a finger having a curved surface forming the section of a roller upon which the cam rides. This finger is to take the side-thrust. Between it and the valve-stem proper there is a straight piece of steel that might be called a tappet. This is the only means of adjustment and is ground to give the proper clearance. This makes a very light valve mechanism and needs very infrequent adjustment.

As to the cooling of the pistons, it is not practical to use the method of heat dissipation through the wall of the piston to the cylinder wall and thence to the water in the jacket, because the wall area necessary in this case to conduct the heat from the pistons is so great as to make the pistons too heavy to travel at the required rate of speed. We have found that it is possible to air-cool these pistons, obviating the large wall area mentioned. This accounts for the unusually large breathers on the side of the engine, one in front and the other in the rear. The front one has a funnel-shaped top covered with a 16-mesh screen which prevents large particles from getting into the crankcase. The air goes in through this front breather-tube, through the crankcase and out through the rear breather, which has an inverted tube facing downward in a compartment separated from the crankcase proper, with a port entering the chamber at the top and also one at the bottom. The breather-tube in this chamber is sealed at the top and has a series of staggered holes down its side. It was designed to take as much air as possible from the crankcase and condense the oil vapor at the same time. The theory is that the air, due to the rotation of the crankshaft, passes in at the upper port and down and around the breather-tube. The oil vapor, settling on the wall surfaces, runs down and out through the lower port and back into the crankcase, while the air escapes through the holes in the wall of the tube and so on to the outside of the car. Of course, there is always more or less oil mixed with the air, and this is lost.

Two separate oiling systems are used on this engine; one mechanical and the other manual. The manual system is for emergencies; it is never used unless something gets out of order in the mechanical system. Both systems are what is known as the dry-sump type. The oil is carried in an 8-gal. tank on the car. There is a two-stage gear-pump which circulates the oil. The lower and smaller pump takes oil from the tank and pumps it through the engine; the upper and larger pump takes oil from the engine and pumps it back to the tank. There is a pipe running from the pressure-pump up the back of the engine and connecting with a pipe cast integrally with the cylinder block. Along the edge of the cylinder there are four plugs, which cover a small compartment from which jets project and deliver oil to rings mounted upon the crankshaft.

At the same point where the pipe enters the rear of the cylinder block there is a small pipe which conveys oil up to the camshaft. This pipe enters the rear end of one camshaft housing and is delivered by another pipe across to the other. The two rear camshaft-bearings each have a groove completely around their circumference and, by this groove and through a hole drilled in the camshaft, the oil is forced along the inside of the camshaft, which is drilled hollow. At the heel of each cam there is a 1/16-in. drilled hole, which supplies oil to each cam mechanism. The oil which escapes from the camshaft, after doing its work, is conveyed along the bottom of the housing to the front of the engine where there is a channel beneath the ball bearing which allows it to run out and down over the timing-gears. The oil that does not escape through the small holes in the heel of each cam passes out through the front of each camshaft and also down and over the timing-gears. After the oil goes down through the timing-gear case it runs into the crankcase and along the bottom to a cone-shaped strainer located in the bottom of the crankcase. Through this strainer it is delivered to a compartment which forms a reservoir to allow dirt and carbon to settle out before being taken up by the scavenger pump. The rib along the bottom of the crankcase is not put there for strength, but to form a baffle-plate to prevent the oil from surging about in the crankcase and also to convey it to the scavenger pump.

On the opposite side of the cylinder from the pressure oiling system there is another pipe cast integrally with the cylinder and having two jets, one at either end and opposite the center cheeks of the crankshaft. The oil is taken from the tank by the hand pump at the outward stroke, delivered to these two jets at the inward stroke and projected against the center crankshaft cheeks. The hole drilled in the cheek picks up a quantity of oil every time it comes opposite the jet. This same pump delivers oil to the camshafts by way of the pipe leading from the back end of the camshaft housing to the pressure gage on the instrument board. The oil is pumped out of the crankcase and back to the reservoir tank by another hand pump.

The spark-plugs in this engine were made especially for the job. We used one spark-plug per cylinder, located in the center between the four valves, an ideal position. This necessitated an extra-long threaded portion, to get down into the combustion-chamber and still permit water to circulate around the valves. If we had tried to use the standard type of spark-plug, the opening needed would have been so large as to take all the water space.

The adoption of two dial thermometers was an important matter as they give accurate account of what goes on in the engine. One of these which is for water is located in the outlet water manifold. The other is for oil and is located in the lowest part of the crankcase. The oil thermometer is very valuable to the mechanician; the moment a part becomes overheated, from either lack of oil or insufficient clearance, the temperature of the oil rises and is indicated upon the dial of the thermometer. In such case the driver should drive immediately to the pits and inspect the engine for the trouble. On certain occasions when connecting-rods become heated rapidly and the mechanician was either inattentive or had not sufficient time to notify the driver, the connecting-rods have left the engine and been lost to view.

At the left of Fig. 2 the cylinder block and lower half of the crankcase without the side-plates are shown. The valves are in place and also the studs which carry the camshafts and their housing. This cylinder construction should be of interest as it is more or less of a departure from regular practice, inasmuch as the crankshaft is supported by the cylinder itself rather than the cylinder being supported by the crankcase. The crankcase in this case acts merely as an oil retainer. This has proved to be a very light, rigid and satisfactory type of construction. Both sides and the rear of the cylinder block are covered with a No. 16 gage aluminum plate, fastened on with No. 10-24 fillister-head cap-screws. The openings which these aluminum plates cover form very large core-prints, which has a tendency toward securing accurate castings. Castings which we have sectioned have shown that the walls, which run from 1/8 to 5/32

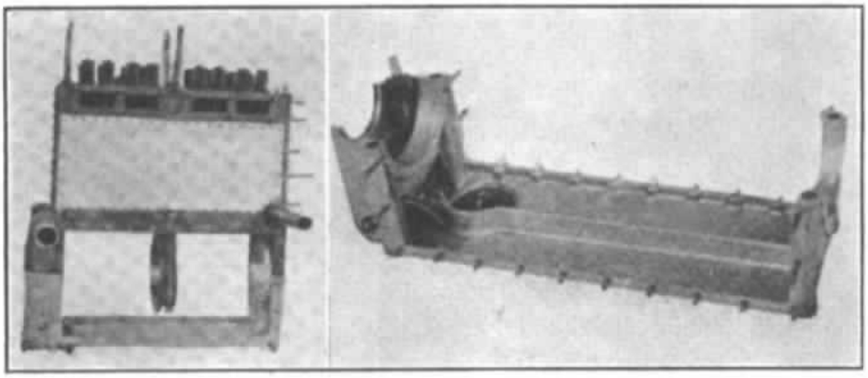

Fig. 2—The Cylinder Block and the Lower Half of the Crank-case without the Side-Plates at the Left and at the Right the Lower Crankcase Which Can Be Removed without Disturbing the Crankshaft

in. in thickness, did not vary. The cylinder block as shown weighs 125 lb. The illustration shows the two steel tubes which support the engine in the frame. By removing the plates on the side of the crankcase, the connecting-rod and piston can be taken out of the engine without disturbing the crankshaft.

The lower crankcase at the right of Fig. 2 can be removed without disturbing the crankshaft, as the center bearing is separate and forms a supporting member. The baffle-plate or rib, already mentioned, can be seen; also the oil-pump and the spiral gear which drives the oil-pump at one-quarter engine speed. This gives the oil-pump a capacity of 1 gal. per min. We have kept the speed of all parts as low as possible to reduce friction losses in the engine.

The view at the left of Fig. 3 shows the connecting-rod and piston. The piston is $2\frac{1}{2}$ in. long, $3\frac{1}{8}$ in. in

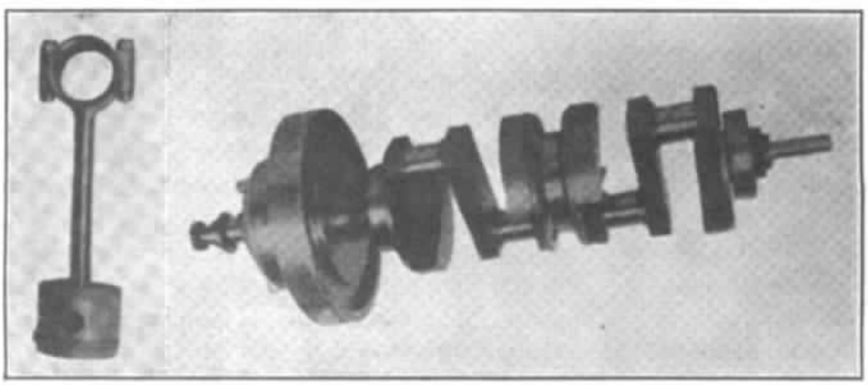

Fig. 3—The Connecting-Rod and Piston at the Left and the Crankshaft, Flywheel and Clutch at the Right

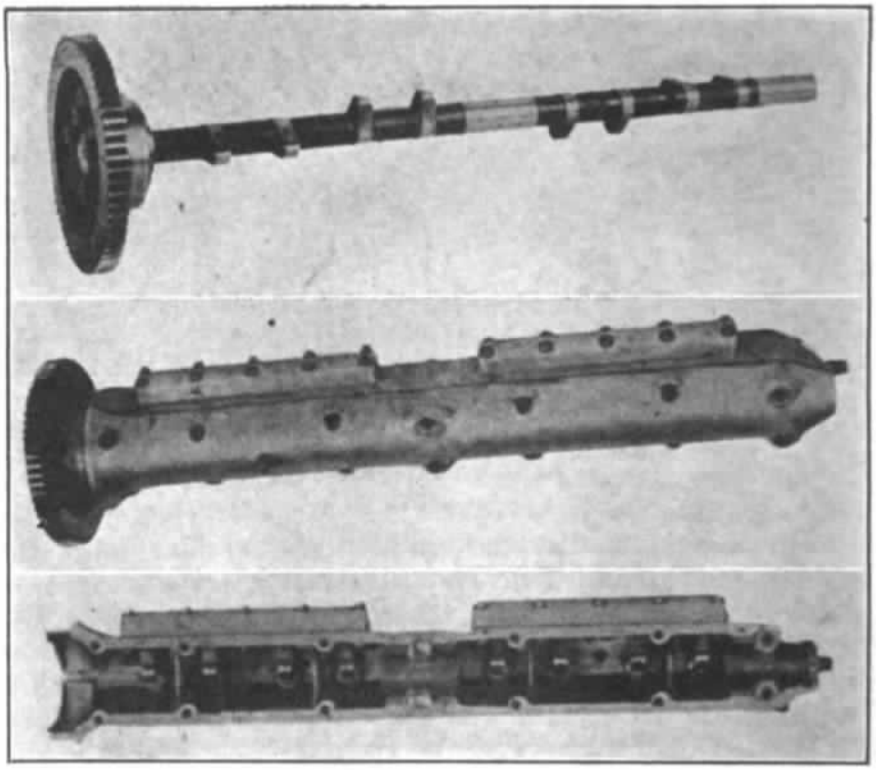

FIG. 4—ONE OF THE CAMSHAFTS AT THE TOP WITH THE COMPLETE CAM HOUSING UNDERNEATH AND AN INTERIOR VIEW OF THE HOUSING WITH THE BRONZE CAPS FORMING CAMSHAFT BEARING AT THE BOTTOM

diameter and has two cast-iron rings, 1/8 in. square. The connecting-rod is made of chromium-vanadium steel containing 0.35 per cent of carbon. The bearing is bronze, babbitt-lined. The connecting-rod has two bolts to hold the bearing cap; the pillar of the rod is drilled hollow and has a wall thickness of 1/16 in. The weight of the piston, with the wristpin and connecting-rod as shown, is 2 lb. 14 oz. The rod is 9 in. between centers. This is short for the amount of stroke, as in ordinary passenger-car practice a stroke such as we have here would call for not less than a 12-in. connecting-rod, but we find that we gain higher mean effective pressures with a short connecting-rod and also decrease the weight of the rod considerably. This connecting-rod has proved very satisfactory and never given trouble. The pistons are of aluminum and rough-machined, heated to about 700 deg. fahr. and then finished. This removes all internal stresses and they hold their shape under the high temperatures they attain in the engine.

The right section of Fig. 3 shows the crankshaft, fly-