CHAPTER 1 – MECHANICAL ARRANGEMENT

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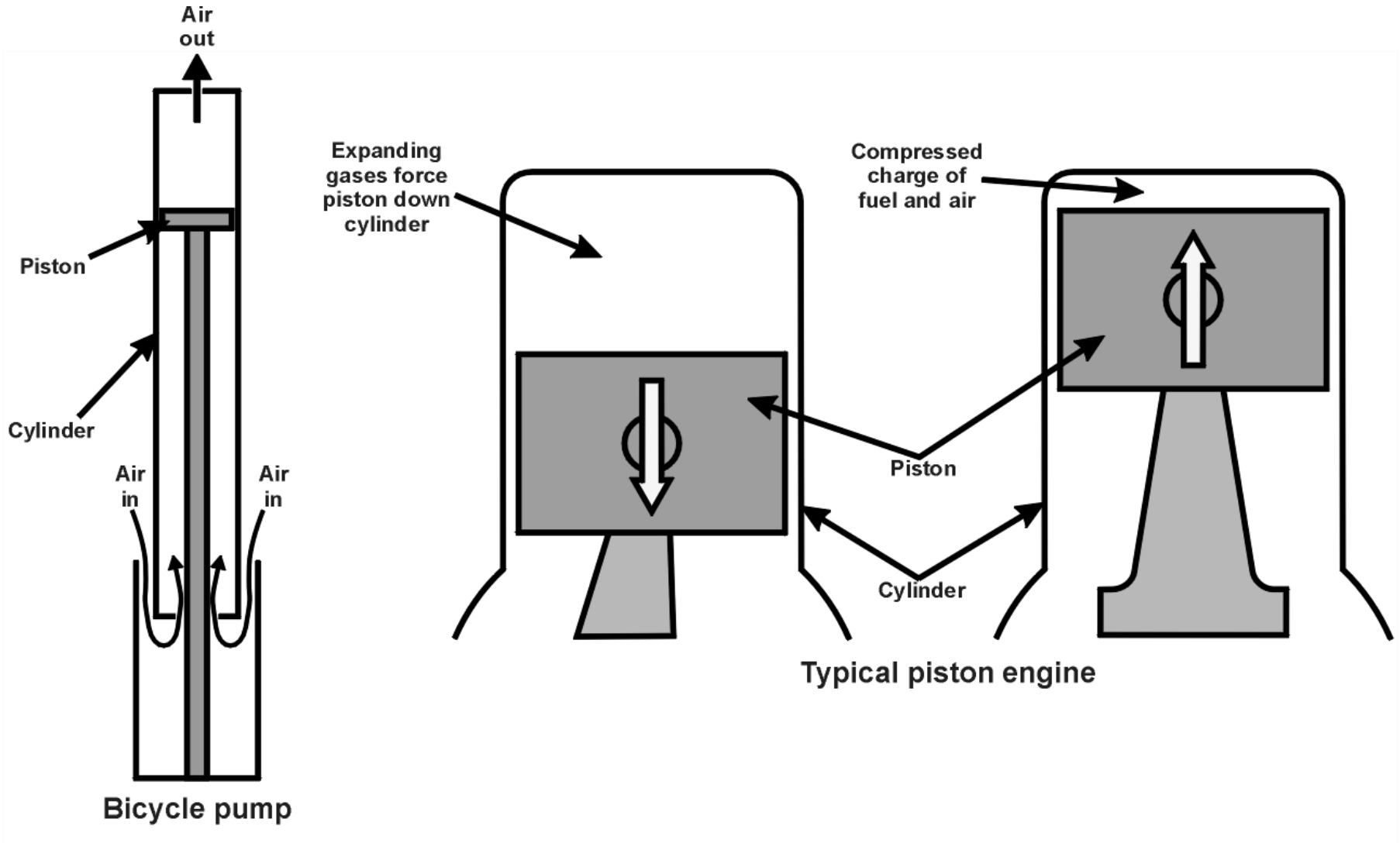
Mechanical Arrangement - Basic Principals

The piston engine is basically similar to a bicycle pump in that it has a cylinder, inside which is a sliding plunger or piston. Connect a bicycle pump to an inner tube of a tyre and force the plunger up the cylinder of the pump will push the air into the tyre.

The air inside the pump is compressed (and as a result of the compression its temperature rises) by the force applied by the muscles in your arms.

If the plunger is released before the air has entered tube, the energy in the hot compressed air will cause the plunger to spring back; just imagine how much force there would be if the trapped and compressed air was quickly heated to a very high temperature.

In action, the piston inside the cylinder of an engine works like the plunger of a bicycle pump. First it compresses the charge of fuel and air inside the cylinder. Next, the fuel is burned inside the cylinder, and the heat energy released does work by moving the piston.



Mechanical Arrangement - Basics

Mechanical Arrangement - Basic Principals

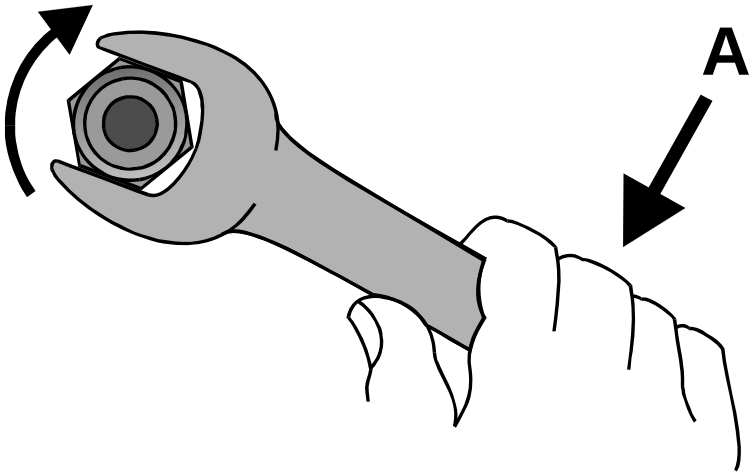
When the charge burns rapidly, it expands, forcing the piston to move down the cylinder. This movement is the driving force of the engine – but the piston's movement is linear (i.e. in a straight line), and we want to use it to make something rotate (e.g. a propeller), so what can we do? Two simple cases of a linear force producing a rotary movement can be seen in everyday use, see below:-

The spanner

When a force is applied in the direction of arrow 'A' (below), the spanner makes the nut revolve around the bolt – a linear force has brought about rotation.

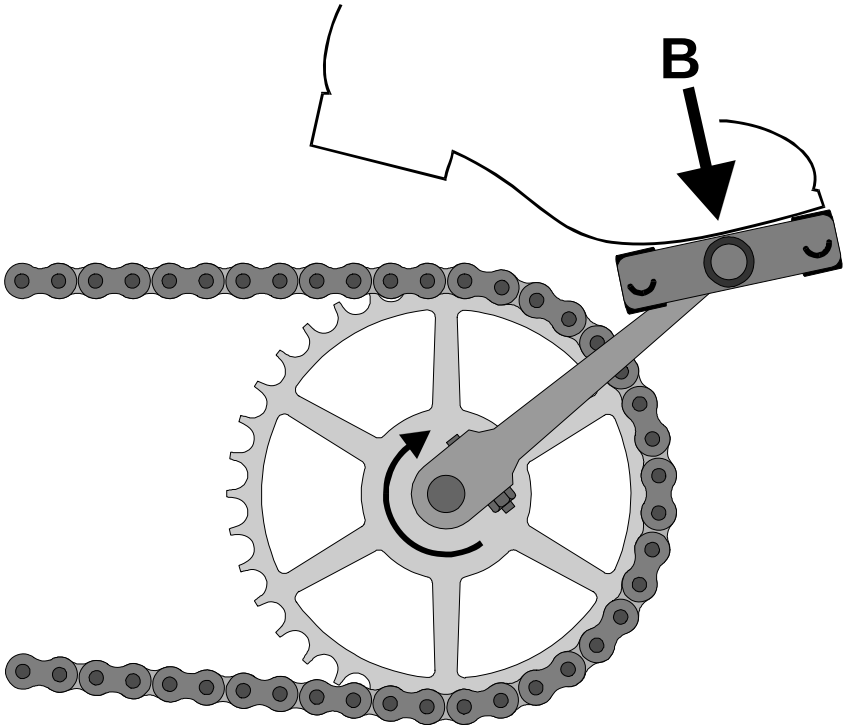
The bicycle pedal and crank

Similarly a downward pressure upon the pedal in the direction arrow 'B' (right) of a bicycle makes the gear wheel rotate.



Hand force in direction
‘A’ gives rotational
force on nut

Leg force in direction
‘B’ gives rotational
force on pedal/crank
propels bicycle along



Mechanical Arrangement - Basics

Mechanical Arrangement - The Crankshaft

In a piston engine there is a crankshaft which works exactly the same way as the bicycle pedals and crank.

The force on the bicycle pedal from leg muscles is the equivalent to the force supplied by burning fuel and air.

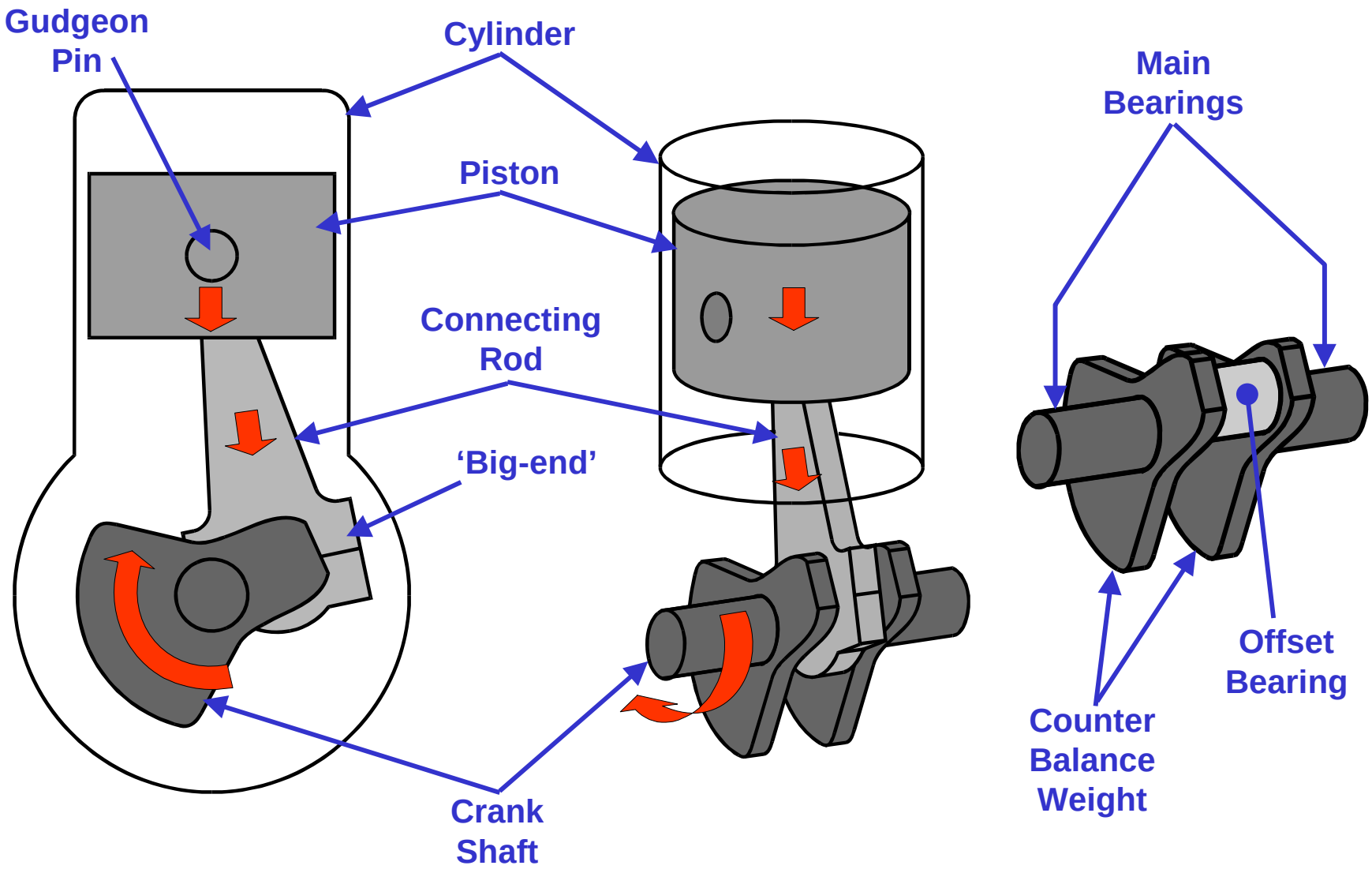
The piston is connected to the crankshaft by a connecting rod (known as the ‘conrod’).

The piston is attached to the conrod small end by a ‘Gudgeon’ pin.

The conrod is then attached to the crankshaft by the ‘Big-end’ bearing.

The piston movement now causes the crankshaft to rotate, so we can use the crankshaft rotation to drive a propeller, or the wheels of a car.

The rotating crankshaft also provides a means of returning the piston to its starting point, so the piston can now produce its linear thrusting movement time after time.



Mechanical Arrangement - Basics

Mechanical Arrangement - Piston Attachment

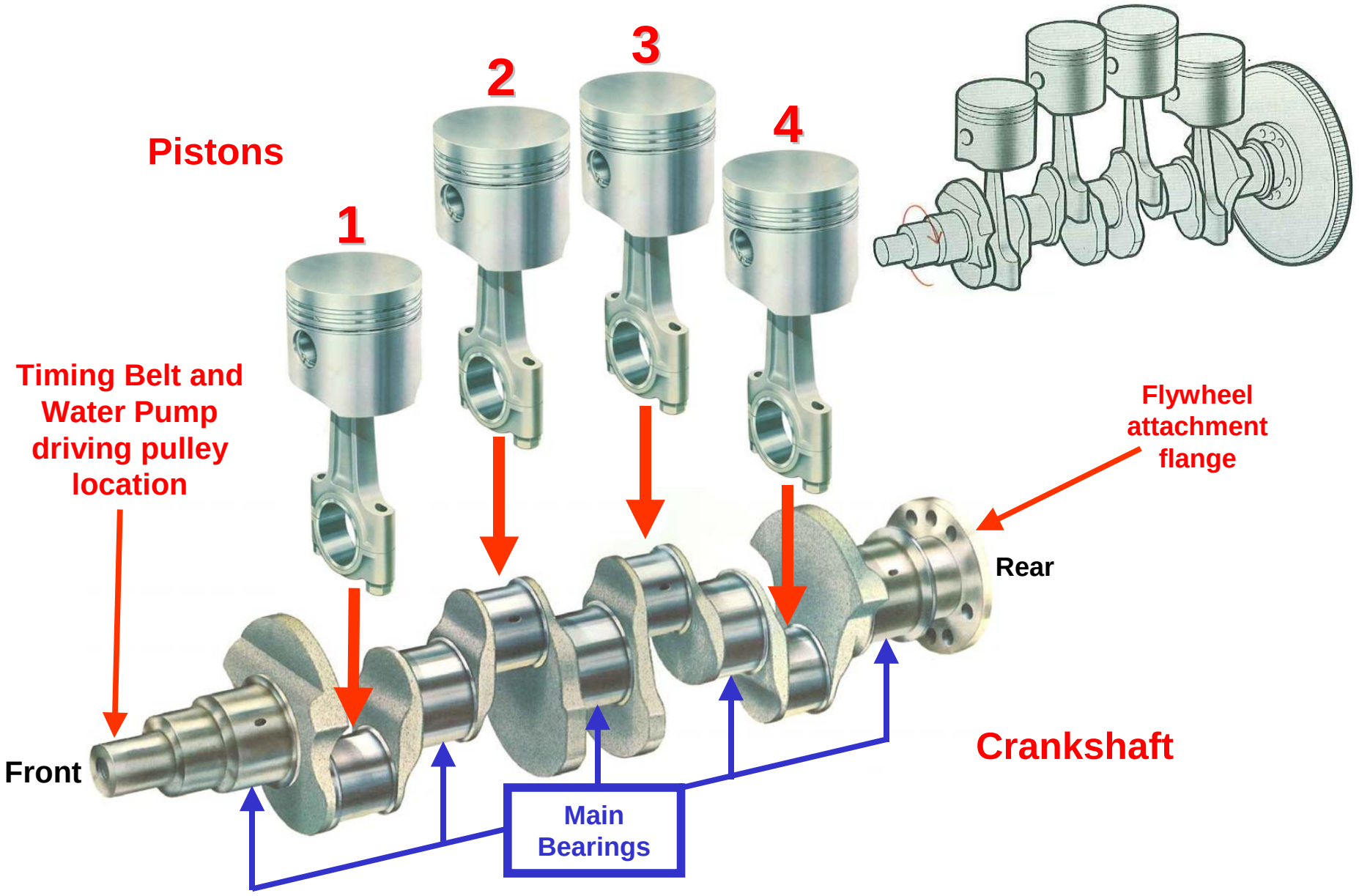
The illustration below shows how the crankshaft is mounted in the engine (in a typical 4 cylinder engine), via the main bearings; on the rotational centre of the crankshaft..

The piston big ends are then attached to the crankshaft on the offsets (‘cranked’ – hence the name crankshaft). The offsets are the equivalent to the pedals on a bicycle.

At the rear of the crankshaft, there is a mounting flange for a flywheel. The flywheel is a rotating mass that helps to keep the engine rotating in between power pulses, and helps to make the engine smoother running.

The rear face of the flywheel is where a vehicle clutch mechanism is mounted. In an aircraft the propeller is mounted directly on the front of the crankshaft, there is no clutch mechanism in aero engines.

The timing gear and ancillaries such as the water pump and the alternator are driven from the front end of the crankshaft.



Mechanical Arrangement - Basics

Mechanical Arrangement – Engine Major Assemblies

Most engines are made up from the following assemblies:-

Cylinder Head

This assembly houses most of the complex valve gear mechanism and the top of the cylinders, there is a gas seal – a gasket – fitted between the head and the block.

The spark plugs, and inlet and exhaust manifolds are bolted to the head.

Cylinder Block

The block has the cylinders, with the pistons inside, and at the bottom end the is the main bearings in which the crankshaft rotates.

Also mounted on the block are internally the oil pump and filter, and externally the water pump, and the alternator, and on some engines a mechanical fuel pump; modern cars usually have an electrically driven fuel pump mounted on the car.

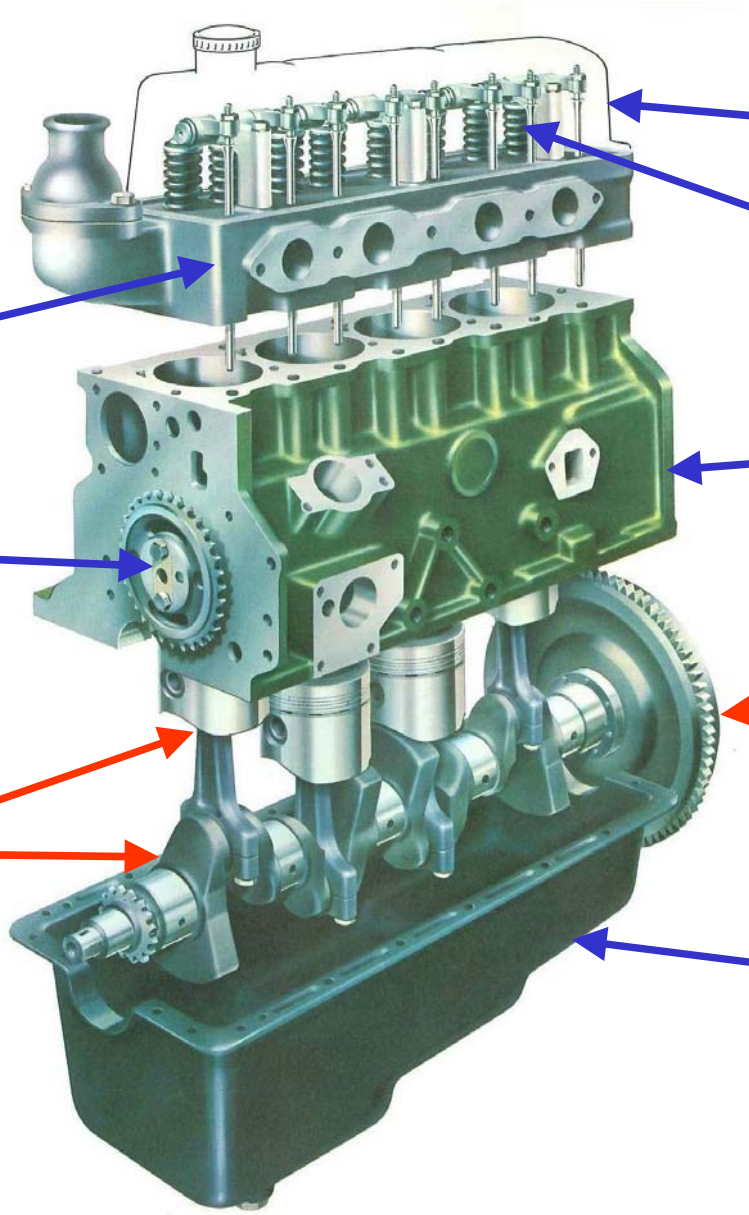
Rocker box cover

Basically it has a simple job of covering all the valve mechanism and contain the lubricating oil. Manufacturers tend to fit elaborate covers on top of the engine purely for esthetic reasons, unfortunately this makes access to the various service replaceable parts more difficult.

The Sump

Like the rocker box, the sump simply covers the bottom end of the engine keeping the oil in. it also doubles on most engines as the oil tank.

Exploded View of the Engine



'Rocker Box' Cover

Valve Gear

Cylinder Head Assembly

Cylinder Block

Timing Shaft

Flywheel

Crankshaft and Pistons

Sump (Oil Tank)

Mechanical Arrangement – Main Parts

Mechanical Arrangement – Valve Gear

In order to compress the fuel air mixture in each cylinder, first it has to be able to get in, then once it is in, it has to be sealed in or compression cannot take place.

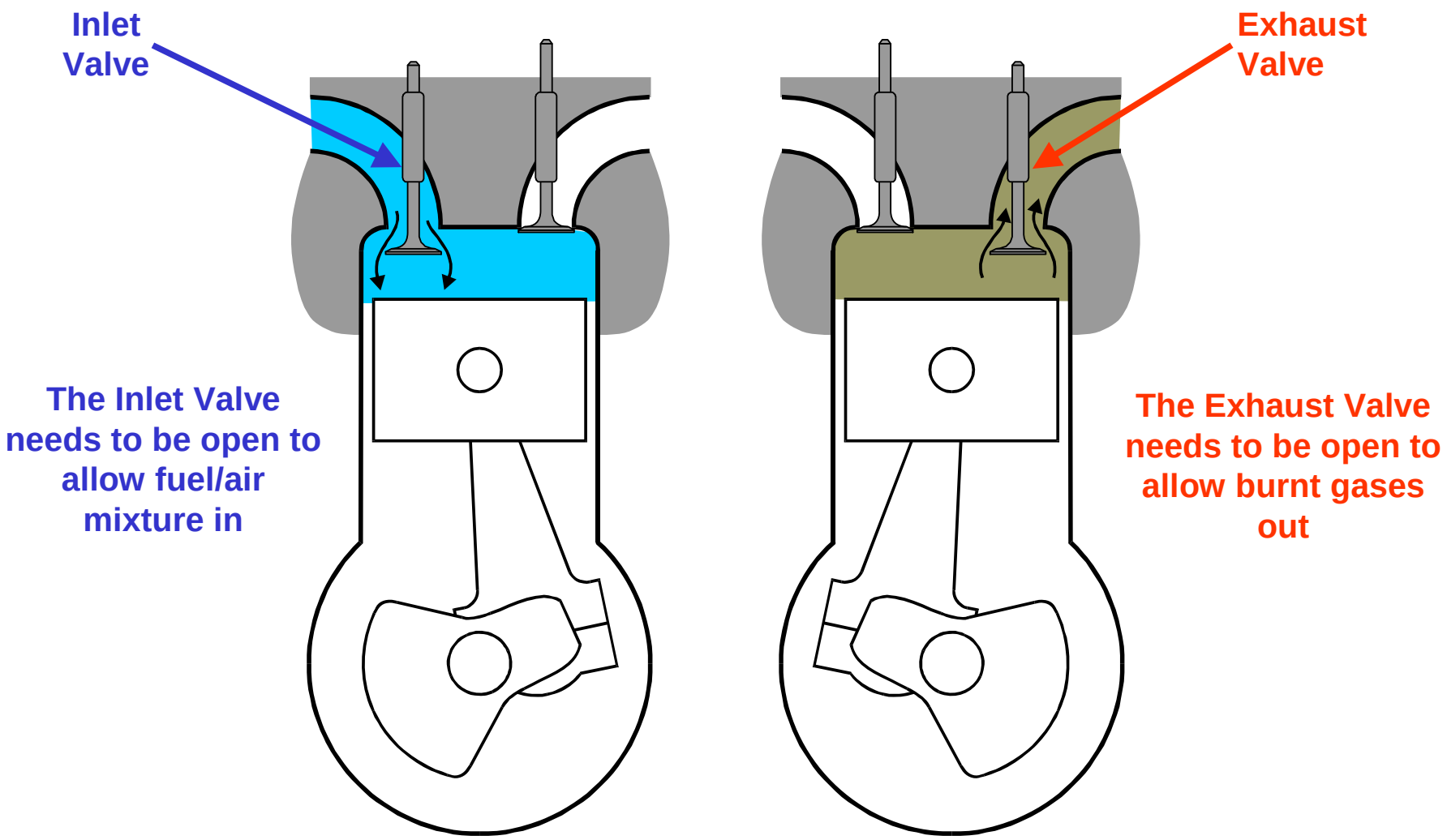
This is done through the operation of inlet and exhaust valves.

They are opened by a mechanical linkage driven by the rotating crankshaft and therefore can be timed to open and close at exactly the correct moment.

The closing force is supplied by a spring, one for each valve. In addition the spring force, the energy in the combustion process also assists in forcing the valves closed.

The seal is provided by a metal to metal conical seal face.

Valve Operation



Mechanical Arrangement – Valve Gear

Mechanical Arrangement – Valve Gear

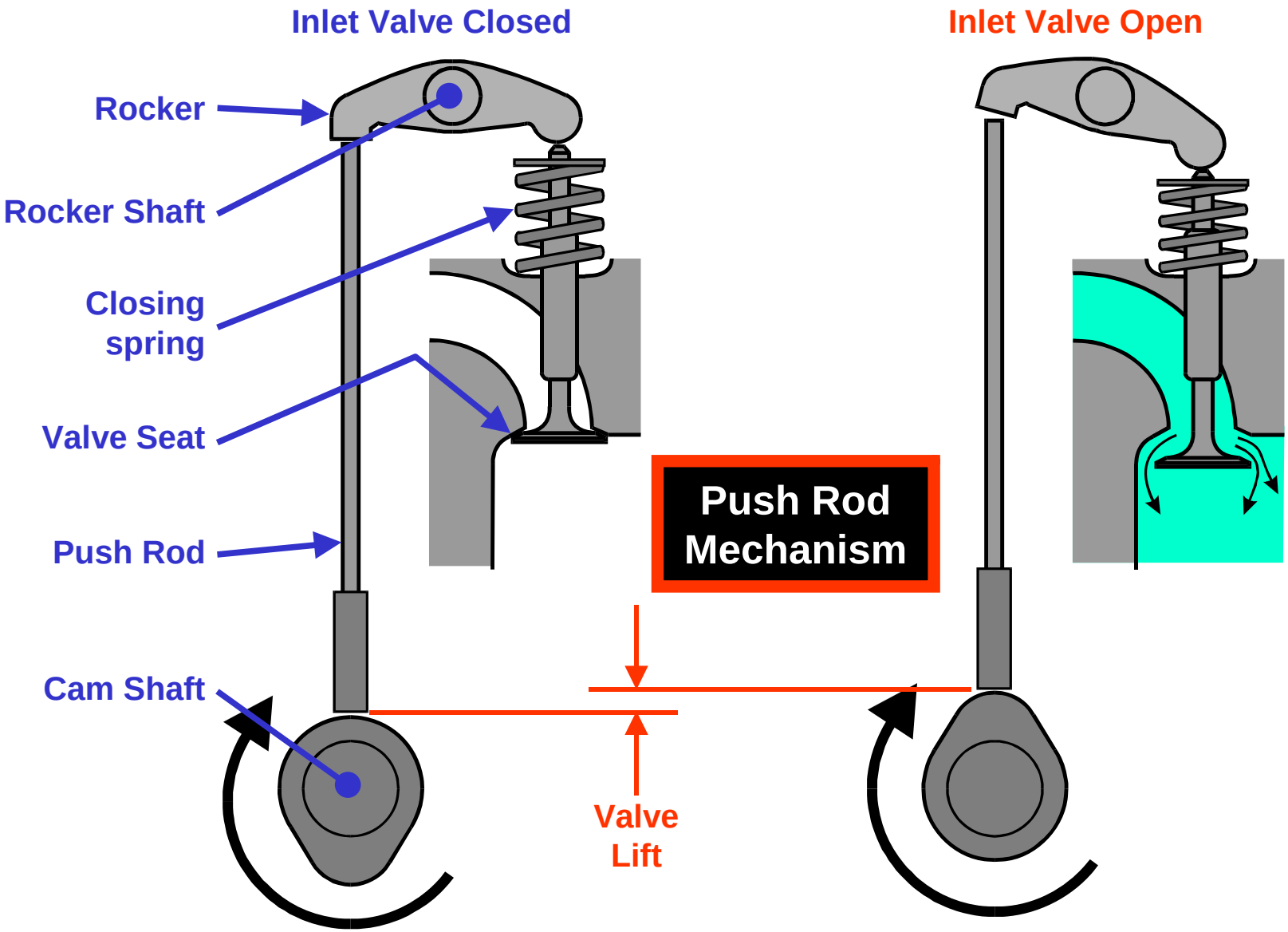
The opening motion comes from a rotating cam shaft. A cam has a raised portion that lifts the cam follower or push rod, which either operates a rocking lever or the cam bears directly on the top end of the valve stem, to open the valve.

When the valve is forced open, the return spring is compressed, so the when the cam rotates to a none raised section, the spring can push the valve closed.

Note: -

1. The inlet and exhaust valve work in exactly the same manner.

2. In a four stroke engine each inlet and exhaust valve opens once for every two turns of the crankshaft, therefore the gearing to the valve camshafts is 2:1.



Mechanical Arrangement – Valve Gear

Mechanical Arrangement – Valve Gear

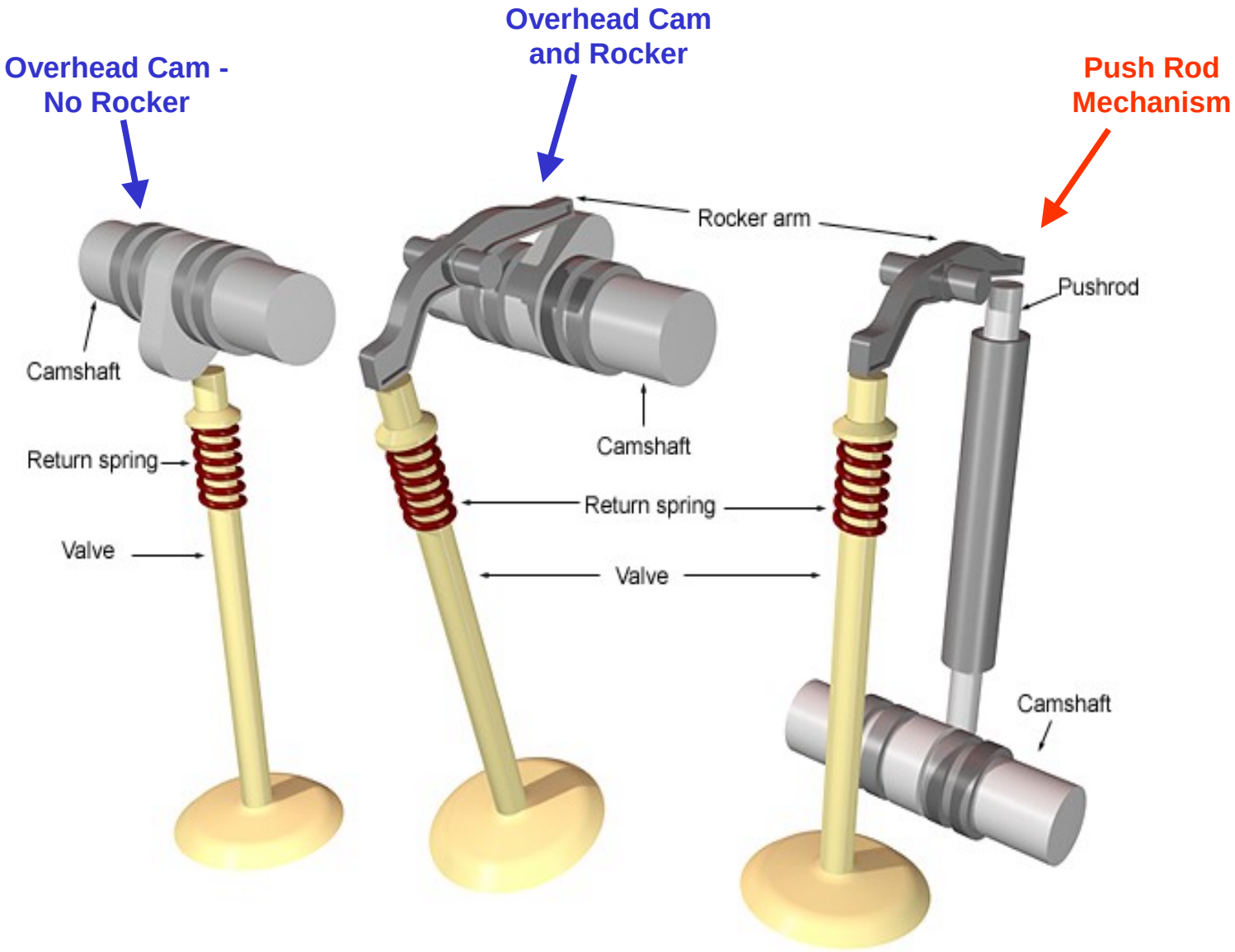
Below are illustrated different valve operating mechanisms; the push rod mechanism is included for comparison.

The other two are overhead cam mechanisms, one with a rocker, one without.

Note: the less parts there are in a mechanism, the more accurately it should work with the opening and closing times, and therefore the more efficient the engine.

Some engines feature a hydraulic system for opening valves (closing is still via a return spring), but driven by a cam

Some manufacturers are now fitting *VARIABLE* valve timing; this is to ensure that the valves operate at the optimum point at all rpm values to gain the maximum efficiency out of a piston engine.



Mechanical Arrangement – Valve Gear

Mechanical Arrangement – Cam Drive

Moving the cam shaft to the cylinder head section of the engine, took away the need for push rods etc.

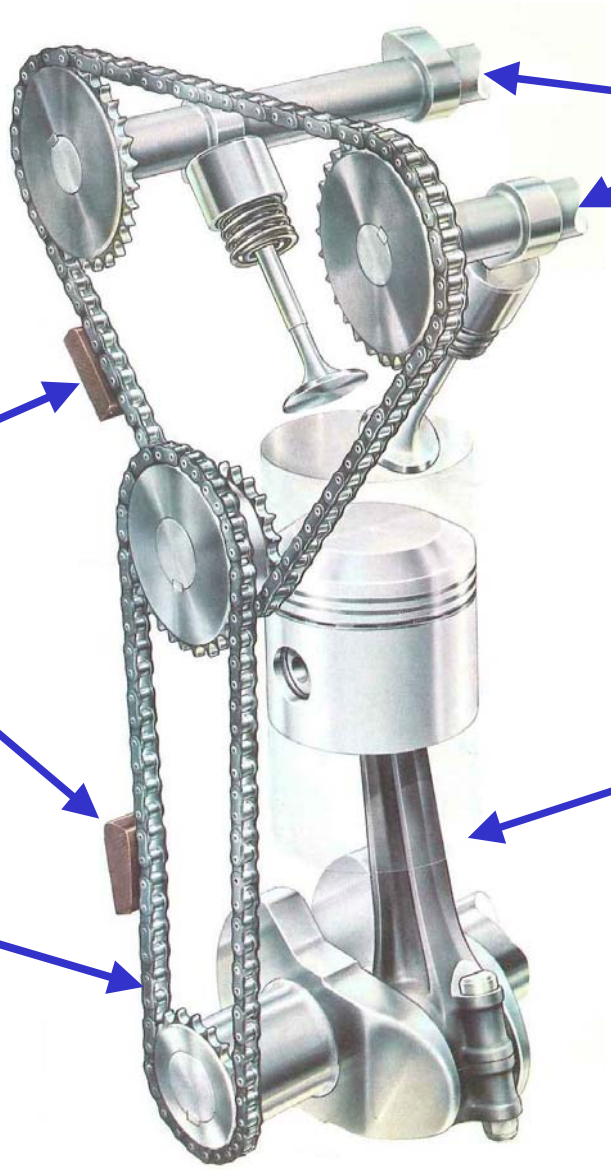
However, driving the ‘overhead’ camshafts required a different method to a direct gear connection possible with the push rod system.

Initially, chains, usually multiple width link (the illustration below shows a single link) were used and some manufacturers continue to use them. Other manufacturers use a toothed rubber belt.

Toothed rubber belts are quieter and need to be changed at the prescribed interval (designated miles or hours) as over time they stretch, this can cause in-efficiency in the engine and loss of power at best, and at worst severe engine damage.

With all types, there are belt tensioners to take out the backlash (play or looseness) inherent in mechanical systems.

Modern Engines use a toothed rubber belt to drive the cam shafts



Mechanical Arrangement – Valve Gear