WANKEL-here to stay?

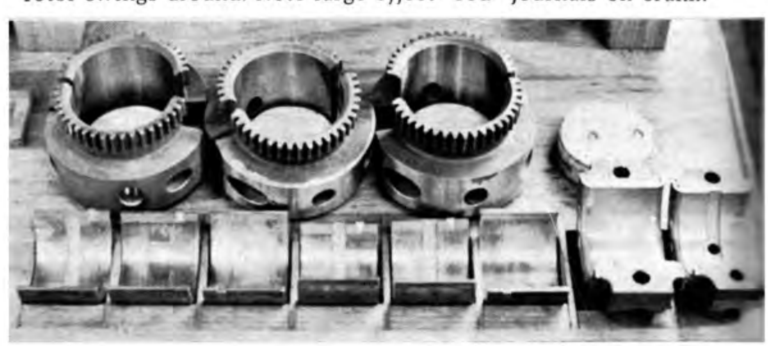
After talking about them for years, foreign automobile manufacturers are now starting to produce these revolutionary powerplants. Mercedes-Benz has only built an experimental model, but it really works

By Ray Brock ▪ For more than a decade the name Wankel has popped up whenever car enthusiasts start talking about advanced-design automotive powerplants. The theory of the Wankel engine goes back to 1954 when Dr. Felix Wankel of Germany patented the epitrochoid principle of using a three-pointed rotor inside a two-lobe casing, thereby using rotary motion to deliver power rather than reciprocating motion. But rather than get involved in a lengthy treatise on all kinds of engine theory, let's get to the point and talk about the star of this story.

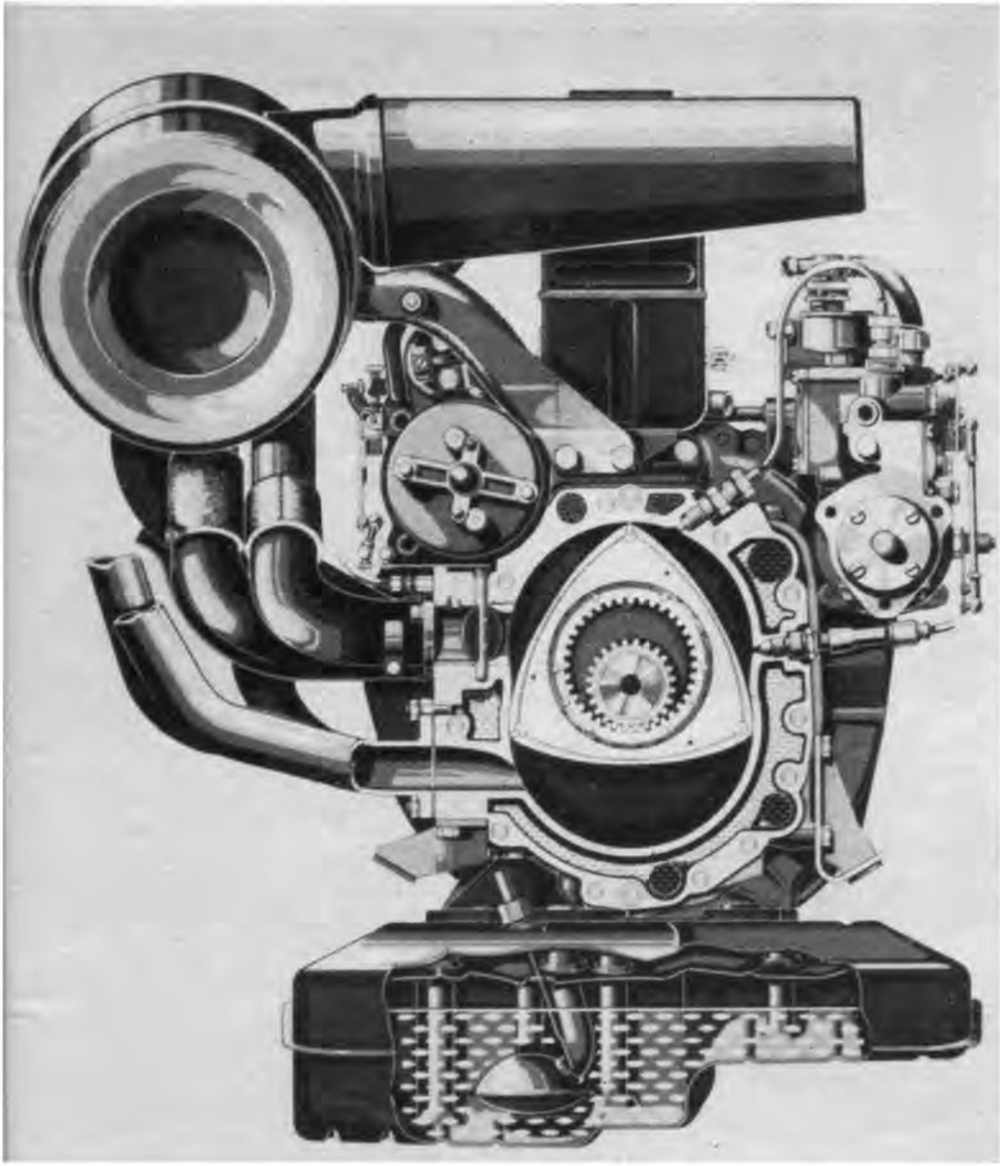
This star happens to be the Mercedes-Benz three-pointed star, for it is the Wankel engine for their revolutionary C 111 gull-winged sports coupe which has attracted our interest. Is this the engine of the future? After a trip through the experimental department of Daimler-Benz (the corporate title of the company that makes Mercedes-Benz automobiles) we would have to venture that it might well be. Although we had seen numerous drawings and read many stories about Wankel engines over the years, it really took a first-hand trip, personal handling of the parts, and talks with the D-B engineers to fully understand the Wankel theory and form our own

ABOVE — Mercedes-Benz C 111 experimental sports coupe has three-rotor Wankel engine located behind the driver. Speed: 160.
BELOW — Group of rotors from test engines showed little wear. Note the combustion chamber cavity in each face of the rotors.

BELOW — Main bearing caps split to accept sleeve bearings and fit over crank journals. When bolted together and fitted into position, the gear shown is fixed and internal gear in rotor swings around. Note large offset "rod" journals on crank.



photography: Daimler-Benz, A.G., and Ray Brock



Cross-section of the C 111 Wankel engine shows routing of intake air from air cleaner to the butterfly valve located in the rotor case casting. Exhaust port is uncovered by the rotor and burned gases move into the header system at a much higher temperature than with a reciprocating engine. Wankel has wet oil sump, Bosch direct injection.

Complete Wankel cycle for one face of one rotor is shown below. On intake "stroke," the chamber has nearly reached maximum charge and rotor is about to close off port. On compression "stroke," fuel has been injected directly in chamber and charge is being squeezed. Spark plug ignites charge, combustion moves rotor, uncovers exhaust.

opinions as to its practicality and use.

D-B has been studying, designing and testing the Wankel for nine years. The fears originally offered by automotive experts that sealing the gases between the odd-shaped rotor and an equally odd-shaped casing would be impossible have been solved. Exotic materials aren't needed in the engine. Unrealistic manufacturing tolerances originally rumored have been easily met. In short, D-B engineers say that they have a Wankel engine which could equal or better the conventional reciprocating engine in all departments.

This includes engine life, fuel economy, oil consumption, power output and cost of manufacture. In some areas, such as smoothness, size, weight and a minimal number of parts, the Wankel has a decided advantage. For instance, the three-chambered C 111 Wankel engine has 950 total parts, produces 330 horsepower and has a displacement rating of 3.6 liters. A nearly comparable displacement Mercedes 3-liter six-cylinder reciprocating engine has 1750 parts, delivers 180 hp.

Despite its simplicity and the presence of about half as many parts, the D-B Wankel is still a little hard to explain. If you can hold the parts in your hands and ask questions, all of a sudden the light bulb goes on. As you look at the cross-section drawing, it's important to remember one thing: That small gear right in the middle of the drawing is fixed. It does not rotate. Now imagine the larger internal gear attached to the three-side rotor is like a Hula-Hoop swinging around the waist of a child. Behind the internal gear in the drawing, there's a large-diameter sleeve bearing that fits over a crankshaft journal and transmits that swinging motion of the rotor to rotating crankshaft motion. Now, before you get all confused, take a look at the pictures again.

As that Hula-Hoop (rotor) swings around, the shape those three points scribe is a wide figure eight, hence the shape of the casing. Simple? Also, the flatter sides of the rotor and the casing walls form a variable chamber that will

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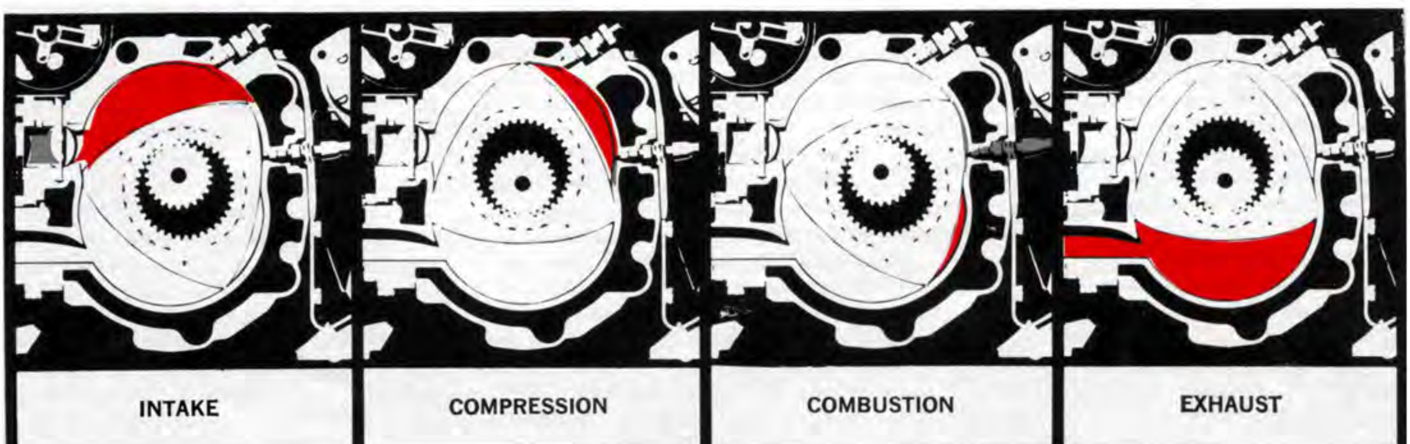


WANKEL

Accessory drives are chain-driven from the front of crank. Chain tensioner is hydraulically actuated to minimize noise.

have a volume as great as 600 cubic centimeters (36.6 cubic inches). D-B does not give a compression ratio for the Wankel, but if we were to assume about 10:1, the minimum volume between rotor and casing would be 60cc or 3.66 cubic inches. As the rotor sweeps by the intake port, it picks up a charge of fresh air as the chamber volume between rotor and casing reaches its maximum. Then as that portion of the rotor continues on around the casing, fuel is injected directly into the chamber by a Bosch timed-injection pump. Continuing the swing, just after reaching the point of the smallest volume (and maximum air/fuel compression) the charge is ignited by a surface-gap type spark plug which feeds the fire through a short port. The burning charge expands, powering the rotor on around to its greatest volume position in the case and uncovers the exhaust port, letting the burned gases escape. As the rotor continues its motion, the last of the burned gases is squeezed out through the exhaust port, the rotor then covers this port and the whole cycle starts over again with the rotor uncovering the intake port. See, we told you it was simple.

In that cycle we just described, we were using only one combustion chamber formed between the rotor and the casing. This chamber reached maximum and minimum size twice during this cycle, just like a reciprocating four-cycle engine. But it also made a complete intake - compression - combustion - exhaust cycle during one revolution, just like a two-cycle engine. Now, multiply everything we've just talked about by three, since there are three sides to that rotor, and you'll see that there are three power strokes per "trip" of the rotor. By the Hula-Hoop action, the crankshaft makes three revolutions as the rotor makes one. Or, for a rotor speed of 2000 rpm, the crankshaft will turn 6000 rpm, one revolution for each power impulse. Since the C 111 powerplant is a three-unit Wankel, there are three power impulses per revolution of the crankshaft.

O.K., that was as simple an explanation as we could offer on the Wankel's operation. Now, we'll get into some of the details but try to stay away from getting too technical. The beautiful thing about the Wankel theory, in addition to those already given, is that if you want more power, you only need to add an extra rotor casing unit . . . or two, or three. The casings are aluminum alloy castings with a carefully contoured inner face that has a special nickel-silicon coating for wear resistance. Water is circulated within the casing for heat transfer. From the sides of the casing, there are four port openings into the area where the work takes place: intake, exhaust, fuel injection nozzle and spark plug ports.

A conventional butterfly is mounted in the intake port and controls airflow from the air cleaner. The exhaust port is a plain and simple passage from the inner wall of the casing to the exhaust header system. Note that there was no mention of valves, rocker arms, camshaft, etc. They're all a thing of the past with the Wankel.

Next, the rotor. It is a cast iron alloy . . . nothing exotic. The triangle faces are slightly convex and a depression in each of these faces provides the needed chamber volume. The width of each rotor must obviously be very closely controlled to match the width of the casing in which it will rotate. We will not go into the precise details of these clearances but they are the most critical of all clearances within the Wankel engine. D-B states that they can be met in production tooling. The inside of the rotor is hollowed and oil bathes the inner surfaces for cooling just as it bathes the bottom sides of the pistons in a reciprocating engine.

The large internal gear shown in the drawing is fixed to the rotor as is a large-diameter sleeve bearing. This bearing fits on the engine's output shaft in what we would normally call the rod journal position. The Wankel "crankshaft" has four main bearing surfaces concentric with the shaft centerline, and three offset, larger-diameter "journals" spaced 120° apart on the shaft. The offset of these journals is approximately one inch, so the "stroke" of the Wankel, or the extremities of the rotor "wobble," is a total of about two inches.

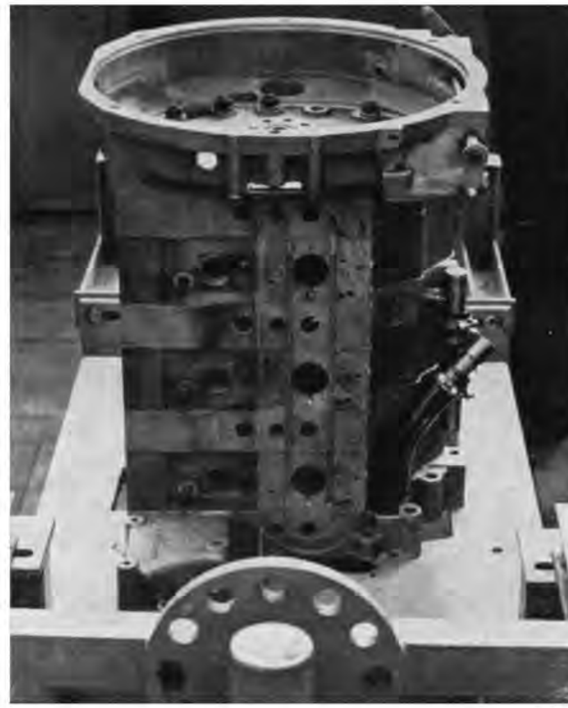
The main bearing caps are split and accept conventional sleeve bearing inserts. The main caps also carry the fixed gear around which the rotor Hula-Hoops. Main caps, inserts and gear, once attached to the shaft, are then bolted into a bore within the cast iron spacer that separates rotor/casing sections. Don't give up, fellows, we're getting close to the end. All right now, seals . . . the critical development that some experts thought would keep the Wankel theory from ever reaching production. All the seals, or piston rings, if you'd like to think of them that way, fit into the rotor. Again, consult the accompanying pictures. Seals across the tips of the rotors are five pieces with three expanders behind them to maintain tension against the "cylinder" walls. They are cast iron and of virtually the same material as the rings in your engine. The straight-edge seal contacts the casing wall with a pair of small triangular-shaped wedges, one on either side of the rotor, to help hold the main scraper in position, with tension from a slightly arced expander. Then, a small button fits each end to capture gases that might slip by the end of the main seal.

Next, there are three grooves in either end of the rotor which carry slightly curved cast iron "rings" with waffled expanders. Then a thin circular ring just outside the internal gear and finally a Belleville spring-type flat ring that fits around the outer diameter of the gear. Compression leakage by this series of seals is minimal (those three small holes in the side of the rotor, between the circular ring and the three curved seals, vent compression blow-by to the crankcase) and oil consumption is less than with a reciprocating engine at this point.

There is oil consumption with the D-B Wankel, however, but it is a controlled amount that is metered into the casing at the edge of the intake port so that the seal on the rotor tips can pick it up and wipe it around the bore of the casing. This takes place on every intake admission and provides needed lubrication to minimize seal and "wall" wear. According to D-B engineers, this oil consumption is less than ½-liter per 1000 kilometers for the three-rotor engine, or about a quart every 1200 miles.

There are, of course, many other components needed to complete the D-B Wankel engine but from this point on they become more or less conventional. Accessory drives off the front of the shaft for water pump, ignition, injector pump and oil pump. The oiling system

LEFT — Bare rotor casting is shown minus bearing, internal gear and seals. Seals below rotor are for one side only. Three small holes outside the round seal vent compression leakage into crankcase. RIGHT — Three-rotor Wankel engine "sandwich" minus all accessories. For the future, add a rotor, add horsepower. BELOW RIGHT — Rotor tip seal has triangular wedges, end buttons and expanders to effectively seal rotor to case. BELOW — Rudi Uhlenhaut, chief passenger car engineer for Daimler-Benz, inspects the oil delivery sleeve which meters oil into casing for distribution by the rotor seal. Rotor casing is cast aluminum with nickel-silicon coating for wear resistance. Casing is precision ground to shape compatible with rotor movement.



is wet sump and a pulley on the front of the shaft spins the alternator and provides a takeoff for any other accessories that might be desired.

So there's your Mercedes-Benz C 111 powerplant. How does a hot rodder go about hopping one up? From inspecting several experimental models we saw around the D-B laboratories, it would appear that port size is the number one contributor toward increased power, and then intake ducting and exhaust header length and diameter are critical and will aid the cause with "ramming" and "scavenging" effects.

The Wankel engine is presently being produced for passenger cars in both Europe and Japan, and we've driven one. It was the NSU RO80, a sweet-running four-door sedan with excellent aerodynamics and styling. It uses a two-rotor Wankel engine that both runs and sounds like a sewing machine. Very quiet and the only problem you have is remembering to shift because the engine is so smooth and just keeps winding. We accidentally exceeded the 6000 rpm red line several times because it just didn't sound like it was running that fast. Without valve train to float, however, no ill effects were noted.

Another Wankel-engined car we drove was the experimental Mercedes-Benz C 111. It was also smooth and has no noticeable torque peaks as does a conventional performance-type reciprocating engine. Just constant acceleration. Its red line was 7000 rpm and it would hustle right up there through the gears. On the Hockenheim racing circuit outside Heidelburg, Germany, we went through the five-speed gearbox and had the speedometer registering 155 mph (250 kph) within about 1½ miles of straightaway. The car was most impressive but we won't go into that now.

So, what are the chances of our having Wankels to play with in this country? Not so hot at the present time. We know of no American automobile manufacturer planning to produce Wankel engines in the near future. And the U.S. air pollution minimums are reportedly harder to meet with the Wankel, so to the best of our knowledge, no European or Japanese manufacturer is planning to import them in quantity.

But Rudi Uhlenhaut, Daimler-Benz's engineer of passenger car development, without admitting or denying that there will be Wankel-engined Mercedes-Benz passenger cars in the near future, says that if the American emissions standards keep getting more strict, then American manufacturers will probably have to start installing afterburner devices on their cars. If and when this takes place, then the Wankel just might be in business. This is because the Wankel has a much higher exhaust gas temperature than does a reciprocating engine and the higher temperature lends itself more readily to an air pump/afterburner device. If all engines have to go to the added expense of afterburners, then the Wankels will not be alone in paying the extra price penalty.

So, we're not making any brash predictions but we are convinced the Wankel is here to stay, most certainly in countries where small engine packages are desired and weight is critical. In this country? Only time will tell. ■■