

Internal combustion engine

"ICEV" redirects here. For the form of water ice, see [Ice V](#). For the high speed train, see [ICE V](#).

"Internal combustion" redirects here. For other uses, see [Internal Combustion](#).

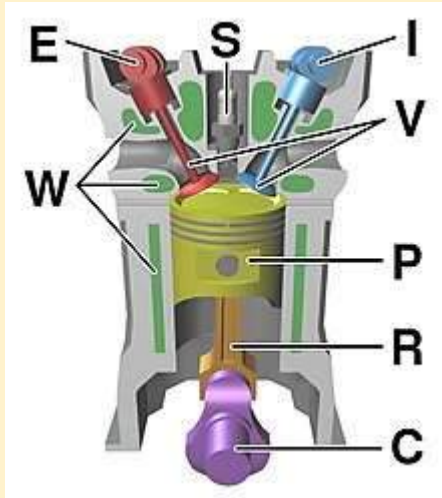


Diagram of a cylinder as found in an overhead cam 4-stroke

gasoline engine:

- C – [crankshaft](#)
- E – exhaust [camshaft](#)
- I – inlet [camshaft](#)
- P – [piston](#)
- R – [connecting rod](#)
- S – [spark plug](#)
- V – [valves](#). red: exhaust, blue: intake.
- W – [cooling water jacket](#)
- gray structure – [engine block](#)

An **internal combustion engine** (ICE or IC engine) is a [heat engine](#) in which the [combustion](#) of a [fuel](#) occurs with an [oxidizer](#) (usually air) in a [combustion chamber](#) that is an integral part of the [working fluid](#) flow circuit. In an internal combustion engine, the expansion of the high-[temperature](#) and high-[pressure](#) gases produced by combustion applies direct [force](#) to some component of the engine. The force is typically applied to [pistons](#) ([piston engine](#)), [turbine blades](#) ([gas turbine](#)), a [rotor](#) ([Wankel engine](#)), or a [nozzle](#) ([jet engine](#)). This force moves the component over a distance. This process transforms [chemical energy](#) into [kinetic energy](#) which is used to propel, move or power whatever the engine is attached to.

The first commercially successful internal combustion engine was created by [Étienne Lenoir](#) around 1860,^[1] and the first modern internal combustion engine, known as the [Otto engine](#), was created in 1876 by [Nicolaus Otto](#). The term [internal combustion engine](#) usually refers to an engine in which combustion is [intermittent](#), such as the more familiar [two-stroke](#) and [four-stroke](#) piston engines, along with variants, such as the [six-stroke](#) piston engine and the [Wankel rotary engine](#). A second class of

internal combustion engines use continuous combustion: [gas turbines](#), [jet engines](#) and most [rocket engines](#), each of which are internal combustion engines on the same principle as previously described.^{[1][2]} ([Firearms](#) are also a form of internal combustion engine,^[2] though of a type so specialized that they are commonly treated as a separate category, along with weaponry such as mortars and anti-aircraft cannons.) In contrast, in [external combustion engines](#), such as [steam](#) or [Stirling engines](#), energy is delivered to a working fluid not consisting of, mixed with, or contaminated by combustion products. Working fluids for *external* combustion engines include air, hot water, [pressurized water](#) or even [boiler-heated liquid sodium](#).

While there are many stationary applications, most ICEs are used in mobile applications and are the primary power supply for [vehicles](#) such as [cars](#), [aircraft](#) and [boats](#). ICEs are typically powered by [hydrocarbon](#)-based fuels like [natural gas](#), [gasoline](#), [diesel fuel](#), or [ethanol](#). [Renewable fuels](#) like [biodiesel](#) are used in compression ignition (CI) engines and [bioethanol](#) or [ETBE](#) (ethyl tert-butyl ether) produced from bioethanol in spark ignition (SI) engines. As early as 1900 the inventor of the diesel engine, [Rudolf Diesel](#), was using peanut oil to run his engines.^[3] Renewable fuels are commonly blended with fossil fuels. [Hydrogen](#), which is rarely used, can be obtained from either fossil fuels or renewable energy.

Brayton walking beam engine from 1872

Various [scientists](#) and [engineers](#) contributed to the development of internal combustion engines. In 1791, [John Barber](#) developed the [gas turbine](#). In 1794 Thomas Mead patented a [gas engine](#). Also in 1794, Robert Street patented an internal combustion engine, which was also the first to use [liquid fuel](#), and built an engine around that time. In 1798, [John Stevens](#) built the first American internal combustion engine. In 1807, [French](#) engineers [Nicéphore Niépce](#) (who went on to invent [photography](#)) and [Claude Niépce](#) ran a prototype internal combustion engine, using controlled dust explosions, the [Pyréolophore](#), which was granted a patent by [Napoleon Bonaparte](#). This engine powered a boat on the [Saône](#) river in France.^{[4][5]} In the same year, [Swiss](#) engineer [François Isaac de Rivaz](#) invented a hydrogen-based internal combustion engine and powered the engine by electric spark. In 1808, De Rivaz fitted his invention to a primitive working vehicle – "the world's first internal combustion powered automobile".^[6] In 1823, [Samuel Brown](#) patented the first internal combustion engine to be applied industrially.

In 1854, in the UK, the Italian inventors [Eugenio Barsanti](#) and [Felice Matteucci](#) obtained the certification: "Obtaining Motive Power by the Explosion of Gases". In 1857 the Great Seal Patent Office conceded them patent No.1655 for the invention of an "Improved Apparatus for Obtaining Motive Power from Gases".^{[7][8][9][10]} Barsanti and Matteucci obtained other patents for the same invention in France, Belgium and Piedmont between 1857 and 1859.^{[11][12]} In 1860, [Belgian](#) engineer [Jean Joseph Etienne Lenoir](#) produced a gas-fired internal combustion engine.^[13] In 1864, [Nicolaus Otto](#) patented the first atmospheric gas engine. In 1872, American [George Brayton](#) invented the first commercial liquid-fueled internal combustion engine. In 1876, [Nicolaus Otto](#) began working with [Gottlieb Daimler](#) and [Wilhelm Maybach](#), patented the compressed charge, four-cycle engine. In 1879, [Karl Benz](#) patented a reliable [two-stroke](#) gasoline engine. Later, in 1886, Benz began the first commercial production of motor vehicles with an internal combustion engine, in which a three-wheeled, four-cycle engine and chassis formed a single unit.^[14] In 1892, [Rudolf Diesel](#) developed the first compressed charge, compression ignition engine. In 1926, [Robert Goddard](#) launched the first liquid-fueled rocket. In 1939, the [Heinkel He 178](#) became the world's first [jet aircraft](#).

At one time, the word *engine* (via [Old French](#), from [Latin](#) *ingenium*, "ability") meant any piece of [machinery](#)—a sense that persists in expressions such as [siege engine](#). A "motor" (from Latin *motor*,

"mover") is any machine that produces mechanical [power](#). Traditionally, [electric motors](#) are not referred to as "engines"; however, combustion engines are often referred to as "motors". (An [electric engine](#) refers to a [locomotive](#) operated by electricity.)

In boating, an internal combustion engine that is installed in the hull is referred to as an engine, but the engines that sit on the transom are referred to as motors.^[15]

[Reciprocating engine](#) of a car [Diesel generator](#) for backup power

Reciprocating piston engines are by far the most common power source for land and water [vehicles](#), including [automobiles](#), [motorcycles](#), [ships](#) and to a lesser extent, [locomotives](#) (some are electrical but most use diesel engines^{[16][17]}). Rotary engines of the Wankel design are used in some automobiles, aircraft and motorcycles. These are collectively known as internal-combustion-engine vehicles (ICEV).^[18]

Where high power-to-weight ratios are required, internal combustion engines appear in the form of [combustion turbines](#), or sometimes Wankel engines. [Powered aircraft](#) typically use an ICE which may be a reciprocating engine. Airplanes can instead use [jet engines](#) and [helicopters](#) can instead employ [turboshafts](#); both of which are types of turbines. In addition to providing propulsion, [airliners](#) may employ a separate ICE as an [auxiliary power unit](#). Wankel engines are fitted to many [unmanned aerial vehicles](#).

ICEs drive large electric generators that power electrical grids. They are found in the form of [combustion turbines](#) with a typical electrical output in the range of some 100 MW. [Combined cycle power plants](#) use the high temperature exhaust to boil and superheat water steam to run a [steam turbine](#). Thus, the efficiency is higher because more energy is extracted from the fuel than what could be extracted by the combustion engine alone. Combined cycle power plants achieve efficiencies in the range of 50–60%. In a smaller scale, [stationary engines](#) like [gas engines](#) or [diesel generators](#) are used for backup or for providing electrical power to areas not connected to an [electric grid](#).

[Small engines](#) (usually 2-stroke gasoline/petrol engines) are a common power source for [lawnmowers](#), [string trimmers](#), [chain saws](#), [leafblowers](#), [pressure washers](#), [snowmobiles](#), [jet skis](#), [outboard motors](#), [mopeds](#), and [motorcycles](#).

There are several possible ways to classify internal combustion engines.