EVALUATION OF ALUMINUM ENGINES

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Research continues to bring cast aluminum engine parts for automotive applications closer to economic and engineering reality. Interest in aluminum engines has been quickened by the trends toward increasing both the horsepower-displacement ratio and the horsepower-weight ratio.

The interest of American industry in the use of aluminum engines is a natural one. In this direction, aluminum companies in this country have developed the sandwich-brazing method for fabricating cast aluminum engine blocks and cylinder heads and are continuing to improve it for eventual use in production. Since it is desirable for aluminum parts to compete cost-wise with ferrous metals, production methods are continuously being improved. At the same time, however, extensive testing is being done on performance and design of aluminum engines. One interesting test project in the use of aluminum has been carried out on the Italian Lancia V-6, Model B-10 engine.

The Lancia Aluminum Engine

This engine combines extensive use of aluminum with an interesting V-6 design. Forty-seven per cent of the engine's total weight is aluminum.

The Lancia B-10 was chosen for test purposes after a survey had been made of European automobiles in which light metals are more extensively used for production models. A Lancia Aurelia sedan was obtained which was powered by the B-10 engine, and the engine was given extensive road and dynamometer testing. Component parts were carefully inspected.

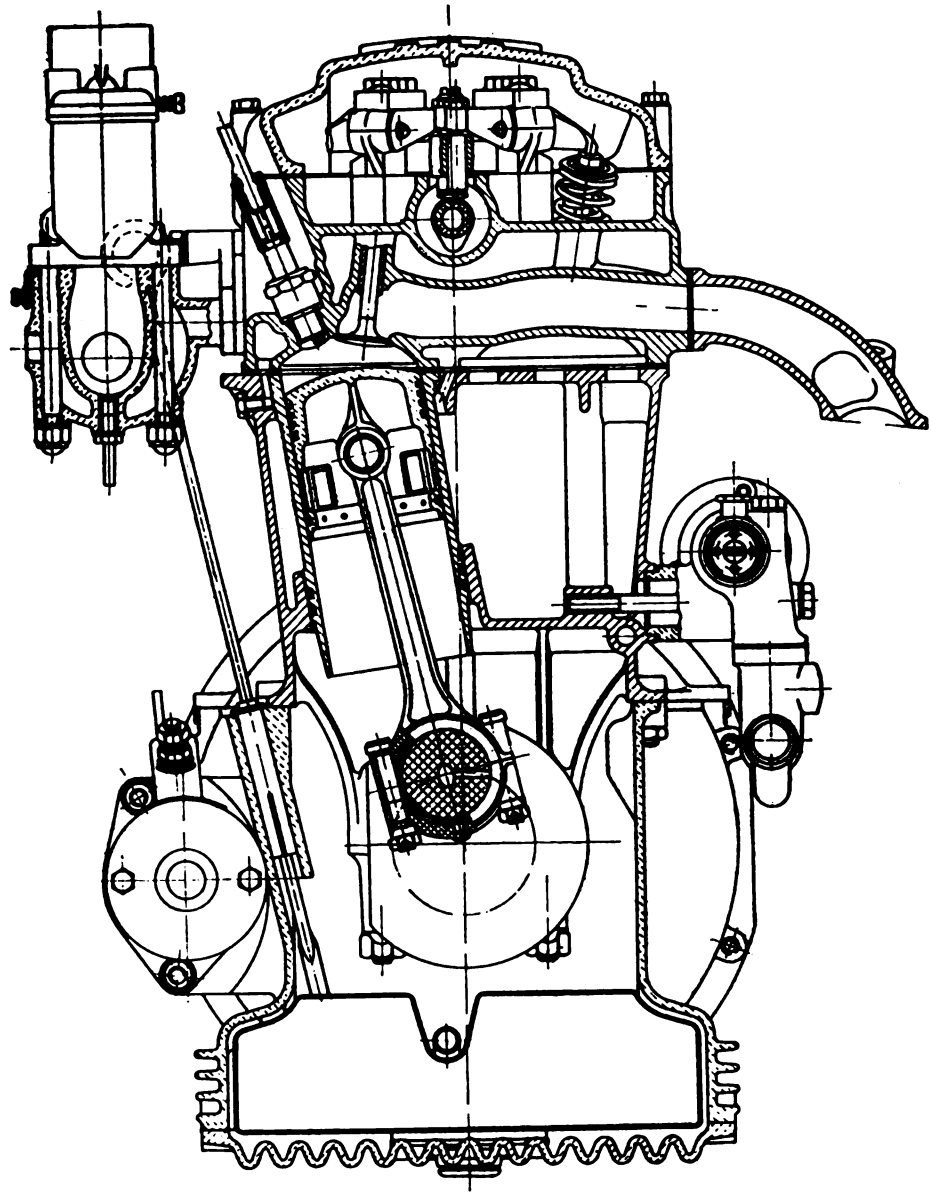
The Model B-10 engine includes many unique features in the 60 deg Vee, six cylinder, overhead valve design. The engine has a 2.75 in. bore, 2.99 in. stroke, and 106.9 cu. in. piston displacement. The compression ratio was measured as 6.82 to 1 and dynamometer testing indicated a maximum horsepower rating of 59.9 at 4400 rpm (corrected to 29.92 in. mercury at 60 F dry air.) A maximum torque of 86.5 lb. ft. was attained at 2800 rpm and a minimum specific fuel consumption of 0.515 lb. per hp-hr was obtained at 2400 rpm.

The four main bearing crankshaft has six crankpins, each spaced at 60 deg. in a clockwise spiral from front to rear.

The firing order of 1-4-3-6-5-2, with the 60 deg. between cylinder banks, results in equally spaced firing every 120 deg. of crank rotation. It might be added that the engine was found to be exceptionally smooth throughout the speed range, even with a full load application at a speed of 800 rpm.

Although most of the oil seals are rather conventional, the crankshaft seal is a novel. A reverse helix on the crankshaft pulley is fitted to a 0.010 in. to 0.015 in. clearance to the cast aluminum timing gear cover which functions as a reverse pump to make the seal. In a like manner, at the rear, a helical gear makes a seal with an adapter plate which is bolted to the crankcase. No leakage was noted in 11,409 miles of road operation.

Lancia Ardea



The crankcase is a permanent mold aluminum alloy casting and incorporates a wet cylinder line design. A careful investigation of the crankcase revealed no use of dry-sand cores. Instead, the design has been so ingeniously developed that iron molds and loose metal cores are used throughout. The cast iron liners are flanged to seat on faces machined in jackets which completely enclose them, leaving about 3/16 in. water space around the sleeve. These are fed by tapered round water galleries on the outside of each bank. The liners are sealed with rubber O-rings at the lower end, and the water circulates up through passages in the flange into the cylinder head. After one and a half years of operation, there was no evidence of corrosion in the block or heads. City water and standard antifreeze had been used throughout this period.

The performance of the main bearings in the aluminum alloy crankcase and bearing caps were of particular interest in view of the possibility of reduced oil clearances at low temperatures. The bearing shells are 0.200 in. thick with a bronze back and lead babbitt facing (about 0.025 in.). Oil clearance was measured as 0.0013 in. at the time the engine was torn down. Engine breakaway torques were obtained at temperatures of —8° and 80° F. with values of 40 lb.-ft. and 17.3 lb.-ft., respectively, being measured. An increase of this magnitude in breakaway torque certainly shows no tendency for the bearings to freeze up because of contraction of the block.

The cylinder heads are aluminum alloy sand castings incorporating 1⅛ in. exhaust valves and 1 7/32 in. intake valves at 26 deg. from the center line of the cylinder, in hemispherical combustion chambers. The wide spacing of the cylinders in each bank allows the valves to lie in the longitudinal central planes of the banks. The 14mm spark plugs are located at an angle of 27 deg. to the longitudinal central planes. The rocker arm covers, which are aluminum alloy permanent mold castings of approximately ¼ in. thickness, serve to reduce valve train noises.

The push rods are fabricated from aluminum tube with pressed-in flanged ends of steel. These push rods were an aid in maintaining proper valve lash with changes in the engine temperature. The tappets run directly in the aluminum block. The camshaft is supported by three split bushings and has a solid flanged bushing at the front. All these bushings are made of an aluminum alloy. The split bushings, held by retainer rings for

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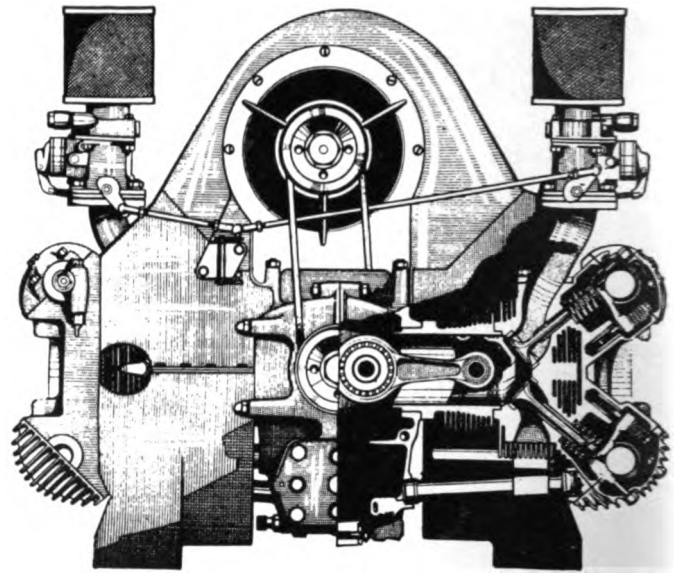


Porsche 550 "Spider" engine is a flat opposed air cooled unit which is establishing this German car as the champion of its class.

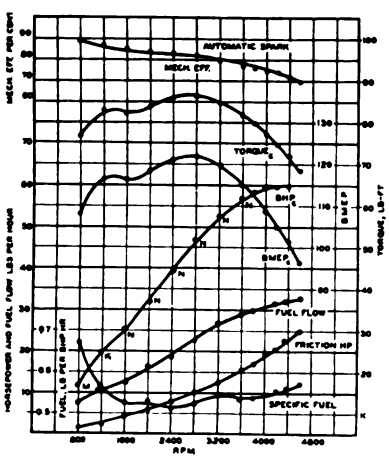
assembly, are prevented from rotating by means of set screws. Valve timing may be varied by use of a vernier adjustment consisting of 12 holes in the camshaft and 11 holes in the camshaft gear.

The oil pan, a permanent mold aluminum alloy casting of approximately 3/16 in. thickness, contributes to the stiffness of the crankcase. The external surface is ribbed for cooling of the lubricant. A large circular cover in the bottom is removable for cleaning of the sump and oil pick-up screen.

Aluminum Parts

The economical permanent mold process of casting aluminum alloys has been put to extensive use in the fabrication of parts for the Lancia Model B-10 engine. Of the aluminum used in the engine, 60 percent of the total weight is made up of full permanent mold castings, while the remainder is in the form of sheet, sand castings, and semi-permanent mold castings. *This extensive use of permanent mold castings, in what might be considered rather limited production, should arouse some interest in this country in the manufacture of aluminum engine parts other than pistons.* Such items as the crankcase, oil pan, rocker box covers, timing gear cover, distributor housing, etc. lend themselves well to the use of the permanent mold process of casting aluminum alloys, as has been shown by the Italians in manufacturing these parts for the Lancia.

Although this discussion deals primarily with the Lancia B-10 engine, mention should be made of the Lancia Aurelia sedan in which the engine was received. Such features as the full independent wheel suspension, unit body and frame construction, the clutch, transmission, and final drive location and design, as well as the extensive use of aluminum, are unique and interesting. The drive unit includes clutch, transmission, differential and brake. Of the 2390 lb. total car weight, approximately 420 lb. has been estimated to consist of aluminum alloys. Aluminum has been utilized in the fabrication of such parts as the clutch, transmission, and differential housings, drive shaft couplings, shock absorber bodies, brake shoes and cylinders. The body and trim include such aluminum parts as the doors, trunk lid, hood, gravel deflectors, pumpers, door handles and window molding.



Results of performance tests of the Model B-10 engine. Corrected to 29.92 in. Hg. at 60 F dry air. Spark knock symbols: M-medium N-none.

Significance of Aluminum

What does such liberal use of aluminum mean to the automobile manufacturer? In general, for each pound of aluminum used in a design, there is a total weight reduction of one pound. A 309 lb. engine, which is 47 per cent aluminum by weight, would therefore weigh approximately 454 lbs. if manufactured entirely of ferrous materials. This would result in an increase in the specific engine weight of from 5.16 lb. per hp. to 7.5 lbs. per hp., all of which would be sprung weight over the front wheels.

Designs tailored for the more economical permanent mold or die casting processes may make cast aluminum automobile parts less costly and reduce weight.