HANDBOOK

for the

Perkins

DIESEL ENGINE

P SERIES

AGRICULTURAL ENGINES

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STARTING THE ENGINE

PREPARATION FOR STARTING

Check the radiator water level.

Check the engine sump oil level.

See that there is fuel oil in the tank.

Make quite sure that the connections on the pipe from the butterfly valve in the venturi to the pneumatic governor are absolutely tight.

Check that the starter battery is fully charged, that all electrical connections are properly made and that all circuits are in order.

PRIMING THE FUEL SYSTEM

In the case of a new engine or an engine which has been standing idle for any length of time it is important for the fuel system to be " bled," *i.e.* for all traces of air to be removed.

As the type of fuel system used may be either pressure fed or gravity fed, the method employed for " bleeding " will depend on the engine application.

The methods to be used in the " bleeding " of the respective fuel systems are given below :—

PRESSURE FED SYSTEM

Slacken the small plug on the top of the final fuel filter and operate the hand primer on the fuel lift pump until fuel oil free from air bubbles issues from the plug hole. Then tighten the plug.

Now slacken the bleed cock on the top of the fuel pump.

Again operate the hand primer on the fuel lift pump until fuel oil issues from the bleed cock and all signs of air have disappeared.

Tighten the bleed cock securely and give the primer a few more strokes in order to deliver the fuel through the relief valve in the final fuel filter, thus clearing this part of the system of air. Prime the fuel lines from the fuel pump to the atomisers by turning the engine. The engine is now ready for starting.

GRAVITY FED SYSTEM

Slacken the small plug in the top of the final fuel filter. Wait until clean fuel absolutely free from air bubbles issues from the plug hole. Tighten the plug.

Now slacken the bleed cock on the top of the fuel pump and again wait until air free fuel oil is observed flowing from the orifice.

Turn the engine in order to prime the fuel lines from the fuel pump to the atomisers.

The engine is now ready for starting.

STARTING THE ENGINE

In some applications two electric push button switches, marked " Heater " and " Starter " respectively, and a hand pump are mounted on the instrument panel or somewhere conveniently near to the engine controls. On some engines, the " Starter " switch is replaced by a starter actuating lever which is placed within the driver's reach.

In warm weather or if the engine has only been recently stopped, depress the clutch, open the throttle and engage the starter.

If the battery is sufficiently charged to turn the starter motor quickly, the engine should start.

COLD STARTING EQUIPMENT

In cold weather, if the engine has been standing, the cold starting equipment should be used.

See that there is fuel oil in the reservoir tank (if fitted).

Turn on the supply tap to the hand pump.

Unscrew the pump plunger and give it one stroke of about half an inch.

Press the " Heater " switch for about half a minute (count forty fairly slowly). Then with the " Heater " switch still pressed, the clutch pedal depressed, and the throttle fully opened, engage the starter at the same time giving short strokes on the hand pump.

The engine should then start.

If it does not, wait half a minute and try again.

If the engine does not start at the third attempt, some fault is present and an examination should be made.

TWO THINGS TO NOTE

Always be sure that the starter pinion has stopped revolving before again engaging the starter, otherwise the pinion or flywheel starter ring may be damaged.

Always screw down the plunger of the hand pump and turn off the feed tap after use, otherwise a leakage may occur with damaging results.

RUNNING INSTRUCTIONS

A diesel engine never has an involuntary stop, other than one caused through mechanical damage due to abuse, so long as there is fuel in the fuel pump and it is reaching the atomisers.
Provided

(a) that the right kind of lubricating oil is used and that it is KEPT CLEAN

(b) that the right kind of fuel oil is used and that it is KEPT CLEAN

It is usually the business of the owner of the Tractor to see that the right kinds of fuel and lubricating oils are used.

It is the driver's job to KEEP THEM CLEAN.

The manufacturers of the Perkins High Speed Diesel have equipped the engine with an efficient set of filters for both lubricating and fuel oils. If they are to work well, they must be kept clean.

It is up to the driver to KEEP THEM CLEAN.

LUBRICATION

For technical reasons the choice of an oil is more important in Diesel engines than in petrol engines.

To use the wrong kind of oil is to ask for trouble.

A list of approved oils is given on page 36.

Do not mix different brands or grades of oil. Carry a spare can of oil on the Tractor for filling up when away from home.

Do not use lubricating oil from a container which has been standing for a while with the bung out or the stopper off. It is sure to have water and dirt in it.

DETERGENT LUBRICATING OILS

When lubricating oils of a detergent type are used, care must be taken to ensure that they are not mixed, either inside or outside the engine, with oils of other grades.

If it is decided to change from a straight type lubricating oil to an oil of detergent type, the following steps *must* be taken to remove all traces of the previous lubricant.

1. Drain all existing oil whilst the engine is hot.
2. Fill the sump to just over the danger mark on the dipstick, with the new (detergent) oil ; run the engine for 10 minutes at 1,000 r.p.m.
3. Drain sump and clean the external oil filter.
4. Fill sump with new clean oil and run the engine for one day only.
5. Drain sump, fit new filter element and refill sump with clean, new oil.
6. Carry on with normal routine operation.

This same procedure should be applied when changing from one brand of detergent oil to a similar oil of different manufacture.

CHANGING THE OIL

The oil in the sump must be emptied away every 250 hours, and replaced by clean new oil. A drain plug is provided at the bottom of the sump.

SUMP CAPACITIES

P6(TA) (Fordson)	24 pints
P4(TA) (Rotary Hoes)	15 pints
P3(TA)	13 pints

LEAKAGES

Make a regular habit, once a week, of wiping the engine over, paying particular attention while doing so to the oil pipe unions, joints in the crankcase, etc., to check for leakages. Oil will leak through any gap and the location of the leakage will be easily observed.

If oil is leaking at any point, take immediate steps to remedy it.

VALVE ROCKER LUBRICATION

Every 1,000 hours, take off the cylinder head cover and, with the engine running, see that the oil is oozing slowly from the edges of the rocker arm bearings.

If it is not, and the bearings seem dry, clean all oil pipes to and from the camshaft reducer which is on the off-side of engine.

FUEL OIL

Use none but good grades of fuel oil.

Be careful that the fuel oil is clean.

Do not use fuel oil from a drum which has been standing for a while with the bung out. It is sure to have water and dirt in it.

It is better to throw away a few gallons than have the engine laid up whilst the damage caused by dirty fuel is repaired.

Some Tractors have a gauze trap in the filler of the fuel tank. This must not be removed when fuel is being poured into the tank.

If there is no filter in the filler, the fuel should be poured through a fine gauze strainer.

NOTE : **Do not store fuel oil in a galvanized container.**

FUEL LEAKAGES

As explained previously, fuel systems employed on P Series tractor engines fall into two categories, namely pressure and gravity fed systems.

PRESSURE FED SYSTEM

With the **pressure fed system,** that part of the piping between the fuel tank and the fuel lift pump inlet is referred to as the **suction side.** That part of the system between the fuel lift pump outlet and the fuel injection pump is known as the **low pressure line** while the **high pressure lines** are those pipes connecting the fuel injection pump and the atomisers.

Leakages in the fuel pipe lines in this kind of system resolve themsleves into two classes. There may be :—

(a) Leakage from the low and high pressure lines.

(b) Leakage on the suction side.

Leakage from the low and high pressure lines can be detected in the same manner as with the lubricating oil lines. Wipe the unions down and watch them while the engine is running.

Do not strain the unions on the high pressure lines.

If leakage from a union on a high pressure line persists after tightening, it may be that one of the " nipples " by which the joint is made, has split.

Removal of a nipple is a job for the repair shop.

Leakage on the suction side allows air to enter the low and high pressure lines.

This may cause misfiring, because air instead of fuel is passing to one or more of the atomisers.

If serious, so that the air passes to all the atomisers, the engine will stop and refuse to start again.

GRAVITY FED SYSTEM

In this system the piping between the fuel tank and the fuel injection pump may be termed the **gravity fall lines.** The expression **high pressure lines** may still be used to describe those pipes connecting the fuel injection pump to the atomisers. Treatment of leakages in the high pressure lines of a gravity fed system should be the same as that previously laid down for similar lines in a pressure fed system.

Leakages in the **gravity fall lines** cannot result in air being drawn into the system. Should leakages occur in these lines they will be similar in character to " pressure " leaks.

AIR IN FUEL SYSTEM

It has been seen in one instance, how air can be introduced into the fuel system. There may, however, be other reasons for air entering the fuel system.

Shortage of fuel in the tank is one possible cause.

Examine the level of fuel in the tank first of all.

Trouble will arise from an empty tank, or one in which there is so little fuel that the end of the delivery pipe inside the tank is uncovered when the fuel runs away from it.

Under these conditions air enters the pipes instead of fuel and even if it is only a little, a bubble or two, that is enough—too much, indeed.

If the engine has been standing for a while, the very small quantity

of air that is always in the fuel may have collected to form one or two bubbles, enough to cause trouble.

If, therefore, misfiring, engine stoppage or difficult starting occurs after the engine has been standing, that may be the cause.

Leakage on the suction side of a pressure fed fuel system may be suspected if

(a) the tank has plenty of fuel in it and

(b) the engine has been running quite well up to the moment when this trouble began.

The remedy is :

(a) Tighten all the unions on the pipe line between the fuel tank and fuel lift pump, missing none of them.

(b) Tighten the joint on the pre-filter (if fitted).

To get rid of the air, the fuel system should be " bled " as instructed on page 7.

After this has been done, the engine should run. If it does so, but soon afterwards begins to give the same trouble, that is a sign that there is still a leakage on the suction side of fuel lift pump.

The unions and joints should again be examined for tightness.

DIFFICULT STARTING

Given good compression, a quick turn over, and fuel at the atomisers, the engine should start.

If it does not, these are the things to look into.

If the compression is poor, the driver can do little about it as this may be due to dry cylinders and piston rings, worn piston rings, worn cylinders or leaky valves.

If the battery is down and will not turn the starter motor quickly enough, the remedy is to replace it by one fully charged.

If no spare battery is available, get help and use the starting handle and starter motor together to speed the pull-up over compression.

FUEL SHORTAGE

If the compression is good and the battery well up, look to the fuel.

Turn the engine by hand, giving a sharp pull over compression and listen.

Or, better still, get someone else to turn the engine while you listen.

As compression is passed, a sharp ping or squeak should be heard coming from each atomiser.

The noise is quite distinctive and cannot be mistaken.

If there is no pinging at all, then no fuel is passing to the atomisers.

Look in the fuel tank first.

If there is fuel in the tank, check for air in the pipe lines going right through the procedure recommended on page 7.

If after getting rid of air, first in the final fuel filter ; second in the fuel pump ; and third up to the return pipe from the final filter (this in pressure fed systems only), it is found that no fuel passes to the atomisers, then the fuel pump is not working.

This is a very rare occurrence indeed and when it happens, the aid of the repair shop is necessary.

TIMING

If there is fuel passing to the atomisers, if pinging is heard from them when the engine is turned over compression and the engine still does not start, the fuel pump coupling may have slipped and the timing gone wrong.

Examine the coupling. There should be a line scribed right across the three discs of which it is made.

A plate with a scribed line in the centre is fitted to the fuel pump and the coupling half is marked with two scribed lines. When the line on the coupling half, marked with the letter " S " coincides with the line on the fuel pump plate, the pump is correctly timed for the engine with No. 1 piston at Top Dead Centre on its compression stroke.

If the timing has slipped, slacken the nuts holding the coupling together and adjust it until the line is continuous across all three discs.

Be sure to tighten the nuts on the coupling after it has been reset, so that it does not slip again.

TESTING FOR FAULTY ATOMISER

If, when it is certain that there is no air in the fuel system and that fuel is reaching the atomisers, one of them fails to give the characteristic ping, take it out for examination.

If in doubt as to the particular atomiser which is faulty, try the method similar to that used on petrol engines to find a faulty sparking plug. Here each plug is shorted in turn, until one is found which, when shorted, does not slow the engine. That is the faulty plug.

So with the atomisers.

Slacken off the union nut on the atomiser end of No. 1 fuel pipe, with the engine running at fast idling speed.

This prevents fuel being pumped to the nozzle of that particular atomiser.

Do this with each atomiser in turn, tightening the union of one before proceeding to the next.

Keep the engine idling all the time and note the effect of cutting out an atomiser.

If cutting one particular atomiser out has no effect on the running, that is the faulty one.

TESTING THE ATOMISER

Couple the atomiser to its fuel pipe, tightening the union properly.

Fix it on the pipe so that it can be laid on the top of the engine in such a position that the jets can be seen and examined.

Slacken the unions of the other atomisers so that the engine will not start.

Keep your hands and face out of the direct line of the jets for atomised fuel oil can quite easily enter the pores of the skin.

Have the engine turned over and watch the jets.

Each jet should be a misty spray, spreading to about 3 ins. diameter at about one foot from the nozzle, then breaking into a fine mist.

There should be two such sprays.

If the two jets are as described, the atomiser is in good order and may be replaced.

An atomiser is faulty if the sprays are not as described, *i.e.* if the spray is unduly wet or streaky, if it is obviously one-sided, or if the nozzle dribbles instead of sprays.

If an atomiser is found to be faulty, it should be forwarded to an authorised agent for attention unless special equipment is available.

An exchange scheme is in operation whereby reconditioned atomisers are quickly available. Further details are given in the "Perpetuity" handbook which can be obtained on request from F. Perkins Ltd., Peterborough or, in export territories, from the Perkins distributors.

ATOMISER PRESSURES

Atomiser injection pressures are set as follows :

P6(TA) and P4(TA) engines	160 atmospheres
P3(TA) engines	120 atmospheres

The pressure can only be set by using special equipment (Atomiser Testing Pump).

The operator should not attempt to reset an atomiser unless he has this equipment.

The atomisers should be checked and cleaned every 500 hours.

REPLACING AN ATOMISER

Care is necessary when replacing an atomiser.

A new copper washer must be fitted.

A copper-and-asbestos sparking-plug type washer will not do.

Use only the proper copper washer. Keep a small stock for use when needed.

Uncouple the fuel pipe altogether before attempting to replace the atomiser.

Enter the nozzle of the atomiser carefully into the cylinder head so that it is truly central and in line.

Screw the holding down nuts evenly, going from one to the other, to ensure that the atomiser sits squarely on its seat.

It is most important that it should not bind.

Having replaced the atomiser, examine the fuel pipe before fitting.

See that the union nut threads are clean and that there is no swarf or dirt in the pipe or unions.

Offer up the pipe to the delivery valve and atomiser unions to check that the pipe fits square at both ends. Do not fit one end and then bend the pipe to square it with the other union.

When fitting the pipe, tighten the unions alternatively a little at a time, first one end and then the other.

If the nipples have been properly fitted and the pipe is square to the unions at each end as described above, no force will be needed to make a good joint. No force should be used.

Use only a standard open ended $\frac{3}{8}$ in. by $\frac{7}{16}$ in. spanner. If the union is tightened excessively, the nipple may collapse and split. The same danger exists if the pipe is not square to and central with the union.

When changing an atomiser always remove the pipe entirely. Never undo one end only, leaving the other tight. Never bend the pipe.

At least one spare atomiser should always be carried. It should be carefully wrapped up and kept clean where it will not be knocked about, or damaged.

ERRATIC RUNNING

If the engine stops after running well for a short time, there may be air in the fuel supply system.

Bleed the system as instructed on page 7.

If the engine stops again in the same way, that is probably a sign that air is leaking into the fuel supply pipes on the suction side of the fuel lift pump. This can only apply in the case of an engine using a pressure fed fuel system.

Go over all the unions and joints in the pipes between the fuel tank and fuel lift pump and stop the leak.

Once more bleed the system.

If the engine races examine the connections from the throttle lever to the butterfly valve to see if that valve is sticking open.

If the throttle connections and valve are in order, turn to the pneumatic governor. It is in a casing at one end of the fuel pump.

Absolute airtightness is essential in the unions and pipe coupling the venturi or throttle valve chamber with the pneumatic governor on the fuel pump.

Check that the unions at both ends of the venturi pipe are tight.

If they are tight, examine the joints in the governor housing. If they are also tightly clamped, and it is unlikely that they will be anything else, there may be a flaw in the leather diaphragm of the governor, or in the pipe.

To repair this is not a job for the driver—it should be done by trained personnel.

Never run the engine without the venturi pipe in position.

See that the air cleaner is kept clean as explained on page 21.

HINTS ON RUNNING

When emptying the water system do not overlook the fact that there is a drain cock on the cylinder block. The radiator must also be drained.

If boiling occurs on refilling the radiator and circulating system after it has been emptied because of the risk of frost, suspect the water pump. Some water may have lodged in the pump and frozen, thus preventing the impellor from turning.

Check the level of the water in the radiator every morning. If the engine overheats, because of shortage of water, the needle valves in the atomisers may be damaged. This may mean a new set will have to be fitted, an expensive job.

Moreover, if the water boils, steam pockets may form in the cylinder head, causing local heating and perhaps a crack.

Do not in any circumstances continue to run the engine with the water boiling. The result may be as just described.

Do not continue to run the engine if there is knocking at high speeds. It may be an atomiser but it might equally be mechanical trouble.

Remember always to screw down the handle of the hand pump of the cold starting equipment after use. If a peculiar knocking comes from the engine soon after starting, check that this handle has been screwed down.

Do not attempt to turn the engine with any atomiser holding-down nuts removed. In so doing the risk of an atomiser flying out is incurred.

Do not run the engine with the air cleaner removed—the result is to upset the balance of the pneumatic governor—the engine may race and come to serious harm.

Never run the engine with the pipe between the venturi and fuel pump out of connection, or with the unions in any way slack. The engine would tend to become uncontrollable from the driver's position, as the result of which damage might occur.

Do not in any circumstances interfere with the damping screw on the end of the pneumatic governor casing. This is carefully set at the works and needs no adjustment.

The same warning is extended in reference to the stop limiting the movement of the control rod on the fuel pump. This must not be touched. If the seal affixed thereto is broken the guarantee may become null and void.

Do not attempt any adjustment of the opening of the butterfly valve on the venturi. This is limited by a setscrew which is carefully adjusted at the works and sealed ; should this seal be broken, the guarantee may become null and void.

Black smoke from the exhaust is a sign of a blocked air cleaner, faulty atomiser or that the fuel pump settings may have been altered, so that the proportions of fuel and air are wrong. In the latter case the pump should be immediately reset by trained personnel.

Do not use the starter if the holding straps are loose. Any such action may cause the teeth on the starting motor to ride over those of the ring on the flywheel and considerable damage may ensue.

There are many reasons why it is a good plan regularly to wipe the engine over with a cloth. One is that oil leaks are immediately disclosed.

Do not run the engine with an obvious oil or fuel leak. Tighten up the offending union (or unions) at once.

If the oil pressure, as shown on the gauge, falls below 20 lb. per square inch, and does not immediately rise and stay at a pressure above 20 lbs. per square inch when the engine is speeded up, stop the engine immediately and investigate.

FILTER MAINTENANCE

AIR FILTER

The time period for cleaning the air filter depends on operating conditions, therefore, under extremely dusty conditions, the time limit recommended hereafter for cleaning should be decreased.

The correct maintenance of the filter will greatly assist in reducing cylinder bore wear, thereby extending the life of the engine.

OIL BATH FILTER

In the oil bath filter, the incoming air impinges upon the surface of the oil carried in a reservoir in the lower part of the filter casing.

As a result of this, particles of foreign matter are carried into the oil by their own momentum and there trapped.

The air next passes through a steel wire element before reaching the induction manifold and in that element are deposited any other particles of foreign matter which still remain in the air after its contact with the oil.

MAINTENANCE

Every 50 hours remove and dismantle the filter. Wash the steel wire element in clean paraffin or fuel oil and allow to drain. The oil in the housing at the base of the filter should be emptied, and the housing thoroughly scraped to remove any sludge deposits. This container should then be washed out using either paraffin or fuel oil. Before re-assembling, refill the oil reservoir with engine oil to level indicated (do not overfill).

FUEL OIL FILTERS

Great care has been taken in the design of the engine to ensure that only clean fuel oil reaches the fuel pump.

Fuel oil filters are provided as well as a dirt trap in the fuel tank.

The first filter is a gauze trap in the filler of the fuel tank. This must not be removed when fuel is being poured into the tank.

It should be taken out every 500 hours, cleaned, washed in fuel oil and immediately replaced.

If there is no filter in the filler, the fuel should be poured through a fine gauze strainer.

The second filter is usually a water trap or a pre-filter and is fitted with a comparatively coarse element.

This filter and element should be cleaned every 250 hours unless the condition of the fuel oil warrants more regular attention.

After cleaning the pre-filter or water trap in a pressure fed system, ensure that a good joint is made between the top of the bowl and the filter body as leakage of air here may cause air locks in the fuel system.

The third and final filter is a paper element type filter. It is not possible to clean the paper element. It should be renewed every 1,000 hours. Every 250 hours, unscrew the drain plug at the bottom of the filter bowl and allow fuel to flow until clean fuel oil appears. Replace the drain plug.

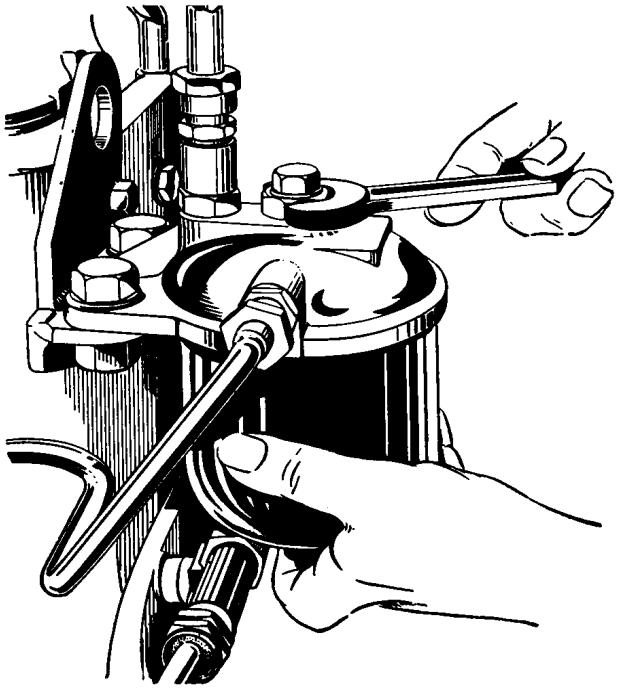


Fig. 1

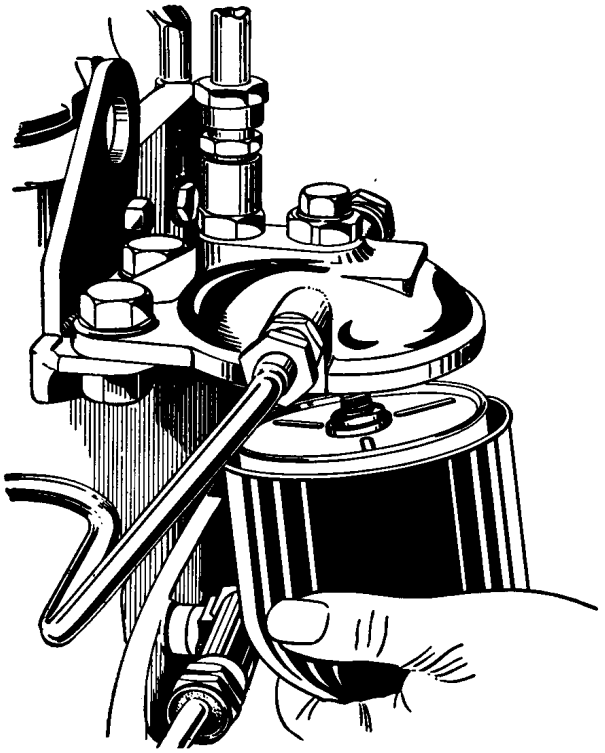


Fig. 2

Fig. 3

To renew the element :—

(1) Unscrew the larger nut in the centre of the cover (see Fig. 1).

(2) Drop filter bowl clear (see Fig. 2).

(3) Remove element and discard (see Fig. 3).

(4) Before putting new element in position, clean the filter bowl and inspect the relief valve.

(5) Ensure that the rubber joints are in good condition, if not, replace with new joints.

LUBRICATING OIL FILTERS

To ensure cleanliness of the lubricating oil, three filters are fitted to the engine. If the periodical attentions relating to these filters are carried out, and the correct grade of clean oil is used, a very long life can be obtained from the engine.

The first filter is a gauze strainer between the oil filler and the cylinder block. It is the first line of protection against dirt in the oil.

Remove this strainer every 500 hours and wash it in fuel oil before replacing. Access is gained to this filter by removing the oil filler tube.

The second filter is in the sump and is also a gauze strainer. All the oil must pass through this filter before it reaches the oil pump and is delivered to the bearings. Remove this filter and clean it in fuel oil every 250 hours.

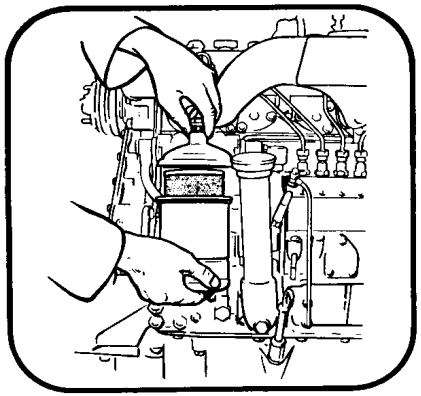


Fig. 4

Fig. 5

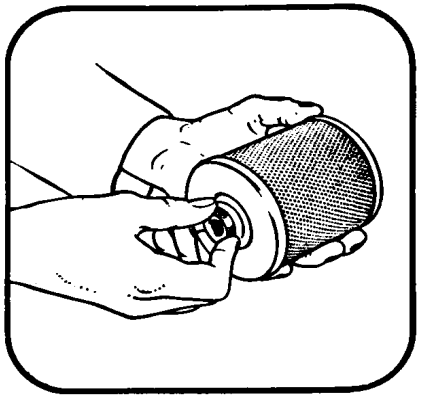


Fig. 6

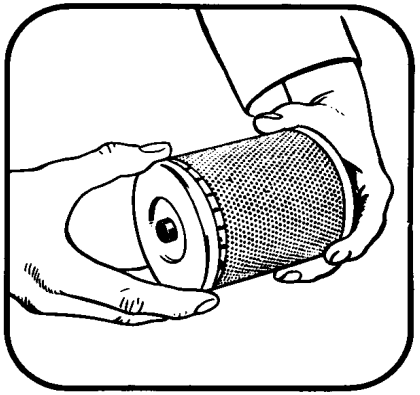


Fig. 7

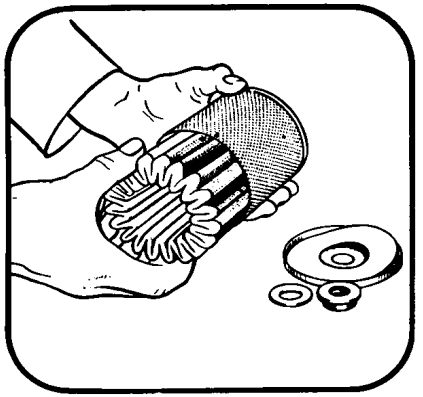


Fig. 8

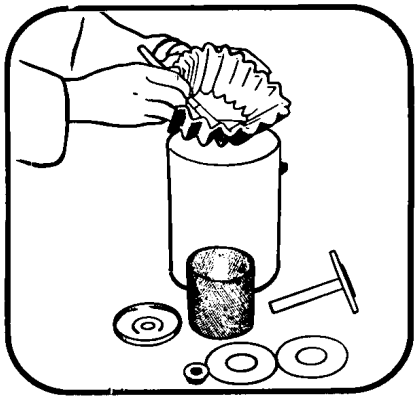


Fig. 9

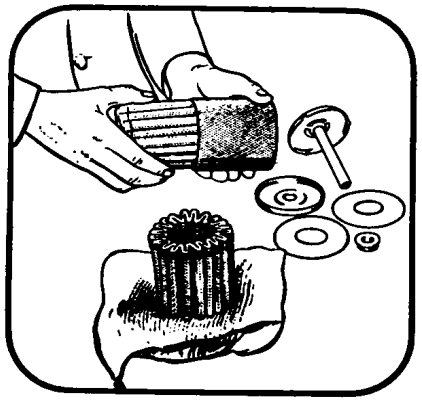


Fig 10

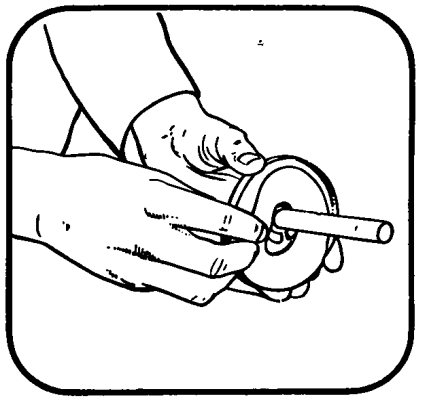


Fig. 11

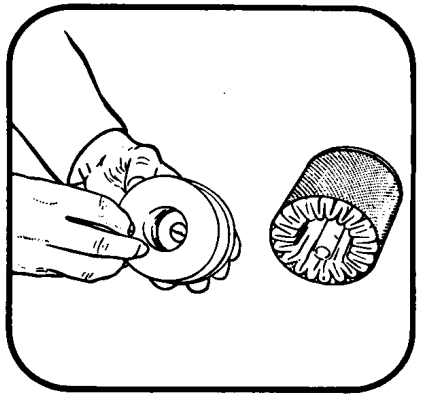


Fig. 12

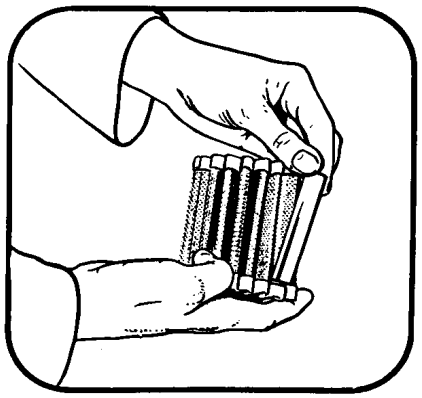


Fig. 13

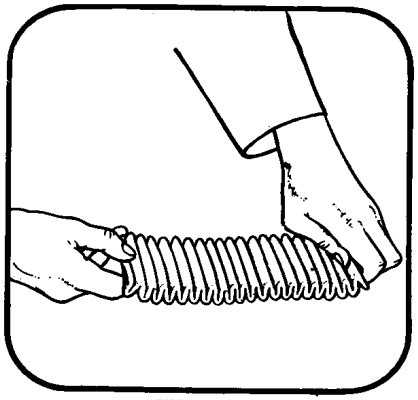


Fig. 14

The third filter is in the external oil pipe lines. The oil passes through this filter after it has left the oil pump and before it reaches the bearings. The felt element should be cleaned in fuel oil or paraffin every 250 hours and renewed every 500 hours.

To clean the element (P6 and P4 engines) :

(1) Unscrew nut on filter head and drop case. Take care that rubber sealing washer in filter head is not damaged (see fig. 4).

(2) Remove element complete with cage from filter bowl, care being taken not to damage cork sealing washer (see fig. 5).

(3) Unscrew knurled nut from centre support (see fig. 6).

(4) Remove top and bottom plates from cage (see fig. 7).

(5) Remove element from cage, and clean cage (see fig. 8).

(6) Stretch out element, if of the type secured by staples, and clean element in fuel oil or paraffin (see fig. 9).

(7) Refold element and replace in cage (see fig. 10).

(8) Clean and replace felt pad on top cover plate (see fig. 11).

(9) Clean and replace felt pad to bottom cover plate before replacing cage and element complete (see fig. 12). Finally replace screw knurl nut on centre support.

(10) Before replacing into the filter bowl, ensure that the bowl is clean.

An alternative method of securing the element together is by means of a metal clip instead of staples.

To clean an element of this type, slide off metal clip, and stretch element out (see figs. 13 and 14) and clean with fuel oil or paraffin and refold before replacing in cage.

FINAL FILTER (P3(TA) ENGINE)

With the P3(TA) engine a different filter is employed. This may be cleaned as follows :

(1) Unscrew centre bolt in filter head (see fig. 15).

(2) Remove filter body (see fig. 15).

(3) Remove filter element (see fig. 16).

(4) Thoroughly clean filter, inside and outside in clean fuel oil or paraffin (see fig. 17).

(5) Wash out filter bowl in clean fuel oil or paraffin.

(6) Re-assemble in reverse order, ensuring that the felt discs and rubber sealing washer are in good condition.

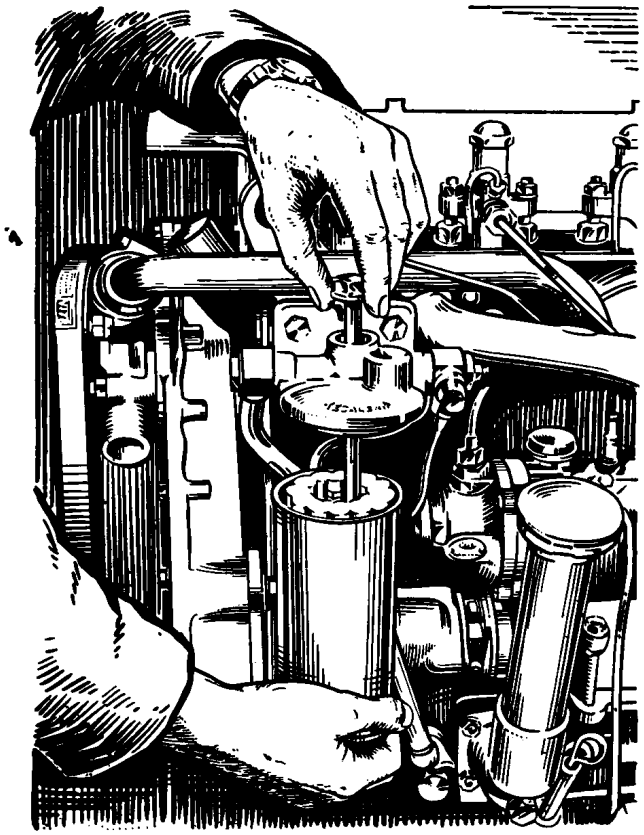


Fig. 15

Fig. 16

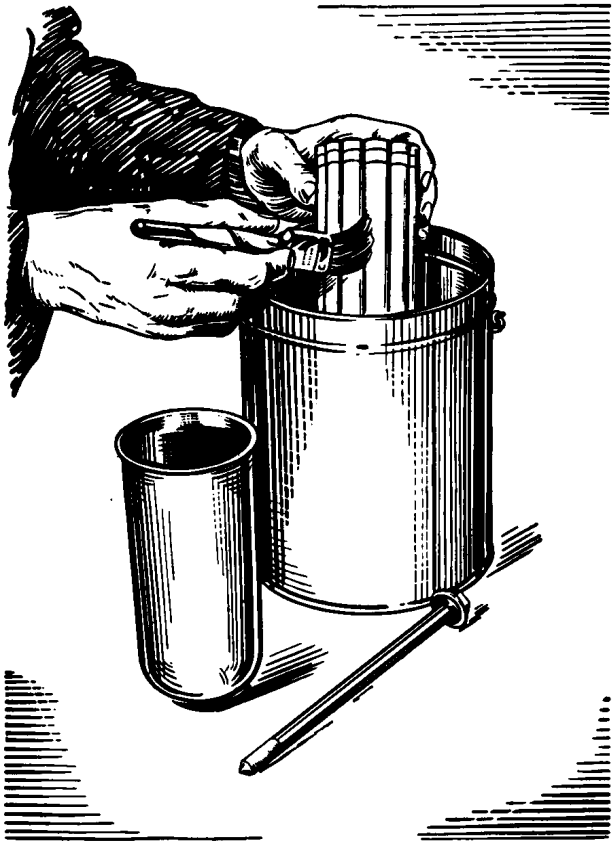


Fig. 17

FROST

Precautions against damage by frost should be taken if the engine is to be left exposed to inclement weather either by adequately draining the water system or where this is not convenient, an anti-freeze of reputable make and incorporating a suitable corrosion inhibitor may be used.

Should it be your policy to protect engines from frost damage by adding anti-freeze to the cooling system, it is advisable that the manufacturers of the relevant mixture be contacted to ascertain whether their products are suitable for use in Perkins engines and also to ensure that their products will have no harmful effect on the cooling system generally.

When draining the water circulating system, it is not enough merely to open the radiator drain tap. The one on the cylinder block must also be opened. This tap may be on the nearside of the cylinder block near the flywheel or on the offside near the middle.

When the engine is drained, the water pump is also drained but the rotation of the pump may be prevented by :—

(a) locking of the impellor by ice due to the pump drain hole being blocked by sediment.

(b) locking of the seal through the freezing of globules of moisture between the seal and the gland.

Operators are therefore advised to take these precautions when operating in temperatures below freezing point :—

(1) Before starting the engine turn the fan and water pump by hand ; this will indicate if freezing has taken place. If freezing has taken place, this should free any ice formation.

(2) If it is impossible to turn the pump by hand, the radiator and engine should be filled with warm water.

(3) To avoid this trouble it is advisable when all water has been drained to run the engine for a few seconds at idling speed, thus dispersing any moisture remaining in the pump.

After an anti-freeze solution has been used, the cooling system should be thoroughly flushed in accordance with the manufacturer's instructions before refilling with normal coolant.

If the foregoing action is taken, no harmful effects should be experienced but F. Perkins Ltd., as engine manufacturers, cannot be held responsible for any corrosion or frost damage which may be incurred.

DO . . .

DO KEEP THE ENGINE CLEAN.
DO keep this book where it is conveniently accessible.
DO pay particular attention to lubrication.
DO use only approved grades of lubricating oil.
DO use only GENUINE PERKINS SPARE PARTS.
DO keep all bolts and nuts tight.
DO eliminate all air from the fuel system and keep all fuel oil unions AIR-TIGHT.
DO examine engine oil level in sump daily and replenish if necessary.
DO completely change engine oil in accordance with periodical attentions, page 34.
DO renew element in lubricating oil filter in accordance with periodical attentions, page 34.
DO check oil flow to rocker arms and examine the valve springs in accordance with periodical attentions, page 34.
DO use only filtered fuel oil. Never tip into the tank a half-empty barrel of fuel oil, the bung of which may have been out for weeks.
DO keep a check on the temperature of the cooling water. It should not be allowed to boil. The best temperature is 140°F—170°F.
DO attend immediately to fuel and lubricating oil leaks.
DO grind in valves when necessary.
DO check tappet clearance from time to time (.010 in.) with warm engine.
DO tighten cylinder head nuts in correct order (see page 54).
DO **quote engine number when ordering spares.**
DO keep essential spares in store.
DO drain radiator if engine is being left idle in frosty weather.
DO drain cylinder block if engine is being left idle in frosty weather (drain tap on side of block).
DO close these drain cocks and refill with water before attempting to re-start next morning.
DO when in doubt, read this Handbook.

DO NOT . . .

DO NOT neglect the routine attentions specified on page 34.

DO NOT race the engine in neutral.

DO NOT run the engine unless the gauge SHOWS OIL PRESSURE.

DO NOT unnecessarily interfere with any adjustments.

DO NOT break the fuel pump seal—**remember if broken your Guarantee may be void.**

DO NOT continue to run the engine if the cooling water boils.

DO NOT forget to grease the water pump.

DO NOT forget to keep the fan belt adjusted.

DO NOT continue to run the engine if black smoke is coming from the exhaust.

DO NOT if the engine stops without apparent reason, fail to make sure first of all that fuel is reaching the fuel pump.

DO NOT omit to wipe the engine over occasionally with a clean rag.

DO NOT take the fuel pump to pieces.

DO NOT use cotton waste or any fluffy cloth when cleaning.

DO NOT use any but approved brands of fuel or lubricating oil.

DO NOT store fuel oil in a galvanized container.

DO NOT subject any engine or tractor to continuous overloading.

DO NOT guess. For additional information contact suppliers of the tractor or engine.

PERIODICAL ATTENTIONS

POST DELIVERY CHECK-OVER

After a customer has taken delivery of his 'P' Series tractor engine, it is advisable, in his own interests, that a general check over of the engine be carried out after the first 25 hours in service.

This check over should comprise the following points :—

1. Drain lubricating oil sump and re-fill up to the full mark on the dipstick with clean new oil (do not overfill). When the sump is drained the sump strainer should be removed and cleaned.
2. Check and if necessary adjust slow running speed.
3. Check external nuts for tightness.
4. Check and adjust tappet clearances (.010 ins. hot).
5. Check fuel pipes from tank to fuel injection pump common chamber for leaks.
6. Check for lubricating oil leaks, and rectify if necessary.
7. Check cooling system for leaks and inspect radiator water level.
8. Check fan belt for tension.
9. Carry out road test to check general performance of engine.
10. Check engine mounting bolts for tightness.

Thereafter maintenance periods should be in accordance with the following instructions.

It is assumed that electrical equipment will have already been checked for such points as dynamo rate of charge, effectiveness of connections and circuits, etc.

KEEP ENGINE CLEAN

DAILY

Check water in radiator.

Check oil level in sump (Make sure the tractor is on level ground).

EVERY 50 HOURS

Check fan belt adjustment.
Clean air cleaner and renew oil (*See Note*).
Grease water pump (P6(TA) and P4(TA) engines only).
Top up batteries with distilled water.
Ensure that cylinder head cover nuts are tight.

EVERY 250 HOURS

Clean element in lubricating oil filter.
Drain oil from sump and renew.
Clean strainer in sump.
Unscrew drain plug on final fuel filter, replace plug when clean fuel appears.
Flush radiator with clean water.
Clean and grease battery terminals.
Clean gauze element in water trap type filter.
Refill greaser on dynamo (when greaser is fitted).
Clean fuel oil pre-filter (when fitted).

EVERY 500 HOURS

Clean and check atomisers.
Renew felt element in lubricating oil filter.
Clean gauze trap in lubricating oil filler body.
Clean gauze trap in fuel oil filler (when fitted).

EVERY 1,000 HOURS

Drain fuel tank, remove and clean.
Inspect commutator and brushes of dynamo.
Remove cylinder head cover and examine valve springs and tappets.
Inspect valve rocker shaft assembly for lubrication.
Renew paper element in final fuel filter.

NOTE

The time for cleaning the air cleaner depends on operating conditions, therefore under extremely dusty conditions, the time limit recommended above for cleaning should be decreased.

The correct maintenance of the air cleaner will greatly assist in reducing bore wear, thereby extending the life of the engine.

APPROVED LUBRICATING OILS

Normal Working Temperature	—20°F. to 30°F.	30°F. to 80°F.	80°F. or over
S.A.E. Designation	10W	20W or 20	30
Esso Petroleum Co. Ltd. Imperial Oil Ltd.	Essolube HD 10 Esstic HD 10 Marvelube Heavy Duty 10W	Essolube HD 20 Esstic HD 20 Marvelube Heavy Duty 20—20W	Essolube HD 30 Esstic HD 30 Marvelube Heavy Duty 30
Shell Mex and B.P. Ltd.	Shell Rotella 10 †Shell Tractor Universal B.P. Energol Diesel D—SAE 10 †B.P. Energol Tractor Universal	Shell Rotella 20—20W †Shell Tractor Universal B.P. Energol Diesel D—SAE 20W †B.P. Energol Tractor Universal	Shell Rotella 30 †Shell Tractor Universal B.P. Energol Diesel D—SAE 30 †B.P. Energol Tractor Universal
Alexander Duckham & Co. Ltd.	Duckhams HD 10/Mil	Duckhams HD 20/Mil	Duckhams HD 30/Mil
Regent Oil Co. Ltd. Caltex/Texaco	RPM Delco Special SAE 10 Ursa X 10**	RPM Delco Special SAE 20 Ursa X 20**	RPM Delco Special SAE 30 Ursa X 30**
Mobiloil Co. Ltd.	Mobiloil 10W (HD) Delvac 910	Mobiloil Arctic (HD) Mobiland Diesel 20 Delvac 920	Mobiloil A (HD) Mobiland Diesel 30 Delvac 930
Vigzol Oil Co. Ltd.	Vitafilm A. 10	Vitafilm A. 20	Vitafilm A. 30
C. C. Wakefield & Co.	Castrol CR 10 Agricastrol HD 10	Castrol CR 20 Agricastrol HD 20	Castrol CR 30 Agricastrol HD 30
Germ Lubricants Ltd.	Germol D 10	Germol D 20	Germol D 30
British American Oil Co.	Peerless Heavy Duty 10W	Peerless Heavy Duty 20—20W	Peerless Heavy Duty 30

†For use in tractor applications only.

And other reputable brands to approved specification including : Any lubricating oils which have passed Approval Tests for the U.S. Ordnance Specification MIL-L-2104A and British Ministry Tests DEF.2101A which are equivalent in their S.A.E. 10 and 30 grades, with a viscosity index of 80 minimum shall be deemed equally acceptable.

Special Note : All grades listed above are fully detergent heavy duty oils.
When these oils are used, care must be taken to ensure that they are not mixed either inside or outside the engine with oils of other grades.

Where conditions of service warrant (*e.g.*, continuous heavy load operation) the grades shown in the right hand column may be used in lieu of those shown in the first and centre columns.

The above Specifications are subject to alterations without notice.

SETTINGS AND DATA

	P6	P4	P3
Bore	3½ in.	3½ in.	3½ in.
Stroke	5 in.	5 in.	5 in.
No. of cylinders	6	4	3
Swept volume	4.73 litres	3.14 litres	2.36 litres
Firing order	1,5,3,6,2,4	1,3,4,2	1,2,3
Compression ratio		16.5 : 1	
Inlet valve opens		13° B.T.D.C.	
Exhaust valve closes		10° A.T.D.C.	
Valve lift		.36 in.	
Spill timing		29° B.T.D.C.	
Tappet clearance		.010 in. hot	
Atomiser settings	All P6(TA) & P4(TA) Engines		160 atmospheres
	All P3(TA) Engines		120 atmospheres

RECOMMENDED TORQUE TENSIONS

	Lbs. ft.
Cylinder head nuts	55—60
Con. rod nuts	60
Main bearing setscrews	110—115
Flywheel setscrews	75

PISTON TYPES

Pistons are made of two alternative materials :

Cast Iron. All P6(TA) and P4(TA) engines with a maximum rated speed up to and including 1,500 r.p.m.

Light Alloy. All P6(TA) and P4(TA) engines with a maximum rated speed in excess of 1,500 r.p.m.

Note : All P3(TA) engines irrespective of rating are fitted with light alloy pistons.

HORSE POWER

Fordson Tractor P6(TA) H.P.	.....	46 b.h.p. at 1,500 r.p.m.
Maximum torque	....	..... 168 lbs. ft.
P4(TA) Maximum rating	....	39 b.h.p. at 2,000 r.p.m.
Maximum torque	....	..... 118 lbs. ft
P3(TA) Maximum rating	....	32 b.h.p. at 2,000 r.p.m.
Maximum torque	....	..... 88 lbs. ft.

Further details regarding power output and ratings of individual engines may be obtained from the Service Department, F. Perkins Limited. In such cases the engine number should be quoted.

SUMP CAPACITIES

P6(TA) (Fordson)	..... 24 Pints
P4(TA) (Rotary Hoes)	..... 15 Pints
P3(TA)	..... 13 Pints

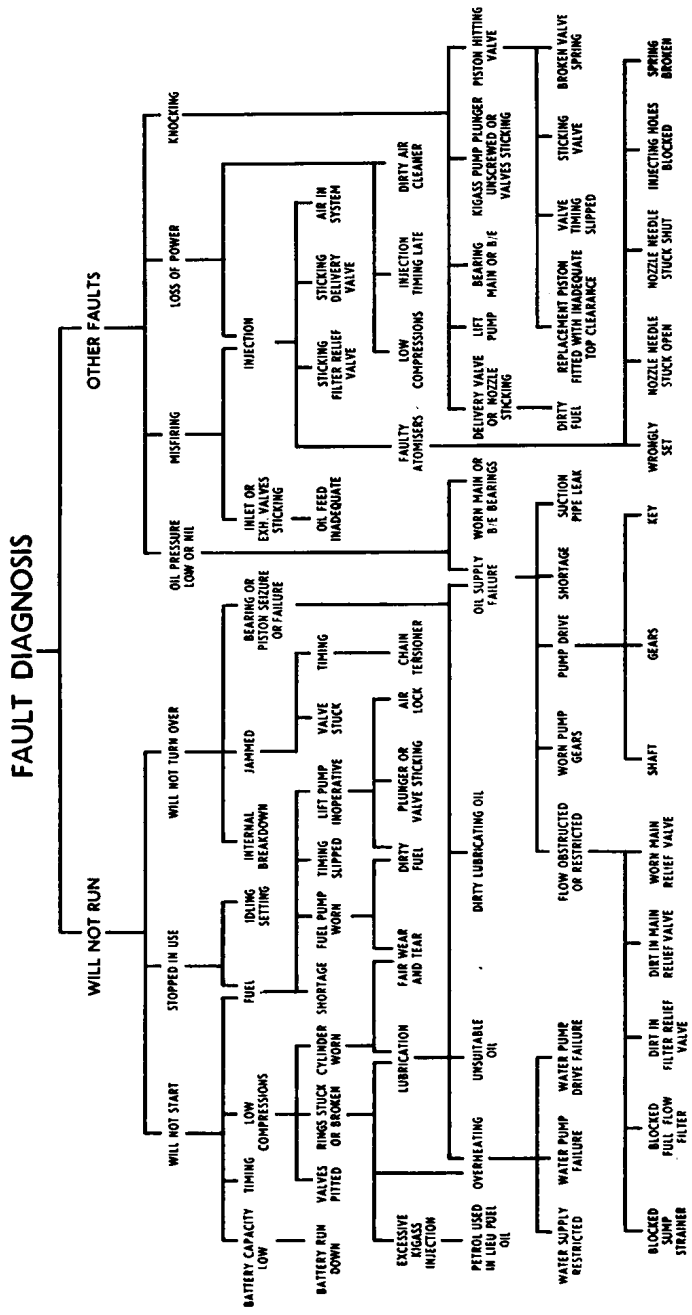
ENGINE NUMBERS

When requesting information regarding a P Series tractor engine, the engine number should be quoted. On P3(TA) engines, this can be found on the top of the camshaft tunnel. On P6(TA) or P4(TA) engines it appears on the top rear corner of the fuel pump side of the cylinder block.

FUEL PUMP

When requesting information regarding the fuel pump the type and number should be quoted. This can be obtained from a plate fitted to the fuel gallery above the inspection plate.

NOTE : De-rating for altitude where engines are called upon to operate in rarified atmospheres occasioned by altitude, such engines should be de-rated. For details regarding engine de-rating for altitude apply to Service Dept., F. Perkins Ltd., Peterborough or to those overseas companies listed on page 2.



FAULT FINDING

DIFFICULT STARTING

NO FUEL AT ATOMISERS :—

(a) No fuel in tank.

(b) Fuel lift pump not working (pressure fed system only).

(c) Loose connections in the fuel system.

(d) Air in the fuel system (Trace from suction side).

Go over the whole of the above and make sure that the atomisers are fully primed and that the " pinging " or " squeaking " noise is heard from each atomiser when the engine is turned over by hand.

ENGINE NOT BEING TURNED OVER QUICK ENOUGH
(Particularly in cold weather)

(a) Lubricating oil too thick (see " Approved Lubricating Oils ")

(b) Battery not fully charged. Fit fully charged battery.

(c) Engine " gummy " due to standing in the cold.

Use the cold starting equipment if fitted. (See " Starting the Engine.")

LOW COMPRESSION

This may be due to dry cylinders and piston rings, worn piston rings, worn cylinders, or leaky valves. For any other than the dry cylinder, the proper course is to have the engine overhauled, but as a temporary expedient starting may be assisted by injecting about a dessert spoonful of lubricating oil into the inlet port by means of a suitable syringe. If this is done the engine should be turned over steadily four or five times so as to allow any excess oil to escape.

DIRT BETWEEN VALVE AND SEAT

Remove cylinder head cover and turn the engine. Note which valves leak. Bring corresponding piston to beginning of compression stroke, turn engine over compression at the same time

bouncing valve open by hitting valve rocker end down with a block of hard wood or the like. Repeat until dirt is blown out and valve holds compression.

ATOMISERS FAULTY

Test atomisers for " ping " or " squeak " as already mentioned. If any atomiser fails to give this " pinging " or " squeaking " noise when that cylinder is pulled smartly over compression and it has been made certain that the atomiser is fully primed, then the atomiser should be tested by removing it from the cylinder head. (See Page 49).

Disconnect pipes on other atomisers while making this test.

STICKING VALVES

Trouble with sticking valves may be due to overheating, the result of choked atomisers, or the use of unsuitable lubricating oil.

Test the atomisers as recommended on Page 49, and clean them if necessary.

The lubricating oil used should be of an approved type. (See " Approved Lubricating Oils.")

To free a valve, squirt a small quantity of paraffin down the valve guide and allow it to seep right through. The valve may then be given a sharp tap. This process will invariable free the valve. A quantity of clean oil should then be poured down the guide to lubricate the valve stem before again starting up the engine.

STICKING ROCKERS

If the rockers stick the cause may be : the use of unsuitable oil, shortage of oil, or sludging. Use only oil of an approved type. (See " Approved Lubricating Oils.") If there is a shortage of lubricant the passages and pipes to and from the camshaft reducer should be cleaned.

To free the rocker squirt a little paraffin into the bearings, allow it to seep through, then gently tap the rocker arm. This will free the rocker. Thoroughly lubricate with clean oil, and the engine may be re-started.

FUEL OIL

It is essential to use clean fuel oil free from water, dirt or sand. The recommended specification for fuel is given in the section dealing with fuel injection equipment. Providing clean fuel is used, no trouble should be experienced with the fuel system but dirty oil will lead to trouble due to choked pipes, choked filters, damaged fuel pump and atomisers. With a pressure fed system, if the engine tends to run well for a short period and then to die away or stop altogether, the fuel system should immediately be suspected. The trouble may be due to the lift pump not working properly, to a loose pipe joint allowing air to get into the fuel system, to a dirty fuel filter, or to a choked fuel pipe.

The pre-filter in the fuel lift pump (when fitted) should be cleaned by washing in clean fuel oil, but the final filter should not need attention more than once in 1,000 hours, when a completely *new* filter element should be fitted. If the operating conditions lead to dust or contamination of the fuel, decrease the maintenance interval.

Always, after disturbing fuel line washers, replace with new washers to ensure the joints are air tight.

AIR CLEANER

In accordance with periodical attentions, clean the filtering element in paraffin or fuel oil. During air filter maintenance, fresh engine oil should be poured into the base, up to the level mark.

For maintenance instructions see section dealing with " Filter Maintenance."

FUEL INJECTION EQUIPMENT

The principal components of the equipment for delivering the fuel oil to the engine cylinders are as follows :—

Filters
Fuel Lift Pump (when fitted)
Fuel Pump
Atomisers

In a pressure fed fuel system the fuel lift pump " lifts " the fuel from the tank to the fuel pump which conveys it in measured quantities, and at appropriate intervals, to the atomisers.

With this fuel system the normal course of the fuel from the tank to the engine is by way of : first, the fuel pre-filter ; then the fuel lift pump ; then the final fuel filter ; and finally fuel pump and the atomisers.

Where no fuel lift pump is fitted, *i.e.*, gravity fed fuel system, fuel flows from the fuel tank through the water trap bowl to the final filter. From there filtered fuel enters the fuel injection pump, from whence it is delivered to the atomisers.

Two conditions are essential for efficient operation.

First, that the fuel oil should be clean, free from water, suspended dirt, sand and other foreign matter and should conform to :—

British Standard No. BS. 209 (1947) Section A.

Second, that the fuel reaches the fuel pump in a perfectly clean state.

Fuel should be filtered before entering the tank.

Given these conditions, ninety per cent at least of potential engine troubles would be eliminated. Attention, therefore, should be earnestly directed towards the section of this handbook which refers to the care and upkeep of the filtering apparatus.

THE FUEL LIFT PUMP

The lift pump is of the simple spring returned plunger type. It is driven by a cam on the camshaft of the fuel pump on the side of which it is fitted.

A hand primer is fitted for use if the supply of fuel from the tank has at any time failed.

To use this primer, unscrew the handle, which is free to lift, and then pump by hand until pipes, lift pump, filters and fuel pump are full of fuel oil. To ensure that this is so, proceed as instructed on page 7.

FUEL PUMP

The fuel pump is an instrument of precision. Its working parts are made to extremely fine limits and mishandling in any shape or form, or the entry of the smallest particle of dirt into its working parts may damage it and diminish its accuracy of operation. Hence the importance of ensuring that the fuel is thoroughly filtered before the pump is reached.

When requesting information regarding the fuel pump, the type and number should be quoted. This can be obtained from a plate fitted to the pump gallery above the inspection plate.

ATOMISERS

Each atomiser consists of a steel body, held to the cylinder head by means of a flange and two studs.

The joint between the atomiser and cylinder head is made by a special copper washer between the lower face of the nozzle cap nut and the recess in the cylinder head.

When preparing to fit the atomiser into place in the cylinder head, care should be taken that only this type of copper washer is used to make this joint. The recess in the cylinder head, the faces of the copper washer and the corresponding face of the nozzle holder cap nut should be perfectly clean if a leakproof joint is to result.

It is advisable to fit a new joint washer when the atomiser is replaced, after having been removed for any reason.

Ensure that the old washer has been removed from the cylinder head or atomiser.

This joint washer should be an easy, but not loose fit for the atomiser nozzle and it is because this is such an important feature that only washers specially made for the purpose should be used

and none other. On no account should ordinary sparking plug type washers be used.

The atomiser can now be fitted in place, care being taken to see that it is an easy fit in the cylinder head and on the holding-down studs, so that it can be placed down on the copper joint without force of any kind. The nuts on the flange should then be tightened down evenly in order to prevent the atomiser nozzle being canted and so 'nipped' in the cylinder head. This is very important since any unevenness in tightening down may cause distortion of the atomiser nozzle, resulting in its failure and will most certainly result in blowby.

FUEL PIPES

No two of the pressure pipes from the fuel pump to the atomisers are alike. Keep this in mind when replacing.

Examine the nipples which will be found on each end of these pipes.

If the union nuts at any time have been overtightened, the nipples may have cracked or be unduly compressed. If so, leakage will result.

In this connection, bear in mind that the working pressure which these joints must sustain is several thousand pounds per square inch. Only a perfect joint is satisfactory.

It is quite easy to replace these nipples.

After removing the old nipple, clean up a length of pipe near the end, using a fine cut file for the purpose, until the new nipple is a sliding fit on the pipe.

Now place the nipple on the end of the pipe, leaving 1/64 in. of the latter protruding.

A steel washer will be found housed loosely in the union nut.

Hold the pipe in a vice so that the nipple rests on this washer and the washer rests on the top of the vice.

Rivet the protruding portion of the pipe over the nipple.

Take care that the hole in the pipe is not closed whilst riveting.

Clean off with a fine cut file.

When refitting, take care that it is the nipple which makes the joint and not the actual riveted portion of the pipe.

After fitting new nipples, **wash the fuel pipe with clean fuel oil** using either an atomiser testing pump or the engine fuel pump, thus removing any filings which may be in the pipe.

Offer up the pipe to the delivery valve and atomiser unions to check that the pipe fits square at both ends. Do not fit one end and then bend the pipe to square it with the other union.

When fitting the pipe, tighten the unions alternatively a little at a time, first one end and then the other.

If the nipples have been properly fitted and the pipe is square to the unions at each end as described above, no force will be needed to make a good joint. No force should be used.

Use only a standard open ended $\frac{3}{8}$ in. $\times$ $\frac{7}{16}$ in. spanner.

If the union is tightened excessively, the nipple may collapse and split. The same danger exists if the pipe is not square to and central with the union.

When changing an atomiser, always remove the pipe entirely. Never undo only one end leaving the other tight. Never bend the pipe.

MAINTENANCE

Atomisers should be taken out for examination at regular intervals. How long this interval should be is difficult to advise, because of the different conditions under which the engine operates.

When combustion conditions in the engine are good and the fuel tank and filtering system are maintained in first class order, it is often sufficient if the atomisers are tested twice yearly. For detailed times refer to Periodical Attentions, page 34.

It is no use taking atomisers out for attention unless an atomiser testing pump is available or spare atomisers are at hand for substitution.

The nearer the ideals of good fitting with adequate cooling and absolutely clean fuel are realised, the less attention the atomisers will need, and so the longer their efficient life. In this connection, since there is no other item of the equipment upon which the performance of the engine depends so much, it pays the user handsomely to see that the engine never runs with any of its atomisers out of order.

TROUBLES IN SERVICE

The first symptoms of atomiser trouble usually fall in one or more of the following headings :—

(1) Knocking in one (or more) cylinders.

(2) Engine overheating.

(3) Loss of power.

(4) Smoky exhaust (black).

(5) Increased fuel consumption.

Often the particular atomiser or atomisers causing trouble may be determined by releasing the pipe union nut on each atomiser in turn, with the engine running at fast ' Tick-over.' This will prevent fuel being pumped through the nozzle to the engine cylinder, thereby altering the engine revolutions. If after slackening a pipe union nut, the engine revolutions remain constant, this denotes a faulty atomiser.

The nuts from the flange of the doubtful atomiser should be removed and the complete unit withdrawn from the cylinder head and turned round, atomiser nozzle outwards, on its pipe, and the unions re-tightened.

After slackening the unions of the other atomiser pipes (to avoid the possibility of the engine starting), the engine should be turned until the nozzle sprays into the air, when it will be seen at once if the spray is in order. If the spray is unduly ' wet ' or ' streaky ' or obviously to one side, or the atomiser nozzle ' dribbles ' the spray holes should be probed with a tool specially made for the purpose (E.T.120). If, after probing the spray holes, the atomiser is still faulty, remove the complete unit.

Great care should be taken to prevent the hand from getting into contact with the spray, as the working pressure will cause the oil to penetrate the skin with ease.

If it is found necessary to replace an atomiser, the spare atomiser from the tool kit should be fitted, the faulty unit being placed in the tool kit securely wrapped in clean greaseproof paper or rag for attention on the maintenance bench.

ATOMISER PRESSURES

The pressure at which the sprays break should be recorded and

checked against the recommended pressures which are as follows :—

P6(TA) and P4(TA) engines	160 atmospheres.
P3(TA) engines	120 atmospheres.

IDENTIFICATION

Atomisers set at 120 atmospheres have no colour code and are usually painted the same colour as the engine.

figure 6 stamped on the right hand fixing lug of the atomiser.

Atomisers set at 160 atmospheres have blue painted caps, and a

Atomisers supplied under the Perpetuity Scheme have green painted caps with the appropriate colour on the top of the cap signify ingpressure setting and type. In cases of atomisers set up at 160 atmospheres the figure 6 is also stamped on the right hand fixing lug.

CYLINDER HEAD MAINTENANCE

The number of hours run has no bearing on when to overhaul the cylinder head on the P Series engine as carbon, beyond a superficial coating, does not form and accumulate in the combustion chambers and on the pistons as is the case with a petrol engine.

Ease of starting and performance are the determining factors, therefore the cylinder head should only be removed when it is absolutely necessary.

TO REMOVE THE CYLINDER HEAD

Drain water from radiator and cylinder block.

Detach water connections from water pump.

If necessary remove radiator and fuel tank or engine cowling.

Remove the fan and fan belt.

Remove the oil feed pipe from the head of the lubricating oil filter to the camshaft oil reducer.

Remove the air cleaner and throttle mechanism.

Detach cold starting equipment connections.

Detach fuel connections where necessary.

Remove the oil pipe from the camshaft oil reducer to the cylinder head.

Remove the pipe between the venturi and the pneumatic governor on the fuel pump. (Note :—replace nut on cylinder head rear cover).

Disconnect the exhaust pipe from the engine exhaust manifold.

Remove the injection pipes from the fuel pump to the atomisers.

WARNING. Cover the fuel delivery valve ports with a piece of clean rag or a strip of " U " shaped metal.

Remove the atomisers.

Release the clips and remove the main leak-off pipe.

Remove the cylinder head cover.

Disconnect the oil pipe to rocker shaft.

Remove rocker shaft assembly bringing above-named oil pipe with it. (Note :—care to be taken only to remove $\frac{3}{8}$ in. B.S.F. nuts.)

Remove the cylinder head nuts.

Remove the cylinder head. Do not insert a screwdriver or any other sharp instrument between the cylinder head and block. Place the cylinder head on a flat surface, preferably wood, to avoid damage.

NOTE : Before the cylinder head can be lifted clear from P3 engines, the water manifold must first be removed as it passes between the exhaust manifold ports before reaching the water jacket connections in the top near side of the cylinder block. When this operation has been carried out, the stripping sequence is common to all " P " Series engines.

TO REMOVE THE VALVES

Place the cylinder head with the machined face downwards on the bench. Depress the spring cap and springs by means of a valve lifter and remove the two half conical cotters. Remove the spring caps and springs, thus liberating the valves which can be taken out when the cylinder head is turned upside down.

The valves and valve seats should be reconditioned in the orthodox way using grinding compound or by means of specialised equipment.

Do not forget that the efficiency of a diesel engine depends largely on the maintenance of good compression. Contact between valves and seatings must therefore be the best possible.

Care should be taken to avoid unnecessary grinding away of the seat.

The maximum clearance between the valve head and cylinder head bottom face should not exceed .140 in.

The valve seat is recessed into the cylinder head and a groove is cut where the proper valve seat ends in the mitred recess in the head.

When valves have been reconditioned several times, it is possible that the valves may become masked by sinking too low in the cylinder head and in these circumstances the groove referred to should be recut accordingly.

All valves are numbered and care should be taken to see that they are replaced correctly. Number all new valves to correspond with the numbering of the old ones.

COMBUSTION CHAMBER CAPS AND JOINTS

It is not as a rule necessary to remove the covers of the combustion chambers during top overhaul as carbon rarely forms in these chambers.

If for any reason these covers are removed, new copper joints should be fitted when they are replaced.

If new copper joints are not available, the old ones may be used provided that they are softened before being refitted.

To soften these copper joints, heat them to a dull red heat and quench in cold water.

Again having in mind the importance of good compression for efficient operation of a diesel engine, special care is necessary when refitting these covers to ensure that there are no leakages at the joints.

GENERAL

All studs on the cylinder head and the top face of the cylinder block should be examined for looseness, damaged threads, etc. The cylinder head nuts should also be examined to ensure the threads are not damaged.

All joint faces should be examined for pitting or defacement.

Wash out and thoroughly clean the water passages in the head, subsequently drying out and finally cleaning with compressed air.

If the water jacket of the cylinder head shows signs of excessive scale, a proprietary brand of descaling solution should be used.

If possible, the cylinder head should be water tested for leaks with warm water at a pressure of 30 lbs. per sq. in.

RE-ASSEMBLY AND REPLACING

Replace valves, springs, collars and cotters, taking care that the numbers on the valves correspond to the numbers stamped adjacent to the valve seat.

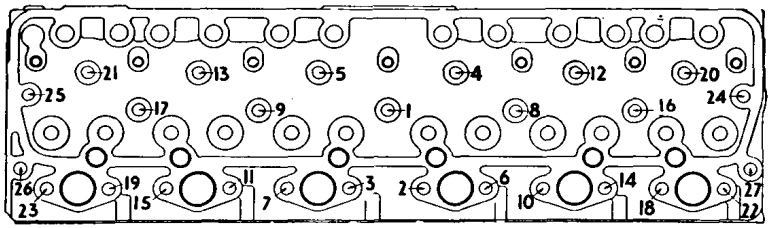


Fig. 18

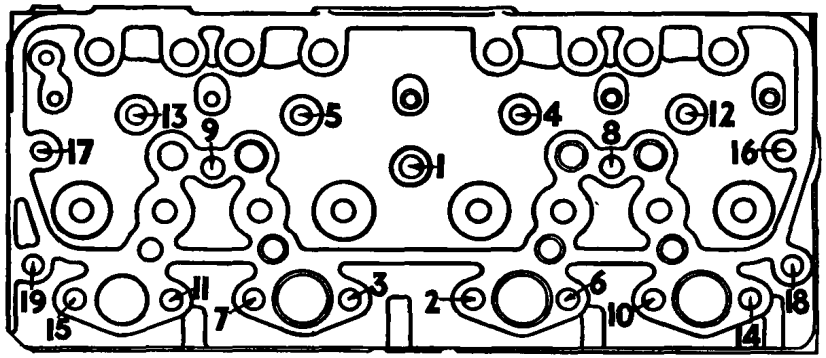


Fig. 19

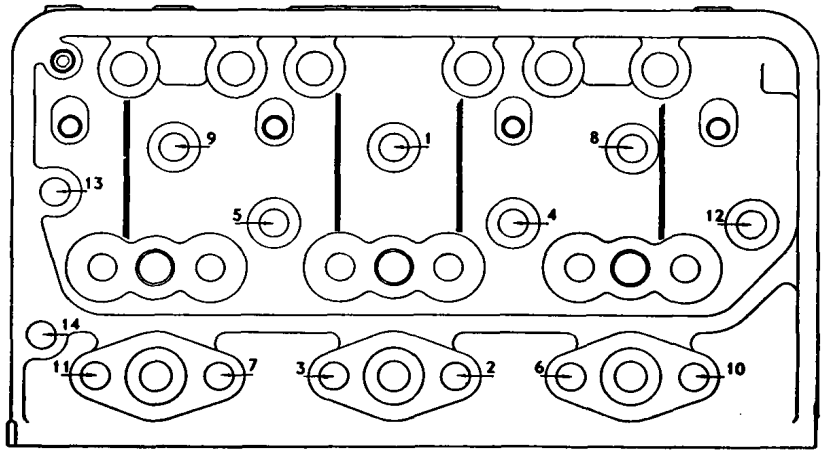


Fig. 20

Replace combustion chamber caps and joints if these have been removed.

Before replacing the cylinder head it is extremely important to ensure that the faces of the cylinder block and cylinder head are perfectly clean.

A new cylinder head gasket should be used. The gasket is marked to indicate how it should be replaced.

Cover both sides of the gasket with a thin coating of good jointing compound and place over the cylinder head through studs.

When the under face of the cylinder head is perfectly clean, the head may be lowered into position on its studs and the nuts tightened down in the order shown in figs. 18, 19 or 20. The cylinder head nuts should be pulled down to the recommended torque (See page 39).

Replace the atomisers (See page 46).

Replace the rocker shaft assembly and set the tappets to .012 in.

Connect up pipes and make connections as mentioned in " To remove the cylinder head."

STARTING THE ENGINE

Proceed as instructed on page 7.

After warming up the engine should be stopped and the atomisers and rocker shaft removed when the cylinder head can again be tightened down. The nuts should be tightened in the order shown in fig. 18, 19 or 20.

Refit the atomisers and rocker shaft and reset the tappets to .012 in.

After warming up the tappets should finally be set to .010 in.

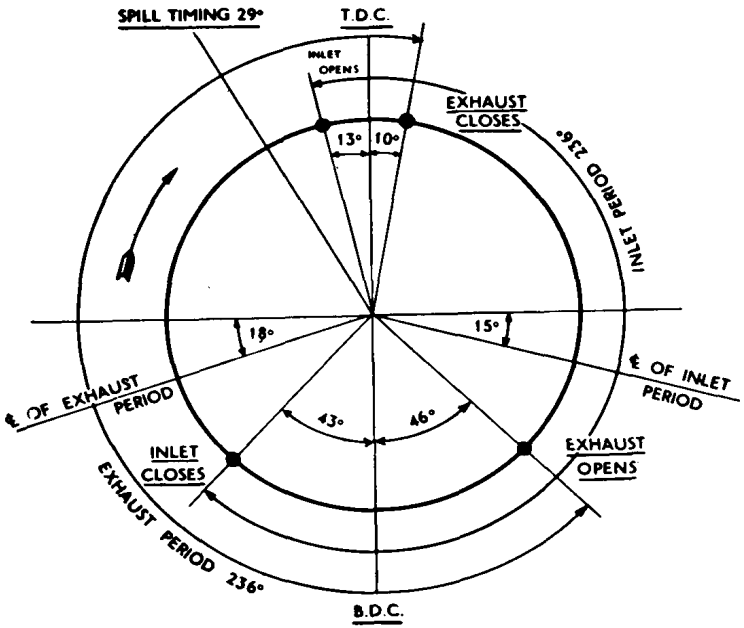
Refit the cylinder head cover.

A new joint should be fitted under the cylinder head cover and care should be taken to see that it is correctly placed, otherwise oil may leak away in a considerable quantity, enough to starve the engine of oil if left unchecked.

TIMING

GENERAL

The timing or re-setting of the timing of the Perkins ' P ' Series tractor engine can be simply and quickly carried out if the following instructions and data are borne in mind.



CRANKSHAFT ANGLES

Viewed from front of engine.

VALVE TIMING DIAGRAM

FLYWHEEL DIAMETER	ONE INCH ON FLYWHEEL RIM	ANGLE IN DEGREES	
		13°	29°
13½"	8.48°	1.53"	3.42"
14½"	7.9°	1.64"	3.65"
14¾"	7.76°	1.68"	3.74"
15"	7.65°	1.7"	3.8"
15½"	7.4°	1.76"	3.92"

It is well to remember that the removal of the cylinder head does not in any way affect the timing of the engine.

TIMING MARKS

When the engine is timed at the factory certain arrow marks are stamped on the timing case and sprockets so that if for any reason the timing has to be broken, the engine can be easily re-set to its original timing.

The method of marking is as follows :—

(a) **Camshaft Sprocket**

With the timing chain in position and No. 1 piston at T.D.C. on compression stroke, an arrow is stamped on the outside edge of the camshaft sprocket. This arrow matches up with an arrow stamped on the timing case front face. An arrow is also stamped on the inside of the camshaft sprocket which matches up with another arrow stamped on the camshaft hub. The purpose of these arrows is to show the original position of the camshaft sprocket in relation to the camshaft hub.

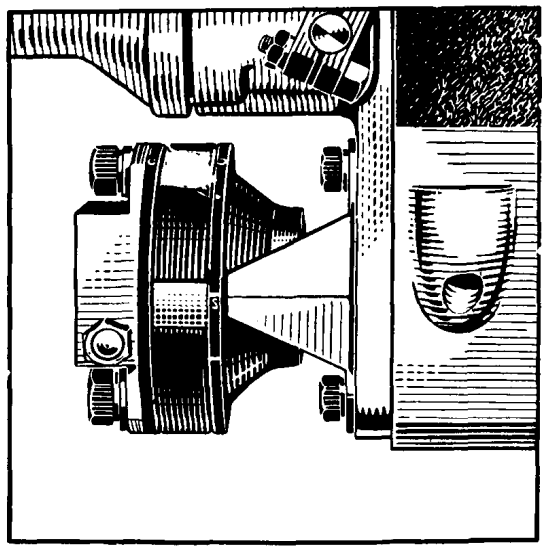


Fig. 21

The sprocket is secured to the camshaft by three setscrews, and it is by removing these setscrews and placing them in the alternate set of holes and/or turning the sprocket rim on the hub one set of

holes, that a difference in valve timing in multiples of 3° of crankshaft angle is achieved.

(b) **Fuel Pump Drive Sprocket**

With the engine and camshaft sprocket set as previously mentioned, an arrow is stamped on the fuel pump drive sprocket which matches up with an arrow stamped on the timing case front face.

(c) **Fuel Pump Timing Marks**

There are three different markings on the fuel pump coupling (See fig. 21). The first is a scribed line stamped with the letter " S " on the fuel pump coupling half which, when it coincides with another line on the preset plate, indicates the correct position of the pump when the engine is at T.D.C. firing on No. 1 cylinder.

The alternate scribed line on the fuel pump half coupling denotes spill timing 29° B.T.D.C.

The third of the coupling marks consists of two noughts stamped on the fuel pump coupling ; one of these noughts is on the driving flange and the other on the driven flange of the fuel injection pump. These two noughts should be in line across the coupling. Particular care should be taken that if the pump is removed, to ensure that the two noughts are in line when the pump is replaced, otherwise the pump timing will be 180° out.

FUEL PUMP COUPLING ADJUSTMENT

On the fuel pump coupling there are ten graduations, that is, five graduations on either side of the neutral line. This provides a fine adjustment to obtain a perfect injection timing point, also the pump can be advanced or retarded easily should the necessity arise later. One graduation on the coupling is equal to approximately 1 in. on the flywheel. If it is desired to advance or retard the injection timing, the two setscrews securing the graduation plate and the driving flange of the coupling should be loosened and the necessary adjustment made. Care should be taken to see that these setscrews are tightened when the adjustment has been made.

When an engine comes off the test bed at the factory, a line is scribed right across the coupling to indicate the original position of the coupling.

TO RESET ENGINE TO ORIGINAL TIMING

Remove rocker assembly and atomisers.

Release the pawls in the automatic tensioner and push it as far to the left as it will go ; wedge it in that position with a piece of wood.

Bring No. 1 piston to T.D.C.

Turn the fuel pump drive until the arrow mark on the sprocket is in line with the arrow on the timing case. The scribed line on the fuel pump coupling marked with the letter " S " should coincide with the line on the preset plate.

Turn the camshaft until the arrow on the sprocket is in line with the arrow on the timing case.

Fit the timing chain (it is advisable to wait until the valve and fuel pump timing have been checked before finally rivetting the chain).

Remove wedge from the auto tensioner.

With the chain in its tensioned position, check the timing to ensure the arrows are in line T.D.C. firing on No. 1 cylinder.

Replace the rocker shaft and adjust the tappets to .012 in.

Replace the atomisers.

The tappets should be adjusted to .010 in. with the engine warm.

REVISING THE VALVE TIMING

Remove the atomisers.

Break locking wire from the three setscrews securing the camshaft sprocket to the camshaft.

Slacken the three setscrews but do not remove.

Turn the engine until equal lift is obtained on the tappets of No. 6 cylinder.

In the case of a 4 cylinder engine refer to No. 4 cylinder.

In the case of a 3 cylinder engine refer to No. 1 cylinder.

Release the pawls in the automatic tensioner and push it as far to the left as it will go. Wedge it there with a piece of wood.

Unscrew the three setscrews and remove the camshaft sprocket.

Bring No. 1 piston to T.D.C. That T.D.C. on No. 1 piston has been obtained can be checked by examining the flywheel or the

crankshaft at the front end where the key for the fan belt pulley should be at the top of its periphery.

Obliterate the old timing marks on the camshaft sprocket.

Place sprocket with chain engaged on camshaft hub.

Slip chain over sprocket teeth and turn the sprocket until one set of holes on the camshaft hub and camshaft sprocket are in line. Replace and tighten the three setscrews. Whilst carrying out this operation the timing chain must be kept as taut as possible between the crankshaft, auxiliary drive and camshaft sprocket ; the slack being between the camshaft sprocket, auto-tensioner and crankshaft sprocket.

Remove the wedge from the auto-tensioner and allow it to take up the slack in the chain.

If revision of the valve timing is necessary it may be found that the arrow stamped on the auxiliary drive sprocket may be slightly out of line with the arrow on the timing case. With No. 1 piston at T.D.C. on its compression stroke (P3 engines, turn crankshaft one complete revolution after revising the valve timing) the fuel pump coupling should be adjusted if necessary to bring the scribed line marked with the letter " S " on the coupling in line with that on the preset plate.

When the valve timing has been checked and found to be correct, bring No. 1 piston to T.D.C. on its compression stroke and mark the camshaft sprocket to coincide with the arrow mark on the timing case.

Refit atomisers and adjust tappets to .010 ins. with the engine warm.

Check the timing as follows.

(a) **Valve Timing**

Turn the engine in the normal direction of rotation until the inlet tappet on No. 1 cylinder just tightens.

When this is done with the engine cold, a .002 in. feeler should be placed between tappet and rocker to ensure that the timing is checked at a tappet clearance (.010 in.) corresponding to that which it will obtain under running conditions. Alternatively set the inlet tappet of No. 1 cylinder at .010 in., resetting to .012 in. after checking the timing. This is the point at which the valve just

begins to open, and for good valve timing this should be 13° B.T.D.C. Valve Timing must be between 11° and 16½° for inlet opening B.T.D.C. If the timing is not within these limits, the necessary adjustments should be made on the camshaft sprocket.

(b) **Injection Timing.**

To check the fuel pump timing proceed as follows :

Remove No. 1 fuel injection pipe.

Feed fuel to the fuel gallery of the fuel pump. The best method is by gravity feed tank with a pipe coupled to the fuel gallery.

Open the bleed screw on the fuel pump and allow fuel to flow until it comes through free from air bubbles and then tighten the bleed screw.

Wipe all surplus fuel oil away from the open end of the delivery valve holder, and slowly turn the engine until fuel just begins to well-up in the delivery valve holder. At this point stop turning the engine. This is the approximate point of port closure which should be 29° B.T.D.C. On a 14¾ in. diameter flywheel this will be 3.74 inches B.T.D.C.

Make any necessary adjustments to the fuel pump sprocket (one tooth equals 18°), or on the fuel pump coupling ; one graduation on this coupling is approximately 1 in. on the flywheel.

When the timing is found to be correct, disconnect gravity feed tank and replace No. 1 fuel injection pipe.

Rivet the timing chain.

Bring the engine to T.D.C. No. 1 piston at the top of its compression stroke. Mark the camshaft and fuel pump drive sprockets and the timing case with arrows to indicate camshaft and fuel pump positions with the engine at T.D.C. No. 1 piston on its compression stroke.

Final adjustments on the fuel pump coupling to find the perfect injection point can be made after testing the engine. This injection point may vary slightly with each individual engine.