

# MOTOR MOWERS

## *STUDENT NOTES*

*for introductory motor courses*



by

**Jim Sheffield**

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# MOTOR MOWERS

*Student Notes  
for  
TAFE and High School Students*

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**Jim Sheffield**



*Wet Paper*

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## ***Motor Mower Notes***

for TAFE and High School Students



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# CHAPTER 1

## FOUR STROKE ENGINES

---

Whether it be an automobile, motor bike, outboard or lawn mower the power source is basically the same, an Internal Combustion Reciprocating Engine.

The source of power is heat, formed by the burning of a combustible mixture of petroleum products and air. In an internal combustion reciprocating engine the burning of this combustible mixture takes place inside a closed cylinder containing a piston.

The resulting expansion from the heat of combustion applies pressure on the piston crown forcing it down the bore, to turn a shaft by means of a connecting rod and crank. (fig 1).

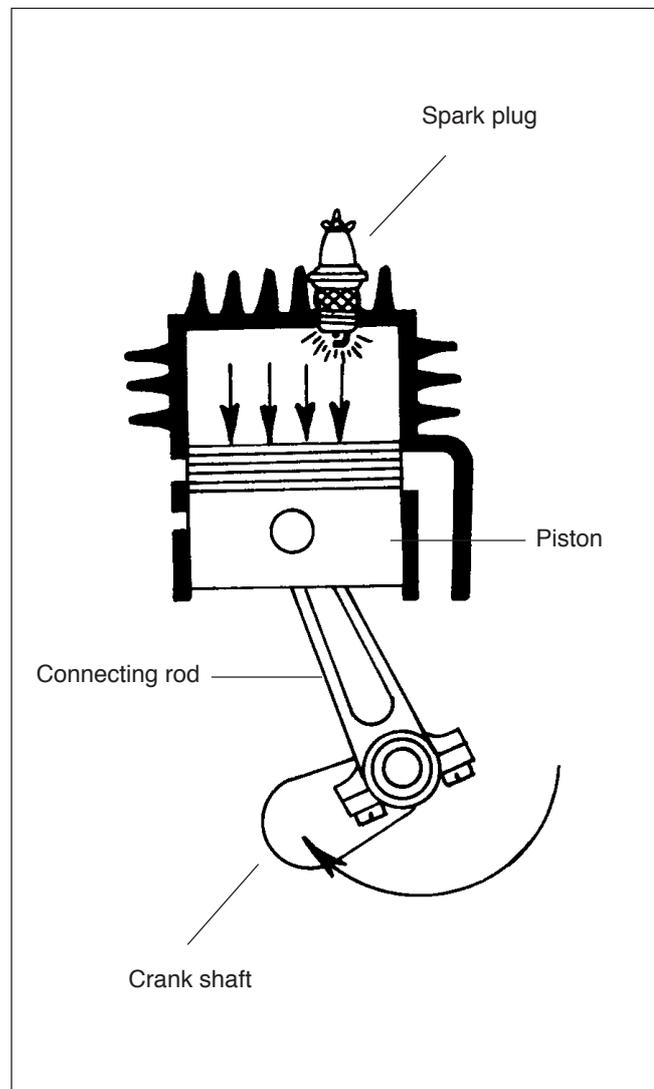
In a reciprocating engine, each movement of the piston (up or down) the bore of the cylinder, is known as a stroke.

The series of events that take place in order for an engine to run may occur in either one revolution of the crankshaft referred to as a TWO STROKE cycle (*clerk*), or in two revolutions of the crankshaft known as a FOUR STROKE cycle (*otto*) engine.

*CLERK* and *OTTO* being the names of the original inventors of the engines.

In either engine, a series of five events are required in order to provide power.

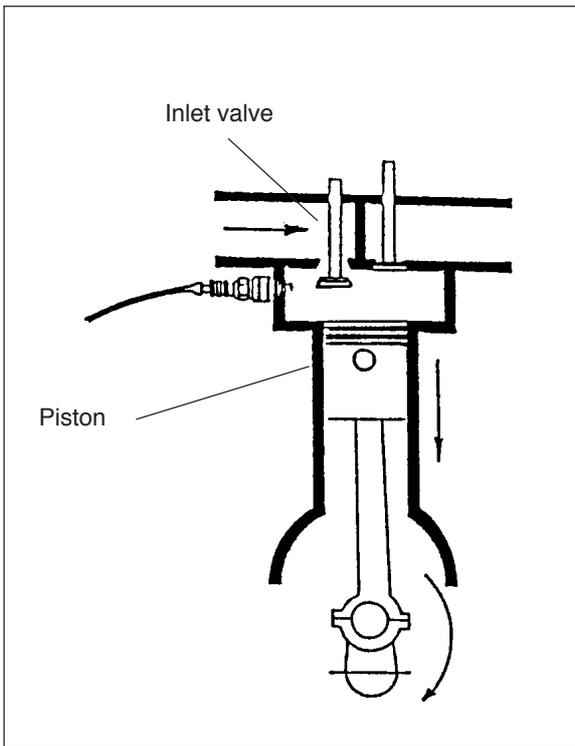
This series of events is called a cycle or (WORK CYCLE) and is repeated in each cylinder as long as work is done.



**Fig 1** Combustion expansion forces piston down to rotate crankshaft

### THE SERIES OF EVENTS ARE AS FOLLOWS

- (1) The mixture of air and fuel is drawn into the cylinder, by reducing cylinder pressure to less than atmospheric pressure.
- (2) The mixture is compressed or reduced in volume.
- (3) The compressed mixture is ignited by an electric spark.
- (4) The expansion of the burning air/fuel mixture forces the piston down thus converting chemical energy into mechanical energy.
- (5) The burnt gases are exhausted to the atmosphere from the cylinder so that the cycle can begin again.



The five events that take place to complete the work cycle are often referred to as INDUCTION, COMPRESSION, IGNITION, POWER, EXHAUST.

The main operational difference between the two and four stroke cycle engines is that the two stroke (CLERK) has a power stroke on every revolution of the crankshaft where as the four stroke (OTTO) unit fires on every second revolution.

## FOUR STROKE ENGINES

The term “STROKE” refers to the distance travelled by the piston from one limiting position to another in the cylinder bore. The upper limit is called TOP DEAD CENTRE (T.D.C.) while the lower limit is referred to as BOTTOM DEAD CENTRE (B.D.C.).

A piston completes a stroke when it moves from B.D.C. to T.D.C. or from T.D.C. to B.D.C.

The four strokes needed to produce one cycle of events are:-

- (1) The inlet or induction stroke
- (2) The compression stroke
- (3) The power stroke
- (4) The exhaust stroke

Two strokes occur during each revolution of the crankshaft.

## THE INLET OR INDUCTION STROKE

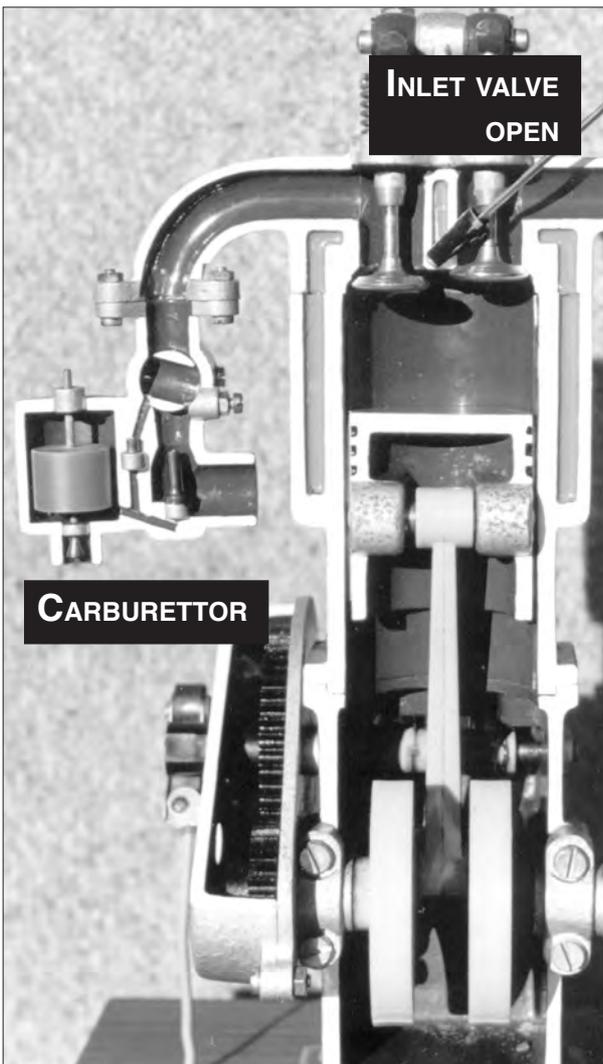
**Inlet valve open - Exhaust valve closed.**

The first stroke of the cycle is the inlet stroke (*fig 2*) where the piston travels down the bore from T.D.C. to B.D.C. creating a low pressure area within the cylinder.

Because atmospheric pressure is now greater than the pressure within the cylinder, air is drawn in through the carburettor and open inlet port to “fill” this vacuum.

The pointer in the photo in figure 2 shows the inlet valve open.

**Fig 2** The piston is moving from T.D.C. to B.D.C. and the crankshaft has turned through 180 degrees. (one half revolution)



As the air passes through the carburettor it becomes charged with petrol vapour and there is now a highly combustible mixture within the cylinder between the piston and the cylinder head (*fig 3*).

When the piston has reached T.D.C. the mixture will have been compressed to between 1/5 and 1/8 of its original volume.

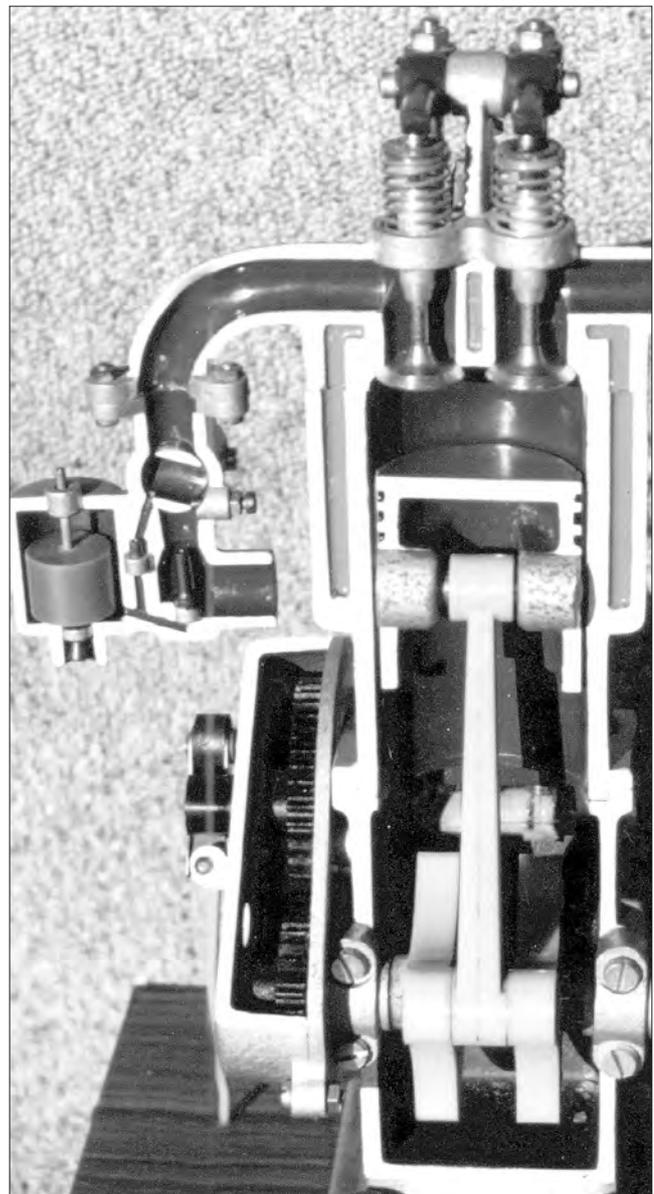
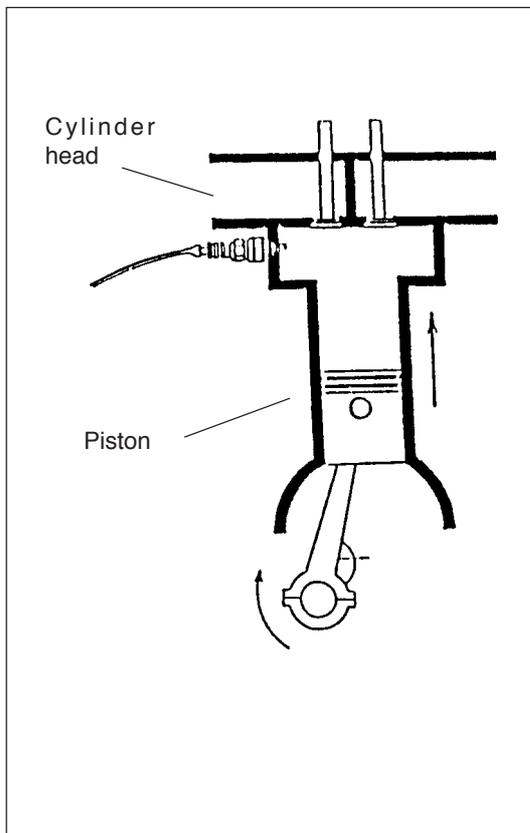
## THE COMPRESSION STROKE

### Both valves closed

On completion of the piston moving down to B.D.C. on the induction stroke, the inlet valve closes. Since the exhaust valve is also closed, the upper end of the cylinder is now sealed.

As the piston travels back up the cylinder the trapped combustible mixture is “squeezed” or compressed between the piston and the cylinder head (*fig 3*). When the piston has reached T.D.C. the mixture will have been compressed to between 1/5 and 1/8 of its original volume.

**On completion of the piston moving down to B.D.C. on the induction stroke, the inlet valve closes**



**Fig 3:** The piston has moved from B.D.C. to T.D.C. and the crankshaft has made one complete revolution of 360 degrees.

# THE POWER STROKE

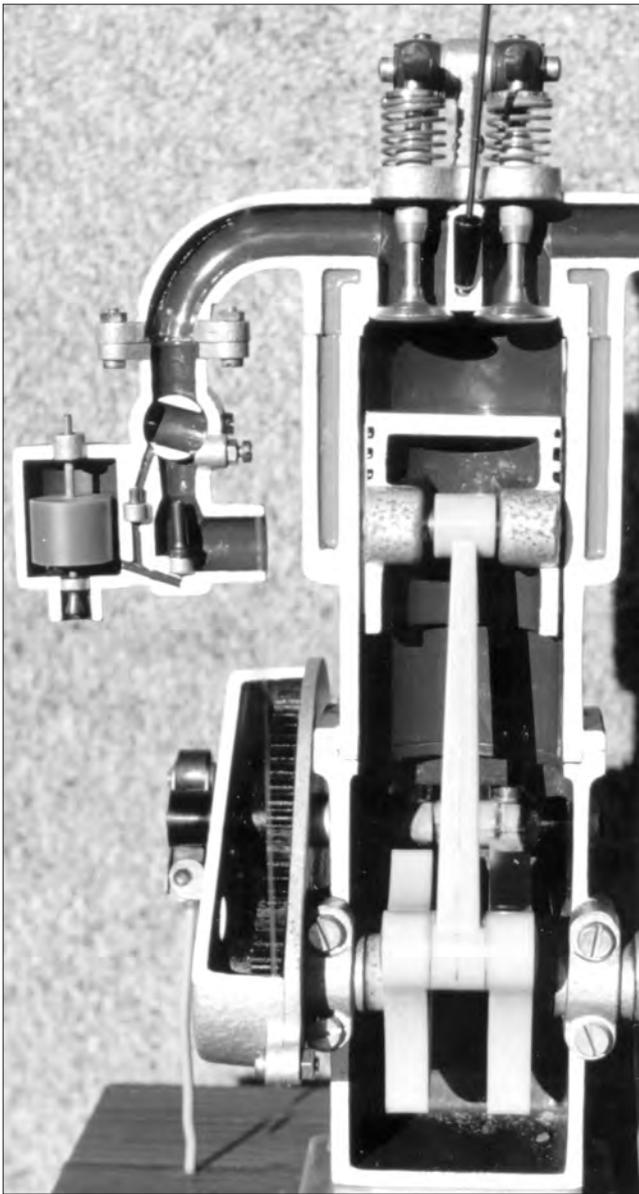
## Both valves closed

Just prior to the piston reaching T.D.C. the ignition system causes a spark to occur at the spark plug gap which ignites or (fires) the combustible mixture within the combustion chamber.

As the mixture burns it expands very rapidly, and with both valves closed the pressure of expansion, forces the piston downward in the cylinder with tremendous force.

The power impulse is then transmitted to the connecting rod which in turn revolves the crankshaft. (fig 4).

Both valves closed



Just prior to the piston reaching T.D.C. the ignition system causes a spark to occur at the spark plug gap which ignites or (fires) the combustible mixture within the combustion chamber

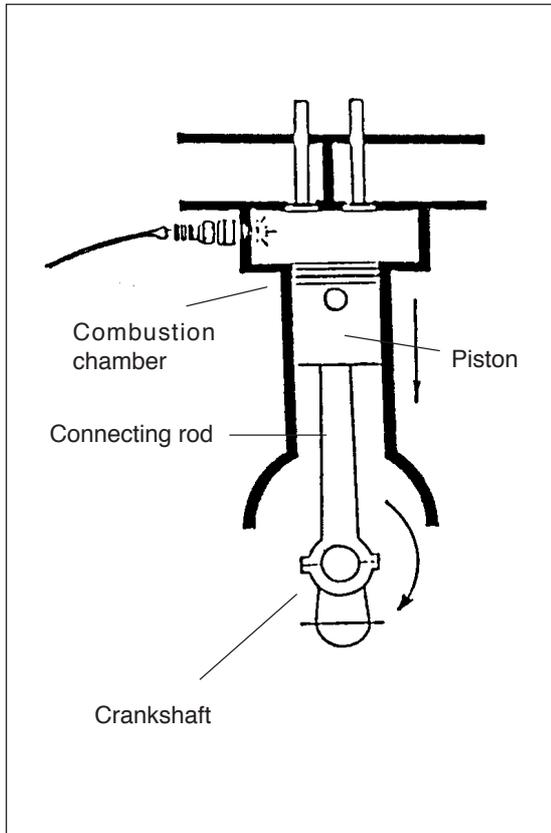


Fig 4 The piston has moved down from T.D.C. to B.D.C. and the crankshaft has revolved 1.5 times or 540 degrees.

## THE EXHAUST STROKE

### Inlet valve closed. Exhaust valve open.

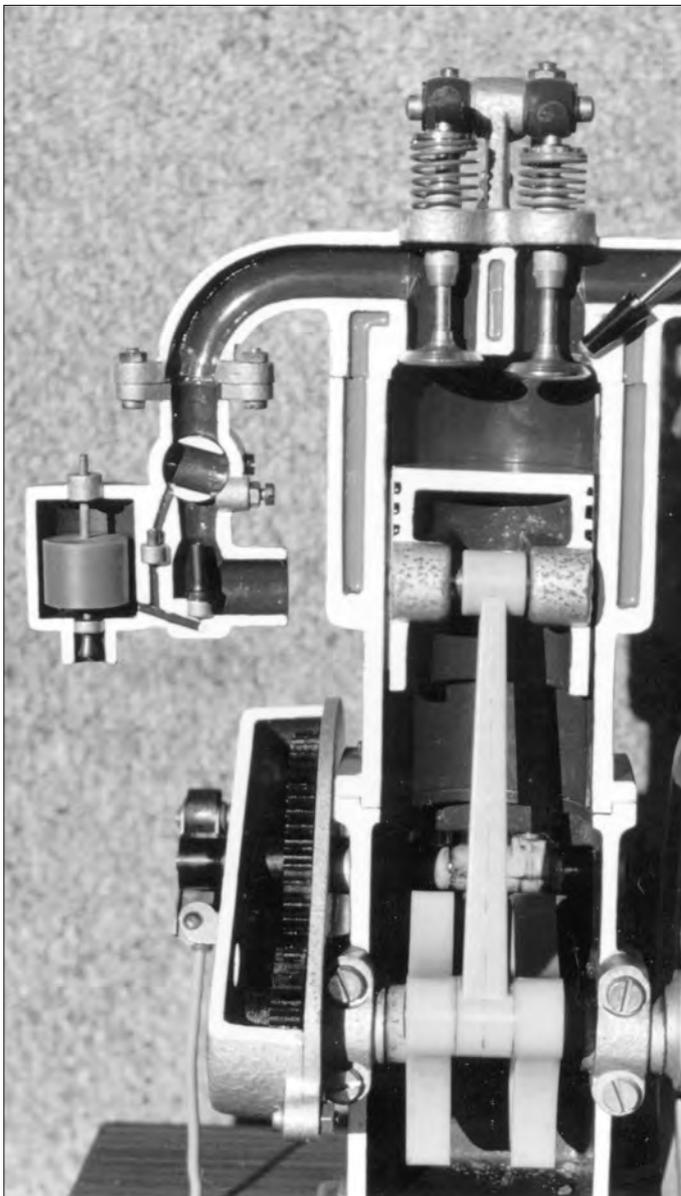
As the piston nears B.D.C. the exhaust valve starts to open and as the piston moves up the cylinder bore it pushes the burnt or “exhausted” gases out past the open exhaust valve and through the exhaust system and into the atmosphere. (fig5).

This exhaust stroke completes the cycle of events of a four stroke engine, the next stroke (a down stroke) being an induction stroke commences the following cycle.

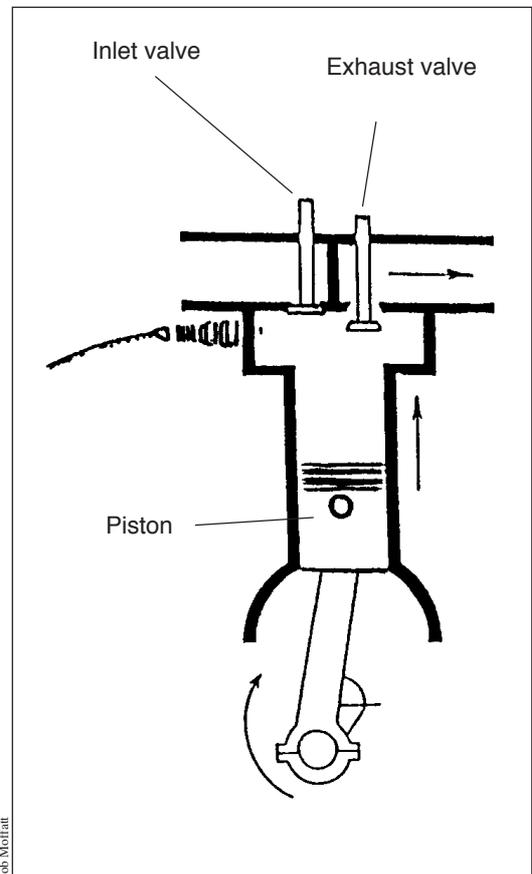
This four stroke cycle is repeated continuously while the engine is running:-

“Intake, Compression, Power, Exhaust” : “Intake, Compression, Power, Exhaust” and so on.

The four stroke engine requires a complicated system of valving and as only one power stroke is obtained every two revolutions of the crankshaft, a heavier flywheel is required to carry the components through the non-working strokes of the cycle.



**Fig 5** The piston has moved up from B.D.C. to T.D.C. and the crankshaft has revolved through 2 complete revolutions or 720 degrees. The pointer in the photograph shows the exhaust valve open



Other factors to consider during the cycle of operation are:

- the intake stroke
- the compression stroke
- the power stroke
- lubrication
- crankcase oil change
- crankcase breathers

*The longer the stroke of the piston on its downward movement from T.D.C. to B.D.C., and the larger the bore diameter, the greater the volume of combustible gases will be within the combustion chamber*

## INTAKE STROKE

The longer the stroke of the piston on its downward movement from T.D.C. to B.D.C., and the larger the bore diameter, the greater the volume of combustible gases will be within the combustion chamber.

The inlet valve must be timed to open at the exact moment to enable full entry of the air/fuel mixture. It must close at the correct time and form a perfect seal during the compression stroke. The shape of the valve head must allow for an unrestricted flow of gasses into the combustion chamber.

An inlet valve head is normally larger than an exhaust valve head so as to allow for the improved flow of gasses (*see fig 6*).

An inlet valve is not subjected to the extreme temperatures that an exhaust valve is due to the cooling effect that the incoming air/fuel mixture has.

## COMPRESSION STROKE

During the compression stroke the air/fuel mixture is compressed into a very small space known as the combustion chamber, and throughout this stroke the both valves have to be perfectly seated (to form a seal), and the piston rings prevent leakage past the piston.

As the piston nears T.D.C. the air/fuel mixture has heated itself through compression, to a point where the fuel will almost ignite spontaneously. So when the spark does occur, the ignition of the air/fuel mixture is almost instantaneous.

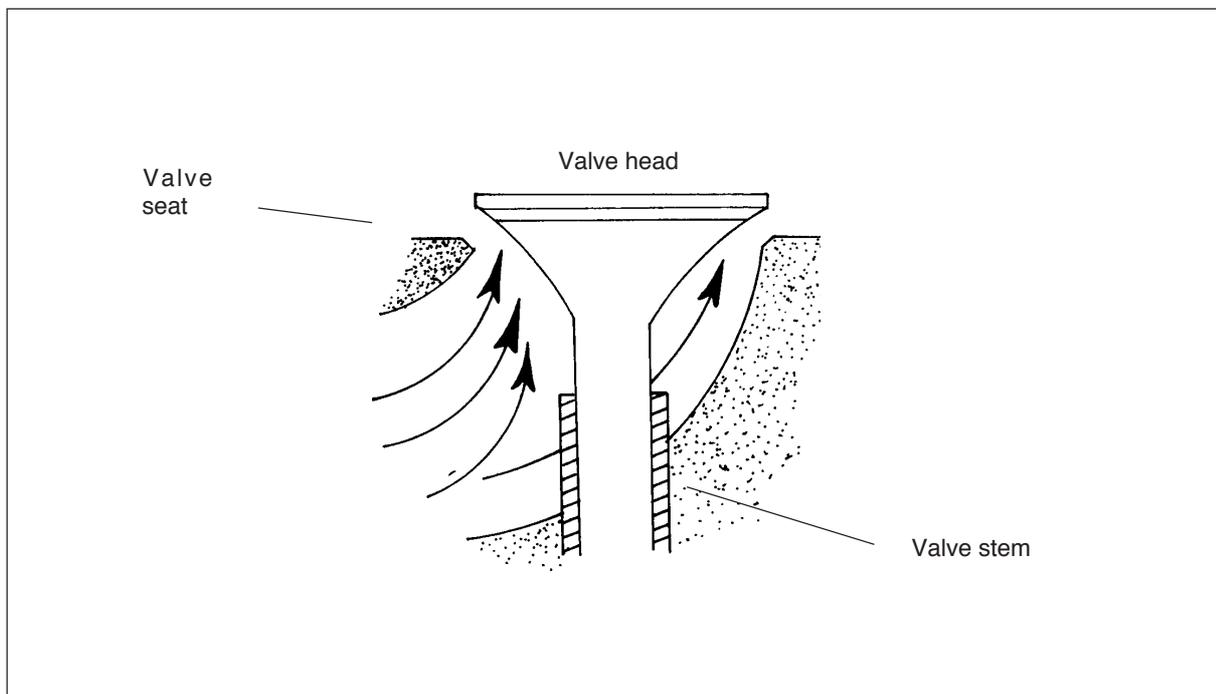


Fig 6 Inlet valve

## POWER STROKE

The ignition of the air/fuel mixture, and the force of the explosion, forces the piston down the cylinder bore.

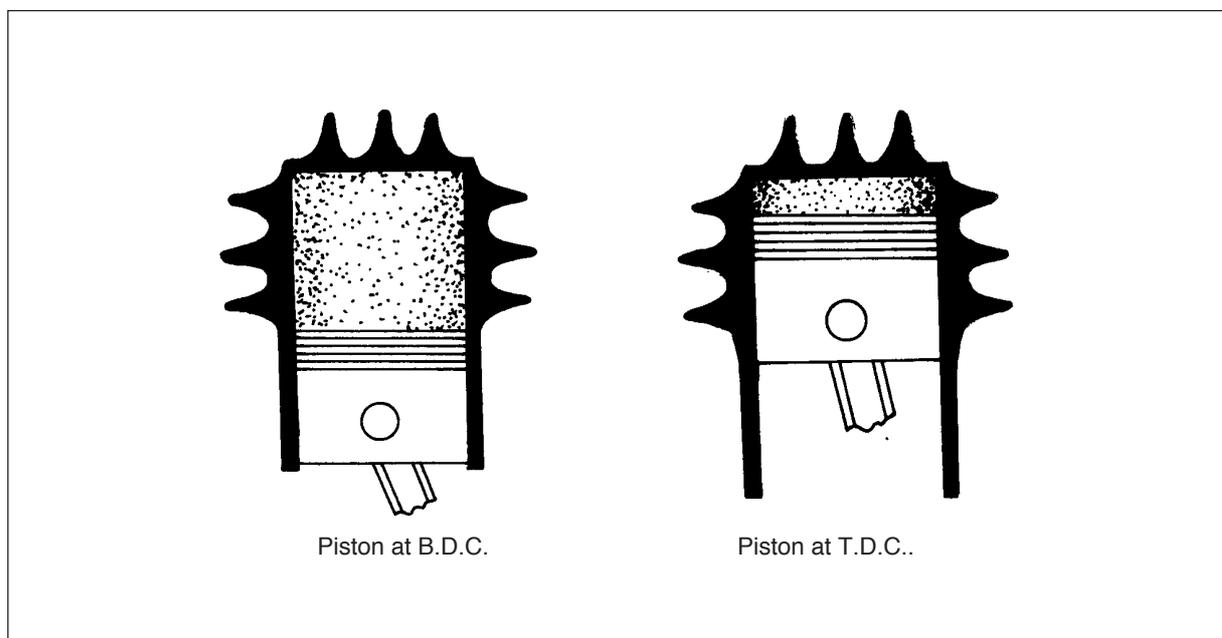
The entire fuel charge does not burn instantly, but progressively burns away from the spark plug, providing an even pressure over the piston crown throughout the stroke.

Most engines have the spark timed to ignite the fuel just prior to T.D.C., this enables a longer period of time for the mixture to burn and accumulate its expanding pressure.

The amount of power produced on this stroke is dependant on two things:-

- (1) The volume of air/fuel mixture that was drawn into the cylinder on the induction stroke.
- (2) The compression ratio of the engine. (The difference in the volume of the cylinder at B.D.C. to the volume of the cylinder at T.D.C.).

However if the compression ratio is too high, the air/fuel charge may be heated to its flash point and ignite too early.



**Fig 7** (Compression ratio is the volume of the cylinder at B.D.C. divided by the volume of the cylinder at T.D.C.)

## EXHAUST STROKE

Once the piston has completed the power stroke the burnt gases must be removed prior to introducing the fresh charge. The exhaust valve opens and the rising piston in the bore pushes out the exhaust gases.

The exhaust valve must operate in the same manner as the inlet valve, where when seated it forms a seal and when open allow an unrestricted flow of gas.

A passage way provided for the exhaust gas to be carried away is called the exhaust port or exhaust manifold. The exhaust valve operates at a much higher temperature than the inlet valve and relies on its cooling through the valve guide and valve seat by means of conduction.

## LUBRICATION

Lubrication of a four stroke engine is by means of an oil reservoir called the SUMP or CRANKCASE. Most common methods used for lubrication are the pump system or splash feed system. Some manufacturers use a combination of both systems.

In the main, manufacturers of small engines used for mowers, chain saws etc. only use the splash system. These systems use a “slinger” or “dipper” fitted to the connecting rod which as it revolves with the crankshaft splashes oil onto the various lower moving components.

With the splash system the lower bore area receives a generous amount of oil, and it is the function of the oil control ring on the piston, to remove any excess oil and return it to the crankcase, otherwise oil burning problems will result.

The connecting rod bearing and gudgeon pin receive lubrication through oil passage holes drilled in the connecting rod. Lubricating oil has to perform a variety of functions which include cooling, cleaning, sealing and lubricating.

Oil cools the engine by absorbing heat while circulating through and around the various parts.

This absorbed heat is transferred to the air and to the oil remaining in the crankcase, which is cooler than the oil returning from the moving engine parts.

Oil cleans the engine by washing the internal parts gathering impurities which have formed as a result of combustion. These impurities are removed from the oil by either the oil filter, (if fitted), or with the oil when drained from the engine. The oil provides a seal between the cylinder bore and the piston rings.

Lubrication is carried out by providing a thin film of oil between the moving components, resulting in reduced wear, by preventing metal to metal contact between the parts.

## **CRANKCASE OIL CHANGE**

The oil should be changed when the engine is hot, and after about 25 hours of operation. (MORE FREQUENTLY IF OPERATING UNDER DUSTY CONDITIONS)

The selection of the oil to be used in the engine is of utmost importance to the life of the engine, and reference to the operators manual should be made.

Oil used in the engine needs to carry out the four functions mentioned earlier, whether the engine is cold or hot, and under the varying operating conditions it may be subjected to.

When the engine is cold, you need a thin free flowing oil, a thick oil would not flow freely enough to lubricate the components. And so the term Viscosity.

*Viscosity refers to the internal resistance to flow. (The “thickness” or “body” of a fluid).*

Oils are classified for their viscosity by numbers, a 10 may be recommended for winter and a 30 for summer operation. A multi-grade oil that reduces change in viscosity over a wide range of operating conditions overcomes these problems.

A multi-grade oil is one which covers more than three classifications. (i.e. 10 W 30 ; 20 - 40 ; 10 - 40).

The mineral oil refined from the crude oil has to have a number of chemical additives added to overcome various by-products of combustion whereby its lubricating qualities are extended.

Some of these additives used are :- Dispersant, Inhibitors, Anti-Scuff Additives, Extreme Pressure Additives, Anti-Foam Agents and Pour Point Depressants.

- (a) DISPERSANT:- This additive is to prevent products of combustion, carbon and sludge from forming within the engine.
- (b) INHIBITORS:- This is added to reduce the oils tendency to produce varnishes or resins. A corrosion inhibitor reduces the acidic products of combustion.
- (c) ANTI-SCUFF ADDITIVES:- These additives reduce scuffing of cams and tappets.
- (d) EXTREME PRESSURE ADDITIVES:- To prevent the oil film on the components from being ruptured.

- (e) ANTI-FOAM AGENTS:- Are used to prevent frothing and to reduce the rate of oxidation.
- (f) POUR-POINT DEPRESSANTS:- Reduce the formation of waxes and maintain fluidity in the lubricant at low temperatures.

Most engine oils lose their ability to lubricate the components not because the oil has worn out, but because it has become loaded with contaminants such as water, acids, unburnt and burnt fuel, dirt and abrasives.

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***Never dispose of old engine oil down a drain***

---

## **CRANKCASE BREATHERS**

A number of four stroke engine manufacturers have a crankcase breather designed to maintain a vacuum in the crankcase. This valve allows air to be pushed from the crankcase area on the downward stroke of the piston, but closes on the upward movement of the piston.

By maintaining a partial vacuum in the crankcase, the operating pressures are reduced on the seals, gaskets and piston rings. It is important that this valve is operational for if this crankcase vacuum is lost exhaust smoke will be evident through the muffler.

Crankcase breathers, (if fitted), will normally have either a hose or pipe, (with rubber elbows) connecting between the crankcase and air cleaner so that dirt does not enter the crankcase.

# **SMALL ENGINES Worksheet 1**

---

## ***FOUR STROKE ENGINE - WORKSHEET***

- (1) Name the five series of events that take place to complete a work cycle.

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- (2) Explain the meaning of the term “STROKE”.

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---

- (3) Name the four strokes that take place in order to complete the four stroke cycle.

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(4) What are two functions of an inlet valve ?

---

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(5) Explain the reason for the difference in temperature between the exhaust and inlet valve.

---

---

(6) Why must the compression ratio be limited in a spark ignition type engine ?

---

(7) What are the two methods used to lubricate a four stroke engine ?

---

(8) What is the name given to a fluids resistance to flow ?

---

(9) State two functions of an engine oil.

---

---

(10) Name two additives used in engine oils and state their functions.

---

---

(11) Why is it necessary to change the engine oil in a small engine ?

---

---

(12) What is the component used to stop the build up of pressure in the crankcase ?

---

# CHAPTER 2

## TWO STROKE ENGINES

---

The two stroke engine performs the same cycle of events as the four stroke engine, the main difference being that Intake, Compression, Power and Exhaust are carried out in only two strokes of the piston, which is only one revolution of the crankshaft.

A two stroke engine has some advantages over the four stroke, the main one being that it is much simpler in design as it does not require valves, camshaft and tappets, therefore the overall weight of the unit is reduced, when compared to a four stroke of equivalent horsepower.

In addition to this, no matter what angle a two stroke is operating on, adequate lubrication is obtained through the PETROIL method of lubrication. (Petroil lubrication described later).

Two stroke engines are used frequently in, lawn mowers, chain saws, outboards, grooming aids for path edges, motor bikes and go-carts.

As in the four stroke engine, fuel mixture must be admitted into the cylinder, compressed, ignited, and the burnt gases released to the atmosphere.

For this cycle of events to occur during only two piston strokes, action must take place both above and below the piston.

In the two stroke engine, the piston carries out the function of the valves in the four stroke, by covering and uncovering ports cast into the engine block during manufacture.

It is essential for the satisfactory operation of the engine that these ports are exactly located to ensure correct timing of the intake, transfer and exhaust functions to take place.

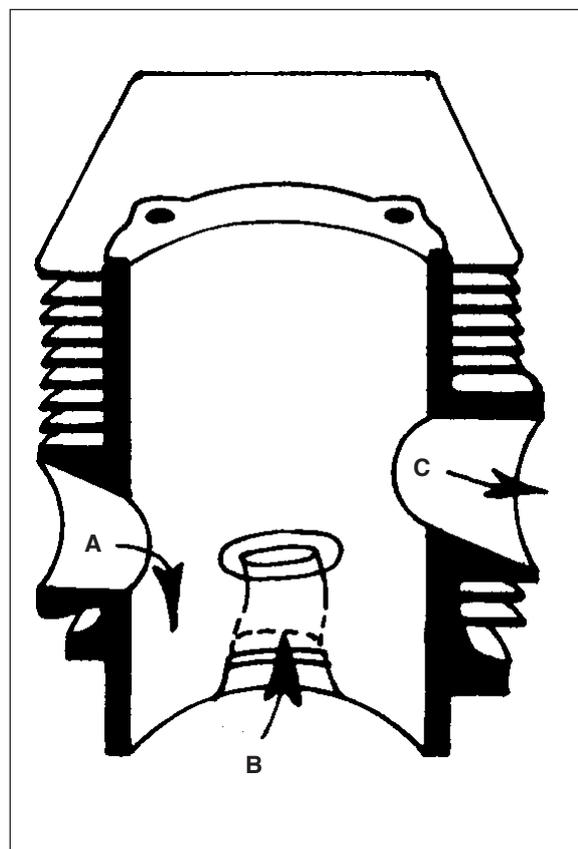
Piston is rising up from B.D.C., there is a charge of fuel mixture in the combustion chamber above the piston. As the piston rises, the transfer port (C) and then the exhaust port (B) are closed.

Continuing upward, the piston compresses the fuel mixture and at the same time creates a partial vacuum in the air tight crankcase.

(NOTE) Two events taking place at once, compression and the creation of a vacuum within the crankcase.

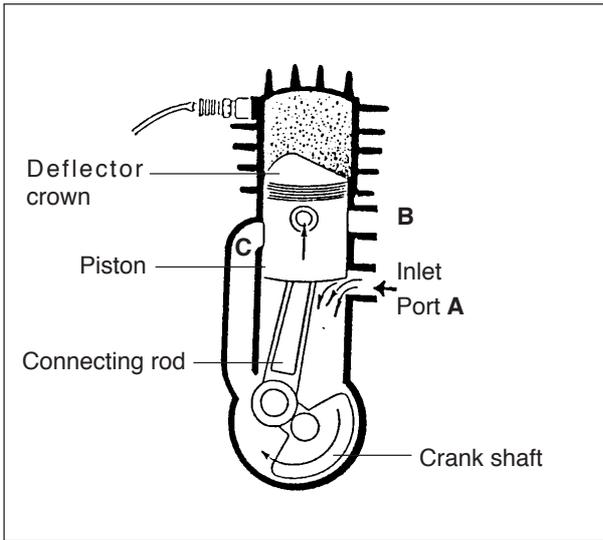
As the piston approaches T.D.C. (as shown in *fig 10*) the lower edge of the piston skirt uncovers the inlet port (A), and the air/fuel mixture rushes in to fill the vacuum in the crankcase.

Just before T.D.C. the compressed air/fuel mixture is ignited, and the high pressure of the burning

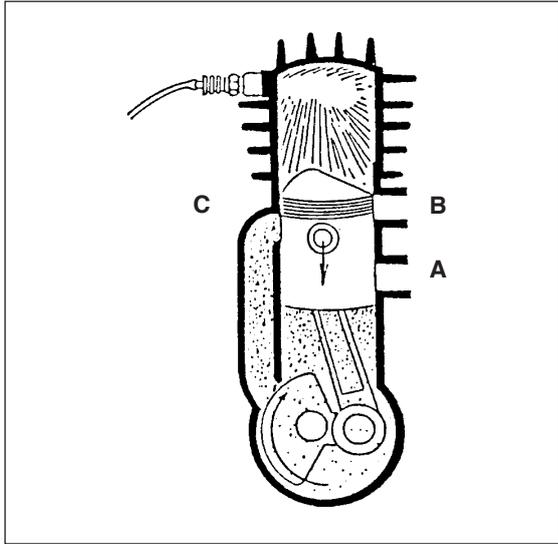


**Fig 8.** A cutaway cylinder showing  
(a) Inlet port  
(b) Exhaust port  
(c) Transfer port

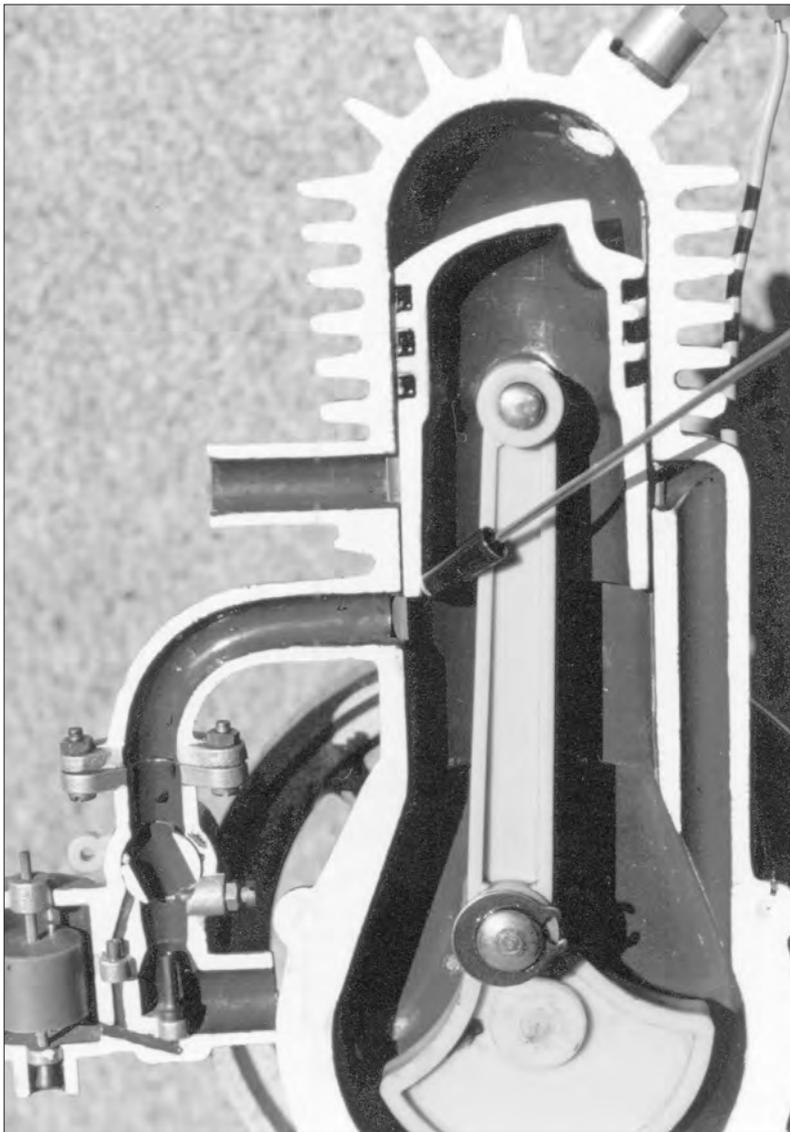
gases forces the piston down on the power stroke. The transfer and exhaust ports are closed. A little after T.D.C. the inlet port is also closed and further downward movement of the piston compresses the mixture trapped in the crankcase as shown in *figure 9b*.



**Fig 9a** Piston approaching T.D.C.



**Fig 9b.** Piston descending



**As the piston approaches T.D.C. the lower edge of the piston skirt uncovers the inlet port as shown by the pointer in the arrow and the air/fuel mixture rushes in to fill the vacuum in the crankcase**

Bob Moffatt

**Fig 10.** Piston approaching T.D.C.

When the piston has travelled far enough down the cylinder to open the exhaust port, the burning gases which still possess some energy, escape to the atmosphere.

As the piston moves further down the bore of the cylinder the transfer port is opened, and the mixture which has been pressurised in the crankcase flows into the cylinder space above the piston. (fig 11).

A deflector designed shape on the piston crown, as shown in the photograph in figure 11, directs the incoming charge upwards, away from the exhaust port. Moving towards the top of the cylinder, the slightly pressurised fresh charge assists in scavenging (cleaning out) the last remnants of the burnt gases.

As the piston rises on the next stroke, the transfer and exhaust ports are closed by the piston, the mixture is compressed and the cycle is repeated.

The events shown in the diagrams (Fig 9 to Fig 12) have all taken place during one crankshaft revolution 360 degrees, while the piston has completed two strokes. Every time the piston reaches T.D.C. in the cylinder bore, it will be driven down on a power stroke.

This type of engine operates on the loop scavenge principle, but is often referred to as the three port two stroke, where the inlet port is located in the cylinder wall, and is opened and closed by the piston skirt.

Another type of two stroke engine is the cross scavenged engine, which is being used considerably in outboard manufacture despite its higher cost to produce. This engine uses two port configuration, (i.e.. transfer and exhaust ports only) with the incoming air/fuel charge controlled by the use of reed valves located in the crankcase. This type is shown in Fig 13.

A reed valve which is essentially a strip of thin springy steel, is positioned over the port to act as a "flapper valve". They are really automatic inlet valves operating on the variations in crankcase pressures.

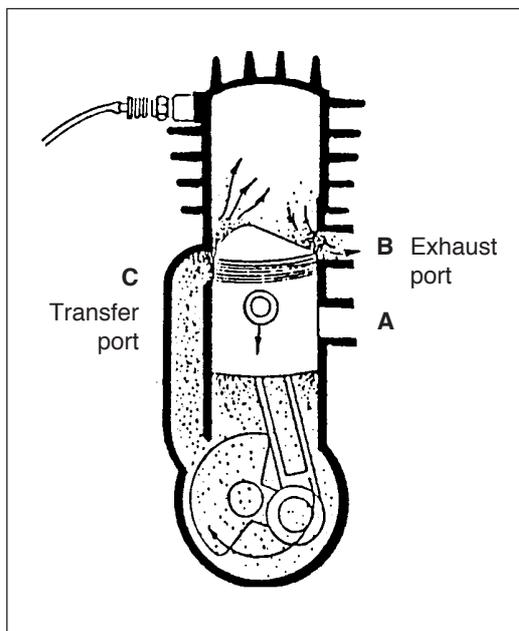
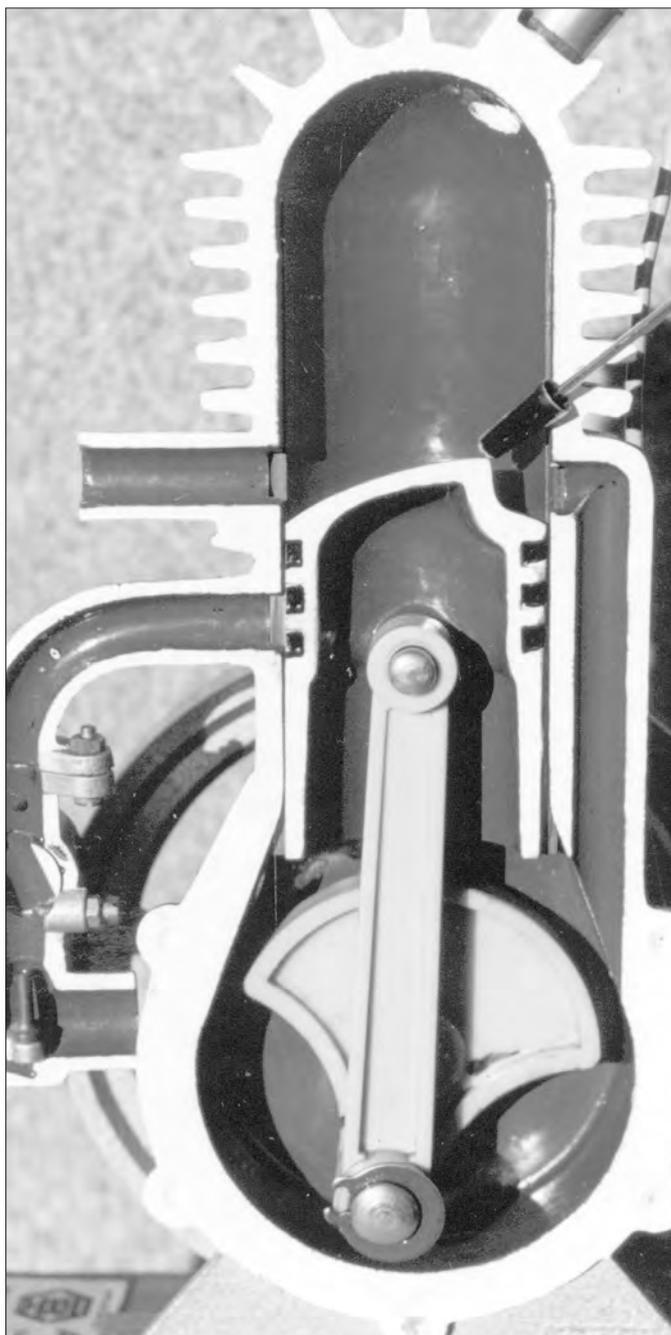


Fig 11. Piston approaching B.D.C.



Reed valves also provide instant power response when the throttle is snapped open, which is a requirement in high performance marine engines.

An advantage of reed valves is that they prevent any loss of performance caused by “blow-back” of the incoming air/fuel charge through the carburettor (which is common to the three port two stroke engine design).

Another advantage is that the reed valve can be located to direct the incoming petrol mixture directly onto highly stressed crankcase components to ensure adequate cooling and lubrication.

---

**Caution: Don't ever lift or bend a reed valve segment with your finger or you may damage its sealing ability**

---

## LUBRICATION

Lubrication of a two stroke engine is by means of a pre-mixed ratio of petrol and oil known as the PETROIL system, or by OIL INJECTION. In either of these systems it is important that the correct type of oil be used for the type of engine. (i.e. water cooled or air cooled).

WATER COOLED TWO STROKE - OUT-BOARD MOTOR OIL  
AIR COOLED TWO STROKE - TWO STROKE OIL

Automotive oil should NOT be used in two stroke engines as it has not been formulated with the necessary chemicals required. Automotive oil is only used in four stroke engines.

Should the incorrect type of oil be used, trouble could be experienced with plug fouling, excessive carbon deposits or reed valve sealing problems.

## PETROIL SYSTEM

This is where the oil and fuel ratio is pre-mixed. This ratio can range between 10:1 and 100:1 depending on the individual manufacturer of the engine.

A very common petrol ratio is 50:1 which means that there is 50 parts of petrol to 1 part of oil. This system assures that sufficient lubrication is provided at all operating speeds and engine load conditions.

## OIL INJECTION

With oil injection systems however, the ratio of oil provided with the fuel sent to the cylinders can be varied instantly and accurately, to provide the optimum ratio for proper lubrication at any operating speed and engine load condition.

Oil injection systems are more common to motor cycles and outboards whereas petrol systems are found more frequently in chain saws and motor mowers etc.

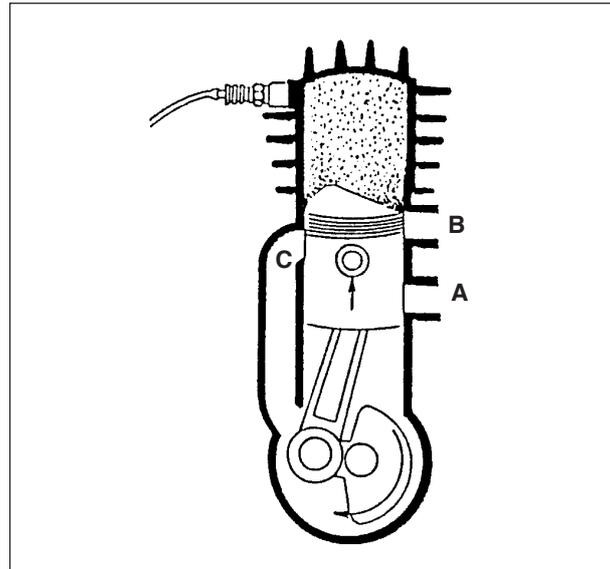


Fig 12 Piston rising

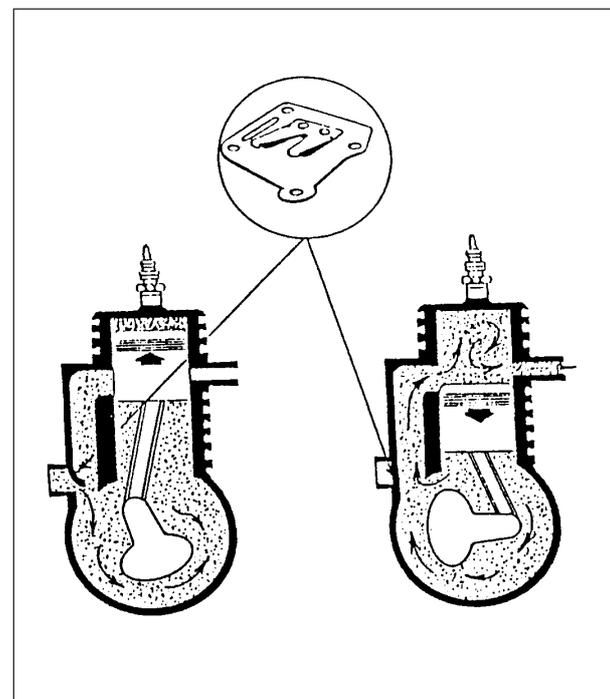


Fig 13 Reed Valves

# SMALL ENGINES Worksheet 2

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## **TWO STROKE ENGINE - WORKSHEET**

(1) Why can two stroke engines be run in any position ?

---

---

---

(2) In a three port two stroke engine what component carries out the function of the valves ?

---

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(3) Name the three ports of a two stroke engine.

---

---

(4) When the piston is rising in the cylinder bore from B.D.C. to T.D.C. .

What is occurring above and below the piston ?

---

---

---

(5) What is the purpose of the deflector shaped crown on the piston ?

---

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(6) What are the two types of scavenging systems used on two stroke engines ?

---

---

(7) What are the advantages of a reed valve ?

---

---

---

(8) What oil should be used when mixing a petrol formula for use in a water cooled two stroke engine ?

---

(9) What oil should be used in the petrol mix for a air cooled two stroke engine ?

---

(10) Name the two types of lubricating systems used in two stroke engines.

---

# CHAPTER 3

## FUEL SYSTEMS

---

### PETROL (Gasolene)

The petrol used in small engines should be clean, free from water contamination and reasonably “fresh”.

After any length of time in storage, (especially in small containers), petrol becomes “stale”, due to oxidation a “gum” like sticky material forms which can cause blockages to the petrol filter, or in the carburettor float bowl causing a restriction in the jets orifices resulting in hard starting and poor performance.

Water contamination can be obtained through having a partially filled container stand during lengthy periods of high humidity conditions. Sweating accumulates above the fuel line inside the container and gradually runs down the walls of the container to mix with the fuel.

(It is not always the fuel suppliers fault that there is water in the fuel tank).

When mixing a petrol mix for your engine always shake the container well before tipping it into the engines fuel tank, and once mixed it should be used within three months otherwise it will start to go off.

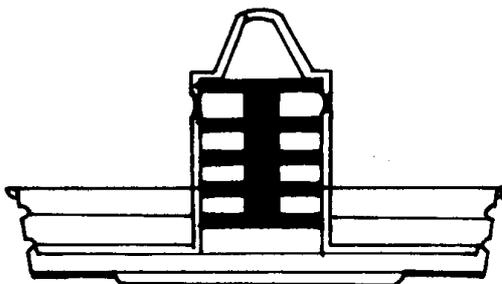
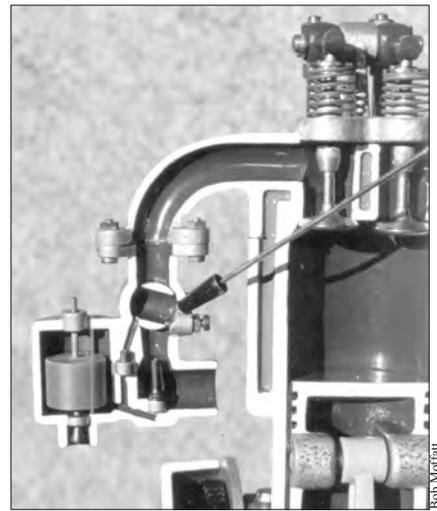
If purchasing pre-mixed petrol from a supplier always ensure it is of the correct ratio as recommended by the manufacturer of your engine.

### FUEL TANKS, LINES AND FITTINGS

Small engine fuel tanks are either made of steel or plastic, and may be mounted either separately or moulded to fit snugly around the engine. In such a case the fuel tank forms part of the air cooling shroud around the engine.

Fuel tanks are either mounted to allow for gravity feed of the fuel to the carburettor, or, if mounted lower than the carburettor (or in the case of a chain saw where it can be used at any angle) a fuel pump is necessary to get the fuel into the carburettor.

The tank filler caps are normally vented to allow the entry of atmospheric pressure as the fuel is used from the tank. If the tank vent becomes blocked, the engine will create enough vacuum to cause fuel starvation. To stop the loss of raw fuel from the filler cap, most caps have filters and baffles. (*fig 14*).



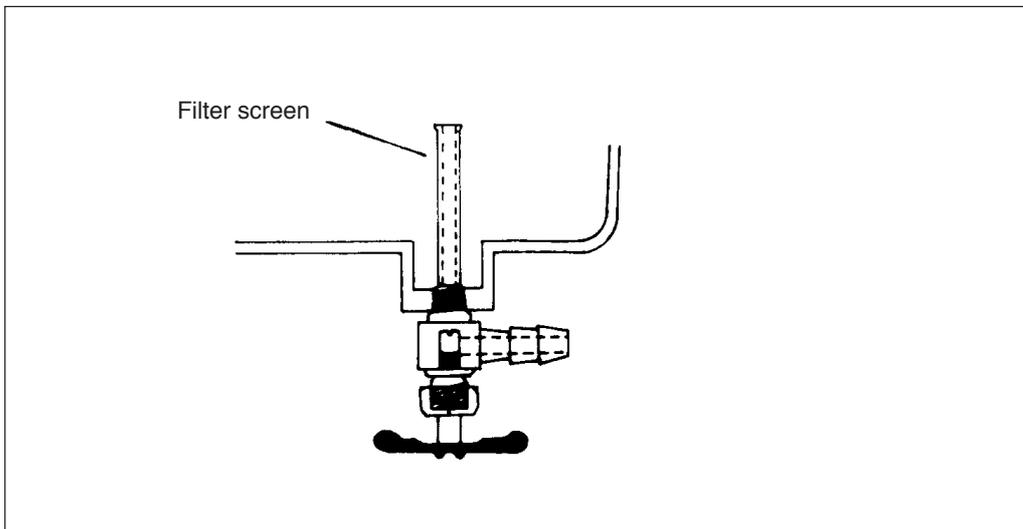
Some filler caps have a screw vent to prevent fuel evaporation when it is closed.

This type of vent should be released prior to starting the engine.

Fig 14 Vented fuel filler cap

Fuel lines and fittings that obtain damage, leaks or deterioration of any sort should only be replaced with genuine replacement parts as some materials on the market are not compatible with petrol and may become dangerous after a short period of operation.

Some small two stroke engines have a fuel filter which is incorporated with the fuel control tap and located in the bottom of the fuel tank (*fig 15*).

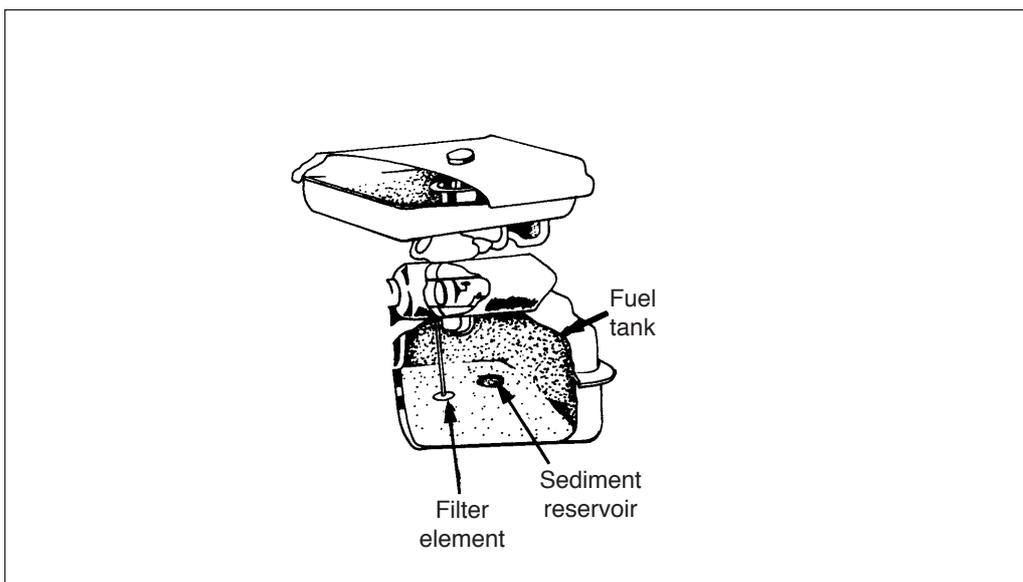


**Fig 15** Some small two stroke engines have a fuel filter which is incorporated with the fuel control tap and located in the bottom of the fuel tank

While some four stroke manufacturers have a filter element on the end of a pick-up tube going down into the fuel tank as shown in (*fig 16*).

Some small engine manufacturers have a sediment indentation in the lower section of the fuel tank, which provides a lower area where solids and other liquids heavier than the petrol, (such as water) can be trapped within the fuel tank.

A leaking fuel tank or line on a small engine is a definite fire hazard, and as half a litre of petrol has as much explosive power as thirty sticks of dynamite **BE CAREFUL**.



**Fig 16** Four stroke manufacturers have a filter element on the end of a pick-up tube going down into the fuel tank

## CARBURETTORS

The purpose of a carburettor is threefold:- it has to meter, atomize and distribute the fuel throughout the air stream and into the combustion chamber.

The energy locked up in the fuel can only be released by combustion satisfactorily when combined with the correct air ratio.

As there are so many varying designs of carburetors it would be impossible to cover every one, however their principles of operation are very similar.

A petrol/air mixture is normally combustible between the limits of 8 parts of air to 1 part of fuel and 25 parts of air to 1 part of fuel.

Because the fuel will not vaporize as well when the engine is cold, a rich mixture is required for cold starting.

The exact ratio depends on the temperature and volatility (ability to vaporize) of the fuel.

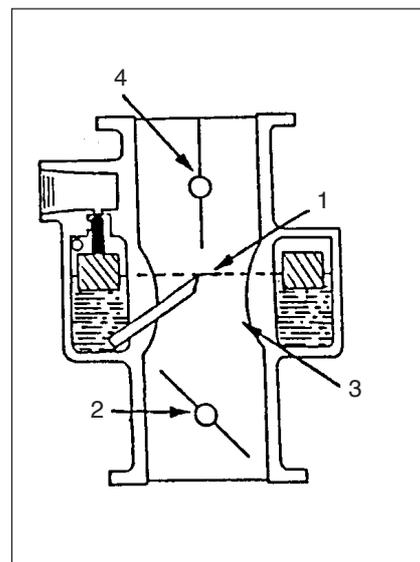
Carburettor operation is based on the venturi principle (shown in *fig 17*) in which a gas or liquid flowing through a restriction will increase in speed and decrease in pressure.

*Fig. 17* shows a simple carburettor with fuel being drawn from the float chamber.

An extension tube (or nozzle) from the fuel reservoir is placed in the air passage with the opening at approximately the narrowest part of the venturi, while the fuel level in the reservoir is maintained just below the opening of the nozzle.

As air passes through a venturi, fuel is drawn into the air stream in amounts relative to the pressure drop. A simple carburettor relying on the venturi principle alone would therefore supply a progressively richer mixture as the engine speed is increased, and would not run at all on idle.

The carburettor must therefore be modified if the engine is to operate efficiently under all conditions.

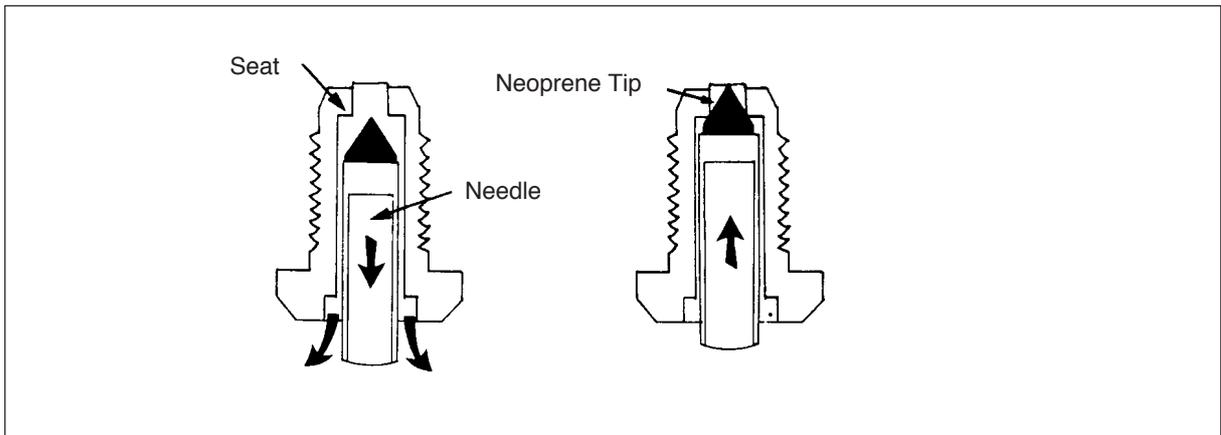


**Fig 17** Parts of the carburettor  
(1) Extension tube (nozzle)  
(2) Throttle butterfly  
(3) Venturi  
(4) Choke Butterfly

The fuel level in the carburettor bowl is regulated by a float, which is normally made of brass or plastic. Floats made of these materials can develop leakage problems, and so some manufacturers are tending to use floats made of flotation materials such as cork, which has been specially treated to prevent the cork from absorbing the petrol and becoming saturated, and therefore sinking.

A carburettor floats purpose is to maintain a constant level of fuel in the float bowl. As fuel is used, the float lowers which takes the needle from its seat allowing the fuel to enter the bowl, and in doing so the fuel level is increased and the float rises pushing the needle back onto its seat shutting off the fuel into the bowl.

Operation of a needle and seat assembly is shown in (fig 18). Needle points are sometimes made of the same material as the needle, however lately there has been a trend to manufacture these needle points from neoprene which is soft and seals well in the seat.

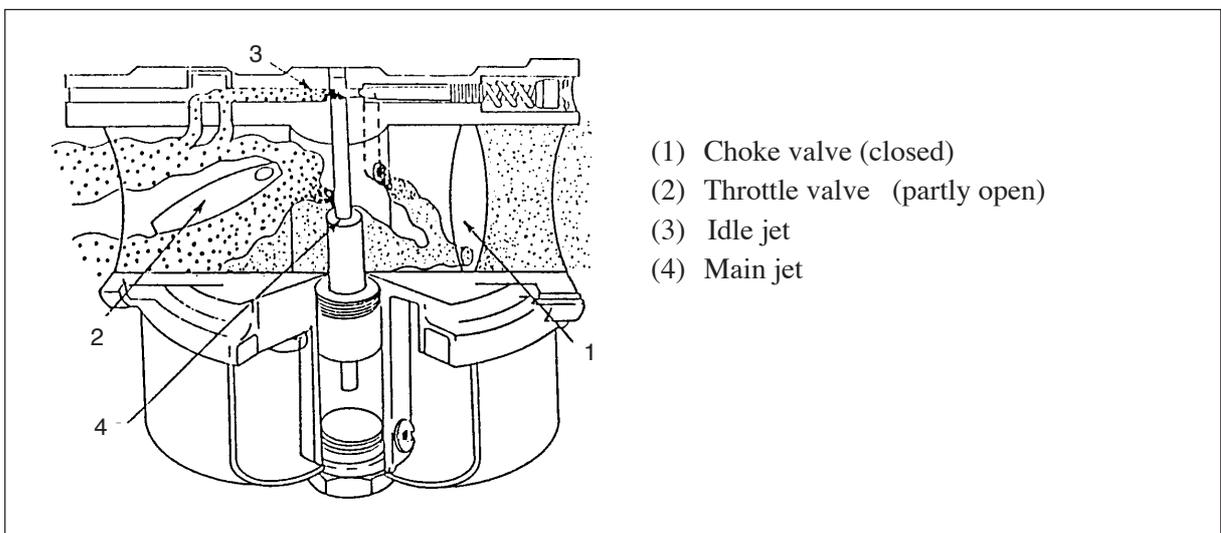


**Fig 18** Needle and seat assembly

## CHOKE OPERATION

When starting a cold engine the choke valve is placed in the closed position, and the throttle valve in a partly open position. As the engine is cranked, suction will be created on the idle and main nozzle tubes lifting the fuel from the fuel bowl and delivering it to the engine through the idle and main jet discharge ports. (Shown in fig 19).

Fuel enrichment is controlled by calibration of the choke valve, which is a round metal disc mounted on a shaft, and located at the air intake end of the carburettor.



- (1) Choke valve (closed)
- (2) Throttle valve (partly open)
- (3) Idle jet
- (4) Main jet

**Fig 19** CHOKE OPERATION (Cold Starting)

When the choke valve is closed for cold starting of the engine, it provides a rich air/fuel mixture by allowing less air to enter. The vacuum created by the engine cranking draws harder on the fuel nozzle resulting in more fuel and less air entering the combustion chamber.

## IDLE OPERATION

The amount of idle fuel delivered is determined by the engine vacuum and the setting of the idle fuel adjustment screw.

As fuel is lifted from the idle fuel tube, air is introduced through the idle air bleed passage that atomizes the fuel, which then passes through the idle adjustment orifice into the bypass chamber mixing with additional air supplied through the secondary idle ports discharging into the throttle bore through the primary idle discharge port. (As shown in *fig 20*).

## INTERMEDIATE OPERATION

During intermediate operation, (half-throttle), the engine speed and air flow increases as the throttle valve opens. As this happens, the secondary idle discharge ports are exposed to engine vacuum which withdraws fuel from the main jet well, through the idle tube into the bypass chamber and discharging into the engine.

Continued throttle opening increases the carburetors air flow and suction on the main jet, which lifts fuel from the nozzle well, and into the air stream.

The open position of the throttle valve determines the quantity of the fuel being delivered from the main jet which mixes down stream with the existing idle fuel already flowing in the system.

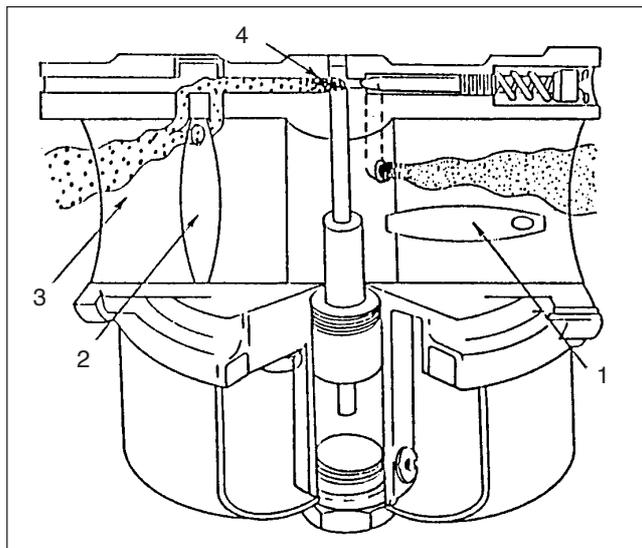
## HIGH SPEED OPERATION

As the throttle is opened to obtain high speed operation, suction at the main jet also increases, lifting greater quantities of fuel from the nozzle well. As this occurs the fuel level within the nozzle well tends to lower.

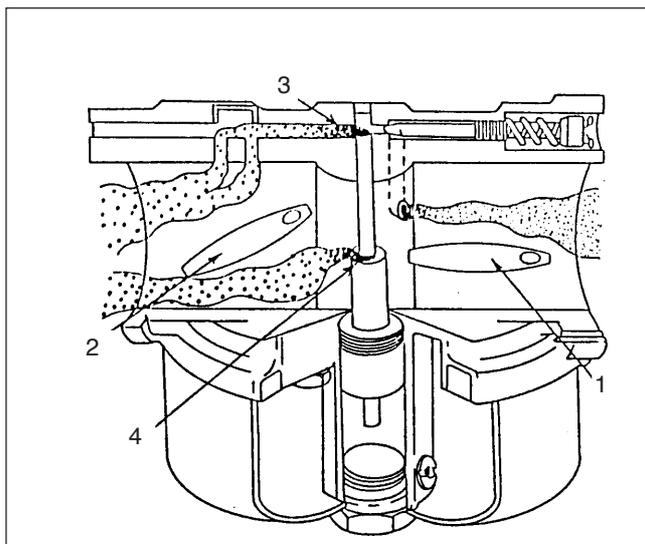
The idle tube being no longer in solid fuel, causes the intermediate fuel being delivered through the idle system to decrease.

At this time the throttle would be wide open, or near wide open position, during maximum or near maximum fuel delivery to the engine.

High speed fuel then flows from the fuel bowl, through the main fuel jet and into the engine.



**Fig 20**  
 (1) Choke Valve (open) (3) Idle jet  
 (2) Throttle Valve (closed at idle) (4) Throttle Bore



**Fig 21**  
 (1) Choke valve (open) (3) Idle jet  
 (2) Throttle valve (half open) (4) Main jet

## AIR FILTERS

Air filters are one of the most important components on a small engine, due to the extremely dusty conditions that most small engines operate under.

Air filters on small engines can be of three types:-

- (1) Dry paper element type
- (2) Polyurethane foam type
- (3) Oil bath type

The servicing of each of the above filters differs so each will be covered separately, however each type of filter should be serviced at the commencement of the season, and then at frequent intervals during the engines operation.

A blocked or partly restricted filter can cause loss of power, hard starting and spark plug fouling.

Servicing a dry element type (paper canister) filter can be carried out by gently tapping it on a flat surface to remove the accumulated dust from the outer surface. Care should be taken not to distort or damage the sealing rubber flanges.

Should the element be heavily loaded with dust, or have damage evident to the filter material (such as holes, or distortion to the sealing flanges) it should be replaced with a new one. This also applies if the paper element has been damaged by oil

Polyurethane foam type filters should be washed or rinsed in petrol or kerosene then squeezed out by hand. Then clean engine oil should be liberally distributed on the foam, and to allow complete saturation, once again it should be squeezed in the hand. The housing of this type of filter should be cleaned out prior to it being replaced.

Oil bath type cleaners should be removed from the engine, the old oil drained, then the housing thoroughly washed in either petrol or kerosene before refilling with clean engine oil, to the manufacturers specifications and to the correct level. Many mower manufacturers use a snorkel assembly so as to position the air cleaner further away from the dusty conditions. It is imperative that when servicing an air filter located on a snorkel assembly, that the snorkel tube and fittings be inspected for damage and secure fitment.

Dust entering through a damaged air cleaner element or snorkel hose, can mix with the fuel and become a very abrasive mixture that is most detrimental to extended engine life. Piston rings and cylinder bores become seriously damaged when dust enters the engine.

## ENGINE GOVERNORS

Governors are an automatic speed controller which provide protection to the engine without the operator having to alter the controls manually.

They can be used to protect the engine from over-revving whereby damage can be caused to the engine in the form of rapid wear, broken crankshafts or bent or broken connecting rods. They are also used to stop the blades on a lawn mower from exceeding a safe limit, where the blade could be thrown from beneath the mower causing considerable damage. Governors that are found on small engines are either the air vane or the centrifugal speed limiter type.

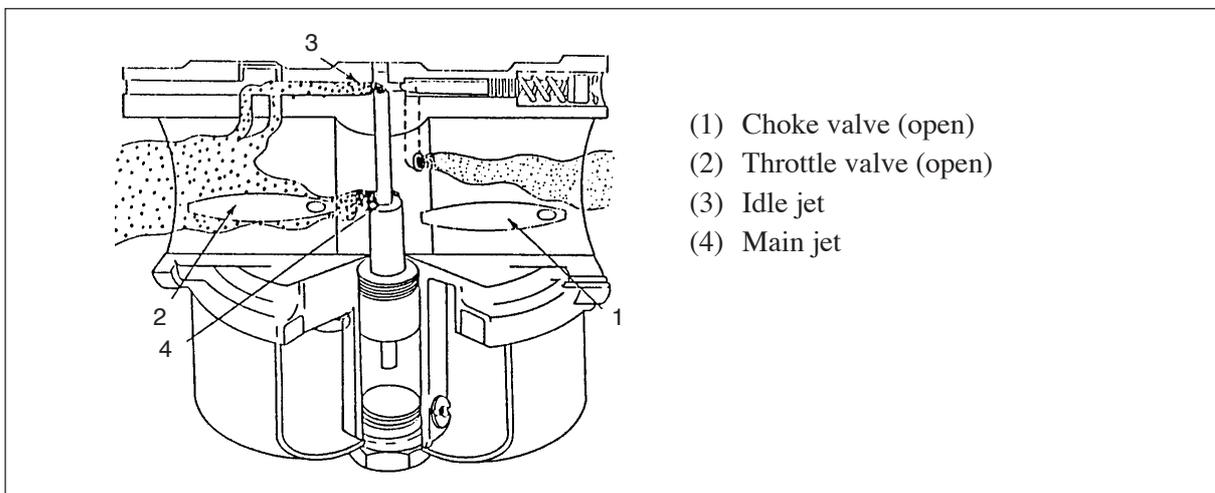


Fig 22

## AIR VANE TYPE

This type of governor uses the engines cooling fan to provide the means for its operation. The cooling fan being the blades (or fins) cast as part of the flywheel.

## AIR VANE GOVERNOR OPERATION

When the engine is stationary (not running ) the spring tension is holding the throttle butterfly in the wide open position (*Fig 23A*).

Once the engine is started, air blowing from the flywheel fins forces against the air vane applying tension to the governor spring. Once sufficient engine speed is reached, the air coming from the fins applies sufficient pressure on the vane to overcome spring tension and the throttle butterfly begins to close. (*Fig 23B*).

A balance is reached between the air from the fins and the governor spring tension, and as such, engine speed is constant until there is a change in engine load.

Should a load be applied to the engine and the speed reduced, air flow drops on the vane, and governor spring tension opens the throttle, increasing engine speed until the balance is reached, but this time with a wider throttle opening than in the no load condition.

If the tension on the governor spring is reduced the engine will just idle. (*Fig 23C*).

The air vane governor is one of the more common types of governors used on motor mowers as it is inexpensive and requires little maintenance.

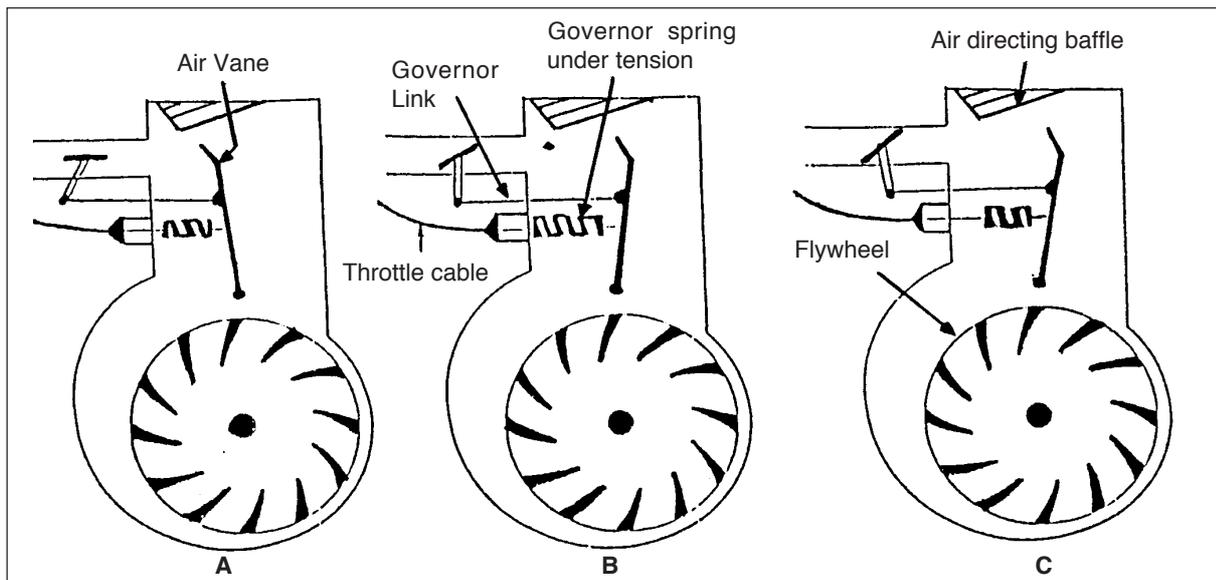


Fig 23 Air vane governor operation

## CENTRIFUGAL GOVERNORS

The operating principle of a centrifugal governor is the same no matter what type of engine it is.

Weights are made to rotate with the engine, and as engine speed is increased the weights are acted upon by centrifugal force which forces them to move.

This movement of the weights is relayed to the carburettor by means of rods, cables or linkages which overcomes the governor spring tension and moves the throttle butterfly.

As seen in *fig 24a* with the engine stationary the governor spring holds the weights fully retracted, with the throttle in the fully open position.

As the engine speeds up, the centrifugal force tries to throw open the weights against the governor springs tension, and until the predetermined speed is reached where the centrifugal force of the weights overcomes spring tension and the throttle butterfly closes (*fig 24B*), can the engine R.P.M. be held.

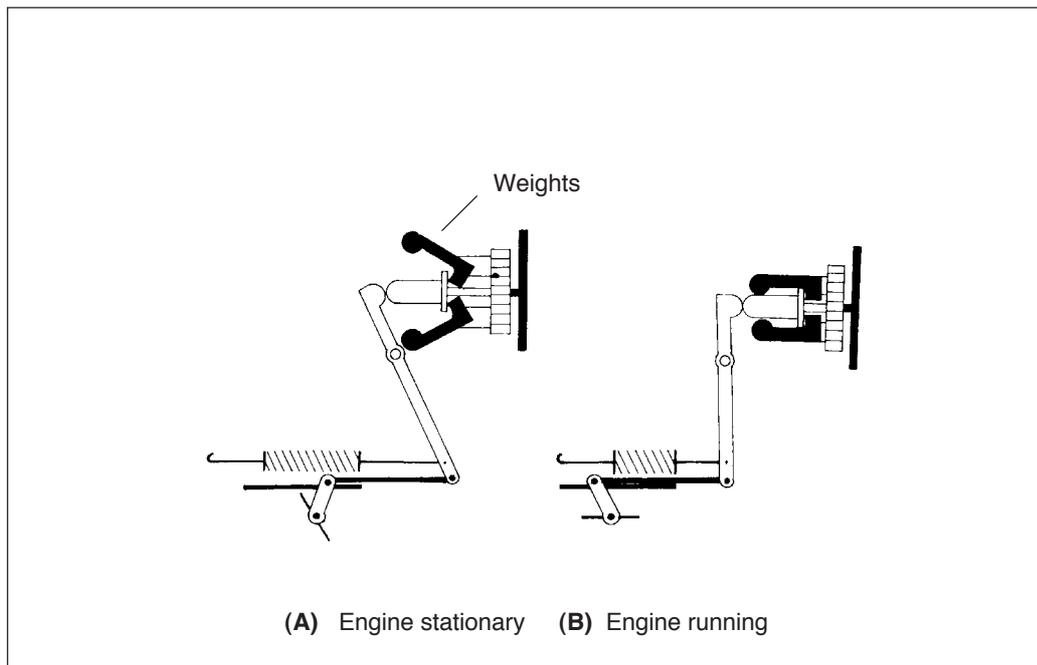
If engine speed is reduced by a load, centrifugal force is also reduced allowing the spring tension to open the throttle butterfly returning the engine to its original speed setting.

There are similarities between the two types of governors operation, however the centrifugal governor can be made to operate far more accurately than an air vane governor.

Manufacturers of equipment that have governors fitted have done this to protect both the equipment and the operator from damage.

To avoid possible dangers to yourself and others you should not tamper with them unless you know what you are doing.

Always refer to an operators or workshop manual for adjustment procedures, and only replace parts (such as springs etc.) with genuine components.



**Fig 24** Operation of central governor

# SMALL ENGINES Worksheet 3

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## **FUEL SYSTEMS - WORKSHEET**

(1) Name the two methods used to get fuel from the fuel tank to the carburettor.

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(2) What is the purpose of the vent in the fuel filler cap ?

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(3) What is the purpose of a carburettor ?

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(4) What is the name given to the principle that carburettor operation is based on ?

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(5) What is the purpose of a carburettor float ?

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(6) Name the three types of air filters found on small engines.

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(7) Describe the procedure to service a Polyurethane Foam type filter.

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(8) What is the purpose of an engine governor ?

---

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(9) Name the two types of governors commonly found on small engines.

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(10) Describe a choke valve and explain where it is located in a carburettor.

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# CHAPTER 4

## IGNITION SYSTEMS



The purpose of an ignition system is to provide a timed spark which ignites the air/fuel charge in the combustion chamber, to provide the greatest power from the combustion.

There are various types of ignition systems in use on small engines, however in the main they are either magneto or electronic ignition systems.

To enable a better understanding of the ignition system operation, a brief coverage will be made on electrical theory.

Materials which allow the flow of electricity are called conductors, and good conductors are normally found to be made of copper or silver. Such materials as wood, glass, porcelain and rubber which resist the flow of electricity are called insulators.

An electrical circuit implies that a series of conductors have been connected together, so that the current can flow through it. A short list of electrical terms and a brief explanation of their meaning is as follows:-

**VOLT:-** The unit of measurement used to designate the force, or pressure of an electrical current.

**AMPERE:-** The unit of measurement used to designate the amount or quantity of flow of an electrical circuit.

**WATT:-** The unit of measurement that designates the ability of an electrical current to perform work; or to measure the amount of work performed.

**OHM:-** The unit of measurement used to designate the resistance of a conductor to the flow of current.

The ignition systems used on two and four stroke engines are made up of various components depending on the type of system:-

Magneto systems are made up of magnets, ignition coil, condenser, contact breaker (sometimes referred to as breaker points) and spark plugs.

While the electronic system is basically made up of a magnet, trigger coil, electronic module, spark coil and spark plugs.

### MAGNETO

A magneto is really only a small dynamo capable of producing a very high voltage and are in common use on engines fitted to lawn mowers, stationary engines and outboards.

On small engines they provide a high tension spark for ignition, with out the need for a battery, and are capable of providing a higher voltage at higher speeds than that of a battery ignition system.

Magnetos are given various names of polar inductor, rotating armature, rotary magnet and flywheel magneto the latter being most common.

The flywheel magneto consists of a magnet cast into the diameter of the engine flywheel. This provides a moving magnetic field. An ignition coil with primary and secondary windings is mounted on a soft iron core.

Contact breaker points are operated from a cam lobe fitted to the crankshaft of the engine and a condenser is connected in parallel with the breaker points.

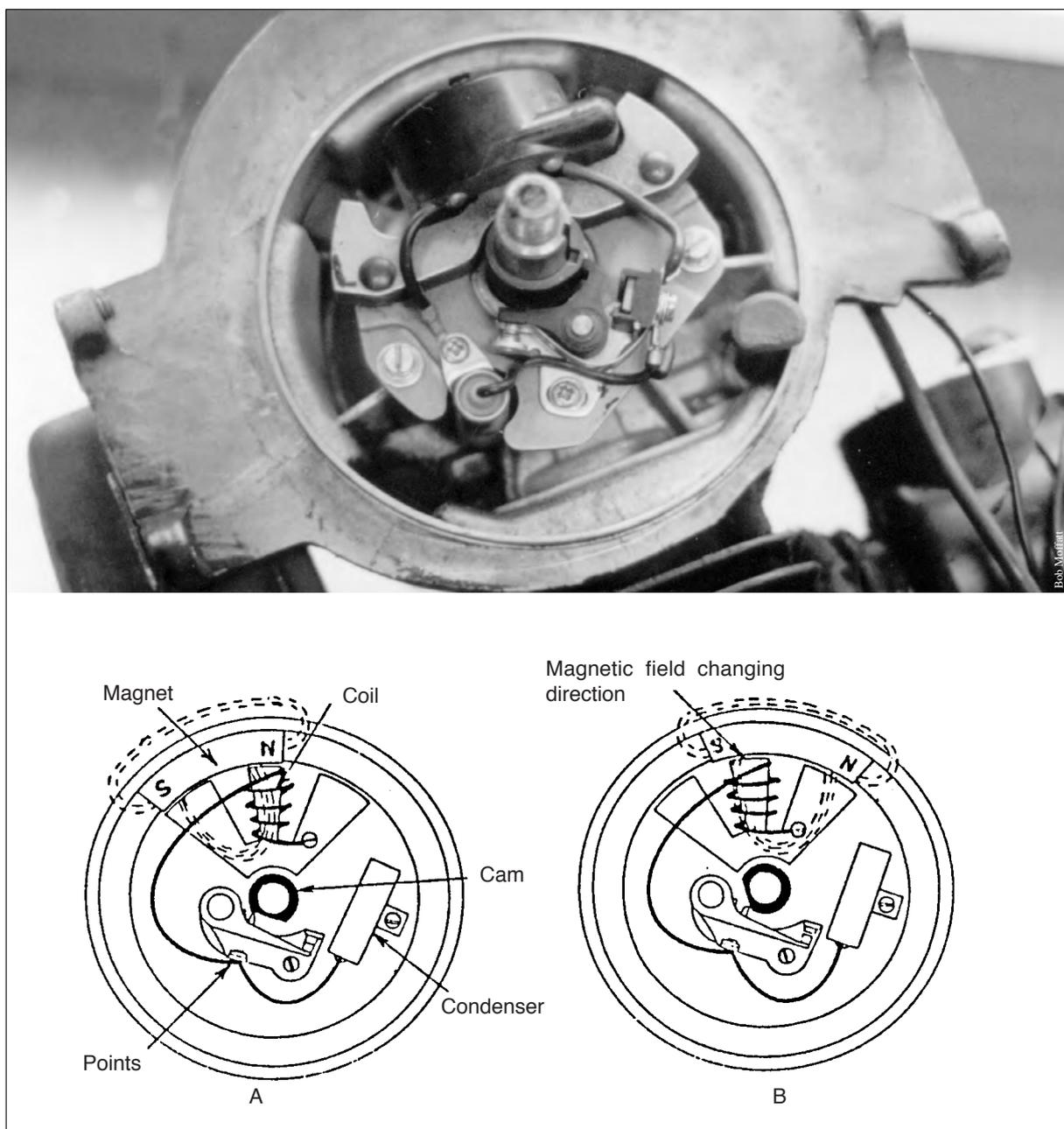
The magneto components are enclosed beneath the flywheel and in the case of a single cylinder two stroke engine provide one spark each crankshaft revolution.

As the flywheel turns to the position shown in illustration (A) of *fig 25* the magnetic lines of force will pass from the North Pole through the centre and left hand limbs of the soft iron core to the South Pole. In doing so an Electro Motive Force (EMF) is induced in the primary coil windings, the breaker points being closed allows the EMF to flow through the windings forming an electro-magnet.

This builds up a magnetic field around the primary windings which penetrates the secondary windings of the coil. The flywheel continues to turn as shown in diagram (B) of *fig 25* where the North Pole of the magnet aligns with the right hand limb of the core and the South Pole moves to the centre limb of the core.

As this occurs the direction of the lines of force from the north pole to the south pole will be reversed through the centre limb and the primary coil winding resulting in a complete collapse and reversal of direction of current flow.

The breaker points open just as the current flow ceases in the primary windings. This in conjunction with the reversal of the magnetic field, causes a sudden collapse of the lines of force in the secondary windings of the coil, which induces a high voltage in these windings which is delivered to the spark plug.



**Fig 25** Shows the operation of a flywheel magneto. (Secondary windings are not shown)

## IGNITION COIL

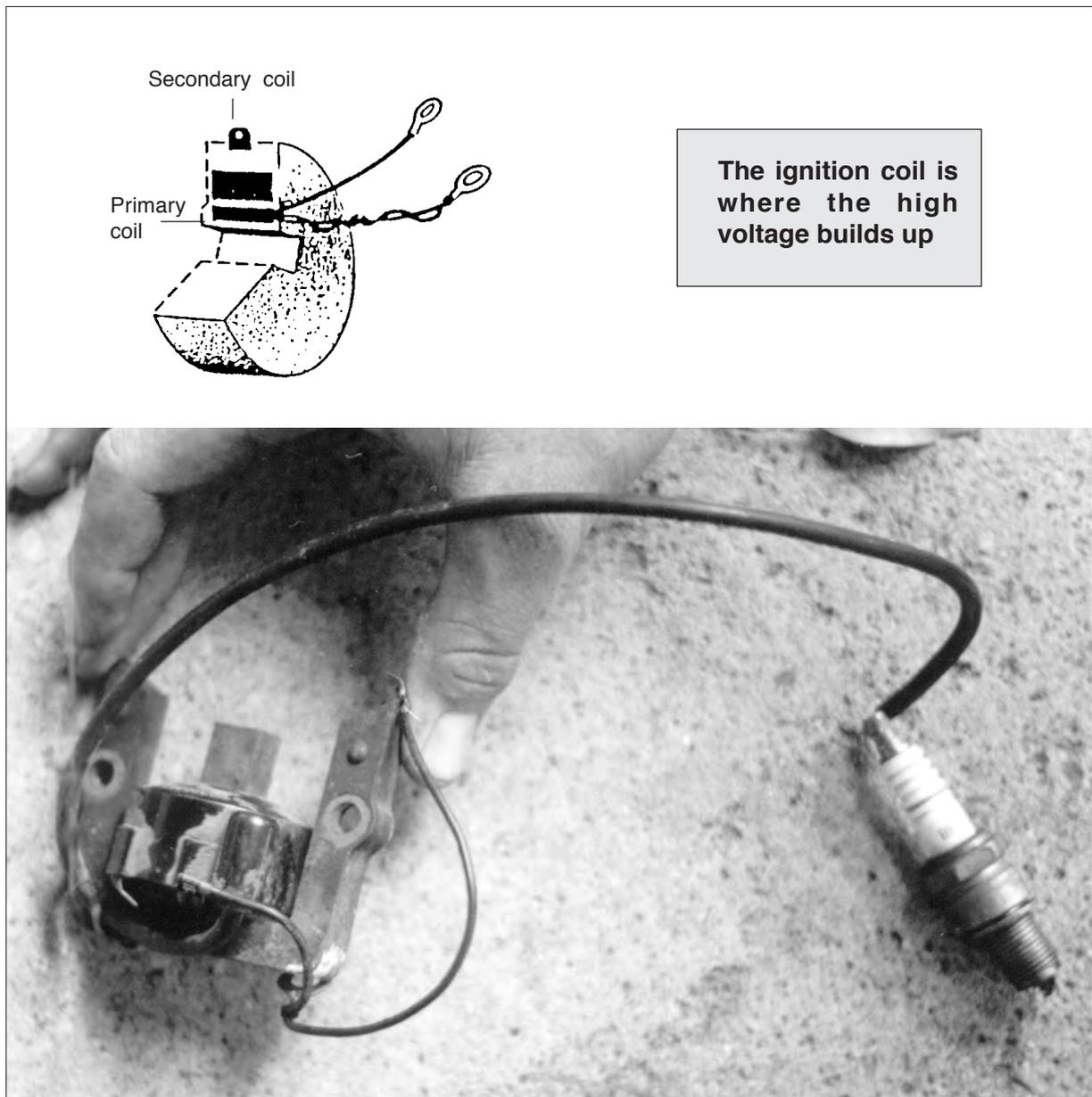
The ignition coil, where the high voltage is built up, has two separate coils, and in most flywheel magneto situations is constructed as follows.

The coil nearest to the soft iron core has a relatively small number of turns of heavy gauge copper wire, and is called the primary winding or primary coil. One end of this winding is connected to the breaker points and the other end to the soft iron core.

Wound over the primary coil but insulated from it is the secondary coil which is made up of many turns of very fine gauge copper wire.

One end of this winding is connected to the frame the other leads to the spark plug via a heavily insulated high tension lead.

The source of energy for this type of coil is a pulsating alternating current induced in the magneto primary windings and derived from permanent magnets as described previously in the magneto operation section. *Fig 26* below shows a typical magneto type ignition coil.



**Fig 26** Magneto type ignition coil

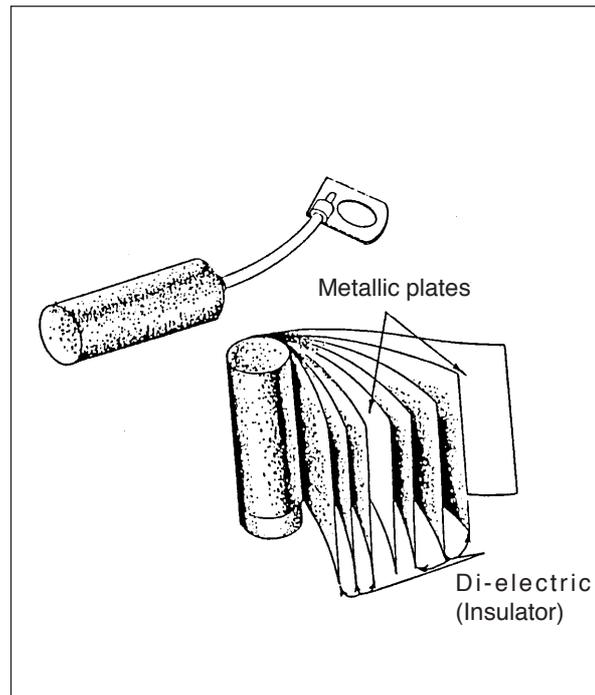
## CONDENSER

(Sometimes referred to as a Capacitor).

The function of the condenser is to prevent sparking or arcing at the face of the breaker points as they open and to also act as a reservoir for the electrons to move (flow of current) at the instant the points first separate.

The condenser shown in *Fig 27* is made up of 2 thin metallic plates separated by an insulator. The plates are made of long narrow strips of aluminium or lead plate and insulated from each other by special condenser paper (called di-electric) and rolled to form a cylinder.

This is then placed in a metal container where one end of the metallic strips is connected to the metal container the other to the lead (or pig tail) which is connected to the breaker points.



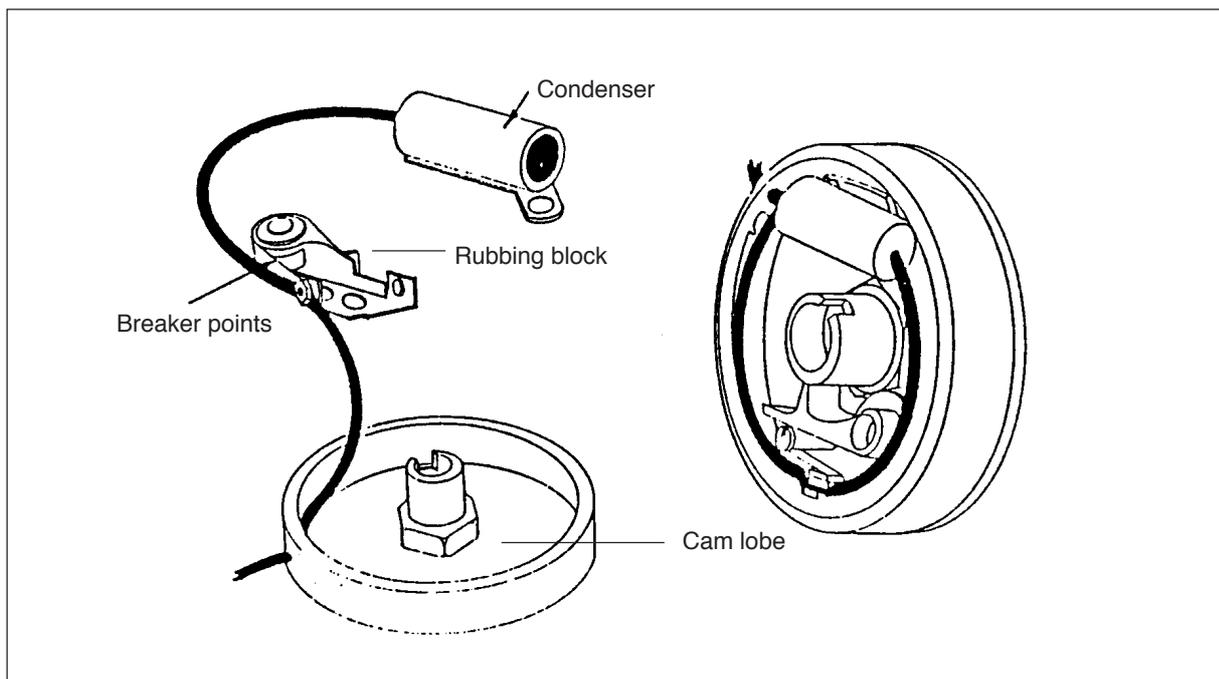
**Fig 27** Condenser

No magneto or battery ignition system will operate correctly if the condenser is faulty or does not have good electrical connections at the mounting screw or lead to the breaker points.

## CONTACT BREAKER

(Also called breaker points or points).

Contact breaker points are in simple terms a mechanically operated switch to make and break the primary circuit current flow. The points achieve this operation by a rubbing block on the moveable arm of the points set coming in contact with a cam lobe.



**Fig 28** Contact breaker point arrangement

On a Clerk two stroke engine with a magneto system the points open on each revolution, where on an Otto four stroke engine the points operate at half engine speed.

The number of lobes on the cam is determined by the number of cylinders the engine has (i.e. a single cylinder engine has one lobe, a 4 cylinder has 4 etc.).

Each time the contact points are opened by the cam lobe, the current flow through the primary winding of the ignition coil is interrupted (as explained in the ignition coil operation previously), and a spark is sent to the spark plug.

Since the opening (or gap) of the contact points is essential for good ignition performance their adjustment is of great importance.

To check this gap rotate the engine so that the rubbing block rests on the high point of one of the cam lobes. Check with feeler gauges to ensure that the clearance (or gap) is at the specification of the engine manufacturer.

When adjusting point clearance always use the maximum reading if the manufacturer has given a range in the specifications

(i.e. 0.4 - 0.5 mm.), this will allow for settling in of the new rubbing block on the points.

## SPARK PLUGS

In any spark ignition system, the spark plug provides the means for igniting the compressed fuel/air mixture in the cylinder. Before an electric charge can move across the air gap the intervening air must become Ionized (or charged with electricity).

If the spark plug is correctly gapped, not more than 7000 volts may be required to initiate a spark. Higher voltage is required as the spark plug warms up, or if the compression pressures, or distance of the air gap is increased.

Compression pressures are highest at full throttle and relatively slow engine speeds, therefore, high voltage requirements or the lack of available secondary voltage most often shows up as a miss during maximum acceleration from a slow engine speed.

There are many different types and sizes of spark plugs which are designed for a number of different requirements. These design features include THREAD SIZE, REACH, and HEAT RANGE.

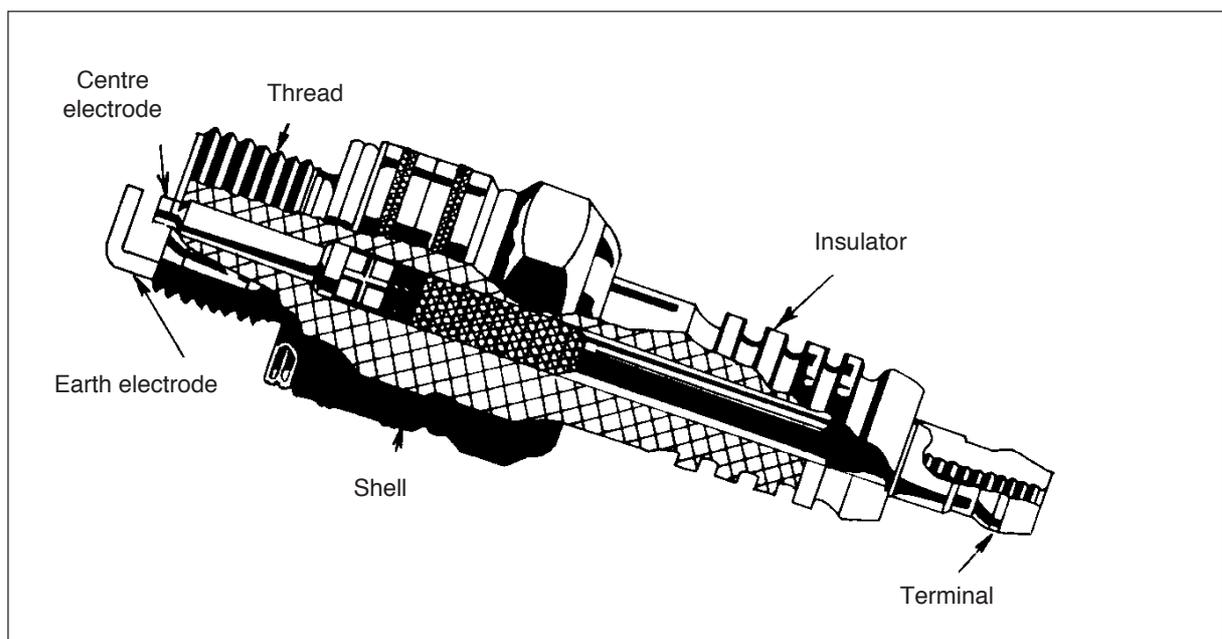


Fig 29 The spark plug

## THREAD SIZE

The threaded shell portion of the spark plug and the attaching holes in the cylinder are manufactured to meet certain industry standards. The diameter is referred to as thread size. Those commonly used are 10mm, 14mm, and 18mm. The 14mm plug is almost universal for small engine use.

## REACH

The length of thread, and the thread depth in the cylinder wall or cylinder head are also standardized throughout the industry.

This dimension is measured from gasket seat of head to cylinder end of thread. Four different reach plugs are commonly used: 3/8 inch, 7/16 inch, 1/2 inch and 3/4 inch. The first two mentioned being common to small engines.

## HEAT RANGE

During engine operation, some of the heat generated during combustion is transferred to the spark plug, and from the plug to the cylinder head through the shell threads and gasket.

The operating temperature of the spark plug plays an important role in engine operation. If the plug retains too much heat the air/fuel mixture may be ignited by contact with the heated surface prior to the ignition spark occurring. This condition is referred to as PRE-IGNITION.

If not enough heat is retained, partially burned combustion products (Soot, Carbon and Oil) may build up on the plug tip resulting in “fouling” or shorting out of the plug. If this happens the engine will misfire.

The operating temperature of the plug tip can be controlled, within limits, by altering the length of the path the heat must follow to reach the threads and gasket of the plug.

Thus a plug with a short stubby insulator around the centre electrode will run cooler than one with a long, slim insulator. (See Fig 30 )

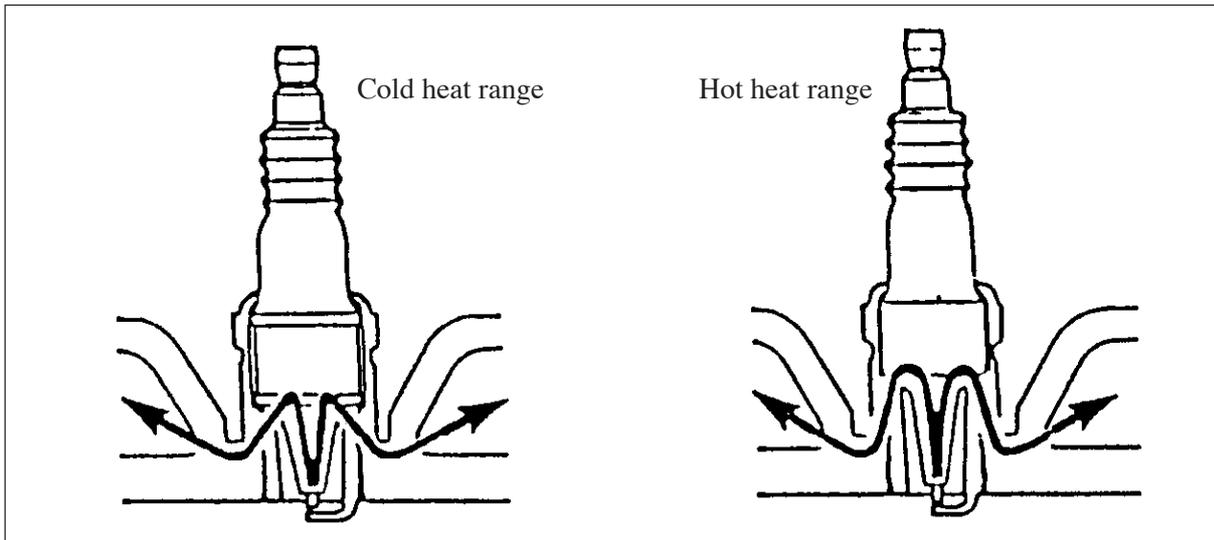
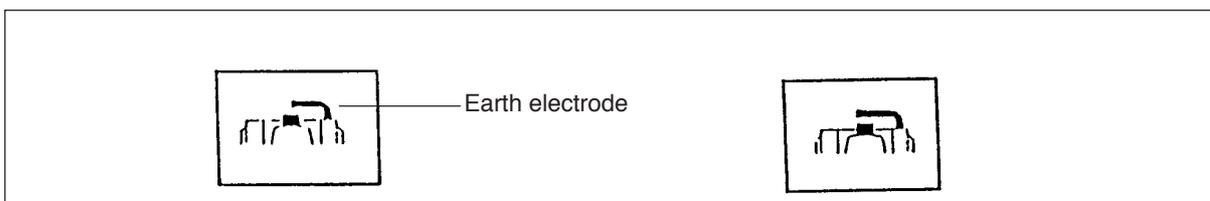


Fig 30 Heat ranges of spark plugs

No one spark plug, can be ideally suited for long periods of slow speed operation, and still be the best possible type for high speed operation. Then there is that middle path for plugs that lie somewhere in between the two extremes



**Fig 31** Standard spark plug for two stroke engine

**Fig 32** Conventional spark plug

## SPECIAL TYPES

Sometimes engine design features or operating conditions call for special plug types designed for a particular purpose. Special types include SHIELDED PLUGS which are extensively used in marine applications, and RESISTOR PLUGS with built in resistance.

Of special interest when dealing with the Clerk two stroke engine is the two stroke spark plug, shown in *Fig 31* above.

In this design of spark plug, the ground electrode is shortened so that its end aligns with the centre of the insulated electrode rather than completely overlapping as with the conventional four stroke spark plug as shown in *Fig 32*.

Another special type found in two stroke outboard engines is the SURFACE GAP PLUG shown in *Fig 33*. This spark plug was engineered for use in high output motors. The plug is capable of efficient operation over a wide range of conditions. All surface gap spark plugs are “COLD” types and virtually pre-ignition free.

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***Surface gap spark plugs can't be inter-changed with a conventional spark plug***

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## ELECTRONIC MODULES

Electronic ignition systems can be triggered by one of three methods:-

- (A) Breaker points
- (B) A Magnetic pick up or
- (C) Photo electric cell

Of these (B) and (C) are becoming more popular as they eliminate the problems of breaker point burning and rubbing block wear.

In a capacitor discharge (CD) ignition system a capacitor is charged by direct power supply. 150 to 250 volts D.C. are supplied by an electronic oscillator, transformer and rectifier.

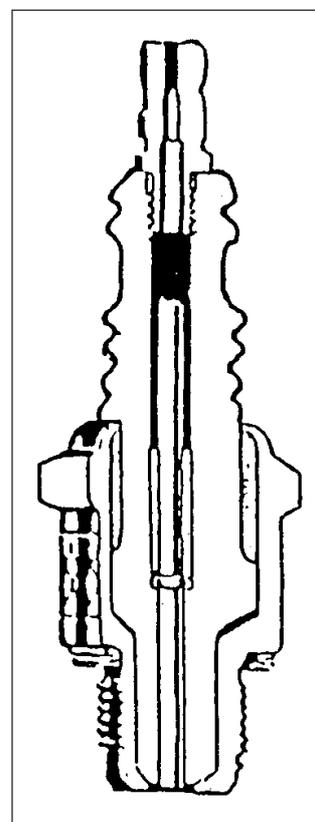
An electronic switch is triggered by the points, magnetic pick-up or photo cell, closing the circuit from the capacitor to the coil.

C.D. systems have an extremely fast “rise time” this is the time required for the ignition system to reach its highest voltage (energy) level.

The control module in most applications cannot be tested for serviceability and very little can be done by the average handyman apart from substituting the suspect module with a known serviceable unit and testing for a spark at the spark plug.

## CAUTION

When doing this test keep hands well clear of high tension leads as they can carry up to 4000 volts and remember improper testing procedures can damage the control units.



**Fig 33**  
Surface gap spark plug

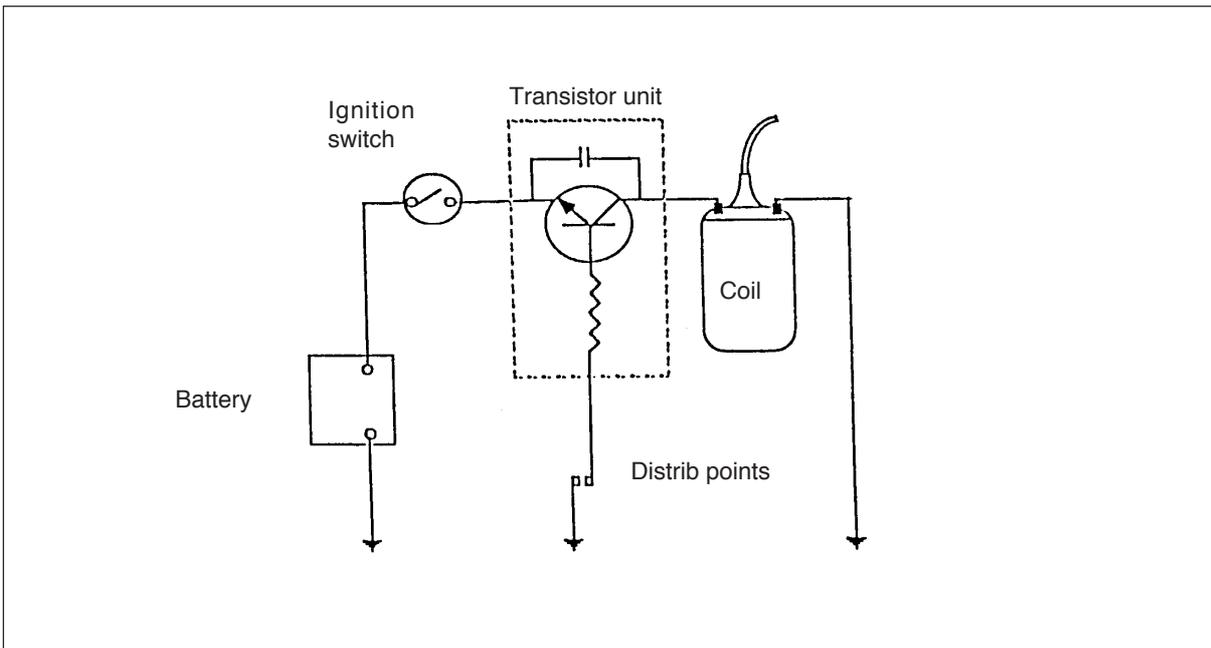


Fig 34 Simplified electronic circuit with breaker points type (A) triggering method

# SMALL ENGINES Worksheet 4

## IGNITION SYSTEMS - WORKSHEET

(1) What is the purpose of an ignition system ?

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(2) List some materials that make good conductors of electricity.

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(3) List some materials that make good insulators of electricity.

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(4) The unit of measure used to designate the force or pressure of an electric current is known as ?

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(5) Name the five components that make up the magneto ignition system.

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(6) In an ignition coil the secondary winding has.

- (a) Many turns of heavy wire
- (b) Many turns of fine wire
- (c) Few turns of heavy wire
- (d) Few turns of fine wire

(7) What is the function of the condenser ?

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(8) What is the purpose of the breaker points ?

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(9) When does the spark occur at the spark plug ?

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(10) How often do the points open on a two stroke engine ?

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(11) What must happen to the air/fuel mixture in the combustion chamber before the spark can jump the air gap of the spark plug.

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(12) What are the three design features of spark plugs ?

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(13) How would you distinguish a “cold” heat range spark plug from a “hot” heat range spark plug ?

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(14) What is the difference between a two stroke spark plug and a four stroke spark plug ?

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(15) What are the three methods of triggering an electronic ignition system ?

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# CHAPTER 5

## ADDITIONAL ITEMS ON MOWERS

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### WHEELS

Mower wheels are either fitted with a special impregnated nylon bush for which no lubrication is necessary, or with ball bearings which are pre-packed with lubricant on manufacture and completely sealed.



The advantage of ball bearing type wheels is that they are easier to push due to the smaller frictional area, creating less rolling resistance.

Ball bearing type wheels are fully reconditionable if they require servicing after long periods of use, as with the nylon bush type, which after removing the hub-cap, and either unbolting or removing a circlip the short tubular sleeves are quickly and cheaply replaced.

Dirt is the enemy of both ball bearing and bush type wheels and each year the wheel assemblies should be removed and thoroughly cleaned and replaced. A thorough inspection of the dust seals should be made at this time and replaced if necessary. On some mower wheel assemblies the hubcaps perform two functions:

- (1) to act as the outer dust seal for the bearings and
- (2) to help hold the circlip in place and prevent the wheel from coming off. Any hubcap that comes off should be refitted as soon as possible.

### BLADES AND DISCS

The blades and disc assembly need to be inspected regularly for any evidence of damage because it is possible for the tips of mower blades to be travelling in excess of 300 K.P.H. (Kilometres Per Hour).

When inspecting the blades and disc assembly, tip the mower up ensuring that the spark plug is uppermost especially in the case of a four stroke engine.

Should the oil in the crankcase seep up past the piston assembly during the inspection serious damage can result, when restarting the engine.

Should the blades show evidence of wear, splitting or one being in a broken condition, they should be replaced prior to using the mower. Always replace the blades in sets, otherwise an unbalanced condition can result in damage to the engine assembly.

Mowers fitted with catchers use a curved blade design to create an uplift air flow to assist in the collection of grass into the catcher, and on inspection of the blades, should the curved section be worn excessively, it will effect the grass catching efficiency of the mower.

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***Caution: Before carrying out any repairs to the blade assembly always disconnect the spark lead and ensure the throttle lever is in the stop position.***

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Most mowers have recessed blades to prevent the head of the bolt becoming worn, however, the bolt and nut assembly should only be used once, as the nut is of the self locking "NYLOCK" type and loses its efficiency as such, after it has been tightened and undone once. This is the same if tension type washers are used on the blade assembly. **ONLY USE THEM ONCE.**

It is important to follow the manufacturers fitting instructions when assembling the blades to the disc assembly, and also when fitting the disc assembly to the engine crankshaft.

## MOWER SAFETY

1. Always inspect the blades and disc assembly prior to using the mower.
2. Make sure there are no bones, sticks, stones or pieces of wire on the lawn before you mow.
3. Ensure children and pets are not in the mowing area prior to starting the mower.
4. Do not allow children to use the mower, or any one who is unfamiliar with the controls.
5. Always fill the fuel tank when the mower is cold to avoid spilling petrol onto a hot engine.
6. Never refuel a fuel tank while smoking.
7. Always run an engine in a well ventilated area to avoid breathing the exhaust fumes. (Carbon Monoxide).
8. Don't over-rev an engine, and never alter the governor speed setting from the recommendation of the manufacturer, as excessive speed will shorten the engine's life and is extremely dangerous.
9. Store fuel in a cool place, and only in a container that has been recommended for that purpose. (Some plastic containers are not suitable).
10. At the conclusion of mowing always turn off the fuel tap and ensure the throttle lever is placed in the "stop" position to avoid accidental starting by a child.

# SMALL ENGINES Worksheet 5

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## ***ADDITIONAL ITEMS ON MOWERS - WORKSHEET***

- (1) What are the two types of wheels used on mowers ?  
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\_\_\_\_\_
- (2) What is the advantage of a ball bearing type wheel ?  
\_\_\_\_\_
- (3) The function of a hubcap on a mower is twofold. What are the two functions ?  
\_\_\_\_\_  
\_\_\_\_\_
- (4) How should a four stroke engine be positioned while inspecting the blade and disc assembly.  
\_\_\_\_\_  
\_\_\_\_\_
- (5) What precaution should be taken prior to working on a blade and disc assembly ?  
\_\_\_\_\_  
\_\_\_\_\_
- (6) What is the purpose of the recess in the blade on some mowers ?  
\_\_\_\_\_  
\_\_\_\_\_
- (7) Why should NYLOCK type nuts only be used once ?  
\_\_\_\_\_  
\_\_\_\_\_
- (8) Make a list of five safety precautions to take with mowers.
  - 1 \_\_\_\_\_
  - 2 \_\_\_\_\_
  - 3 \_\_\_\_\_
  - 4 \_\_\_\_\_
  - 5 \_\_\_\_\_

# CHAPTER 6

## FAULT FINDING AND TROUBLE SHOOTING



Most small engine repairs are simple if the operator follows a simple procedure and has a manufacturers repair manual with the specifications for the particular engine.

Sometimes the cause of an engine problem such as; engine hard to start, runs rough, lacks power or will not run at all, is simply a matter of reasoning and the use of the process of elimination. Always check the most probable cause first BUT always bear in mind that their could be more than one problem that is causing the trouble.

## TWO STROKE ENGINES

### ENGINE WON'T START

#### (1) NO FUEL REACHING THE ENGINE

- Fuel tank empty
- Fuel tap turned off
- Fuel tank cap vent hole blocked
- Blocked fuel line
- Fuel filter blocked
- Float needle and seat valve stuck closed
- Air leak at the crankcase seals
- Jets blocked in the carburettor

#### (2) TOO MUCH FUEL IN THE ENGINE

- Over use of the choke
- Engine flooded with fuel tap left on
- Snorkel tube restricting air flow
- Air cleaner blocked or restricted
- Float needle and seat valve stuck open
- Incorrect petrol mixture

#### (3) NO AIR REACHING THE ENGINE

- Snorkel tube restricting air flow
- Blocked air cleaner element
- Throttle valve in the carburettor stuck closed
- Throttle cable broken or disconnected

#### (4) NO SPARK TO PLUG GAP

- Faulty spark plug
- Damaged cut out switch
- Fouled or dirty spark plug
- Shorted out ignition wire
- Dirty or damaged breaker points
- Faulty high tension lead
- Faulty coil
- Faulty condenser
- Flywheel key (woodruff) sheared

#### (5) NO COMPRESSION:-

- Head gasket blown
- Decompression valve stuck open
- Broken con rod
- Engine extensively worn

Most small engine repairs are simple if the operator follows a simple procedure and has a manufacturers repair manual with the specifications for the particular engine

## Two stroke engines (cont'd)

### ENGINE LOSING POWER

- (1) IGNITION BREAKING DOWN
  - Spark plug fouled or misfiring
  - Incorrect spark plug
  - Dirty breaker point contacts
  - Ignition coil breaking down
  - Faulty condenser
  - Breaker point gap incorrectly adjusted
  - Ignition wire shorting (touching earth)
- (2) RESTRICTED EXHAUST SYSTEM
  - Muffler partially blocked with carbon
  - Insufficient compression through worn rings, piston or cylinder bore
  - Damaged or worn crankcase seals or gaskets
  - Worn bearings

## FOUR STROKE ENGINES

### ENGINE WONT START

- (1) NO FUEL REACHING THE ENGINE:-
  - Fuel tank empty
  - Fuel tap turned off
  - Blocked fuel line
  - Fuel tank cap vent hole blocked
  - Fuel filter blocked
  - Float needle and seat valve stuck closed
  - Jets blocked in the carburettor
  - Gaskets leaking between carburettor and engine block
  - Main jet screw incorrectly adjusted
  - Broken camshaft or incorrect camshaft timing
- (2) TOO MUCH FUEL IN THE ENGINE:-
  - Engine flooded (fuel tap left on or excessive choke use)
  - Snorkel tube restricting air flow
  - Air cleaner blocked or restricted
  - Main jet screw incorrectly adjusted
  - Automatic choke malfunction (if fitted)
- (3) NO SPARK TO PLUG GAP:-
  - Incorrect coil to armature air gap
  - Faulty spark plug
  - Damaged cut out switch
  - Fouled or dirty spark plug
  - Shorted out ignition wire
  - Dirty or damaged breaker points
  - Faulty high tension lead
  - Faulty coil
  - Faulty condenser
  - Flywheel woodruff key sheared
- (4) COMPRESSION LOSS:-
  - Head gasket blown
  - Broken con rod
  - Engine extensively worn (piston rings or cylinder bore)
  - Engine valves damaged, burnt or worn
  - Engine valve stuck open (by foreign matter or damage)

It is only possible on some makes to obtain a true compression "feel" by turning the engine flywheel in the opposite direction to normal. (Refer to the manufacturers hand book for details).

## Four stroke engines (cont'd)

### ENGINE LOSING POWER:-

#### (1) IGNITION BREAKING DOWN:-

- Spark plug fouled or misfiring
- Incorrect spark plug
- Dirty breaker point contacts
- Ignition coil breaking down
- Faulty condenser
- Breaker point gap incorrectly adjusted
- Ignition wire shorting (touching earth)
- Incorrect coil to flywheel armature air gap

#### (2) RESTRICTED AIR SUPPLY:-

- Partially blocked air cleaner element
- Snorkel tube restricting air flow

#### (3) MIXTURE TOO LEAN:-

- Carburettor jets partly blocked
- Fuel tank vent hole partly blocked
- Fuel filter screen partly blocked
- Fuel tap not fully on
- Main jet screw not correctly adjusted
- Carburettor diaphragm faulty
- Leaking gaskets between carburettor and cylinder block

#### (4) MIXTURE TOO RICH:-

- Air cleaner element blocked or restricted
- Snorkel tube restricting the air flow
- Float needle and seat valve stuck open
- Damaged carburettor float
- Choke butterfly not fully open
- Incorrect main jet adjustment

Sometimes the cause of an engine problem such as; engine hard to start, runs rough, lacks power or will not run at all, is simply a matter of reasoning and the use of the process of elimination.

Always check the most probable cause first BUT always bear in mind that there could be more than one problem that is causing the trouble.

## UNUSUAL PROBLEMS

#### (1) CONTINUAL SHEARING OF FLYWHEEL KEYS

This can be caused by the blade disc being loose, the blades hitting hard objects while mowing, flywheel nut being loose or the keyways in the crankshaft or flywheel being worn.

#### (2) MOWER VIBRATION

Can be caused by a blade being missing or broken, the blades not being the same weight or the blade disc being bent or damaged.

# STARTERS

In the main there are two types of starting mechanisms in use on small engines these being the Impulse Type, and the Rewind or Recoil Type.

The rewind type is being found more frequently on current mowers than the impulse type.

## IMPULSE TYPE

The impulse type is operated by winding up a coil spring which is enclosed within a housing by a handle. On complete tensioning of the spring the handle is folded in out of the way, and the spring is released to turn over the engine.

This type of starter can be quite dangerous if left wound up when putting the mower away, and if for some reason the starter will not release, NEVER try to dismantle it without the aid of an experienced person or serious injuries could result.

## REWIND or RECOIL TYPE

Nearly all small engines currently manufactured have this type of starting mechanism, which if operated correctly don't give many problems and are not as dangerous as the impulse type.

Tips on using this type of starting mechanism are:-

- The rope should be pulled slowly until the mechanism is engaged, and then with an even smooth stroke, not a sharp jerk pull over the engine.
- Always ensure the engine is ready to be started (i.e. Fuel tank filled, fuel tap on and carburettor primed).
- Never pull the rope out to its full length as this puts a tremendous strain on the knot at the opposite end to the handle, and the rope is likely to break.
- Pulling the rope on an angle to the starting mechanism causes the rope to fray, always try to pull the rope out straight.
- Always hold the rope while it rewinds slowly.



Bob Moffat

## STARTER PROBLEMS

### RECOIL STARTER

<i>PROBLEM</i>	<i>CAUSE</i>
Rope doesn't rewind fully	Rope stretched Spring has lost tension Pulley tight on spindle Spring fouled with dirt/dust etc.
Rope does not rewind	Spring broken Spring end not located properly
Does not engage	Pawls blunt or broken Friction washers damaged or worn

### IMPULSE STARTERS

<i>PROBLEM</i>	<i>CAUSE</i>
Winds up but wont release	Release dog jammed Engine seized
Won't wind up	Broken main spring Release dog sticking
Winds up but won't turn when released	Worn spring housing Worn dog retainer cup Broken starter cup Starter cup loose on flywheel
Starter works but is noisy	Dog retainer cup brake has lost tension

# SMALL ENGINES Worksheet 6

## ***FAULT FINDING AND TROUBLE SHOOTING***

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(1) List four reasons why a two stroke engine may not start.

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(2) What would three of the most likely causes be for fuel not to be reaching the two stroke engine ?

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(3) If a two stroke engine was losing power, what would be four of the problems to look for ?

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(4) There is no spark evident at the plug gap, list four reasons for this condition.

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(5) A two stroke engine has no compression, what would be two of the most likely causes.

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(6) Make a list of the causes for continual shearing of the flywheel key.

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(7) Name the two types of starters found on small engines.

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(8) If a rewind starter rope did not fully rewind what would be the most likely cause ?

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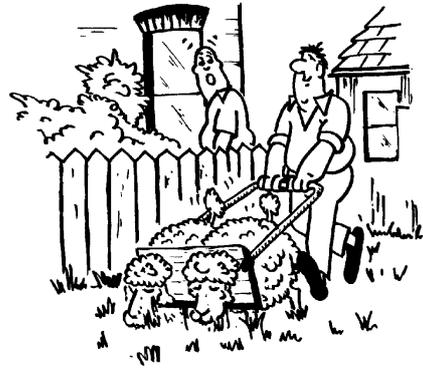
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# CHAPTER 7

## GLOSSARY OF TERMS

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### ADVANCE

A term used to indicate that ignition occurs before the piston reaches T.D.C.; To adjust ignition to fire earlier.

### AIR BLEED

A device to permit additional air to enter the main nozzle of a carburettor to balance the air/fuel ratio at higher speeds.

### AIR COOLED ENGINE

An internal combustion engine cooled by forced air.

### AIR/FUEL RATIO

The ratio of the weight of air to the weight of fuel.

### AIR GAP

The space between spark plug electrodes.

### AMPERE

Unit of measurement of flow of electrical current. An ampere is the current that will flow with 1 volt potential (pressure) through a conductor of 1 Ohm resistance.

### ATOMIZATION

The process of breaking up a liquid into small particles.

### BOTTOM DEAD CENTRE (B.D.C.)

The lower limit of piston movement.

### BRAKE HORSEPOWER

The power an engine actually delivers as measured at the crankshaft.

### BUTTERFLY VALVE

A valve which rotates on a shaft. Used in the carburettor to control the air/fuel flow into the manifold.

### CAMSHAFT

A shaft with cams machined at correct intervals to actuate the valve lifting mechanism.

### CARBON MONOXIDE

A colourless, tasteless, odourless and very poisonous gas resulting from combustion.

### CARBURATION

The measuring and mixing of fuels with air, and passing the mixture to the engine.

### CHOKE

A device in the carburettor used to limit the flow of air and enrich the air/fuel mixture.

## CIRCUIT

The path through which electrical current, fuel or oil flows.

## COMBUSTION CHAMBER

The space within the cylinder in which the air/fuel mixture is burned, all the space at the top of the piston when at top dead centre and the cylinder head.

## COMPRESSION

To be pressed into a smaller space, to be condensed or reduced in size or volume.

## COMPRESSION PRESSURE

The amount of pressure resulting from the compression stroke of a piston when it has reached top dead centre.

## CONDUCTOR

A material through which electricity will flow.

## CONNECTING ROD

The link between the piston and the crankshaft.

## COOLING SYSTEM

The particular group of units that carries off and dissipates the unused heat generated in the engine.

## CRANKSHAFT

The main shaft of an engine, on which offset sections form cranks which swing in a circle as the shaft rotates.

## CURRENT

The flow of electricity.

## CYCLE

A series of events, operations or movements that repeat themselves in an established sequence.

## CYLINDER BLOCK

A group of cylinders cast as one piece.

## CYLINDER WALL

The area of the cylinder which the piston rings come in contact with.

## D.C. (DIRECT CURRENT)

A current of electrons that move in one direction only.

## DEFLECTOR

The shape of the crown of a piston which changes the direction of the incoming air/fuel charge on a two stroke engine.

## FLOAT SYSTEM

The part of a carburettor, consisting of a float and needle valve, which maintains the fuel at the correct level.

## FLYWHEEL

A heavy wheel on the end of a crankshaft which absorbs power and causes the engine to run smoothly between power impulses.

#### FOUR STROKE CYCLE

A cycle of engine operation which requires four strokes in 720 degrees for completion.

#### GROUND

Connection of an electrical unit to the engine frame etc. to return the current to its source (also known as "earth").

#### HORSEPOWER

A unit for measuring power. It is the rate of doing work.

#### HOT PLUG

A spark plug which runs warmer than others in an engine.

#### IDLING

Engine running without load at the lowest speed possible without stalling.

#### JET

A hole or orifice of a specific size to limit the flow of fuel in a carburettor.

#### MAGNETIC FIELD

The space around a magnet through which the magnetic lines of force travel.

#### NORTH POLE

The pole of a magnet from which the lines of force travel.

#### OHM

The unit of measurement of electrical resistance. One ohm allows one ampere of current to flow through a conductor of one volt potential.

#### OPEN CIRCUIT

A circuit through which no current can pass.

#### OTTO CYCLE

A cycle of four events which occur in a gasoline engine in the following order:

- (1) INTAKE
- (2) COMPRESSION
- (3) POWER
- (4) EXHAUST

#### PETROIL

The terminology used for the petrol and oil ratio used in a two stroke engine.

#### PISTON DISPLACEMENT

The cubical content of the cylindrical space created as the piston moves from B.D.C. to T.D.C. of its strokes.

#### PISTON SKIRT

The section of a piston below the gudgeon pin.

#### PISTON STROKE

The length of piston travel within a cylinder.

## PORTS

Openings in the cylinder block or sleeve for intake, exhaust, water and oil etc.

## POWER

The capacity to do work, capacity to do mechanical work as measured at the rate it is being done.

## RECIPROCATING

A back and forth or up and down linear motion such as the action of pistons in an engine.

## RESISTANCE

A quality of a part of, or the whole of an electrical circuit that opposes the flow of current through it.

## SCAVENGING

The expelling, or cleaning out of exhaust gases from the combustion chamber.

## SOUTH POLE

The end of a magnet at which the lines of force enter (return). Opposite to the north pole.

## SPARK COIL

A device used to raise (or step up) the voltage by electromagnetic induction.

## STROKE

The length or distance the piston travels up or down inside the cylinder.

## TOP DEAD CENTRE (T.D.C.)

The upper limit of piston movement.

## TWO STROKE CYCLE

An engine which requires two strokes to complete a cycle of operation 360 degrees of crankshaft movement.

## VACUUM

Result of reducing atmospheric pressure.

## VALVE

A device for opening and closing an aperture.

## VALVE SEAT

That part of the combustion chamber upon which the valve face rests.

## VENTURI

A restriction in the main air passage of a carburettor.

## VISCOSITY

The internal resistance to flow within a liquid. ("thickness or body" of a fluid).

## VOLT

A unit of electrical measurement of potential; (electromotive force) the potential necessary to cause a current of one ampere to flow through a conductor of one ohm resistance.

## WATT

Unit of electrical measurement of power. One watt of power = one ampere of current times one volt of potential to flow through a conductor of one ohm resistance.

