The Two-Cycle Automobile Motor.

By E. W. Roberts.

There are in practical use in automobiles two distinct types of hydrocarbon motors, distinct in their method of supplying the cylinder of the motor with the explosive mixture of combustible vapor and air and in their method of discharging the products of combustion (the burned mixture) to the atmosphere. These types are known as the four-cycle and the two-cycle motor.

In order that the reader may understand the terms used I will explain briefly the meaning of the term "cycle." The word cycle is employed for the complete series of operations beginning with the drawing of the explosive mixture from the carbureter or mixing device (suction) and ending with the discharge of the spent gas (exhaust). A stroke of the piston is its travel in one direction, and two strokes take place for each revolution of the shaft from which the power of the motor is taken to the driving mechanism of the car.

Strictly speaking, the term "four-cycle" should be "four-stroke cycle," since it requires four strokes of the motor to complete the cycle. This cycle consists first in drawing the fresh mixture from the carbureter through a valve known as the inlet valve, much in the same manner as water is drawn into a pump. In a few of the four-cycle motors this valve is drawn open by the suction of the piston, but more generally it is opened by the mechanism of the motor. The piston, having completed its stroke, returns and, the inlet valve being closed, compresses the mixture, which is ignited by an electric spark just before the stroke is completed. The ensuing explosion of the mixed vapor and air raises the pressure within the cylinder, driving the piston before it, on the next stroke, in the opposite direction. The stroke following drives the gases from the cylinder through the exhaust valve, which is opened by the mechanism of the motor, thereby completing the cycle. Thus the four parts of the cycle are the suction stroke, the compression stroke, the expansion or explosion stroke, and the exhaust stroke.

In the two-stroke cycle of the two-cycle motor, precisely the same series of operations occurs, but in such a way that the cycle is completed in two strokes of the piston. Suppose that the mixture instead of being drawn in by the suction of the motor piston, were to be drawn first into an air pump and then slightly compressed. Assume that the cycle has progressed as far as the completion of the expansion stroke, and that the piston at the end of this stroke has uncovered a large opening in the wall of the cylinder, thereby permitting the exhaust gases to escape. If at this stage of the cycle communication be made with the pump containing the mixture under pressure and with the motor, the cylinder would be filled with fresh mixture, and at the same time the fresh mixture coming in would assist in clearing the cylinder of the burned gas. The exhaust stroke would then be transformed into a compression stroke, and the suction stroke would be eliminated. Note particularly that the cylinder is filled by the pump during a very short portion of the stroke and very quickly, leaving the greater portion of the stroke for compression of the mixture.

Suppose, that, instead of the separate air pump, the lower end of the piston were to be made to perform this function, by making the base of the motor air-tight and supplying proper valves and passages to draw the mixture into the base from the carbureter and to force it into the cylinder above the piston. We should then have the two-cycle motor in its usual form, which I will now describe by means of diagrams.

In Fig. 1 is shown a vertical two-cycle motor in section with the piston *P*, on its upward stroke, drawing the mixture from the carbureter into the base through the check valve *C*. A charge is also being compressed on the upper side of the piston, suction and compression taking place at the same time. Just before the up-stroke is completed, the mixture is ignited by the spark at the spark plug and, when exploded, gives the pressure to drive the piston downward and furnish power.

In Fig. 2, the piston has nearly completed its downward stroke and the burned gases are escaping through an opening in the wall of the cylinder, the exhaust port *E*. During the down-stroke the valve *C* is closed and the piston compresses the mixture to a pressure of from four to eight pounds. The inlet port *I* opens a little later than the exhaust port and after the pressure in the cylinder has fallen nearly or quite to that of the atmosphere. As soon as the inlet port opens, the pressure of the gas in the base or crankcase drives it through the passage *B*, called the by-pass or transfer port, through the port *I* into the upper portion of the cylinder. These ports are so designed that little or none of the fresh mixture escapes through the exhaust port; and the piston, covering the ports on its upward stroke, compresses the mixture above the piston and draws a new charge into the base, thus beginning another cycle. For the reason that there are but two openings or ports in the wall of the cylinder opened and closed by the piston, this particular form of two-cycle engine, in which the mixture is drawn into the base through a check valve, is known as a two-port motor.

Another form of two-cycle engine is shown in Fig. 3 in which the check valve is not used, but, in its stead, a third port in the cylinder wall, which port is uncovered by the piston when nearly at the top of its stroke. On the up-stroke of the piston the base is closed and a vacuum is produced. Hence the pressure in the base, when the piston is near the top of its stroke, is from two to four pounds below the pressure of atmosphere, so that, when the port *C* is uncovered, the fresh mixture rushes into the base from the carbureter and fills it. The other functions of the cycle are performed in exactly the same manner as in the two-port motor. Because of the fact that there are three ports in the cylinder wall, instead of two, this form is called a three-port motor.

The honor of placing upon the market the first automobile powered with a two-cycle motor, belongs to the Elmore Manufacturing Company. This company started with a wheel-friction-drive car in 1900, but the first car which could be called a commercial success was their 1902 model. For several years the Elmore Company had the only two-cycle automobile in the field.

Fig. 4 shows the Elmore automobile motor in section. It is of the three-port type, with the base divided in the horizontal plane passing through the axis of the crankshaft. The base is an aluminium alloy casting, and the cylinders, of gray iron, are bolted on. The special feature of this motor is the use of a wire screen of fine mesh in the by-pass to prevent the flame from the burning charge from traveling through the by-pass and setting fire to the mixture below the piston, and causing a base explosion. In order to prevent rupture, the fine wire screen is held between two plates of perforated metal with comparatively large openings, as shown in the smaller figure at *X*, *C* being the fine wire screen and *D D* the perforated plates supporting it.

A modified form of the two-port motor is that used in the Atlas car made by the Atlas Motor Car Company and shown in Fig. 5. It has several features which are departures from customary two-cycle practice. One of these is the disk valve, between the carbureter and the base, used first on a motor called the "Yale," formerly built somewhere in New England. The name of the inventor and the locality I am unable, at this writing, to recall. Another feature is the arrangement of the by-pass and the cylinder ports, which entirely surround the cylinder. Referring to the figure, the disk valve to the crankcase is shown in the lower right-hand corner and in section to the left. The disk *D* is held to the side of the case by the springs *S*, making a gas-tight joint. As the disk revolves with the crank, the opening *O* in the disk uncovers the opening *Y*, shown by dotted lines, and makes communication with the carbureter through the crankcase inlet *C*. It will be seen by the location of the opening *O* with relation to the crank pin *K*, that the valve does not begin to open until the piston has made a small portion of its upward stroke and that it closes shortly after the piston has started on its downward stroke. The by-pass *G* entirely surrounds the cylinder, and through it the mixture passes from the base to the inlet ports *I* and thence to the cylinder. After the mixture enters the cylinder it passes under the deflecting hoods *F*, which throw it to the top of the cylinder and prevent it from mixing with the exhaust as it passes out through the exhaust ports *X* and thence to the atmosphere through the passage *X*. The exhaust ports open considerably in advance of the inlet ports, their relative positions being shown at the middle right of the cut.

The general external appearance of the two-cycle automobile motor is shown in Fig. 6, which illustrates an automobile two-cycle motor of the three-port type designed by the writer for large cars. This figure serves to illustrate the freedom from exterior mechanism which is characteristic of the two-cycle. It further shows the general arrangement of the inlet and the exhaust pipes or manifolds and their general design. Special attention is called to the broad sweep of the exhaust piping, which is very necessary in a four-cylinder of this type in order to prevent the exhaust from one cylinder from interfering with that from another. Observe also the diameter of these pipes as compared with a four-cycle of the same size. The inlet and the exhaust pipes on this motor are two inches inside diameter, and the dimensions of the motor are 4½-inch bore by 5-inch stroke. These large pipes are made necessary because the time for the gas to get into and out of the engine is very small as compared to the four-cycle. In fact, it is less than half.

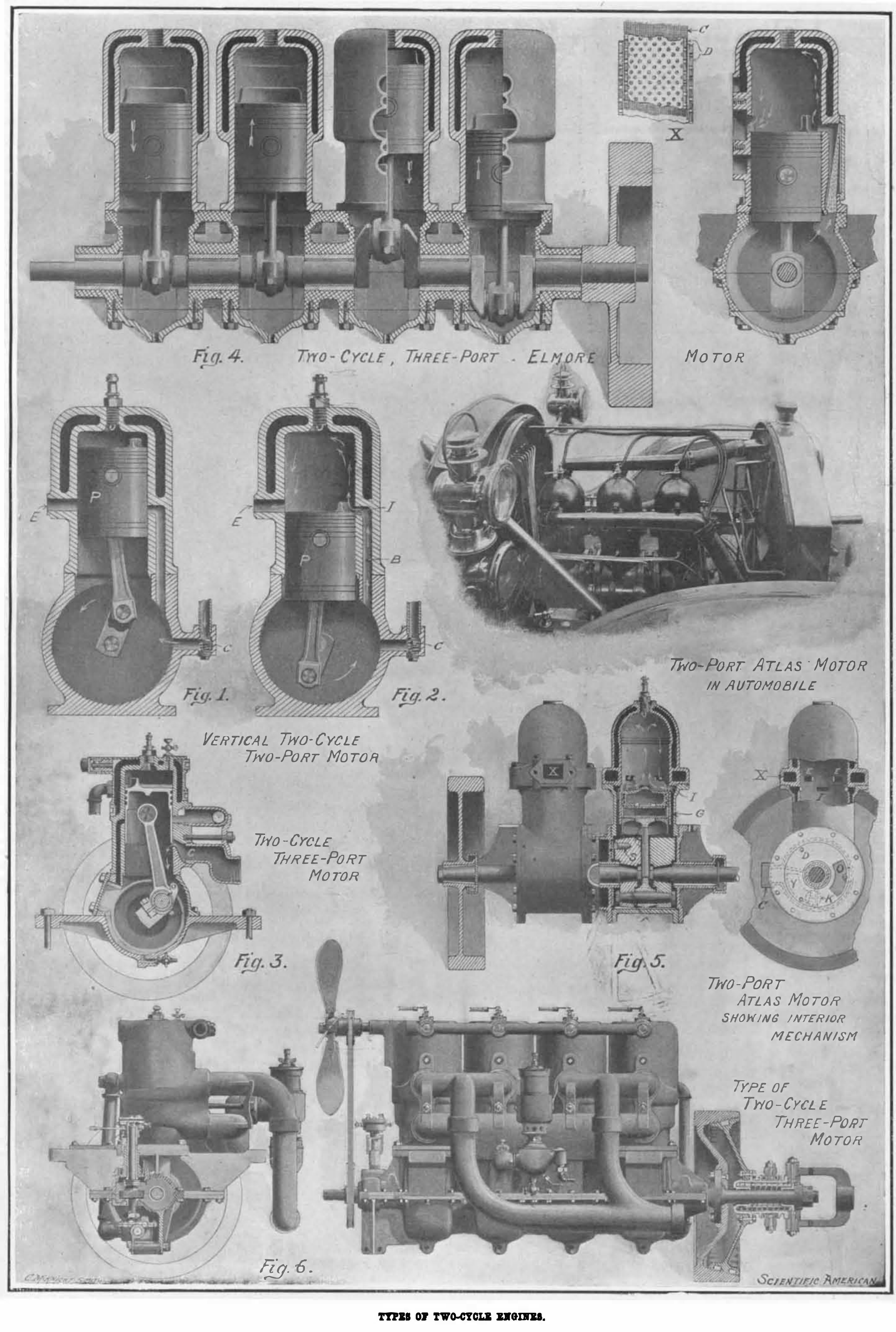
It is probable that the slow introduction of the two-cycle motor as an automobile power is due more than anything else to two factors. One of these is the prejudice caused by the cheap two-cycle marine motor, which, while it will work well when set for one speed, is not flexible and often difficult to control at low speeds. This is not true of every well-designed two-cycle engine. The other factor is the poor understanding of these motors by the majority of designers, and the difficulty they have in breaking away from four-cycle practice. The problem is a difficult one in a way, and, like every other in engineering, requires experience.

One of the annoying features of the average two-cycle is the tendency to base explosions, or the firing of the mixture in the base before it reaches the cylinder. This generally occurs at low speed, and invariably checks the speed. It can be avoided by careful design of the ports and other elements and by some means of extinguishing the flame from the cylinder when it attempts to pass downward through the transfer port. This can be accomplished by some cooling surface such as the screen in the by-pass of the Elmore motor. Properly designed, the two-cycle is practically free from this trouble and will explode through the carbureter less than a good four-cycle. Another method of avoiding base explosions is to operate the motor on a mixture rich in gasoline, and this plan is quite generally employed on marine motors. A good two-cycle automobile motor should not "back-fire" on any mixture, and if it is so designed it will operate as economically in regard to fuel consumption as the four-cycle.

The difference in action between the two types is especially marked when there is heavy work to do. Generally speaking the two-cycle will hang on to its load better at low speeds and therefore climb steeper grades or go through heavier roads on the high gear. It is at no disadvantage on high speed and it will drive a car just as fast as the four-cycle. I am aware that there is considerable evidence to the contrary, but it will be found that motors giving such testimony have small pipes for the intake to the base. Generally, a two-cycle will begin to drag after it passes a certain number of revolutions per minute, and often a motor that will give 6 horse-power at 600 will give scarcely 8 at 1,000. Give the same motor larger inlet and exhaust passages and it can be made to give 10 horse-power at 1,000 and 12 horse-power at 1,200. The usual gain in power by using the two-cycle principle is about 50 per cent. That is, taking two motors of the same bore and stroke, the two-cycle will give 50 per cent more power than the four-cycle.

There are further advantages in the two-cycle type, among which may be mentioned the fact that the greater frequency of the explosions gives a smoother running motor and one with less vibration. Moreover, there are fewer parts and hence less liability to disorder, and fewer breakdowns. The liability to derangement in the hands of a careless or ignorant operator is small, and the life of the motor is fully equal to, if not greater than, that of the older type.

The use of cork as a frictional surface in clutches and brakes of automobiles has assumed surprising proportions, clutches of this type being used by forty-eight manufacturers in 1908, with every indication of a material increase in number of manufacturers and of cars produced using these clutches in 1909. This surface, which is a combination of cork and metal, and obtained by compressing corks into sockets or holes in one or the other of the engaging surfaces, is fast becoming one of the necessary features of car clutches.



TYPES OF TWO-CYCLE ENGINES.