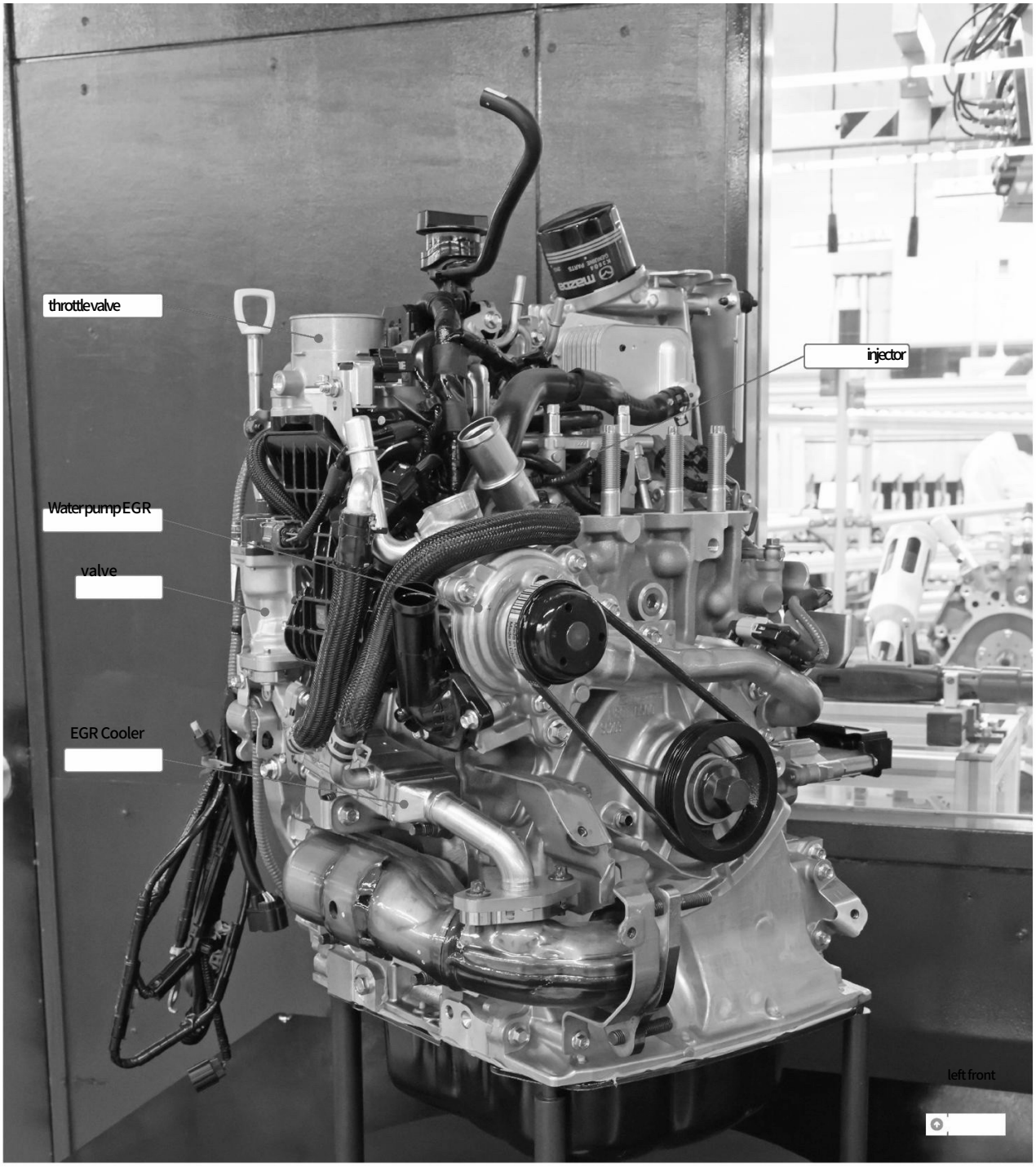
The rotary engine is back.
As of 2023, the situation is such that even the survival of the engine itself is in jeopardy, Mazda has reintroduced the RE, which was once withdrawn from the market due to its inability to meet fuel efficiency and emission regulations. Moreover, it is a completely new model with a new design and, of course, the SKYACTIV crown.
The use is as a prime mover to drive a generator for a series hybrid. AVL once tailored an RE in a similar direction, but it was only a prototype,
Mazda has introduced this as a system and has placed it in production vehicles.
A new RE riding the great wave of electrification; why is this new and what are its advantages over reciprocating machines?
Is it a new model with a huge investment and can it be expected to pay off? There is no end to the interest. The 8C rotary engine is attracting worldwide attention. Let's take an in-depth look at it.

PHOTO:Hiroya YAMAGAMI

New Generation Rotary

Mazda 8C 完全解説

Wankel rotary engine **comes back!**



New Generation Rotary!

世界よ、これが8Cだ。

The e-SKYACTIV R-EV hybrid unit had already been exhibited, but since it was a cutaway model, we could not get a detailed look at the engine. This was the first time we were able to get a full view of the engine. Let us introduce the e-SKYACTIV R-EV from various angles.

TEXT: MFi PHOTO:Hiroya YAMAGAMI/MFi

oilcooler

oilpump

ignition coil

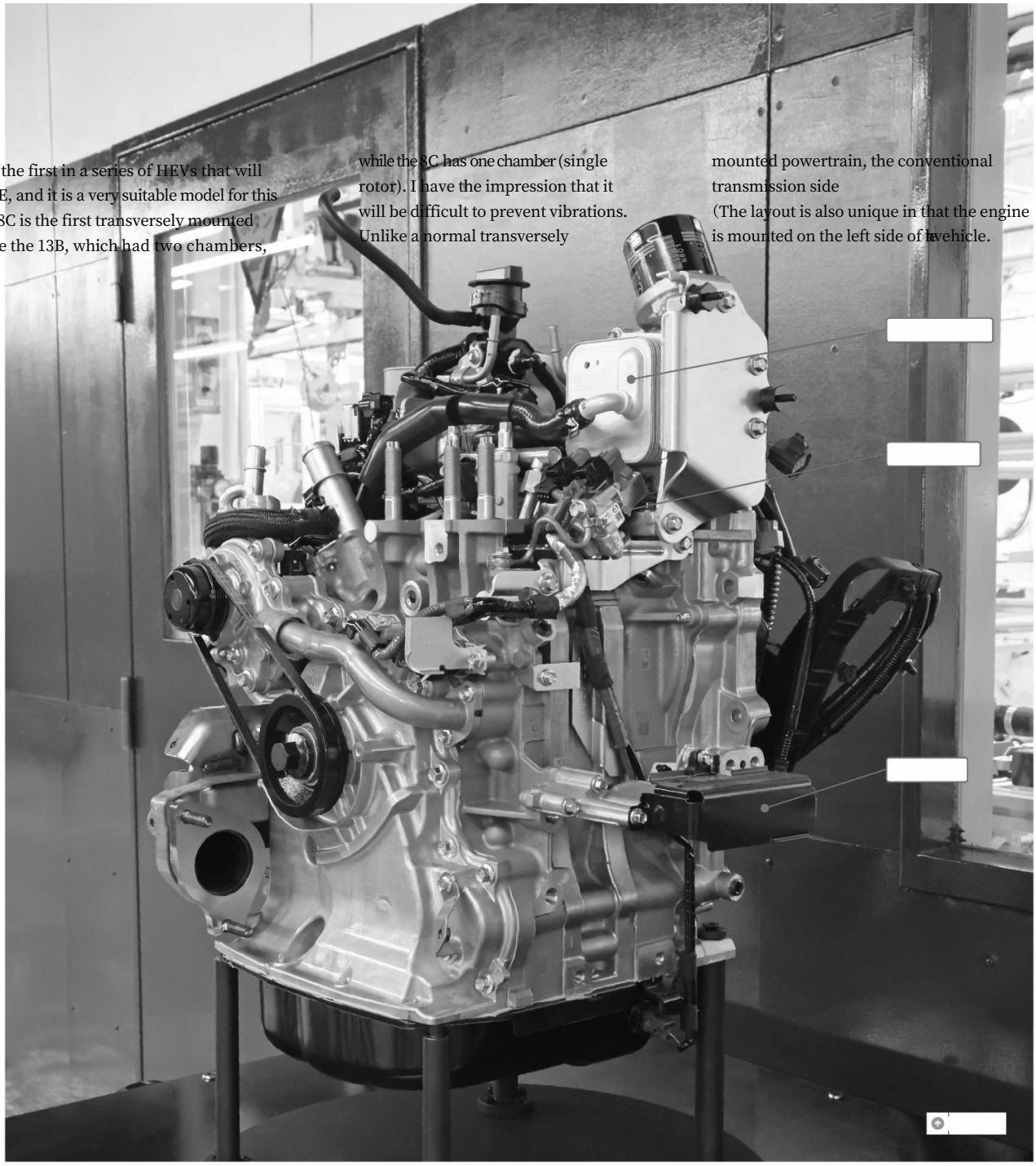
left rear

The actual machine, which I saw for the first time, was larger than I had expected. However, upon closer inspection, one could see that it was due to the auxiliary equipment on top of the engine, and that if this was excluded, it was as compact as a cube.

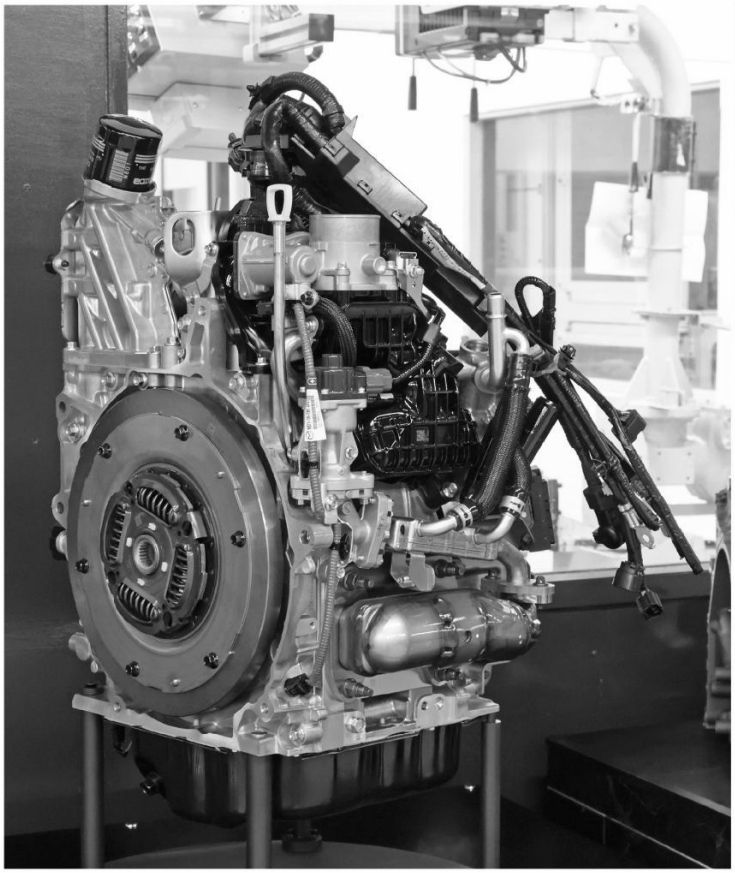
Mazda's new rotary engine, The new model, named 8C, is an ambitious work that incorporates many of the SKYACTIV concepts that have taken the world by surprise with the reciprocating engine, and pursues thermal efficiency. The rotary engine is huge and flat, and its moving combustion chamber makes cooling loss difficult.

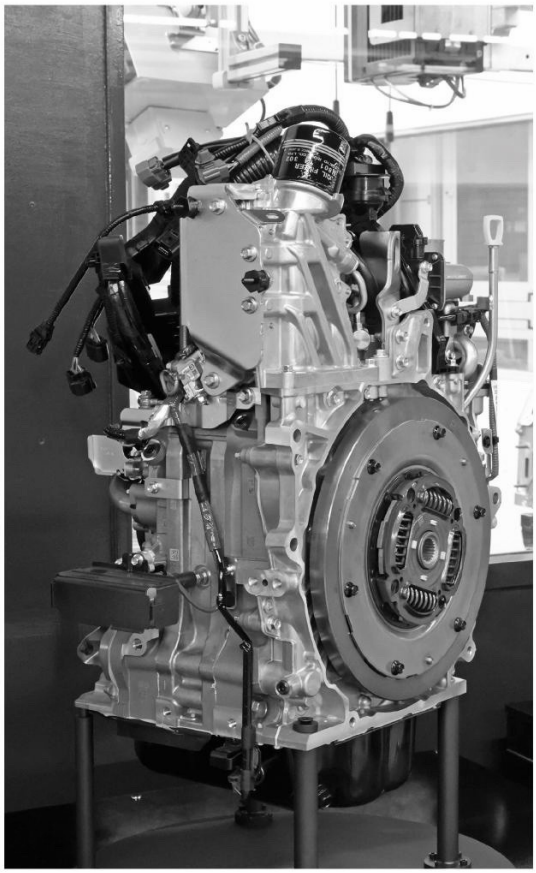
However, the 8C isaseries hybrid power generator only (actually, a DHE: probably the world's first level of hybrid-only engine for production vehicles, along with Nissan's HR14DDe), which is thought to bring the operating range to the point of high efficiency. The 8C is a series hybrid power generator only (in fact, it is a DHE: probably the world's first level of hybrid-only engine for production vehicles along with Nissan's HR14DDe). Mazda's signature MBD (Model Based Development) is also used for the combustion technology to analyze the complex behavior of RE combustion and achieve high-speed combustion in combination with direct injection technology. The first model equipped with this technology was the MX-30, which was one of the first Mazda models to use this

technology.



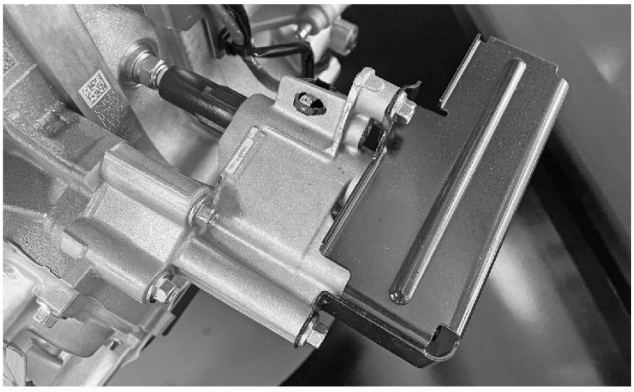
The 8C is the first in a series of HEVs that will use the RE, and it is a very suitable model for this role. The 8C is the first transversely mounted RE, unlike the 13B, which had two chambers, while the 8C has one chamber (single rotor). I have the impression that it will be difficult to prevent vibrations. Unlike a normal transversely mounted powertrain, the conventional transmission side
(The layout is also unique in that the engine is mounted on the left side of the vehicle.



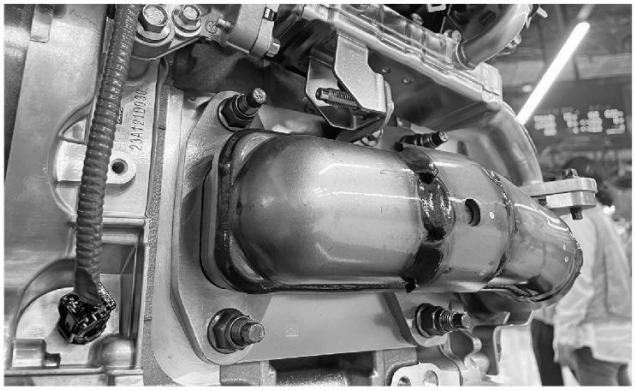


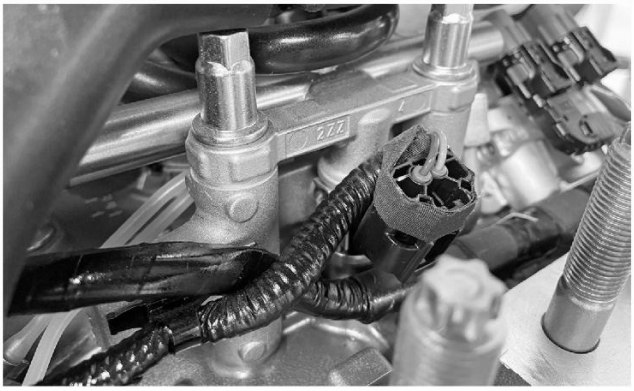
Output shaft side

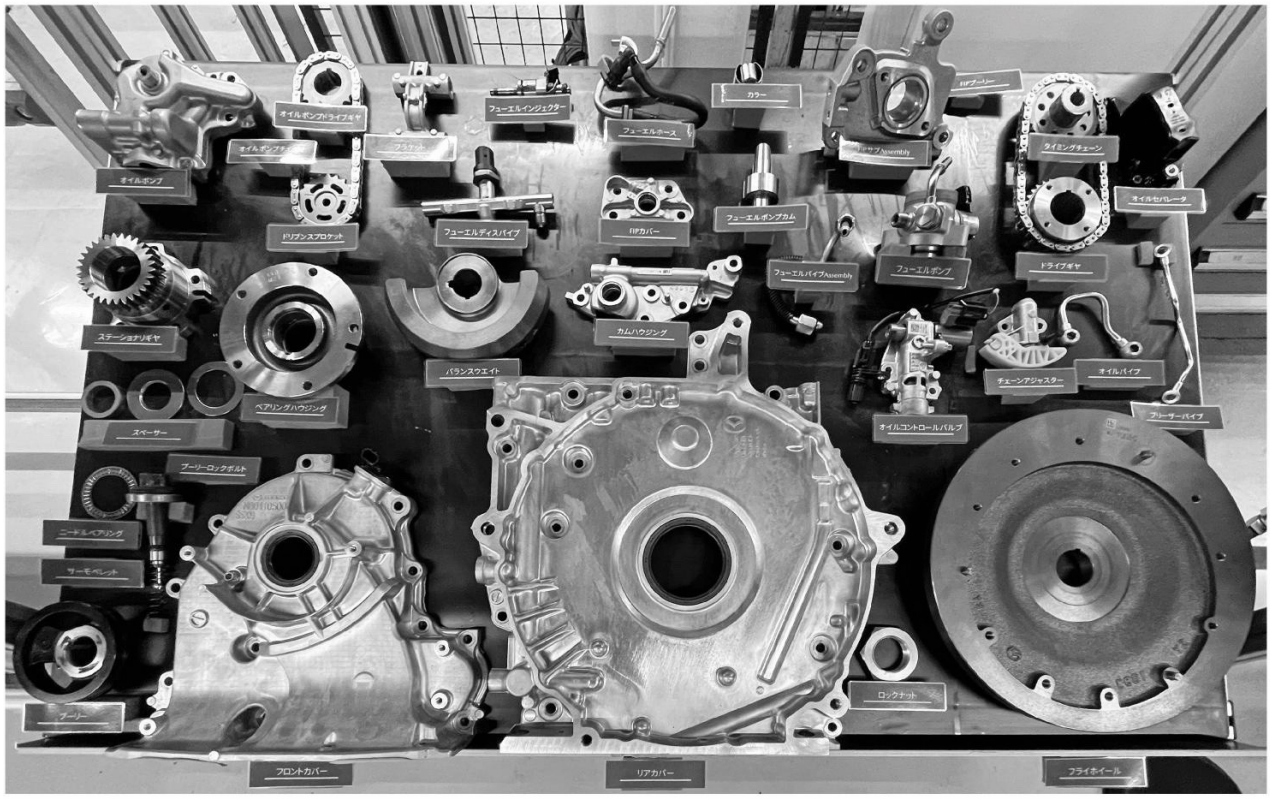
↑The compactness of the unit can be seen when viewed from the rear, where few auxiliary devices are mounted. The rear side of the RE is for the oil pump and the front side is for the fuel intake including the throttle valve. The use of direct injection seems to have caused some difficulty in lubrication for the RE, which sends oil directly to the operating chamber. The exhaust is discharged from the lower front side, and the piping is bent 90 degrees to send it to the rear. The actual exhaust pipe, including the catalyst, could not be verified. A damper to suppress vibration can be seen at the coupling with the generator.



↓(bottom)Exhaust manifold. The EGR distribution pipe is located just before the flange joining the catalytic converter. The EGR is returned to the intake pipe via a water-cooled cooler. (Right)Ignition coil and spark plugs: REs up to 13B were equipped with two spark plugs (leading and trailing), while 8C had only one. The 8C has a single ignition plug, which may be a specially shaped ignition plug for REs. The fuel rail is held in place by two bolts, and the injectors are installed under the rail between the two bolts.

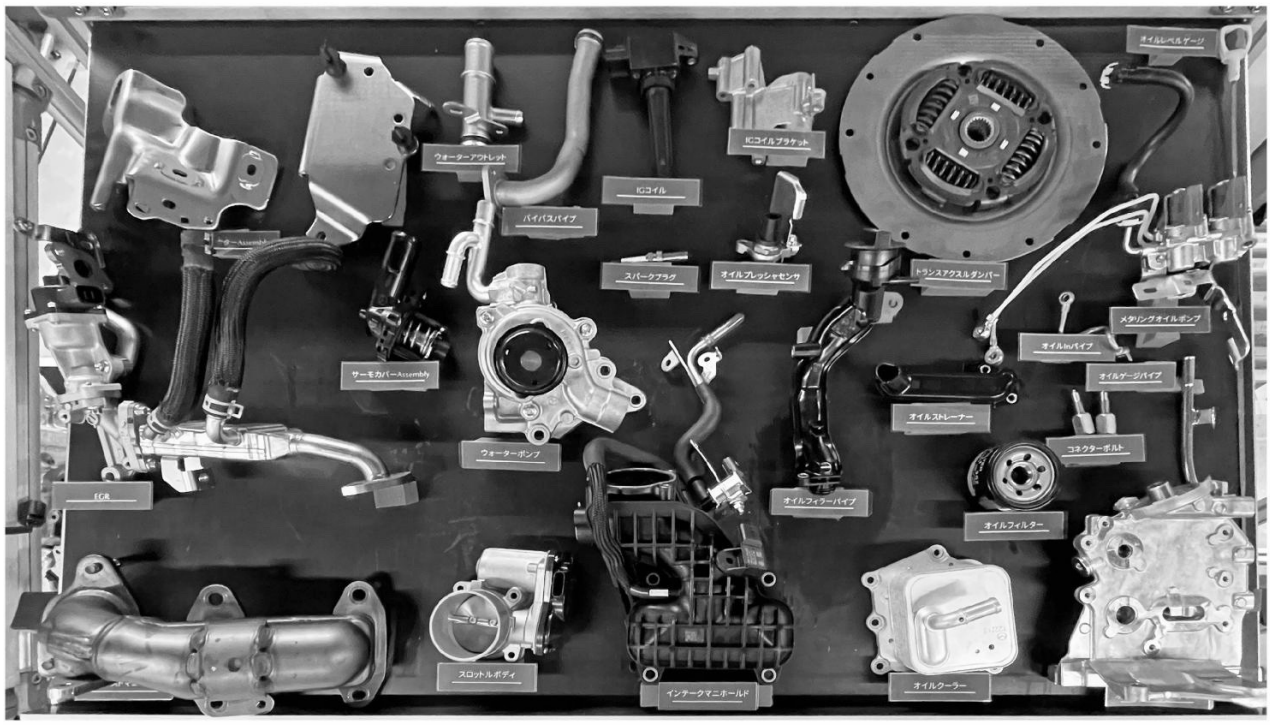






↑ Parts attached to the engine body, which shows the small number of parts used in the RE. The flywheel has an eccentric structure as can be seen from the bolt flange. It is probably used in combination with the balance weight to suppress the vibration of the unit. The fuel pump for direct injection requires high pressure, so it relies on gear and chain drive, as in reciprocating engines. The oil pump is also a separate gear and chain drive shaft.

↓ This is the auxiliary equipment. In reciprocating engines, EGR reflux is used to reduce pumping loss for high efficiency operation, but in the 8C, is EGR used to lower the mixture temperature? No specific explanation was given. The lubrication system integrates a water-cooled oil cooler. Two supply pipes can be seen extending from the oil pump body. These are connected above the housing, in front of the fuel injectors.



A word that always appears in explanations of rotary engines is trochoid curve. The original meaning is "the path drawn by a point fixed to a circle as the circle rolls along an arbitrarily curved track without sliding." Although the motion appears complex, this curve can be calculated geometrically. If two rotors (outer and inner) are combined to follow this curve exactly, it is possible to create a variable volume while sealing, and there have been many examples of this in oil pumps for many years.

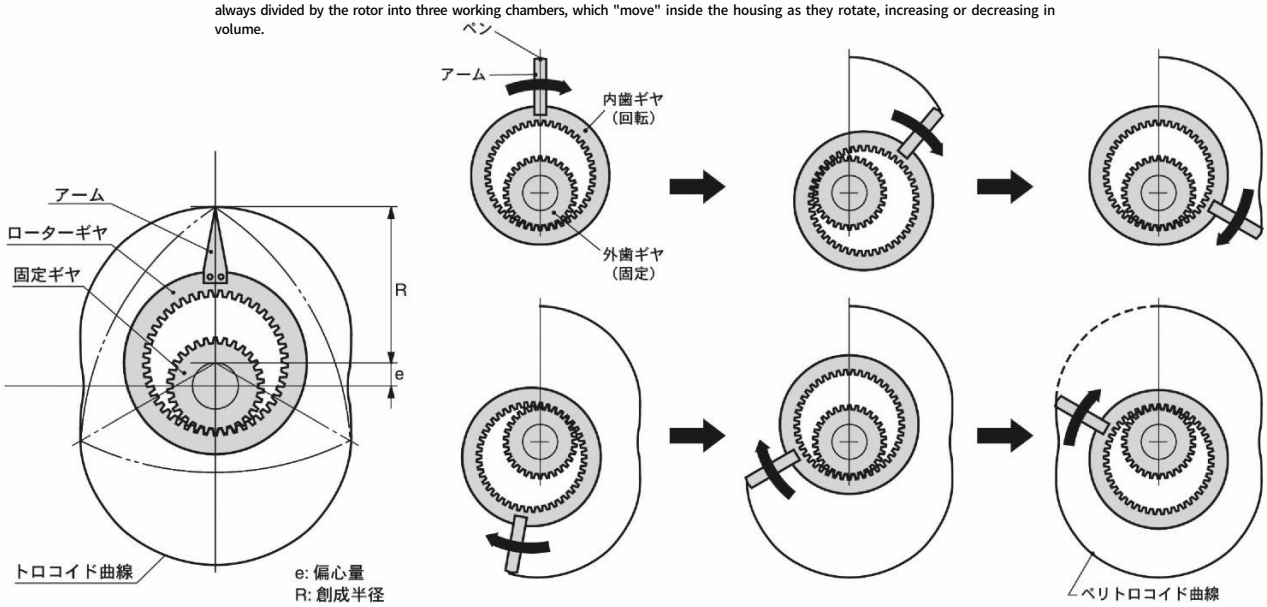
In other words, a trochoid curve is not something that is utilized only for rotary engines, but is just one of the trajectories generated by rotational motion. It represents the position of a point away from the center of a circle as it is moved by rotation. The rotary engine uses this trochoid curve in its internal combustion engine. Unlike the general reciprocating internal combustion engine that uses a piston, the rotary engine was already in use in the late 16th century as a prime mover that could extract driving power directly from the circular motion.

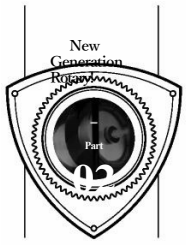
There was a time when the originator of the "Bunker engine" appeared in the literature, and numerous researchers competed with each other on various ideas. However, none were put into practical use until 1957, when a German, Dr. Felix Bankel, perfected the Bankel-type engine with a triangular rotor.

Dr. Bunkel researched and analyzed various rotary engine designs to create the optimum trochoidal shape. Originally, Dr. Bunker studied rotary valves for aircraft engines and airtight seals for turbochargers.

Peritrochoid curve with two nodes in a Bankel-type rotary

The illustration below shows how to make a trochoidal curve, which Dr. Bankel's team devised at a time when simulation was not yet mature. An external gear is fixed in the center, and a rotor gear with internal teeth is meshed with it. When a pen is combined with an arm sized according to the rotor shape and rotated, the pen draws a cocoon-shaped trochoid curve. The trochoid chamber inside the housing is always divided by the rotor into three working chambers, which "move" inside the housing as they rotate, increasing or decreasing in volume.



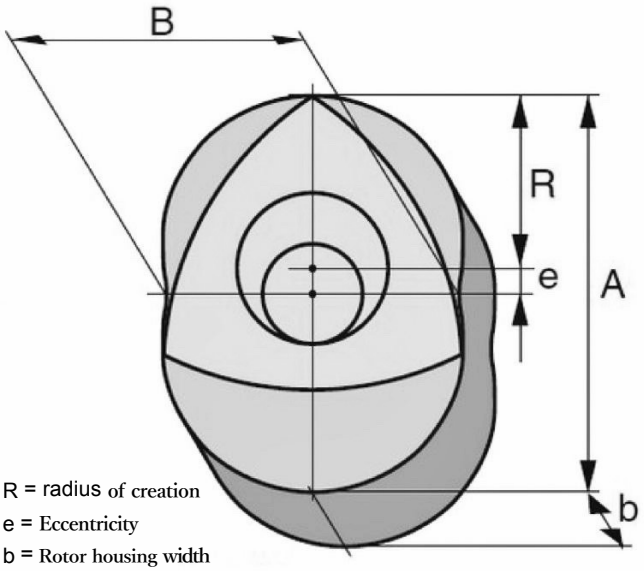


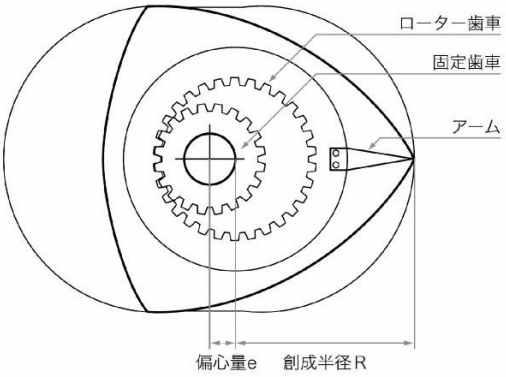
Overview_02

トロコイド曲線とは何か

A rotary engine produces power by the eccentric rotary motion of a rotor inside a housing.
The cocoon-shaped line connecting the trajectories of the apexes of the rotor as it moves is the trochoid curve. Although it appears to be a complex movement, all of these operations are based on the inevitability of geometrical calculations.

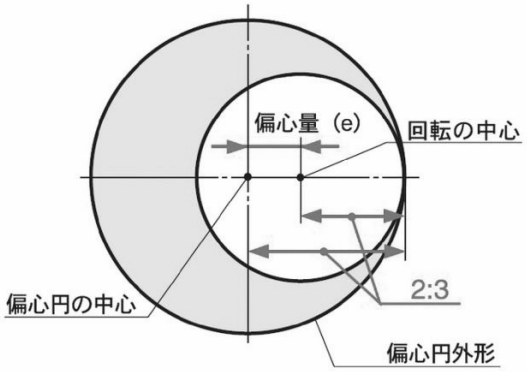
TEXT: MFi FIGURE: MAZDA /Toshinao KUMAGAI





R = radius of creation
e = Eccentricity
b = Rotor housing width
A = length of trochoidal major axis [2(R′+e)
B = length of trochoidal minor axis [2(R′-e)
VH = process volume

$$VH = 3\sqrt{3}R'eb$$



Calculation of displacement for rotary engines with complexly shaped working chambers

As mentioned above, the trochoid curve follows a geometrically derived constant, and the volume of the process can be calculated by calculation, although the formula is complicated as shown in the figure above. The displacement of a rotary engine is the maximum volume minus the minimum volume derived from this calculation. The 8 C rotary engine is an all-new design, with both the radius of creation and the eccentricity being changed from Mazda's long-standing units of the past. The eccentric has been lengthened to achieve what is called a long stroke in a conventional reciprocating engine.

The result is a product of the extensive experience gained through the development of this new type of engine. In this process, the inner circumference of the housing must have a trochoidal shape. Suppose a triangular-shaped rotor is placed in a circular housing. In this case, the volume of the working chamber does not change even if the rotor rotates, and even if the air mixture is ignited, the pressure only works toward the center of the rotor and does not lead to rotational motion.

However, the combination of a trochoid-shaped housing and a rotor attached to an eccentric shaft (eccentric shaft) produces two volume changes per revolution in the working chamber, enabling the processes of an internal combustion engine: intake, compression, expansion, and exhaust. The triangular-shaped rotor rotates eccentrically in the housing to achieve smooth operation with a small number of parts, and the trochoid curve supports the operation of the Bunker rotary engine.

Peritrochoid curve of the Type 8C rotary

The illustration on the right shows the housing and rotor shape of the 8C unit, which can be mounted on the same body frame as the MX-30 BEV model, and the radius of creation was set at 120 mm, 15 mm larger than the RENESIS 13B engine mounted on the RX-8, considering the required power characteristics. The eccentricity was set at 17.5 mm, which was determined after a zero-based study. Since the values were very close to those of the 13A, the same specifications as for the 13A were selected for the trochoidal shape, leading to rapid development. However, other technical elements have evolved considerably, hence the "C" designation. The displacement was increased from 654 cc of the 13B to 830 cc (the RX-8 had two rotors)