TABLE 10.1
(Continued)

Model Year	1966–1967	1968–1969	1970–1971
Car line	Plymouth, Dodge	Plymouth, Dodge	Plymouth, Dodge
Model	Street Hemi®	Street Hemi®	Street Hemi®
Engine code			E74
Displacement (cu. in.)	426	426	426
Bore	4.25	4.25	4.25
Stroke	3.75	3.75	3.75
Compression ratio	10.25:1	10.25:1	10.25:1
BHP @ rpm	425 @ 5000	425 @ 5000	425 @ 5000
Torque (lb-ft) @ rpm	490 @ 4000	490 @ 4000	490 @ 4000
Combustion chamber	Hemispherical	Hemispherical	Hemispherical
Cyl. head material	Cast iron	Cast iron	Cast iron
Cyl. block mat'l.—skirt type	Cast iron—deep, cross-bolts	Cast iron—deep, cross-bolts	Cast iron—deep, cross-bolts
Cyl. block deck height	10.725	10.725	10.725
Cyl. block length	23.46	23.46	23.46
Cyl. bore spacing	4.8	4.8	4.8
No. of main brgs.—ck/s mat'l.	5—forged steel	5—forged steel	5—forged steel
Ck/shaft main journal dia.	2.75	2.75	2.75
Crankpin journal dia.	2.375	2.375	2.375
Piston mat'l.—no. of rings	Forged aluminum—3	Forged aluminum—3	Forged aluminum—3
Connecting rod centers	6.861	6.861	6.861
Valve system	OHV—dual rocker shafts	OHV—dual rocker shafts	OHV—dual rocker shafts
Valve events	276-276-52	284-284-60	284-284-60
Camshaft drive	Double-row roller chain	Double-row roller chain	Double-row roller chain
Valve head dia.	Intake 2.25; exhaust 1.94	Intake 2.25; exhaust 1.94	Intake 2.25; exhaust 1.94
Valve lash adjustment	Mech.—rocker arm screw	Mech.—rocker arm screw	Hydraulic tappet
Oil pump/distributor drive	Diagonal at front of block	Diagonal at front of block	Diagonal at front of block
Fuel system	Tandem 4-barrel carbs	Tandem 4-barrel carbs	Tandem 4-barrel carbs

Chart 10.1
Time Lines—RB Hemi® Head V-8

Engines, Car Lines, and Displacements (cu. in.)

	Car	- - Model Years - -							
Engine	Line	1964	1965	1966	1967	1968	1969	1970	1971
RB Hemi Head V-8	Plymouth	426	426	426	426	426	426	426	426
4.8 cyl. bore centers	Model	VP2	AR2	BR2	CR2	DR	ER	FB, FR	GB, GR
	Dodge	426	426	426	426	426	426	426	426
	Model	VD2	AW2	BW2	CW2	DW	EW	FJ, FW, FX	GJ, GW

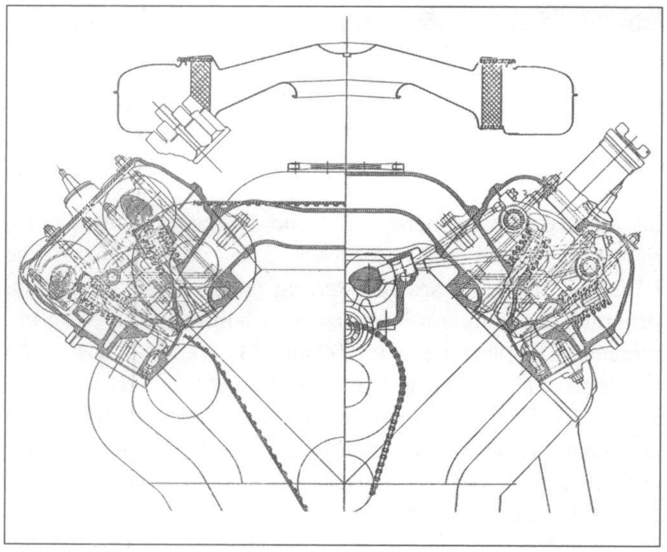

Fig. 10.11 *A cross section of the A925 426-cu.-in. RB V-8 engine with four valves per chamber. The left side of the layout shows the double overhead camshaft version. The right side shows the overhead valve version with dual camshafts and pushrods for operating the valves, 1964.*

Rather than rushing straight into the procurement of multi-cylinder engines for testing the double overhead camshaft concept that was the prime focus, it was decided to first procure enough parts to build a valve gear test engine so the double overhead cam system and its timing belt drive could be checked before procuring and building complete engines. The valve gear test engine did require the procurement of right and left aluminum cylinder heads, machined exactly as intended for the race engine, together with all the valve gear parts. Inside the cylinder block provided for the test engine, connecting rods and pistons were omitted. The crankshaft of the engine was driven by a motoring dynamometer with controls and capacity to drive the rig through the entire anticipated speed range. Problems surfaced shortly after testing started. One problem was slippage of the drive belt system. A more serious problem was cracking of the cast aluminum tappet carriers. Solutions were underway when a message quickly was relayed to Engine Design and Development managers—the A925 program was cancelled! All design and development work was to cease!

This sudden change in plans was the result of a Chrysler victory of sorts at a conference with NASCAR officials. Although work was underway on the A925 engine, Chrysler by far preferred keeping the Hemi® engine as its main race engine, avoiding expensive new programs for both the engine and the cars. Arranging a meeting with NASCAR, Ronnie Householder, the Chrysler circuit race manager and a former champion race car driver, showed a photograph of the A925 valve gear test engine (displayed on Fig. 10.12) that, mounted on a dynamometer with an intake manifold and other parts added, looked similar to an actual operating engine.[6] He explained that development of the engine had started and that if the single overhead camshaft 427 Ford engine was permitted to run, Chrysler would counter as fast as possible with the A925 double overhead camshaft engine-powered cars. NASCAR responded, informing Householder that it was not in favor of these factory-backed escalations of power and would take steps to ensure that neither the Chrysler nor the Ford overhead camshaft engines would be permitted to run on their tracks. Householder lost no time in sending that message to Engineering, triggering the cancellation of the program.

However, NASCAR still wanted to level the playing field and give the other makes a better chance at winning, which led to the progressive handicaps for the Hemi® engine as previously noted. The Ford 427-cu.-in. single overhead camshaft engine did appear on dragstrips and showed itself to be a tough competitor.

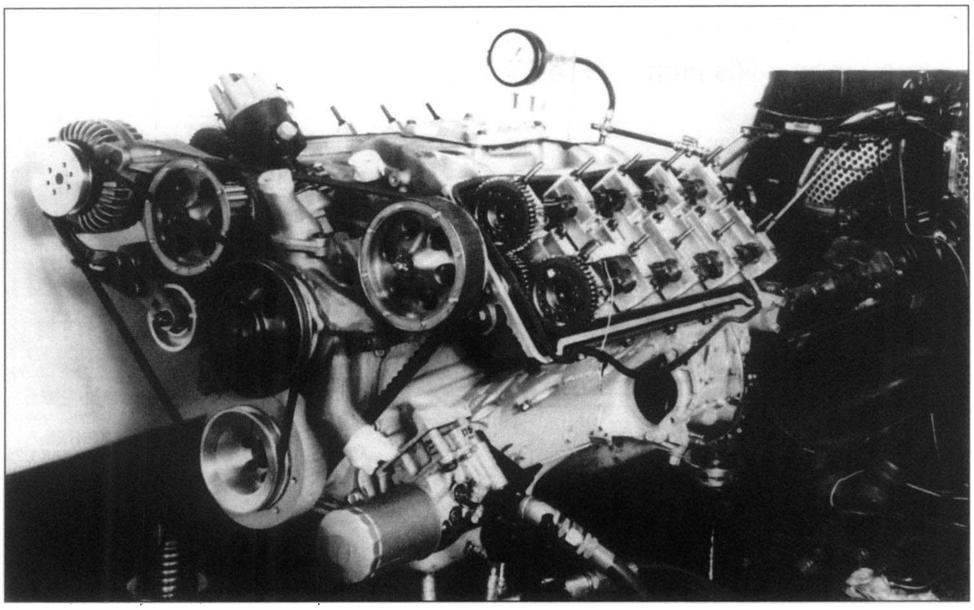

Fig. 10.12 *The A925 valve gear test engine mounted on an Engineering dynamometer. Used for testing the double overhead camshaft system, this was not a running engine.*

Some time after program cancellation, with storage space needed for hardware for new programs, the A925 valve gear test engine was sent, as customary, to the By-Products department for scrapping. Sold as-is, it was purchased by an outside enthusiast. Sold and resold several times, it has appeared at various meets. A well-written article about the engine, titled "The Doomsday Machine—Chrysler's 1964 DOHC 426—The Ultimate Hemi," authored by Tom Shaw, was published in the June 1989 issue of *Muscle Car Review*. The article includes a photo of the engine mounted on a dynamometer test stand—the same photo that Ronnie Householder showed to NASCAR.[7]

High Performance for All—The A279 LB V-8 Engine

An affordable engine dedicated to high performance. That's what the vehicle planners wanted to create in the late 1960s. An engine between the high-priced, low-volume, high-power Street Hemi® and the high-volume, standard Low-B and Raised-B V-8s. It would have the same displacement range as the LB and RB engines but, unlike the LB-RB engine, would have only one block height for maximum parts commonality. An engine with a cylinder head much more amenable to high-volume production than the complex double rocker shaft system of the Hemi® but with valve sizes and a combustion chamber shape that would be at least a close match with that of the Hemi®. Could it be done? Engine designers long for that kind of assignment.

Coded A279 when the project was started in 1968, the engine quickly took form on the drafting table. Initially pegged at having two displacements—396 and 440 cu. in., with a common 4.32-in. bore and two strokes, 3.3875 and 3.75-in.—the LB block structure was the starting point. Later during the program, the common bore size was bumped up to 4.34 in., increasing displacements to 400 and 444 cu. in. Revisions to the crankcase gave clearance for swinging the longer 3.75-in. stroke. Designing the cylinder head was a considerably greater challenge. However, recent designs of an overhead valve six-cylinder engine for Chrysler Australia, described in Chapter 11, had incorporated a separate pedestal for each rocker arm, allowing the valves to be positioned so that the combustion chamber achieved a hemispherical-like shape. Similar in principle to the rocker arm systems used for years by Chevrolet and Ford engines, the Chrysler pedestal design used only a single part rather than multiple parts to anchor the stamped-steel rocker arm and to provide a ball-shaped seat about which the arm could rotate. Taking advantage of the resulting freedom in positioning the valves, the valves were splayed or canted to provide free-flowing intake and exhaust ports, large valves with the same head diameters as those of the Hemi® engine, good spark plug cooling, and, as mentioned, to obtain an almost hemispherical shape for the combustion chamber. Of interest, when the first design for the cylinder head was made, a stud was used for anchoring each rocker arm, giving rise to the engine nickname "Ball Stud Hemi," a name always considered temporary—a bit too aggressive as a permanent name for the engine if it were to enter production. The cross section of the engine as shown on Fig. 10.13 illustrates the details of the engine design.

Following procurement of the first of about a dozen 440-cu.-in. prototype engines, dynamometer testing commenced. A development engine soon was producing power where predicted,

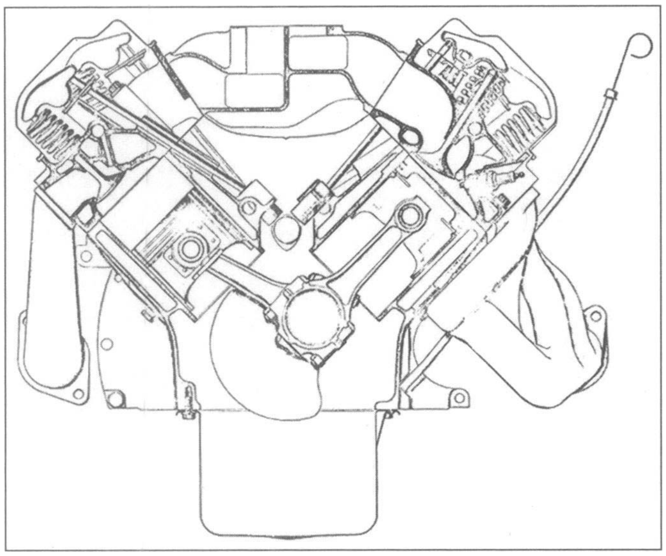

Fig. 10.13 *A cross section of the A279 V-8 engine. Using a modified LB V-8 cylinder block, the high-performance, canted-valve engine with almost hemispherical combustion chambers was designed for high-volume production at displacements of 396 and 440 cu. in., later boosted to 400 and 444 cu. in., 1968.*

better than the wedge-head RB engine but not quite as good as the real Hemi® engine. Then in 1970, about two years after the start of the program, the same outside factors that included the escalating emission requirements and higher insurance premiums as previously discussed and that caused the Hemi® engine to be cancelled likewise caused the A279 engine program to be reappraised. Clearly, investing scarce corporate resources in the continued development and production tooling needed for a new, big-displacement, high-performance engine faced with so many uncertainties would not be a prudent investment. Program termination followed.

Two prototype engine assemblies were known to survive. One engine, after residing in storage for a number of years, was offered by Product Planning to a professional drag racer with strong factory ties, Richard (Dick) Landy. The engine came back home, in a way, when, in 2003, it was loaned by Landy for public display at the Walter P. Chrysler Museum during a special Hemi® engine exhibit. Later, with additional ownership changes, the engine was installed in a suitable contemporary vehicle, a 1969 Plymouth Barracuda hardtop notchback once owned by Tom Hoover, and has made appearances at Chrysler products enthusiasts' meets.[8]

CHAPTER 11

Overhead Valve In-Line Sixes

The Enduring Slant Six Engine

The Slant Six engine produced by Chrysler Corporation from 1960 to 1991 became one of the best recognized and most durable of all engines manufactured by Chrysler. The story of the Slant Six engine is related in this section.

During the late 1950s, many car buyers became attracted to cars with a smaller size and better fuel economy than the standard high-volume Fords, Chevrolets, and Plymouths offered by the "Big Three." A notable import that offered low cost, small size, and excellent fuel economy was the Volkswagen Beetle powered by a horizontally opposed, four-cylinder, air-cooled, overhead valve (OHV) engine. The 1959 Studebaker Lark VI powered with a 169-cu.-in. L-head six-cylinder engine and the AMC Rambler American with its 196-cu.-in. L-head six-cylinder engine were domestic offerings. Substantial sales volumes by these three makes showed that the market was well worth entering.

General Motors, Ford, and Chrysler moved almost simultaneously into this market segment with compacts of their own. Three quite different cars were designed, developed, and produced for the 1960 model year, with each corporation deciding separately on the best approach for capturing the market.

The General Motors entry was the Chevrolet Corvair, powered with a 140-cu.-in. air-cooled, horizontally opposed, aluminum-rich, six-cylinder engine located behind the driver. The Ford entry was the Falcon, a basic car with a conventional driveline and an appropriately basic 144-cu.-in., all-iron but lightweight, in-line six-cylinder engine. The Chrysler entry was the Valiant, which combined a conventional engine-up-front rear-wheel-drive arrangement, with the front torsion bars and the rear leaf springs suspension system introduced on its larger cars in 1957, as can be seen on Fig. 11.1.

A special engineering team, under Robert M. (Bob) Sinclair, the Engineering executive in charge of the Valiant program, was assembled to design the car that was assigned the engineering code A901. Most of the team members were chassis and body engineers. Engine responsibility, however, was retained by the existing Engine Design and Engine Development departments.

Selecting an engine for the Valiant was a special challenge. Engine Design under Assistant Chief Engineer Robert S. (Bob) Rarey and me as Managing Engineer supplied information to the Valiant team on a number of candidate engines, including four-cylinder engines, in-line sixes, and V-6s, with iron and aluminum versions of each type. The need to keep the length of the car to a minimum while providing space for six passengers precluded the use of any in-line, upright, six-cylinder engine having a water pump located in front of the engine—the conventional approach. A true breakthrough came when the lead designer Fred Rose and the Engine Design supervisor Ray Latham came up with the idea of leaning the engine over to one side so the water pump could be located alongside the cylinder block instead of in front of it, thereby considerably shortening the engine.[1]

The Valiant team chassis engineers determined that a lean to the right was best for a number of reasons. Chief among the reasons was that with the engine centerline offset to the right of the car centerline (a common practice to provide room for the driver's foot), the engine fan achieved a desired location near the center of the radiator.

In a meeting on the morning of April 10, 1958, Engine Design requested that the engine type and size be finalized by the Valiant team and senior management by May 1, 1958, so the engine design could be completed and detail drawings started. Bob Rarey and I preferred an in-line, six-cylinder engine with a displacement of 170 cu. in., with a 3.4-in. bore, a 3.125-in. stroke, and cylinders slanted 30 deg to the right.

Later that same day, Harry Chesebrough, vice president of the Plymouth Division, asked Engineering management that, if possible, the new Valiant engine be designed to have a large-displacement version. The large version would be aimed at replacing the obsolete 230-cu.-in. L-head six-cylinder engine

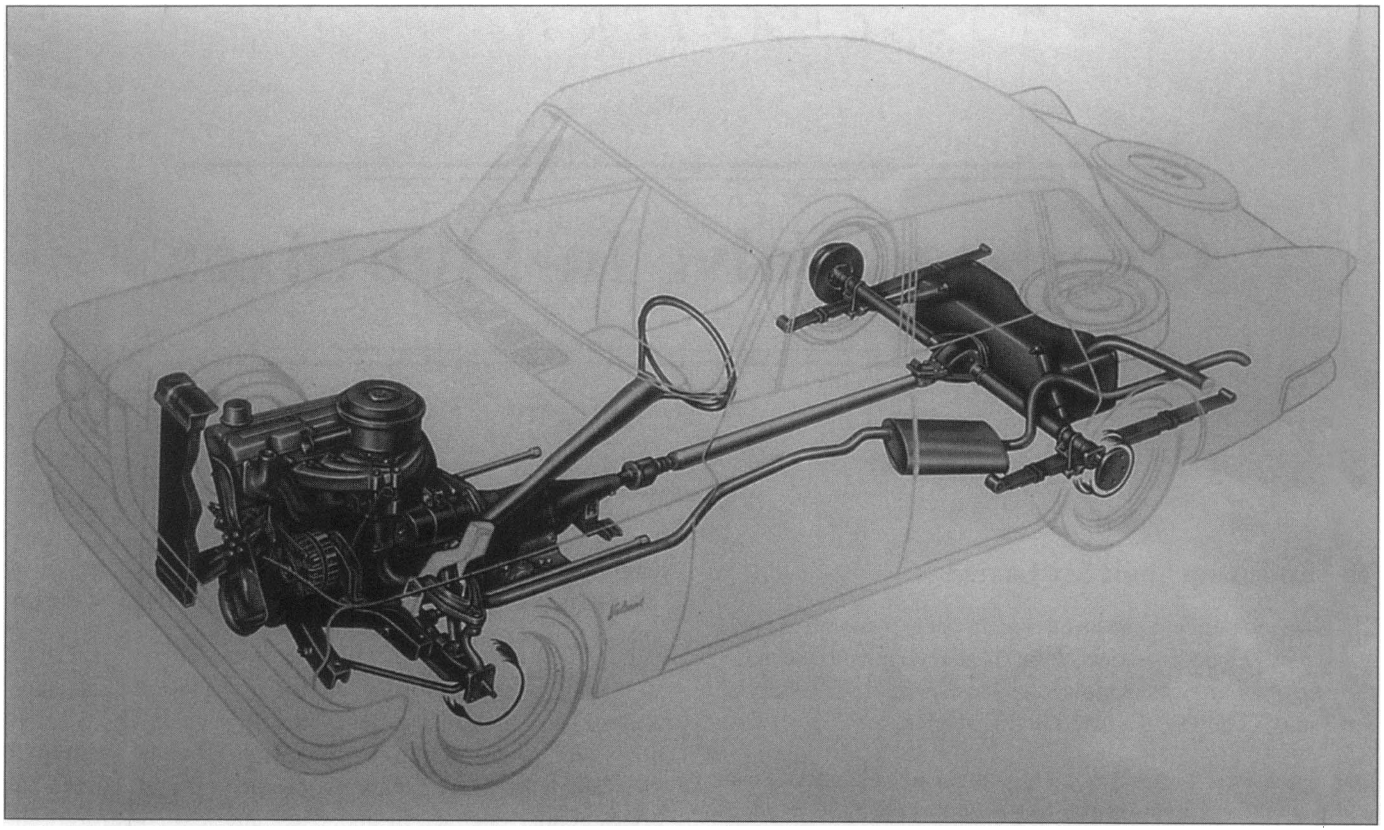

Fig. 11.1 *The 1960 Valiant engine and chassis arrangement. Note the compact engine length, the torsion bars at the front, and the leaf springs at the rear.*

still powering standard-size Plymouth and Dodge cars. This request was quickly relayed to Bob Rarey, and the design investigation started immediately.[2]

An increase in the bore size was ruled out. With the longitudinal tightness of the 170 Valiant engine and engine compartment, no space was available to increase the bores. I remember asking Bob Sinclair, who was in charge of the Valiant program, for a modest one-quarter-inch increase in the engine length. The request was politely but firmly denied; therefore, a stroke increase was the only solution. Within five days, it was determined that there could be a second version of the engine with a 1-in.-longer 4.125-in. stroke, giving a 225-cu.-in. displacement. This second version would require a stroked crankshaft, a cylinder block with a greater deck height, longer connecting rods, and longer pushrods. Other than these four parts, virtually all parts would be identical between the two engines—a real boon to Manufacturing and Service.

On April 16, 1958, a review meeting was held with Paul Ackerman, vice president of Engineering, where three engine proposals—two approaches involving families of four- and six-cylinder engines, and the combined 170/225 Slant Six engine approach—were presented. Later in the month, Ackerman decided Engineering should proceed with only the 170/225 Slant Six engine. With that decision, work on the Slant Six engine moved ahead at wide-open throttle.

With the engine tilted to the right, a great deal of space was available on the left side of the engine for the intake manifold. Engine Design engineer John Hurst took advantage of this space to come up with a manifold having especially long branches opening into a plenum chamber below the carburetor mounting pad. Engine Development engineers John Platner and Don Moore perfected this intake manifold and the complementary exhaust manifold to obtain the best performance and equal fuel/air mixture to all cylinders. The five innovators, Messrs. Rose, Latham, Hurst, Platner, and Moore, were awarded U.S. Patent #3,109,416, its first page illustrated on Fig. 11.2, for the overall engine arrangement.

Further engine details were as follows. Both the intake and exhaust ports were located on the same side of the cylinder head, so that the exhaust gas from all six cylinders could be used to quickly warm the central floor of the intake manifold, minimizing the use of the automatic choke, enhancing cold-start

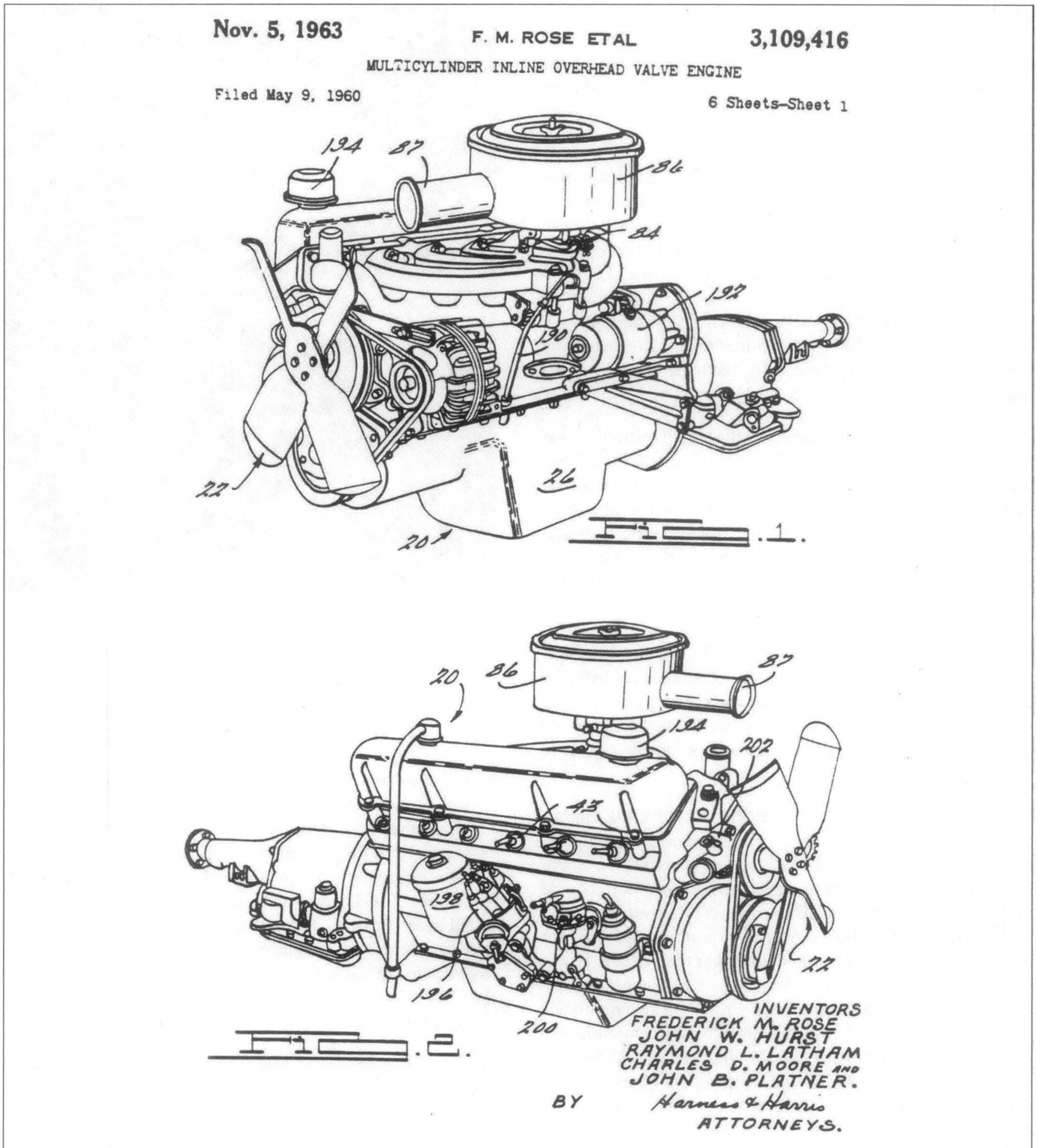

Fig. 11.2 *Sheet 1 of the Slant Six engine patent #3,109,416.*

drivability, and improving fuel economy. No two exhaust ports were located adjacent to each other for optimum valve seat cooling and maximum valve durability.

In terms of the bore and stroke ratio, the 170-cu.-in. engine's 3.4 × 3.125 in. dimensions gave it a desirable oversquare ratio, similar to those of the V-8 engines. The 3.4 × 4.125 in. of the

225-cu.-in. engine made the larger version definitely undersquare, reminiscent of L-head engines. It would have good torque characteristics but, with the bore size restricting the valve sizes, would be limited in power. However, customers wanting extra power certainly could opt for the V-8 engines available on all the larger cars.

A design feature imposed by the engine length restriction was the use of four crankshaft main bearings instead of seven main bearings. It actually was not much of a loss because Advance Engine Design supervisor Ray Latham knew that crankshafts with four bearings generally were less expensive and torsionally stiffer than those with seven bearings. His advice was to steer clear of "those whippy seven main bearing crankshafts."[3] With four bearings and a long 4.125-in. stroke, the main bearing diameter was made a husky 2.75 in., the same diameter as the main bearings in the big-block RB V-8 engine.

Another design challenge caused by the length restriction was the type of tappet to be used. The lead designer, Fred Rose, found there was enough room to use mushroom tappets with large heads and small-diameter stems as were used on the L-head engines, but not enough room for the large-diameter cylindrical tappets that were being used 100% on the V-8 engines. Bob Rarey and I knew that the engine simply had to have the V-8 type of tappet to ensure a low-cost supply and to make the tappets serviceable from the top of the engine. The three of us spent an afternoon and evening at Fred's drafting table, exploring all the possibilities of tappet locations, camshaft lobe locations, camshaft bearing lengths, and everything else along that critical section of the engine until we finally had squeezed the cylindrical tappets in place without needing any change to the engine length.[4]

Following the pattern set by the B/RB big-block V-8 engine, the cylinder head of the Slant Six engine was designed with overhead in-line valves and wedge-shaped combustion chambers. A tappet chamber running the length of the right side of the cylinder block was designed to receive overhead valve lubricating oil from the cylinder head without the need for drilled holes in either the cylinder head or the cylinder block. Rocker arms were precision-fabricated steel stampings. The pushrod end of the rocker arm had a screw with an interference thread for adjusting the valve lash. The stringent engine length restrictions led to the use of thin aluminum tubes with O-rings rather than cast walls for separating the spark plugs from the adjacent pushrods. Although more expensive, the thin tubes did provide a weight savings. Figure 11.3 shows a cutaway view of a portion of the valve arrangement.

For possible weight reduction, an aluminum version of the cylinder head, intended to be made by a semi-permanent mold process, also was designed and experimentally procured. Its design incorporated valve seat inserts, valve guides, and large-diameter head bolt bosses. It later was abandoned in favor of cast iron, as related in the following paragraphs.

Fig. 11.3 *Cutaway view of the 1960 225-cu.-in. RG Slant Six engine.*

Figures 11.4 and 11.5 show a longitudinal section and a cross section of the 170-cu.-in. engine, respectively. Figures 11.6 and 11.7 the show right-front and left-front outside views, respectively. A longitudinal section and a cross section of the 225-cu.-in. engine appear on Figs. 11.8 and 11.9, respectively. The similarity of the two engines is well illustrated by these hard-to-tell-apart sections. Both engines had iron cylinder blocks and iron cylinder heads. Engineering Program number A907 was assigned to the 170-cu.-in. engine, and A734 was assigned to the 225-cu.-in. engine. They also were given the designators LG (for low G) and RG (for raised G), respectively.

However, Engine Design was far from finished with its tasks. The choice between iron and aluminum for the cylinder block and cylinder head had yet to be made. The use of aluminum was desirable to minimize car weight and possibly to reduce tooling costs because aluminum had much higher machining speeds than cast iron and would require fewer machine tools. A decision was made to proceed with both materials, with cast iron being considered a backup in case unforeseen problems occurred during the development of the aluminum parts.

In an unprecedented move to expedite the aluminum cylinder block design, Bob Kring, a die design engineer with the Chrysler

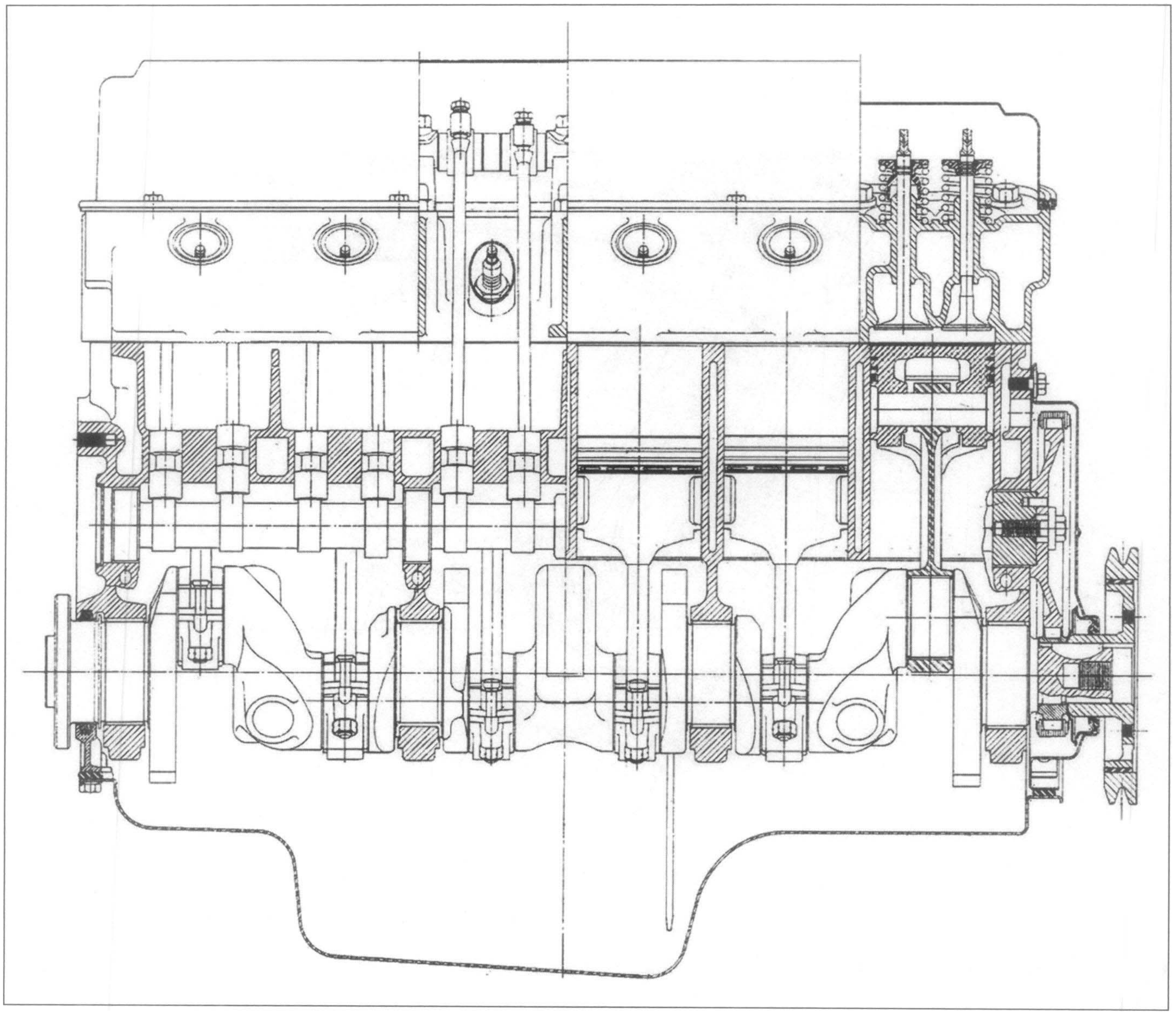

Fig. 11.4 *A longitudinal section of the 1962 170-cu.-in. LG Slant Six engine.*

casting plant in Kokomo, Indiana, was temporarily assigned to Engine Design so the design of the cylinder block casting dies could proceed simultaneously with the design of the cylinder block. The continual information interchange between Kring and the cylinder block designer ensured that the first design would satisfy the requirements of both Engineering and the production casting source of the die-cast blocks.

The die-cast aluminum cylinder block had two features of special interest: cast-in bore liners made of iron, and cast iron upper main bearing caps. The bore liners were preheated and placed in the die before the high-pressure aluminum shot entered the die cavity. These liners gave an excellent wear surface for the aluminum pistons of the engine. The cast iron upper main bearing caps, assembled to the machined block with customary cast iron lower main bearing caps, guaranteed that the main bearing clearances of the forged steel crankshaft would be held constant throughout the operating temperature range of the engine.

Experimental cylinder blocks made of cast iron and sand-cast aluminum for each displacement version of the engine were procured immediately. The sand-cast aluminum blocks would provide some development information prior to arrival of die-cast aluminum blocks, which would require longer procurement times.