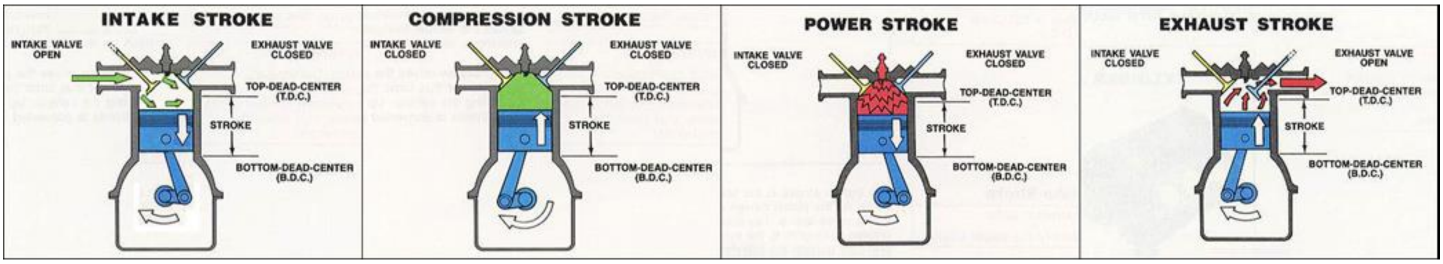
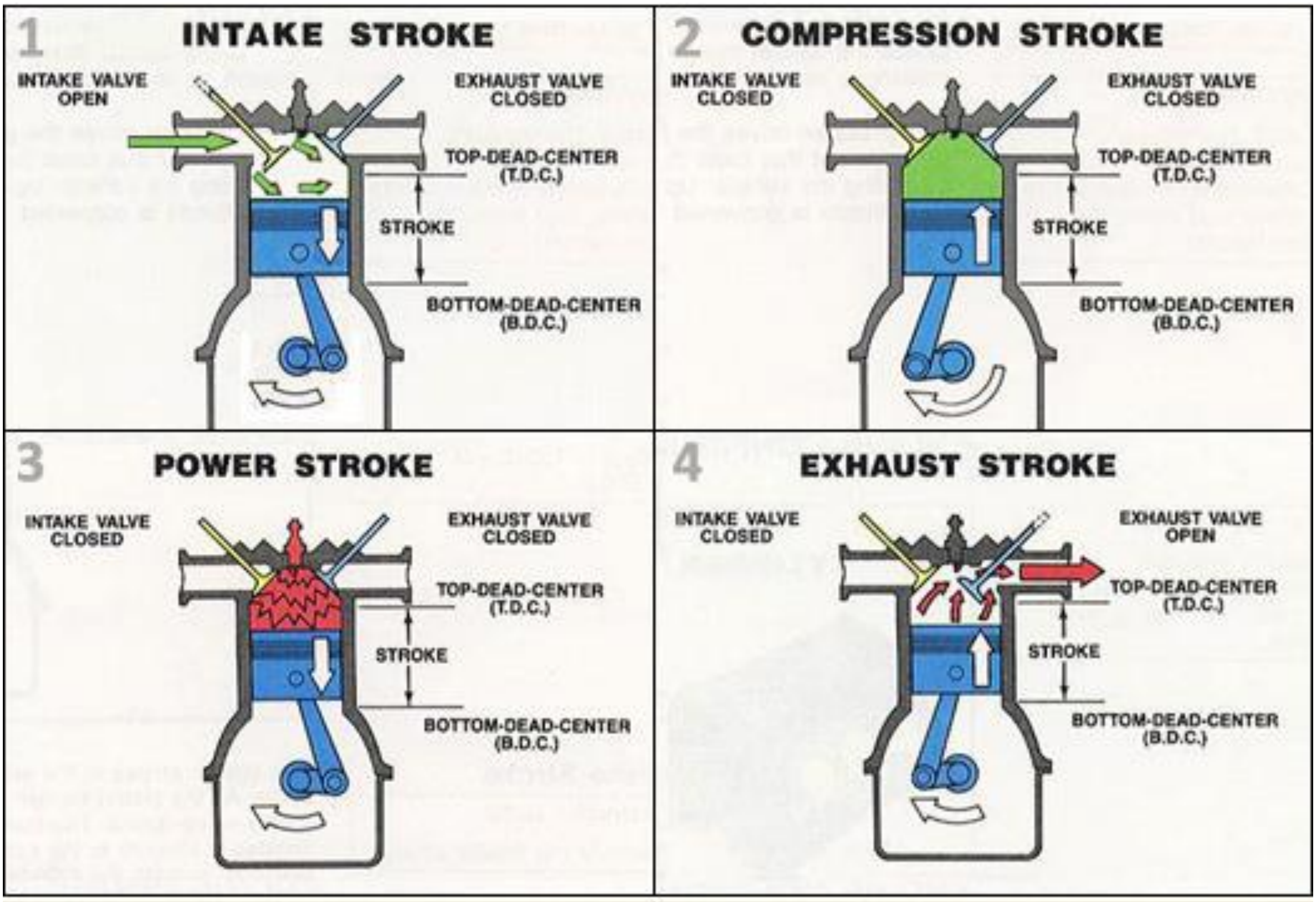
The four stroke engine and ignition system

Any four stroke petrol engine requires four things to work: fuel, air, compression and a spark – see graph here.
Air and fuel are drawn into the cylinder during the intake cycle. The mixture is compressed, to raise the temperature and cause vapourisation. The spark causes rapid burning, increasing the pressure, forcing the piston down on the power stroke. It is essential that all the fuel burns in the cylinder; a spark being delivered to the correct cylinder in time.



A 4-stroke engine has one power stroke in each cylinder for very two revs of the crank. Since a camshaft has 1 bump on each lobe, its driven at ½ engine speed, so the cam opens the valve at every other revolution of the crank as necessary.



Stroke	Piston Moves	Crankshaft Rotates	Inlet Valve	Exhaust Valve	Purpose of Stroke
Induction	Down	180°	Open	Closed	To draw mixture into cylinder.
Compression	Up	180°	Closed	Closed	To compress the mixture.
Power	Down	180°	Closed	Closed	To force the piston down thus providing power to drive the engine.
Exhaust	Up	180°	Closed	Open	To expel burnt gases from cylinder.

Connecting a wire to a power supply isn't the only way to produce a current in a wire. **Electromagnetic induction** creates electricity (inducing a voltage) by placing a wire in a moving magnetic field. The size of the induced voltage will increase if: (1) the strength of the magnet is increased (2) the number of turns on the coil is increased and (3) the magnet is moved into the coil of wire faster.

Transformers are used to increase the voltage (which lowers the current) of electricity moving through power lines. The lower the current, the less energy wasted as it travels through the cables. Step-up transformers increase the voltage. They have more turns ("high tension"; HT) on the secondary coil than the (LT) primary coil. Step-down transformers decrease the voltage. They work by having more turns on the primary coil than the secondary coil. The voltage at the secondary coil is less than the voltage at the primary coil.

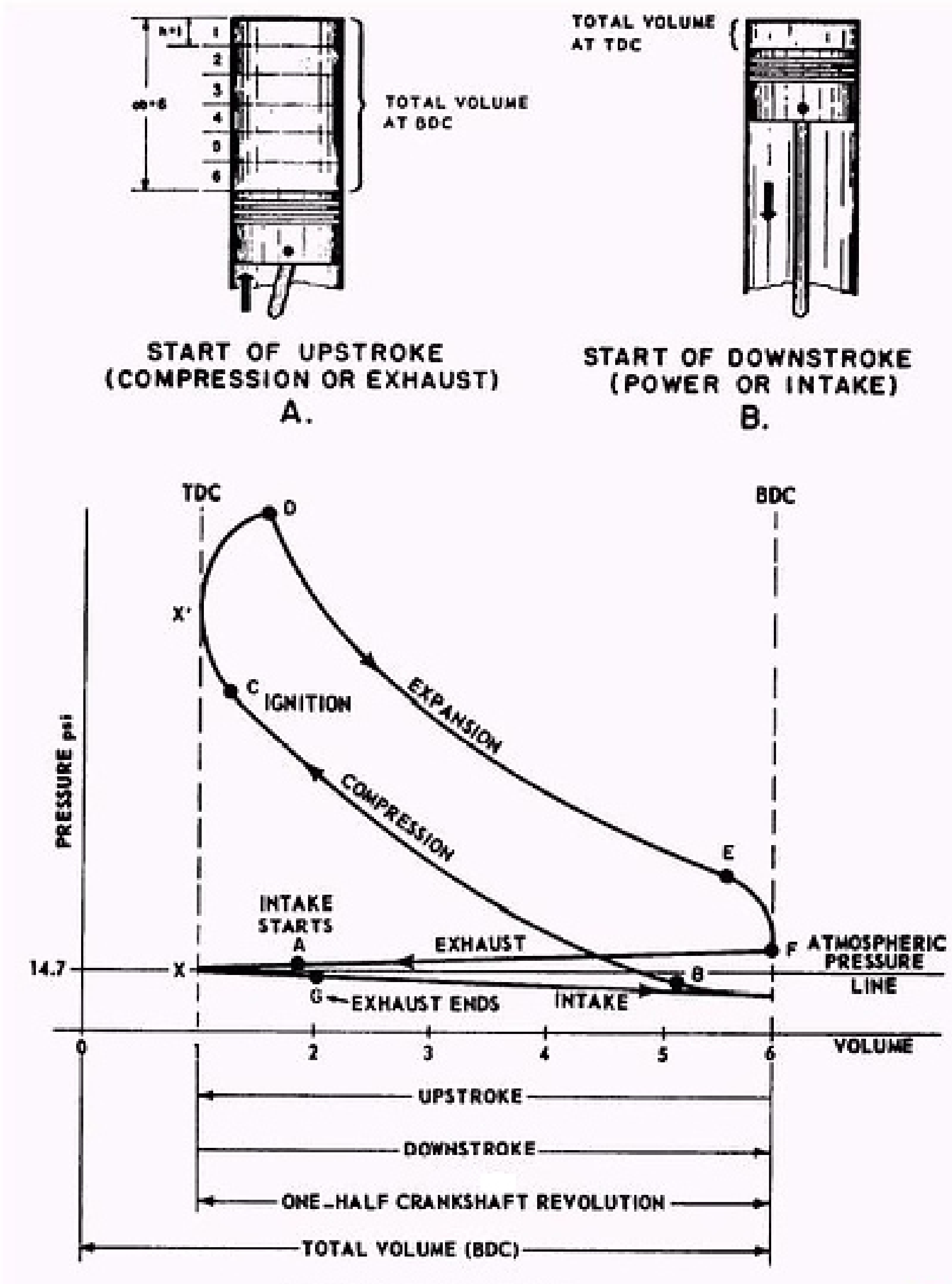
Alternating current is used in transformers (the constantly changing magnetic field created in the primary coil produces a continuous inductive current in the secondary coil). In an **ignition** system direct current (DC) is used because a steady continuous induction is not required, but one single, dramatic induction from the sudden collapse of a magnetic field. The **coil** in the ignition system is a type of step-up transformer. Power equals voltage times current (P = V*I).

A high electrical pressure (voltage) is required to form a spark. As the points of the contact breaker close, the coil is earthed so that a current flows through it charging up the iron core of the coil with magnetism. When the points open this magnetic field collapses inducing a voltage in the coil. The rate of flow 'speed' of the electrical current is given by the ampere. The ignition coil transforms the primary (battery) voltage of low volts and high amps to a very high secondary voltage of high volts and low amps, of sufficient duration to form a good spark. The electrical charge flows at low pressure but high speed through the primary winding and at high pressure and low speed through the secondary winding to the spark plugs. The HT produces a spark, but so does the lesser voltage of the primary winding. It is the job of the capacitor in the distributor to absorb this 'back voltage' and minimise sparking. The magnetism built up is determined by the current allowed to flow into the coil which then has to be switched off by the points. There is a practical limit to how long points can last continuously switching a current of several amps. So the design of conventional coils is limited by the ability of the points.

The rate at which the ignition coil can magnetise (when the contact breaker closes) & demagnetise (when the contact breaker opens) determines the effectiveness of HT output, most importantly at high revs. The time constant (time taken for coil to fully magnetise) of the primary circuit is determined by the ratio of inductance to resistance (i.e. resistance of coil primary + resistance of ballast resistor). The time constant will be *lower* in a 24v ballasted system than a 12v un-ballasted system. This reduces the time available in which to create a spark - an increasing problem as the engine speed increases. Also, as the engine speed increases, the fuel ignition point must take place earlier so there is sufficient time for the vapour to burn effectively in the cylinder. The time constant in a purely 12v system will have a similar inductance but the resistance of the primary circuit will just be the resistance of the primary winding. So the time constant of will be lower in a 24v ballasted system than a 12v unballasted system. Think of it as water coming out of a tap. 24V has a higher pressure than 12V.

Thus it is better to reduce the inductance & increase the resistance of the primary circuit. This ensures a more sustained voltage output at high revs. The HT derived from the coil is dependent on the magnetism you can build up in the coil before the magnetism collapses as the points open. This is usually between 3 – 25 kV, depending upon engine conditions. This graph shows that the 12 volt coil in a 24 volt system working with ballast resistors draws current faster than a conventional 12 volt coil. The time the points of the contact breaker are closed is called the dwell time. When the contact breaker is closed for long enough – increased dwell time – both coils draw a similar current, but only at low speeds.

The dwell angle is determined by the size of the cam on the drive shaft, but also by the gap between the points of the contact breaker. Over time this can change as the points wear, as will the Paxolin insulator as it rubs on the cam. Paxolin is made of phenol-formaldehyde resin-bonded paper. Also, the points will pit, just as an arc welder transfers metal through an electric charge.



C-CYCLE DIAGRAM

C.