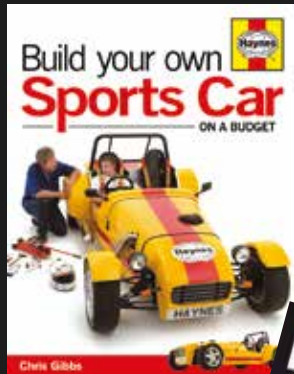
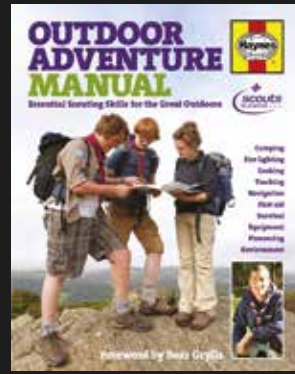
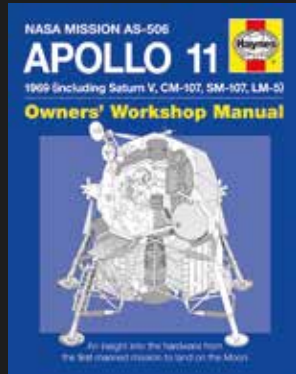


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Age range 10 +

# BUILD YOUR OWN V-TWIN MOTORCYCLE ENGINE

## HAYNES ASSEMBLY MANUAL



A working model  
of a motorcycle engine

Includes an explanation  
of how a V-Twin  
engine  
works

**HMV2R Haynes Build Your Own  
V-Twin Motorcycle Engine Kit**

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# BUILD YOUR OWN V-TWIN MOTORCYCLE ENGINE

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## INTRODUCTION

There are many different shapes and sizes of internal combustion engine, from small single-cylinder model aircraft engines, right up to the large multi-cylinder engines used in industrial machinery and ships. Motorcycles have been around since the late 1880s, and their engines have steadily evolved to suit a wide range of uses, including day-to-day commuting, long distance touring and racing. This kit is designed to represent a type of engine commonly used in motorcycles ('bikes'), so it's this configuration we'll concentrate on.

Production motorcycle engine designs have included single, twin, triple, four and six-cylinder layouts, the most common being the four cylinder arrangement. As a general rule, the greater the number of pistons, the more power that is produced, and the smoother the running of the engine. They are almost exclusively petrol (gasoline) engines, operating on a two- or four-stroke cycle. Two-stroke engines were once more common, but ever-stricter emission controls have reduced their use in motorcycles.

The layout of the cylinders in a motorcycle tends to be 'straight' (a single row of cylinders running across the width of the bike), a 'V' (two rows of cylinders), or a 'boxer' arrangement (two or more cylinders operating in a horizontal plane).

V-twin engines have existed since 1889, and had come into widespread use by the early part of the 1900s. The term 'V-twin' is used to denote any twin cylinder engine in which the cylinders are arranged at an angle between 0 and 180 degrees. The one exception is Ducati, who refer to their 90 degree twin engine as an 'L-twin', because when mounted in the bike, one cylinder is near horizontal and the other near vertical (so it looks like the letter 'L' when viewed from the side).

Most V-twin engines have the pistons connected to a single crankpin, with the connecting rods sitting side by side. A 90 degree V arrangement can, with the correct counterweights, give perfect primary balance (in other words, there is no vibration arising from one rotation of the crankshaft). An engine with an arrangement of less than 90 degrees is more compact, at the expense of inferior mechanical balance and increased vibration.

V-twin motorcycle engines can be mounted with the crankshaft transverse to the frame (with one cylinder in front of the other), or with the crankshaft longitudinal to the frame (with one cylinder on either side of the frame). The transverse arrangement is the most common, and is favoured by present-day manufacturers such as Ducati, Harley-Davidson, KTM, Aprilia and most Japanese marques. Because the engine is narrower, it can be mounted lower in the frame to improve handling, though cooling problems can be experienced with air-cooled engines due to restricted air flow to the rear cylinder. The longitudinal crankshaft configuration is used by Moto-Guzzi, and on some machines by Honda. Having the cylinders protruding from either side of the bike makes air cooling more effective, though the longitudinal crankshaft can induce a torque reaction if the throttle is opened or closed rapidly and is particularly noticeable at low engine revs. Some taller riders can also find that their knees hit the protruding cylinder heads, making riding more uncomfortable.

## INTRODUCTION

The valves on engines tend to be operated by pushrods, or by chain-driven or gear-driven overhead camshafts, each design having its own advantages and disadvantages. Pushrod engines are simpler – a camshaft is mounted in the engine block, and a series of rods transfer the up/down profile of the cam to the valves via rockers. An overhead camshaft (OHC) design has the camshaft mounted in the cylinder head, which operates the valves directly or via rockers. The greater number of moving parts in the pushrod valve mechanism means that it cannot operate as fast as the OHC design, so is more suited to lower performance engines. The OHC valve arrangement is lighter and can operate at much higher speeds, though the mechanism required to drive the camshaft, typically a long chain or toothed belt with tensioners and idler pulleys to maintain precise valve timing, is much more complex.

This kit has been designed to be straightforward and fun to build, and to provide a practical illustration of the principles of a real V-twin motorcycle engine. It is not intended to be a replica of any specific real-life engine, and any similarities that exist are purely coincidental. It has a transverse crankshaft, with the V-angle set at 90 degrees. A single overhead camshaft on each cylinder is driven by its own toothed belt, operating the two valves per cylinder via rockers. Ignition timing is provided by an ignition system mounted inside the engine.

We hope you enjoy building your own V-twin engine and learning about the principles of how it operates.

## INTRODUCTION

### Haynes International Motor Museum

The Haynes International Motor Museum, at Sparkford in Somerset, is an educational charitable trust, chaired by Haynes Publishing Group Founder Director, John Haynes OBE, and established in 1985. The museum contains a collection of over 400 cars, motorcycles and automotive memorabilia, from the dawn of motoring to classics of the last 25 years. The collection is housed in ten halls, along with a restaurant, gift shop and comprehensive conference facilities. The museum is open throughout the year, with the exception of December 24th, 25th and 26th and January 1st. For further details see [www.haynesmotormuseum.com](http://www.haynesmotormuseum.com) or call 01963 440804.



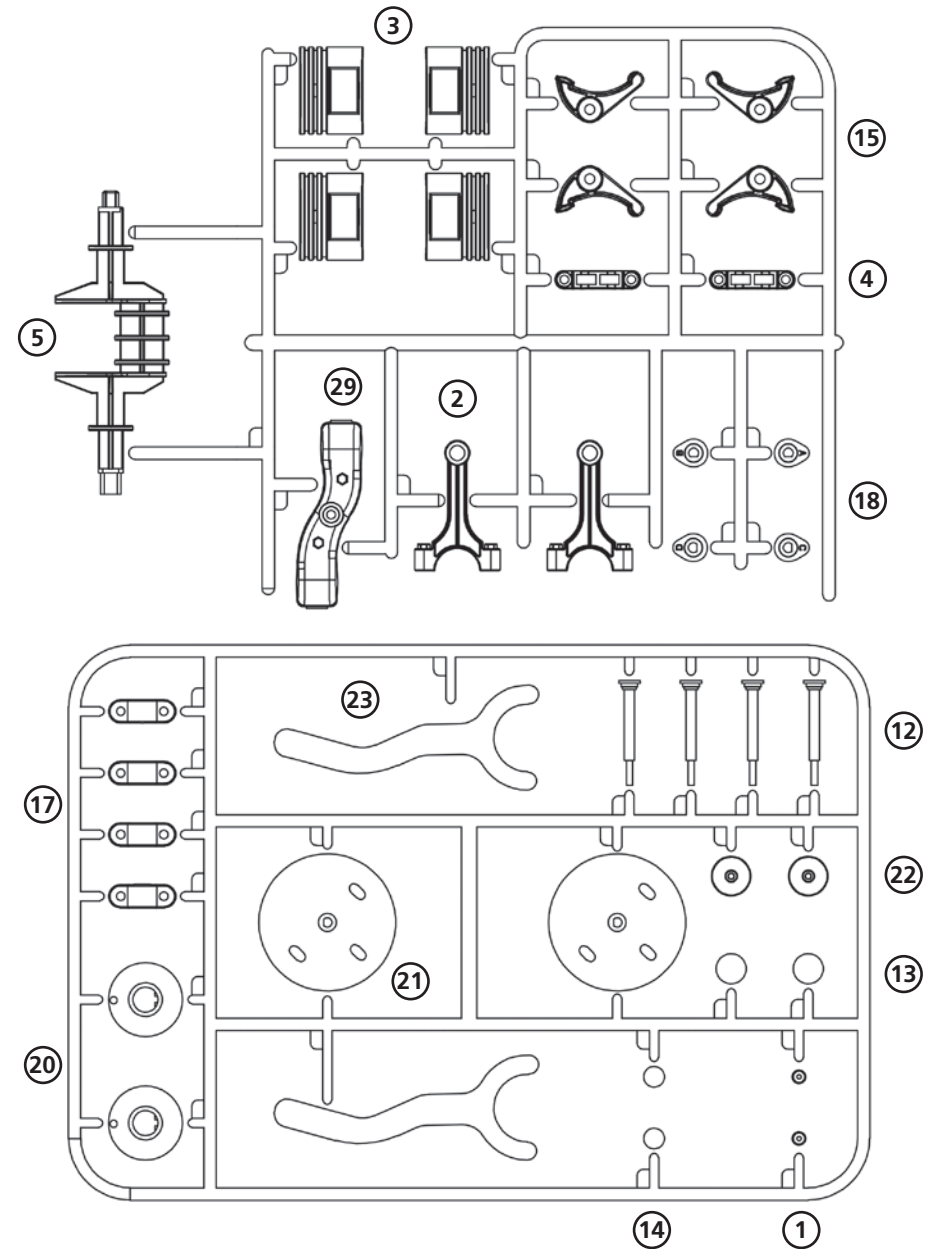
## NOTES AND ADVICE

- All parts with the suffix 'A' are used to make the front cylinder and all parts with the suffix 'B' are used to make the rear cylinder.
- Identify the various parts by looking at the list of components and the corresponding illustrations.
- Use a sharp knife to trim any excess plastic from the components after they have been removed from their carrier frames.
- Take care not to over-tighten the screws as this may permanently damage the plastic.
- Non-rechargeable batteries are not to be recharged.
- Rechargeable batteries are only to be charged under adult supervision.
- Rechargeable batteries are to be removed from the toy before being charged.
- Different types of batteries or new and used batteries are not to be mixed.
- Batteries are to be inserted with the correct polarity.
- Exhausted batteries are to be removed from the toy.
- The supply terminals are not to be short-circuited.

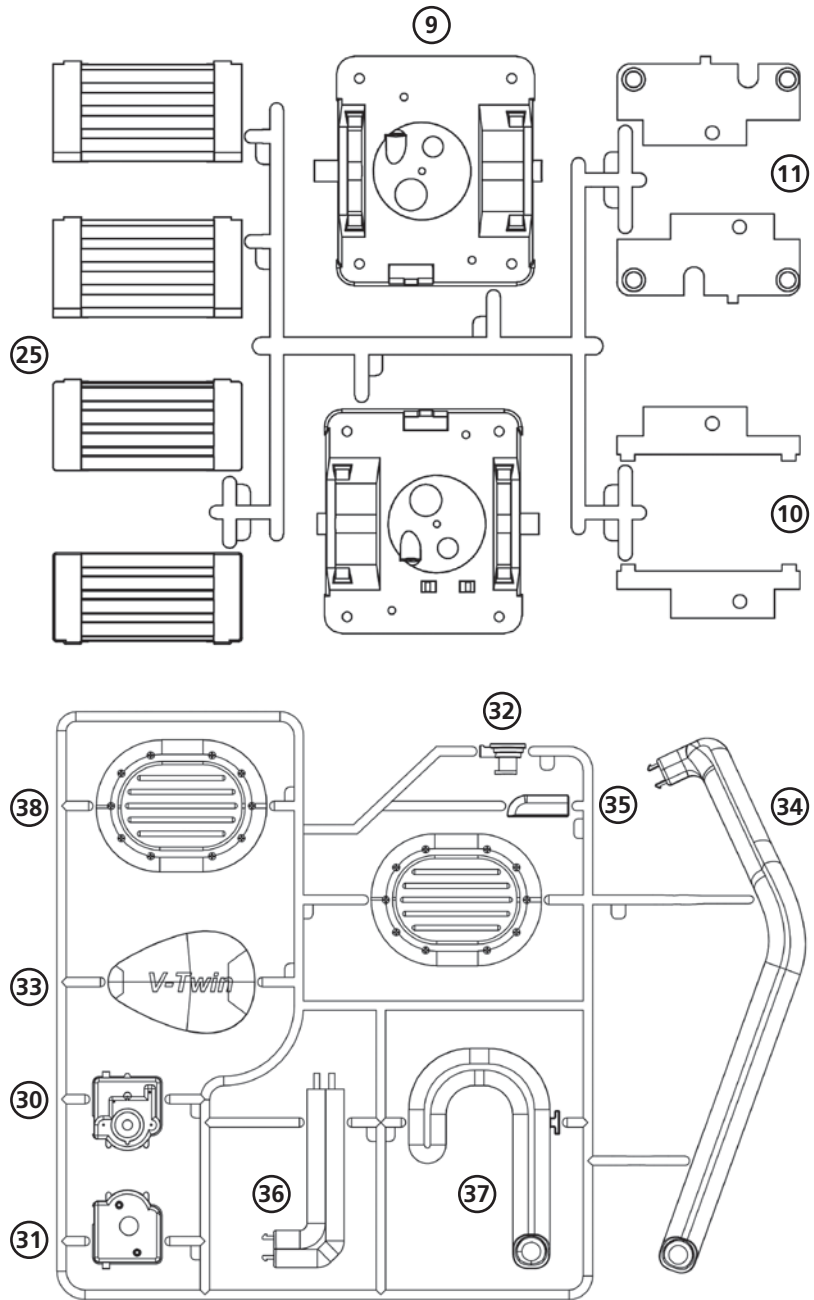
# PARTS LIST

Qty.	Part	Part No.	Qty.	Part	Part No.
2	Gudgeon pins	1	1	Middle Transmission Case	26
2	Connecting rods	2	1	Ignition assembly	27
4	Piston halves	3	1	Gearbox assembly	28
2	Connecting rod bearing caps	4	1	Inlet manifold	29
1	Crankshaft	5	1	Carburettor top	30
1	Sump pan	6	1	Carburettor bottom	31
1	Lower crankcase	7	1	Air intake	32
1	Cylinder block	8	1	Air filter cover	33
2	Lower cylinder heads	9	1	Exhaust - front cylinder (a)	34
2	Small cylinder head plates	10	1	Exhaust - front cylinder (b)	35
2	Large cylinder head plates	11	1	Exhaust - rear (a)	36
4	Valve stems	12	1	Exhaust - rear (b)	37
2	Inlet valves	13	2	Engine side covers	38
2	Exhaust valves	14	2	Cam belts	39
4	Rocker arms	15	1	Gearbox gear	
2	Upper cylinder head	16	1	Screwdriver	
4	Rocker bearing caps	17	2	Cylinder head gaskets	
4	Cams	18	65	Screws	
2	Rocker covers	19	4	Valve springs	
2	Crankshaft sprocket	20	2	Camshafts	
2	Camshaft sprocket	21	2	Rocker shafts	
2	Idler pulleys	22	1	Base	
2	Timing alignment tool	23			
2	Engine timing belt covers	24			
4	Engine filler plates	25			

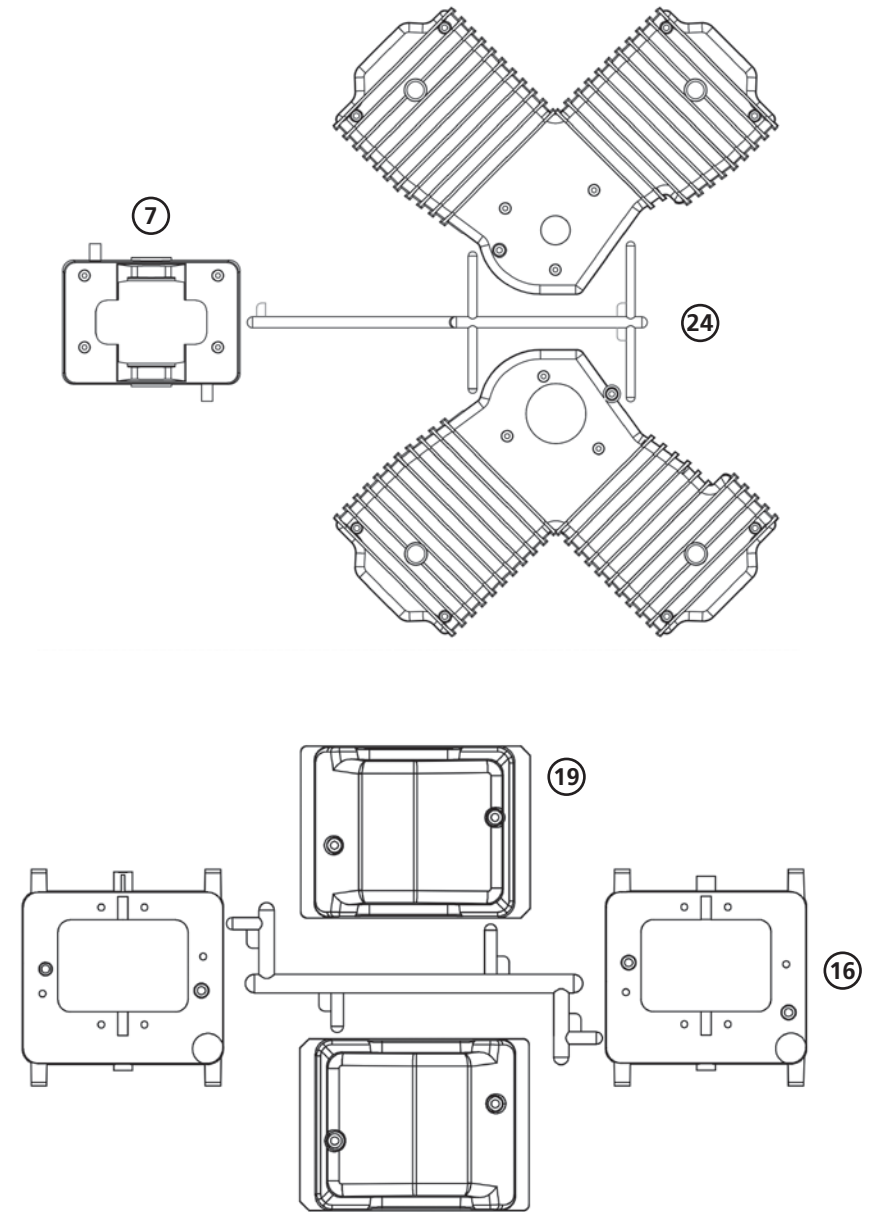
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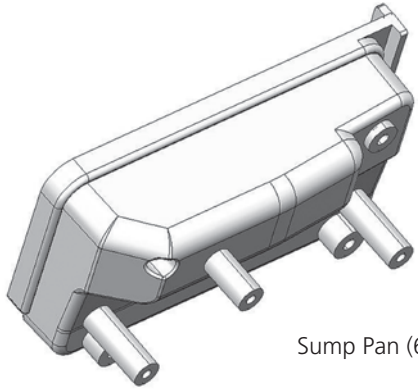
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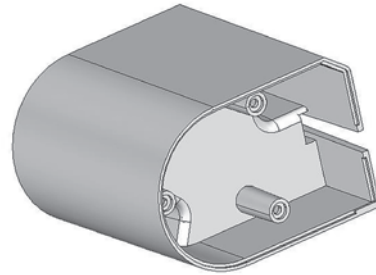
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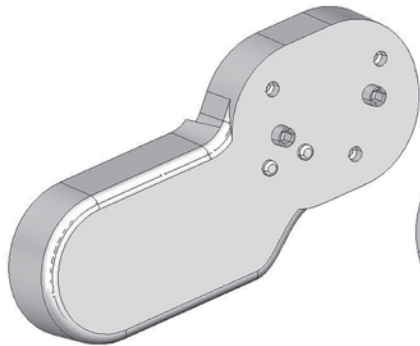
## PARTS LIST



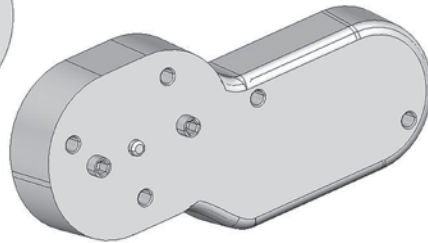
Sump Pan (6)



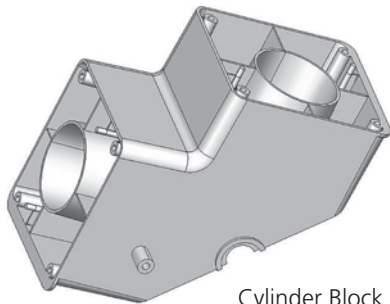
Middle Transmission Case (26)



Gearbox Assembly (28)

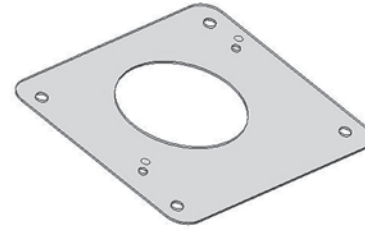


Ignition Assembly (27)



Cylinder Block (8)

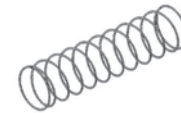
## PARTS LIST



Head Gasket x 2



Cam Belt x 2 (39)



Valve Springs x 4

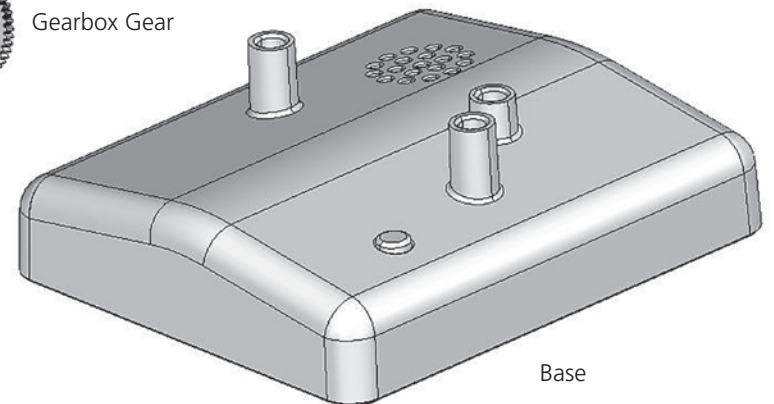
Camshaft (72mm) x 2



Rocker Shaft (43mm) x 2



Gearbox Gear



Base

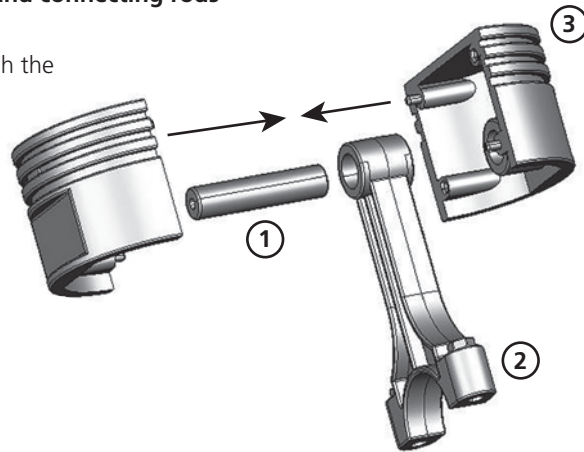


## ASSEMBLING THE ENGINE

### Step 1 - Assemble the pistons and connecting rods

Push a gudgeon (wrist) pin through the small end of a connecting rod. Push two halves of a piston together over the gudgeon pin and press firmly together.

Repeat for the other piston/rod assembly.

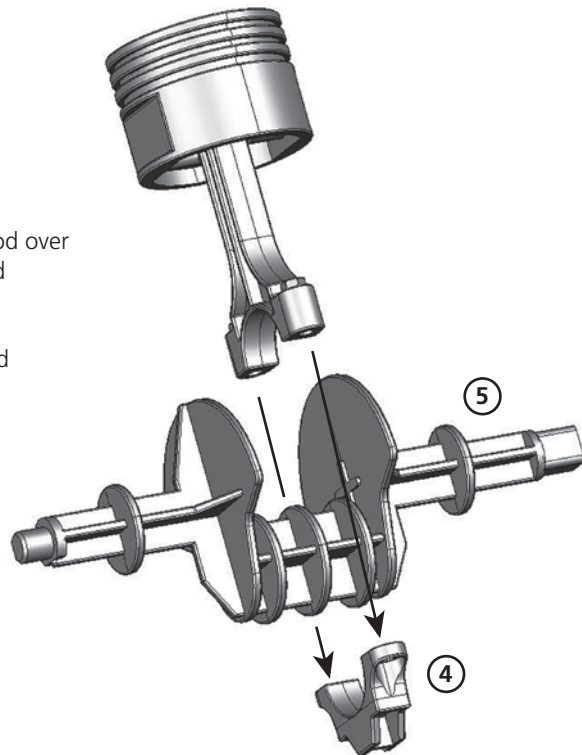


### Step 2 - Fit the piston/connecting rod assemblies to crankshaft

The connecting rods attach to the crankshaft as shown.

In each case, place the connecting rod over the crankshaft, fit a bearing cap, and secure with two screws.

Check that the piston/connecting rod assemblies rotate freely around the crankshaft.

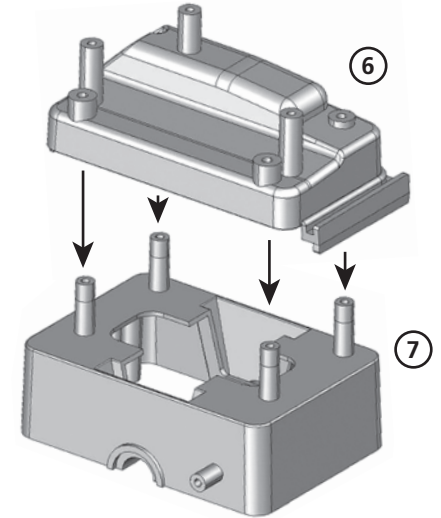


## ASSEMBLING THE ENGINE

### Step 3 - Fit the lower crankcase to the sump

Place the sump pan over the bottom of the lower crankcase and secure with four screws.

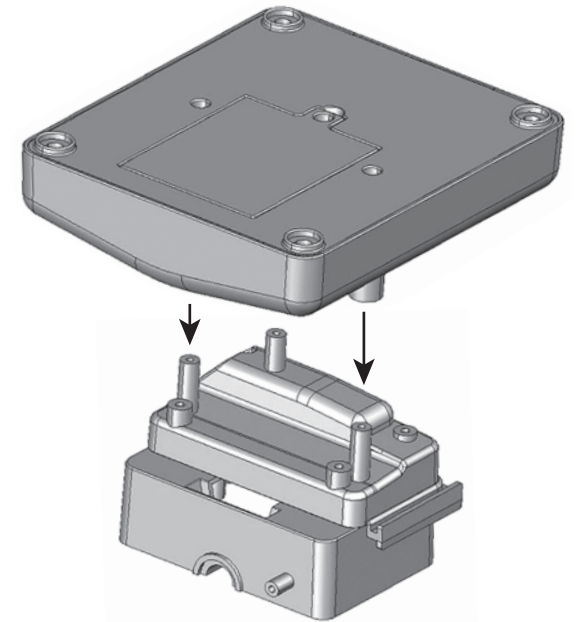
**Note:** This will only fit one way.



### Step 4 - Fit the sump to the base

Fit the base to the sump pan and secure with three screws.

**Note:** The legs are positioned so that this will only fit one way.



## ASSEMBLING THE ENGINE

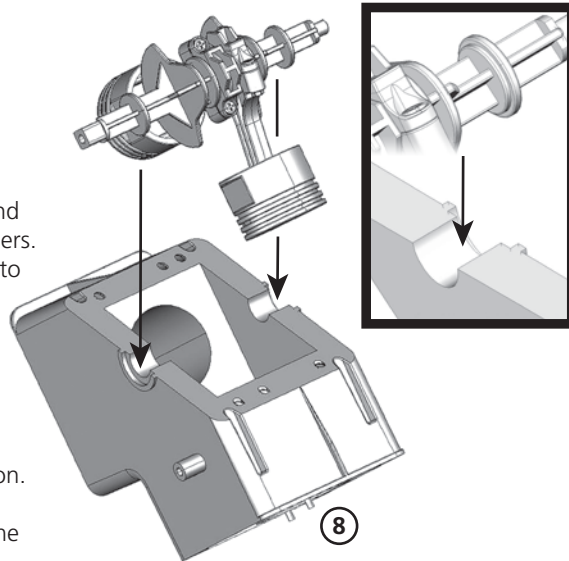
### Step 5 - Fit the piston/crankshaft assembly to the cylinder block

Turn the cylinder block upside down.

Hold the piston/crankshaft assembly and gently insert the pistons into the cylinders. Note that the crankshaft will only fit into the block one way. One of the flanges has a step (refer to close up image) that fits into a matching groove in the bearing surface in the block.

You may need to rotate the crankshaft slightly to move the pistons into position.

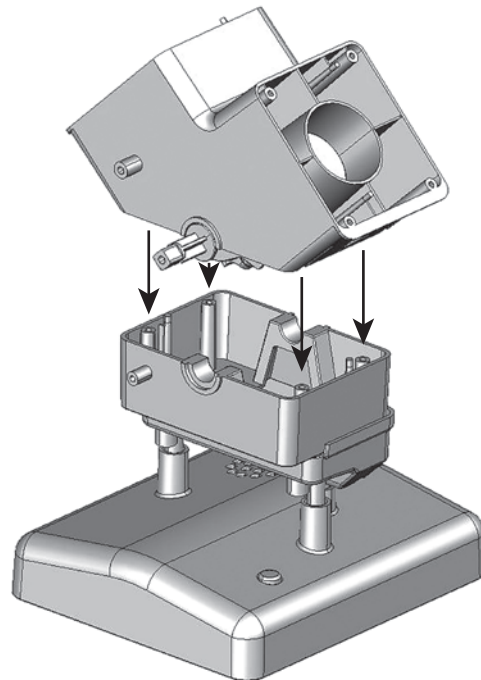
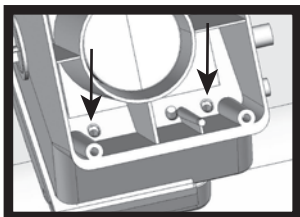
Lower the crankshaft until it rests on the bearing surfaces.



### Step 6 - Fit the cylinder block to the lower crankcase

Turn the cylinder block the right way up, with the crankshaft underneath. Hold the ends of the assembly so the crankshaft stays in position. Fit to the lower crankcase and secure with four screws. The block will only fit one way.

DO NOT OVERTIGHTEN the screws. Gently turn the crankshaft to make sure that it and the pistons move freely. If the crankshaft does not move freely, try loosening the screws by a 1/4 turn.



## ASSEMBLING THE ENGINE

### Step 7 - Fit the valves to the lower cylinder heads

Fit the cylinder head plates to the lower cylinder heads. Note that each head uses one narrow plate and one wide plate.

The narrow plate fits on the side of the head with the small hole, and the wide plate on the side with the large hole (the plates have round studs that face downwards into the head).

The plates must be pushed down firmly so they clip into position. TIP: use the end of the screwdriver to push the narrow plates into position. Plates labelled 'B' should be fitted to cylinder head '9B' and plates 'A' to head '9A'.

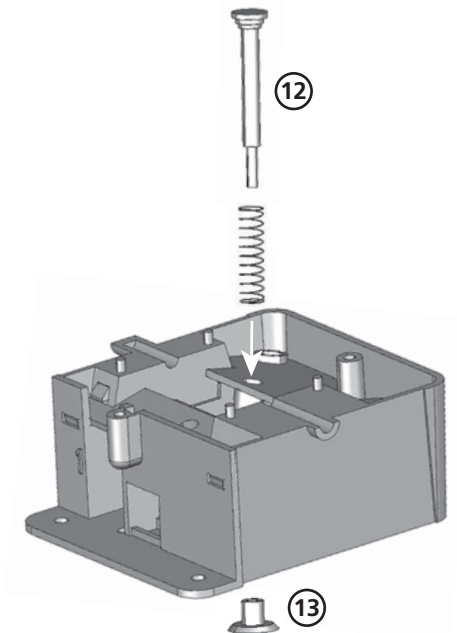
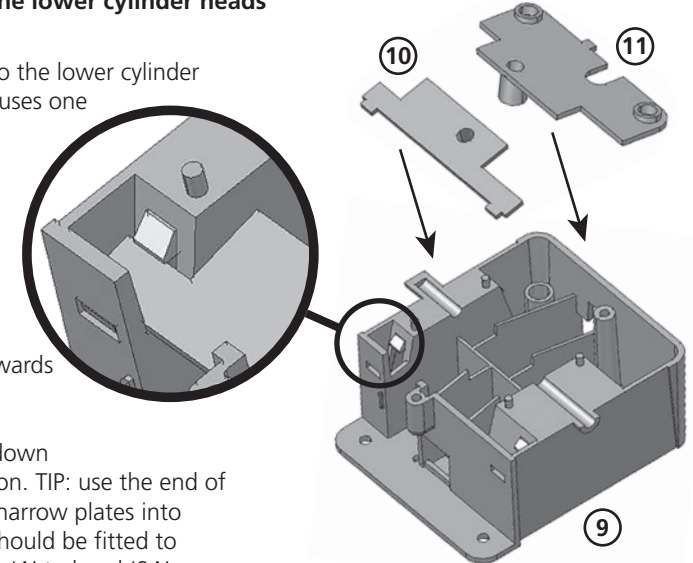
Remove the 4 valve stems, 2 inlet valves and 2 exhaust valves from the carrier frames. Note that the exhaust valves are smaller than the inlet valves. Carefully trim away any excess plastic with a sharp knife.

Slide a spring over a valve stem, and then insert the stem into the hole in the wide head plate. Gently push the valve stem, compressing the spring until the end of the stem sticks out of the bottom of the head. Carefully push an inlet valve on to the step. Note that the end of the valve stem has a step - push the valve until it touches the edge of the step.

DO NOT force the valve - these parts are delicate.

The studs in the narrow plate carry the exhaust valves. Fit these in the same way as described above for the inlet valves.

Repeat for the exhaust and inlet valves on the other lower cylinder head. Check that the valves move up and down smoothly.

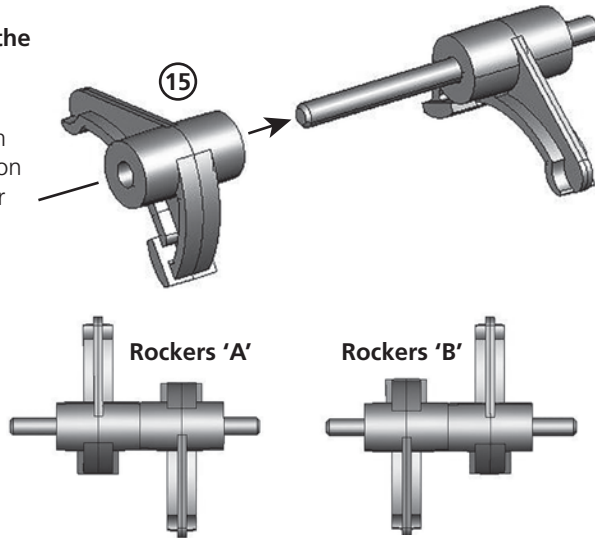


## ASSEMBLING THE ENGINE

### Step 8 - Fit the rocker arms to the rocker shafts

Remove the four rocker arms from the carrier frame. Slide two arms on to each of the 43mm metal rocker shafts exactly as shown in the diagram.

Note that the two rocker arm assemblies are mirror images. Refer to the diagrams below.



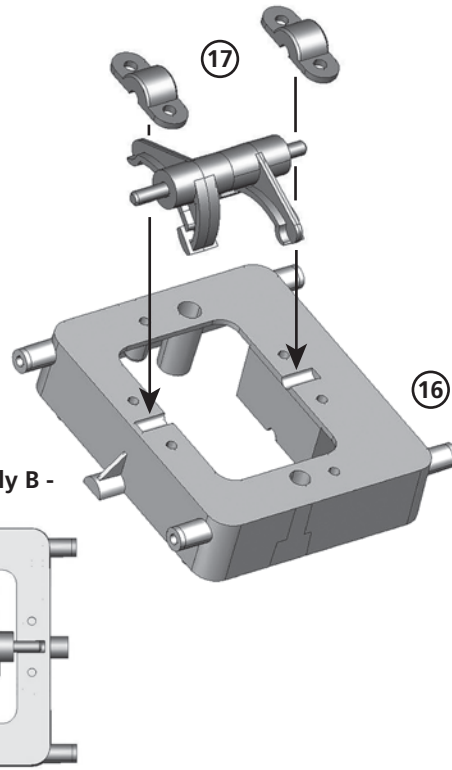
### Step 9 - Fit the rocker arm assemblies to the upper cylinder heads

Lower the rocker arm assemblies on to the upper cylinder heads. Rocker assembly 'A' should be fitted to upper cylinder head '16A' and assembly 'B' to head '16B'.

Attach the bearing caps as shown, using two screws for each, and then check that the rocker arms move smoothly.

Rocker Assembly A - front cylinder

Rocker Assembly B - rear cylinder

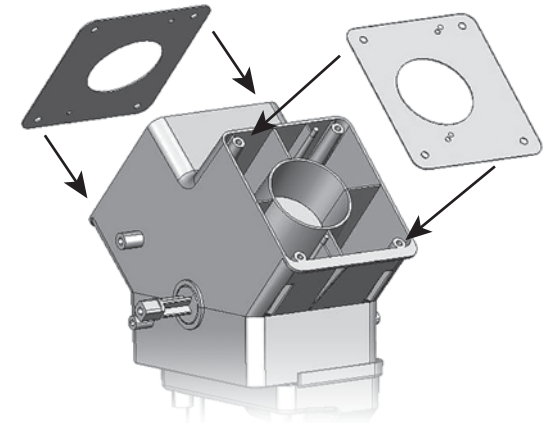


## ASSEMBLING THE ENGINE

### Step 10 - Fit the cylinder head gaskets

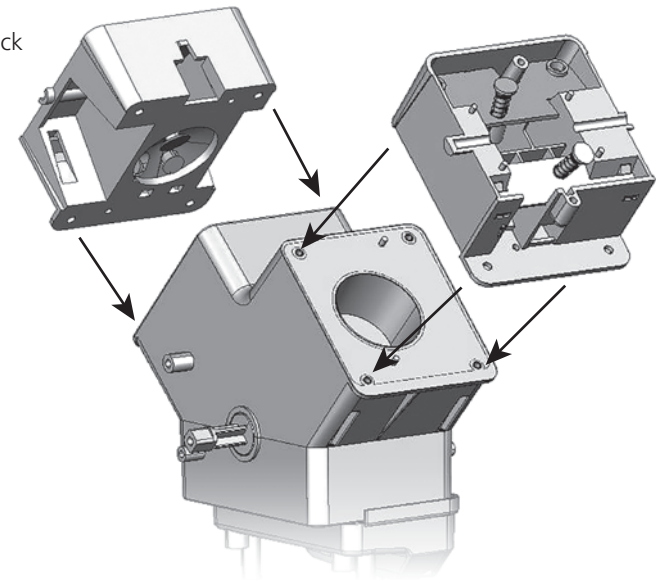
Place the cylinder head gaskets over the cylinder block. There are pegs in the block which match holes in the gasket to ensure correct alignment. Make sure the holes for the piston in each gasket align with the hole in the block.

Each gasket will only fit on one half of the block - they are not interchangeable.



### Step 11 - Fit the lower cylinder heads to cylinder block

Fit the lower cylinder heads to the cylinder block. The pegs in the block fit into the holes in the bottom of the heads to ensure correct alignment. They will only fit one way. Secure each head with four screws.

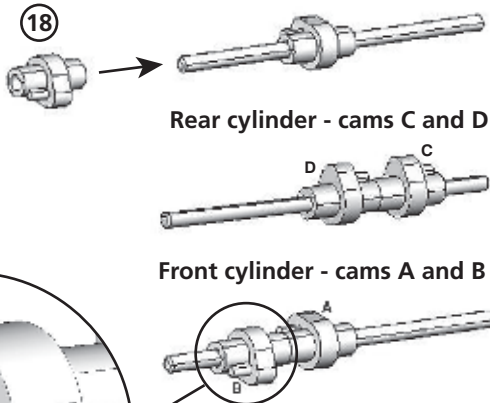


## ASSEMBLING THE ENGINE

### Step 12 - Assemble the camshafts

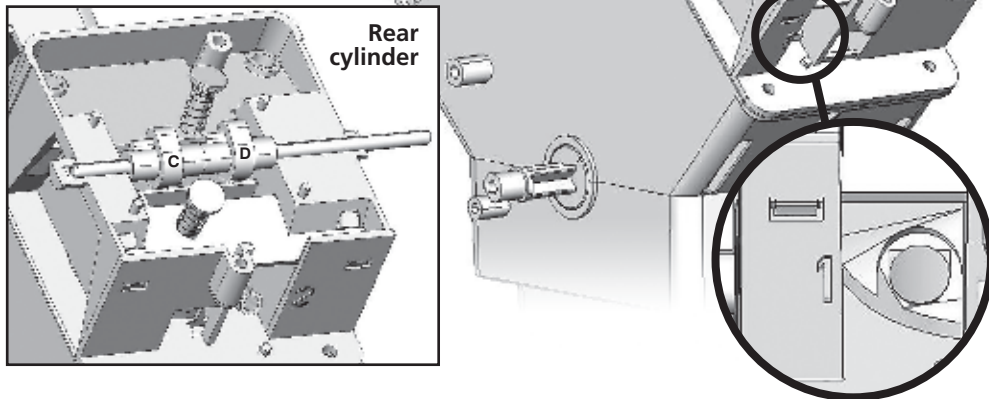
Remove the four cams, two labelled A and B, and the other two labelled C and D from the carrier frames. Slide cams A and B on to one camshaft. Each cam will only fit in one position - there is a flat surface on the inside of each which matches the flat surface on the camshaft.

Please also note the rib on one end of each cam - these must all face the same way. Repeat for the two cams labelled C and D.



### Step 13 - Fit camshafts to lower cylinder heads

Fit the camshaft with cams A and B to the front cylinder made from parts 'A' (note that there is a "1" engraved on the front of the cylinder head). Carefully observe the position of the ribs on the cams.

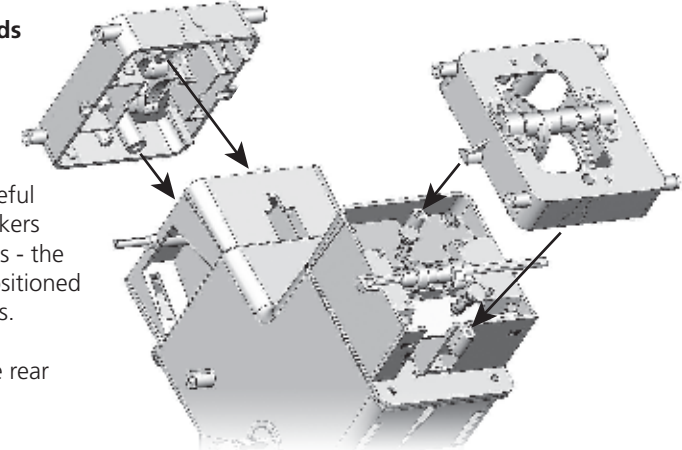


## ASSEMBLING THE ENGINE

### Step 14 - Fit upper cylinder heads to lower cylinder heads

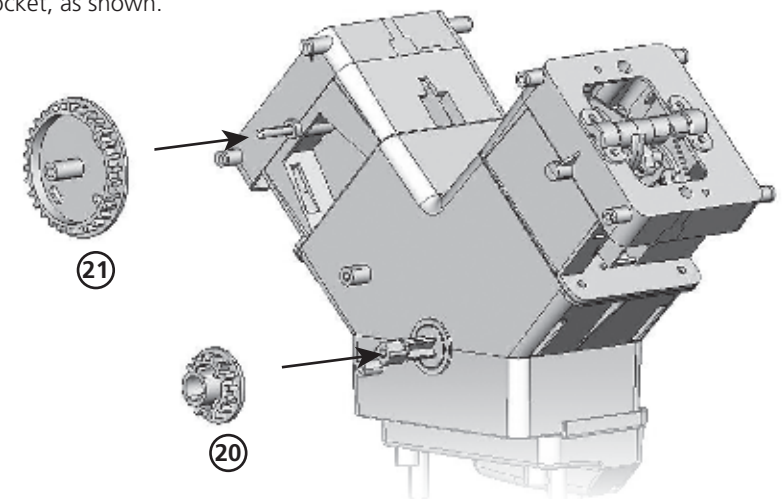
Fit the upper cylinder head assembly "A" to the lower head on the front cylinder and secure with two screws. Be careful that the longer arms of the rockers match the position of the valves - the ends of the rockers must be positioned over the tops of the valve stems.

Repeat Steps 13 and 14 for the rear cylinder.



### Step 15 - Fit crankshaft and camshaft sprockets

Fit the camshaft sprocket to the cylinder head marked "B" and the corresponding crankshaft sprocket, as shown.



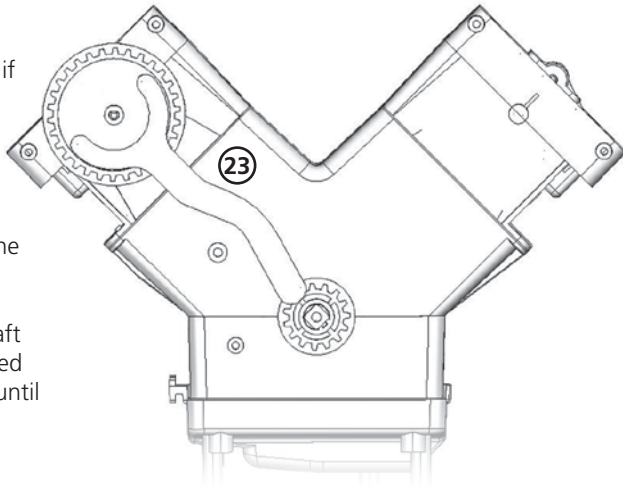
## ASSEMBLING THE ENGINE

### Step 16 - Fit timing tool

To complete this step, it is easiest if the engine is laid flat across your legs, with the sprockets facing upwards. Make sure that the rocker shaft on the front cylinder (which will be facing downwards) does not slide out when the engine is laid flat.

Fit the timing tool to the crankshaft and camshaft pulleys. You will need to rotate the camshaft sprockets until the timing tool fits in the holes as shown.

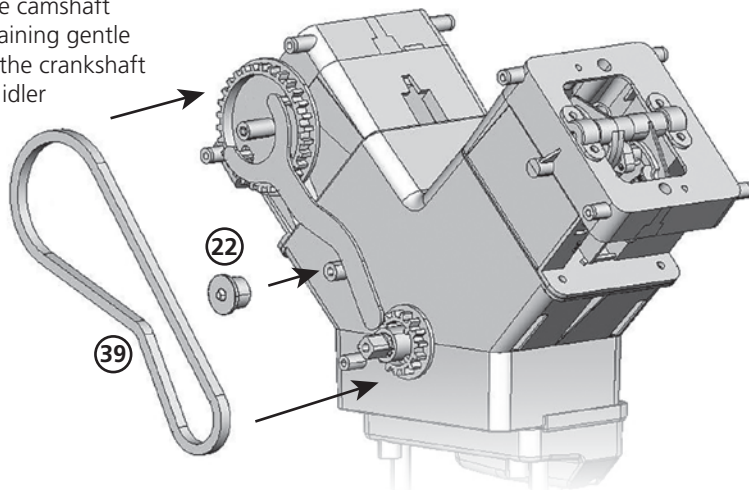
Note that the belt has chain links moulded on one side - these should face outwards.



### Step 17 - Fit timing belt and idler pulley

Fit the timing belt to the camshaft pulley, and while maintaining gentle tension, pass it around the crankshaft sprocket. Finally, fit the idler pulley so the belt passes over it.

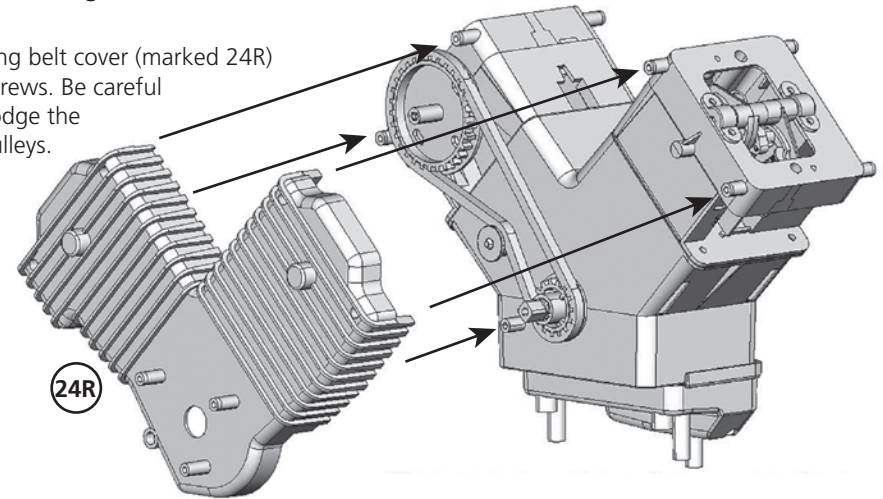
Carefully remove the timing tool without disturbing the belt.



## ASSEMBLING THE ENGINE

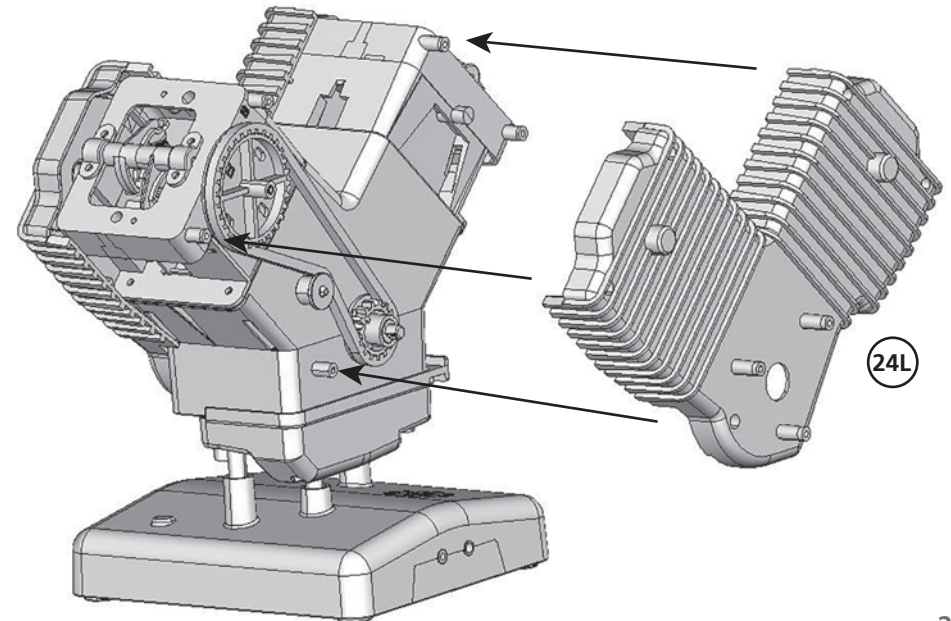
### Step 18 - Fit timing belt cover

Fit the timing belt cover (marked 24R) with five screws. Be careful not to dislodge the belt and pulleys.



### Step 19 - Fit second timing belt cover

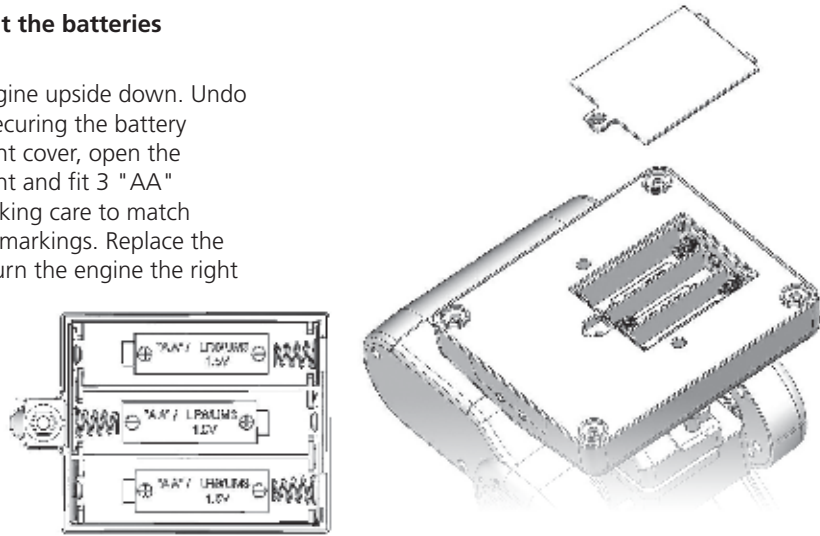
Repeat steps 15 - 18 for the other side of the engine.



## ASSEMBLING THE ENGINE

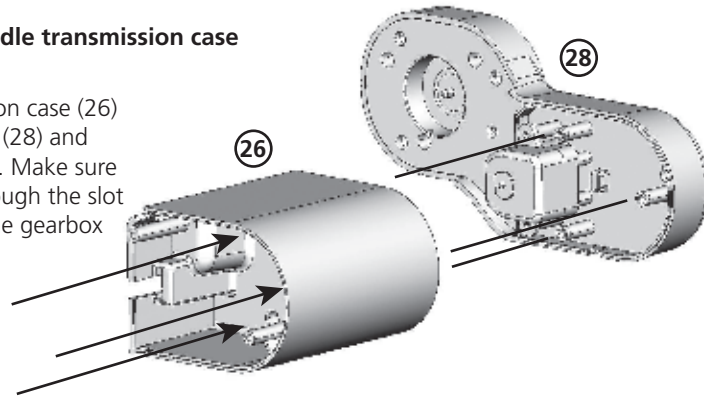
### Step 20 - Fit the batteries

Turn the engine upside down. Undo the screw securing the battery compartment cover, open the compartment and fit 3 "AA" batteries, taking care to match the + and - markings. Replace the cover and turn the engine the right way up.



### Step 21 - Gearbox/middle transmission case

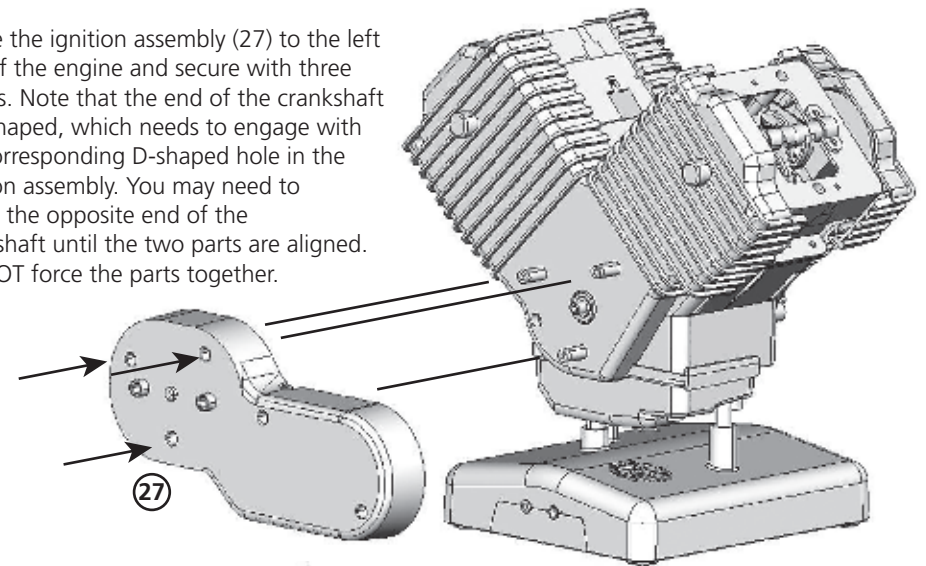
Fit the middle transmission case (26) to the gearbox assembly (28) and secure with three screws. Make sure the wires are routed through the slot in the bottom edge of the gearbox assembly.



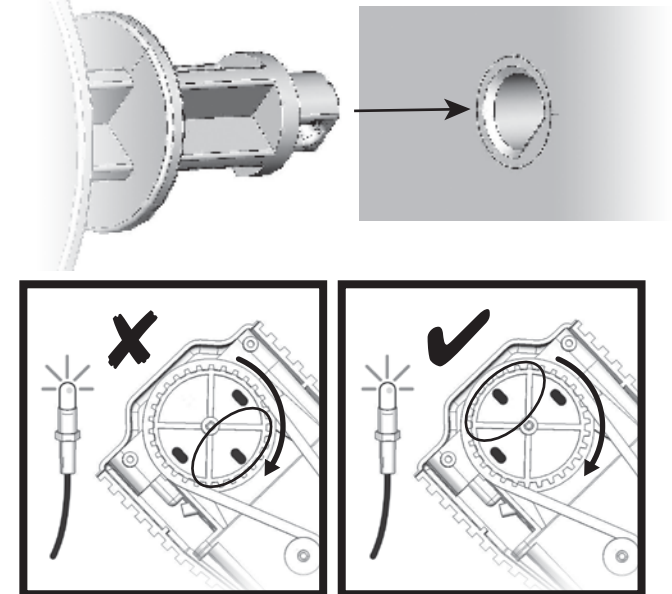
## ASSEMBLING THE ENGINE

### Step 22 - Fit ignition assembly

Fit the the ignition assembly (27) to the left side of the engine and secure with three screws. Note that the end of the crankshaft is D-shaped, which needs to engage with the corresponding D-shaped hole in the ignition assembly. You may need to rotate the opposite end of the crankshaft until the two parts are aligned. DO NOT force the parts together.



To check that the ignition timing is correct, plug the distributor lead into the base (the plug will only fit one of the two holes). Identify the spark plug for the front cylinder - it will have longer wires than the one for the rear. Press the starter button on the base and rotate the free end of the crankshaft counterclockwise. The spark plug should illuminate at, or just after, the point where the camshaft sprocket reaches the position shown far right (ticked). If the spark plug illuminates when the camshaft sprocket is as shown right (cross), remove the distributor assembly, rotate the crankshaft 360 degrees, and then replace.

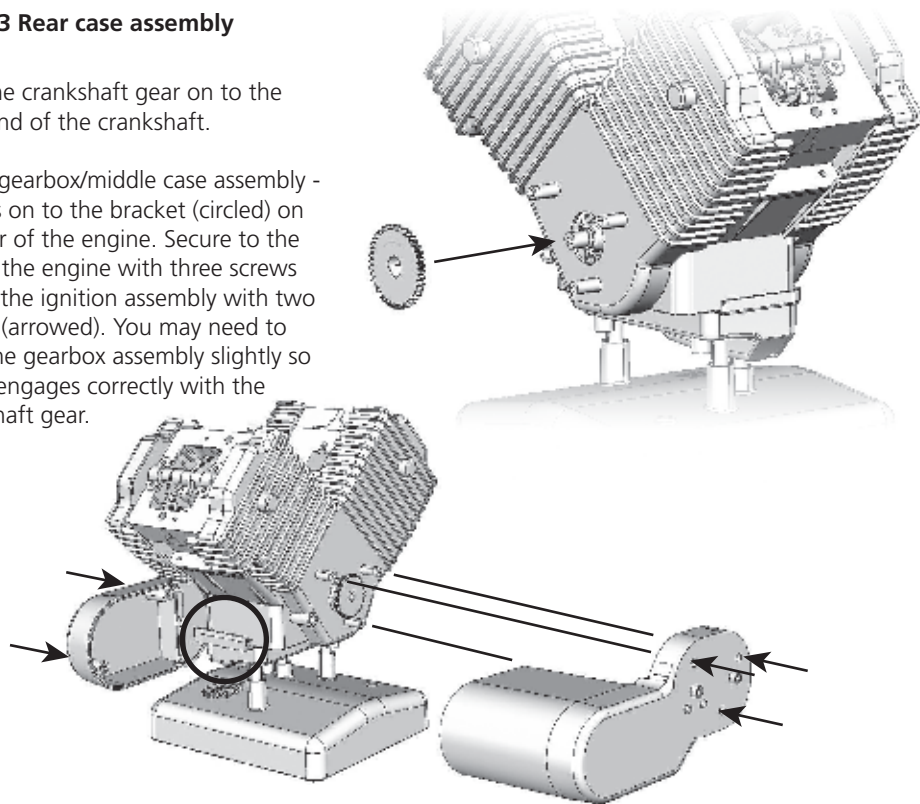


## ASSEMBLING THE ENGINE

### Step 23 Rear case assembly

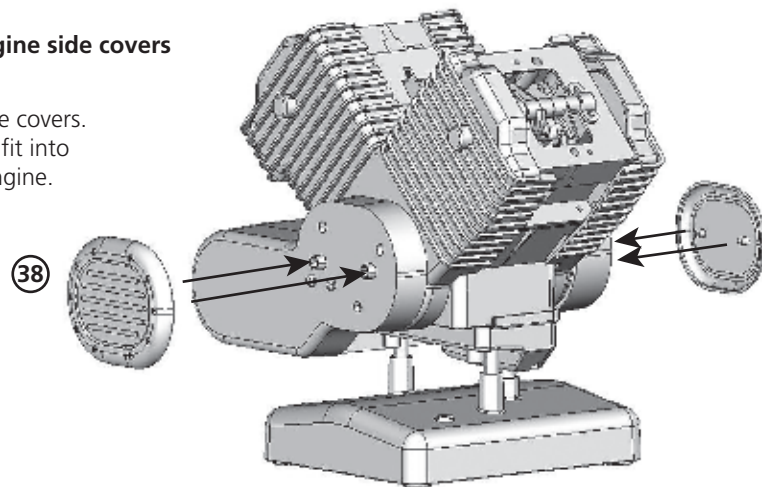
Slide the crankshaft gear on to the large end of the crankshaft.

Fit the gearbox/middle case assembly - it slides on to the bracket (circled) on the rear of the engine. Secure to the side of the engine with three screws and to the ignition assembly with two screws (arrowed). You may need to twist the gearbox assembly slightly so that it engages correctly with the crankshaft gear.



### Step 24 - Fit engine side covers

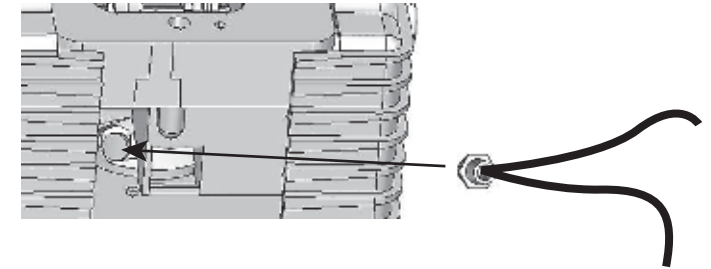
Fit the engine side covers. These are a push fit into the side of the engine.



## ASSEMBLING THE ENGINE

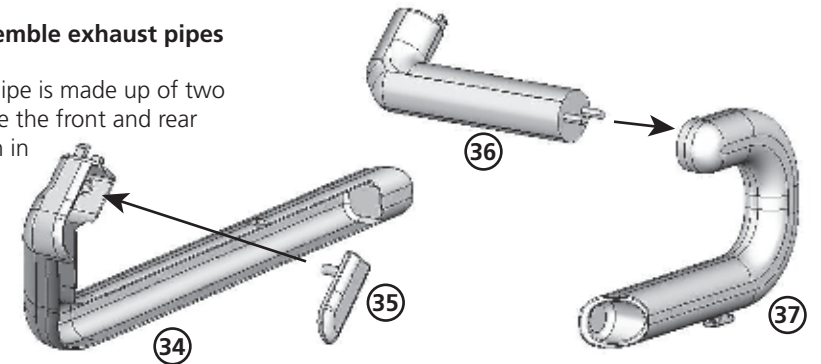
### Step 25 - Fit spark plugs

Fit the spark plugs. Note that the leads to the front spark plug are longer than those to the one at the rear.



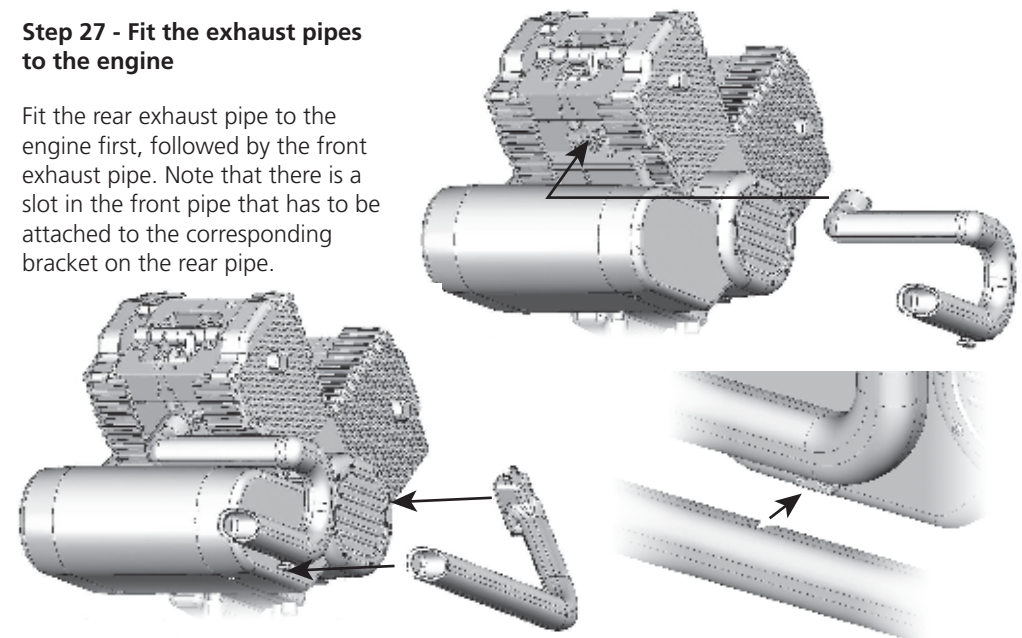
### Step 26 - Assemble exhaust pipes

Each exhaust pipe is made up of two parts. Assemble the front and rear pipes as shown in the diagrams.



### Step 27 - Fit the exhaust pipes to the engine

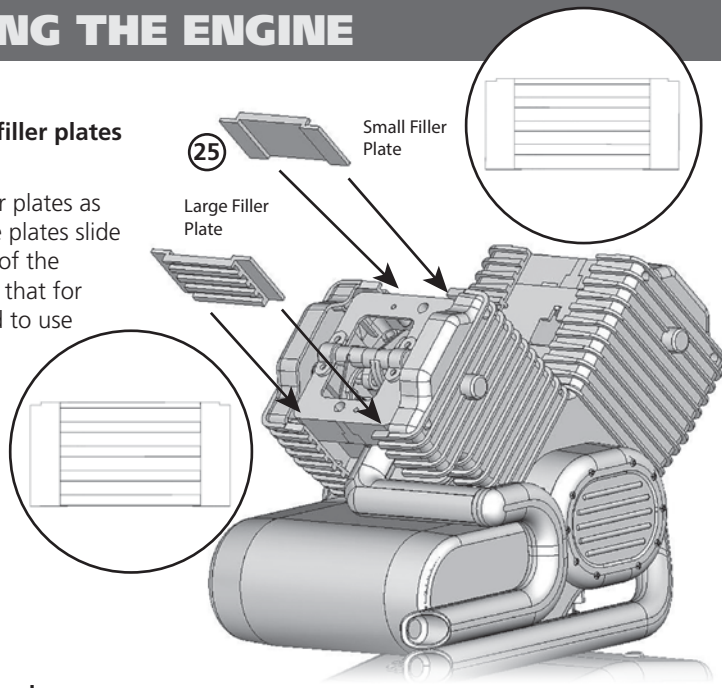
Fit the rear exhaust pipe to the engine first, followed by the front exhaust pipe. Note that there is a slot in the front pipe that has to be attached to the corresponding bracket on the rear pipe.



## ASSEMBLING THE ENGINE

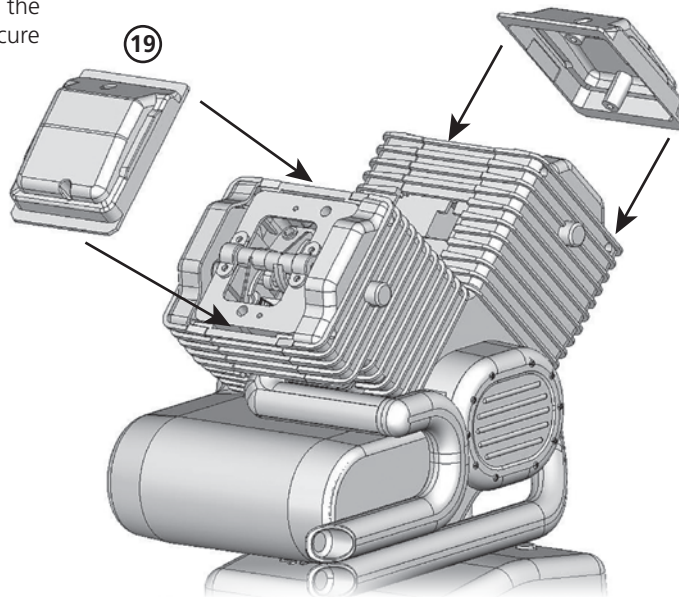
### Step 28 - Fit the head filler plates

Fit the cylinder head filler plates as shown. The edges of the plates slide down behind the edges of the engine side covers. Note that for each head, you will need to use one small and one large plate. Also note that the plate needs to be fitted with the raised parts on the top (circled).



### Step 29 - Attach the head covers

Fit head covers to the top of the upper cylinder heads and secure each with two screws. Note that these will only fit one way.

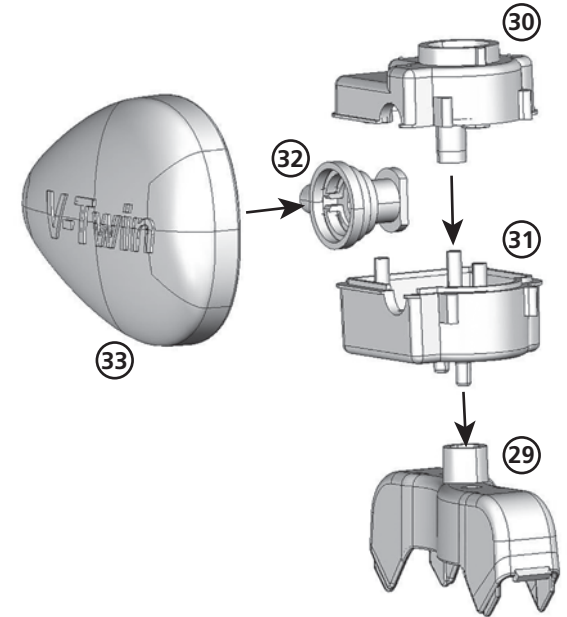


## ASSEMBLING THE ENGINE

### Step 30 - Assemble the carburettor

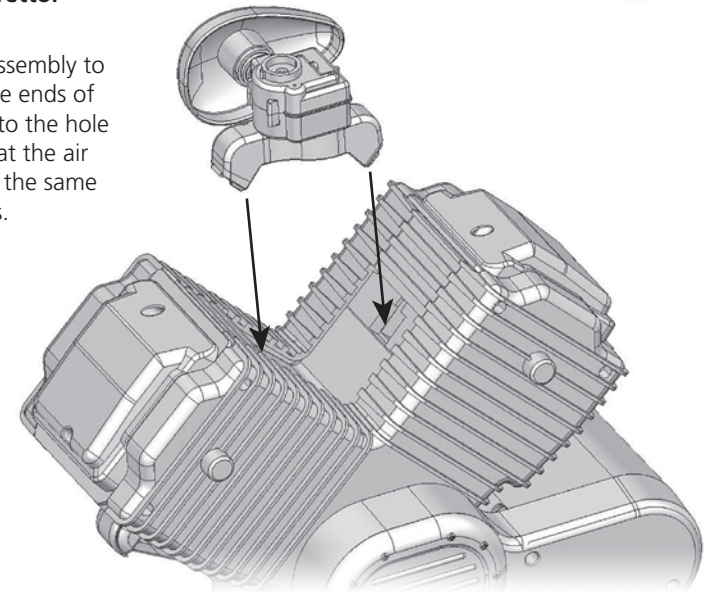
Fit the air intake (32) to the air filter cover (33) and secure with a screw.

Place the air intake between the top and bottom of the carburettor body (30 and 31), then fit this assembly to the inlet manifold (29). Secure the parts together using a screw inserted through the base of the inlet manifold.



### Step 31 - Fit the carburettor

Attach the carburettor assembly to the engine as shown. The ends of the inlet manifold clip into the hole in each cylinder. Note that the air filter cover should be on the same side as the exhaust pipes.

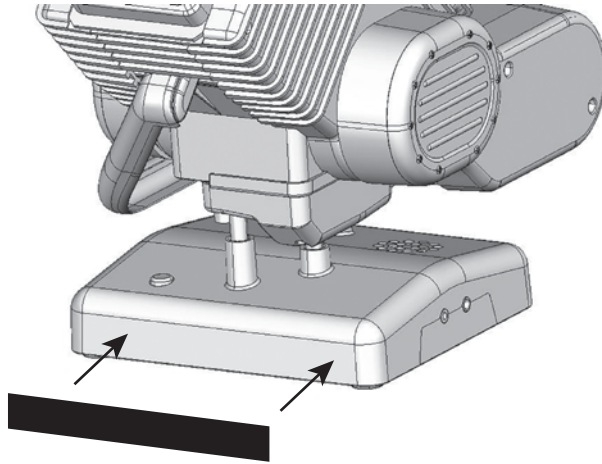




## ASSEMBLING THE ENGINE

### Step 32 - Attach sticker to base

Peel the self-adhesive label from its backing and apply to the base as shown.



### Step 33 - Starting the engine

Insert the two plugs into the base - note that they are different sizes and will only fit one way. Press the red "Start" button. The engine will run for approximately 30 seconds.

## HOW AN ENGINE WORKS

### Basic Principles

To explain how a full-size V-twin works, we'll use a simplified version of a real engine – our model engine in fact. You can switch on your finished model as you read this explanation, and it will help you to understand how a real engine works.

The crankshaft is called a crankshaft because it is a 'cranked' shaft – the shaft on our model has one cranked section, and the piston/connecting rod assemblies connect to this. As the crankshaft turns, the cranked section rotates around the centreline of the crankshaft, and this allows the pistons to move up and down as the crankshaft turns.

When the piston moves down, it pushes the connecting rod down, which pushes against the cranked part of the crankshaft, making the crankshaft rotate. This converts the up-and-down movement of the piston into the turning movement of the crankshaft.

The engine's crankshaft drives the transmission, which includes various different components connected together to drive the bike's rear wheel, making it move. A bike will normally have a chain to drive the rear wheel, though some use a shaft.

Let's look at how the engine works in more detail. We'll look at just one cylinder of the engine. A cylinder is the hollow cylinder inside the engine in which one piston moves up and down. The piston has seals, called piston rings, around its edge, which aren't shown on our model, and these seals stop gases passing round the sides of the piston.

When you press the starter button on the bike, the starter (a powerful electric motor, powered by the bike's battery) turns the crankshaft, moving the pistons up and down.

As a piston moves down from its highest position inside the cylinder (called 'Top Dead Centre', or 'TDC'), a mixture of petrol and air is sucked into the space inside the cylinder above the piston. This is called the **intake** stroke.

The starter continues to turn the crankshaft, and as the piston moves back up towards the top of its cylinder, the petrol/air mixture is compressed (squashed) in the space above the piston. This is called the **compression** stroke.

As the piston reaches its highest point, a spark plug creates a spark above the piston, and this spark ignites the petrol/air mixture, causing a small controlled explosion above the piston. The explosion pushes the piston downwards, and this is called the **power** stroke.

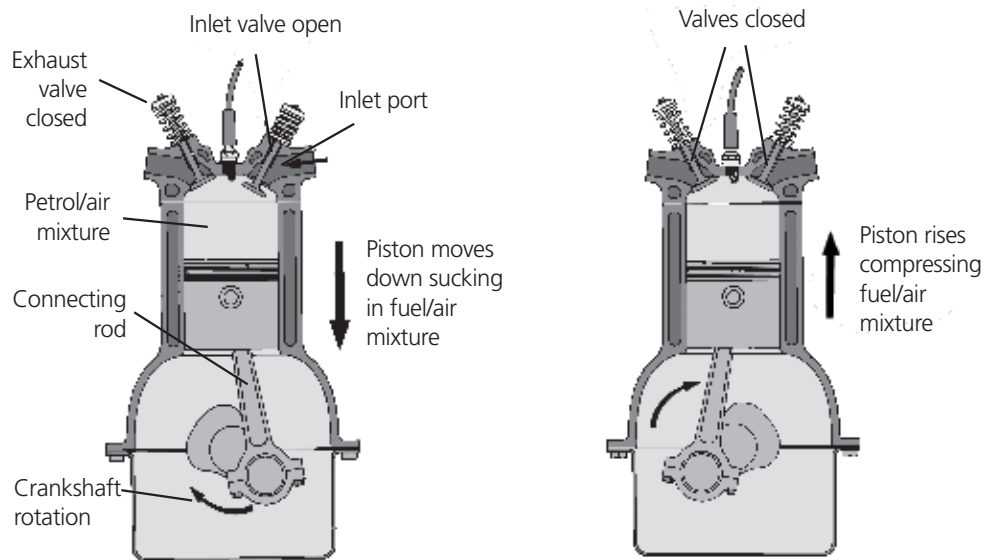
Once the piston has reached its lowest point, it starts to move back up its cylinder, pushing the burnt gases out through the top of the cylinder. This is called the **exhaust** stroke.

To summarise, the engine has four strokes: intake, compression, power and exhaust, or 'suck', 'squeeze', 'bang' and 'blow' to make it simpler. These four strokes make up the 4-stroke cycle.

## HOW AN ENGINE WORKS

The petrol/air mixture flows into the space above the piston, called the combustion chamber. The mixture flows in through a small hole which is opened and closed by the inlet valve. The burnt gas flows out of the cylinder through another hole which is opened and closed by the exhaust valve. The valves are normally held closed by springs, but as the engine turns, the valves are pushed open in the correct order by the rocker arms, which are moved by the camshaft. The rocker arm pushes the valve down against its spring, and as the rocker moves up, the spring pushes the valve closed.

Let's look at the 4-stroke cycle in more detail.



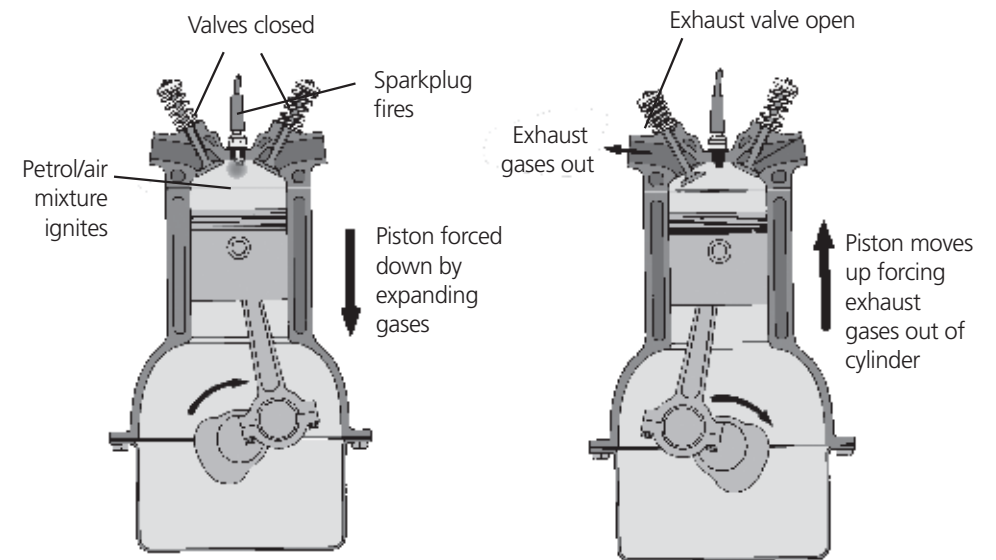
### The 1st stroke (Intake)

The piston starts off at the top of the cylinder. The exhaust valve is closed, and the inlet valve is open. As the crankshaft turns, and the piston moves down inside the cylinder, petrol/air mixture is sucked in through the inlet valve. When the piston reaches its lowest point inside the cylinder, the cylinder is filled with petrol/air mixture, and the inlet valve closes. This is the end of the intake stroke.

### The 2nd stroke (Compression)

At the start of the compression stroke, the piston is at its lowest point inside the cylinder, and the inlet and exhaust valves are closed. The crankshaft continues turning, and the piston moves upwards. As the piston moves upwards, it squeezes (compresses) the petrol/air mixture, and this increases the temperature of the mixture very quickly. When the piston reaches its highest point, the mixture is fully compressed, and this is the end of the compression stroke.

## HOW AN ENGINE WORKS



### The 3rd stroke (Power)

The very high pressure and temperature inside the combustion chamber cause the petrol/air mixture to break up into very fine particles, like a mist. These are perfect conditions for burning a gas. All that's needed to start the burning (or 'combustion' – a kind of controlled explosion) is a spark. A very high electrical voltage supplied to the spark plug causes a spark to jump across the gap at the end of the spark plug. This ignites the petrol/air mixture, and starts the combustion. The force of the controlled explosion and the expanding gases forces the piston downwards, which pushes the crankshaft round. During the power stroke, three things happen to the petrol/air mixture – it ignites, combusts (burns) and expands. The expansion of the gas pushes the piston down, which transfers the power to the crankshaft. When the piston reaches its lowest point inside the cylinder, this is the end of the power stroke.

### The 4th stroke (Exhaust)

As the piston starts to move up inside the cylinder again, the exhaust valve opens to allow the burnt (exhaust) gas to escape from the cylinder, and as the piston moves up the cylinder, it pushes the gas out through the exhaust valve. As the piston reaches the top of the cylinder, the exhaust valve closes, the exhaust stroke ends, and the 4-stroke cycle begins again with another intake stroke.

## HOW AN ENGINE WORKS

### The model engine

You can see how the 4-stroke cycle works by starting your model engine, and watching how the components inside move. Watch how the camshaft and rockers move the valves as each piston moves up and down inside its cylinder. If you watch the piston in one cylinder, you should be able to recognise the four strokes – watch the valves, and see if you can tell which stroke is which. Remember that:

- On the intake stroke, the piston moves down, the inlet valve is open, and the exhaust valve is closed.
- On the compression stroke, the piston moves up and the inlet and exhaust valves are closed.
- On the power stroke, the piston moves down and the inlet and exhaust valves are closed.
- On the exhaust stroke, the piston moves up, the inlet valve is closed, and the exhaust valve is open.

The exhaust valves are both positioned on the outside of each cylinder, next to the exhaust pipes, and the inlet valves are on the inside of each cylinder, next to the inlet manifold/carburettor.

You'll notice that the two cylinders in the model engine are on different 'strokes' – watch how the pistons move as the crankshaft turns, and you'll see that the position of the front piston is slightly ahead of the piston in the rear cylinder. You can tell which piston is about to start its power stroke, because the spark plug will fire (the bulb will light) in the cylinder head above the piston which has just reached the end of its compression stroke and is about to start its power stroke.

## BASIC ENGINE TERMS

Here's a list of common terms connected with a car engine, with simple explanations of what they mean.

**Air filter** – A paper or foam filter that removes dirt from the air that's sucked into the engine.

**Alternator** – An electrical generator driven by the engine. It provides electricity for the car's electrical system when the engine's running, and to charge the battery.

**Antifreeze** – A fluid that's added to water to produce engine coolant. The antifreeze stops the coolant freezing in cold weather, and prevents corrosion inside the engine.

**Battery** – A 'reservoir' that stores electricity. Provides the power to start the engine, and power for the electrical systems when the engine's stopped, and is charged by the alternator when the engine's running.

**Bearing** – A metal or other hard-wearing surface that another part moves against. A bearing is designed to reduce friction and wear, and is usually lubricated with oil or grease.

**Big-end** – The lower end of a **connecting rod** attached to the engine's **crankshaft**. It has a bearing, and transmits the movement of the connecting rod to the crankshaft.

## BASIC ENGINE TERMS

**Bore** – A term used to describe the diameter of a cylinder in an engine.

**Breather** – An opening or valve that allows air or fumes out of the engine, or fresh air into the engine.

**Cam belt** – See **Timing belt**.

**Cam follower (tappet)** – A component fitted between the **camshaft** and a valve to operate the **valves**.

**Camshaft** – A rotating shaft driven from the **crankshaft**, with cams that push the valves open.

**Catalytic converter** – A device fitted in the exhaust system that reduces the amount of harmful gases released into the atmosphere.

**Clutch** – A part that allows two separate rotating components to be coupled together smoothly, without the need for either component to stop moving.

**Combustion chamber** – A shaped area into which the fuel/air mixture is compressed by the **piston**, and where the mixture is ignited. The combustion chamber may be in the **cylinder head**, or sometimes in the top of the **piston**.

**Compression ratio (CR)** – A term to describe the amount by which the fuel/air mixture is compressed as a **piston** moves from the bottom to the top of its travel.

**Connecting rod (con rod)** – A metal rod in the engine connecting a **piston** to the **crankshaft**. The connecting rod transfers the up-and-down motion of the piston to the crankshaft.

**Coolant** – A mixture of water and **antifreeze**, used in a car's engine cooling system.

**Coolant (water) pump** – A pump driven by the engine that pumps the coolant around the cooling system.

**Crankcase** – The area of the **cylinder block** below the **pistons**, which houses the **crankshaft**.

**Crankshaft** – A cranked metal shaft that changes the up-and-down motion of the **pistons** and **connecting rods** into rotary motion.

**Cylinder** – A metal tube in the engine, in which a **piston** slides.

**Cylinder block** – The main engine casing, which houses the **cylinders**, **crankshaft**, **pistons** and **connecting rods**.

**Cylinder head** – The casing at the top of the engine that houses the valves and valve gear. The cylinder head is bolted to the **cylinder block**.

**Cylinder head gasket** – The gasket that makes a seal between the **cylinder head** and the **cylinder block**.

**Dipstick** – A metal or plastic rod used to check the engine oil level.

**Distributor** – A device used to distribute the ignition **HT** circuit current to the individual **spark plugs**.

**DOHC** – Double Overhead Camshafts. An engine with two **camshafts**, where one operates the inlet **valves**, and the other operates the exhaust valves.

**Drivebelt** – A belt, usually made from rubber, used to transmit drive between two pulleys or sprockets. Often used to drive the **camshafts** and engine ancillaries.

**Emissions** – Harmful substances (gases or particles) released into the atmosphere from a car's engine.

**Emissions control** – A way of reducing the **emissions** released into the atmosphere.

**Engine management system** – A system which uses an electronic control unit to control the **ignition system** and **fuel injection system**, improving engine efficiency and reducing emissions.

## HOW AN ENGINE WORKS

**Exhaust manifold** – A ducting used for directing the exhaust gases from the engine's **cylinder head** into the exhaust system.

**Firing order** – The order in which the **pistons** in the cylinders of an engine reach their **firing points**.

**Firing point** – The instant at which the fuel/air mixture in the **cylinder** of an engine ignites in the **combustion chamber**.

**Flywheel** – A heavy metal disc attached to one end of the **crankshaft** in an engine, used to smooth out the power pulses from the **pistons**.

**Four-stroke** – A term used to describe the four operating strokes of a **piston** in an engine.

**Fuel injection** – A method of injecting a measured amount of fuel into an engine.

**Fuel injector** – A device used to inject fuel into an engine. Some engines use a single fuel injector, whilst some use one fuel injector for each cylinder of the engine.

**Gasket** – A material used between two surfaces to give a leakproof joint.

**Head gasket** (cylinder head gasket) – A gasket fitted to provide a leakproof seal between an engine's **cylinder block** and **cylinder head**.

**Ignition coil** – An electrical coil that generates the high voltage needed in a petrol engine **ignition system** to fire the **spark plugs**.

**Ignition system** – The electrical system that controls the spark used to ignite the petrol/air mixture in a petrol engine.

**Ignition timing** – A measure of the instant in the **cylinder** firing cycle at which the ignition spark (provided by the **spark plug**) happens in a petrol engine.

**Inlet manifold** – A ducting, usually made of metal or plastic, which directs the air, or fuel/air mixture into the engine's **cylinder head**.

**Mixture** – The fuel/air mixture burnt by an engine to produce power.

**Oil filter** – A renewable filter that removes dirt from the engine oil.

**Piston** – Cylindrical component which slides in a close-fitting **cylinder**. The pistons in an engine compress the fuel/air mixture, transmit power to the **crankshaft** through the **connecting rods**, and push the burnt gases out through the exhaust **valves**.

**Piston ring** – A hardened metal ring that fits in a groove running around a **piston**. The piston ring ensures a gas-tight seal between the piston and the cylinder.

**Radiator** – A cooling device, usually positioned at the front of the car, through which the hot coolant is passed. As the car moves forward, the airflow cools the coolant in the radiator.

**Rocker arm** – A lever used in an engine's **valve**-operating mechanism which rocks on a pivot, with one end moved up and down by the **camshaft**, and the other end operating a valve.

**Spark plug** – A device that provides the spark in a petrol engine's **combustion chamber** to ignite the petrol/air mixture.

**Starter motor** – An electric motor used to start the engine.

**Stroke** – The total distance travelled by a single **piston** in a **cylinder** when it moves from the bottom to the top of the cylinder.

**Sump** – The main reservoir for the engine oil. Bolted to the bottom of the engine.

**Tappet** – See **Cam follower**.

## BASIC ENGINE TERMS

**Timing belt (cam belt)** – Toothed drivebelt, used to transmit drive from the **crankshaft** to the **camshaft**.

**Top Dead Centre (TDC)** – The exact point when a piston is at the top of its **stroke**.

**Turbocharger** – A device that forces air into the engine. This pushes more fuel/air mixture into the engine and increases the engine's power.

**Twin-cam** – Abbreviation for twin overhead **camshafts** – see **DOHC**.

**Valve** – A device that opens and closes to stop or allow gas or liquid to flow.

**Valve clearance** – The clearance between the top of a **valve** and the **camshaft**.

**Valve lifter** – See **Cam follower**.

**16-valve** – A term used to describe a four-cylinder engine with four **valves** in each cylinder, usually two exhaust and two inlet valves.

**Vee-engine** – An engine design where the **cylinders** are arranged in two rows forming a 'V' when viewed from one end. For example a V8 has two rows of four cylinders each.