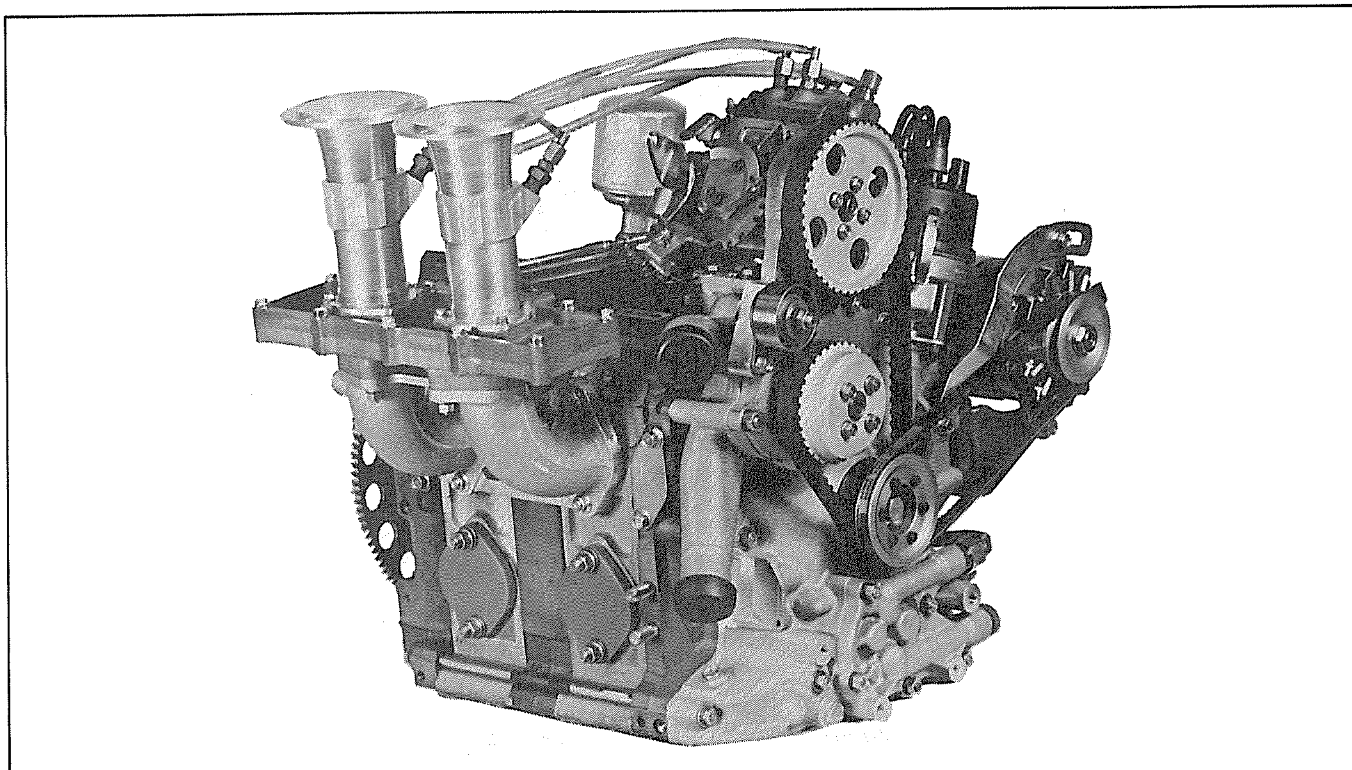
MAZDA ROTARY



When BFGoodrich decided to campaign a car in IMSA's GTP category and in World Endurance Championship, engine reliability was a top priority. A Mazda 13B was selected and installed in a Lola T616 chassis. Engine produced 300 HP at 8500 rpm and weighed a mere 231 pounds.

MAZDA—THE ROTARY ROCKET

In spite of all the Wankel engine development undertaken by NSU, the rotary never achieved broad viability until Toyo Kogyo (Mazda) bought a license to manufacture Wankel gasoline engines of 200 HP or less. However, Mazda wasn't the first licensee; Yanmar Diesel, also of Japan, was licensed two days before Toyo Kogyo (1961). Other companies, including Daimler-Benz, Alfa-Romeo, Nissan, General Motors, Suzuki, Curtiss-Wright, Porsche and even Rolls Royce, also purchased licenses to produce rotary engines of various power ratings. However, Mazda is the company that truly put the rotary engine on the map.

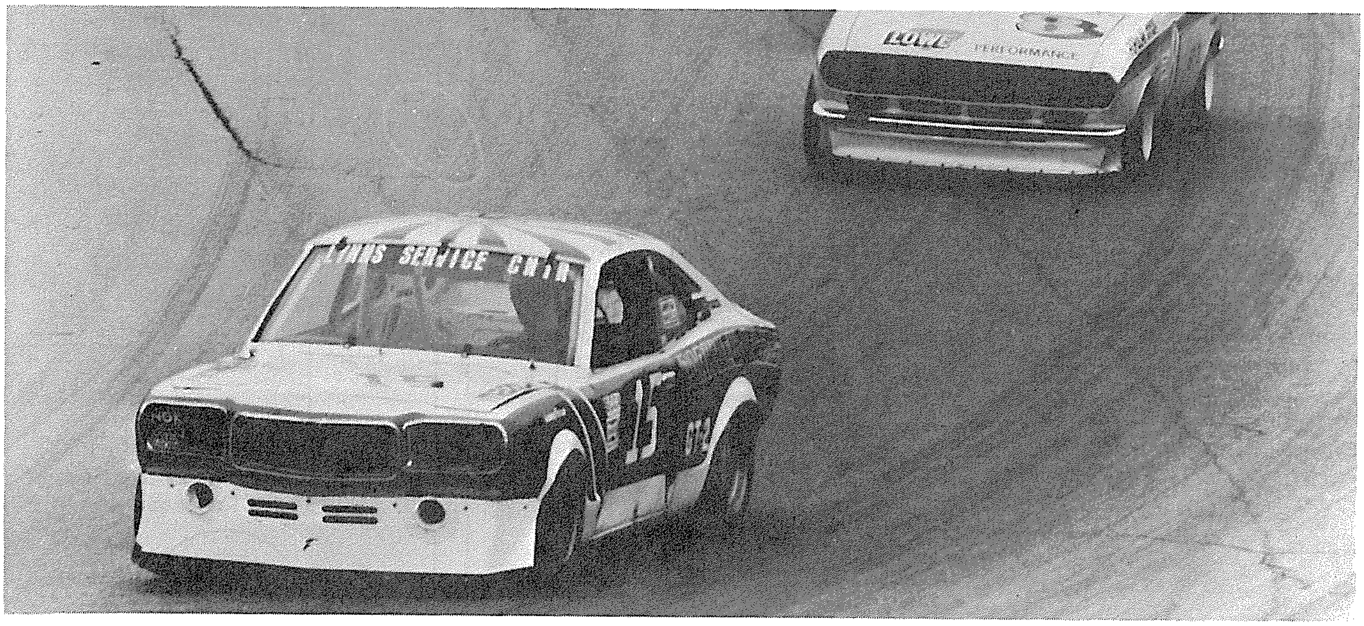
Mazda began developing its own version of the Wankel shortly after obtaining its manufacturing license from NSU. Under the leadership of Kenichi Yamamoto, who was then manager of rotary engine development and is now president of Mazda, the original NSU design was refined over a five-year period.

The first Mazda prototype rotary engine, a single-rotor model, was at best disheartening. It vibrated badly at low speeds and consumed prodigious amounts of oil. A second prototype was little better and Mazda engineers soon determined that a twin-rotor engine would be required if the rotary was ever to be used in a passenger car.

After building a twin-rotor prototype and making countless modifications, Mazda engineers finally got the rotary whipped into shape. The first Mazda rotary engine released for public consumption finally appeared in the 1967 Mazda Cosmo Sports.

The first Mazda rotary-engined vehicle hummed its way to the United States in the R100 passenger car which debuted in 1971. In 1972, the RX-2, with a 12A engine was introduced and the rotary revolution was under way. Engine size was increased in 1974 when the 13B made its debut.

In the Mazda scheme of things, "12A" represents a powerplant with a nominal 1200cc, or 70 cubic inch (in.^{3}), displacement; "13B", as might be expected, indicates a nominal 1300cc (80 in.^{3}) engine. The 13B's additional displacement is achieved by virtue of wider rotors and

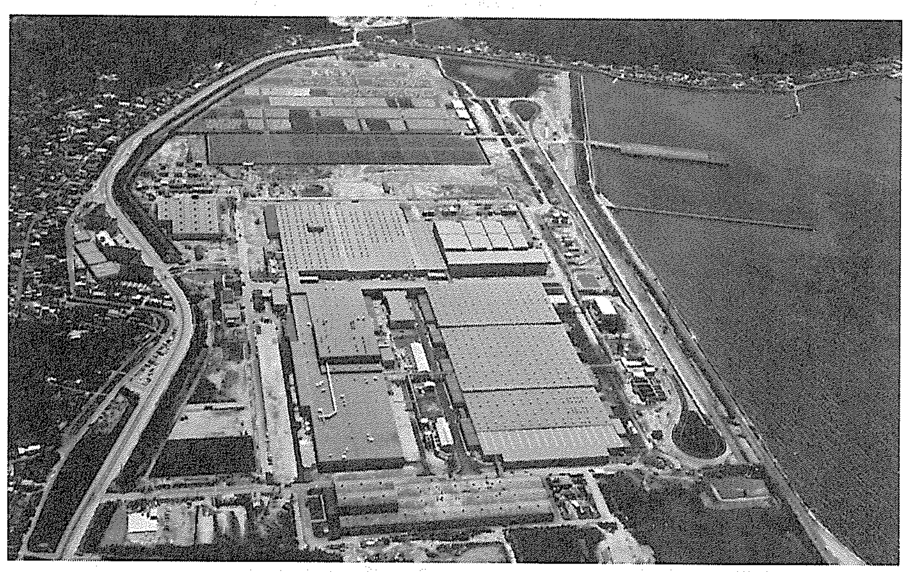


Rotary engines are strong competitors in a variety of SCCA classes. This RX-3, driven by Chris Dembs, won the GT-2 class at the 1982 runoffs at Road Atlanta.

rotor housings. Housing widths are 70mm for 12A and 80mm for 13B engines. In computing these displacements, a rotary is considered a "two-cylinder" engine with each "cylinder" (rotor housing) having a displacement of 654cc in the case of a 13B and 573cc in the case of a 12A.

While rotary engines were reasonably successful in Mazda RX-2, RX-3 and RX-4 automobiles, and in the rotary pickup truck, the engine rocketed to popularity when the RX-7 sports car debuted in 1978. Over the years, the continuing refinements made by Mazda have eliminated virtually all of the drawbacks associated with early rotary engines.

Engine Model/ Disp.	Years Produced	Induction System
12A/1146cc (70 in.^{3})	1971-1985	Carburetor
13B/1308cc (80 in.^{3})	1974-1978	Carburetor
13B/1308cc (80 in.^{3})	1984-present	F/inj. six-port induction

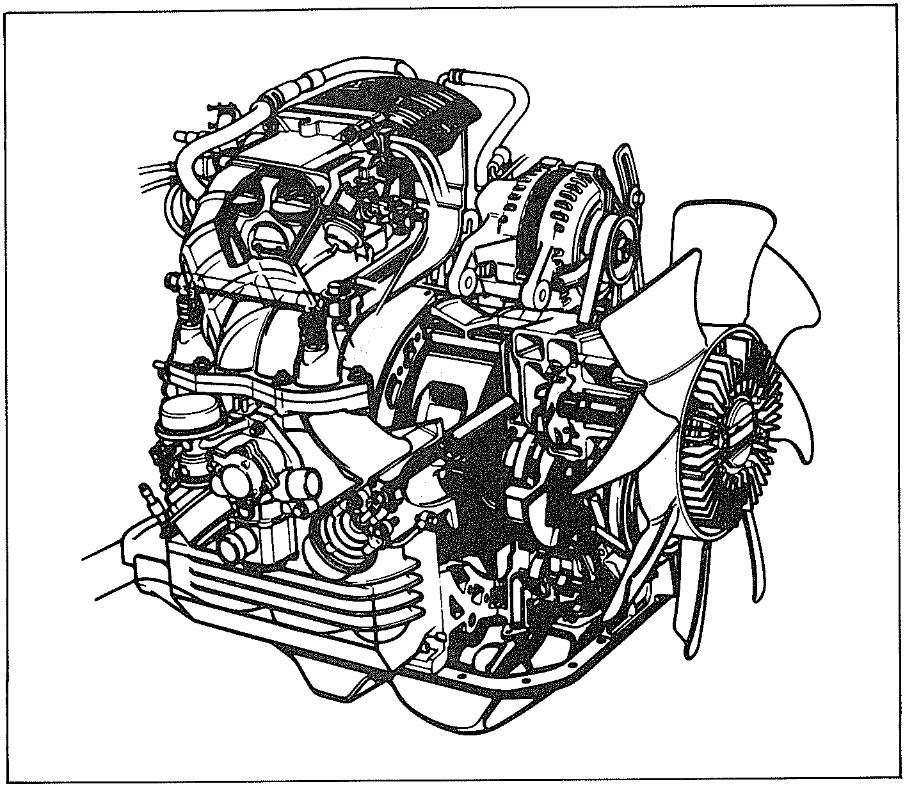


Although Mazda's headquarters is in Hiroshima, the company has a production facility in Hofu City, about 56 miles away. The plant site covers 198 acres.

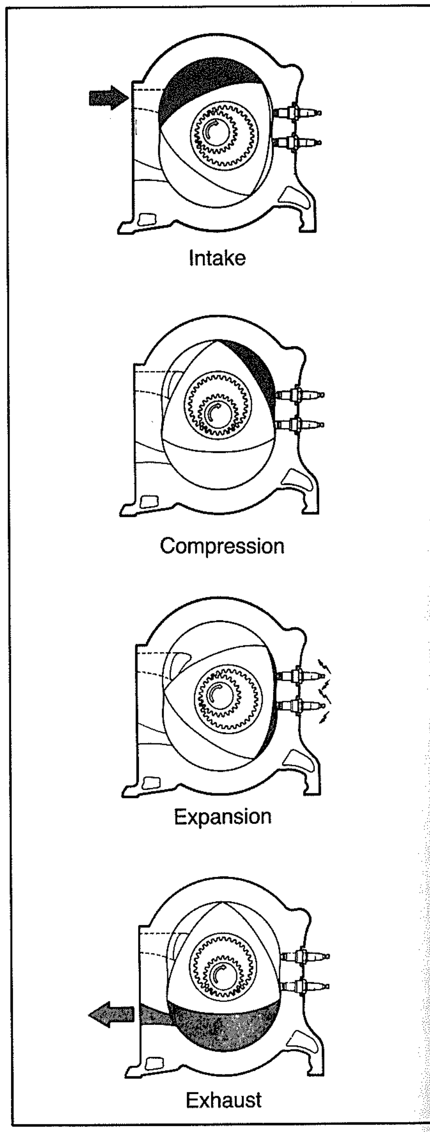
INNER WORKINGS

With comparatively few moving parts, the operation of a rotary engine is relatively simple. Rather than pistons, connecting rods and a crankshaft, a rotary utilizes rotors revolving around an eccentric—also called *output*—shaft as a means of converting the force of combustion into shaft power. In a two-rotor engine, both rotors revolve around a single eccentric shaft, which has a bearing journal and stationary gear for each rotor.

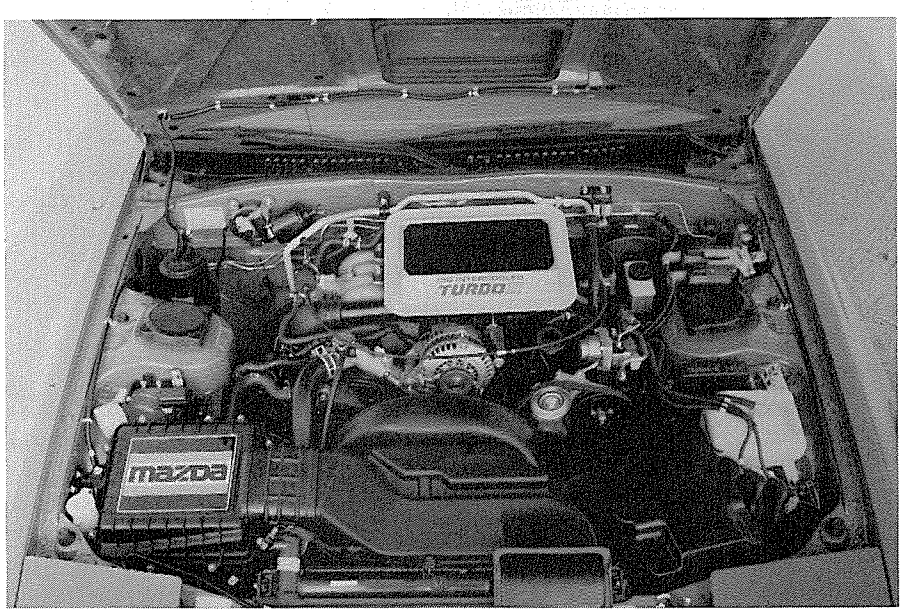
As the rotor orbits the eccentric shaft,



Late-model 13B engine with electronic fuel injection and six-port induction is obviously more complex than earlier models. But internal componentry is basically unchanged so rotary engine advantages are uncompromised.



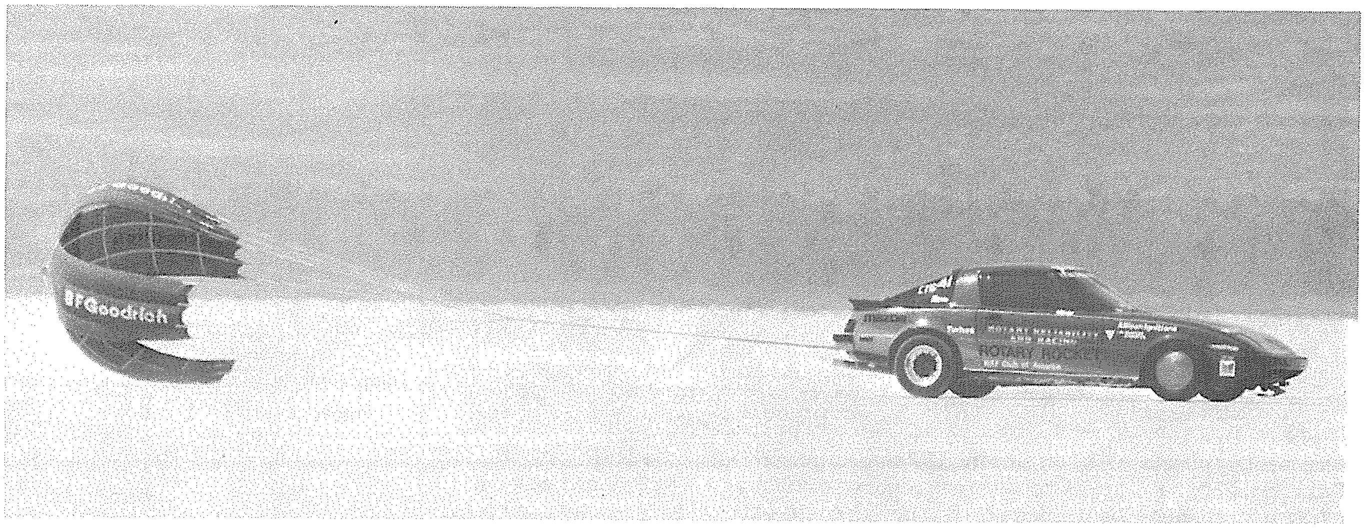
A rotary engine completes all four cycles of the combustion process without valves and all the attending hardware. As the rotor spins, it opens and closes the intake and exhaust ports. Drawing courtesy Rotary Rocket.



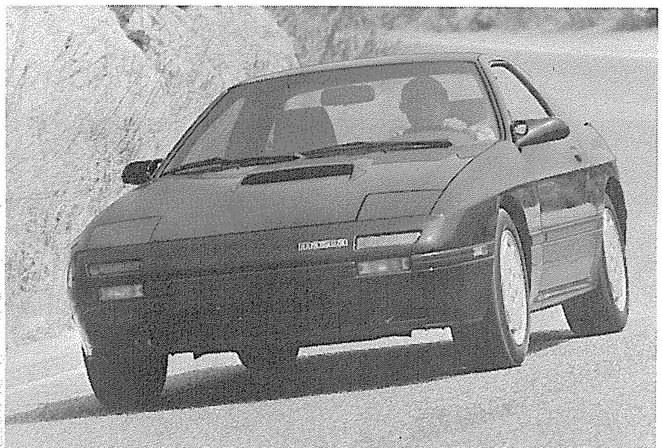
The first production turbocharged rotary engine was introduced in 1986. Assisted by an intercooler, the 13B turbo develops 182 HP at 6500 rpm and 183 ft-lb of torque at 3500 rpm. It moves the RX-7 from 0 to 60 in 6.7 seconds and to a top speed of approximately 145 mph.

the gear teeth on its inside diameter mesh with the teeth on the stationary gear. The path described by the rotor *apexes* is known as a *peritrochoid curve* which is the inner shape of the rotor housing. This inner surface bounds the working chambers on the periphery; the ends are capped by an end housing on one side and an intermediate housing on the other.

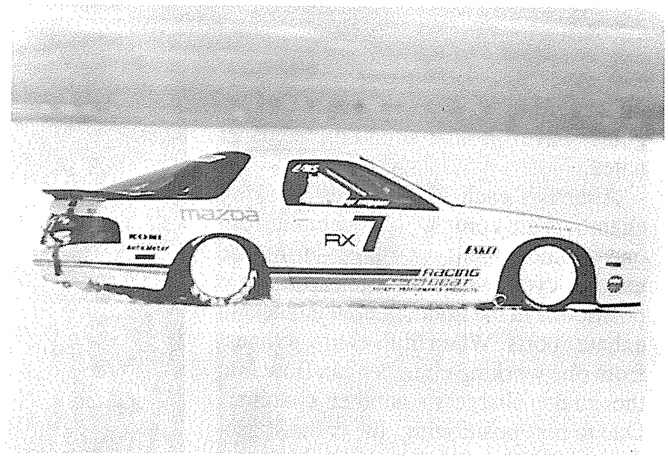
As a rotor spins within its housing, it uncovers an intake port and then creates a vacuum—much like a piston moving



Rotary engines have also been successful at Bonneville. In 1985, Rick Van Nugteren drove an RX-7 built by Rotary Reliability and Racing to a record speed of 190.985 mph. Surprisingly, the car was equipped with BFGoodrich Comp T/A radial street tires.



With all its sophistication, the 1986 RX-7 was the ideal chassis in which to install the turbocharged 13B engine. The second-generation RX-7 offers world-class performance and appearance.



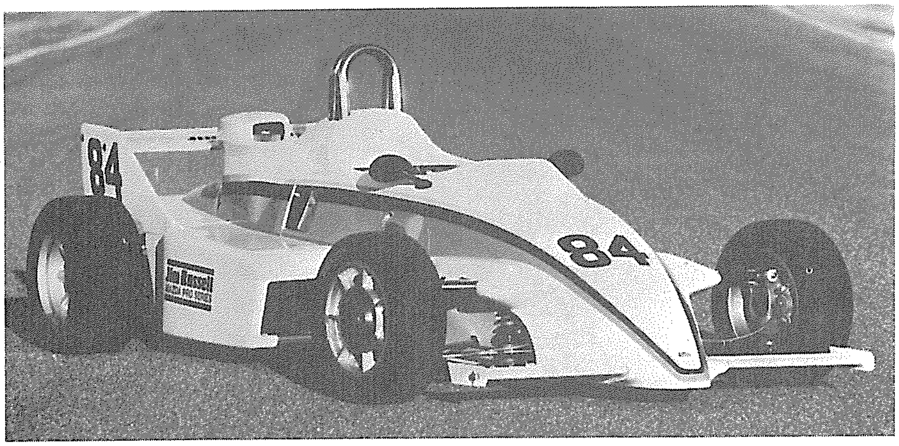
In 1986, *Car and Driver* magazine editor Don Sherman broke the C/Grand Touring record at the Bonneville National Speed Trials. The turbocharged 13B engine, built by Racing Beat, propelled the car to a record of 238.422 mph.

downward on the intake stroke. This vacuum pulls air and fuel into the space—called a working chamber—behind it. As the rotor continues to spin through its travel, it closes the intake port, while simultaneously moving in such a manner that it compresses the air/fuel mixture.

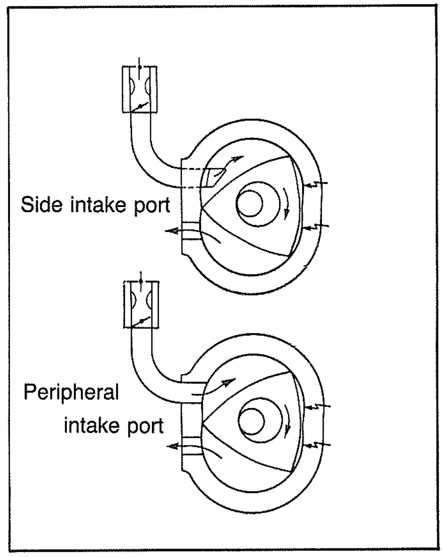
Near "top dead center" the mixture is ignited and as the burning gasses expand, force is exerted against the rotor flank which, in turn, transmits a rotating force to the eccentric shaft.

Always spinning in the same direction, the rotor next moves to the section of the housing containing the exhaust port; the leading apex uncovers the port and the trailing apex covers it. The entire combustion cycle begins again when the leading apex uncovers the intake port. However, with each rotor having three flanks, three individual working chambers—formed by a flank on one side and the rotor housing on the other—are active simultaneously. Therefore, while the mixture in one working chamber is being ignited, another chamber is moving through its exhaust stroke and the third is rotating through its intake stroke.

With this arrangement, an ignition cycle occurs on each rotor every time the eccentric shaft makes one revolution. This relationship is essentially the same in a two-stroke reciprocating engine, which is one reason why two-stroke en-



Mazda rotary engine reliability made the 13B an ideal powerplant for the Jim Russell/Mazda Pro Series. Formula Russell cars were introduced in 1984 as a means of combining the excitement of open-wheel racing with reasonable costs—at least as reasonable as costs ever get in racing.

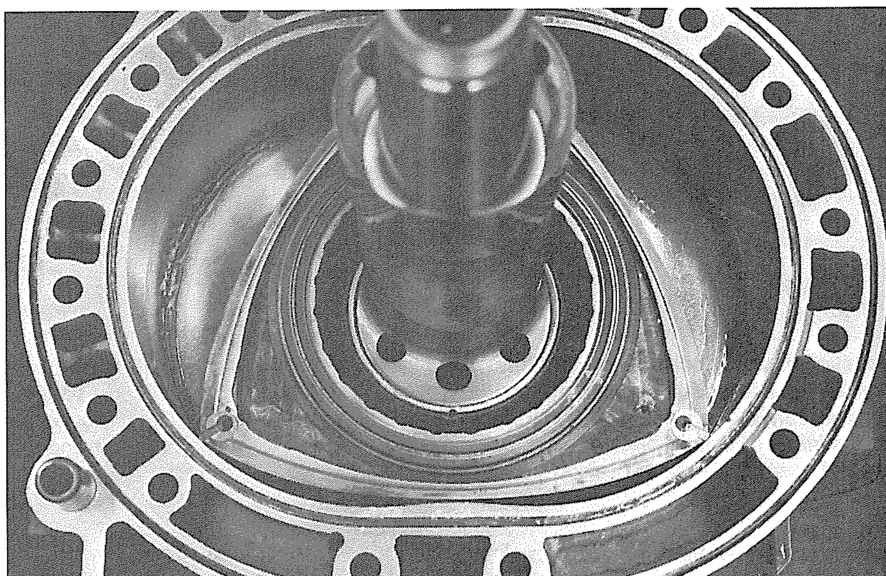


Side inlet ports are found in production engines, peripheral inlet ports are employed in unlimited race engines. In addition to greater flow capacity, peripheral intake ports provide a longer intake event. Drawing courtesy Mazda.

gines have similar-sounding exhaust notes.

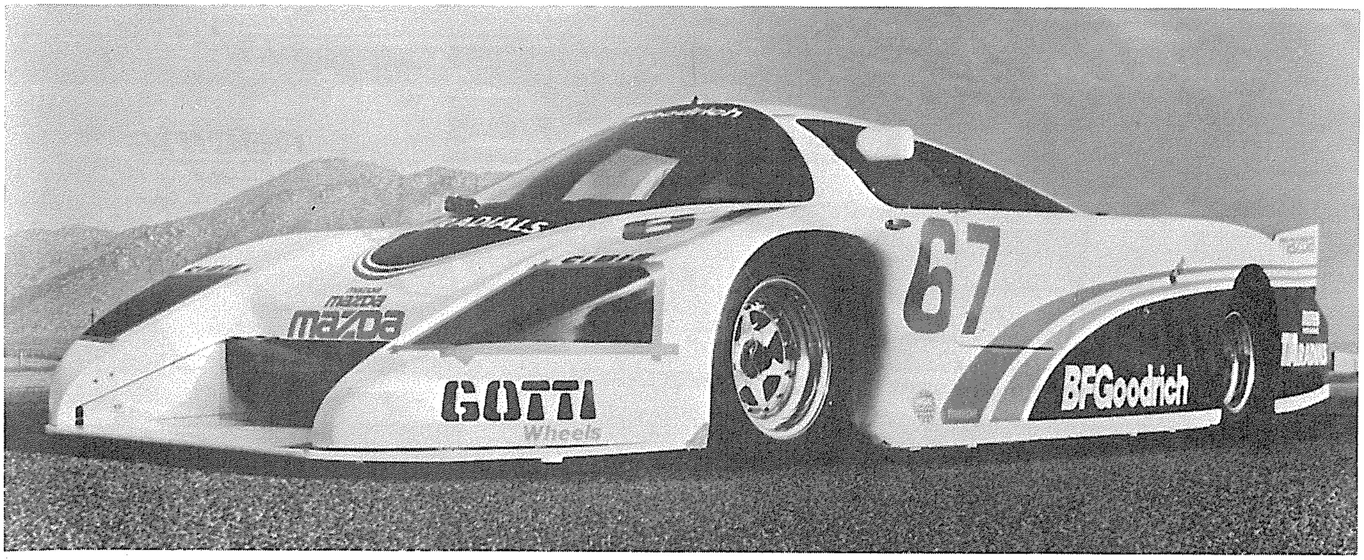
Although each of the three working chambers are completely separated from one another, there are times during the exhaust cycle when the rotor apexes are positioned in the middle of the intake and exhaust ports. When this occurs, exhaust from one working chamber can flow into the intake charge in another chamber. Due to port positioning, the exhaust gasses can still be under considerable pressure during this *port-overlap* period. Consequently, as explained in Chapter 2, a free-flowing exhaust system is critical to rotary-engine performance.

Port Configurations—Within the realm of Mazda rotaries, the intake ports on production engines are in the end and intermediate housings; the exhaust ports are in the rotor housings. Race engines utilize special rotor housings that contain both an intake and an exhaust port. These engines are commonly referred to as being of the *peripheral intake-port* variety whereas the production powerplants are of the *side intake-port* persuasion. (Exhaust ports in Mazda rotaries are always peripheral.)

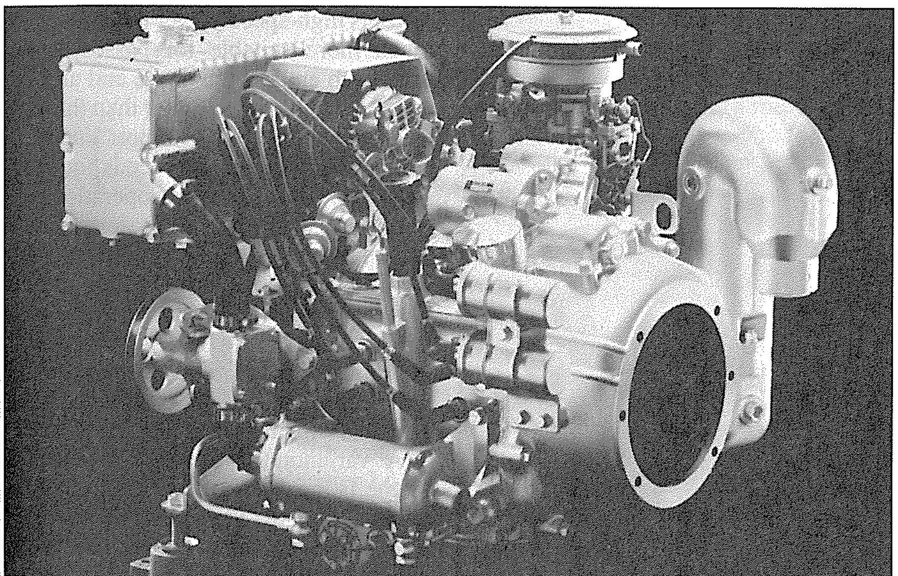


The three working chambers of a rotary engine are active at all times. With rotor positioned as shown, chamber at upper right is on the compression cycle while one at upper left is on the power stroke and is approaching the exhaust cycle. Chamber at bottom has pretty well completed the exhaust cycle and is about to begin a new intake cycle.

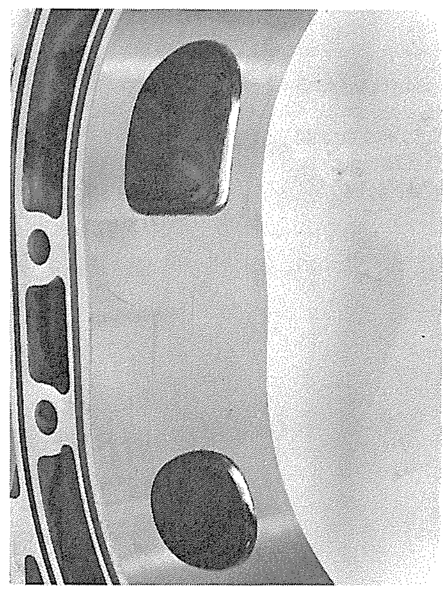
With its large cross-section and straight, direct entry, the peripheral intake port is understandably more efficient than its side-port counterpart. But, in addition to its shape, its position and height are also influential with respect to intake-charging efficiency. On the negative side of the ledger, due to its position and height, a peripheral intake port is



BFGoodrich Mazda/Lola 616 was constructed as a rolling test laboratory for experimental street tires. With an excellent record in competition, the Goodrich cars highlighted the Mazda reputation for rotary-engine reliability.



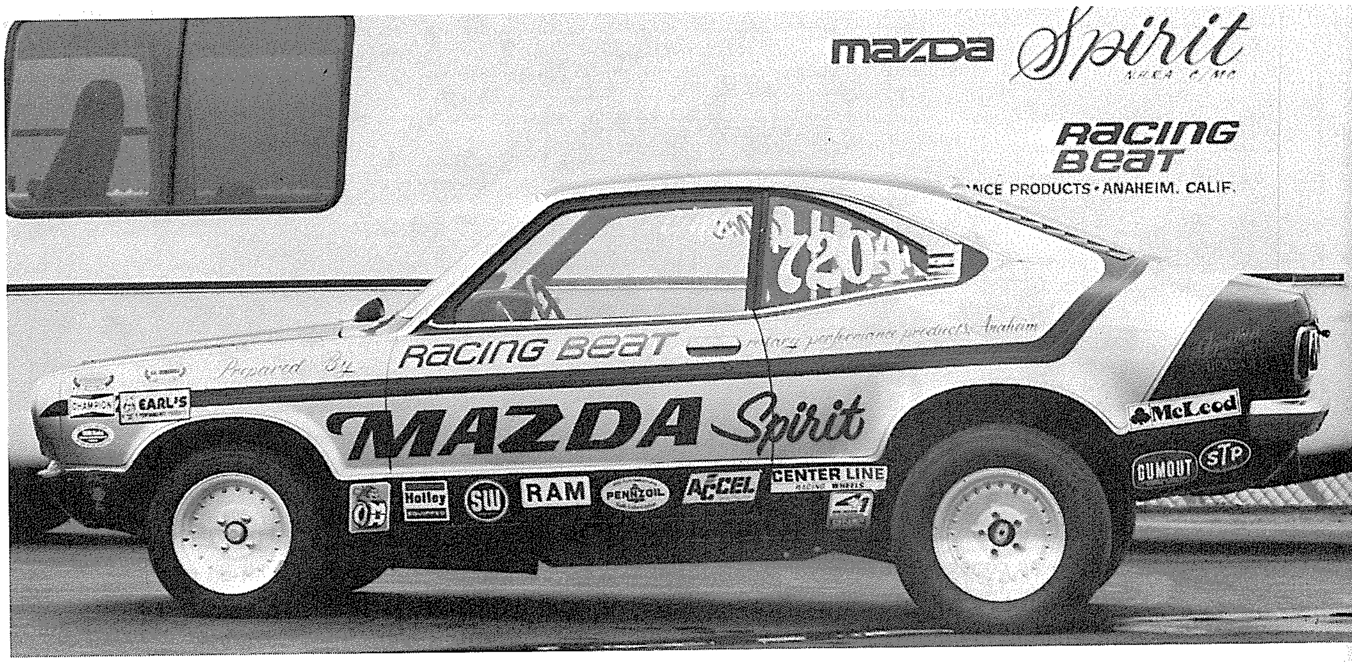
The characteristics that make a rotary engine appealing on land make it ideal at sea. This 13B has been specifically configured for marine use.



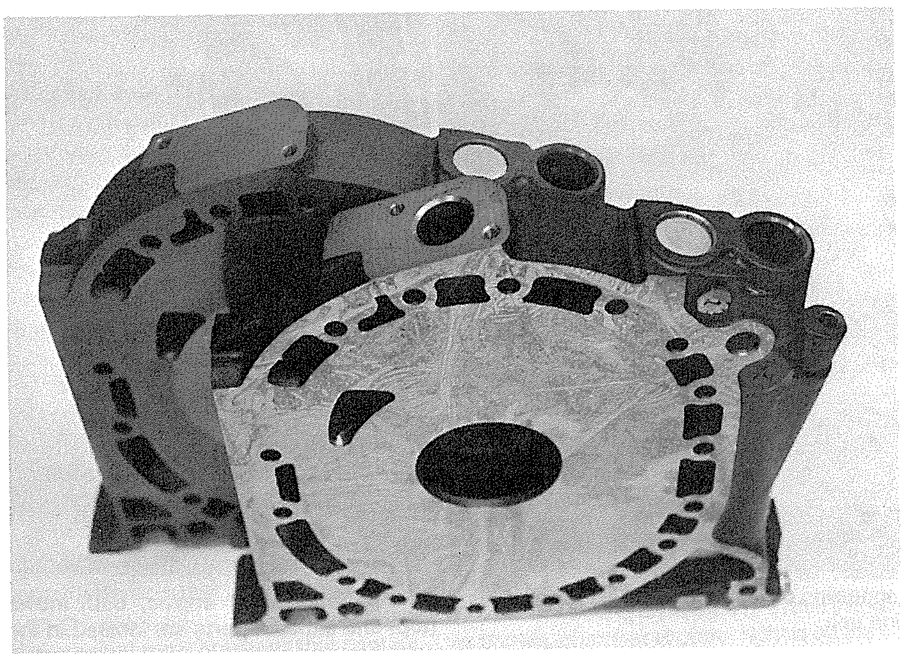
In a peripheral-port engine, both intake (top) and exhaust ports are located in the rotor housing.

open longer than a side intake port. This leads to a longer overlap period—where intake and exhaust are open simultaneously. As overlap is increased, so is the amount of exhaust dilution of the intake charge. The situation is analogous to that of a piston engine with a long-duration camshaft. In both cases, the extended-overlap period is acceptable at high rpm, but leads to reduced torque and poor driveability at low engine speeds.

Although the side-port configuration



Rotary engines have also been successful in drag racing. This RX-3, prepared by Racing Beat, was all but unbeatable in NHRA's Modified Eliminator category. Photo courtesy Racing Beat.


Production engines have their intake ports in the side housings. Several side-housing designs and different port configurations have been used over the years.

restricts high-speed power potential, it is much more suitable for passenger-car use. With entry through the end and intermediate housings, rather than through the rotor housing, intake-port *timing* is compatible with engine speeds found in passenger- and sports-car operation.

In terms of increasing torque and horsepower for high-performance and racing applications, many of the principles that apply to a reciprocating engine are applicable to a rotary. Obviously, execution of those principles requires an approach unique to the rotary engine—which is why this is but the first chapter.

A variation on the side intake-port theme is the *bridge port*. This involves greatly enlarging the port while leaving a thin bridge of material between the original contour and the newly ported area to support the seals. Bridge porting gives opening and closing timing that is similar to, but slightly shorter than that achieved with peripheral ports. Bridge porting is used instead of peripheral ports where class rules specify original-production equipment must be retained.