Front Wheel Drive
The story of pioneers of the front wheel drive motorcar

To most British motorists that think about such things, the Mini, was the beginning of the front wheel drive revolution. The revolutionary concept that was the Mini was it’s packaging. The packing of the engine, gearbox and final drive into a very compact unit, leaving sufficient space in a very small car for four people. The Mini didn’t start the front wheel drive revolution but the packaging revolution that has spread throughout the worlds motor industry. This was made possible because of the developments in front wheel drive technology that had gone on during the previous forty years, but until that time had been almost ignored by the British motor industry. The combination of front wheel drive and efficient packaging has revolutionised the world’s motor industry, being almost universally used, except were considerations of cost and or size are not important. This is the story of those years before the Mini and the pioneers of front wheel drive.

From the Carriage to the Horseless Carriage

For the thousands of years, from the time of their invention, wheeled vehicles were pulled from the front. This was because it was an inherently stable arrangement, it made steering easier and gave maximum control. This lasted as long as the foot was used to transmit the motive power to the road, but once the wheel was used to transmit the power of an onboard engine to the road the situation changed. This was due to the correct and universal understanding that the front wheels must be used for steering, and as it was so much simpler to drive the none steerable wheels, rear wheel drive became the accepted method used for the pioneer self propelled vehicle.
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A few attempts to replace the horse in the horseless carriage with a means of pulling it were tried, as the following report in Le Sport Universel Illustre on the Latil et Riancey displayed at the Salon de l'Automobile in Paris in 1899. The H. de Riancey Automobile Company is showing a voiterette which is receiving approval by the most competent experts, including Baudry de Saunier. “M. de Riancey has started from the principle that it is more sensible to pull than to push his voiterette. He has invented an aggregate which pulls and steers, thus playing the part of the horse before your dogcart, dear reader. This concession to your equestrian tastes will no doubt attract you and, I hope, will make a visit worth while”.

Perhaps it was like this “Victorian Combination” made in France in 1900

“There are special technical advantages: the mechanism is in one group, it can easily be protected, and there is no vibration. Apart from the excellent balance thus achieved, the whole arrangement gives lightness to the carriage, a quality as yet rare among internal combustion vehicles. The complete fore-carriage enables many a transformation to be made, for it can be attached to the front of a horse-drawn vehicle after very slight changes.”

Another interesting but limited concept, was the Lohner-Porsche “Mixed” of 1901. A development of the Lohner electric car, that used electric motors in the hubs to drive the front wheels. The “Mixed” was a development that had a motor/generator set in place of batteries. Both were the work of the young Ferdinand Porsche, who went on to use the system on all wheel drive military tractors used by the Austrian army in the first world war. The concept was soon abandoned, I’m sure due to the cost and weight of the electrical equipment and the high unsprung weight of the front axle. The picture here is of a “Lohner Porsche Mixed”. The driver is Ferdinand Porsche during his military service and the passenger is the Archduke Ferdinand of Austria, taken in 1902.
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In 1898 Louise Renault designed a car based on the Systeme Panhard, which consisted of the engine in the front (better cooling,) gearbox in the middle (easier gear-changing); but with the replacement of shaft drive to the rear axle instead of the chains as used by Panhard. It was successful because it used the technology of the time to its best advantage, but the packaging was terrible, making a high relatively unstable car. But as speeds where low at the time this didn't much matter. Unfortunately most engineers carried on using this layout in various refined forms for the next eighty years, some still do where good packaging is not a priority.

A 1891 Panhard                                                        The 1898 Renault

Not all engineers were satisfied with this situation and by the early nineteen twenties began to experiment with other layouts. Amongst them were various front-wheel drive systems.
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The Experimental Years

As with all fundamental ideas, no one person invented front wheel drive for cars and no one person
turned it from an idea to the dominant means of transmitting powers to the road that it is today.
Various methods were tried to get the drive to the front wheels, particularly on the three wheeled
cars, one British experimenter, Harry Stanhope used belts and chains, but the system that was
adopted by most designers, were variations of the system first used on the 1899 De Dion-Bouton
voiturette to drive the rear axle. This consisted of a final drive assembly mounted on the chassis
and shafts universally jointed at both ends, to each of the driven wheels.

An experimental FWD car the Stanhope

Front wheel drive "Miller Special

In the United States, in 1925 Harry Miller a successful designer of racing cars at this time, made a
front wheel drive racing car using the complete De Dion arrangement using a beam axle linking the
front wheels. He went on design the first Cord cars.

Alvis 12/75 2-Seater Sports
The Tracta Gephi

In England, GT Smith-Clarke at the Alvis company experimented with front wheel drive starting in
1925 and in France JA Gregoire developed the Tracta sports car starting in 1926. They both used
independent front suspension, this was to be the preferred layout for almost all front wheel drive
cars, while "Conventional" cars mostly carried on using beam front axles and 1/2 elliptic springs for
the next fifteen to twenty years.
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The Alvis Car & Engineering Company was formed in 1919, Captain GT Smith-Clarke joined the company as chief engineer in 1922. He developed the company's existing models, which were in every way conventional and by 1925 had designed and developed a very unconventional car, the Alvis 12/75. It had independent suspension on all wheels, using two 1/4 elliptic springs for each wheel, mounted as leading links at the rear and as transverse links at the front like wishbones, front wheel drive with the brakes mounted inboard each side of the final drive assembly. Fitted with a modified version of the 1 1/2 litre engine used in the company's 12/50 model, in supercharged form it produced 100 bhp and the car was capable of 85 mph. Weighting only 9.5cwt (483 kg) it was a lively performer. Two cars were entered for the Le Mans 24 hour race in 1928, taking first and second place in their class.

In 1926 they produced another front wheel drive car, it was designed to comply with the 1 1/2litre Grand Prix formula of that year and was fitted with a supercharged straight-eight engine that produced 125 bhp. The car was not a success.

The 12/75 was sold from 1928 until 1930 but only 155 purchasers were found, disappointing even for a small producer like Alvis. During and after the withdrawal of the 12/75, Alvis carried on producing conventional cars.

Alvis 12/75 Sports Saloon

There were two reasons for the poor sales of the 12/75, complexity and handling. It was a very complex car for its day and this was at a time when cars required much more regular attention to keep it serviceable than today, also the handling was considered poor for a sporting car. This was considered to be due to its long wheelbase and low centre of gravity, but was probable due to the long wheelbase, but also poor weight distribution and transmission shortcomings.

One convention of that period that Smith-Clarke adhered to as did most of the pioneers of front wheel drive was that of mounting all of the machinery within the wheelbase of the car, thereby missing many of the advantages of the front wheel drive layout. These will be explained later as will the transmission shortcomings. As you can see in the picture on this page, the car had a long bonnet. This was necessary because of the layout of the final drive, gearbox and engine, in that order located from the front wheels backwards, taking up a lot of space making a long wheelbase necessary to get the passengers in.
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The Tracta car emerged out of the enthusiasm of two Frenchmen Jean Albert Gregiore, a garage owner from Versailles, and Pierre Fenaille, a wealthy client. Both were motor sports enthusiasts and competed in various events. Fenaille, in the unusual manner of being driven by his chauffeur, suggested that they build their own car to enter in motor races. Fenaille provided the finance and Gregiore the expertise. Fenaille, being interested in novel concepts of engineering, suggested they make the car with front wheel drive. From that suggestion, Gregoire's long connection with front wheel drive cars and transmission technology began. The car that they devised had the main components in a similar configuration as the Alvis, but the one front brake was located in an even more difficult place to service, between the gearbox and the final drive. Also, the independent front suspension system was by sliding pillars, as still used on Morgan cars. They christened the car the Tracta Gephi, and the car first ran in the summer of 1926.

Jean Albert Gregoire and Pierre Fenaille  A 1928 Tracta showing the transmission

The car was long and low, with the minimum of ground clearance. JA Gregoire described the road holding as exceptional, compared to the sports cars of the period he had driven. He was at first worried that the drive would lock up while cornering as was predicted by conventional automobile engineers. They considered front wheel drive dangerous at that time, but after testing the car he had complete confidence in the system, using the car to compete in rallies and hill climbs. What did happen when cornering was that the transmission “kicked” and “Snatched,” an unpleasant phenomenon that also caused excessive wear in the transmission and steering gear, presumably the same affect that led to the Alvis 12/75 being labelled as difficult to handle. To explain this phenomenon I can no better than Quote JA Gregoire’s own words.

“It is easy to explain this. In a cardan joint, when the driven shaft forms an angle with the driving shaft and the latter turns at constant speed, the velocity of the, driven shaft is irregular, sometimes turning faster and sometimes slower than the driving shaft. Therefore at each revolution when the front wheels are turned for steering, alternate acceleration and deceleration is imparted to them. This then produces a spasmodic movement which is felt in the steering. In 1690 the British engineer Hooke described this phenomenon kinematically and showed that, to transmit movement correctly via cardan joints, it will suffice to use two, which are set at right angles were the axes of the driving and driven shafts meet.It is therefore necessary to use a Hooke joint within the pivot of each of the driven front wheels”. To overcome this problem Fenaille suggested to create a constant velocity joint in each front wheel hub, by using an enclosed double universal joint. This idea was developed to become the “Tracta Joint”. The promotion and licensed use of the “Tracta Joint” became the primary purpose of the Societe Anonymedes Automobiles Tracta after 1932. It was the recognition of this weakness in simple front wheel drive arrangements, and the provision of a solution for others to use, that was Gregiore and Fenaille’s great contribution to the advance in the use of front wheel drive.
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Errett Lobban Cord was born in 1894. He worked his way up from being a used-car salesman in 1920 to the position of president and chief stockholder of the Auburn and Duesenberg car companies in the United States by 1926. The 1920s were a boom time and Cord decided to add yet another exotic model to his range. This time it would bear the name Cord. He commissioned the racing car builder Harry Miller to design a front wheel drive car. Miller assisted by Cornelius Van Ranst, another designer with some front wheel drive experience, produced a design using existing Auburn components, adapted to the front wheel drive layout as first used by Miller on his 1924 racing car. The result was the 1929 Cord L-29. At the very front the L-29 had a tubular axle beam ahead of the final drive unit, which was itself ahead of the three-speed gearbox and behind the gearbox was the engine. This was a modified Auburn 298.6-cubic-inch straight eight, producing 125 horsepower. The whole assembly being very long, resulting in a very long car. The front brakes were mounted on either side of the final drive unit, inboard of the drive shafts to the front wheels. I don’t have details of the drive shaft components, only that Premium Cardon constant-velocity joints, were fitted. The front axle was mounted on Quarter elliptic springs, with a dead axle and half-elliptic springs at the rear.

The car was not a success, due to various factors. Traction was poor due to the layout creating a rear weight bias. (Designers had not yet learned of the true advantages of front wheel drive, a compact power train and a weight bias over driving wheels.) Another factor was the lack of durability of the drive shaft that needed replacement frequently. Being a new concept didn’t help, when it was dropped in 1932, only five thousand and ten examples had been produced.
The 1920s were years of experiment, with finally the production of a small number of specialist front wheel drive cars, sports and luxury, all relatively costly. The 1930s saw these joined by front wheel drive cars at the other end of the price range.

In Britain BSA made 10,000 of a varied range of three and four wheeled car from 1929 to 1940. In Germany DKW started making their series of cars prefixed F, making over 200,000 by 1939. In the middle of the price range Adler produced the Trumpt and Trumpt Junior in large numbers, and Audi produced the Front, the first in a long and distinguished line of front wheel drive cars with the Audi name. In France, Citroen began their long association with front wheel drive in 1934 with the Traction Avant, and JA Gregoire created for Hotchkiss, the Amilcar Compound, which was made in relatively small numbers from 1938 to 1940. There was also front wheel drive models from Georges Irat. Cord in the USA return to front wheel drive car production in 1936 with the 810 and 812.

The first inexpensive front wheel drive vehicle to reach the British market, the BSA “Three Wheeler Twin," although not mass produced, was made in large numbers compared with it’s predecessors and could not have been more different. A three wheeled cycle car, as ultra light cars were then described. The specification in many respects was normal, being similar in layout to the “Morgan” three wheeler. With two wheels at the front and one wheel at the rear and a 1021 c.c. Vee twin-cylinder air-cooled engine was mounted in front. A simple channel-section chassis that was formed in the rear with a large-diameter central tube; the single rear wheel was mounted on a hinged arm having as an extension a leaf spring that was enclosed within the central chassis tube. The major difference was the transmission that was similar in layout to the Alvis 12/75 including the inboard drum brakes. Four quarter elliptic springs each side were used for the independent front suspension. A four wheeled version was available only in 1932, the FW32. In 1933 a four-cylinder engine version of the three and four-wheeled car was added to the range. With a 1075c.c.side-valve water-cooled engine in place of the twin being the only major change. The three wheeled cars were dropped after 1936, the “Scout” series of cars being available from 1935 to 1940, being the last BSA cars.

The company DKW was founded by Jorgen Skafte Rasmussen, a Danish engineer. The initials DKW came from an unsuccessful venture, a steam powered vehicle, in German Dampt Kraft Wagon. Fortunately the company became successful as motorcycle manufacturers, with a factory at Zschopen in the German region of Saxony. Between 1919 and 1930 the company made an assortment of rear wheel drive cycle cars and light cars. The first front wheel drive car from DKW, the FA, later to be called the F-1, was introduced in 1931. It was an ultra lightweight car, weighing only 450 kg. It had a water-cooled 2 cylinder 2stroke engine, mounted transversely in the chassis, with the 3-speed gearbox in front and the final drive assembly in front of that between the front wheels, Twin transverse ½ elliptic springs were used at the front and the rear of the steel ladder
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chassis for the all independent suspension. With 15bhp from the engine a maximum speed of 75 kpm was attained. It was made in roadster, cabriolet and saloon form. After the first revolutionary step of producing the FA, the F series of cars that followed evolved, with changes introduced as the model numbers progressed. The F-2 a 584cc engined version of the F-1 was introduced in 1933, with a little more power and a little more speed. An engine capacity of 584cc was available until 1938. The F-4 of 1934 saw the spur gear drive between the engine and gearbox replaced with a chain. The F-5 also of 1934 had major engine changes using the Schnuerle deflectorless-piston loop-scavenge system, which made an important contribution to efficient two-stroke engine operation.

The rear suspension was changed to a dead axle and a transverse leaf spring. The F-5 was also available with 684cc engine. The F-7 had the front suspension changed to one leaf spring and wishbones. The last model before the Second World War was the F-8. That had a revised chassis frame incorporating rack and pinion steering and an engine of 589cc. In 1939 a 692cc engine was fitted in some models and was made until 1942.

After the war, two versions of the F series were produced. The factory at Zwickau were the DKW were produced before the war was then in the DDR, the eastern communist part of Germany and a car named the IFA F-8 was produced there from 1948 until 1955. The second F series car the DKW F-89 was made in Dusseldorf in West German, by the pre-war management. Based on the F-8 but with the 684cc engine moved ahead of the front wheels. This was in production from 1950 until 1954. Between 1931 and 1955 around 300,000 FA’s to F-89’s had been made. These cars can justifiably be claimed to the first mass produced front wheel drive cars, the fore runner’s to all the millions produced since.
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J S Rasmussen the founder of DKW took over the ailing Audi concern in 1928, making DKW along side the Audi’s at their Zwickau factory. To counter the worsening economic crisis in the German motor industry, in 1932, DKW, Audi and two other motor manufacturers located in Saxony Wanderer and Horch, merged to form Auto Union AG. One of the first products of the merger was the Audi “Front”, which was as inferred by it’s name was a front wheel drive car. It had a 2.3 litre six-cylinder engine designed by Professor Porsche and made by Wanderer. That was mounted behind the final drive and four-speed gearbox as in the Tracta. With power steering system made under licence to a US design combined with a ZF steering box. The box section backbone chassis had transverse leaf springs front and rear, combined with wishbones at the front and swing axles at the rear. The cars place in the market was similar the Audi’s produced today, being of medium price and high quality. It was made from 1933 to 1938 in the Horch factory in Zwickau.

1934 Audi Front

JA Gregiore designed an 11cv 6 cylinder car for Donnet in 1932. Only four prototypes were produced, one being show at the Paris Salon of 1932, before Donnet went into liquidation. He then worked with Lucian Chennard to design two cars for Chennard and Walcker. They where of advanced design but were not a commercial success. In 1937 he designed the Amilcar Compound, produced by Hotchkiss from 1938 to the Second World War, by which time 681 examples had been made. It was constructed using another of Gregiore's idea's, a cast Alpax (light alloy) chassis frame. Other advanced features were, rack and pinion steering, and all independent suspension. But the car had it's bad points, cable brakes and gear-change linkage, also a side valve engine. The latter still common at this time, although an overhead valve version came later.

Amilcar Compound

Aluminium Francais-Gregiore

lightauto.com
Adler of Franfurt on Main, Germany, started by making bicycles in 1880, later typewriters and commenced car production in 1900. The first of their front wheel drive cars, the Trumpf, was designed by the company technical director of the time, Rohr. This was in 1932. As well as front wheel drive, the car had other advanced features, The body was electrically welded to the box section chassis, making it a near monocoque. All independent suspension using torsion bars and rack and pinion steering. The layout of the power train was similar to the Tracta and the Alvis, with the final drive at the front, with the four-speed gearbox next and then the engine. This resulted in a long bonnet, which fortunately was still fashionable at the time. Tracta joints were used in the outboard end of the transmission. The car was light for its time, being just over a thousand kilos in 4-seat saloon form. The engine and the brakes were as most other cars of that date, the engine being a side-valve, four, of 1500cc to 1700cc producing 38bhp to 40bhp, and the brakes were mechanically operated.

In 1936 another car bearing the name "Cord" was produced, the V-8 engined 810. It is mainly remembered for it's stunning body style, designed by Gordon Buehig it was an instant classic. This time the designers had got the layout right, with the gearbox, a four-speed Bendix preselector unit, ahead of the final-drive unit and the engine behind, making a much more compact assembly. Front suspension was by independent trailing arms and a transverse leaf spring. The engine, a 288.6 cubic inch Lycoming product, produced 125bhp in basic form, but a supercharged version could be fitted producing 190bhp, with a top speed of 110mph. A longer wheelbase version was also produced the 812, but a combined total of less than three thousand examples of the 810 and 812 were made by the time the Cord empire collapsed in 1937.
Andre Citroen set a design team to work on the car that was to become the Traction Avant in 1932. He had decided to produce a car of advanced specification that would replace all his existing models. The whole car was to be completely new. It would have front wheel drive and a low profile similar to the Adler Trumpf, combined with a monocoque chassis/body unit, built using the Budd process. Another feature to be incorporated into the design and almost its undoing, was the use of a torque converter in place of a conventional gearbox. As is the practice today, the "Traction Avant," was designed by a team, each being a specialist in the various components. The design team leader was Andre Lefebvre. Andre Citroen had recruited him for the task when the project was falling behind schedule. Citroen had taken a licence, and purchased machinery from America, to manufacture the "Rzappa joint". This was to be used at the outboard end of the drive shafts. But then thought better of it.

It would be almost thirty years before versions of the "Rzappa joint" were used successfully in mass-produced cars. Then J.A. Gregoire was retained as a transmission consultant. "Tracta joints" were fitted to the prototypes and some early production cars, but proved unsatisfactory. According to JA Gregoire's account, this was due to poor quality machining. The Tracta joints were then replaced by the double Hardy Spicer joints that were used through out the life of the car. The drive joints were not the only problem with the early cars. The torque converter proved to be unsuitable for the car and if the design team had not produced a conventional gearbox quickly the whole project would have failed. The layout of the power train was more compact than the Tracta's and the Adler's, in that the gearbox was ahead of the final drive, with engine behind and the weight distribution was improved as a conscience. The suspension was independent on all wheels with torsion bar springs and at first friction dampers. The friction damper, were replaced by telescopic hydraulic dampers in 1935. The steering gearbox was initially of worm and sector type, but was discarded for rack and pinion in 1936. Hydraulic brakes completed an advanced specification. Over two hundred and eighty-thousand of the various 7cv and 11cv models were produced between 1934 and 1940. But Andre Citroen did not live to see the Traction Avant flourish. The early problems with the car, ruined Citroen and the company past to other hand, soon after which Andre Citroen died.
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During the Second World War JA Gregoire secretly worked with his design team at his works at Asnieres on a small car the Aluminium Francais-Gregiore. It had a chassis-body frame of light alloy, front wheel drive, an air-cooled flat twin engine and independent suspension on all wheels. A four-seat car weighting only 880 pounds, it could make 60 mph and 70 mpg. This design was to form the basis of the 1950 Dyna Panhard.

The Tracta Joint, was extensively used in wheeled military vehicles during the Second World War by most of the major combatants, the largest user being Willy in the USA, who fitted them to a quarter of a million Jeeps.
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Post War Progress

Front wheel drive car production had stopped by 1941 when the last Adler Trumpf-Juniors was produced. It took time after peace came to restart production in the factories that were in a condition to do so, but Citroen had the Traction Avant back in production in 1945. BSA Group in Britain and Hotchkiss in France had decided not to restore production of their front wheel drive models and Adler in Germany chose not to make any cars at all. Auto Union, the group that had made Audi and DKW cars had lost their factories with the division of Germany and were unable to produce anything for the time being.

Panhard were the first offer a new front wheel drive model after the war, in 1946. In the new DDR (East Germany) a new company IFA. was set up to produce cars in the factory in Zwickau that had produced DKW cars before the war and restarted production by 1948. The next year saw the first SAAB the 92 and the first Citroen 2CV on the road.

The Auto Union management had re-established itself in Dusseldorf in the West German republic and DKW cars were in production by 1950. Also in that year Hotchkiss produced another front wheel drive Gregoire design. The only new front wheel drive cars in Britain were 11CV Citroens assembled at Slough.

The "Dyna" was the Panhard version of the Gregoire designed "Aluminium Francais-Gregoire" mentioned previously. Gregoire sold drawings of the AFG. to Henry J. Kaiser in the United States, and to Hartnett in Australia, but neither took it any further and he submitted prototypes to Simca and Panhard in France. The Dyna Panhard, was based on the AFG, but Panhard made many changes to the design while retaining the principle features of the Gregoire design. First produced in 1946, with a 610cc engine that produced 25bhp, weighed 1052 lb and could reach 60mph.

In 1950 the engine size was increased to 750cc producing 33bhp and a top speed has risen to 71mph despite a weight increase of 220lb. By 1954 an 850cc engine was standardised on all models.

Also that year the original Gregoire devised chassis that had been made for Panhard by Facel Mettalon. It was replaced in a new model, the Dyna 54, but it was still constructed of aluminium, as was the body. The Dyna 54 was a six-seat car and could reach 80 mph, on 42bhp. In 1957 the aluminium construction was replaced by steel with an increase in weight of 440lb. The Dyna 54 was replaced by the PL17 in 1959, the most prolific model, with one hundred and thirty-thousand examples produced by 1964.

The last of the breed the 24CT, which was the last Panhard car produced was a 2+2 coupe made from 1963 until 1967. Citroen had taken over the company in 1957 and from 1967 Panhard only produced armoured cars. Despite it's advanced layout the Dyna had not been properly developed and was expensive to produce never reaching mass popularity.
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Citroen had started work on the 2CV in 1938 and had 300 prototypes running in France before the country was occupied by the Germans during the Second World War. It took until 1948 before the car was first shown to the public at the Paris Show. Citroen's aim was to provide rural France with a car that would replace the horse and trap, as Henry Ford had done for America with his model T thirty years before. To carry up to four people at speeds up to 40MPH along French country roads in a car that needed a minimum of maintenance at minimum cost, required an exceptional design and the 2CV was that. Every part of it was new from the power train to the basic almost crude body. Initially the air-cooled flat twin engine was of only 375cc producing 9bhp.

2cv Chassis 1954

Citroen 2CV

It was at the front of a platform chassis, with the drive going to the front wheels with at first, simple universal joints at both ends of the drive shafts. This didn't matter at first due to the low performance and the need to keep the cost down. The drawings also show the unique suspension devised to deal with those country roads. Long travel leading arms at the front, were linked to long travel trailing arm at the rear by rods that operated on coil springs located at the side of the chassis. Suspension movement at the front was transmitted to the spring and then to the rear by the linkage, leading to a smoother ride. To make the car as usable for its designed purpose, the body was very simple with most components removable to provide access and space as required. The 2CV at first glance could be taken for a crude car but looks are deceiving and where it mattered everything was produced to a high standard, with hydraulic brakes, inboard at the front and rack and pinion steering. The engine was increased to 424cc in 1954 and later 602cc, but performance wasn't what the 2CV had been designed for, it was as a work horse. Total production was 3,872,583 of 2CV's alone by 1990, not counting the models derived from it.

After the war, two versions of the DKW, F series were produced. The factory at Zwickau where the DKW were produced before the war was then in the DDR, the eastern communist part of Germany and a car named the IFA F-8 was produced there from 1948 until 1955. The new model that DKW had ready for production in 1939, the F 9 was shown at the Leipzig Show in 1948, as the IFA, F 9. Produced from 1950 until 1956, almost forty-one thousand were produced, after 1953 in the former BMW factory at Eisenach. After 1956, and clothed in a new body, the F 9 reappeared as the Wartburg 311. With various body changes but the same mechanical layout and two-stroke engine, the Wartburg was manufactured until 1988.
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SAAB was and is a Swedish aircraft manufacturer. In the early nineteen forties they felt that with only one customer, the Swedish government they were very vulnerable. Their solution was to diversify, to manufacture cars. Before the Second World War Sweden only had one motor manufacturer Volvo and most cars were imported. Until the flow of imports stopped due to the war, DKW cars were becoming increasingly popular in Sweden, so SAAB decided to design and produce a car similar in principle to the DKW but incorporating the latest design thinking. The first car the 92 designed by two Swedish engineers Gunnar Ljungstrom designed the car while Sixten Sason designed the body. Having limited manufacturing capabilities Ljungstrom opted for a twin-cylinder two-stroke engine, located in front of the front wheels, transversely with the gearbox in line and the final drive behind, using the minimum space inside the wheelbase, which could then be utilised for passenger space. (This was the layout used in the Trabant, produced by IFA in the DDR for thirty plus years.) The car had a low drag unitary chassis/body, rack and pinion steering and all independent suspension with torsion bar springs. Just over twenty-thousand SAAB 92’s were produced in six years when discontinued in 1956 after the introduction of the SAAB 93 in 1955. This had a similar layout to the DKW F 9, also with a three cylinder two-stroke engine.

IFA F9  Saab 92

The pre-war management of Auto Union set up in business in Ingolstadt, West Germany after the war, at first making spare parts for the remaining DKW cars produced before the war. But by 1950, began producing new a DKW car in the form of the F-89 New Meisterklasse. It was made in Dusseldorf also in West German. Based on the pre-war F-8 but with the 684cc engine moved ahead of the front wheels in a new chassis and clothed by the body designed for the F 9. This was in production from 1950 until 1954. Between 1931 and 1955 around 300,000 transverse engined DKW or IFA car from the FA to the F-89 had been made, and many others made under license. It took another three years before they could get their version of the F 9 in to production as the F-91 Sonderklasse. The F-91 evolved into the F-93 then the Auto Union 1000, with a larger engine. Four hundred thousand examples of this design were produced from 1953 to 1963. By then the F-9 layout was established as the standard at AUTO UNION and later, when owned by Volkswagen the name was changed to AUDI.
In 1950 another Hotchkiss car the "Hotchkiss-Gregoire," was produced again with an alloy chassis and body. With independent suspension on all four wheels and fitted with a water cooled flat four engine of 2 litres, ahead of the front axle, it was fast, with a top speed of 94mph, but the car was expensive and only 250 examples were made by 1954. In 1956 Gregoire produced a two seat convertible with a 2.2 litre supercharged flat four engine producing 130bhp, and as in the case of the cars mentioned previously front wheel drive. All of ten cars made were fitted with bodies designed and built by Henri Chapron.

The Citroen Traction Avant remained in production until 1957. It was replaced by an equally revolutionary design the DS19 first produced in 1955. The front wheel drive assembly had no revolutionary features, as it was similar to Traction Avant in principle with the engine inline behind the front wheels but with the double hook joints accommodated in the massive front hubs. It was The hydraulic systems fitted to the car, power steering, load-levelling suspension and gear change that was new. The DS19 and DS21, DS23 and simpler ID19 were large cars. Almost one and a half million examples were made in twenty years of production.
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The Front Wheel Drive Revolution

At the end of the nineteen fifties, front wheel drive had become almost conventional. Citroen and Panhard in France DKW/AUTO UNION in Germany Wartburg in the DDR and SAAB in Sweden were producing cars exclusively of this type. The preferred layout being with the engine inline, ahead of the front wheels, with the exception of the Citroen DS19 that had the engine behind. The transverse engine layout had almost gone out of favour, with only the Trabant made for a captive market in the DDR and a small number of ultra light cars the latter day cycle cars made by Berkeley in the UK.

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.

DKW Junior

A front wheel drive version of the Morris Minor was built but not developed, in 1951/2. With a transverse engine with the gearbox inline and equal length drive shafts with an intermediate jack shaft to extend one of the shafts. It wasn't developed for production. The British Motor Corporation decided to produce a new small car and the design work started in March 1957 Alex Issigonis who had designed the Minor, returned to the front wheel drive layout for this new design. The aim was to produce a very compact car with maximum space utilisation. To achieve this Issigonis decided to fit the engine transversely in the car, with the gearbox located in the engine sump. With the final drive unit gear driven from the gearbox it could be located centrally. This allowed equal length drive shafts to be used, without the need for an added jack shaft. The component that made the design acceptable to Alex Issigonis was the Birfield-Rzeppa constant velocity joints made by Hardy Spicer fitted at the outer end of the drive shafts. Early Mini's had flexible rubber drive couplings at the inboard end of the drive shafts. Later manual gearbox models had offset sphere type joints. While Auto-box and Cooper S models had universal joints and sliding joint shafts. Other features of the Mini design where rubber springs and ten-inch wheels. Prototypes where running on the road in October 1957 and production started in 1959. It was first marketed as the Austin Seven and the Morris Mini-Minor and it wasn't until 1962 that the name was changed to Mini, after popular usage.

In 1961 Citroen introduced the Ami 6. The 2CV platform was fitted with a 602cc 22bhp engine and an odd four door body. It was produced until 1971 and over a million examples were produced.

Lancia's first front wheel drive car the Flavia was introduced in 1960. Fitted with a 1488cc flat four engine mounted inline ahead of the final drive. With independent front suspension using a transverse leaf spring and a dead rear axle with half elliptic springs.

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Renault abandoned their rear engined small car policy when they introduced the R3 and R4 in 1961. The engine/transmission layout of the 4CV, with the gearbox ahead of the inline engine, was located in the front of a practical hatchback unitary chassis, with the necessary changes to the drive shafts and transmission joints. The long forgotten R3 had a 603cc engine and the R4 a 747cc or 845cc engine. Over eight million R4’s were made by 1992 when production ceased. Renault didn’t convert fully to the front wheel drive concept until the 1970s.

The next Issigonis design the 1100, was introduced in 1962. At first badged as a Morris but Austin and other brands where later available using a 1098cc version of BMC’s “A” series engine in an installation the same as the mini. Rubber springs where again used but this time interconnected hydraulically. A system that was fitted to Mini’s for a while. The chassis/body unit, styled by Pinin Farina was much roomier than the Mini.
Front Wheel Drive

In 1962, Ford of Germany introduced their first front wheel drive car the 12M (Cardinal). It had a 1.2 litre V4 engine ahead of the front wheels, as can be seen in the picture below. This engine was later used in the Saab 96.

Lancia’s next new car also had front wheel drive. The Fulvia was first produced in 1963. The 1100cc narrow angle "V" double overhead camshaft four engine was mounted inline ahead of the final drive and four speed gearbox. The suspension was similar to the Flavia.

Ford M12 Power Train                             Lancia Fulvia

The last of the two-stroke DKW/Auto union cars the F 102 was first produced in 1964. With a 1175cc three cylinder engine mounted in usual DKW manner.

DKW F102

Diversity of drive train configuration was still a feature of front wheel drive cars of this period, this was to change in the years to come.
Front Wheel Drive

Maturity

Dante Giacosa's first front wheel drive car was the Autobianchi Primula. Autobianchi was a subsidiary of Fiat. Ready for production in 1964, it had a four cylinder water-cooled engine of 1221cc that was already fitted in the Fiat 1100D. The rest of the car was of all new design. The engine was transversely mounted with the four-speed gearbox located inline with the crankshaft. With a gear train to the offset differential and final drive and unequal length drive shafts. This is the arrangement we see under the bonnet of most front wheel drive cars today. Other features of the design are not so familiar, such as the gear change on the steering column. Also the wishbone and transverse leaf spring front suspension and the dead rear axle with half-elliptic springs. The steering was by rack and pinion, a first for Giacosa, but almost twenty years after it's first use by Issigonis.

Autobianchi Primula

Peugeot 204 power train and suspension

The next Issigonis front wheel drive design followed the same theme to his previous creations but was again bigger. The 1800 was a six example of the Mini packaging with similar uncompromising body design. Marketed as an Austin, Morris or Wolseley, two hundred and ten thousand examples were produced in an eleven year run. In 1965, the DKW 102 became the Audi Heron. The two-stroke engine being replaced by a four-stroke four, from Daimler-Benz the new owners. Peugeot joined the ranks of front wheel drive car makers with the 204. This was in 1965. The 204 had a 1130cc four cylinder inline engine mounted transversely in front of the gearbox and final drive. It had equal length drive shafts and as the picture below shows, McPherson strut front suspension. In production from 1965 to 1977, with 1.6 million examples produced.

Standard Triumph's first front wheel drive car the 1300 of 1965, had a unique power train layout. The four cylinder inline engine was mounted fore and aft over the front wheels with the gearbox and final drive located underneath, but not in the engine sump as in the mini but in a separate enclosure. The 1300 was produced until 1970 and the 1500 that replaced it was in production until 1973, but only just over two hundred thousand examples were produced in that time when Triumph abandoned front wheel drive. The only other front wheel drive Triumph was a Honda designed car the "Acclaim," made by the British Layland Motor Corporation from 1981 to 1984.

The R16 was Renault's first family size front wheel drive car. First produced in 1965, it had a hatchback body which was advanced for its time, but the power train arrangement was the old fashioned French layout of a fore and aft engine located behind the front wheels with the gearbox in front.
The Japanese company Mikasa produced a series of small front wheel drive cars fitted with an air cooled twin cylinder engine, from 1957 to 1961, but the first significant Japanese front wheel drive car was the Subaru FF-1. Introduced in 1966 the FF-1 was the first in a long line of Subaru models that continues to this day, with a water cooled flat four engine mounted ahead of the front wheels. Originally fitted with a 977cc engine, this was increased to 1088cc and then 1267cc by 1970. The FF-1 was superseded by the Leone in 1971.

Honda also introduced their first front wheel drive car in 1966 the N360. It was fitted with a transversely mounted air cooled O.H.C four stroke parallel twin cylinder engine. Honda had extensive experience of this type of engine in their motorcycles. Other versions were the N400, N500, and N600. That had engine sizes to match the name. Over 1.1 million examples had been produced by 1971 when the "N" series cars were replaced.

Front wheel drive was usually the preserve of the small car, but in the United States in 1966 Oldsmobile, a division of General Motors produced the Tornado. The Tornado had yet another power train layout that seems to be unique to that model. The large V eight engine was located fore and aft over the front wheels, the power then went through a torque converter at the rear of the engine and was conveyed by chain to the automatic gearbox that was located on the left hand side of the engine. I have no details of the final drive unit, but presume it was at the front of the gearbox. Engines up to 7.5 litres were fitted in some models of the Tornado. A true test of the front wheel drive principle.
Front Wheel Drive

When NSU produced their first front wheel drive car in 1967, they didn't just move the engine from the rear to the front but produced a completely new car with a new type of engine. The Ro80 was the second NSU car with a Wankel rotary engine. The 995cc twin rotor engine was located ahead of the front wheels, fore and aft, next was a torque converter and a servo operated clutch ahead of the final drive unit with a three speed gearbox behind. The Ro80 chassis was also of advanced design with passive safety a high priority. That combined with an aerodynamic body shape made it a milestone in automobile design. Unfortunately due to engine reliability problems it didn't become a big sales success. Only thirty-seven thousand two hundred and four examples were produced by 1977. By then NSU had been absorbed into the Volkswagen empire, the Ro80 being the last car to carry an NSU badge. This is often the price of innovation.
Simca had been producing rear engined cars since the beginning of the decade, but produced a front wheel drive car in 1967 the 1100. They reused an old engine, but it's transverse location and the transmission that went with it was new. The 1100 remained in production for twelve years, during that time Simca became Chrysler-France.

The Fiat 128 of 1969 was the final break through by Dante Giacosa. After a lifetime of exceptional car designs both conventional front engined and also rear engined cars. In the 128 he brought together all the features that are considered conventional today. Transverse engine/gear box / off set final drive with unequal length drive shafts, in conjunction with McPherson strut front suspension. Rack and pinion steering and disc brakes on the front wheels. The 128 had wishbone and transverse half-elliptic spring independent rear suspension.

Fiat had dealt with all the bugs associated with a new concept in the Primula and the 128 was a great success with one and a quarter million produced by 1972. Although the wheelbase was 2.45 metres, the overhang each end was minimal, resulting in a compact car but with ample passenger space. In the same year Autobianchi produced a smaller car using a layout similar to the Primula but this time using McPherson struts instead of the wishbone front suspension. The A112, was fitted with a 903cc engine that was also fitted to the rear engined Fiat 850. The next Autobianchi model was the A111, introduced in 1970. Again similar in layout to the Primula but larger and with a1438cc engine as fitted to the Fiat 124. The following year, Montebone, Giacosea's successor produced the Fiat 127. A smaller version of the 128, fitted with the 903cc engine. From that time the Giacosa configuration proliferated as other manufacturers adopted front wheel drive for their new models.

Autobianchi A111
Fiat 127

By 1970 NSU had developed a conventionally powered front wheel drive car. The K70 utilised the Ro80 floor-pan and suspension. It was clothed in an angular body. In place of the rotary engine it had a water-cooled inline four single overhead camshaft engine of 1605cc developed from previous NSU air-cooled units and a conventional for speed gearbox. It was ready for production when NSU merged with Audi that was already part of the Volkswagen group of companies. The K70 was never marketed as an NSU but in 1969 it became the Volkswagen K70. This was the first Volkswagen front wheel drive car although every detail was of NSU origin. Over two hundred thousand examples were produced a five year run, not much by Volkswagen standards, but it was the beginning of the end of the rear engined VW.

The Cherry 100A of 1970, was Nissan's first venture into front wheel drive. By 1986 and four models later, over three and a half million examples had been made. The Cherry had the by now classic transversely mounted inline four cylinder engine, as have all subsequent Nissan front wheel drive cars to date.

The configuration of the components as used in the Fiat 128 was to become the preferred layout used by the manufacturers that increasingly turned to front wheel drive for their new models. Also in time some manufacturers that had been producing front wheel drive cars with their own configurations also turned to this layout.
Front Wheel Drive

Front Wheel Drive Configurations

The layout of the main components of a front wheel drive cars power train can be in many configurations. The main components are the engine, gearbox and final drive assembly (differential and drive shafts). The FWD cars of the nineteen twenties and thirties located the engine well behind the front axle line, as was common practice at that time. At first with the gearbox in front of it, with the final drive between the front wheels Inline, as in the case of the Tracta, Cord, BSA, Alvis, Audi, Adler and Amilcar. Or Transverse across the car, connected by chains or spur gears as in the DKW. This layout took up a lot of space and didn't make full use of the possible advantages of FWD, a compact power train and good weight distribution. J.A.Gregoire stated in his book "Front Wheel Drive," "Technical honesty obliges me, therefore, to recognise that one of the principle advantages of front wheel drive does not derive from the system itself, but from of its secondary consequences; the predominance of front axle loading". Citroen made a small step forward with Traction Avant, by locating the gearbox ahead of the final drive assembly, making a limited improvement in weight distribution and space utilisation (See picture in part three). The DKW, F 9 was the first car ready for production in 1939, but not produced until 1950, that had a layout that took full advantage of a front wheel drive configuration, with the engine in line ahead of the final drive assembly with the gearbox behind. This is the layout that has been used in most of "DKW"/AUTO UNION/AUDI cars since.

After practical experience JA Gregiore came to the conclusion that this was the way to go. His Aluminium Francais-Gregoire, developed during the Second World War and produced in the form of the Panhard "Dyna," in 1946 and all his later FWD designs had the engine out front. The Citroen" 2CV," designers also adopted this layout as it suited the installation of horizontally opposed, air-cooled engines perfectly. Citroen went on to produce the AMI 6/8, the Dyane 4/6, also the GS/GSA, and smallest of the VISA models with the same layout.
Front Wheel Drive

The transverse engine configuration had not been forgotten. In 1946 a prototype of the first SAAB, the 92, was produced with a transversely mounted twin cylinder, two-stroke engine with the clutch and gearbox located inline with the crankshaft and these components located ahead of the final drive assembly. The 92 went into production at the end of 1949, In their first post war model the F 89, DKW moved the engine to a position in front of the final drive, In production by 1950. This was the last of the two-stroke twins from DKW. The last transverse engined vehicle from DKW was the three cylinder F-91/4 Munga, four wheel drive utility made for the German arm forces in 1955. Not until the advent of the AUDI 50 in 1974 that they fitted a transverse engine again.

The next innovation, was the mounting of a four-cylinder engine transversely in a front wheel drive car. This came with the MINI in 1959. The difficulty with the use of a four-cylinder engine in this way was that it was longer than the engines fitted previously, which wouldn't allow the final drive to be located an equal distance between the driven wheels. As unequal length drive shafts cause transmission fluctuations. The answer to this problem was solved in the MINI by incorporating the gearbox into the engine sump. The drawback to this arrangement is that the engine/gearbox unit is tall, also the gears run in a lubricant that is not ideal. Almost 10 million cars with this arrangement were produced by the British Motor Corporation/BLMC.
Front Wheel Drive

The advantages of the transverse engine arrangement in improving the packaging of a car became apparent with the MINI, so a means of using a four-cylinder engine with a separate gearbox mounted inline with it and overcoming the drawbacks of the MINI arrangement was sought. The answer was to find a way of using unequal length drive shafts without the associated drive problems. The solution was to make the unequal length drive shafts of equal torsional stiffness, this was achieved by Dante Giacosa of FIAT, first in the Autobianchi Primula, of 1964 which was a stepping stone to his big breakthrough the FIAT 128.

The 128, was the first front wheel drive FIAT. By incorporating features, not new but not used in combination with front wheel drive before, such as a transverse engine (utilising his new layout and drive shaft arrangement). Adding McPherson strut front suspension and rack and pinion steering, he produced the layout that is almost universal at the beginning of the this century.

Another configuration used by Triumph in the 1300 and Saab in the 99. It consisted of the engine mounted inline with a separate gearbox and final drive located underneath the engine with its own lubrication system (As opposed to the shared lubrication used by Issigonis.). The advantages of this system were a compact layout for an inline engines and equal length drive shafts. The disadvantage is a tall engine /gearbox assembly. To overcome this, the engine was inclined. The Triumph 1300 was not a success, but the Saab went on to a long production run.

The only other layout in use at this time is that with the engine mounted inline ahead of the final drive unit and the gearbox behind, as used by AUDI and SAAB.

The earlier front wheel drive layouts didn't fall into disuse with the advent of the more compact systems for a long time. Citroen with the DS and ID series (1955 to 1975) continued to produce cars with the engine inline behind the final drive and the gearbox in front. Renault used the same layout for their early front wheel drive cars, the "4" (1961 to 1991) the first "5" (1972 to 1984) and the "6" (1968 to 1980).
Front Wheel Drive
Conclusions

At the time production got underway after the Second World War there were six companies making front wheel drive cars. By 1970 there were eighteen. Of the 1950 manufacturers, Panhard had been taken over by Citroen and car production discontinued. In East Germany IFA had been replaced by Wartburg, who made an updated version of the DKW F 9 design, which remained in production until 1988, finally with a Volkswagen Polo engine after that company had acquired the factory. The other East German front wheel drive car was the Trabant. The Trabant was the successor to the IFA F 8 and evolved from that design. It too finished up with a Polo engine replacing the two-stoke twin cylinder unit in the last model the P601. That was towards the end of production, which was in 1990.

The reformed DKW company in West Germany, had been renamed Audi, and had joined Volkswagen and NSU in a group. SAAB was continuing to grow, but Hotchkiss had gone out of business.

Of those that had joined the ranks of front wheel drive car makers BMC makers of the Mini and the 1100 and many others, continue to make front wheel drive cars under the name of MG Rover in the factory at Longbridge Birmingham were the original Mini was produced.

After a lapse of ten year, Ford Europe returned to the ranks of front wheel drive car manufacturers in 1976 with the Fiesta made in a new factory in Spain. The name NSU disappeared with the demise of the Ro80. Lancia became part of the Fiat empire and continue to make front wheel drive cars based on Fiat designs as does Autobianchi. The French manufacturers, Citroen, Renault, Peugeot and Simca until being part of the Chrysler group, remained completely committed to front wheel drive.

In Japan, Subaru continued to make front wheel drive cars until all wheel drive cars became their speciality. Honda continued to expand its model range with front wheel drive cars and Nissan replaced old rear wheel drive models with new front wheel drive designs. Volkswagen in Europe phased out its rear engined models with front wheel drive cars that took their design principles from Audi, starting with the Passat. The Oldsmobile Tornado was a design dead end, but remained in production until more conventional front wheel drive designs appeared in the United States.


The trend towards front wheel drive continued with more manufacturers adding cars to their model ranges. In the USA Chevrolet introduced the Citation and Ford the Escort that was based on a Ford Europe design in 1981. Also that year Suzuki produced their first front wheel drive car. Seat in Spain introduced the Marbella which was a Fiat Panda clone in 1982. Toyota produced their first front wheel drive car in 1983 and Hyundai, Volvo, Lada, Proton and Skoda followed in the next five years.

Cars have been manufactured in the town of Mlada Boleslav in the region of Bohemia in Czech Republic for almost a hundred years. They have been made under the name of Skoda for almost eighty of those years.

Skoda engineers experimented with a small front wheel drive car as well as other layouts before settling on a rear engine configuration for the 1000MB. They didn't get another chance to produce a front wheel drive car until they started work on what was to become the Favorit. The Favorit was the last Skoda designed and introduced in the Communist era. After many frustrating years Skoda had to assemble a design team to produce an up to date car in a very limited time. The team led by Jaroslav Kindl rose to the occasion. The Favorit's specification followed the by now universal transverse layout with an all alloy, over head valve four cylinder 1289cc engine, McPherson strut from suspension, with trailing arm and torsion bar independent rear suspension. It was clothed in a body designed by Bertone, giving it a touch of Italian style. On sale in 1987, a million Favorit's had been produced by 1994.
Front Wheel Drive

The Felicia introduced in 1994, was the first model to be produced after Skoda joined the Volkswagen Group. It used the same engine as the Favorit.

Even the most determined proponents of the old order have had to produce front wheel drive models to extend their model range. Mercedes-Benz introduced the "A" series in 1999. BMW had become manufacturers of front wheel drive cars by default with their brief ownership of MG Rover. They now produce the new Mini since giving up ownership of MG Rover and 43 years after the original Mini design that did so much to promote front wheel drive cars. That has left a small minority of manufacturers without at least one front wheel drive model. These are mainly prestige or sporting carmakers with a limited ranged of models.

It is shown in the proceeding chapters that there are many different front wheel drive configurations, each with it's advantages and disadvantages. Those that had the engine within the wheelbase have fallen out of favour as the advantages of compactness and forward weight distribution become apparent.

The fore and aft configuration is the only one to use if a horizontal-opposed engine is used, but they have been little used since the 1980s. The use of a long inline engine also requires an fore and aft configuration, as the engine/gearbox package would not fit into the space available. The inline four-cylinder engine predominately used in the last twenty years has proven to be very suitable for transverse installation as has small Vee six's.

Various versions of the Rzappa joint are universally used, both at the outer end of the drive shaft, and at the inner end as pot joints, taking up the variations in shaft length as well as the angular variations. The development in front wheel drive transmissions have been utilised in rear wheel and all wheel drive transmissions, transforming drive train technology to a state of sophistication unimaginable forty years ago.

What of the future, as the development of front wheel drive has helped all wheel drive to become commonplace will all wheel drive continue its spread to all cars as the technology evolves. Only time will tell.

The End