Engine. A motor or prime mover which is capable of absorbing the inherent forces of material substances such as steam, gas, and water through the medium of heat and pressure, and then converting those forces into mechanical energy in the form of motion, which may be utilized for doing mechanical work, thus distinguishing it from a "machine," which can receive motion only from a motor or engine external to itself.

The various forms of engines may be classified into two general groups – heat engines and hydraulic engines, according to the manner in which they convert the natural forces into mechanical energy, power, or work.

All heat engines act through the medium of a working substance which absorbs heat, converts a portion of that heat into mechanical energy, which is represented by the work performed by the engine, and rejects the remaining portion of the heat, still in the form of heat. The working substance may be a gas, a liquid, or a solid, and incidentally affords a basis upon which the various practically successful forms of heat engines may be conveniently grouped into three general classes – steam engines, gas and oil engines, and steam turbines.

Steam Engines. – In all forms of actual steam engines, the working substance is saturated steam, a fluid consisting of a mixture of water and steam in varying proportions, the expansive energy of which is utilized to drive or impart motion to a piston working within a cylinder.

They may be classified as follows: (1) according to the manner in which the steam is utilized; (2) according to the mechanical arrangement of their parts; and (3) according to the purposes for which they are used.

The first class includes the high-speed and low-speed engines; the single-acting and double-acting engines; the direct-acting and indirect-acting engines; the expansive working and non-expansive working engines; the condensing and non-condensing engines; and the simple engines, compound engines, and multiple-expansion engines, which may be briefly described as follows:

High-Speed Engine. – One in which the piston speed exceeds 900 feet per minute. It possesses the advantages of small dimensions and small weight for a given power, and on account of the frequency of its strokes, is capable of meeting variations in loading more quickly than a low-speed engine. Its disadvantages consist in the greater waste of steam, the greater wear, and the increased danger of the heating of the moving parts. Also, the higher cost of construction and operation.

Low-Speed Engine. – One in which the piston speed is less than 600 feet per minute.

Single-Acting Engine. – One in which the pressure of the steam is exerted only on one side or the under side of the piston, which is pressed down again by the pressure of the atmosphere on the other side against the vacuum produced by the condensation of the spent steam. They were formerly used chiefly for pumping purposes, and in connection with steam hammers but are now practically out of date.

Double-Acting Engine. – One in which the steam acts alternately on both sides of the piston, either against the pressure of the air, or against the vacuum of the condenser. Originally, all engines were made single-acting, but all modern engines are made double-acting.

Direct-Acting Engine. – One in which the action of the piston is transmitted directly to the crank-shaft. Nearly all engines are direct acting engines.

Indirect-Acting Engine. – One in which the motion of the piston is communicated to the crank-shaft by means of intermediate levers. In the beam-engine, the connection between the piston and the connecting rods consists of a beam, the oscillating point of which is placed midway between the two rods. They are chiefly employed for pumping purposes, and for driving paddle-wheel steamers. Other than in this limited field, they are becoming practically obsolete.

Expansive Working Engine. – An engine is worked expansively when the steam, instead of being admitted at full pressure into the cylinder until the termination of the stroke, is cut off at some fractional part of the stroke and thus caused to do work simply by its own expansion. The steam may be expanded in one or more cylinders. The amount of steam consumed is low as compared to the amount of work done. It is universally used where circumstances will permit, on account of its greater economy as compared to the engines of the non-expansive working type.

Non-expansive Working Engine. – An engine in which the steam is allowed to enter the cylinder at boiler pressure, and is maintained at that pressure behind the piston during the whole of the stroke. The amount of steam consumed is disproportionately high as compared to the work done. It is never used except in cases where circumstances will not permit of the use of an expansive working engine.

Condensing Engine. – One in which the spent steam in the cylinder is exhausted into a vacuum and condensed into water, thus obliterating the back pressure of the atmosphere, and consequently effecting a gain of pressure equivalent to 14.7 pounds per square inch, in the effective working pressure of the steam.

Non-condensing Engine. – One in which the spent steam in the cylinder is exhausted into the air at atmospheric pressure, thus entailing the work of forcing the piston against a back pressure of 14.7 pounds per square inch, at the expense of the effective working pressure of the steam.

Simple Engine. – One in which the steam after having forced the piston through its stroke is exhausted into the air, or into a vacuum or condenser.

Compound Engine. – An engine with two or more cylinders in which the steam after having expanded and performed its work in one cylinder passes into the next cylinder, of larger size, and continues to expand and perform work. The different types of compound engines are distinguished by the number of cylinders employed for the expansive working of the steam, and

are designated as the two-cylinder compound engine, the three-cylinder or triple-expansion engine, and the four-cylinder or quadruple-expansion engine. The cylinders are usually arranged side by side or parallel with each other. Sometimes, as in the case of the "tandem-compound," they are placed "in line" one behind the other, and also vertically one above the other as in the case of the "steeple-compound." In a "cross-compound" the cylinders are placed side by side and parallel to each other, but sufficiently far apart to allow space for a fly-wheel between them. Up to the present time, the quadruple-expansion engine appears to be the limit beyond which the number of expansions have not been carried with success. The great practical advantage of the multiple expansion engines lies in their high steam economy.

The second class of steam engines includes the various types of reciprocating engines which are more definitely designated as horizontal engines, vertical engines, and inclined engines, according to the position of the axis of the piston, and various forms of direct-acting and indirect-acting engines, such as beam engines, oscillating engines, trunk engines, back-acting engines, and various forms of rotary engines.

The third-class includes the various forms of marine engines, stationary or land engines, locomotive engines, and a great variety of portable engines. The engines included in these two classes may be briefly described as follows:

Reciprocating Engine. – One in which the piston moves backward and forward alternately, in a right line. Almost all heat engines are of this type.

Horizontal Engine. – One in which the axis of the cylinder and piston rod is horizontal.

Vertical Engine. – One in which the axis of the cylinder and piston rod is vertical. Vertical engines are made in a great variety of forms, and are usually arranged with the cylinders uppermost. Very few of them are constructed with the cylinders lowermost, and those are only of the smallest sizes. The principal advantages of the vertical engines consist in the small space required for their foundations, and the uniformity of wear on the cylinders, pistons, and rods. The type includes many forms of steam hammers, launch engines, screw engines, and inverted cylinder engines.

Inverted Cylinder Engine. – A vertical engine in which the cylinder is inverted or placed above the piston rod, connecting rod, and crank-shaft. It is typical of the marine engines employed to drive screw propellers.

Inclined Engine or Inclined Cylinder Engine. – A form of marine engine in which the cylinders are inclined toward each other at an angle of about 120 degrees, and make a triangle with the base. They are connected by cranks to a common crank-shaft.

Beam Engine. – An indirect-acting engine in which the piston rod is connected to the connecting rods by means of a lever in the form of a beam. It is more fully described under the term Indirect-Acting Engine.

Oscillating Engine. – A marine engine of the direct-acting type in which the cylinders are suspended upon hollow trunnions and oscillate thereon, thus allowing the motion of the piston rods to accommodate itself to that of the crank at all parts of the revolution. It occupies but little space, and is peculiarly adapted for paddlewheel steamers. For screw propulsion, it has been entirely supplanted by the various forms of multiple-expansion engines of the inverted cylinder type.

Trunk Engine. – An interesting though practically obsolete form of marine engine formerly used on war vessels. The aim of its design is compactness of arrangement, so as to place all of its working parts below the waterline, thus protecting them from the enemy's shot. Its distinguishing feature is a hollow, trunk-shaped piston rod which passes through both ends of the cylinder and is encircled in the middle by the piston head. The connecting rod is attached to the interior of the piston rod, thus saving the length of the piston rod in all of the vertical dimensions of the engine. Its chief defect consists in its low steam economy, due to the great loss of heat by radiation from the large conducting surfaces of the hollow piston rod which are exposed to the air.

Bogie Engine. – A locomotive provided with a bogie or swiveling framework which carries the axle of the main driving wheels, and enables the main framing- to accommodate itself to curves of short radii. In the single bogie, the main driving- wheels are the bogies; in the double bogie, both the main driving wheels and the back driving or trailing wheels are bogies. A bogie truck is a short four-wheeled truck pivoted at its centre to the main frame of the engine, and enables the engine to run around sharp curves.

Corliss Engine. – A very economical type of engine in which the valves are controlled automatically from the governor, and the steam supply proportioned to the requirements of the engine at each moment during its working stroke. The valve forms a segment of a circle and revolves through an arc of a circle, and alternately covers and uncovers the steam port. It is operated by a rod from a wrist plate, but is disconnected at every stroke of the engine, and the supply valve closed instantaneously by means of a dash-piston and spring.

Cornish Engine. – A standard type of pumping-engine, originally of the single-acting type. At the present time it appears in two forms the beam engines and the direct-acting engines. The valves of a Cornish engine are operated by a special device called a cataract consisting of a weighted piston which works in a cylinder provided with a large inlet valve and a small discharge valve. The working stroke of the pump lifts the weighted piston and draws the water into the cylinder through the former, and the return stroke discharges it through the latter, and at the same time actuates the valves of the steam cylinder of the pump so as to cause another working stroke.

Marine Engine. – Any form of engine used for propelling a vessel. They are usually of the compound or multiple-expansion type.

Stationary Engine. – An engine on fixed foundations, as distinguished from the locomotive, portable, and marine engines.

Locomotive Engine. – A high pressure steam engine and multitibular complete, mounted on a carriage, and provided with suitable wheels to enable it to draw loaded cars upon a permanent way or railway track.

Portable Engine. – An engine of the locomotive type, mounted on a carriage which permits of its being moved from place to place for use in connection with work of a temporary character. Portable engines are extensively used for agricultural purposes, and for general traction purposes on ordinary highways.

Gas and Oil Engines. – These classes of heat engines are commonly designated as internal combustion engines for the purpose of distinguishing them from the various more or less impracticable forms of hot air engines in which the working substance consists of air alone, which is heated from an external furnace, the heat being conducted through the walls of the containing vessel.

In the gas engines, the working substance or charge is a mixture of coal gas and air, explosive in character, which is introduced into the working cylinder where it is compressed by the action of the piston, and then ignited and exploded by a special device. The energy developed by the explosion is utilized to actuate the piston or do mechanical work.

This method of heating the working substance is called the gas engine method. It is one feature possessed in common by all gas engines irrespective of variations in form, or of working cycles, and serves to distinguish them from all other forms of heat engines.

The various types of gas engines may be conveniently divided into three general classes, according to their mode of operation as follows: (1) Those in which a specified amount or constant volume of gas is drawn into the cylinder at atmospheric pressure or without compression, and then ignited, as in the case of the Lenoir, Hugon, and the Otto-Langen engines, which were quite successful for powers under one horse power, but are practically obsolete; (2) those in which the working substance is first compressed in an auxiliary cylinder and then admitted to the working cylinder and ignited, as in the case of the Brayton engine, which although the most successful engine of this class is also practically obsolete; and (3) those in which a specified amount or constant volume of gas is admitted to the working cylinder where it is compressed by the piston and then ignited, as in the case of the Otto engine, and in, by far, the greater number of other gas engines in successful use at the present time.

Gas engines are also designated as two-cycle, four-cycle, and six-cycle engines, according to the number of distinct operations in their working cycles. The six-cycle engines were of the scavenging type, but were not successful, and are obsolete. The four-cycle engines represent the application of the Beau de Rochas or Otto cycle, and constitute the most successful type developed up to the present time. The two cycle engines are as yet in a comparatively experimental state, but possess great possibilities of successful development, and may eventually supplant all the other forms.

Up to within the last few years, the gas engines were rarely made in sizes capable of developing an amount of power equivalent to 50, 75, or 100 horsepower, and rivaled steam engines of equal capacity only in special and limited fields of application; but now, since the introduction of the various gas producer systems, gas engines developing 4,000 horsepower are in successful use, and others capable of developing as high as 6,000 horse-power are in the process of construction.

The oil engine differs from the gas engine principally in the character of the charge, which consists of a mixture of vaporized petroleum, gasoline, or paraffin oil and air. They may be conveniently classified, (1) according to the method employed to vaporize the oil; or (2) according to the method employed to ignite the charge.

The first class includes those in which the oil is subjected to a spraying operation before being vaporized; those in which the oil is injected into and vaporized within the cylinder; and those in which the oil is vaporized by a special apparatus outside the cylinder and then admitted into the cylinder in the form of a vapor.

The second class includes those in which the charge is ignited by means of an electric spark; those in which the charge is ignited by an incandescent tube; and those in which the charge is ignited by the heat of the internal surfaces of the combustion chamber.

Steam Turbines comprise a class of heat engines in which the kinetic energy of expanding steam is utilized to drive a wheel and thus convert the natural heat energy of steam directly into mechanical energy in the form of rotary motion. The principal forms are the Parsons, De Laval, Seger, and Dow turbines, and their chief field of application and development appears to be in the marine service. Noteworthy examples of their latest applications are those of the Cunard Line Passenger Steamship “Carmania,” and the battleship “Dreadnaught,” of the British Royal Navy, the largest warship in the world built up to date.

Hydraulic Engines. – Mechanical power is obtained from flowing water by its weight, pressure, or impact, utilized in various forms of water wheels, turbines, hydraulic rams, and water pressure engines. In the water pressure engine the pressure of the water only is utilized to drive a piston in a cylinder. In some forms the action of the piston is reciprocating, and in others rotary. In all of them the actual amount of pressure expended is only that which is needed to impart motion to the fluid to follow the piston and escape from the cylinder, and, therefore, the greatest efficiency is obtained by making the piston as small as practicable and using a large pressure. The majority of them are of the reciprocating, low-speed type, and are

particularly useful as secondary motors for operating the opening machinery of various forms of swing, draw, and lifting or rolling bridges, and in connection with cranes and various forms of hydraulic lifts.

For further detailed information relative to the construction, operation, and application of the various forms of engines, consult the articles under the titles: GAS ENGINES; LOCOMOTIVE; LOCOMOTIVE, DESIGN AND CONSTRUCTION OF THE MODERN; LOCOMOTIVE ENGINE; PUMPS AND PUMPING MACHINERY; ROTARY STEAM ENGINE; TRACTION ENGINES; TURBINES; WATER MOTOR; AND WATER WHEELS, in this Encyclopedia.

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