wheel and clutch. The crankshaft is very heavy, weighing 165 lb., and is counterbalanced. It might be advantageous to drill this shaft hollow and lighten it considerably, especially the crankpins. This would reduce also the weight of the counterbalances and thereby decrease the total weight of the shaft without lessening its strength much. The crankshaft is mounted on three ball bearings. It is made in two pieces and assembled in the center. It is locked rigidly by three hardened keys and can be taken apart and reassembled without disturbing its alignment. If we were building another crankshaft of this type we would make the center cheeks more nearly square and drill the center from end-to-end hollow, making it rigid and lighter at the same time. At the front end of the crankshaft the gear which transmits the power required to drive the camshafts is shown.

The upper view in Fig. 4 shows one of the camshafts. There are two plain bearings and one ball bearing in

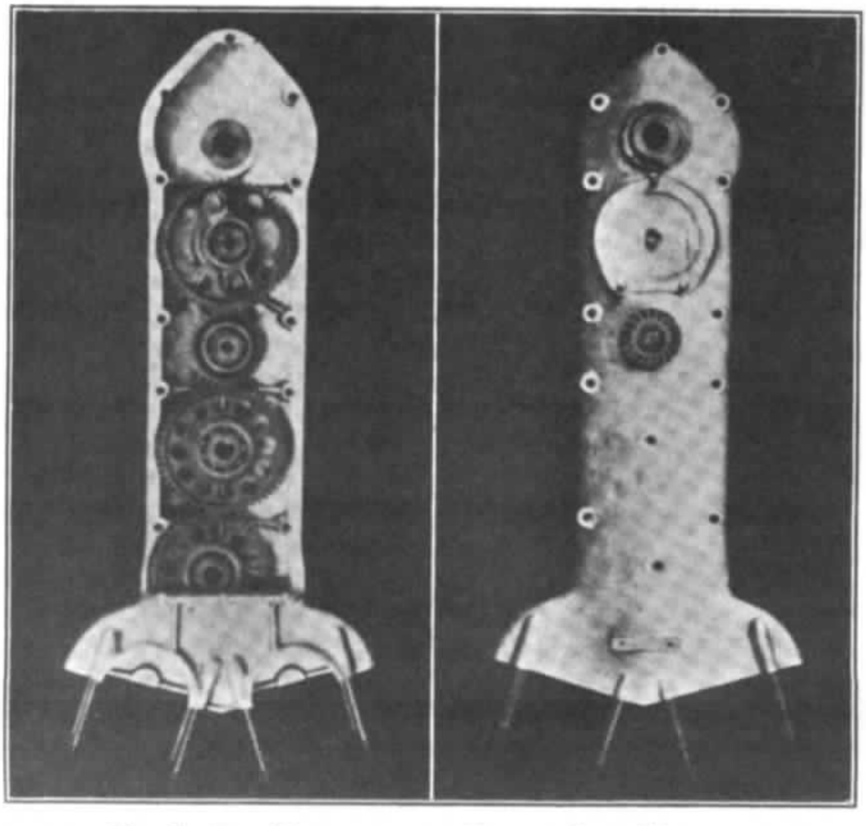

FIG. 5—TWO VIEWS OF THE TIMING-GEAR HOUSING

The View at the Left Shows the One Side of the Housing with the Gears in Place, While the View at the Right Is Looking Toward the Front of the Housing Which Is Fastened to the Forward End of the Engine.

front which supports the timing-gear. Attention should be called to the heavy rim on the camshaft gear; this is for a flywheel effect. The camshafts run at sufficiently high speeds to store up considerable energy, which assists in opening the valves against the high spring-pressures we use. These are in the neighborhood of 125 lb. The cam has a lift of 7/16 in. The camshaft, drilled hollow as mentioned, has a wall thickness of 1/8 in.

The complete cam housing is illustrated in the middle portion of Fig. 4, while the bottom view shows the interior of this housing with the bronze caps forming the camshaft bearing and the fingers, which have been mentioned before, in place with their housing. By removing small screws the fingers can be removed in units of four, inspected, repaired if necessary and replaced in a very short time. The channel, which has been mentioned, is shown underneath the ball bearing, where the oil is allowed to run out at the front of the housing. The fingers do not have rollers but simply curved surfaces.

Fig. 5 presents two views of the timing-gear housing. That at the right is looking at the front of the housing, which is fastened to the forward end of the engine. The bottom hole is where the crankshaft projects through. The machined surface above it is for the water-pump and generator bracket. The shaft in the middle drives the water-pump. Above it is a toothed flange which is part of the generator coupling. The coupling at the generator has one tooth less. A rubber member which fits in between the flanges enables a micrometer adjustment to be made and the rubber center member provides a flexible joint that absorbs much of the shock present in timing-gears. The other side of the timing-gear housing is shown at the left of this illustration with the timing-gears in place. These gears are made of chromium-vanadium 0.50-per cent carbon-steel, heat-treated. The teeth are 12-pitch. The webs are drilled hollow for lightness and mounted on a single-row ball bearing. The ball bearings are held in the gear by simply turning over the edge of the gear against the chamfer on the outer race of the ball bearing. The lower gear drives the water-pump. The one directly above and meshing with this gear drives the generator. This gear is really smaller than it should be, as the engine was originally designed to take a magneto that had to run at crankshaft speed, which is much faster than is really necessary to run a low-voltage generator.

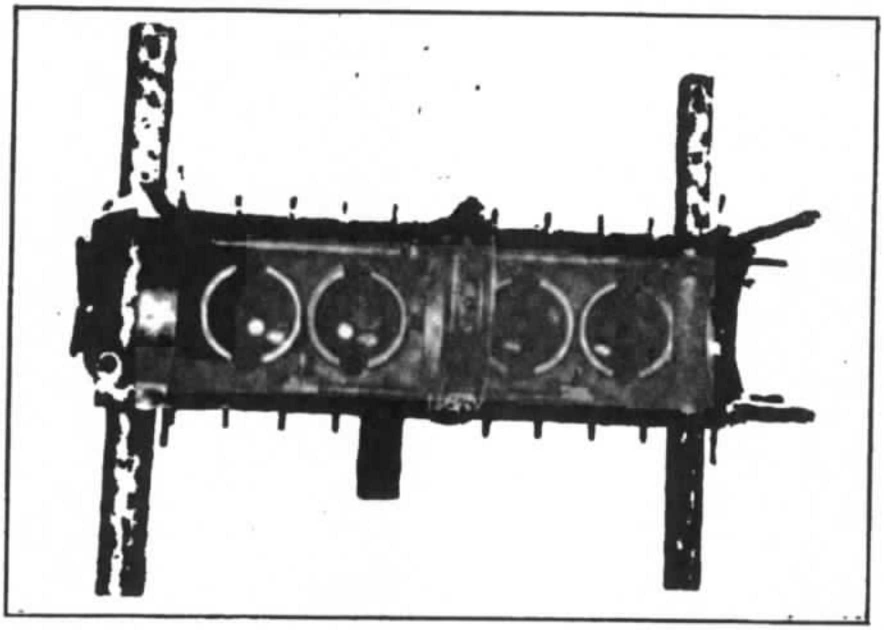

FIG. 6—LOOKING INTO THE CYLINDERS FROM THE BOTTOM

It was determined after test to use the battery system of ignition in place of a magneto on account of the high engine speed, which is from 3400 to 3600 r.p.m.

Fig. 6 is the view seen when looking into the cylinders from the bottom. It shows clearly the oil-pipes already spoken of, the valves in place in the head of the cylinder and also the steel supporting tubes.

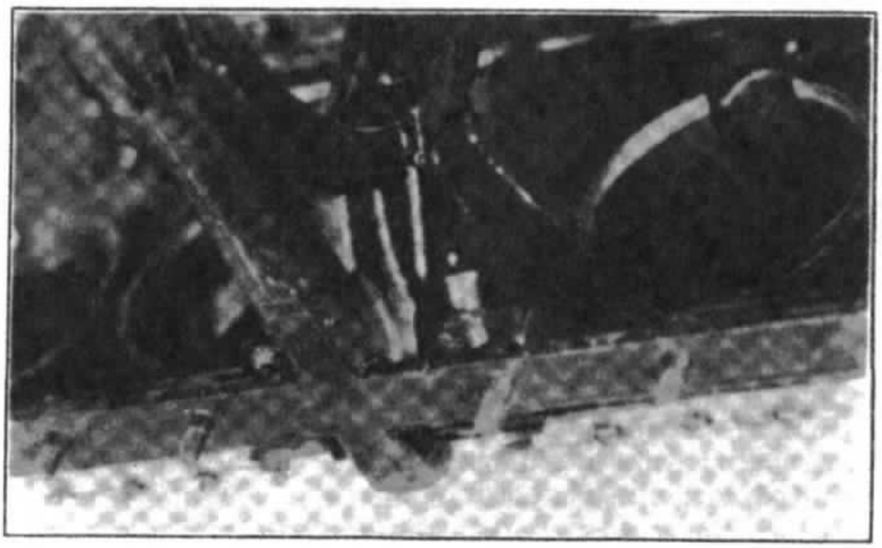

FIG. 7—THE OIL-JET WHICH SUPPLIES LUBRICANT TO THE OIL-RING ON THE CRANKSHAFT

Fig. 7 is a close-up view of the oil-jet which supplies the oil to the oil-ring on the crankshaft. The oil leaving this jet is directed against the side of the oil-ring and carried by centrifugal force into a deep groove inside the ring and a hole connecting this groove with the connecting-rod bearing. The centrifugal force in this ring of oil exerts a pressure of about 40 lb. per sq. in. at the connecting-rod bearing. This system of oiling has its advantages and disadvantages, a very good feature being that the oil can be carried under high pressures to the connecting-rod without excessive pressures in the pipe lines which go to and from the engine. This does away with the danger of leakage through joints, as the pressure carried in the pipe lines need never exceed 5 lb. per sq. in. One disadvantage, however, is that the system is very sensitive to dirt and, if care is not taken to clean the jets and oil-rings, they will become clogged and cause bearing trouble. However, if the system is carefully watched, satisfactory results will be obtained.

Fig. 8 at the left shows the generator, distributor and water-pump unit, which is fastened into the forward end of the engine. This might have been executed in a more compact manner had it not been a replacement for magneto equipment. For the high speed at which this engine ran, battery ignition proved to be very successful. At no time during our season of racing have we had ignition trouble.

A view of the complete engine, with the magneto equipment as when the engine was first built, is presented in the right portion of Fig. 8. Attention is called to some experience we had with the distribution of gases. The manifold shown has an inside diameter of 2 in.; owing to its shape, we found that at high engine speeds the gases would travel toward the front and back of the engine; before cylinders Nos. 2 and 3 could take in a charge, it was necessary for the gas to bank-up in the end of the manifold and form its own passage to cylinders Nos. 2 and 3. This, of course, had a tendency to starve the two middle cylinders. A mixture suitable for the end cylinders would cause overheating of the two middle cylinders, resulting in the overheating of the valves. Not having time to experiment with manifolds, we substituted a small baffle-plate in the outer wall of the manifold, which served to deflect the gases toward the center. By a small amount of experimenting, which was merely cutting off the end of this baffle-plate and watching the

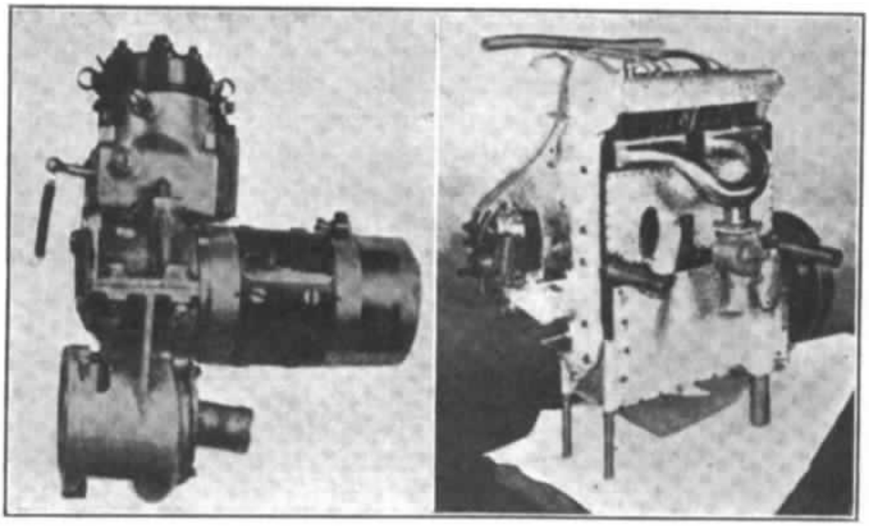

FIG. 8—THE GENERATOR, DISTRIBUTOR AND WATER-PUMP UNIT WHICH IS FASTENED INTO THE FORWARD END OF THE ENGINE AT THE LEFT AND AT THE RIGHT A VIEW OF THE COMPLETE ENGINE AS IT WAS FIRST BUILT WITH THE MAGNETO EQUIPMENT

exhaust, we were able to determine the proper setting. Unfortunately, this held good only at one certain speed; dropping below or going above that speed tended to reverse conditions and again cause trouble; but, as in our case the engine ran practically at a constant speed, we were able to use the manifold with fairly good results. We also tried the use of two carbureters with separate manifolds, but this was not at all satisfactory. The velocity of the gases was so great that when the valves closed there was a plus pressure against the back of the valves which resulted in a blow-back through the carbureter. To correct this we tried a by-pass from one manifold to another to allow the plus pressure to be conveyed to the other manifold, but this did not prove successful.

The valves in this engine have a diameter of 1 7/16 in. in the clear, and a lift of 7/16 in. The area of opening for one valve is 1.70 sq. in.; the total valve area is 6.81 sq. in. The engine, on the dynamometer, delivered 86 hp. at 3200 r.p.m. This is not as high as has been reported from tests of eight-cylinder engines of the same piston displacement. On a test under a wide-open throttle this engine, running at 3200 r.p.m., delivered an average of 78 hp. for 1 hr. The result might have been better had the air in the test-room not been contaminated with exhaust gases, causing a considerable drop in the horse-