

## The Three Phases of the Three Cylinder Automobile Engine

While studying the history of the twin cylinder engine I realised that today the alternative to the twin cylinder small capacity engines is not as it was in most of the twentieth century a fussy four, but a gasoline three-cylinder four-stroke unit. The high tech one litre three cylinder four stroke engine is now in fashion, as engineers have been able to produce refined units with excellent economy and low emissions.

I have long been aware of the three-cylinder two-stroke engines of middle of the last century, but was surprised to also discover a brief period at the beginning of that century with numerous producers of four-stroke three-cylinder power cars.

I wrote the following paragraph as a summary at the end of my article on The Evolution of the Modern Ultralight Economy car. It occurred to me that it would also serve as an introduction to this article.

*An engines configuration is a compromise between cost of manufacture, weight and refinement and for the first fifty years of the car ultralight economy cars usually had a twin cylinder engines at the cheaper end of the range and four cylinder engines at the more expensive end with some exceptions; but from the nineteen forties there emerged the two stroke triple.*

*First produced in Germany and then in Sweden and later by Suzuki in Japan who after producing two stroke twins began producing two stroke triples. At the beginning of the twentieth century there was a short lived fashion for the four stroke inline three cylinder engine; but I cannot find any evidence of an engine of that configuration until Daihatsu began producing their CB10 engine as fitted in the 1977 Charade. Suzuki converted from the two stroke triple to the four stroke triple in 1981 with their F5A 543 cc engine and the F8B 796 cc engine both being fitted in the Alto. The change was necessitated by their inability to meet the future emission standards required, using the two stroke engine then in production. Daihatsu went on to extending their range of triples with the 550 cc EB in 1985, the 850 cc ED in 1986, the 660 cc EF in 1990 and the 989 cc EJ in 1998, the Toyota 1KR-Fe is also a Daihatsu design. As Daihatsu and Suzuki designs dominate the ultralight car sector and are the bases for Maruti, Perodua and the early Daewoo models as well as supplying engines for other makes, the inline four stroke three cylinder engine is now almost universal in this sector. But the situation has moved on since then as the following will shown.*



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Daihatsu Mira

## The First Phase of the Three

This began in 1904 and was all over by 1908. The following information on some of these cars has been gleaned from Graces Guide.

### THE CRYSTAL PALACE MOTOR CAR SHOW



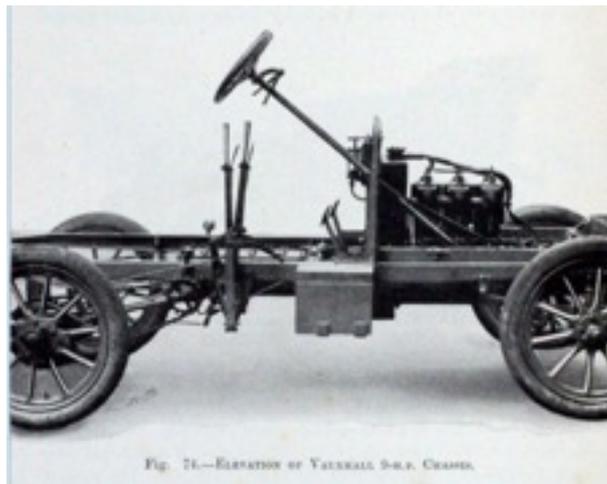
29 TH January to 6 TH February 1904

The Belsize Company also showed a 16-20 horse-power car, in which the power is furnished by a three-cylinder vertical petrol engine, with mechanically operated valves, the lift of the inlet valves being variable. The valves are operated by two cam shafts running down each side of the crank case and driven by two gear wheels, outside the main crank chamber, but enclosed in a separate chamber on the front of the engine. The admission cam shaft is arranged so as to slide longitudinally, and the cams are stepped down in such a manner that the lift of the inlet valves can be altered at will. This can be regulated from the steering post by a small lever, enabling the engines to be run quietly and economically. Each cylinder is cast separately, and the valves, as in the smaller car, are placed on top of the cylinders. The crank shaft is now of nickel steel, instead of being built up as formerly. The crank case is constructed in two pieces only, and so arranged that the lower half can be removed without disturbing the crank shaft and bearings. When at any time it is necessary to take out the crank shaft and pistons, it is sufficient to remove the lower half of the crank case; take the bottom caps off the main crank bearings, and the whole shaft, connecting-rods and pistons can be let down, leaving the top portion of the crank case, cylinders and valve mechanisms intact, and the bedding down of the engine undisturbed. The electrical ignition device is such that all three cylinders are worked from one trembler coil, ensuring uniformity of firing for each cylinder. The commutator is fitted to the dashboard, and has only one platinum-pointed adjusting screw for all three cylinders.

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The Duryea car, which, although of American origin, is now being made in this country for the Duryea Company, Coventry. The Duryea carriage differs in its essential features from any other car on the market. It has a three-cylinder inclined engine, with simple, interchangeable, mechanically operated valves. The diameter of the cylinders is 4.5in. On the top speed the engine drives a live rear axle direct by means of a single chain, but on the two lower speeds, and for reversing, an ingenious system of epicyclic gearing on the main axle is brought into use. The new cars are also fitted with an improved automatic governed carburettor and throttle, which, it is claimed, gives the correct mixture of gas and air, and prevents racing. The ignition is effected by means of a high-tension magneto



apparatus and ordinary sparking plugs, which gives a firing spark at the slowest speeds.

THE VAUXHALL IRONWORKS CO., LTD London.

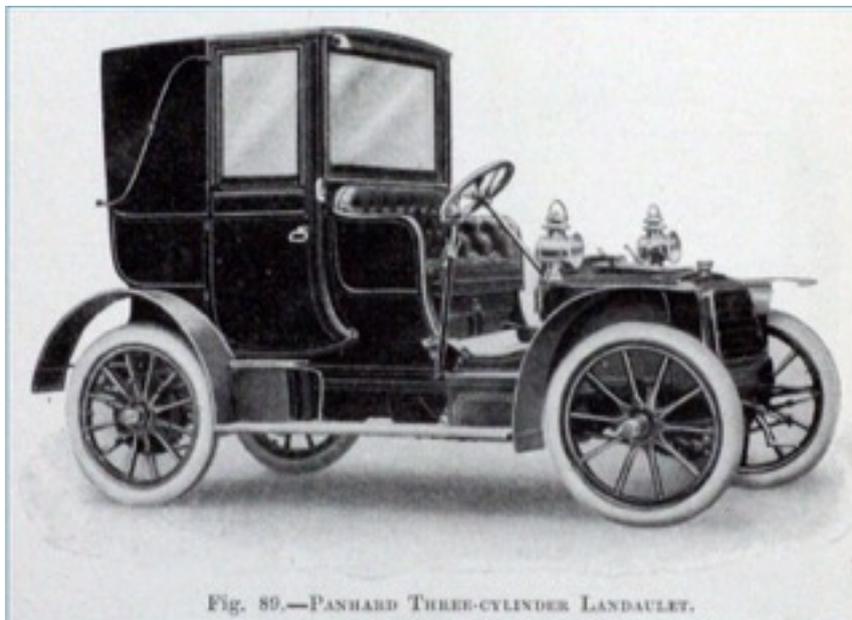
The three-cylinder Vauxhall is now the standard and only pattern turned out by this firm. We dealt with it so thoroughly in our issues of Nov. 12th and 19th last that we cannot do better than refer our readers to these numbers for a description. We may say, however, that the car follows modern ideas in the matter of pressed steel frame, and accessibility, combined with the protection of parts against mud; And dust. A new model on the same lines has been introduced; it is of A 7 h.p. This is particularly well adapted for doctors' use, and a very nice specimen of such a vehicle is with a Cape cart hood and front screen, and is sold complete with lamps, etc., at a really moderate figure. Another car is on tonneau lines, Baal the rear seat entrance is from the front, the left-hand seat being movable for this purpose. The back seat is of considerable width, and below it is an extensive locker, which can be got at from behind the car without disturbing the passengers in any way. Both the 12 h.p., and the 7 h.p. cars displayed certainly show a considerable advance on anything the company have hitherto done.

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Clyde.

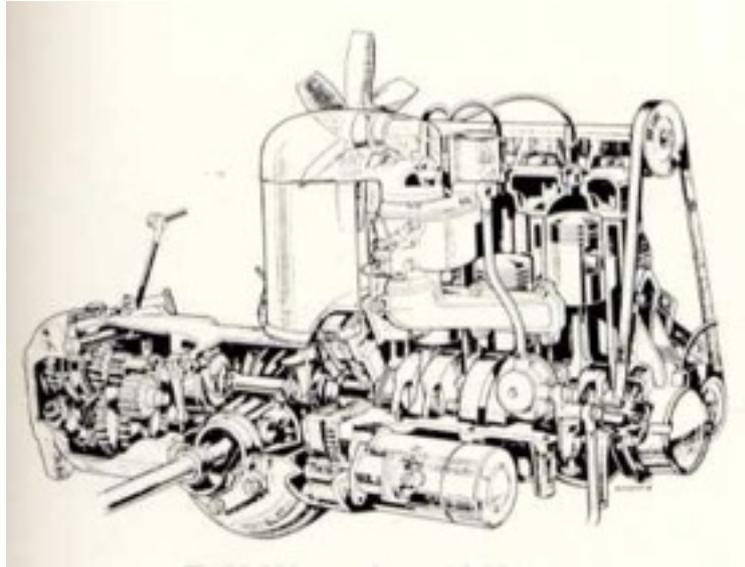
Direct drive, or a drive as nearly direct as it is possible to obtain it in motorcar construction, has been a feature of Clyde cars for the last ten years, which is a guarantee that it has been found successful, and its retention in the 1909 models was therefore to be expected. In order to obtain this drive the engine is set athwart the frame. The two, three and four-cylinder types, an example of each of which is shown by G. H. Wait and Co., of Leicester, on Stand No. 141, in the Annexe, are all constructed on these lines. Under the bonnet, fitted in front of the dashboard, as in the ordinary type of car, the engine is suspended transversely from two cross-members, the flywheel being fitted on the off side. Between the latter and the crankcase is the sprocket for the Hans Reynold chain that drives directly to the primary shaft of the gearbox, which forms part of the rear axle casing.

Panhard built a wide range of cars in the early 1900s, including a 1.8-litre three-cylinder 8/11 cv.



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## The Second Phase of the Three The Two-Stroke Phase

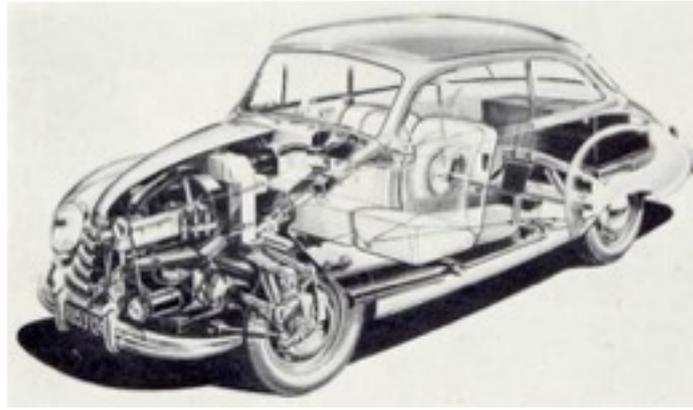


The originator was the DKW F-9 with a 900cc water-cooled two-stroke three-cylinder engine, was at the preproduction stage in 1939., but before production could commence it was shelved due to the demands of war material production. The DKW was part of the Auto Union group of companies and the DKW and Audi factories was at that time in the town of Zwickau in the German State of Saxony. The engine was mounted longitudinally ahead of the front axle, with the front wheel final drive between it and the gearbox behind, in the same layout as used by Audi to this day.



The first to be produced after the end of the Second World War, the Auto Union factories in the town of Zwickau was now in East Germany, The DDR part of the Soviet Block. The work on the F-9 was put to good use in 1950 when the first car were produced at the Audi factory to those designs as the IFA 9. Production was later moved to the ex-BMW plant at Eisenach also in the DDR. Over forty-thousand were produced before production ceased in 1956.

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After losing all their factories in East Germany, The Auto Union management had re-established themselves in West Germany and by 1950 were begin car production. In 1953 they produced the first DKW Three the F-91 Sonderklasse, based on the design of the F 9. It was produced until 1959 in various body forms as the F 93 the F 94 and the Monza Sports car. The next East German model the Wartburg 311/312 in production from 1955 to 1966, was based on the F-9 underpinning with a 900cc engine and a stylish new body and was made at the ex-BMW factory at Eisenach. The final Wartburg models the 353 and Knight were produced between 1966 and 1988.

DKW began producing a military model the F-91/4 Munga. in 1955 for the West German army. There were two design departures from previous models, in that its three cylinder engine was mounted transversely ahead of the front wheels and the vehicle had four wheel drive.

The first Saab three cylinder engined car the 93 similar in concept to the F-9, but was a totally original design in every detail. Produced from 1955 to 1960, it had a 750cc two-stroke engine. The second Saab Three the 95 had a 841cc engine also an estate body and was made from 1959 to 1968. The last two-stroke engined model the Saab 96 was restyled 93 with the 841 cc engine and was in production from 1960 to 1968. The final Saab Three the Sports Monte Carlo model with a 841cc engine was in production from 1962 to 1968 also The first few hundred examples of the Saab Sonnet were fitted the two-stroke three cylinder engine as fitted in Saab Monte Carlo. Between 1956 and 1968 Saab made over six hundred thousand three cylinder cars.

DKW produced a prototype Junior in 1957. A 700cc twin cylinder engine was specified, but when the Junior reached production in 1959 it had a 741cc three cylinder engine in an inline layout. It was a small version of the F 91. The F 91 had evolved through the F 93 with a slightly larger engine, to become the Auto Union 1000, now with a 980cc engine. The Junior which increased in overall size and engine capacity to 890cc as the F 12, was made from 1963 until 1965.

Berkeley manufactured caravans in GRP at their factory in Biggleswade England. The company decided to enter car production with an unorthodox roadster designed Laurie Bond. Bond had designed a number of unusual micro cars that were produced in Britain. The Berkeley car had a GRP monocoque chassis/body, front wheel drive using motorcycle components and at first a 322cc two-stroke engine. Between 1958 and 1959 an other engine options were available for the SE492 model, that had a 492 cc air-cooled three cylinder two-stroke engine Excelsior motor cycle engine. Production was only of the order of 666 units.

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The last of the European three cylinder two-stroke engine cars was the Polish produced **FSO Syrena 104**. The original Syrena had been produced with twin-cylinder since 1960 and in 1966 an updated model that had a three-cylinder two-stroke engine with a capacity of 843 cc that was also later produced by FSM in Warsaw. Between then they produced over half a million Syrena by 1983. By then the two-stroke triple had been adopted by the Japanese motor industry.

Suzuki produced a model in 1964 to compliment the Suzulight SF, the Front 800. It was a front wheel drive saloon with a unitary body/chassis fitted with a 785 cc three-cylinder two-stroke engine that produced 41 hp, a four speed synchromesh gearbox and independent suspension front and rear. Only three-thousand had been made when production stopped in 1969 to concentrate Kei car production.

In 1967 Suzuki replaced the Suzulight with the Fronte 360 LC10, it had a rear mounted lightweight three-cylinder air-cooled two-stroke engine the produced 25 hp that gave it a maximum speed of 110 km/h and was produced until 1970.

In 1976 Suzuki introduced two new Kei cars the **Cervo** SS20 a two seat rear engine model and the Front 7-S a four seat also with a rear engine both with a three-cylinder inline two-stroke engine, The Front initially with a 443 cc version later sharing the 539 cc version with the Cervo. Export versions of the Cervo as the SC100 were fitted with a four-cylinder water-cooled overhead camshaft engine of 797 cc or 970 cc. The Front 7-S was produced until 1979 and a later version of the Cervo the SS40 until 1990.

Suzuki introduced the first in the line of Fronte/Alto models the SS30/40 in 1979 and produced it until 1984, it had the T5B 539cc three-cylinder two-stroke engine at first.



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## The Third Phase The Second Four-Stroke Phase



The first of a new breed was the 1977 **Daihatsu Charade**, fitted with the first of the CB series engines, the CB10 of 993cc. The Daihatsu Charade was a new front wheel drive model with a new three-cylinder belt driven overhead camshaft engine the Daihatsu C series engine of 843 cc or 993 cc. Japanese Car of the Year in 1979 and was made with successive revisions from 1977 to 1993. It was assembled from kits in many countries around the world.

In 1981 Suzuki replaced the two-stroke engine in the Alto SS30/40 by a 543 cc single overhead camshaft three-cylinder four-stroke engine the F5A. The engine was transversely mounted at the front driving the front wheels that were sprung by coils struts the rear axle being dead beam located and sprung by leaf springs. Export versions of the Alto had 796 cc version of the same engine the F8B and was also in production in India by Maruti as the 800 model.

1982 Innocenti fitted their Mini with a range of Daihatsu three cylinder four stroke engines, including the 548 cc Daihatsu EB I3, the 617 cc Daihatsu AD I2, the 659 cc Daihatsu EF I3, the 993 cc Daihatsu CB22 I3, 993 cc Daihatsu CB-DT/CB60/61 turbo I3 and the 993 cc Daihatsu CL10 diesel I3.

1983. The Subaru Justy was a front engined front wheel drive later four wheel drive hatchback and the Subaru Sumo rear engined rear wheel drive later four wheel drive micro van. Both were fitted with the Subaru EF10 of 997cc, or the EF12 of 1189cc. Both single overhead camshaft, water-cooled, three-cylinder units. This version of the Justy was produced from 1984 to 1994 and the Sumo from 1983 to 1998.

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The Suzuki SA310 was a front wheel drive car and had a 993 cc three cylinder overhead camshaft engine. It was assembled in seven countries around the world and sold with many names such as **Suzuki Swift**, Cultus, Khyber, Forsa, Holden Barina in Australia, Chevrolet Sprint/Sprint Metro, Pontiac Firefly in Canada, Isuzu Geminett in Japan and was in production from 1983 to 1988 in its first version.

1984. The Mitsubishi Minica/Econo was a front wheel drive car, it had a 546 cc single overhead camshaft three cylinder engine the 3G81 and was revised in 1989. In 1990 it was revised as the 647cc 3G83.

1985. Daihatsu began fitting a range of three engines in the **Mira L 70** They were the EB10 of 547cc, the ED-10A of 798cc, and the ED-10 of 847cc.

1985. The Suzuki Cultus was fitted with the 993cc G10 engine.

1988. Honda produced their first four stroke triple the engine the E07A 547 cc fitted in the Today And Acty models, from 1988 to 1990, and the 656 cc E07A engine was fitted in the Today, Life Acty Beat and Z.

1993. GM Europe produced their first three cylinder four stroke engine the 1 litre X10XE that was fitted in the Corsa B of 1993 to 2000, and is available in the 2012 Adam.

1994. The Daihatsu EF of 847cc engine was fitted in the Mira I50V? between 1994 to 1998 and Perodua used the Daihatsu ED-series

1999. The Honda ECA1 1 litre engine was fitted in the Insight hybrid from 1999 to 2006.

2000. Models that had been superseded in Japan were being produced all over Asia by local companies for local consumption and in some cases export, for example In India in 2000 production began of the Maruti Alto, based on the fifth generation Alto, with the 796 cc Suzuki F8D engine, becoming India's best selling hatchback,

2001. Perodua produced the Kalisa which was based on the L 700 Mira and in 2007 the Viva, based on the seventh generation of the Mira, produced with engine capacities ranging from 659 cc to 989 cc.

2003. Mitsubishi produced in conjunction with Daimler-Chrysler the 3A9 series of engine. They were fitted in the Mitsubishi Colt and Smart Forfour models.

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2005 The Toyota 1KR-FE is a Daihatsu designed three cylinder unit that is produced in Japan and Poland and had been fitted in a range of models such as the Toyota Aygo, **Citroen C1**, Peugeot 107, Toyota Yaris and the Daihatsu Boon.

2007. A three cylinder 1 litre version of the Hyundai Kappa II engine has been fitted to some Hyundai and Kia models, such as the i10, Picanto, i20, Rio and ix20 since 2008.

2008. An all new model was first produced by Maruti Suzuki in India the Maruti A Star, fitted with the 998 cc three-cylinder K10B engine that was developed especially for the new car. It has been sold around the world under various names such as Nissan Pixo, Chaungu- Suzuki Alto.

2011. VW Group produced the VW 1.0 R3 12v engine that is fitted in the Skoda Citigo/ SIAT Mii/VW Up/Skoda Fabia/VW Polo/SIAT Ibeza models.

2012. PSA Group first produced the 1.2 litre EB2 stratified charge direct injection engine. It is fitted in a range of Citroen, Peugeot and DS models.

Add a Turbo-Charger to improve specific output.

1988. Some versions of the Suzuki Cultis/Metro models were fitted the G10T turbo-charged version of the G10 engine.

1990. Mitsubishi introduced the first turbo-charged Kai model the Minica *Dangan ZZ*. The turbo-charged 3G83T engine with double overhead camshafts and the world's first mass-produced five-valve-per-cylinder engine producing 64 PS (47 kW). This engine is also utilised in the ek model range in production in 2016.

2004. The Mitsubishi 3B2 656cc engine was fitted to the Mitsubishi i. and the Smart Fortwo in turbo-charged form.

2012. The Honda S07A Turbo (Earth Dream) engine is fitted in the kai models the N-One/ N-Box and the S 660 sports .

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Convert to direct fuel injection (FSI) to improve combustion and fuel efficiency.

2010. The three cylinder version of the Nissan/Renault HR12DDR engine is fitted to some Nissan Micra and Note models.

2012. The Renault TCe90 engine is fitted in the Renault Twingo/Smart Fortwo/Smart Forfour models.

2012. The Ford 1 litre three cylinder **EcoBoost engine** is fitted in some versions of the Fiesta/C-max/B-max/Focus/Mondeo models.

2013. The BMW B38 engine is fitted in some Mini One/Mini Cooper/BMW 118/218/318 models.

2014. PSA Group first produced the 1.2 litre EB2DT and EB2DTS turbo-charged and stratified charge direct injection engine. They are fitted in a range of Citroen, Peugeot and DS models

2014. The three cylinder version of the GM *Small gasoline SIDI engine*, is fitted in GM Europe Corsa/Adam/Opel Karl/Vauxhall Viva/Astra models.

2015. Suzuki introduced the Boosterjet range of engines. The 1 litre version is fitted in the Baleno and the 1.4 litre version is fitted in the Swift and Vitara models.

2015. The VW Group 1 litre TSI/TSFI Bluemotion engine is available in the Polo and Golf models.

The small capacity, three cylinder, water-cooled, double overhead camshaft, turbo-charged, stratified charge direct injection engine is the state of the art in efficient, low emission gasoline engines today 2016. Whether it will provide the promised results expected, when in service again larger, simpler engines only time will tell.