightening. To do this, the three nuts b (Fig. 8) which hold the belt pulley together should be removed and the movable front cheek c (Fig. 8) of the pulley be pulled off. This cheek is then turned a distance of one hole in the clockwise direction (the direction of rotation of the crankshaft) and refitted. In order to avoid pinching the belt when reassembling the pulley, the bolts should be tightened one by one, each bolt being successively positioned vertically above the crankshaft and then tightened. When is this position, each bolt will pull together only that part of the pulley which is not enclosed within the loop of the belt. After turning the crankshaft a few times and simultaneously tightening the bolts in this way, the belt will have been forced outwards and have acquired the correct tension.

5. **FAN BEARING**

On engines not equipped with a dynamo the fan bearing is provided with a grease cup a (Fig. 9), the screw cap of which should be filled at least once a month with fresh grease (chassis grease or anti-friction bearing grease) and securely retightened.

6. **LUBRICATION OF DYNAMO**

To lubricate the dynamo mounted on the fan shaft, a quarter of a tube of speedometer drive grase should be squeezed into the hole provided in the housing beside the fan blades. This should be done once in every 300 running hours. The grease hole is closed with a slotted hexagon head screw.

7. **COOLING WATER**

The radiator a (Fig. 12) should always contain sufficient water to ensure that proper circulation of the water is maintained in the upper tank of the radiator. Every day, before starting the engine, the water in the radiator should be replenished to make sure overflowing. At the same time a quick check should be made to that the ball in the relief valve moves easily and is not jammed by "fur" (lime deposit). The

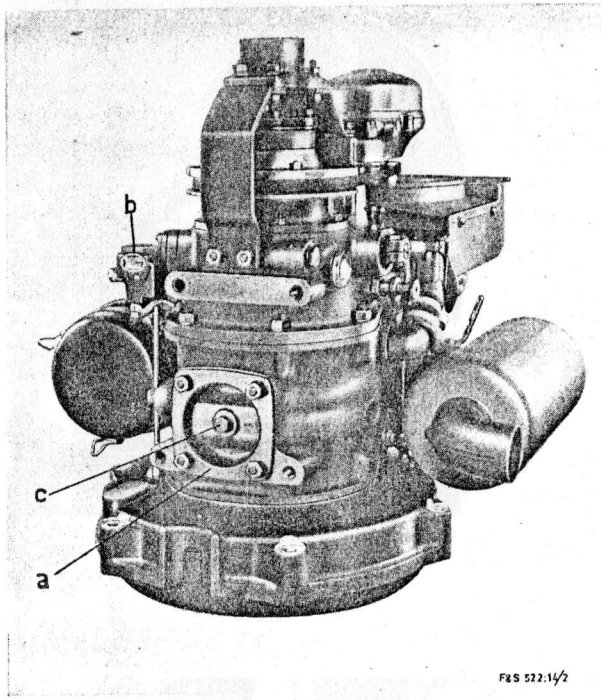

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Fig. 7:
Engine viewed from below
a) Access cover
b) Lubricating oil pump
c) Oil drain plug

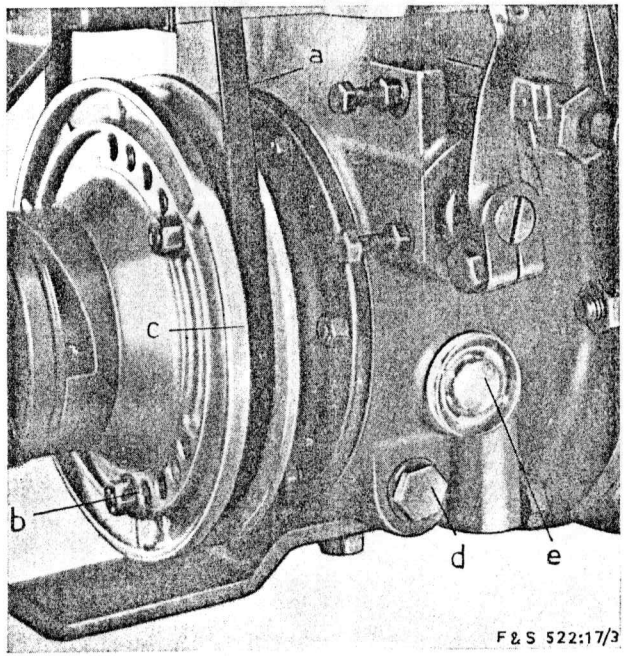

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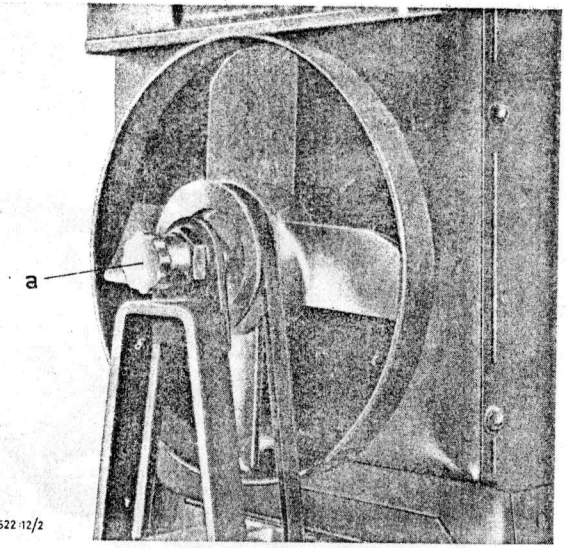
Fig. 8:
Tightening the V-belt
a) V-belt
b) Nut
c) Front cheek of belt pulley
d) Oil drain plug on unit head
e) Oil level glass

Fig. 9:
Lubrication of fan shaft
a) Grease cup



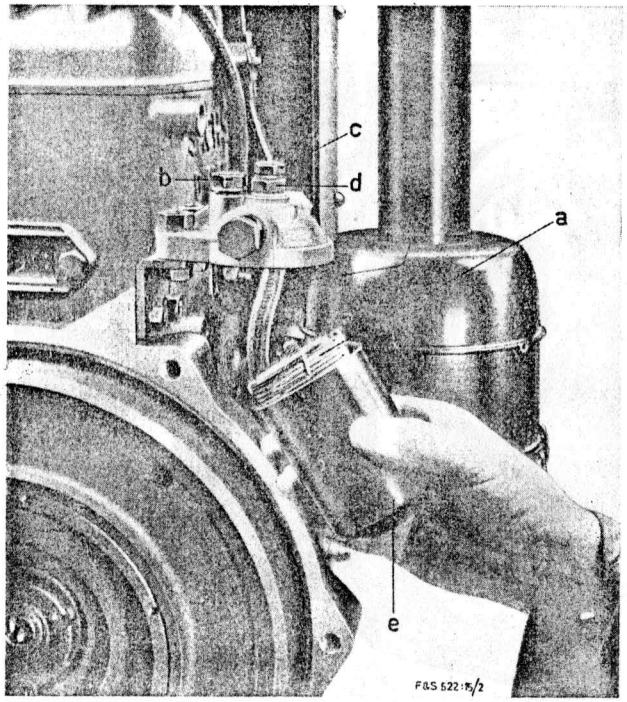


Fig. 10:
Fitting a new fuel filter element
a) Filter element
b) Air-vent screw for outer filter chamber
c) Air-vent screw for inner filter chamber
d) Hollow screw for fixing filter bowl
e) Filter bowl

water should have a low lime content. In frosty weather anti-freeze should be added or, alternatively, the cooling water should be drained off after the engine has been finally stopped. Both the drain cocks at the bottom of the cylinder, on the right-hand and left-hand side respectively, should be opened; they should be closed again as soon as the water has been drained.

The total capacitiy of the cooling system is 4 litres.

8. FUEL FILTER MAINTENANCE

8.1 Checking for deposited water.

At intervals of about 150 running hours the fuel filter should be inspected to ascertain whether water, which may have been mixed with the fuel (lack of care in filling the tank, condensation signs), has been deposited in the filter. The presence of water in the filter interferes with the proper fuel supply to the engine. To dismantle the fuel filter the hollow screw d (Fig. 10) at the centre of the filter cover should be slackened (using the 17 mm spanner). The bowl, or body, of the filter can then be detached. Any water that may be present in the filter bowl should be poured out and the bowl dried. Water that has got into filter element must likewise be carefully removed. The filter element should be very thoroughly rinsed in clean diesel fuel and then be left to dry for several hours (preferably overnight) in moderately warm surroundings. Before reassembling the filter, the filter element should be immersed in diesel fuel for about five minutes so that it can soak up the fuel and get rid of the air in its pores. If this is not done, the operation of air-venting the fuel filter — which is in any case necessary after refitting the filter — will have to be done a second a time after only a few minutes.

8.2 Fitting a new fuel filter element

After a fairly long period of operation — at the end of about 1000 running hours or when the engine has consumed the contents of five 200-litre drums of fuel (approx. 220 gallons) — the fuel filter element will have to be renewed. For this purpose the filter must be dismantled as described under section 8.1. The new filter element should also be immersed in diesel fuel for five minutes so as to soak up fuel. The fuel filter should then be vented (as described on page 18).

9. CLEANING THE SILENCER AND EXHAUST PORT

When the engine begins to lose power and sparks appear in the exhaust gases, the silencer should be detached and the carbon deposited in it be removed. If oil comes out of the exhaust pipe, the silencer should likewise be detached and cleaned by burning it out. If the engine is used for haulage work or generally operates under light loads, it will sooner be necessary to clean the exhaust system than when the engine is operated under heavy loads. Broadly speaking, it should be cleaned at approximately 100-hourly intervals. To burn out the carbon, the components of the silencer should be made red hot in a forge or with a welding torch. Then scrape off the carbon coating with the aid of a sharp tool (scraper). On no account must the holes in the silencer be altered, as this is liable to cause fluctuations in the power output of the engine.

When cleaning the silencer, place the piston at **bottom dead centre** and check whether carbon has been desposited in the exhaust port. Any carbon deposited there can be scraped out with aid of a tool such as a screwdriver (do not use a very sharp tool for the purpose).

10. TESTING THE INJECTION NOZZLE

A decline in engine power or a tendency to develop rough running may be due to combustion products (oil carbon and coke-like deposits) or to the use of badly filtered fuel, which may have impaired the functioning of the injection nozzle or caused jamming of the needle. Should this occur, and preferably also at intervals of about 1000 running hours (i. e. every time the fuel filter element is due for renewal, the nozzle and nozzle holder should be dismantled and cleaned or, alternatively, a new nozzle and holder fitted. Use a new copper sealing ring for refitting the nozzle holder into the cylinder head.

Special skill and special tools are required for dismantling these components, and it is highly advisable to have this work carried out by a SACHS or Bosch service station. In cases where no service station is near at hand, it is best to keep a spare nozzle holder and nozzle in reserve.

Before refitting the nozzle holder, the hole for the holder and the combustion passage in the cylinder head should be cleaned and freed of carbon deposits. The fixing screws for the nozzle holder should be tightened gradually and uniformly.

PRECAUTIONS SUBSEQUENT TO REPAIRS

Air-venting the fuel injection system (Fig. 11)

When carrying out work on the fuel injection system, it is most essential, before slackening any screws or plugs associated with this system, to clean the surroundings of such screws or plugs very thoroughly so as to remove any dust or dirt adhering there. The areas affected by the operations should preferably be cleaned with a brush and a liberal quantity of diesel fuel. On no account must any foreign matter get into the plug holes, as this would quickly ruin the injection pump and nozzle.

All the banjo plugs of the fuel feed pipe to the pump, and the union nuts of the fuel delivery pipe, should be slackened for venting, but they should not be screwed right out (as a precaution to prevent dirt getting in).

When the fuel tank has been filled, the first thing to do is to vent the **fuel filter.** Slacken the hexagon head screw b (Fig. 10) over the outer chamber of the filter to such an extent that the fuel emerges here and is free from bubbles. Air which has collected in the inner chamber of the filter is allowed to escape through the air vent at the centre of the cover. When the upper screw is being slackened (using 14 mm spanner), the hollow screw below it must be held with a 17 mm spanner.

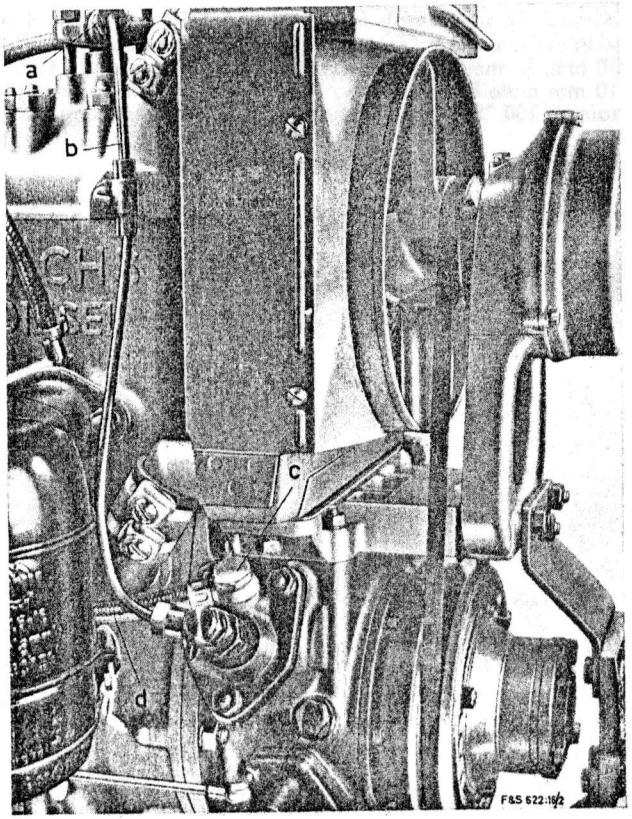


Fig. 11:
Air-venting the fuel injection system
a) Nozzle holder with nozzle
b) Fuel delivery pipe
c) Hollow screw of fuel feed pipe to pump
d) Fuel feed pipe to pump

Air in the **fuel injection pump** can be removed by slackening the banjo plug c (Fig. 11) which connects the fuel feed pipe to the pump. To get rid of air in the **fuel delivery pipe,** the union nut at the nozzle holder should be slackened. Then turn the crankshaft until fuel emerges free from bubbles (rotating the crankshaft can be done with the aid of the starting crank or starter pulley with handle inserted). While doing this, pull out the starting knob b (Fig. 3) and move the hand control lever to the "fully open" position. Then carefully retighten all screws and plugs.

Venting is done:

1. Between oil tank and oil pump
   Slacken the banjo plug connecting the feed pipe from the oil tank to the lubricating oil pump (hollow screw). Only when the oil emerges at this point free from bubbles, the screw plug can be retightened.
2. Between oil pump and point of lubrication
   Remove the plugs on the hollow screws on the oil pump. Squirt a liberal quantity (about 5—10 ccm) of H. D. oil SAE 20, with the aid of an oil feed can. Now, wait ten minutes and then let the excess oil drain off through the oil drain plug c (Fig. 7).

Starting the engine after major repairs

When starting the engine for the first time following the execution of major repairs — involving, for example, the removal and subsequent refitting of the piston — it is necessary first of all to drain off the motor oil which is liberally applied to the piston and other components during assembly and which collects in the crankcase. This is done by opening the oil drain plug c (Fig. 7) in the crankcase cover underneath the engine. Also if it should occur under rough conditions of operation, especially

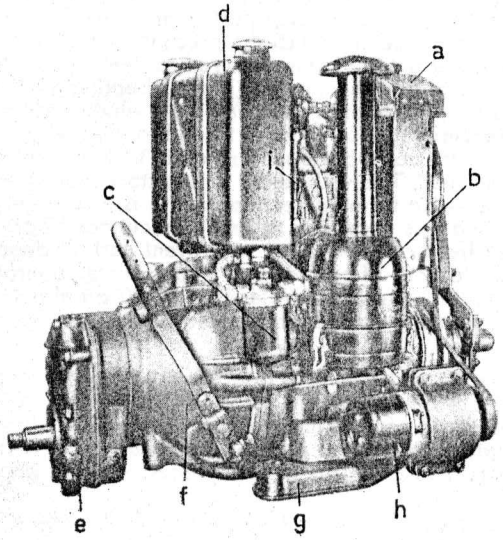


Fig. 12:
a) Radiator
b) Air cleaner
c) Fuel filter
d) Fuel tank
e) Gearbox
f) Clutch housing
g) Pedestal
h) Dynamo 75 Watt
i) Oil gauge glass

when driving agricultural two-wheel tractors, that the whole engine is overturned (in which event the engine should be stopped at once — by screwing out the fuse holder, if need be), the above-mentioned oil drain plug should be opened after the engine has been restored to the upright position. This will enable any oil from the oil-bath air cleaner which may have entered the engine through the induction pipe to drain away. When starting the engine it should always be checked that there is no appreciable quantity of oil in the crankcase.

WINTER PRECAUTIONS

When cold weather sets in, the following precautions should be taken:

1. **Servicing**

At the start of the frosty period inspect the fuel filter, the oil filter, the fuel tank and the oil tank to ascertain whether water has been deposited in them. If this water freezes, it may stop the supply of fuel or, worse still, the supply of lubricating oil to the engine and thus cause serious damage. After emptying the fuel tank and oil tank, blow them out with compressed air before filling them up with new fuel and oil respectively.

Important: Having filled the tanks, the next thing to do is to vent the lubricating oil system and fuel injection system (see page 18 and 19).

2. **Drain off cooling water** before each standstill or fill in anti-freeze.

3. **Changing to winter grade oil**

The lubricating oil in the tank should be changed over from H. D. SAE 40 to H. D. SAE 20.

4. **Use winter grade fuel**

In winter, when the external temperature drops well below freezing point, trouble is liable to occur in the operation of diesel engines. One particular source of trouble can be eliminated by using winter grade fuel, in which the precipitation of paraffin wax in the form of flakes does not occur until the temperature has descended below — 11° to — 15° C. (in summer grade fuel this phenomenon starts already at —5° C.). An effective method of combating the formation of paraffin wax, which chokes the whole fuel injection system and especially the fuel filter, is to add to the fuel a small quantity of H. D. SAE 20 motor oil in the ratio of about 1 : 8 or 1 : 10 (i. e., one part of oil to eight or ten parts of diesel fuel). This will permit satisfactory operation of the engine at temperatures down to —20° C. In winter the engine is more likely to stand idle for fairly long periods, and it is necessary to take precautions to protect the vulnerable injection equipment from corrosion and to prevent carbon deposits choking the nozzle, which is liable to cool off excessively under winter operating conditions. To overcome these troubles, diesel grade H. D. SAE 20 oil should be added to the fuel. The oil and fuel should be thoroughly mixed before putting them into the fuel tank.

The fuel-and-oil mixture should be put into the tank in good time so that the engine can run on it for several hours before being stopped for a fairly long period. This will provide effective corrosion protection for all the injection components in contact with the mixture. If the oil is added too late to prevent precipitation of paraffin wax from the fuel, it will be necessary to clean the injection equipment, which is a troublesome task.

Practical examples for preparing the correct fuel-and-oil mixture in the proportion of nine parts of fuel to one part of oil:

Suppose the tank already contains 4 litres of fuel. This means it can take another 6 litres. Mix 1 litre of H. D. SAE 20 oil thoroughly with 5 litres of fuel and pour this mixture into the tank.

Or suppose the tank contains 7 litres of fuel. It can take another 3 litres. Mix 1 litre of H. D. SAE 20 oil thoroughly with 2 litres of fuel and pour this mixture into the tank.

In both cases the fuel-and-oil mixture in the tank will then be in the proportion 9:1.

5. **Unit head**

If a grade of oil other than H. D. SAE 20 is being used in the unit head, it should be completely drained off and replaced by 0.5 litre (1 pint) of H. D. SAE 20 oil.

6. **Air cleaner**

In the cold season a low-viscosity motor oil should be used in the oil-bath air cleaner as well.

7. **Starting the engine in winter**

The nozzle should be in good order, the control lever should be moved to the "fully open" position, and the engine should be completely disconnected (by means of the clutch) from the gear unit and driven machinery. Now take out the fuse holder and turn the engine a number of times while the control lever is kept at full throttle. The starting knob should not, however, be pulled out until the engine is actually being started, otherwise the cylinder is liable to be excessively flooded with fuel. In the case of an engine equipped with an electric starting device, pulling out the starting knob when starting the engine will help to preserve the battery, which is subject to particulary severe working conditions in winter.

TOOLS

A complete set of tools for carrying out the work described in this section is supplied with every engine. The tool kit comprises one spanner of each of the following sizes: 10 mm, 11 mm, 12 mm, 14 mm, 17 mm, 19 mm and 24 mm, 6 mm male hexagon key, 10 mm male hexagon key, 14 mm and 17 mm box spanner, starting crank, tin containing 100 "Self-igniting fuses for SACHS diesel engines."

TRACING AND REMEDYING ENGINE TROUBLES

If the SACHS Diesel 500 refuses to start, the cause of the trouble is quite likely to be in the **injection nozzle** or in the **injection pump.** A quick check can be made as follows:

Place the control lever in the fully open position, pull out the starting knob. Disconnect the fuel delivery pipe from the nozzle and screw out the latter. Now crank the engine.

While the engine is being cranked, fuel should flow from the delivery pipe. If this is so, insert the nozzle in the reverse position (i. e., with the nozzle openings placed upwards) into the holder on the cylinder head. Now reconnect the fuel delivery pipe to the nozzle and again crank the engine. After about 15 to 20 turns the nozzle should start functioning, i. e., fuel should issue from the nozzle openings in the form of fine jets. Be careful not to put your finger on the nozzle openings. There is a risk of poisoning!

If the nozzle fails to spray, a new nozzle should be tried. If the latter likewise fails to function, the fault must be in the injection pump.

If no fuel emerges from the delivery pipe when the engine is cranked (see above), the fault will primarily have to be sought **before** the injection pump.

Now disconnect the fuel feed pipe from the pump. If fuel emerges from the pipe, wait and see whether it is free from bubbles. If it is, then check pump again (see above). If the pump still fails to produce a spray, a new pump will have to be fitted. If no fuel emerges from the feed pipe at the pump, then the fault must be sought in the tank or the fuel filter.

Repairs to injection pumps, nozzles and governors, and adjustments to smoke stops, should always be carried out by a SACHS or Bosch service station.

Below are listed a number of engine faults that may arise, together with indications as to how they can be remedied. It is advisable to carry out the various checks and remedial operations in the sequence presented.

A. ENGINE WILL NOT START

1. **Due to a mistake in the starting manipulations**

   Hand starting:

   a) Starting knob has not been pulled out.

   b) Starting fuse is damp or oiled up.

   c) The necessary swing for starting is not obtained, as the engine is too cold. Go on cranking the engine a number of times (disengage the clutch if need be).

   d) Engine has been cranked for too long with the fuse holder unscrewed, with the result that the film of lubricating oil between piston and cylinder wall has been washed off by injected fuel.

   Electric starting:

   a) Preliminary heating-up time of incandescent starting plug not long enough.

   b) Engine is still too cold: disengage the clutch for starting up.

   c) Starting knob has not been pulled out.

2. **Due to lack of fuel because . . .**

   a) there is no fuel in the tank;

   b) air has got into the fuel injection system;

   c) fuel filter is blocked;

   d) fuel outlet opening in tank and fuel feed pipes are clogged with dirt;

   e) fuel delivery pipe is not securely fixed or has a crack in it;

   f) fuel injection pump not functioning properly because its adjustment is upset or because pump spring or plunger is broken;

   g) injection nozzle is coked up or corroded.

3. **Due to faults in the electrical equipment**

   a) battery run down;

   b) electrical connections charred;

   c) incandescent starting plug is faulty or is being by passed by current escaping to "earth".

4. **Due to inadequate compression because . . .**

   a) injection nozzle is not securely fixed;

   b) cylinder head gasket is burned through;

   c) film of oil on cylinder wall has been washed off by excessive fuel injection;

   d) piston rings sticking due to burned oil deposits (wrong type of lubricating oil being used);

   e) cylinder is worn;

   f) piston rings broken or worn;

   g) cylinder head cracked;

   h) crankcase not gastight.

5. **Due to mechanical factors because . . .**

   a) adjustment of injected quantity of fuel is upset (smoke stop);

   b) components of the speed governor are worn;

   c) cam worn or damaged;

   d) cam wrongly fitted when effecting repairs to engine.

6. **Due to lack of air because . . .**

   a) air cleaner is clogged with dirt;

   b) exhaust system is blocked with oil carbon deposits.

B. ENGINE STARTS BUT SOON STOPS

1. **Due to lack of fuel because . . .**

   a) air has got into the fuel injection system;

b) there is water in the fuel;
c) injection system has been affected in some other way.

2. **Due to mechanical factors because . . .**
   a) engine is still too cold (winter), and the viscous oil in the unit head prevents accurate functioning of the governor;
   b) governor adjustment is upset;
   c) governor sticks and thus fails to function properly;
   d) piston jamming in cylinder.

C. ENGINE POWER DWINDLES

1. **Due to lack of fuel because . . .**
   a) governor adjustment is upset (smoke stop);
   b) injection nozzle not spraying properly;
   c) injection pump plunger is worn.

2. **Due to inadequate compression because . . .**
   a) piston rings sticking due to burned oil deposits;
   b) cylinder is worn;
   c) crankcase not gastight.

3. **Due to lack of air because . . .**
   a) air cleaner is clogged with dirt;
   b) exhaust system is blocked wih oil carbon deposits.

D. EXCESSIVE FUEL CONSUMPTION

1. **Due to fuel escaping before the pump because . . .**
   a) fuel tank is leaking;
   b) pipe from tank to fuel filter not properly connected or faulty;
   c) fuel filter is leaking;
   d) air vent plugs on fuel filter are loose;
   e) fuel feed pipe to pump is leaking;
   f) banjo plug on fuel pump not securely tightened.

2. **Due to mechanical factors because . . .**
   a) governor adjustment is upset (smoke stop);
   b) injection delivery pipe is leaking.

E. VERY DIRTY EXHAUST

1. **Light smoke (oil smoke) because . . .**
   a) exhaust silencer has not been decarbonised;
   b) on downhill runs the driver relied entirely on the braking action of the engine;
   c) oil return pipe blocked or constricted;
   d) oil level in air cleaner too high, so that engine is drawing in oil;
   e) engine not correctly loaded, so that oil is not fully consumed.

2. **Dark smoke (fuel smoke) because . . .**
   a) injection nozzle delivering too much fuel;
   b) injection nozzle is faulty (dribbling).

F. ENGINE KNOCKING

1. **Due to faulty injection system because . . .**
   a) injection timing of pump is incorrect;
   b) injection pressure of nozzle is incorrect (too high or too low);
   c) inadequate compression and therefore excessively long ignition lag;
   d) combustion chamber damaged.

2. **Due to mechanical factors because . . .**
   a) carbon layer on piston and cylinder head too thick, causing piston to hit cylinder head;
   b) bearings of crankshaft, big-end bearing and small-end bearing worn.

G. IRREGULAR RUNNING, ENGINE SPEED FLUCTUATES WIDELY

1. **Due to lack of fuel because . . .**
   a) fuel filter is blocked;
   b) injection pump is not functioning correctly;
   c) air has got into the fuel pipe;
   d) injection nozzle is coked up;
   e) governor is not functioning correctly;
   f) too much play in the joints of the governor linkage.

H. ENGINE STOPS WHEN IDLING because . . .

a) idling speed is too low (for adjustment see Fig. 3);
b) fuel delivery pipe is leaking;
c) air has got into the fuel pipe.

J. ENGINE RUNS TOO FAST OR RACES

(If the engine starts racing, it can be stopped by disconnecting the fuel delivery pipe or unscrewing the fuse holder: keep clear of the fuse holder, as it may come popping out!)

1. **Due to mechanical factors because . . .**

a) governor is not regulating the engine speed;
b) governor linkage is jamming;
c) maximum stop (adjusting screw) screwed out too far.

2. **Due to ingress of oil because . . .**

a) oil from air cleaner has got into the induction pipe (due to engine being tilted, as is liable to occur on a tractor);
b) oil has collected in crankcase due to fairly long period of idleness of engine.

K. OIL EMERGES FROM EXHAUST PIPE

1. **Due to excessive fuel supply or oil because . . .**

a) injection nozzle not functioning properly;
b) adjustment of injected quantity of fuel is upset;
c) engine received too much lubricating oil due to running downhill in first gear without load;

Remedy (apart from the above points):

By burning out the carbon from the silencer.