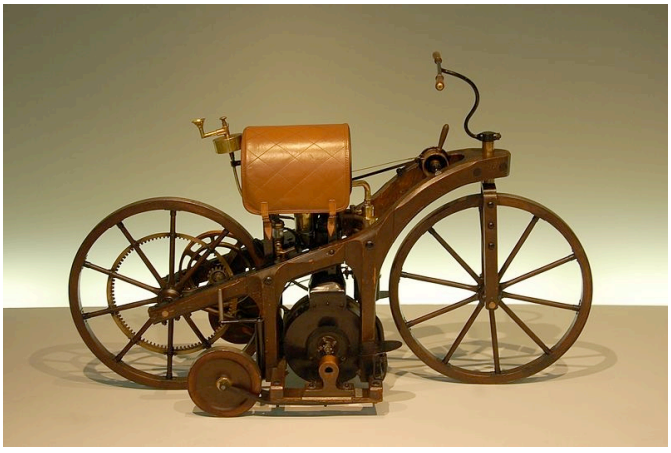
A Summary of Early Motorcycle Engine Design
Compiled by Mary Bobbitt

The first motorbike was built in 1868. It was not powered by a gasoline engine, but by a steam engine. Its builder was Sylvester Howard Roper. His steam-powered bike was demonstrated at fairs and circuses in the eastern US in 1867 and did not catch on, but it anticipated many modern motorbike features, including the hand twist grip throttle control. It was powered by a charcoal-fired two-cylinder engine, whose connecting rods directly drove a crank on the rear wheel. This machine predates the invention of the safety bicycle by many years, so its chassis is also based on the "bone-crusher" bike. "Bone-Crusher's" appeared around 1800, used iron-banded wagon wheels, and were called "bone-crushers," both for their jarring ride, and their tendency to toss their riders.

Modern Motorcycles are descended from the "safety" bicycle, bicycles with front and rear wheels of similar size, with a pedal crank chain drive mechanism to the rear wheel. Most frames were tubular, consisted of two triangles and referred to as diamond frame another design is the step-through frame commonly referred to as a ladies bike.

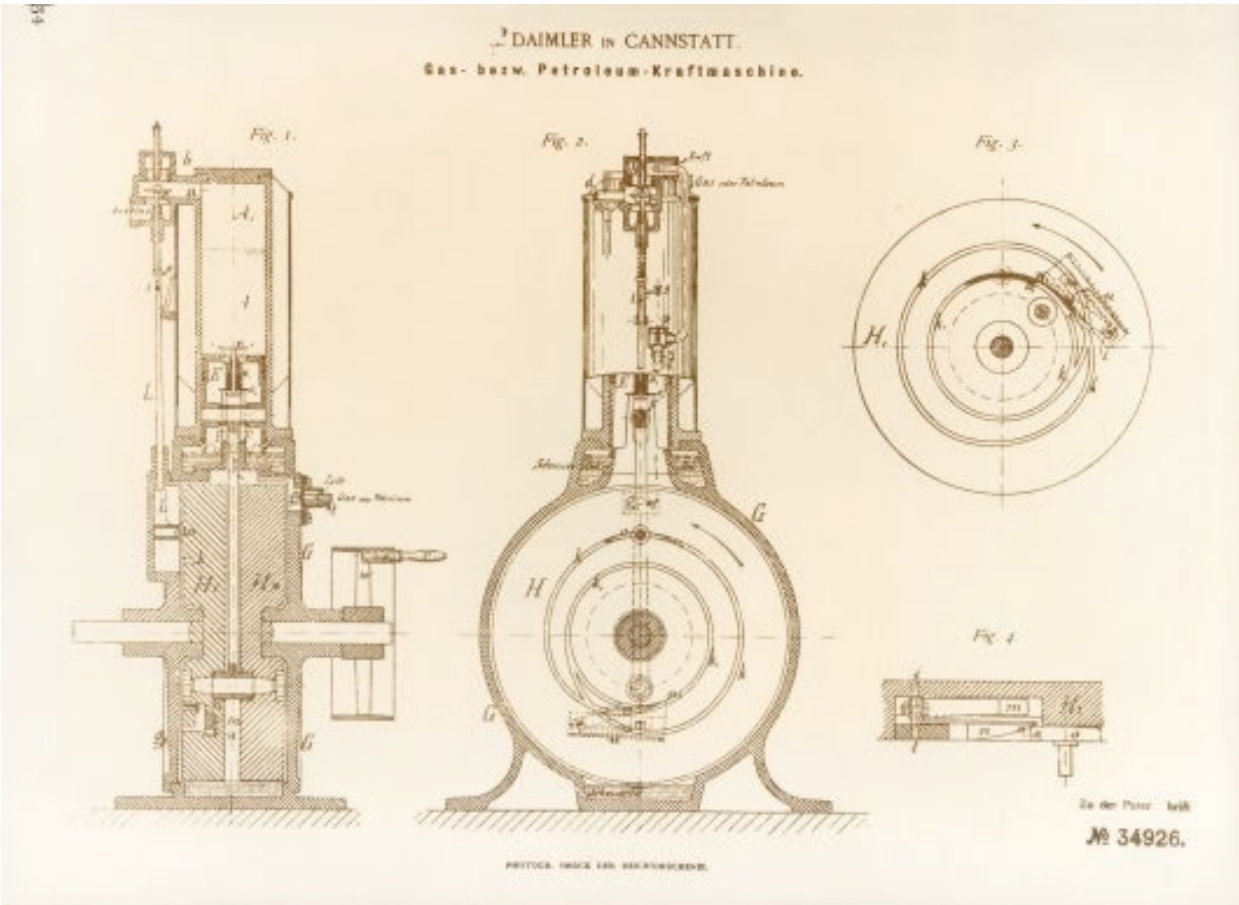
Internal Combustion and “Motorcycles”



The 1885 Daimler/Maybach Petroleum Reitwagen (Riding Car) was the first motor vehicle using an internal combustion engine. Gottlieb Daimler and Wilhelm Maybach had created an engine called the "Grandfather Clock" engine. Many consider this the first motorcycle as it has two large wheels front and back but it has two wheels on the sides like trainer wheels so it actually has four wheels.

The Grandfather Clock engine was based on Nichols Otto’s 1874 four cycle internal combustion engine known as the “Otto Cycle engine ".

Work on a useable gas powered engine goes back to Jean Joseph Étienne Lenoir also known as Jean J. Lenoir, a Belgian engineer who developed the internal combustion engine in 1858. Prior designs for such engines were patented as early as 1807, but



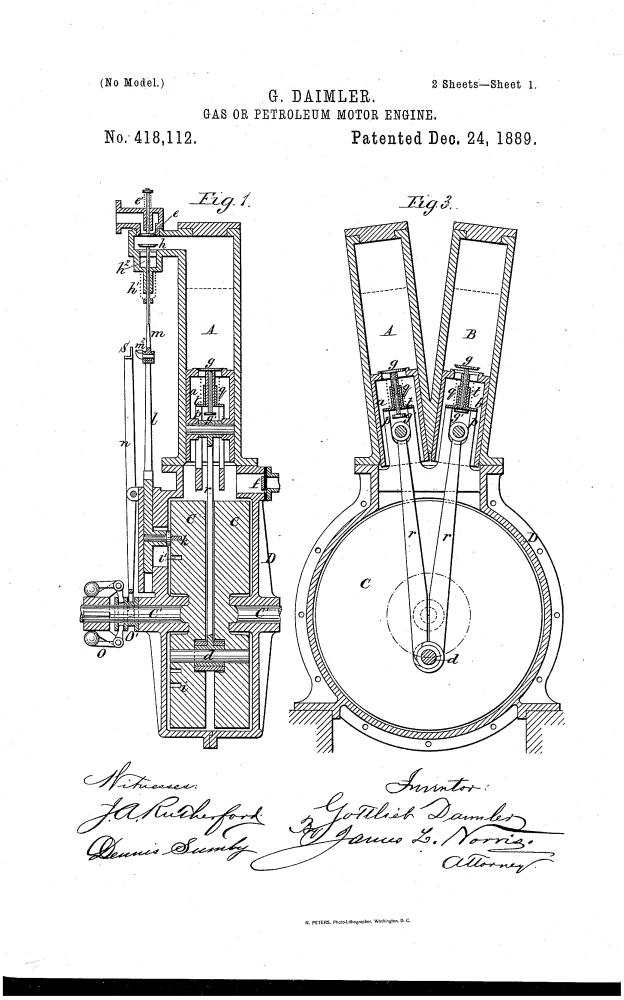
none were commercially successful. Lenoir's engine was commercialized in sufficient quantities to be considered a success, a first for the internal combustion engine. Otto was familiar with Lenoir's engine as he had tested the engine and was aware of its problems and the effect of compression on fuel. There had been an 1862 patent by Christian Reithmann in 1860 and another by Alphonse Beau de Roch for a four stroke engine but they never actually built an engine. In 1862 Otto had attempted to correct the Lenoir's problem with a "compression engine", then in 1864 built another engine called the "atmospheric engine", but it was only in 1874 that he made a functional gas powered four stroke. Virtually all of the world's makers of four stroke engines are using the "Otto cycle" engines that are so ubiquitous as to be referred to as gasoline engines.

This was the first commercially successful engine to use in-cylinder compression, but as it was designed for stationary applications the stroke is an upward or downward movement of a piston in a cylinder. Used later in an adapted form as an automobile engine, four strokes are involved: (1) downward *intake* stroke—coal-gas and air enter the piston chamber, (2) upward *compression* stroke—the piston compresses the mixture, (3) downward *power* stroke—ignites the fuel mixture by electric spark, and (4) upward *exhaust* stroke—releases exhaust gas from the piston chamber. . It featured a slider valve control with *gas flame ignition*, which overcame the problems that Lenoir could not overcome with electric ignition, which was unreliable at that time. In the 15 years prior to the development of the Otto engine power output never exceeded 3 hp. In only a few years Otto stationary engines' reached 1000 hp. Otto's Company was named

Deutz and is still in existence making engines for heavy industrial uses.

Otto and his manager Gottlieb Daimler had a major disagreement on the future direction of the Otto engine. While Otto wanted to produce large engines for stationary applications Daimler wanted to produce engines small enough to be used in transportation. After a period of disagreement Daimler left Otto's employ and took Wilhelm Maybach with him. In 1883 Daimler and Maybach created a .5 hp engine that was small and efficient. In order to evade the patents that Otto held on the engine design, a pretense was found concerning a patent issued to Beau De Rochas in 1862, the same year that Otto failed to create his four cycle engine the first time.

Daimler always referred to his design as an explosion engine, to contrast it against Otto's engine and was able to evade paying royalties to Otto. In 1885 he and Maybach created an engine called the "Grandfather Clock" engine and built a two wheeled frame around it. This became the first Otto engine vehicle.


(No Model.) 2 Sheets—Sheet 1.

G. DAIMLER.

GAS OR PETROLEUM MOTOR ENGINE.

No. 418,112. Patented Dec. 24, 1889.

Fig. 1. Fig. 3.

Witnesses: Inventor:

J. A. Rutherford Gottlieb Daimler

Dennis Sandy By James L. Norris,

Attorney

Daimler patented a V twin gasoline engine on Christmas Eve, 1889. Studying the patent image shows us the basics of this early yet modern motor design. The first item that may look familiar is the common crank pin, labeled “d”. Both pistons and their rods were connected to the crankshaft at one location on the flywheel, the pistons come to TDC one right after the other as the crank rolls around. This is how motor manufacturers from Daimler’s time through the V twins built today. It is possible to separate the connecting rods into two locations on the flywheel “C, this brings the pistons up at alternating times, to change the vibration characteristics, exhaust sounds and induction restrictions. Separate the crank has been done but manufacturing issues, motor width considerations and high component stresses have prevented the widespread adoption of the idea however.

Daimler’s V twin motor has a very narrow V angle between cylinders “A” and “B”, this angle has been varied in engines to reduce vibration, and more recently, to control the torque delivery from their motors. A hold over from steam engines is clearly seen are

the balls on the speed governor, item “O”. An interesting story is the origin of the term “BALLS OUT”, meaning to be going fast. The governors spun with the motor, and as the speed increased, the balls were flung further away from their pivot axis due to centrifugal force. Hence, High Speed = Balls Out.

These early motors used “atmospheric” or “automatic” inlet valves, item “e”. The valves were opened through the suction force as the piston descended down the bore, as opposed to valve actuation through a cam pushing the valve open, as shown for the exhaust valve “h”. It was a simple and cheap method; however it limited the amount of air/fuel mixture that could enter the motor. The valve timing was somewhat erratic over the rpm range, and could not be varied or optimized, other than by using softer or firmer valve springs. Another limitation to this construction was that the inlet valve could never be opened before TDC, a timing that helps motor breathing efficiency. Mechanical or Cams and followers were later used on inlets, just as they had always been used on exhaust and motor speeds and powers went up. Carl Benz also invented a gas four stroke engine the same year.

The first truly two wheeled motorcycle is likely the 1892 five cylinder Millet built in France. The interesting feature of this machine was the five cylinder rotary engine mounted in the rear wheel. The cylinders turned along with the wheel while the crank was stationary. This was not the last time that such a motor was used in a motorcycle, although the next one to use this design had the motor mounted in the front wheel.

1894 Hilderbrand and Wolfmuller of France is the world’s first production motorcycle. It came with a 1428 cc water cooled four-stroke motor producing 2.5 hp. and a top speed of 25 mph. The motor was a parallel twin with one forward piston and one rearward with the connecting rods running to a crank mounted on the rear wheel. Instead of using a flywheel to store energy between firings, it used large elastic cords, one each outbound of the pistons. It was first made in France under license for one year under the name Petrolette and remained in production until 1897.

There had been steam-driven ‘boneshakers’ on both sides of the Atlantic in the 1860s and, of course, Gottlieb Daimler’s gasoline-engined Einspur of 1885, but the Hildebrand & Wolfmüller was the first powered two-wheeler to enter series production. It is the first such device to which the name ‘motorcycle’ (motorrad in German), the name was registered for the new invention, which was patented in January 1894. (Daimler’s “motorcycle” was only a test-bed for his high-revving internal combustion engine, and as soon as that was powerful enough he turned his attention to automobiles).

Like many of their contemporaries, the Hildebrand brothers, Henry and Wilhelm, began by experimenting with steam power before turning to a (two-stroke) gasoline engine, the latter having been developed in partnership with Alois Wolfmüller and his mechanic, Hans Geisenhof. The quartet’s next design was a water-cooled, four-stroke parallel twin displacing 1,488cc, which until relatively recent times was the largest power unit ever fitted to a motorcycle.

The Hildebrands were in the bicycle business so their new engine was mounted in a bicycle frame of the newly developed ‘safety’ configuration. When this proved insufficiently robust, a more integrated arrangement was devised, based on that of the Hildebrands’ defunct steamer. Steam locomotive practice was further recalled by the long connecting rods directly linking the pistons to the rear wheel, which opened and closed the mechanical exhaust valves via pushrods actuated by a cam on the hub. The latter contained an epicyclic reduction gear and there was no crankshaft flywheel, the solid disc rear wheel serving that purpose. Rubber bands assisted the pistons on the return stroke at low revs. Fuel mixture was fed from the tank that also acted as a surface carburetor and thence via atmospheric inlet valves to the cylinders where it was ignited by nickel hot tube, as developed by Daimler. The box-like rear mudguard acted as a reservoir for the engine’s cooling water, while two of the frame tubes served as the oil tank. The tires, manufactured under license from Dunlop by Veith in Germany, were the first of the pneumatic variety ever fitted to a motorcycle.

Although modern in many respects, the H&W was primitive in others, most notably the brakes, which consisted of a steel 'spoon' working on the front tire, the application of which automatically closed the throttle. The rider controlled the latter by means of a rotating thumbscrew; there was no clutch, which made starting an athletic procedure, the machine being pushed until it fired, whereupon its rider leapt aboard while simultaneously trying to regulate engine speed. Despite producing only 2.5bhp at 240rpm, the H&W was capable of speeds approaching 30mph, an exciting prospect at a time when powered road transport of any sort was still a novelty.

The H&W's announcement was greeted with considerable enthusiasm and plans drawn up to build a factory in Munich to produce it. In the meantime, numerous small workshops manufactured parts for the machine, which was also licensed to the firm of Duncan, Superbie et Cie for manufacture at its plant in Croissy, France where it would be marketed as 'La Petrolette'. Six Petrolettes were exhibited at the first Paris Motor Salon held in December 1895 and by 1896 some 50-or-so had been delivered.

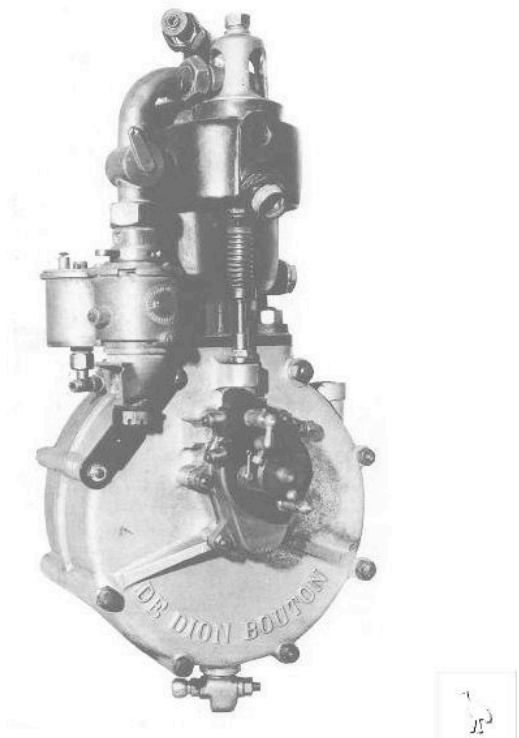
Despite some impressive demonstration performances by factory riders, the H&W's shortcomings became all too apparent once deliveries to paying customers commenced. The crudity of the hot tube ignition meant that starting was difficult and, once under way, progress was erratic because of the rear wheel's poor flywheel effect. Duncan, Superbie et Cie lost a court case against a dissatisfied customer, whereupon many others promptly demanded their money back. Early in 1897 both the German and French ventures collapsed. Opinion differs with regard to how many machines were produced, figures ranging from as low as 800 to as high as 2,000 being quoted.

Although ultimately a failure, the Hildebrand & Wolfmüller nevertheless deserves its place in history as the World's first ever production motorcycle. If Motorcycling can be said to have started anywhere in particular - it started here.

1894 De Dion Bouton

De Dion, Bouton et Trépardoux was formed in Paris in 1883. This became the de Dion-Bouton automobile company, the world's largest automobile manufacturer for a time, becoming well known for their quality, reliability, and durability. They first manufactured Steam powered cars.

Marquis Jules Félix Philippe Albert de Dion was becoming convinced the future lay in the internal combustion engine, and the company had even built a ten-cylinder two-row rotary. After Trépardoux resigned in 1894, the company became De Dion, Bouton et Compagnie. For 1895, Bouton created a new 137 cc (8.4 in^3) one-cylinder engine with trembler coil ignition. Proving troublesome at its designed speed of 900 rpm (throwing bearings and running rough), when Bouton increased the revs, the problems vanished; in trials, it hit an unheard of 3500 rpm, and was usually run at 2,000 rpm, a limit imposed by its atmospheric valves and surface carburetor. In this design both inlet and



exhaust valves were overhead and a flywheel was fitted to each end of the crankshaft.

This engine was fitted behind the rear axle of a tricycle frame bought in from Decauville, fitted with the new Michelin pneumatic tires. It showed superb performance, and went on the market in 1896 with the engine enlarged to 1¼ CV (Horsepower) (932 W) 185 cc (11.3 in^3), with 1¾ CV (1.3 kW) in 1897. By the time production of the petite voiture tricar stopped in 1901, it had 2¾ CV (2 kW), while racers had as much as 8 CV (6 kW).

In 1898, Louis Renault had a De Dion-Bouton modified with fixed drive shaft and ring and pinion gear, making "perhaps the first hot rod in history". The same year, the tricar was joined by a four-wheeler and in 1900 by a vis a vis voiturette, the Model D, with its 3¾ CV (2.8 kW) 402 cc (24.5 in^3) single-cylinder engine under the seat and drive to the rear wheels through a two speed gearbox. This curious design had the passenger facing the driver, who sat in the rear seat. The voiturette had one inestimable advantage: a lever on the steering column operated the expanding clutches of the gearbox. The Model D was developed through Models E, G, I, and J, with 6 CV (4.5 kW) by 1902, when the 8 CV (6 kW) Model K rear-entry phaeton appeared, with front-end styling resembling the contemporary Renault. Until World War I, de Dions had an unusual decelerator pedal that reduced engine speed and ultimately applied a transmission brake.[6] In 1902, the Model O introduced three speeds, which was standard for all de Dions in 1904. A small number of electric cars were also made in 1901.

De Dion is important as an engine supplier to moto bicycle builders and the De Dion-Bouton engine is considered to the first high speed lightweight internal combustion engine. It was licensed to more than 150 manufacturers and was a popular choice among assemblers of moto bicycles. The small lightweight four cycle engine used a battery and coil ignition that was less trouble than the hot tube ignition. The bore of 50 mm and stroke of 70 mm gave this engine an output of 1KW. It was used on many pioneering moto bicycle brands and was widely copied by many makers including US Brands Indian and Harley-Davidson.

Orient

In 1898 the first American made motorcycle was one built by the Metz Company, in Waltham, Mass called the Orient-Aster. It used an Aster engine that was a French copy

of the DeDion-Burton, reportedly the forerunner of all motorcycle engines. It predates Indian and Harley-Davidson, both of which first used engines based on DeDion-Burton design. Note also the location of the engine which was mounted in the lower part of the frame where it has remained to this day (with a few exceptions) and is chain driven, another feature which remain in use to this day

Charles H. Metz is credited with being the first to coin the term "motor cycle," first used in an 1899 advertisement for the upcoming Orient. Waltham Manufacturing's 1900 Orient Light Roadster and "Orient-Aster" were America's first mass-production motor driven cycles, which were also known simply as the "Orient Motorcycle."

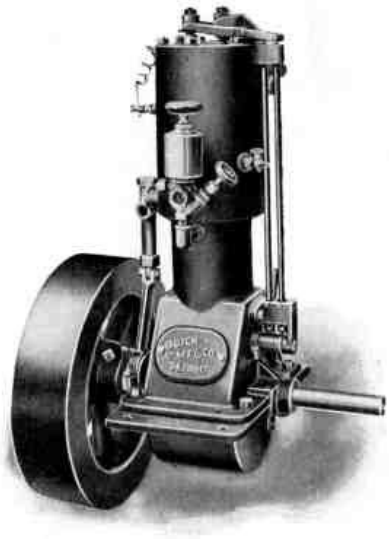
Metz first introduced his creation to the world in July 1900, at the Charles River Race Track in Boston, marking the first recorded motorcycle speed event in the United States. The Orient set a track time of 7 minutes over a five mile course. Below is a 1900 Orient Light Roadster.

The "Aster" portion of the name came from their use of a motor made by the French manufacturing firm of Aster, while the French-built de Dion-Bouton engine powered the earlier Orient Light Roadster. The Aster motor was built by the French firm of Ateliers de Construction Mecanique l'Aster in Saint-Denis, France. Aster built motors based on the

revolutionary design of the 1895 French DeDion-Buton motor, which was one of the first mass-production gasoline engines and a leading engine supplier between 1898 and 1910. They made engines for Achilles, Argyll, Ariès, Automobiles Barré, Bolide (automobile), Belhaven Engineering and Motors Bij 't Vuur, Century Engineering Co, Clément, Darracq, Dennis, Durham, Churchill and Co, Ernst (automobile), Excelsior, Gladiator, Hanzer, Hoflack, Hurtu, Korn et Latil, La Torpille, Lucerna (automobile) , Parisienne (automobile), Passy-Thellier, Pearson (motorcycles), Prunel, Rochet (automobile), Rouxel, Reyrol, Sage (automobile), Siddeley-Deasy, Simplicia, Singer, Swift, Vulcan, West-Aster, Whippet Motor and Cycle Co, Whitlock and Le Zèbre.

The Orient-Aster's power-plant was a 138cc single-cylinder gasoline powered motor producing 1/2 horsepower. The Orient-Aster was produced until 1904. Both of the Orient's engines were situated high in the frame, at the center of the bike for even weight distribution. The engine's height had the added bonus of allowing the rider to easily adjust its carburetor while driving.

By 1902, Waltham also produced a gasoline-powered automobile known as the "Orient Buckboard." The Orient Model 1902 sold for around $875.00 With the immediate success of the Orient Buckboard automobile, Waltham Manufacturing soon came to be known as the "Metz Car Company." Among Metz' many other achievements, he also built one of the first electric cars, sponsored by Charles Coffin of the General Electric Company. Metz left the Waltham Manufacturing Company in 1902, to begin the "Metz Motorcycle Company" on Whitney Avenue behind a Woolworths Department Store in Waltham, Massachusetts.



4-CYCLE MARINE GASOLINE.

The new 'Metz motorcycle' was another instant success, establishing another American speed record for a 70 second one-mile run at 51.42 mph. Waltham Manufacturing continued to manufacture watches, speedometers, compasses, stoves, boilers, aircraft parts, gramophones, Victrolas and radios through the mid 1900s, later focusing only on specialized clocks and chronographs for use in aircraft control panels. Waltham was sold in 1994, becoming the Waltham Aircraft Clock Corporation in Ozark, Alabama.

With the success of the Metz motorcycle, Charles Metz joined into a partnership with David Marsh, who was the designer of the first Waltham watch. Marsh had already begun the Marsh Motorcycle Company in Brockton, Massachusetts in 1905, and the merger between the two created the "American Motorcycle Company" in Brockton. It was here that the "Marsh-Metz," also known as the "M-M" was born.

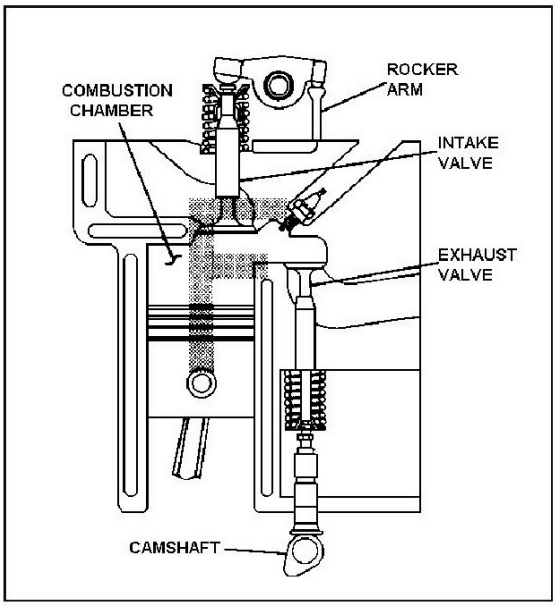
The newly formed American Motorcycle Company built its first two-cylinder engine in 1906, a 4 horsepower 1000cc v-twin that powered the MM (Marsh Metz). By 1908, Waltham Manufacturing had run out of money ant the current owners wanted Metz to return as the new owner. To revive the company, and raise cash fast, Metz designed an inexpensive kit-car called the "Plan Car," which could be assembled by the consumer from fourteen separate kits. Although the Plan Car was not a huge success, Metz did turn the company around, and in 1911 the company expanded to the Gore Estate, using the first floor of the converted mansion as a new car showroom.

Over Head Valves in 1902

As a side note the first OHV engine was designed in 1902 David Buick and his engineer Eugene Richard has invented the revolutionary Valve in Head Over head Valve engine. Shown left. It employs pushrod-actuated valves parallel to the pistons. It was first used as a stationary engine. This design is still used today in some cars and is the grandfather of all over head cam engines in use today and becomes important much later in motorcycle engines, but this push rod type of OHV was used for racing as early as 1916.

F Heads

The “atmospheric” or “automatic” inlet valves, intake/inlet over exhaust (IOE) engine, also known as F-head and pocket valve, is a valve train configuration used in early four stroke Internal Combustion engines. The configuration consists of intake valves located in the cylinder head and exhaust valves located. This configuration, known as the F Head was used for almost all engines before 1900. American motorcycles including Harley Davidson and Indian used this design for their early years.



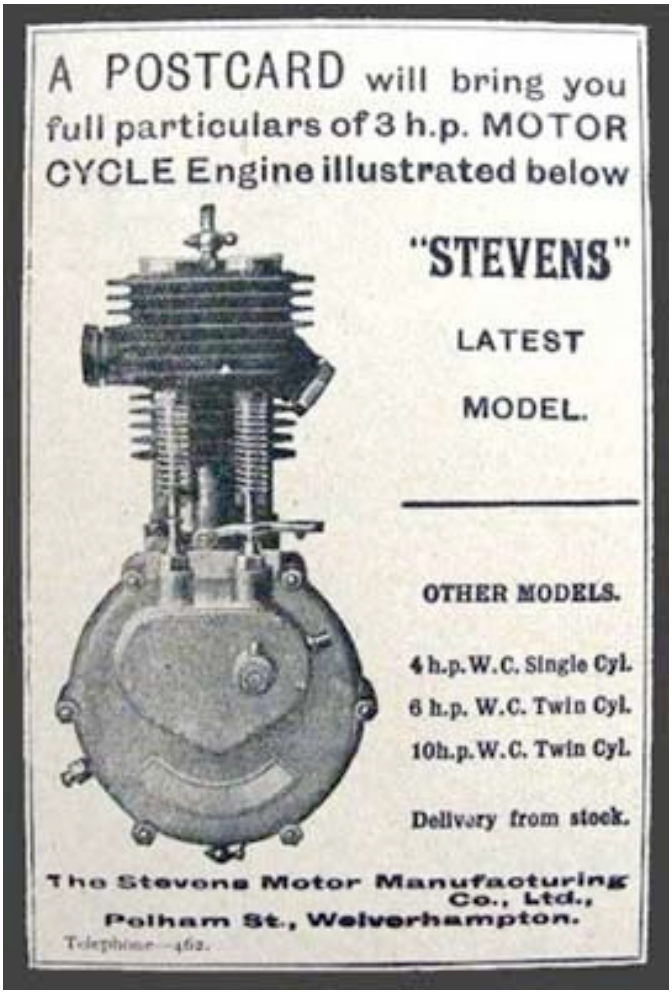
In the F-head layout (not to be confused with flathead) the intake manifold and its valves are located atop the cylinders and are operated by pushrods, but the exhaust manifold and its valves are located beside the cylinders in the block. The exhaust valves are either roughly or exactly parallel with the pistons; their faces point upwards and they are not operated by pushrods, but by direct contact with a lifter contacting the camshaft. Reverse variation of F-head with side intake and in head exhaust were also made- the Ford V8 overhead exhaust valve conversions to flathead engines were to decrease the overheating under load problems in commercial service. The Indian /Henderson 4-cylinder motorcycle engine family used both designs- the overhead exhaust was again an overheating consideration design.

This was a more expensive engine design. Its advantages over later L-head or Flat head engines included more power from its higher compression, better intake mixture flow, less susceptibility to pinging, and greater reliability from its cooling of the exhaust valve and its spring (and having half the number of pushrods of an OHV engine). With only one valve in the head, and one in the block, larger valves can be used than in an OHV engine, to offset the poorer airflow of a side exhaust valve.

For years the British motor car firms Rolls-Royce and Rover used this arrangement. From 1927 to 1929, the American firm Hudson used a 6-cylinder engine of this form as well, but this engine is not to be confused with that of the race-winning Hudsons of the 1950s. The last major use was the Willys Hurricane engine, used in civilian Jeeps in the 1950s and 1960s.

T-heads to L-heads

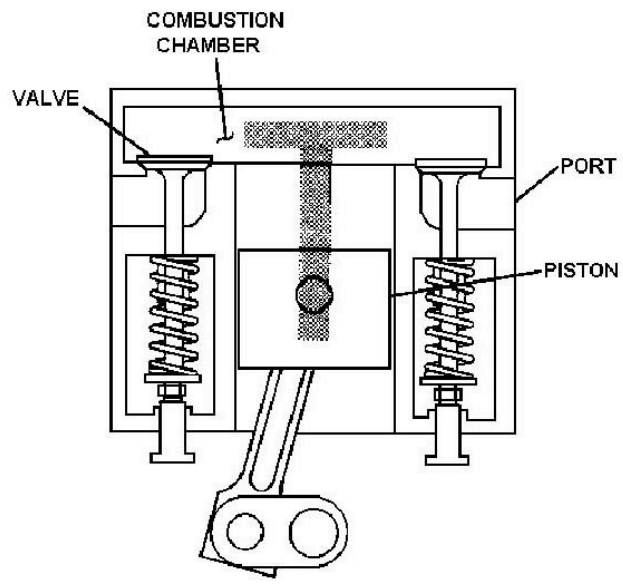
Daimler developed what is known as a T head engine for his successful D Style engine around 1900. At the end of 1902, Minerva (they built bicycle frames and engine kits) presented in London the new program for 1903. A new engine of 239 cc (66 x 70) produced 2 H.P. thanks to the two mechanically operated valves or T-head. Minerva was one of the first to build engines with both valves mechanically operated. Due to the better filling of the gasses and hence the lower engine temperatures, the cooling ribs at the base of the cylinder were deleted.



Not having yet perfected a gasket capable of forming a seal between cylinders and cylinder heads. Thus, each cylinder had to have its head cast integrally, with intake and exhaust valves set in caps that were screwed into each head. They named this setup T-head, because the valves straddled the piston.

Each set of valves was operated by its own camshaft. The two shafts -- one for intake valves and one fore exhaust valves -- were located in the crankcase. They pushed up on long stems that lifted the valves off their seats. As the cam lobes moved off the valve

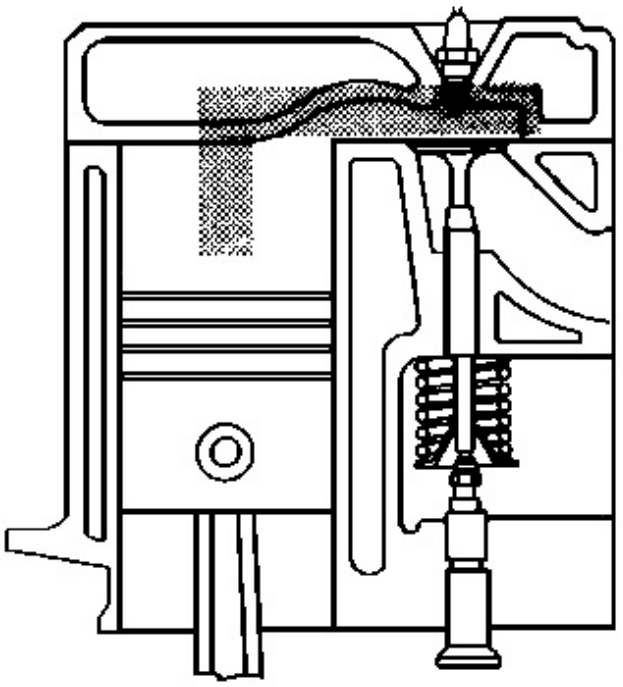
stem tips, heavy springs caused the valve to slam shut.



By 1909 this basic design was being used in the Stevens Motor Manufacturing Co in England in both a single and V twin. This company became A.J.S. but Stevens' engines were also used in early BSA and other frames. The T-head engine gave way to the L-head (also called the flat-head or side-valve) engine in which both valves were placed on one side of the engine.

Henry Ford used an L Head in 1908 for his model T cars. L-head (*flathead*) refers to the pushrod valve train configuration in which the valves are placed in the engine block beside the pistons. The design was common on early engine designs and most cars starting in this period used this design until OHV or I head took hold.

Generally L-head engines use a small chamber on one side of the cylinder to carry the valves. This has a number of advantages, primarily in that it makes the cylinder head much simpler. It also means that the valve can be operated by pushing directly up on it, as opposed to needing some sort of mechanical arrangement to push the valves down.



It may also lead to slightly easier cooling, as the valves and operating rods are out of the way of the cylinder, making a cooling jacket simpler to construct (but see below). The line of intakes along the side of the engine lead to the name L-head, due to the cylinders having the shape of an upside-down L. This configuration is also known as side valve, as the valves are located be*side* the cylinders.

On the downside, the L-head engine also requires the airflow to make at least a 90° turn to enter the cylinder, which makes it less efficient; colloquially it's said that such an engine has poorer "breathing". Breathing was not greatly emphasized in past production cars because engines could not run long and

reliably at high speed due to other factors. This was a minor concern given the benefits in simplicity.

Early American Motorcycles 1899-1929

As we have seen the first motorcycles used atmospheric F heads, then some British brands adopted the T heads. The first American Motorcycles also used the F head. The intake over exhaust (IOE) or F head valve train layout was used extensively in American motorcycles. Initially a bicycle maker, the Hendee Manufacturing Company was founded in 1897. Oscar Hedstrom made a tandem motorcycle in 1899 for use as pacer for bicycle racing. He and his partner George Hendee started making motorcycles in 1901 as Indian Motorcycles, they were renamed Indian Motocycle Manufacturing Company in 1923. At first Aurora Machine and

1916 Indian side valve “Powerplus” engine

Tool Co. in Illinois built the single engines for Hendee based on the De Dion atmospheric F valves. In 1905 they built a V twin racer and introduced

mechanical intakes in 1908. Indian started making their own engines starting in March of 1907. (Aurora was making Thor Motorcycles). By 1912 Indian had made 32,000 units and was the world's largest motorcycle manufacturer.

Harley Davidson started designing it's first motorcycle in 1901 and produced its first machine in 1903. Ole Evinrude helped them built their first engine. They introduced a V Twin in 1907. Harley was using IOE engines with atmospheric inlet valves until 1912, changing to mechanically driven inlet valves from 1911 to the late 1920s.

Top: 1916 Harley Davison OHV board Racer; Side: 1906 Reading flathead

Indian continued to used IOE valve trains on all of their four cylinder bikes except those built in 1936 and 1937 even after their twins used the L

head. Other American motorcycle manufacturers that used IOE engines include early companies such Excelsior, Henderson and Ace.

In 1906 Reading Standard offered America its first Flat head motorcycle designed by Charles F. Gustafson before he transferred to the Indian Motorcycle Co.

In 1916 Indian Introduced their first side-valve 1000 cc, 42 degree V-twin engine with more powerful and quieter than previous designs, giving a top speed of 60 mph, called the “Powerplus” engine. Shown previous page.

Harley Davidson mostly stuck with the F head except went they went racing. Then they added OHV engines to the fray along with the F heads in 1916. The OHV engines such as this 1917 racer (shown prior page) were fast but in those days they created so much heat they often burned up before the race was run. Harley Davison did produce a flat head, opposed twin flathead called the Model W sport between 1919 and 1923 (shown above). Then also used a flat head on Harley1924 single cylinder Model B, which was produced mainly for export. In 1929 they offered their first V twin Flat Head with the DL model and continued developing Flat Head engines through the K engines. Harley continued to make flat head engines for use in a 3 three wheeler call the Servi-car through 1974.

In 1930, the 74 cubic inches (1,210 cc) VL flathead replaced the JD Big Twin, which had featured intake-over-exhaust (IOE) valve configuration. The VL had a single down tube frame and total loss oiling, culminating in an 80 cubic inches (1,300 cc) version (VLH) in 1935. In 1937, that engine was redesigned to include a recirculating lubrication system, and designated the model U, and it went into the same frame and running gear configuration as the model E Knucklehead, which had originated in 1936. The U continued to be produced in varying configurations as a 74& cubic inch U & UL (1937 to 1948), and 80 cubic inch UH & ULH engine (1937 to 1941). By that time, the first year of the aluminum-head Panhead, it had been thoroughly superseded and outsold in the marketplace by the superior performance of the overhead valve model Big Twins.

In 1952, the K series flatheads was introduced, selling in parallel with the W series (which was discontinued after 1952), designed to compete with British sporting motorcycles of the time, as the American motorcycle Association allowed the 750 cc side valves to compete against 500 cc overhead-valve bikes. The K models featured a

unit construction engine and transmission case, right side foot shift and left side foot brake, and evolved from 45 cubic inch (1952 to 1953) to 55 cubic inches by a 0.75 inches (19 mm) increase in stroke length (1954 to 1956) over its five year retail market run. The K series was replaced by the overhead valve Sportster series in the retail market in 1957. However, racing versions of the 750 cc K model, designated KR, continued to be produced in very limited numbers for some time after, winning both road races and dirt track events against overhead valve bikes limited to 500 cc through 1969, when the American Motorcycle Association finally decided to change the rules and make the venerable flatheads uncompetitive. The K racers were replaced first by the “iron head” XR 750cc with cast iron cylinders was a overhead valve engine with aluminum heads, and two years later later by the alloy cylinder, which continues in service in flat track racing to this day. Not unlike other Harley-Davidson engines, the unit construction left and right engine cases split vertically, and formed four cavities: a center front crankcase, a center rear gearbox, a right side cavity gear case for the timing train, where the four camshafts are housed, and a left cavity for the three row primary drive chain. A row of four camshafts had also been used on the KR racers, inherited from the side valve Model WL, and even earlier Model DL of 1929. While the single camshaft of other Harley-Davidson designs was cheaper to manufacture, and quieter, four cams allowed better performance, such as greater flexibility in adjusting the cam timing, and the short single camshafts are durable, and give the pushrods a straighter path to the rocker arms.

Early Motorcycle manufacturer

America

Ace - 1920 to 1927
American Motor Cycle Co. - c.1909 to c.1913
Black Hawk - 1911 to 1912
Cleveland USA - 1915 to 1929
Crocker - 1936 to 1942
Cyclone - 1912 to 1917
Dayton - 1914 to 1918
E. R. Thomas Auto-Bi - 1901 to 1909
Evans Power Cycle - 1919 to 1925
Excelsior - 1909 to 1931
Flying Merkel - 1901 to 1914
Harley Davidson - 1903 to 1966
Harley Davidson Two-Strokes - 1948 to 1974
Henderson - 1911 to 1917
Henderson (Excelsior/Schwinn) - 1917 to 1931
Indian (Hendee) - 1901 to 1953
Iver Johnson - 1907 to 1915
Marsh Metz & Waltham Mfg. - 1898 to 1921
Marvel - 1910 to 1913
Orient - 1900 to 1903
Pennington 1897 sold to Humber
Perk and birch 1899 sold to singer1900
Sears - 1912 to 1916
Shaw - 1909 to 1914
Waverley (Jefferson) - 1905 to 1915
Yale (Yale-California) - 1903 to 1915

Belgium
FN Fabrique Nationale - 1902 to 1913

Britain
AJS - 1909 to 1974
Ariel - 1901 to 1967 It started as a Bike Co. in 1870. They invented tensioned spoke wheels. Introduced a 1897 tricycle with de Dion engine
Brough Superior - 1919 to 1940
Calvert 1899-1904
Clyde 1898-1912
BSA - 1903 to 1975 started in 1880 making bicycles
Coventry Monette 1898-
DMW - 1945 to 1971
Eadie 1889. Founded Royal Enfield Motorcycle in 1904.
Egli-Vincent & Norvin - 1967 to Present
Excelsior 1874 as bicycle company, motorcycles added in 1896 using Minerva motors. First British motorcycle company
Holden 1898-1903
Humber 1868 as bicycle company. 1896 motors added using de Dion engines
Ixion - 1913 to 1920s
J.A. Prestwich (engines only at first) - 1895 to 1969
James - 1902 to 1966
Lea-Francis - 1912 to 1924
Levis - 1911 to 1940
Matchless 1899 to 1966 founded by Collier family. Bicycles with de Dion engines until 1902
Norton 1898 to 1975 started as bicycle company. Motors added in 1901 using a French Clement engine (under license from de Dion)
Ok Supreme bicycles since 1882. Motors added in 1899
Releigh 1899-1906 used a Schwann engine
Premier Cycle - 1908 to 1923
Riley 1870 bicycle maker. 1899 added motors
Royal Enfield - 1901 to 1970 1899 using Minerva engine. 1892 started as bicycle company.
Rudge - 1909 to 1939
Sopwith ABC - 1914 to 1923
Sunbeam - 1912 to 1956
Stafford - 1898
Star - 1898-1914
Triumph - 1902 to 1983
Velocette - 1904 to 1971
Vincent HRD - 1924 to 1955
Stevens engines only – 1897 became JAP
Beeston cycle trike 1896, motor bike 1897

Czechoslovakia
Jawa (CZ) - 1929 to Present
Orion - 1902 to 1933

Czechoslovakia
Orion - 1902 to 1933

France
de Dion-Bouton (engines) - 1889 to 1902
Peugeot - 1902 to Present
Clément and Gladiator
From 1895 Clément cycles started to focus on motorized vehicles. In 1895 it introduced its first internal combustion vehicle, a naphtha powered tricycle. In 1902 they offered a motorized bicycle with a 142 cc engine bolted to the frame, using overhead valves and a detachable cylinder head; the inlet valve 'automatic' (controlled by engine suction), the exhaust valve mechanically operated. A coil-and-battery ignition was used, and a two-barrel carburetor controlled by small levers attached to the frame top tube. An external flywheel kept the crankcase very small, and a long belt from the engine pulley to a 'dummy' rim on the rear wheel was tensioned by a small 'jockey' pulley on the seat tube. The front brake pressed direct on the front tire, the rear was a 'coaster' brake activated by back-pedaling. This 'motorisation adaptation' was sold on both Clément and Gladiator cycles. Clément-Garrard was In Britain these popular motorised cycles were known as Clément-Garrards. James Lansdowne Norton built Clément bicycle frames under license, and used the Clément clip-on engine for his first Norton motorcycles.

Engine makers

DeDion Buton
Minvera
Stevens
Ateliers de Construction Mecanique l'Aster