ratios, give high efficiency on relatively low-cost nonhazardous fuel, and need no ignition system.

Maximum Pressure. On the other hand, engines operating at lower compression ratios usually cost less to manufacture. Strictly speaking, it is the pressure reached after firing rather than compression pressure that is important in this connection. A pressure rise always follows firing; how much depends on the way the fuel burns. When fuel-air mixture is compressed and ignited by a spark, combustion is fast, practically an explosion, and pressure rises rapidly. When fuel is injected into compressed air, rate of burning can be controlled to some extent and pressure rise is less rapid.

Because most spark-ignition engines operate at fairly low compression pressures, rapid pressure rise after firing doesn't usually raise *maximum* pressure above 400-500 psi. Low-compression pressures and slow pressure rise of surface ignition engines give maximum pressures of about 250 psi. Although diesel compression pressures are high, slow rate of pressure rise holds maximum pressure down to about 600-1200 psi, large low-speed engines showing the lower figures.

Low maximum pressure means less stress in engine frame and parts and lower loads on bearings. This permits relatively simple design and lower manufacturing costs. Presence or absence of a high-pressure injection system also influences first cost. There are many applications where investment cost is more important than operating economy.

Gas-Diesels, Dual-Fuel. Considerable interest attaches to recent development of high-compression engines for burning gas. In the first of these, air only is compressed. Gas is injected under about 1100-psi pressure. To stabilize the combustion, a small quantity of "pilot" oil is also injected. Diesel efficiencies obtain when burning gas; conversion to oil can be effected in a matter of hours.

The so-called dual-fuel engine operates at diesel pressures, with diesel efficiencies, can switch from gas to oil or oil to gas under load, and can burn combinations of oil and gas. It apparently violates all the rules by mixing fuel and air *before* compression and then raising the mixture to high pressures. Preignition does not occur; in fact, burning is started and maintained by injecting pilot oil into the heated mixture.

Difference in fuel-air ratios between these engines and conventional gas and gasoline engines probably accounts for differences in ignition behavior. Gas engines operate with a nearly "perfect" mixture, readily ignited, explosive in its burning. The dual-fuel engine, being essentially a diesel, operates with high excess air, or a "lean" mixture. Even at high temperatures, such a mixture does not self-ignite in the short time available. (For a full discussion see POWER, May 1945, pp 64-70.)

Cycles. Some internal-combustion engines operate on the 4-*stroke* cycle, others on the 2-*stroke cycle*. This simply means that, in the first case, four strokes, or two complete revolutions are needed for the full cycle of intake, compression, expansion and exhaust. In the second case, the same cycle is completed in two strokes, or one complete revolution. In other words, the 2-cycle engine fires twice as often as the 4-cycle.

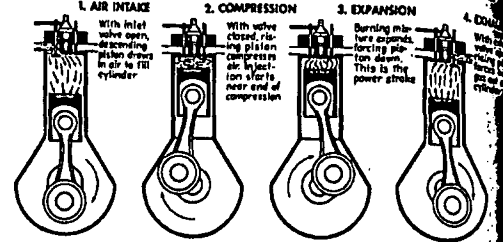
Diagrams above show the sequence of events of these two cycles. Note that in 2-cycle engines to blow the exhaust gas out of the cylinder and fill it with fresh air, air at a pressure slightly above atmospheric is needed. This is called *scavenging air*. In the diagram, air under pressure is obtained by using the crankcase and underside of the piston as an air compressor. This is called *crankcase scavenging;* other methods of scavenging, and supercharging, which should not be confused with it, are described later.

Cylinder Arrangement. In the common form of internal-combustion engine, cylinders are arranged vertically, in line. Number of cylinders ranges from one to 10, normally. Engines are also built with horizontal cylinders, usually single- or twin-cylinder.

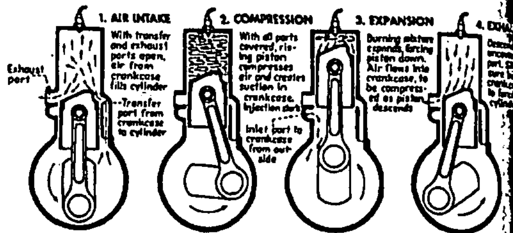
The compact "V" design is frequently employed, usually in 8-, 12- or 16-cylinder combinations. If the V is opened out to 90 deg, we have an *angle* type. Where a flat engine is desired, the V may be opened out to 180 deg, yielding an *opposed-cylinder* engine. This should not be confused with the *opposed-piston* engine, shown on p 89, in which two pistons operate in what is essentially a single cylinder, with a combustion chamber in the center between the pistons and a crankshaft at each end.

Essential elements of a vertical diesel are illustrated above; same parts in different arrangement comprise engines of other types. Next page shows typical auxiliaries serving the main engine in a stationary plant.

2-STROKE AND 4-STROKE CYCLES

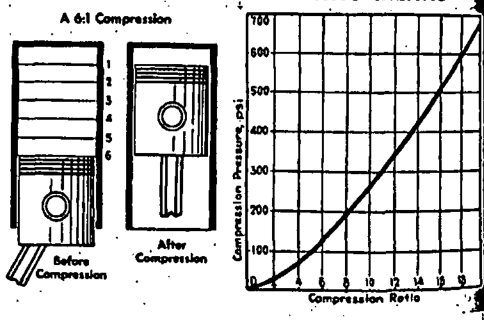


4-STROKE CYCLE—ONE POWER STROKE TO TWO FULL REVOLUTIONS



2-STROKE CYCLE—ONE POWER STROKE TO EACH FULL REVOLUTION

WHAT COMPRESSION RATIO MEANS



ESSENTIAL DIESEL ELEMENTS AND WHAT THEY DO

section of a typical vertical 4-cycle engine modified and simplified to show the basic more clearly. On a *bedplate* rests the *frame*, carries the *cylinder liners*. The *cylinder head* one end of the cylinder, the *piston* forms a enclosure at the other. The cylinder head the *fuel nozzle*, *inlet* and *exhaust valves*, and connecting the valve *ports* to inlet and *manifolds*. Both cylinder and head are with *jackets* in which cooling water

connecting rod joins the piston and *crank*. upper end carries the *wristpin bearing* lower end the *crankpin bearing*. The crank in the *main bearings*, supported by the The enclosed space formed by frame and below the cylinders, through which the runs, is called the *crankcase*.

crankshaft drives the *camshaft*, by chain or *Cams* actuate *push rods* which, in turn, *rocker arms* and the respective valves. The *pump*, which supplies high-pressure fuel to is usually *camshaft-driven*.

arrangement shown is typical, but location of parts varies from engine to engine, and all parts shown appear in all engines.

Parts Do. The functions of the parts can as follows: The cylinder head, liner form the *combustion space*, in which the is compressed and into which the *fuel system* (pumps, fuel lines, nozzles) dis metered amount of fuel, properly atom good combustion.

force produced by burning fuel drives down and, through the connecting rod, energy to the crankshaft. *Valve mechanism* and drive, push rods, rocker arms) and times the movement of the valves controlling flow of fresh air into the cylinder and discharge of combustion products.

be seen that engine parts break down into groups: (1) structural parts—bedplate, liners, heads (2) major moving parts—piston, rods, crankshaft, and their respective (3) arrangements for getting air in and out—valves, valve mechanism, manifolds, and supercharging systems and (4) fuel-system—pumps, nozzles, control devices. these will be covered in greater detail in that follow.