Internal-Combustion Cam Engines.

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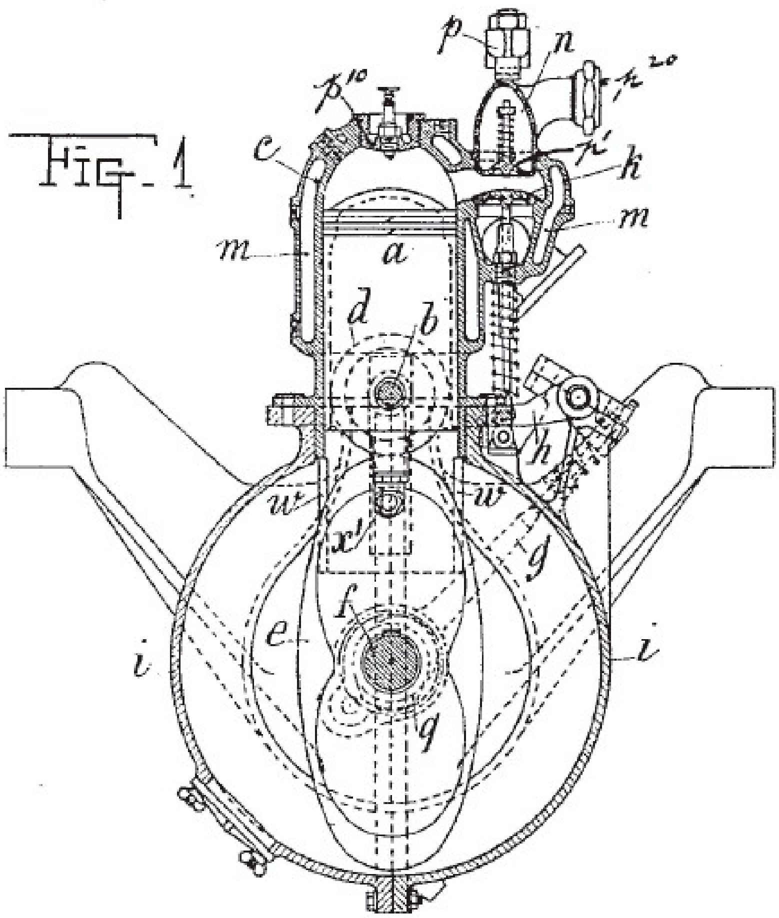
Updated: 4 Nov 2008
Michel cam engine animated

Cam engines do not have conventional connecting rods and cranks, but instead rollers bearing upon cams to convert the piston thrust into rotation. This gallery only shows engines that have this cam mechanism as their *main* unusual feature.

Other cam engines, such as The Sparost Cam Engine or the The Dynacam Enginecan be found on The Axial engine page.

No IC cam engines have achieved any sustained success so far.

THE DANIEL CAM ENGINE: 1906



Left: The Daniel cam engine patent: US 817,905 of 17th April 1906.

This French engine by Paul Daniel of Levallois-Perret, near Paris, is the first to appear in the Cam-Engine Gallery because it was the subject of quite a comprehensive description in *Model Engineer & Electrician* for 28th April 1904. It is described as having been exhibited in "the last few days of the Paris salon", which possibly refers to the Exposition Universelle of 1900 in Paris, though that it would seem to indicate a pretty serious delay in reporting the fact. Perhaps some other exhibition is meant. The report did not say if the engine was running.

There is a big roller ***d*** built into the bottom of the piston ***a*** which pushes on the top of the big elliptical cam e, and a little roller ***x'*** which bears on the inside of the cam. There is an automatic inlet valve ***p'***, and an exhaust valve ***k*** operated by rocking lever ***h***, which is driven by an eccentric on the main output shaft; since this went round once per cycle, there was no need for a separate cam-shaft running at half engine speed.

The Daniel engine was a water-cooled four-stroke, the cam system allowing it to complete one cycle for each revolution of the output shaft. The patent shows a four-cylinder engine with two groups of

cylinders and cams, and air-spring cylinders to take up the backlash in the cam system.

From US Patent 817,905 of 17th April 1906

The "Daniel" Petrol Engine, in which elliptical cams replace the cranks on the main shaft, and no connecting-rods are employed, brought out by the Société des Etudes Mécaniques, was exhibited during the last few days of the Paris Salon. The engine has four cylinders, which are mounted vertically in pairs above the crank chamber. These cylinders are fitted with the usual valves and igniters, and they work on the four-stroke cycle. The curious feature of the Daniel engine is that the pistons are fitted with small rollers instead of with connecting-rods, and that the shaft beneath them has elliptical cams with which the rollers engage. One roller presses upon the outer surface of its cam, and the other runs beneath the projecting face of the cam, and lies inside it. The peculiarity of this arrangement is that each of the cylinders performs a complete cycle (the four usual operations) during every revolution of the main shaft, so that each piston gives an impulse to the shaft during each revolution, although the impulse extends over a quarter of a revolution only; in other words, each piston reciprocates downwards and upwards twice for each revolution of the shaft.

When a piston is being forced downward by the explosion, its roller—which rests upon the outer surface of its elliptical cam—forces the shaft round through a quarter of a turn by pressing upon it. During the next quarter turn, the cam pressing against the roller forces the piston upward, expelling the exhaust gases. For the suction stroke which follows, the cam would have to draw the piston downward by engaging with its other roller, which is inside the rim of the cam, and thus any lost motion between the two rollers and the rim of the cam would cause objectionable free play, but for the fact that the pistons are connected with small pumps lying alongside the cylinder; these pumps form air cushions, which tend to keep the upper rollers in contact with the cams during the suction stroke of the pistons. The suction stroke, of course, is complete during a quarter revolution of the shaft and, during the remaining quarter turn of the shaft, the cam forces the piston upwards once more, compressing the charge in just the same way that the exhaust stroke was performed during the second quarter turn.

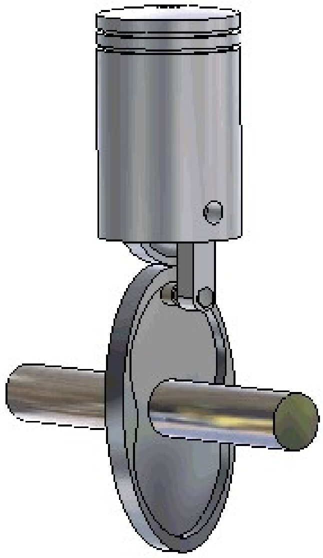
The cams for each pair of cylinders lie parallel with one another, and the two sets of cams are placed at right angles to one another. By this arrangement, therefore, it is possible to connect the pistons in each pair of cylinders together—although we are not clear as to whether this has actually been done—and thus cause the working stroke of the one piston to correspond with the suction stroke of the other, still further ensuring an absence of free play between the pistons and the cams, by rendering the lower and inner rollers inoperative under normal running conditions.

The net result gained by this arrangement is that, for the same piston speed, the engine shaft revolves at half the speed that it does with an ordinary engine, and that an equivalent effect is, therefore, ensured to that of gearing down in the ratio of two to one, but without any gear wheels. It is difficult to foresee whether any actual increase in the output of such an engine would be obtained, because the power developed in ordinary petrol engines is limited largely by the weight of the reciprocating parts, and we do not know whether the reciprocating parts in the Daniel engine can be made lighter than usual. The direct claim, however, which is made for it is that there are no connecting-rod bearings to run hot or to require adjustment. The weak point in the engine, of course, is the tendency for play to occur between the cams and the two rollers on each piston, and this is the real reason why the pumps alongside the working cylinders are provided. These pumps are also utilised for forcing air into a pressure drum, so that the engine can be started at any time, without manual effort, by using the energy thus stored up for the purpose.

The inlet and exhaust valves are operated by eccentrics, which are mounted between each pair of cams on the main shaft, for it will be noticed that no additional cam shaft is needed, since the main shaft runs at the speed of the cam shafts on an ordinary petrol engine. The commutator is mounted on the forward end of the shaft outside the crank chamber, and a centrifugal governor is mounted close up to the flange to which the flywheel is bolted at the other end. Strictly speaking, a flywheel of twice the usual size is, of course, needed.

This particular engine is of 80 h.-p., and its range of speed is said to be from 80 to 1000 revolutions per minute. It can be built with two cylinders instead of four, and for any power between about 8 and 100 h.-p. At present it is intended to manufacture twin-cylinder 12 h.-p. and 4-cylinder 16 and 20 h-p. models. The car will only have two speeds and a reverse, the forward speeds giving about 42 and 84 miles an hour, respectively. The car will have a wheel base of 14 ft. 9 ins., and the track will be 4 ft. 9 ins. An armoured wood frame will be used, and the engine and the change-speed-gear fixed direct to it.—*The Automotor Journal.*

Above: The Daniel cam engine as described in *Model Engineer & Electrician* for 28th April 1904.



Left: The Daniel cam engine in action.

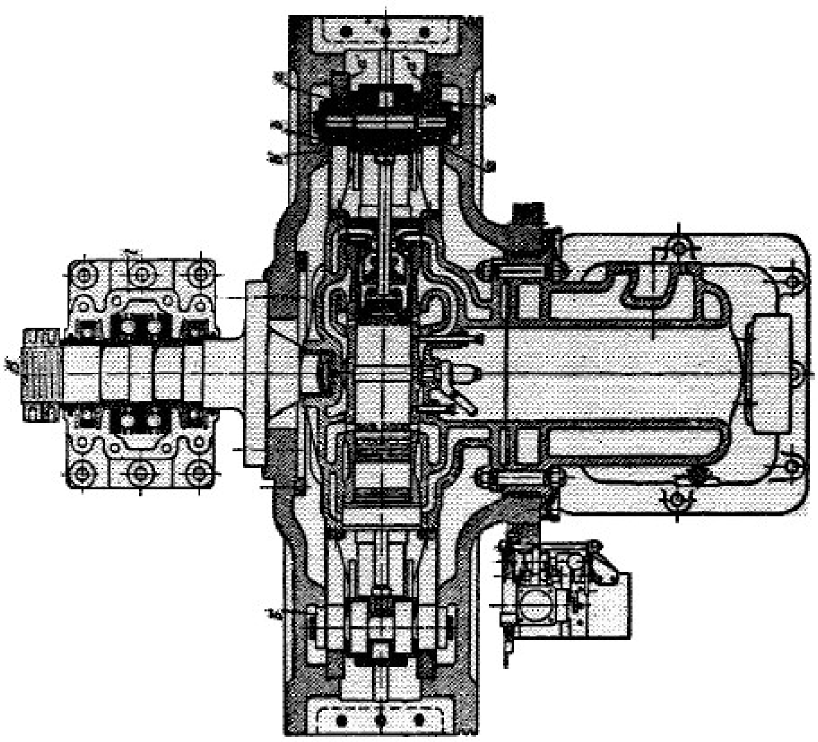
Note how the thickness of the cam rim has to vary as the angle it makes with the cam rollers alters.

Another fine animation by Bill Todd

THE GERMAN MICHEL CAM ENGINE: 1921

This cam engine has no connection beyond a coincidence of names with The Michell swashplate engine of 1920, which worked on a completely different principle. I have referred to this one throughout as The German Michel Cam Engine to underline the point.

The original documentation and the drawings are unfortunately neither as clear as they might be.

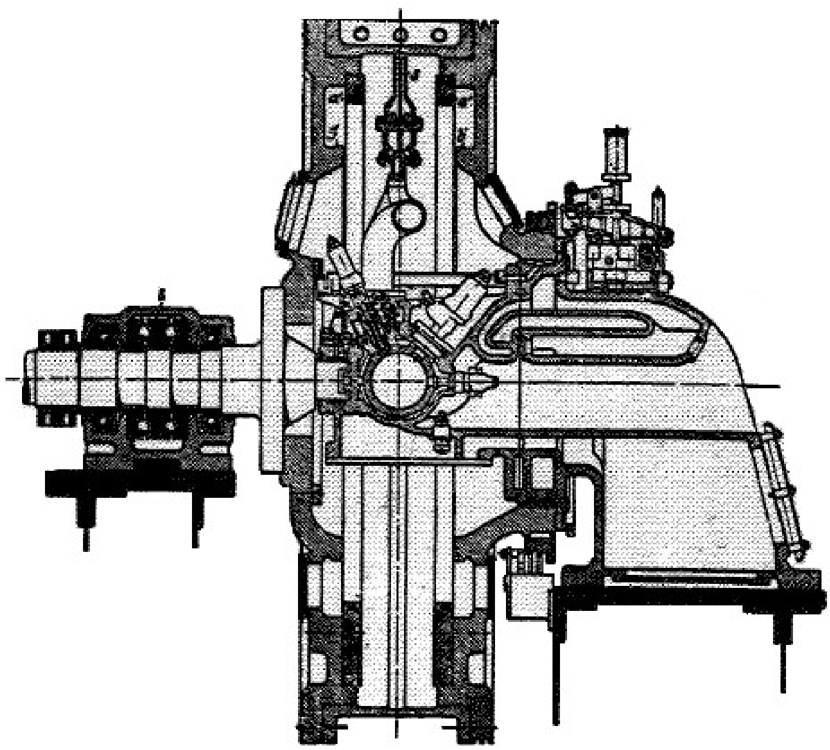


Left: The German Michel Cam Engine: 1921

This engine was produced by the Michel Engine Company of Kiel, in Germany. It was a water-cooled two-stroke Diesel with three radial cylinders 120 degrees apart. The three cylinders shared a commmon central star-shaped combustion chamber, with the cam on the outside of the cylinders. The NACA report says the three cylinders revolved along with the fuel injection pump, while the cams and housing stayed stationary, but a look at the Michel patent shows the cam rotating around the outside.

To quote from the NACA report: "The introduction of fuel, lubricating oil, and cooling water into the revolving cylinders is said to cause no difficulty." Oh really? Was there a version where the cylinders did rotate? Confusing.

From NACA technical memorandum No 462, translation of *Motorwagen* Nov 20, 1927
Original source: *Zeitschrift Des Vereines Deutscher Ingenieure* (The magazine of the Association of German Engineers) p1405, 1925



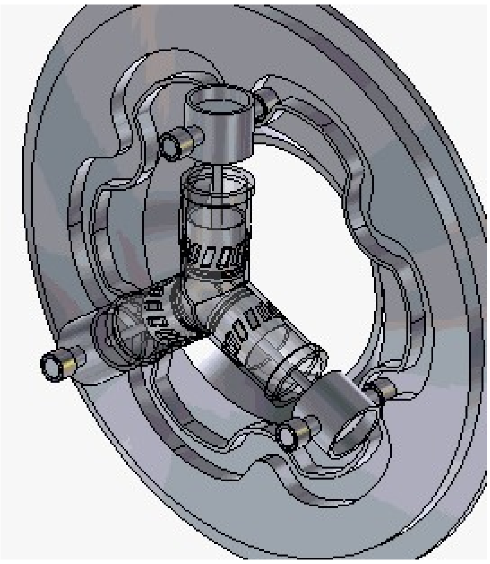
Left: The German Michel Cam Engine: 1921

To quote from the NACA report again: "The cam shape is so constructed that the pistons execute four or six working cycles per revolution of the star-shaped cylinder, thus automatically reducing the engine speed, (for example), from 660 to 110 rpm, which is of considerable importance in marine installations. In spite of this, a proposed Michel engine of 1000 HP with a propeller shaft speed of 120 rpm, weighs about 42,000 kg, as against 128,000 kg for a four-stroke-cycle Diesel engine of 1000 IHP at 135 rpm; that is, the Michel engine with 50 to 60 kg/HP, is nearly twice as heavy as a submarine Diesel engine which weighs 25 to 30 kg/HP at 350 to 450 revolutions per minute."

The above doesn't much sense unless you assume that the two weights have been swopped by the original author, or more plausibly, that an unwanted 1 has crept in front of 28,000 kg.

"Whether the poor accessibility of the inclosed Michel engine with its revolving fuel pumps and nozzles; will give any trouble in an endurance test , and whether (especially in the case of the large units of the Michel engine) it is off-set by the saving in volume and weight, is still to be proved. In the recently built engines the roller bearings in the crossheads are said to be replaced by plain bearings, evidently due to difficulties with the rollers."

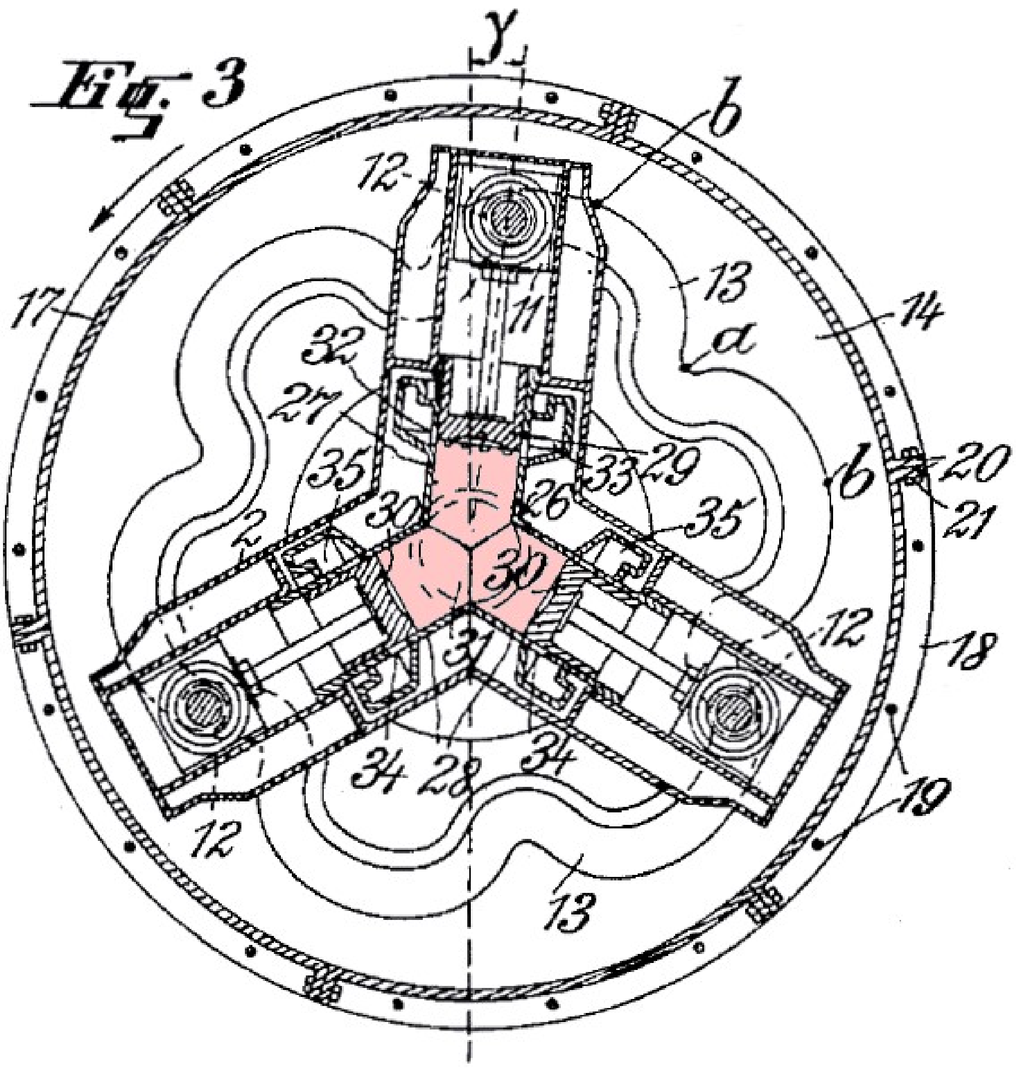
From NACA technical memorandum No 462, translation of *Motorwagen* Nov 20, 1927
Original source: *Zeitschrift Des Vereines Deutscher Ingenieure* (The magazine of the Association of German Engineers) p1405, 1925



Left: The Michel Cam Engine animated

If you find the drawings less than clear (and they seem to have defeated the the original author of the document) this should make all plain.

Animation by Bill Todd; another gem.



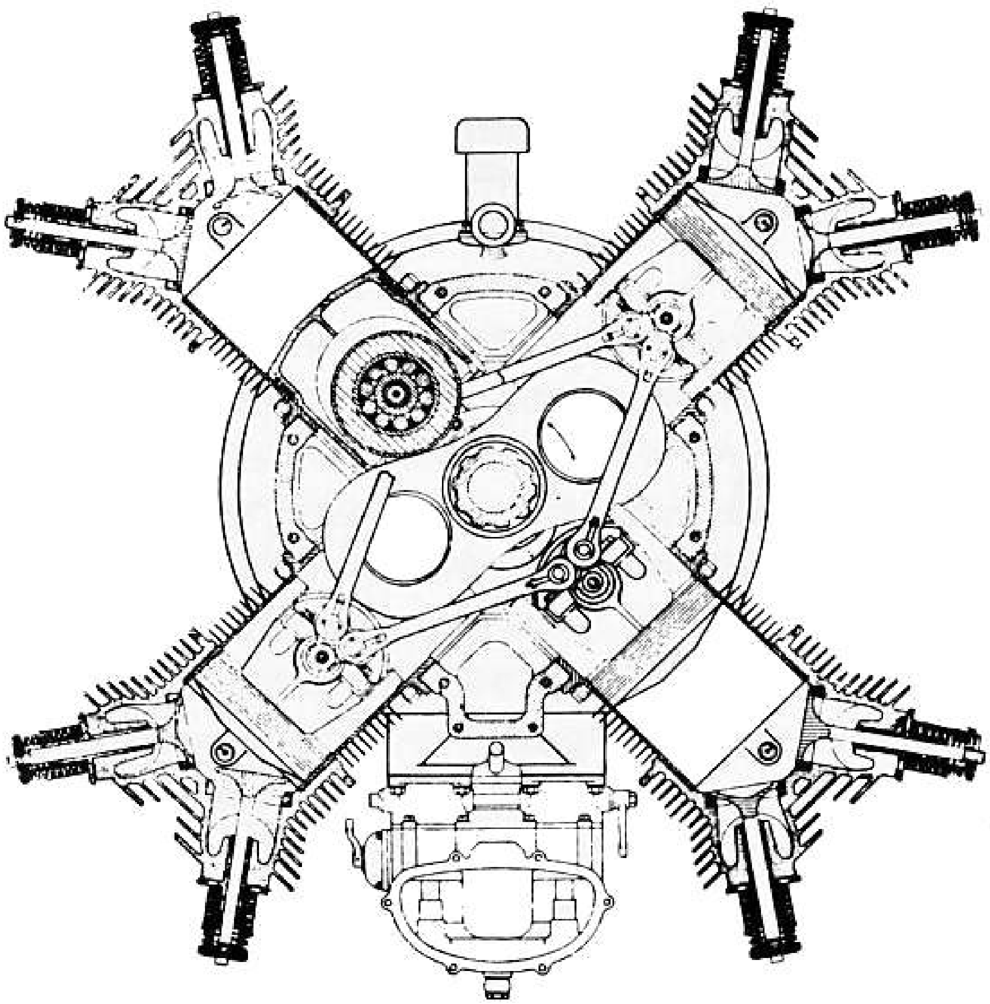
Left: The Michel Cam Engine patent: 1921

The inlet ports in the lower two cylinders carry scavenging air into the combustion chamber. The upper cylinder has the exhaust ports. The exhaust cylinder is canted over a few degrees in advance of the inlet cylinders, (the angle shown as gamma) to allow the exhaust port to open before the inlet ports (to decompress the combustion chamber prior to scavenging) and to allow the inlets to close after the exhaust. (to allow a small amount of super-charging)

The combustion chamber is here coloured a tasteful shade of pink.

From the Michel patent of 1921 (No 1,603,969)
Text by Bill Todd

THE FAIRCHILD-CAMINEZ CAM ENGINE: 1926



Left: The Fairchild-Caminez Cam Engine: 1926.

The Fairchild-Caminez 447 engine was a four-cylinder air-cooled radial intended for aircraft useage. It was designed by Harold Caminez, who had previously worked in the Engine Design Section of the US Army Air Service. The pistons acted on a leminiscate-shape cam, which made only one revolution for every two piston cycles, so for the same number of power impulses the engine ran at half speed. The pistons were connected by steel links to keep them pressed against the cam; the cylinder were steel with aluminium heads. The Fairchild-Caminez 447 was first flown in an Avro 504 from Farmdale, Long Island, New York, in 1926. It was successfully endurance-tested in 1927, and was the first ever axial engine to receive a US Dept of commerce type certificate.

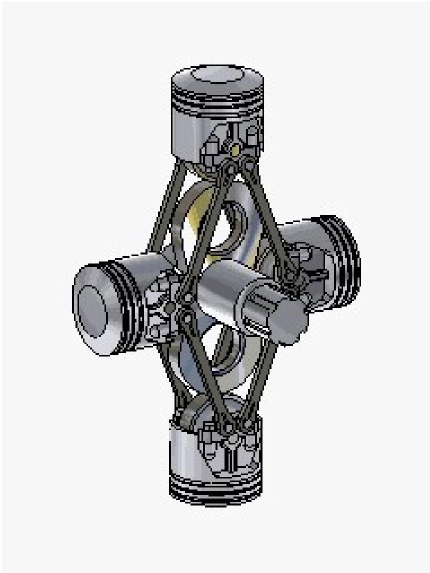
An IC engine expert speaks:
"Flight tests revealed what should have been predicted: a very large fourth-order torque variation due to the unusually heavy piston assemblies with their large ball-bearing rollers. Since the cam had two lobes, the second-order interia torque of the conventional 4-cylnder engine becomes fourth order in the arrangement in question. The engine was abandoned on this account."

(Quote from *The Internal-Combustion Engine in Theory and Practice* by Charles Fayette Taylor, 2nd edition, pub MIT press 1985, p579. This is a standard work on IC engines)

It was indeed abandoned due to vibration problems in 1929.

Stroke:	**115 mm**
Bore:	**143 mm**
Capacity:	**7.3 litres**
Compression ratio:	**5.2**

Power:	**150HP at 2400 rpm**
Flying weight:	**164 kg (1.1kg/HP)**
Output/volume:	**20.5 HP/litre**



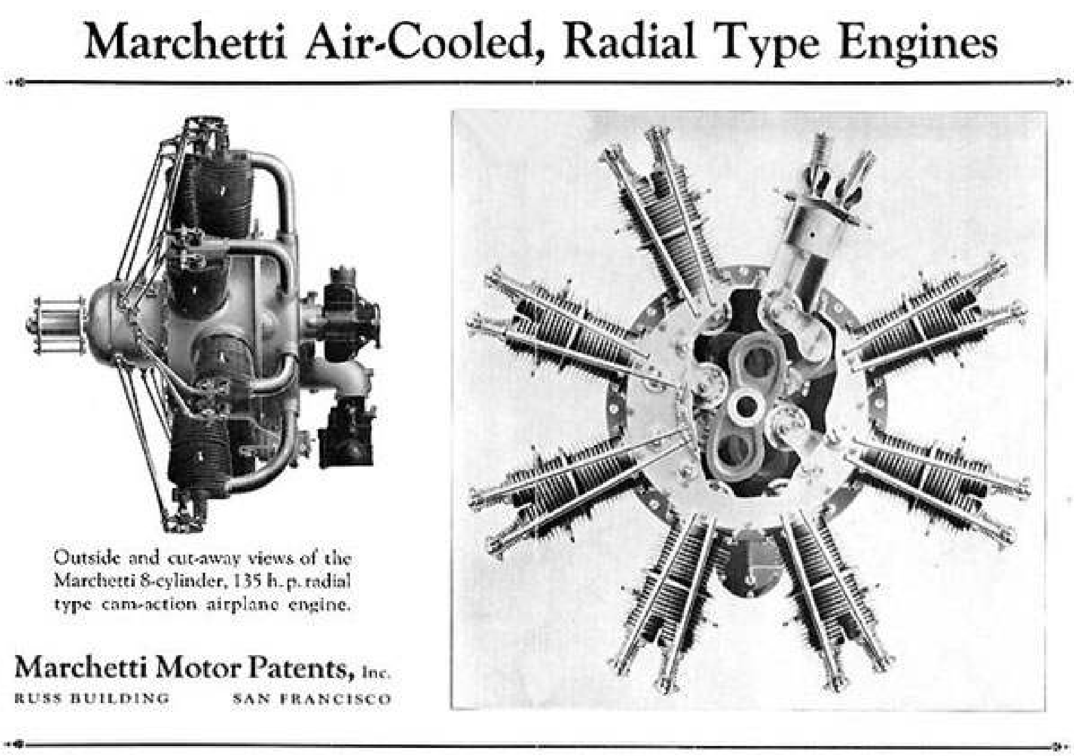
Far left: Advert for the Fairchild-Caminez Engine

Left: The Fairchild-Caminez Engine animated.

Another fine animation by Bill Todd

Data on the Fairchild-Caminez engine mostly from NACA technical memorandum No 462, translation of *Motorwagen* Nov 20, 1927: original source was *Zeitschrift Des Vereines Deutscher Ingenieure* (The magazine of the Association of German Engineers) p1405, 1925

THE MARCHETTI CAM ENGINE: 1927



Left: The Marchetti Cam Engine

This 8-cylinder radial cam engine appears to have had two cams 45 degrees out of phase, both driving rocker arms that could pull and push on each piston. Not much known at present.

But surely a radial engine has to have an odd number of cylinders to get even firing angles? Not in this case. As Bill Todd points out: "A cam engine fires every 360 degrees, so a two, four or eight will give 180, 90 or 45 degrees between firings and can be evenly spaced in a circle."

Only one prototype was made, for Paul Marchetti of Marchetti Motor Patents Inc, Mills Field, San Bruno, Calif. Marchetti took out US patent no. 1654378 for cam engines in December 1927. It does not show the engine in the form it appears here.

It appears that a highly modified Cessna AW with monocoque fuselage and lengthened wings was built to accept the prototype engine, but Paul Marchetti was killed in a crash during flight training. Keith Rider, who had been one of Marchetti's employees, acquired the company in 1930, and then sold the property and assets to United States Aircraft Ltd. of San Francisco, later in the same year.

Start Stop

Left: The Marchetti Cam Engine animated! Click on buttons to start/stop.

Note that the bell-crank cam followers are pivoted on arms that move the pivot point inwards.

Animation by Bill Todd, who's come up with a beauty here. Javascript must be enabled for buttons to work.

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