Pontiac and Ford OHCs Are Pointing The Way

BY ROGER HUNTINGTON

MORE OVERHEAD CAMS?

OVERHEAD CAMSHAFTS suddenly have become of major interest to the American auto industry. Overhead cams always have held a certain popularity in European passenger cars, but in the U.S. the feature was ignored for many years. The first glimmer of new light came in 1962, when Willys updated its old long-stroke Six by adapting a new free-breathing cylinder head with a chain-driven overhead camshaft. Then, a year ago, Ford Engineering designed new single overhead-camshaft heads for its 427-cu. in. competition engine—to generate more than 600 bhp at up to 8000 rpm on gasoline. In the past months, Pontiac has introduced a new utility Six with an unique cog-belt drive to a single overhead camshaft.

What does all this mean? Is the overhead camshaft really coming back in the American auto industry? Are there sound technical reasons for using it? Is it strictly a performance feature? Or is it just a gimmick that has no inherent functional advantage over the classic pushrod-rocker system of valve actuation?

First, why an overhead camshaft? Certainly the major advantage is drastic reduction in valve gear reciprocating weight by eliminating the moving mass of lifters, pushrods and, in some cases, the rocker arms. This reduced reciprocating mass allows the engine to turn at much higher rpm without floating the valves. This difference in rpm potential, other factors equal, is certainly from 1000 to 2000 rpm. It's not just a matter of using stiffer valve springs with the pushrod engine to catch up with the ohc. Maximum usable spring stiffness is limited by rubbing forces between cam lobes and lifters. Extremely stiff valve springs often will bend pushrods. There is no way a pushrod engine can equal an ohc design in rpm potential.

Overhead cams had another important attraction in the early days of the automobile that is no longer valid. That is, in the old days, when the sciences of metallurgy and heat treating were in their infancy, valve spring breakage was a terrible problem. In those days, overhead cams, with their big reduction in valve gear reciprocating weight, allowed engine builders to use much lighter stresses in the springs so they would last longer. This is why many early-day engines used overhead cams. It wasn't for any need of a broader rpm range because the long strokes and crude bearings and lubrication systems limited speeds to 1500-2000 rpm. Designers simply found that valve springs operated longer with the overhead camshaft. This, of course, no longer is an argument for overhead camshafts. Valve springs usually last the life of the car.

WILLYS HAD a rather special reason for adopting the overhead cam in 1962. Engineers wanted to update an old long-stroke Six block with modern breathing, but with a minimum of new tooling. The ideal answer was a hemispherical combustion chamber with large inclined valves and streamlined ports. With that cylinder block layout, it was much easier to produce the desired results with an overhead camshaft than with pushrods and rocker arms pivoted in opposite directions on dual rocker shafts (such as in the Chrysler Hemi layout). The overhead camshaft was a more convenient way to do the job on the Willys Six. Willys, however, was not interested in the superior rpm potential of the layout. This was basically a commercial engine that was rated at only 4000 rpm.

There are a few other inherent advantages of the overhead camshaft layout. Theoretically an ohc engine should be cheaper to build. That is, the lifters, pushrods and rockers can be eliminated. If the cost of the drive to the overhead cam does not rise excessively, the overall cost of the engine should be a bit less. (Willys figured its ohc Six was 2-3% cheaper than the pushrod version.) Another advantage is that the cylinder-head designer is virtually unlimited in choice of a configuration with an overhead camshaft. When pushrods come up through the head casting, sometimes the ports must take some efficiency-destroying bends to miss them. Ford engineers say this freedom of port design is an important secret of their ohc 427 racing engine. They use huge round ports where the equivalent pushrod 427 displayed very high rectangular ports with some sharp bends. Volumetric efficiency is considerably better with overhead cams, although use of rocker arms to allow the inclined valves and hemispherical chamber with a single overhead camshaft does increase the reciprocating weight.

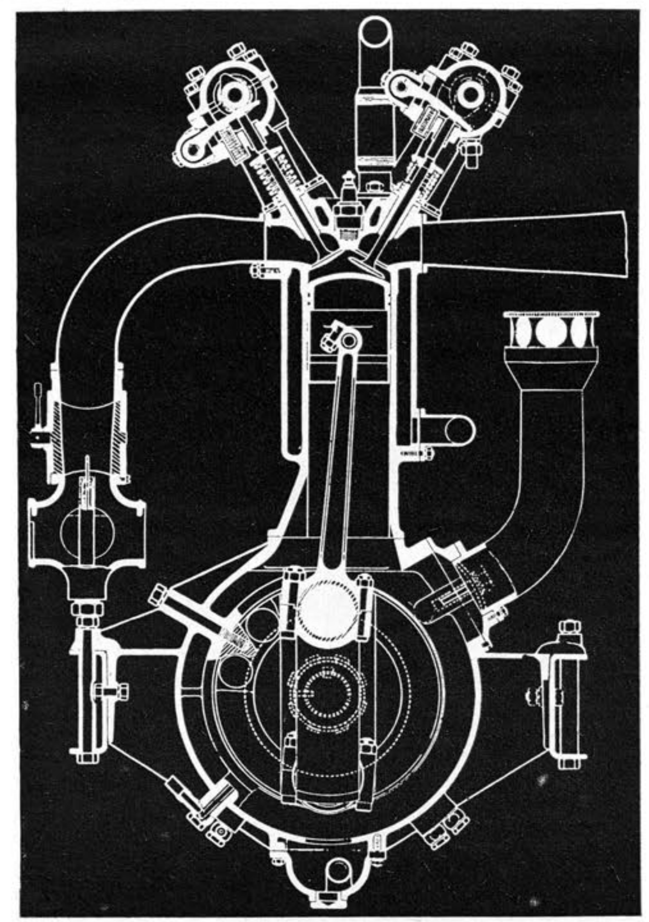
However, there are problems with overhead camshafts. The major one is in designing a camshaft drive that is quiet. Chains and gears are noisy for passenger cars, though they are used in Europe. Vertical shaft drive with bevel gears is an expensive compromise. Perhaps Pontiac finally has found the answer with the unique drive which uses a fiberglass-reinforced rubber cog-belt on toothed pulleys. This drive is cheap, almost completely quiet, requires no lubrication and is said to last almost the life of the engine. If this drive proves to have no unexpected bugs, then apparently the drive no longer is a problem with overhead camshafts.

Quieting valve clatter is another problem. In most modern ohc engines no particular attempt has been made to do this. Pontiac does so by inserting a pivoting finger between the cam lobe and valve stem, with a hydraulic plunger at one end to take up the slack between the lobe and stem. It works beautifully and completely eliminates valve noise to complement the silence of the rubber belt cam drive. It is difficult to believe there's an overhead camshaft in this engine. But, this hydraulic lash system costs money. An educated guess is that the cost of silence absorbs any savings from eliminating lifters, pushrods and rockers in this engine. The overall cost may be at least as much as the previous pushrod design.

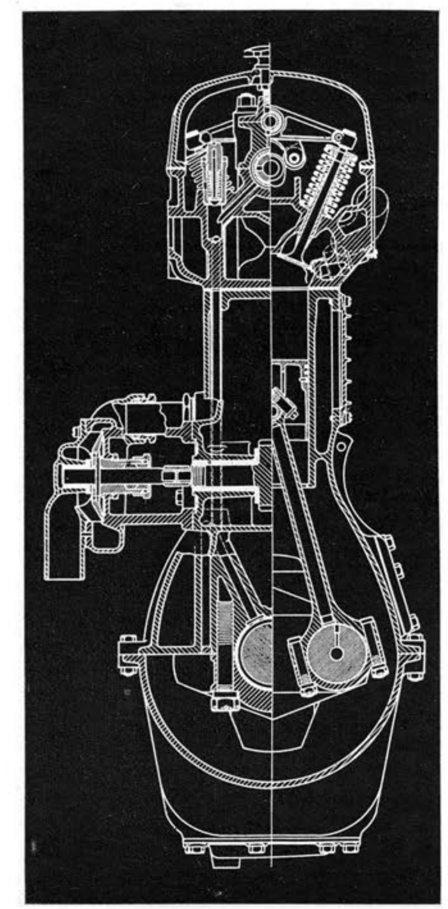
OTHER OHC problems are accessibility for valve lash adjustment, and engine height. Putting the camshaft above the overhead valves tends to make the engine taller. This will be an increasing problem with ever-lower hoodlines. It can be solved with V-type engines, or by tilting in-line engines to one side. Engine height was no problem when fitting an overhead camshaft in the new Tempest. However, there is a space problem in attempting to adapt this engine to Pontiac's Mustang-type economy sports car, which may be out in '67.

Tracing the history of overhead cam engines is interesting and informative. Actually they're as old as the automobile itself. The American Wilkinson car operated with an overhead camshaft in 1898, probably the first such design in this country. After the turn of the century the American Welch car featured a single overhead camshaft, operating inclined valves in a hemispherical combustion chamber through rocker arms, much as does the present-day Ford sohc 427. In Europe, Mercedes, Clement-Bayard and others used overhead camshafts before 1910. All of these were single shafts, operating valves directly or through rocker arms. Camshaft drive generally was through a vertical shaft and bevel gears.

A major breakthrough came in 1912. Probably the main credit for the idea should go to two engineer-drivers on the French Peugeot Grand Prix racing team, Georges Boillot and Paul Zuccarelli. They sketched out an idea for the "ideal" racing engine. Their plan was for double overhead camshafts operating four inclined valves per hemispherical combustion chamber, with the spark plug in the center of the dome between the two camshaft housings. This layout promised optimum breathing, short flame travel for control of detonation—a terrible problem in those days—and minimum valve gear reciprocating weight for maximum usable rpm and lower valve spring stresses. Using four ▶



FIRST DOHC design was for Peugeot's 1912 Grand Prix engine. Long (7.9-in.) stroke limited performance to 2200 rpm.



DUESENBERG SOHC Model A engine of 1921 was built on racing pattern.

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light valves instead of two heavier ones helped in this respect. Peugeot management was impressed with the idea and retained a young Swiss engineer named Ernst Henri to translate the design into working drawings. The first dohc 4-cyl. 16-valve engines appeared in the 1912 racing season, both in Peugeot light racing cars and the full Grand Prix machines. They were an immediate, booming success. However, performance of the engines was greatly limited by the practice of using very long stroke lengths, up to 7.9 in., on the Grand Prix automobiles. This limited usable range to 2000-3000 rpm and held power output well under 0.5 bhp per cu. in. The full potential of the dohc layout was not realized until years later, but it was a vital breakthrough in design.

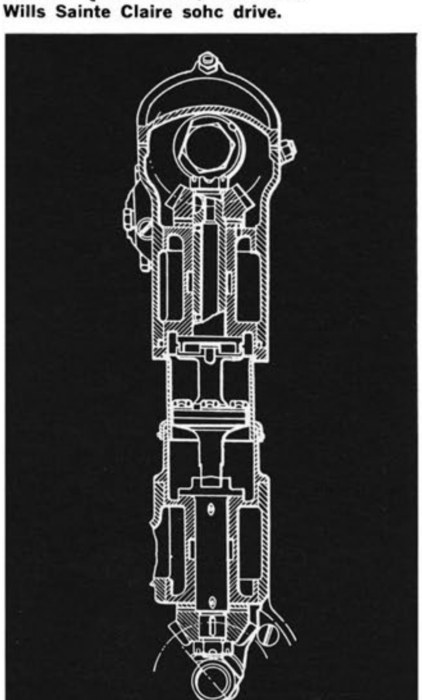
The first Peugeot dohc engines drove the overhead camshafts through a vertical shaft and bevel gears. In 1913, Peugeot switched to a train of spur gears—noisier, but more reliable. This general layout has been the pattern for the world's top racing engines to this day. This design always has been very popular for high-performance sports cars, though they more often use chain camshaft drive and two valves per cylinder. The layout had image as well as function and many wealthy buyers were willing to pay the price. The list of European sports cars using double overhead camshaft design in the 1920s and 1930s includes Alfa Romeo, Bugatti, Alvis, Frazer-Nash, Invicta, Lagonda, Ballot, Maserati, Salmson and Sunbeam. Of course, practically all top racing engines after 1920 employed the dohc principle. Harry Miller was the first to switch in this country. Duesenberg followed. They built most of the special racing engines in this country up to World War II, though Fred Offenhauser took over Miller's business in the early 1930s.

The trend to overhead camshafts on high-performance luxury cars in the 1920s is more interesting. This list includes Duesenberg, Stutz, Wills Sainte Claire and Leach in this country, and such names as Mercedes, Hispano-Suiza, Bentley and Bugatti in Europe. In most cases these were of single overhead camshaft design, operating the valves either directly or through rocker arms. In most cases the camshaft was driven by a vertical shaft and bevel gears, to reduce noise. Bentley developed an unique idea in the mid-1920s for its large 6- and 8-liter luxury 6-cyl. engines. Bentley drove the overhead camshaft through a pair of long connecting rods at the rear of the engine. These worked on eccentric "crankshafts" and more or less cranked the camshaft when the main crankshaft rotated. The drive was very quiet, but costly. On the other hand Duesenberg and Stutz drove their overhead camshafts with chains, which were very noisy. In fact, the last versions of these engines, the Model J Duesenberg of 1928 and the DV-32 Stutz of 1931, featured double overhead camshafts and four valves per cylinder in hemispherical combustion chambers, very similar to the all-out racing engines of the day.

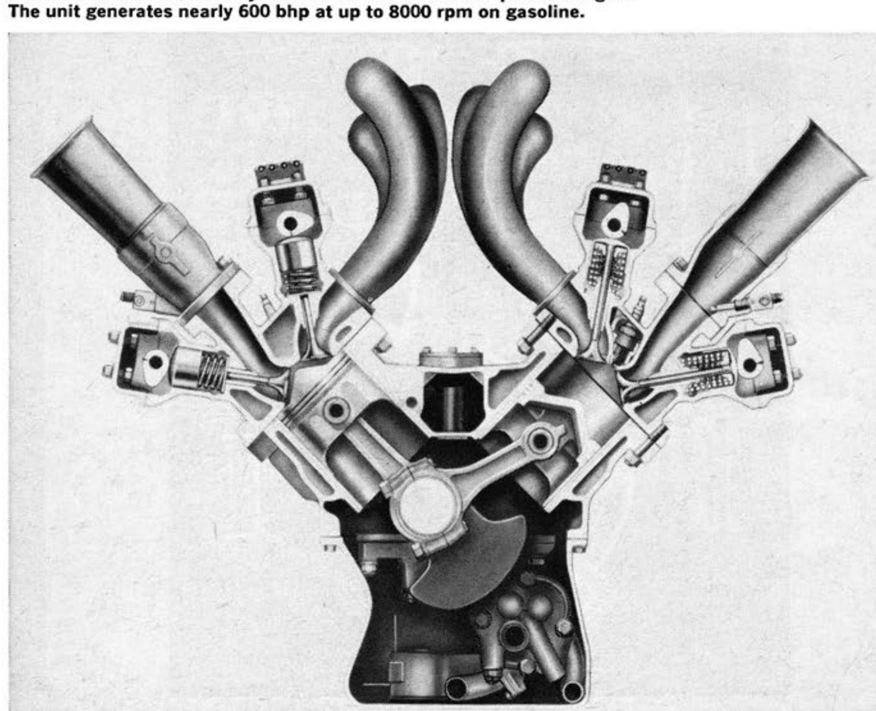
None of these luxury engines were designed for maximum bhp per cu. in. None were intended to run at more than 4000 rpm in normal operation. Why all this concentration on camshaft and valve gear layouts, the only virtue of which was more efficient high-speed operation? The only answer to this question is that designers were seeking "image." Even in that day of general public ignorance about automotive technology (newsstands carried no magazines such as *CAR LIFE*), overhead camshafts conjured up images of performance, power and prestige. Overhead camshafts were closely connected with all-out sports and racing engines. They carried punch. They made an engine appear different under the hood, especially the double-overhead-camshaft designs of Stutz and Duesenberg.

THIS IMAGE held sales appeal in a day when low income taxes left people wealthy enough to afford to pay ten times more for their cars than could John Q. A similar situation exists today in the new sohc Tempest Six engine. This engine doesn't cost

COSTLY QUIET marked the 1925 Wills Sainte Claire sohc drive.



FORD ADOPTED the dohc system for its 255-cu. in. competition engine. The unit generates nearly 600 bhp at up to 8000 rpm on gasoline.



more than average, but what does it have to offer other than the ability to produce 7000 rpm? Those who desire performance can get a lot more from a V-8. Certainly the 7000 rpm capability will be of no importance whatsoever to 90% of the buyers, who rarely exceed 4000 rpm in normal driving. So why did Pontiac spend millions tooling for this engine? Again it must be mainly image. Pontiac's sohc Six is a radical new engineering feature that has youth and performance impact that can be seen by lifting the hood. Pontiac officials are gambling that this will sell a lot of 6-cyl. Tempests in the next few years.

BACK TO HISTORY. After the Stutz and Duesenberg, and after the Roosevelt administration started to level out incomes, the expensive ohc passenger car engines quickly died out in America. They held on in Europe, but mainly for sports cars. Several new ohc European sports engines have been tooled since World War II. These include Jaguar, Aston Martin, Alfa Romeo, Ferrari, Maserati, Porsche and Mercedes-Benz. Some have used single camshafts, others have twin arrangements. Today, as previously, these sports engines are tuned tightly enough so their usable rpm range on the road, not just in racing, can utilize the full potential of the expensive valve gear layout.

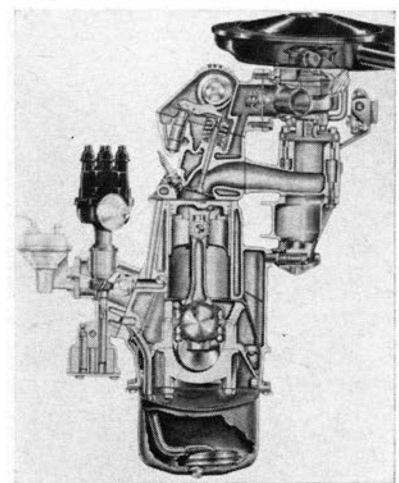
Overhead camshafts always will have a place in sports cars. Their rpm potential can't be matched with the most advanced pushrod systems, though the GM-introduced system, using light, stamped ball-joint rocker arms and tubular pushrods as on the 1955 Chevrolet V-8, comes quite close to the reciprocating weight reduction.

What about overhead camshafts in utility passenger cars? Crosley used an overhead cam on its tiny 44-cu. in., 4-cyl. economy engine in 1948. But this wasn't an economic success and soon went out of production. Since then, and until the development of the sohc Willys in 1962, overhead camshafts have recorded a checkered history, even in Europe. A few stalwarts such as Mercedes, Lancia and Citroen have maintained overhead camshaft design in basically semi-luxury passenger cars. The majority of European builders, however, returned to pushrods. In the past few months, however, the trend has reversed again. New engine designs are emerging from Rover and Hillman in England and Ford (Taunus) and GM's Opel subsidiary in Germany. All of these are more or less mass-produced engines for passenger cars. It may be that these designers are looking down the road five years or more for these new basic engine designs. Perhaps they foresee a need to broaden the usable rpm range in the future to produce more horsepower without major tooling changes. The trend in Europe to automatic transmissions for small cars strengthens this idea. Designing these engines right off the bat with overhead camshafts may make a lot of sense. Perhaps European manufacturers are saving money with these designs. An ohc engine is potentially cheaper. The new Pontiac design doesn't qualify, but the new European designs without hydraulic valve lash mechanisms may be cheaper.

How about the future of overhead camshafts in the U.S.? A safe prediction is that more of them will be seen.

The new Pontiac Six is only the beginning. All the large companies have experimental ohc engines on their dynamometers. It is known that Pontiac is far in advance with a sohc V-8, for 1968 perhaps. This might be a performance option at first, but Pontiac usually adopts performance equipment as standard eventually. The breakthrough with the rubber belt drive for overhead cams was the key factor. This makes these ohc engines really practical for American cars. But the majority of companies won't be willing to switch from pushrods just because overhead camshaft engines have youthful appeal and a performance image—unless there is very strong public demand. Most company cost analysts insist that ohc engines be cheaper to produce. This is entirely possible. The problem of maintaining zero valve lash and valve silence tightens cost problems. Pontiac's fingers and hydraulic plungers appear overly expensive. Detroit probably will need a simpler way to accomplish this task before it jumps head first into ohc engine production. However, there is every possibility for immediate limited-production ohc performance engines. Some of these may use double overhead camshafts with hemispherical combustion chambers and central spark plugs in the classic racing engine tradition. Chrysler has been considering this design. The Detroit companies more and more are likely to design limited-production performance engines these days in light of the increasing importance of the youth market in overall sales. This could be the key factor in bringing ohc engines to American cars years sooner. ■

THE PONTIAC belt-driven sohc may start a modern-day trend.



CAM LOBES both opened and closed valves in desmodromic action of the Mercedes layout for the 300 SLR, a sports racing leader in the 1950s.