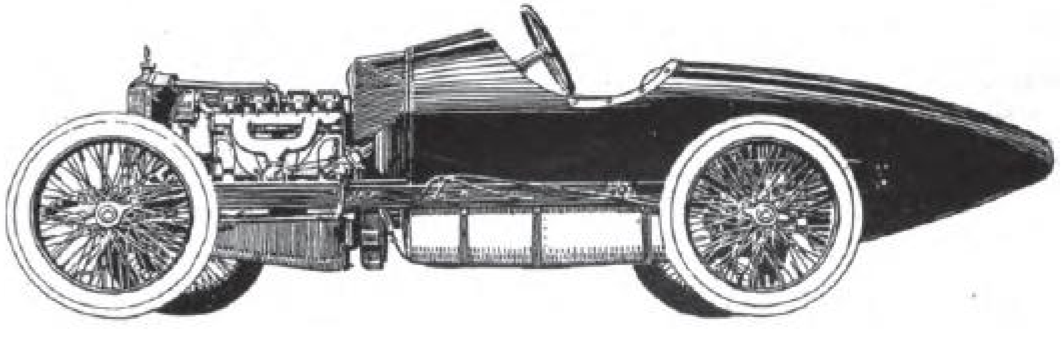
The Frontenac Aluminum Racing Car



View of Car with Engine Exposed, Also Showing Lines of Torpedo Shaped Aluminum Body Which Secures a Minimum of Wind Friction.

By CHESTER S. RICKER, M. E.

It is particularly interesting to note that the Frontenac motor developed by Chevrolet weighs 390 pounds complete and carries 354 pounds of fuel and water for a six-hour run. The tanks and radiator necessary for carrying this fuel probably weighs 150 pounds more, making a total weight of 994 pounds, or 7.65 pounds per horsepower. This is assuming 130 B. H. P. is developed by this motor.

The weight of the motor, with all accessories, is 3.77 pounds per B. H. P. Comparing these figures with those given by Mr. Louis Coatalen for the modern aircraft motor is quite illuminating. He gives antebellum air craft motor weights as follows: Mercedes, 3.5 pounds per B. H. P. and 2.6 pounds per B. H. P. as the latest results. For pre-war motors complete with fuel for five hours' run, he gives 7.3 pounds for rotating motors and 11.9 pounds for water cooled stationary types per B. H. P. Larger units are now being built with 5.36 pounds per B. H. P. The fact that this motor is light enough for aeronautical work shows how advanced the design really is.—Editor.

FIVE years ago, on the 26th of June, 1912, Boillot, driving a Peugeot racing car, won the Grand Priz race over the Dieppe course in France and demonstrated conclusively the advantage of the 16 valve in the head motor, a construction now familiar to every racing enthusiast. Since then, all of the big road and speedway races have been won by cars equipped with motors of this type, for Stutz, Peugeot and Mercedes cars were equipped with this type of 16 valve overhead motors. For racing purposes they have no peer.

The Aluminum Motor Established.

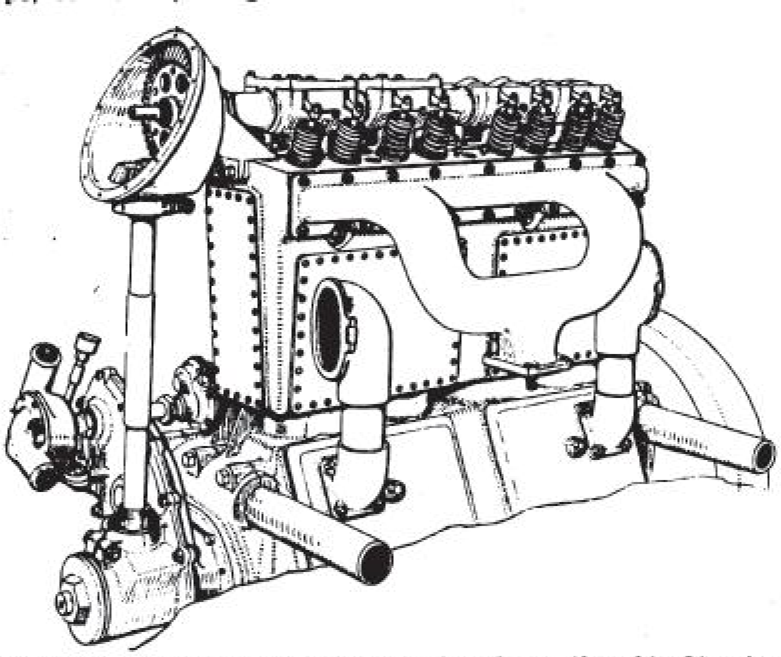
At the New York Automobile Show in 1916, the motoring public first saw the famous Marmon "34" chassis with the aluminum motor and light weight chassis construction which set a new standard in automobile design. Last year at the automobile show another aluminum motor, the Premier, was exhibited. The development of these motors extended over a period of nearly two years prior to their introduction to the automobile trade and to their being placed in the users hands. Hence the idea of an aluminum automobile motor, now two years old, but untried in the public's hands.

Therefore, when Louis Chevrolet conceived the idea of building an aluminum racing motor, or what might be called an aluminum racing car, there were "knows it alls" who said that the scheme was not feasible. However, during the winter and spring of 1911 Louis Chevrolet designed an aluminum racer and with the co-operation of the Aluminum Castings Company, the makers of Lynite, a special high grade aluminum alloy, and particularly suitable for motors and pistons, he was able to produce a new car which was first introduced to the racing world at the Indianapolis Motor Speedway on May 30, 1916.

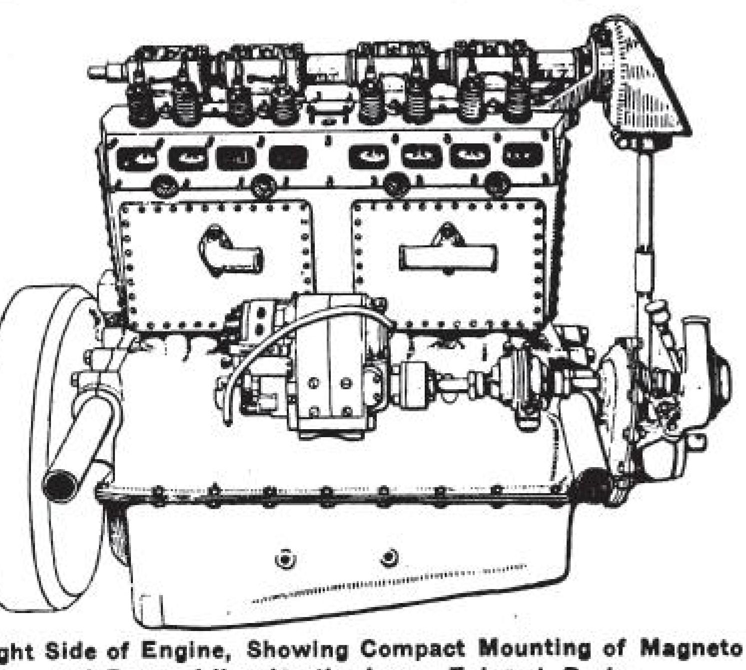
The Race Car Problem.

Suppose you were in Chevrolet's position in 1915. With many years of strenuous experience in racing he knew that the motors of the Peugeot type had been developed in their highest efficiency and therefore that some other tack must be taken by engineers in order to make a car which would be superior instead of being the equal of the Peugeot and Stutz, which were then supreme on American speedways and tracks. By the extensive use of aluminum in the designing and construction of his new racing cars, which he named Frontenac, he was able to use a 300 cubic inch aluminum motor and chassis, which complete weighed 500 pounds, less than any similar car. This light weight did not mean so much in the way of speed as it did in the saving of tires, and, therefore, in the reduction of the number of stops required during a long distance race. What is true of the reduction of the tire troubles on the race car is equally true on the commercial or pleasure car. This is exemplified in the long life of the tires on cars of the Marmon, Premier and Franklin type, all three of which are noted for their particularly light weight and the extensive use of Lynite aluminum alloys.

With characteristic foresight, Chevrolet was not far wrong in his conception of the requirements for an up-to-date racing car. The motor was designed along Peugeot lines, but at the same time was far lighter, due to the extensive use of aluminum. That he was immediately successful in the first races is no discredit to the motor or the car design, for as all race fans know, there have been very few race cars turned out at any time in the history of racing which were



Left Side of Engine Where Method of Promoting Air Circulation in the Crank Case and the Camshaft Drive Are Seen.



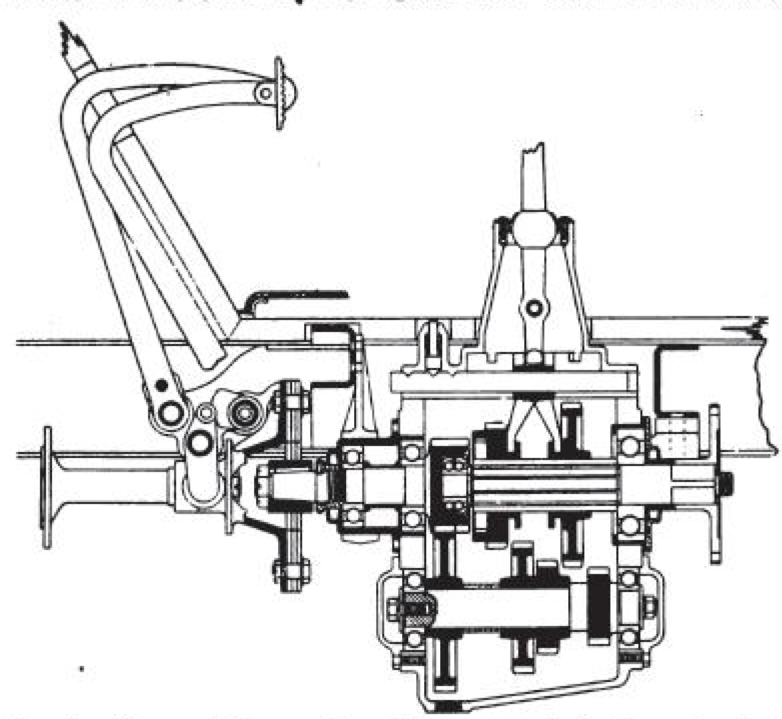
Right Side of Engine, Showing Compact Mounting of Magneto and Pump, Likewise the Large Exhaust Ports.

perfect in the first race which they entered. There are so many trivial things which are liable to get out of order or which are not exactly adjusted the first time they are used.

Frontenac Racing Performance.

For that reason it was nearly the end of the 1916 season before Chevrolet was able to eliminate all of the little "bugs" that had given him trouble and he won the Uniontown Speedway race, the last one of the season. The first race of the 1917 season he might have easily won had he not slowed down while still two laps in the lead and fouled his spark plugs. It cost him two minutes to clean them and it put him in fourth place instead of first. His team mate, however, ran second and made a very close finish. At Cincinnati the same car which had led almost to the finish at the Uniontown race easily led the field and won hands down.

The way in which this car goes through a long gruelling high speed race on the speedway without tire trouble is beginning to cause much favorable comment. What is meant by the aluminum racing car? It is a racing car with iron and steel used only where it is necessary to carry weight or to transmit power. In the Frontenac motor the cylinders, crank case, camshaft, housing, intake manifolds, gear housing, oil pan, pistons and water and oil pumps are all made from aluminum. In addition, the clutch, carburetor, transmission, rear axle housing, brake carriers, hood and body and underpan are all made from aluminum.



Construction and Suspension of Components in Cross Section of the Gearset.

Light Weight on Frontenac.

The car complete, ready for the road, but without oil, grease and water, weighs just a bit over 1600 pounds, whereas the average racing car weighs 2100 to 2600 pounds. Hence this car weighs anywhere from 60 to 75 per cent. as much as competitive cars. Ready for the race the weight of the car is slightly more, the addition being 236 pounds of gasoline, 58 pounds of oil, 10 pounds of grease and 50 pounds of water, making a total additional weight of 354 pounds. On account of the light weight of the chassis it is possible to carry more fuel and therefore not have to make stops in even a 500-mile race. At that, with the added weight of 354 pounds the car is still so much lighter than the average machine that it is possible to use 32x4½-inch Goodyear tires and not expect to have any tire changes in a race of that length.

Let us look over the chassis and see where it has been possible to reduce the weight by the use of this light weight aluminum alloy, Lynite. The motor complete with magneto wires, exhaust manifold, inlet manifold, carburetor flywheel, clutch, starting crank and tubular supporting arm, weighs 490 pounds. The cylinder block and upper half of the crank case, which is cast integral together with the cast iron sleeves, weighs 89 pounds. This is less than one-third of the weight of the average motor built of cast iron of this type. On most race cars the cylinder block is separate from the upper half of the crank case and therefore there is a considerable saving, since aluminum alloy is used for the upper half of the crank case. In this design the motor, cylinder block and upper half of the crank case would weigh around 180 and 200 pounds.

Some of the steel parts which go into the make up of the motor weigh considerably more than the main body of the motor, such as the cylinder, water jackets and crank case. For example, the crankshaft alone weighs 92 pounds. The flywheel, clutch, cone, bearings and spring weigh 140 pounds. Some of the other main constituents of the motor weigh as follows: Oil pan or lower half of the crank case, 20 pounds; camshaft and driving gears, 15 pounds; exhaust manifold, the heaviest individual item, 30 pounds; magneto, 24 pounds; four connecting rods, seven pounds; four pistons, three pounds, and the carburetor, 10 pounds. From these figures you will see how it is possible to build a light motor by using a large amount of aluminum alloy in its makeup. By its use the weight of the rear axle with the wheel adapted is reduced to only 200 pounds, where the average axle weighs 350 to 400 pounds. A certain amount of this weight, however, is removed by the elimination of the differential, which is not used on any of these cars.

Design of Motor.

From the mechanical standpoint the motor has many very interesting features which are not common to the average racing motor of this type. For example, the single overhead camshaft is driven by means of bevel gears instead of by a train of spur gears. The only motor using bevel gears that has been built and operated successfully up to this time was the Mercédes. On the latter motor the gears are placed at the flywheel instead of at the front. On the Frontenac a train of three spur gears are used to drive the water and oil pump and the magneto. It will be noticed that the spur driving and the bevel gears are attached to the front end of the crankshaft and are made from a single piece, which reduces the weight and adds strength.

The aluminum cylinder walls do not come in contact with the pistons, but instead cast iron liners of thin sections are inserted into the cylinder bore to take this wear. These liners are inserted from the bottom and held in place by friction only. As they are introduced while the cylinders are maintained at a high temperature by means of steam in the water jackets, they are automatically clamped tightly in place at normal temperature when the cooling water is in the jackets instead of the steam. Also, as soon as the motor is started up under its own power the temperature on the inside of the cast iron sleeve rises so much higher than that of the water cooled aluminum which surrounds them that the cast iron sleeves expand and tighten up inside of the aluminum rather than the aluminum expanding away from the cast iron sleeves. This construction takes care of the piston and cylinder wall conditions ideally, but it still leaves the question of the valve seats to be considered.

On the Marmon and Premier pleasure car motors this is not an item which has to be considered so seriously, because a detachable cylinder head is used and the detachable head is made from cast iron. This gives these pleasure car motors exactly the same conditions for their valves and valve seats that are found on the conventional type of cast iron cylinder motors. But Chevrolet's motor is not built with a detachable head, as the detachable head motor has not been found entirely successful for racing car use. For that reason some other expedient has to be used to provide cast iron seats for the valves. As will be seen from the end section of the Frontenac motor the seats for the valves are made up from iron castings with dove tailed edges and cast in the aluminum. This makes the cast iron seats an integral part of the aluminum cylinder casting and has been found to give absolutely no trouble during the life of these motors, which has extended over a period of nearly 18 months. One piece is used for each group of four valves. By the use of these individual cast iron valve seats the difference of the expansion of the cast iron and the aluminum does not effect the alignment of the adjacent cylinders.

The dimensions of the motor are 3.875 inches bore, 6.375 inches stroke, making a motor of just under 300 cubic inches displacement. With 105 pounds per square inch, compression pressure, it is possible to obtain 135 to 140 horsepower from this motor, so Louis Chevrolet claims. It will be noticed that two valve sizes are employed, the intake being made lighter and larger in diameter than the exhaust, as is clearly shown in the section drawing of the motor. The diameter measures two inches in the clear, while the exhaust measures only 1¾ inches.

Unique Valve Spring Construction.

The construction of the valve springs on this motor is rather unusual. It is customary to use two springs on all racing motors and, in fact, there are several pleasure car motors built in this way—i. e., Marmon. The point where Chevrolet's differs from other two spring constructions is in the use of a very short inside spring instead of one approximately the same length as the outside. The use of a short inside spring makes it possible to get it very stiff and therefore return the valves very quickly to their seats. The wide difference in the length of these two springs also makes it possible to dampen out any vibration which either one or the other of the springs may have when running at some critical speed.

Although not shown on the drawing reproduced herewith, the sides of the rocker arms are now packed with felt so that there is no oil leakage at this point. This makes it possible to pack the individual camshafts, housings and the rocker arms with oil at the start of the race instead of having to supply it up with oil under pressure as on the first motors that were produced. All of these motors are furnished with double magneto and two independent sets of spark plugs, one on each side of the cylinder.

In order to keep the weight of the driving gears and the size of the vertical shaft small, the reduction has been made at the tip instead of at the bottom, so that the vertical shafts run at crankshaft speed.

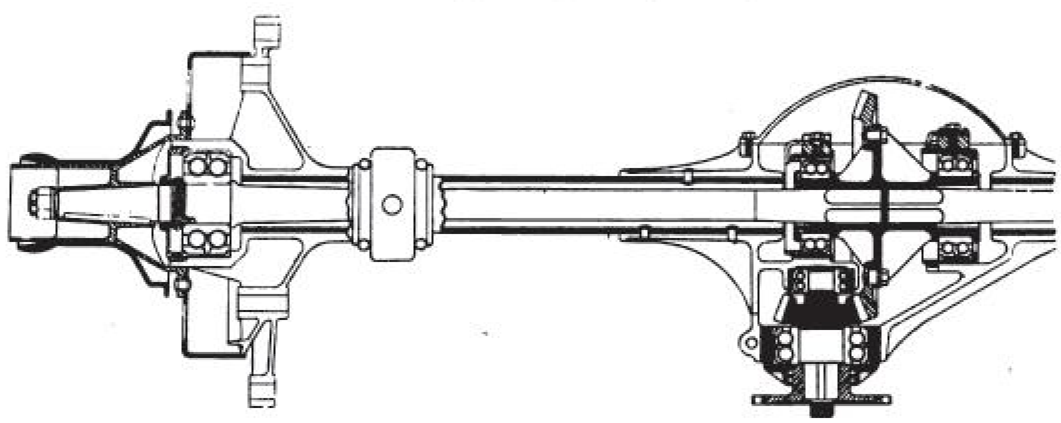
With the exception of the connecting rod, piston pin and the camshaft bearings, all of the other bearings used on the motor are annular ball. Those on the crankshaft are Nos. 3.3 and 314 from front to rear respectively.

In order to use these bearings on the crankshaft it is necessary to make the shaft up in two pieces joined at the middle. It is held together by means of one large through bolt and three smaller ones. At the points where these small bolts pass the division in the crankshaft, hardened steel bushings closely fitted are used to take the torque. They act like keys in this case and relieve the bolts of driving stresses.

Dry Crank Case Lubricating System.

The method of lubricating these motors differs from that in which plain bearings are used in the crankshaft, but in other ways does not differ from those where ball bearings are used. "Banjo" or centrifugal thrower rings are attached to each of the crankcheeks and oil is fed from them to the crankpin on each throw of the crankshaft. No chance is taken of one hole being stopped up and hence two feeds are made to each of the crankpin bearings. This will be noticed in the right hand crank throw, which is sectioned. The oil leads are carried to the caps on the bottom of each of the main bearings and a small feed tube is carried to the caps on the bottom of each of the main bearings and a small feed tube is carried out from these caps into the adjacent "banjo ring." In order to better support these rings and also to provide a counter balancing effect, the arm of the crankshaft has been extended across the centre line of the motor, as is clearly indicated in the attached drawings. It will also be noticed that the oil pan is deeply ribbed in order to keep cool the lubricating oil in this motor.

But this is not depended upon entirely for the lubricating system has two gear pumps mounted on the secondary shaft, which also drives the water pump and magneto. One of these oil pumps draws oil from the supply tank, which is independent of the motor, and the other one draws oil from the bottom of the sump and delivers it to the supply tank. This is called the "dry crank case" system and is by far the most successful that has been used on racing cars. It is the same system that is used on the Sunbeam aeronautical and Peugeot motors. It permits cool lubricating oil to be supplied to the motor at all times, as the heat from the motor cannot be conducted to the oil during its short stay in the oil pan.



Sturdy Cross Members Are Shown In This Cross Section of the Left Side of the Rear Axle and the Absence of Differential Is Noted.

In order to still further cool the oil a large semi-circular oil tank has been placed on the front of the dash and provided with copper radiating fins. This holds 12 gallons of oil and all of the air passing through the hood is directed over this tank and out of the side of the body, where suitable openings have been made.

Unlike most race motors of this type no under pan encloses the bottom of the motor compartment, so all of the air coming through the radiator and the louvres of the hood has an easy exit.

Other Parts of Aluminum.

The entire transmission is carried in an aluminum housing and the gear shift lever is mounted on an aluminum plate. The power is transmitted from the transmission to the rear axle by a double universal joint Hotchkiss drive. This is particularly satisfactory where a very light weight axle can be used and in this case the axle is lighter by far than the average. From the sectional view of the axle it will be noticed that no differential is provided and that the housing for the driving is made from aluminum. The spring seat and the brake housing are likewise made from aluminum, as will be clearly seen in the attached sectional drawing. With this type of housing it is possible to use four different gear ratios, namely, 2.312, 2.366, 2.642 and 2.161 to 1. This is a sufficient variety to meet all speedway and road work.

There are also a number of small features about the design of the car which are unique. One of them is the suspension of the fuel tank beneath the body inside of the frame. The other is the use of a one-piece aluminum body continuous from the dash to the tip of the tail. Another is the use of a cable instead of a rod to operate the brakes, as it is not only light in weight, but offers a very simple means of equalizing the brakes.

On account of the light weight and short wheelbase (104 inches), small tires, 32x4½; underslung tanks, which bring the centre of gravity low, this car is able to negotiate the speedway tracks faster and with less tire trouble than any other car which has ever been produced for speedway racing. For this the extensive use of aluminum must be given the credit.

In mentioning the fact that the motor was without an under pan it should not be considered that this applies to the entire car, because from the flywheel back to the tip of the tail there is an aluminum under pan which gives a perfectly smooth underbody to the car and thereby reduces the wind resistance. This underbody harmonizes closely with the frame and the super structure which carries the seats. Both the under pan and the body are made from sheet aluminum and are very light.