Service.

Self-Study Programme 303

The V10-TDI engine

with pump-jet fuel injection system

Design and function

303_U2

With the V10-TDI engine, Volkswagen once again sets new standards in diesel technology.
Due to a multitude of innovative techniques, the highest demands in terms of performance, torque and emissions made of a diesel motor are fulfilled for the luxury vehicle class.

The V10-TDI engine crowns 25 years of diesel engine development at Volkswagen.
It is the most powerful series passenger-vehicle diesel engine in the world.

NEW

Caution
Note

The Self-Study Programme describes the design and function of new developments!
The contents are not updated.

Please always refer to the relevant service literature for up-to-date inspection, adjustment and repair instructions.

At a glance

Introduction

The V10-TDI engine

The V10-TDI engine is a newly developed diesel engine in which innovative light-weight construction and enormous power are united within compact dimensions.

It has a cylinder block made of aluminium, where the two rows of cylinders are arranged at an angle of 90° to one another.
The control and ancillary unit is driven by gearwheels The tried-and-tested pump-jet fuel injection system ensures a high performance yield at low exhaust emissions.

The V10-TDI engine is used as a high-performance engine in the Volkswagen Touareg and Phaeton.

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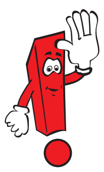
Engine mechanics technical features

- Cylinder block made of aluminium with an end bracket made of cast-iron
- Joining of cylinder head and cylinder block via tie-rod screw connection
- Contol and ancillary unit driven by gearwheels
- Balancer shaft for reducing vibrations

Engine management technical features

- Two motor controllers
- Charged by two adjustable turbochargers
- Exhaust gas recirculation effected with pneumatically controlled exhaust gas recirculation valves with electrically-operated intake manifold flaps
- Lambda probes for controlling exhaust gas recirculation

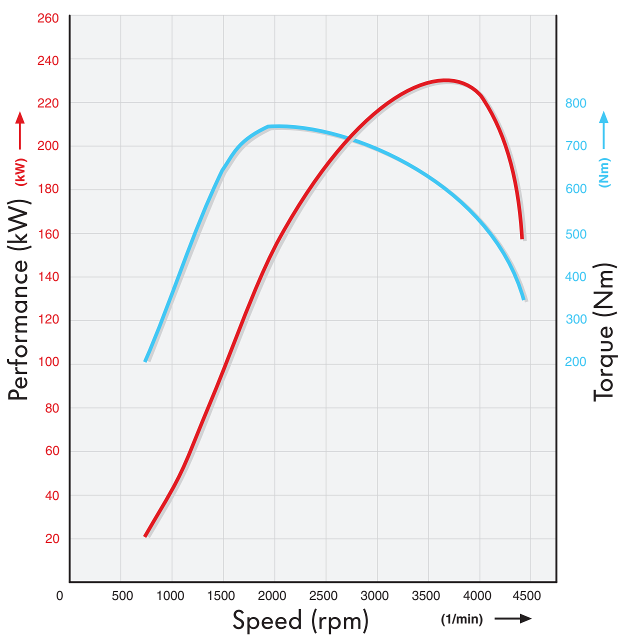


A detailed description of the engine management system for the V10-TDI engine can be found in Self-Study Programme No. 304 ”Electronic Diesel Control EDC 16”.

Technical data

Engine code	AYH (in the Touareg)	AJS (in the Phaeton)
Construction	V engine, 90° V-angle	
Displacement	4921 cm^3	
Bore	81 mm	
Stroke	95.5 mm	
Valves per cylinder	2	
Compression ratio	18 : 1	
Max. output	230 kW at 4000 rpm	
Max. torque	750 Nm at 2000 rpm	
Engine management	Bosch EDC 16	
Fuel	Diesel at least 49 CZ or biodiesel	
Exhaust treatment	Exhaust gas recirculation and oxidation catalytic converter	
Ignition sequence	1 - 6 - 5 - 10 - 2 - 7 - 3 - 8 - 4 - 9	
Exhaust emission standard	EU 3	

Power/torque diagram



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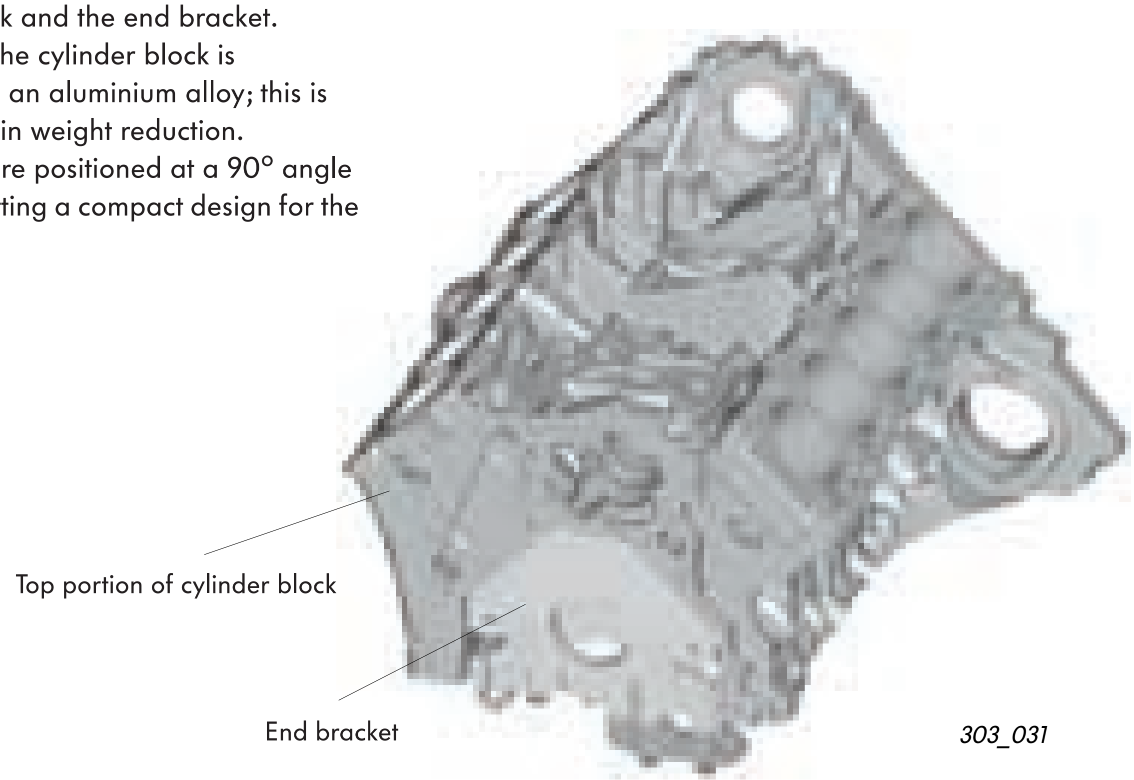
The V10-TDI engine develops a maximum torque of 750 Nm at a speed as low as 2000 rpm.

The nominal output of 230 kW is achieved at 4000 rpm.

Cylinder block

The cylinder block consists of the top portion of the cylinder block and the end bracket.
The top portion of the cylinder block is manufactured from an aluminium alloy; this is a significant factor in weight reduction.
The cylinder rows are positioned at a 90° angle to one other, permitting a compact design for the engine as a whole.



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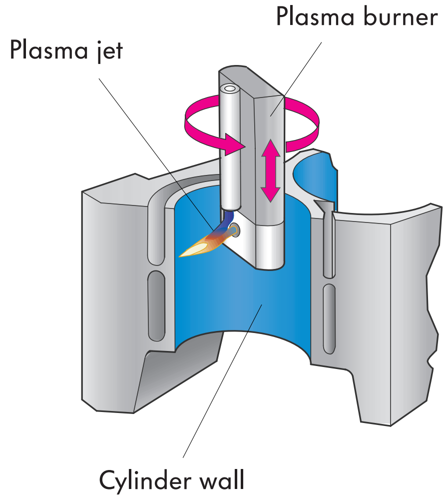
Cylinder walls with plasma-sprayed running film

For the first time for diesel engines, a plasma-sprayed running film is applied to the cylinder walls. As a result, the use of cylinder liners in the aluminium cylinder block is no longer necessary. This reduces the weight of the engine and permits compact dimensions due to a short distance between the cylinder bores.



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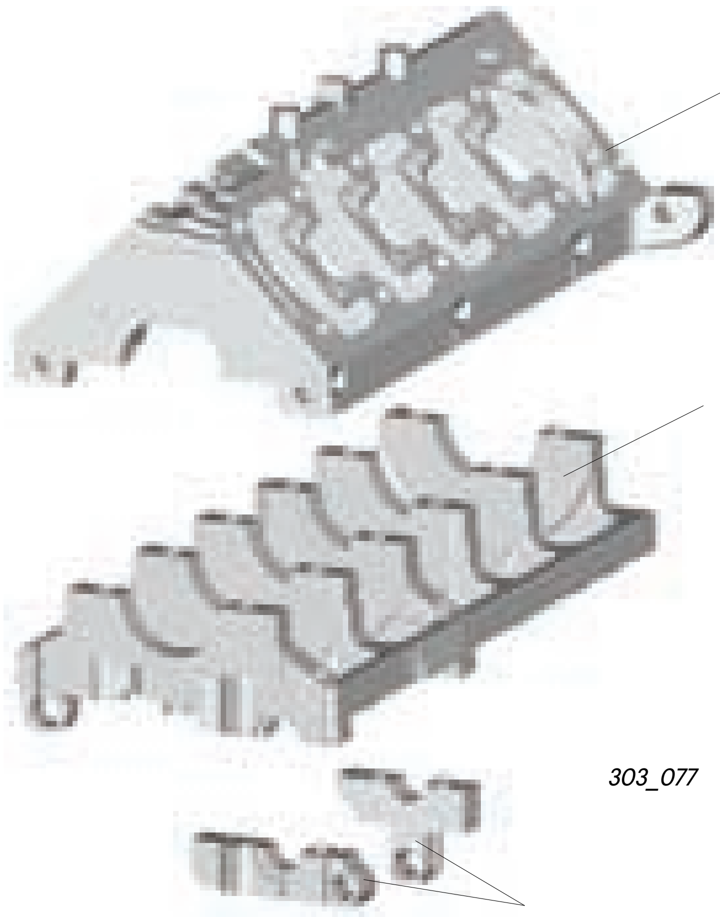
Detailled information regarding the plasma coating principle can be found in Self-Study Programme No. 252 ”The 1.4l/77 kW Engine with Direct Fuel Injection in the Lupo FSI”.

End bracket

The two-part end bracket is manufactured from high-tensile cast-iron.

The upper and lower portions of the end bracket are attached by a press fit; in addition, they are screwed together. This provides the crankshaft bearing with the required sturdiness, so that the high combustion forces can be safely absorbed in the end bracket area.



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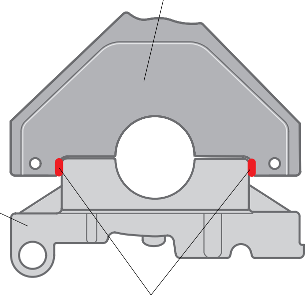

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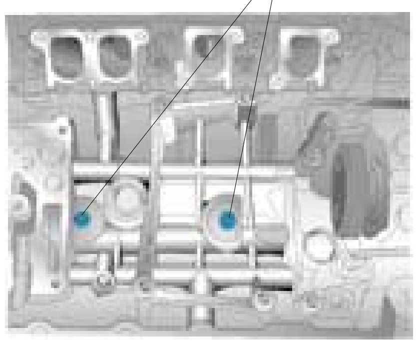

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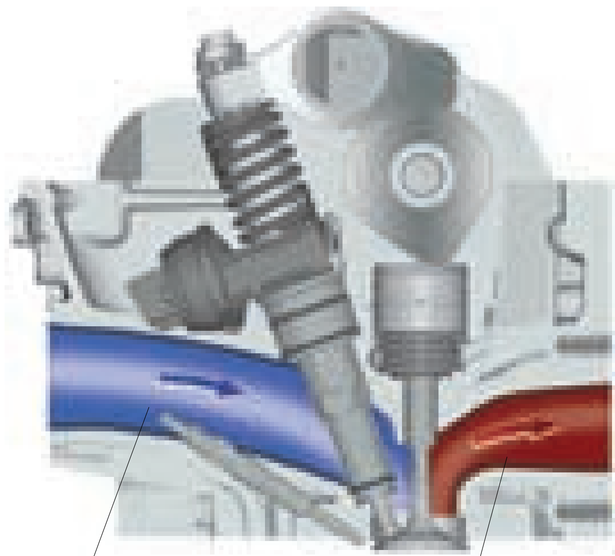
The bolted connection of the cylinder block with the upper portion of the end bracket must not be loosened; otherwise, the cylinder block could deform. Please observe the instructions in the repair guidelines.

Cylinder head

The V10-TDI engine has two aluminium-alloy cylinder heads. The inlet and outlet channels are arranged according to the crossflow principle. The inlet and outlet channels are located on the side opposite of the cylinder head. This arrangement provides good gas exchange and thus good cylinder filling. The inlet channels are located in the V space of the engine, while the outlet channels are on the engine exterior.



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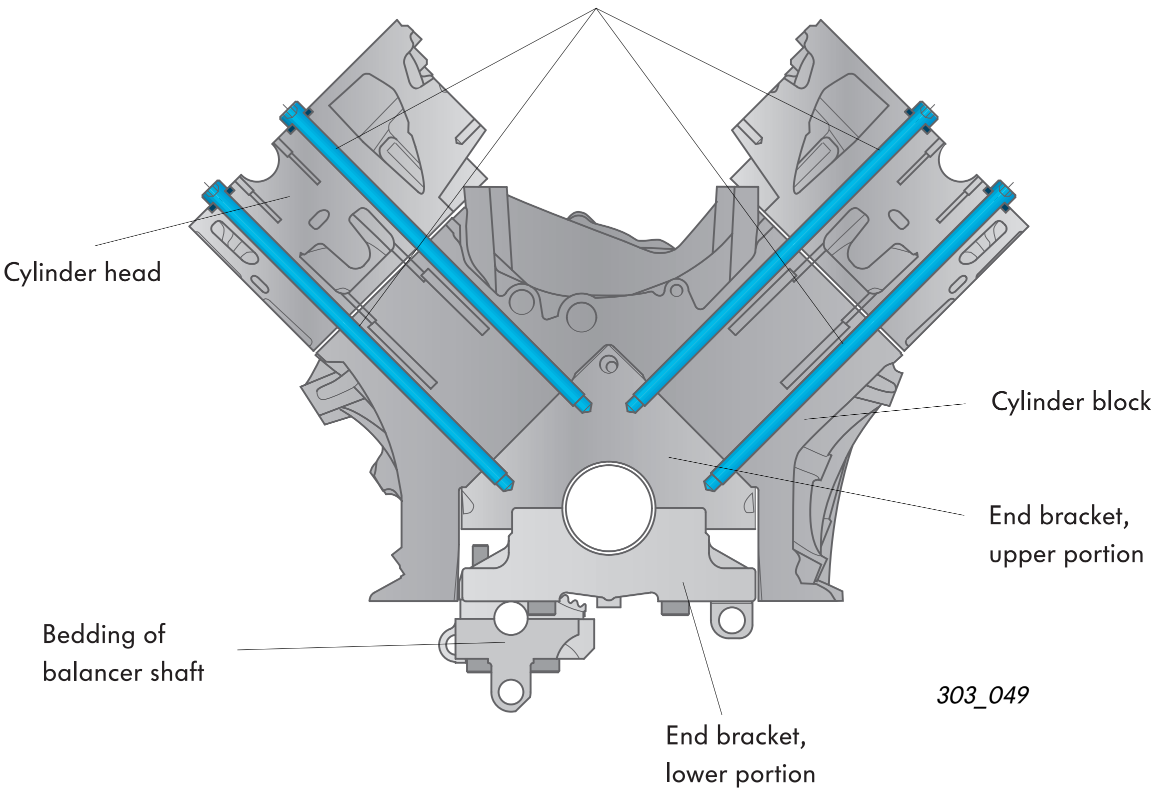
Tie rod principle

In order to prevent tension in the cylinder block, the cylinder heads, the cylinder block and the end bracket are screwed to each other using tie rods.



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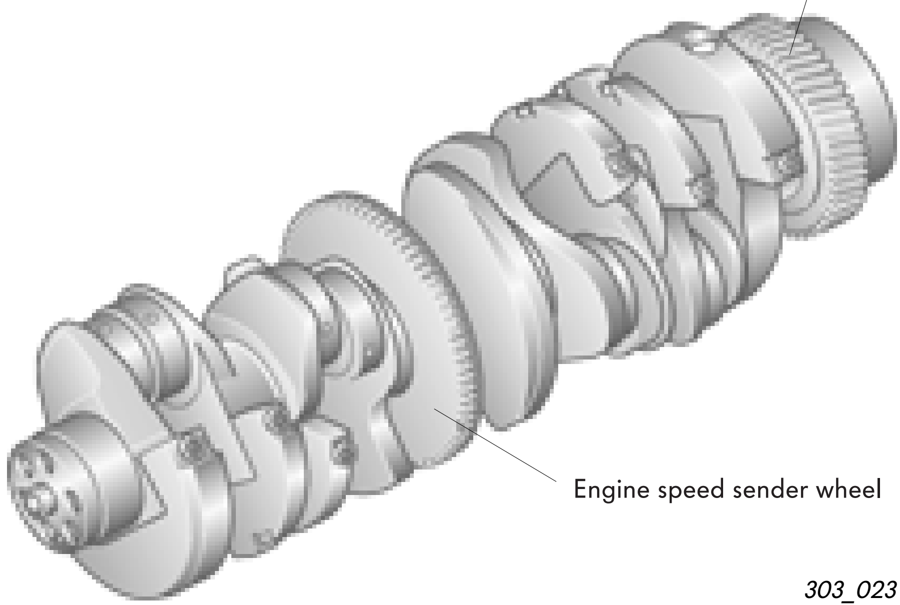
Crankshaft

The crankshaft of the V10-TDI engine is made of tempering steel. It is forged from one part. The drive wheel for the geared drive, the sender wheel for the engine speed sender and screwed-on counterweights are located on the crankshaft.



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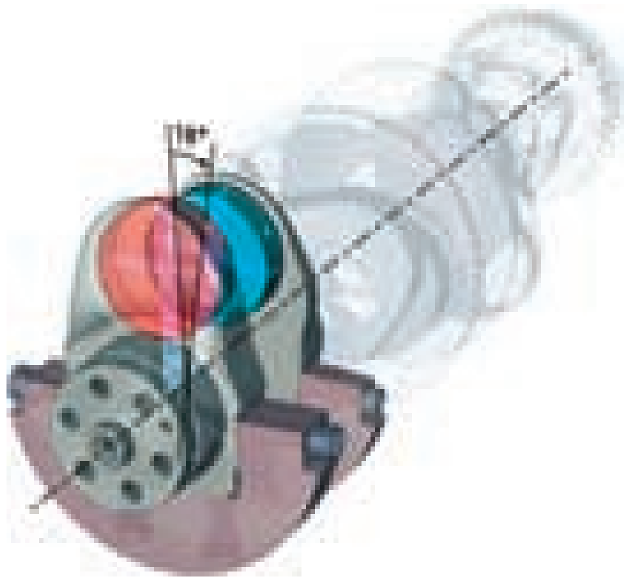
Split pin displacement

All the cylinders of a 4-stroke engine ignite within a crankshaft angle of 720°.
In order to attain uniform ignition, the ignition angle for a 10-cylinder engine must be 72°.

$$\frac{\textbf{720° crankshaft angle}}{\textbf{10 cylinders}} = \textbf{72° ignition angle}$$

A 10-cylinder V-engine must therefore have a V-angle of 72°.
Since the V10-TDI engine has a V-angle of 90°, the split pin must be displaced by 18° in order to attain uniform ignition.



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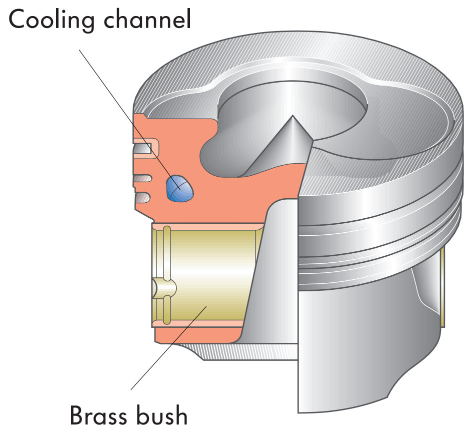
90° V-angle - 72° ignition angle = 18° split pin displacement

Engine mechanics

Piston and connecting rods

In order keep the demands on the piston and connecting rods low at the high combustion pressures, the piston pin bosses and the connecting rod boss have a trapezoidal shape. This distributes the combustion forces over a broader area. The piston pin bosses are also strengthened by brass bushes.

A cooling channel is infused into the piston to cool the piston ring zone. Oil is injected into this cooling channel from the oil-spraying jets as soon as the piston is located in the bottom dead centre.



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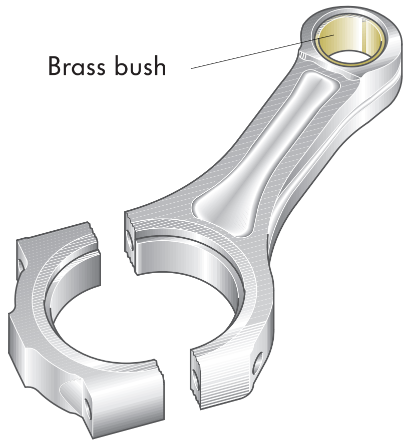
Connecting rod

The connecting rod and the connecting rod lid are separated diagonally; they are separated by the crack procedure.



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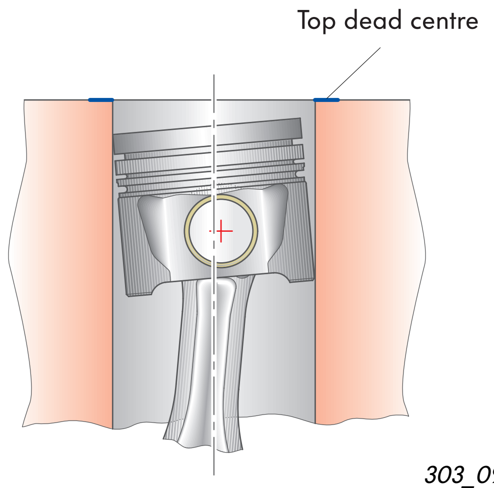
Displacement of the piston pin axis

The piston pin axis is decentrally arranged in order to prevent noise from the tilting of the piston in the top dead centre.

Each time that the connecting rod is in a sloping position, lateral piston forces occur which alternatingly press the piston against the cylinder walls.
The lateral piston force changes direction in the top dead centre. The piston is tilted to the opposite cylinder wall there, thus resulting in noise.
To prevent this, the piston pin axis is decentrally arranged.
Due to the decentral arrangement of the piston pin axis, the piston changes sides before it reaches the top dead centre and then supports itself on the opposite cylinder wall.



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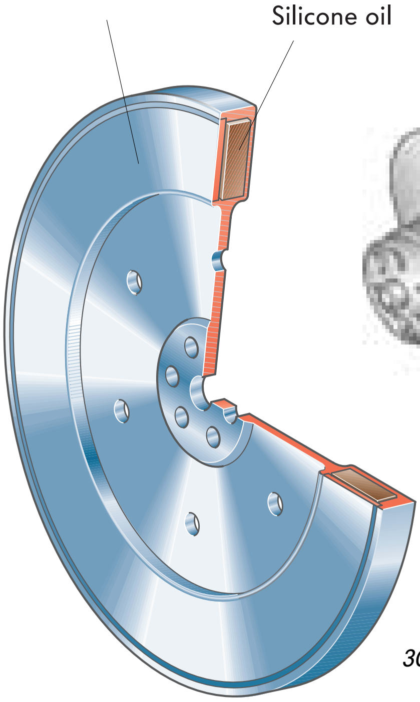
Mass balancing

In order to attain low-vibration running of the engine, the moments of inertia must be balanced.

For this, 6 counterweights are attached to the chrankshaft. In addition, a counter-rotating balancing shaft and a weight located in the drive wheel of the balancing shaft eliminate the moments of inertia. The balancing shaft is driven by the chrankshaft; at the same time, it serves as a driveshaft for the oil pump.

The counterweights are made of a tungsten alloy. As tungsten has a high density, the weights can have small sizes, which saves space.



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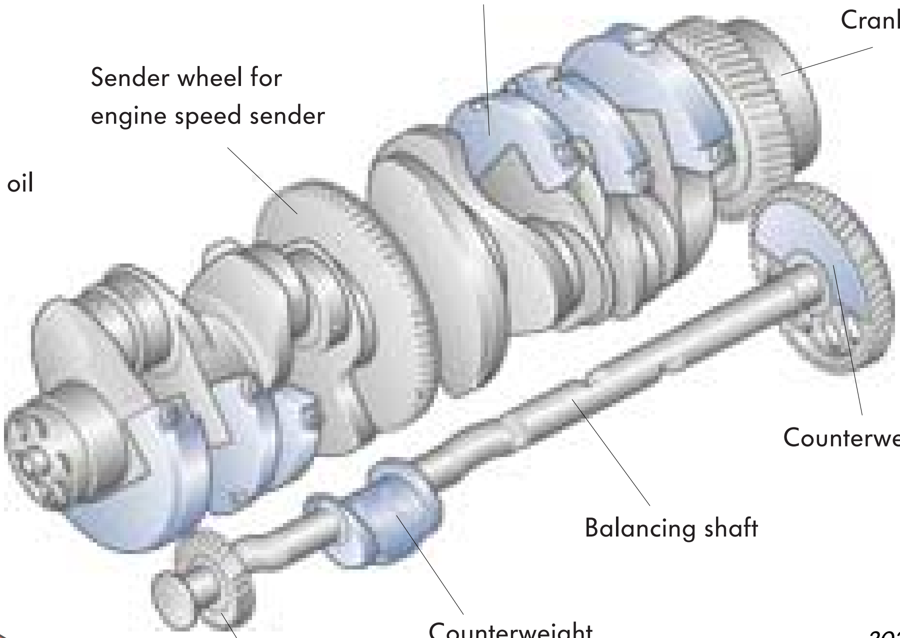

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Vibration damper

The vibration damper reduces the rotational vibrations of the crankshaft. It is filled with a silicone oil.

The rotational vibrations of the crankshaft that occur are eliminated by the shear forces of the silicone oil.

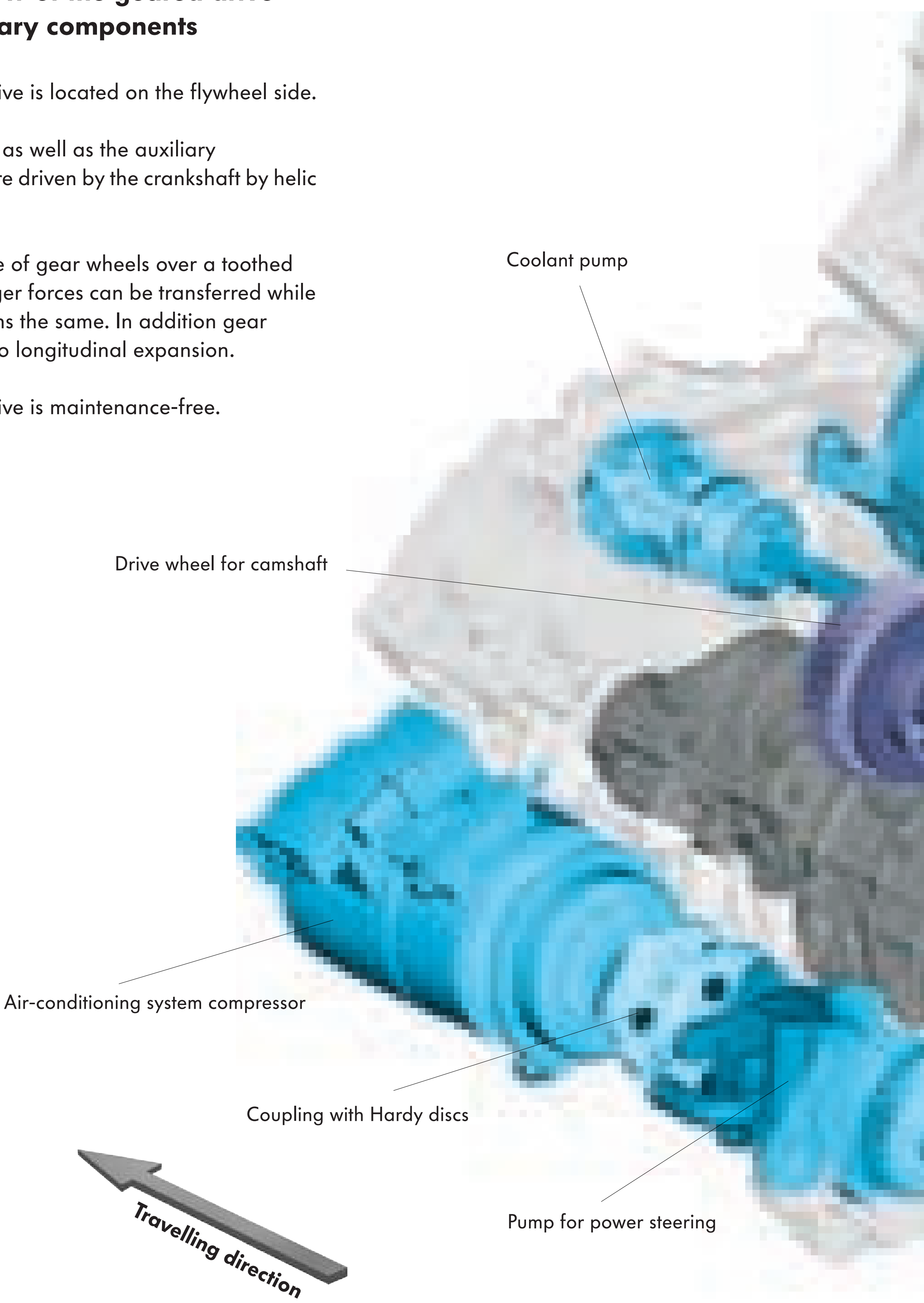
Overall view of the geared drive with auxiliary components

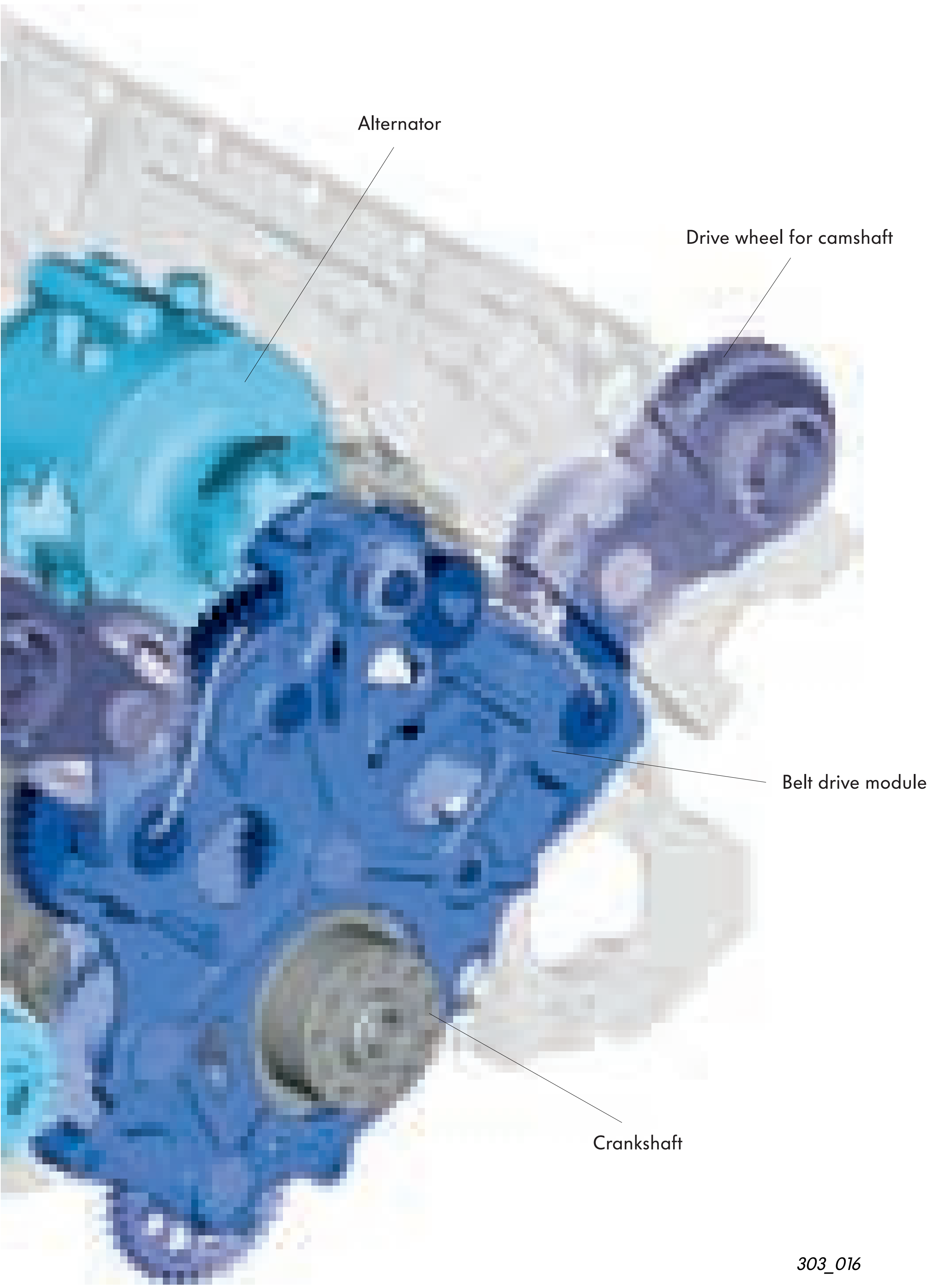
The geared drive is located on the flywheel side.

The camshafts as well as the auxiliary components are driven by the crankshaft by helic gear wheels.

The advantage of gear wheels over a toothed belt is that larger forces can be transferred while the size remains the same. In addition gear wheels have no longitudinal expansion.

The geared drive is maintenance-free.




Alternator
Drive wheel for camshaft
Belt drive module
Crankshaft

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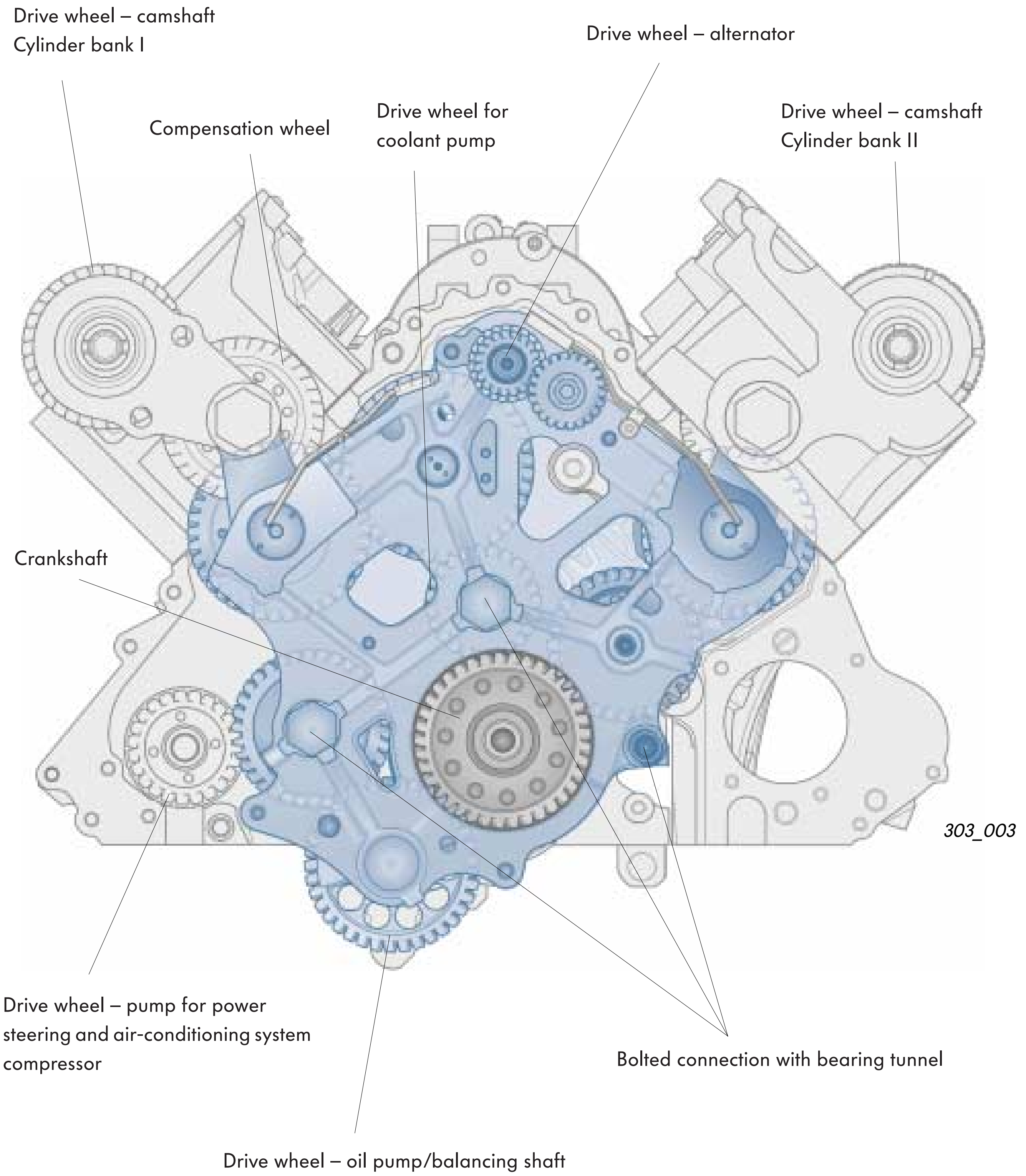
Geared drive assembly

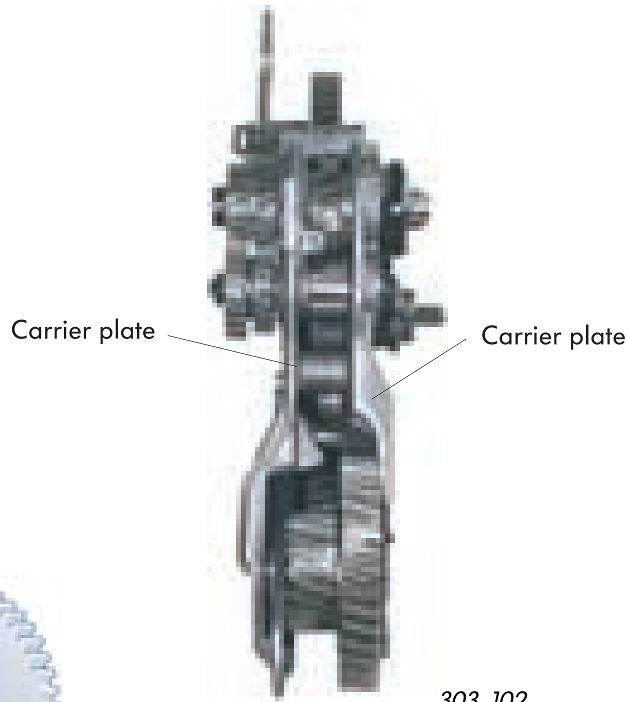


Belt drive module

The belt drive module is a component in which helic gear wheels are positioned between two carrier plates.

To ensure that all components of the belt drive module expand uniformly when exposed to heat and, as a result, to ensure that the face play is the same in all operating states, the carrier plates of the belt drive module are manufactured from tempered cast-iron.
The belt drive module is connected by three screws to the bearing tunnel, which is also manufactured from cast-iron.

The gearwheels are made of steel. They have a helix angle of 15°; as a result, two tooth pairs are always meshing. In comparison to spur-toothed gearwheels, larger forces can be transferred, thus providing a high smoothness of running.



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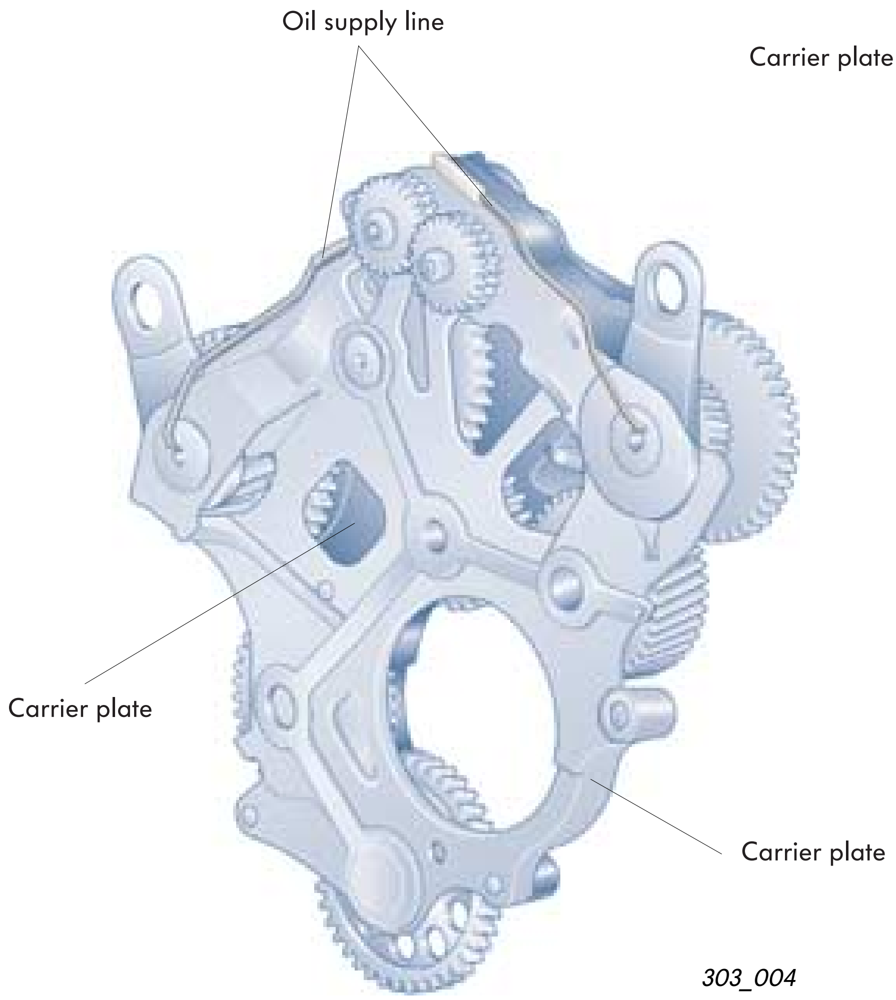

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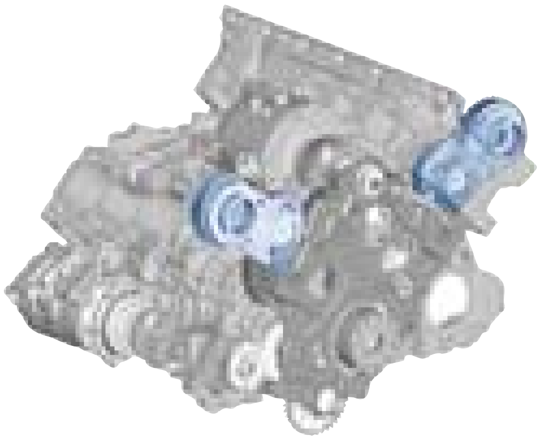
Engine mechanics

Shackle joint

The drive wheels of the camshafts are connected to the geared drive by a shackle joint.
The camshafts are located in the aluminium cylinder head. The carrier plates of the belt drive module are made of cast iron.

As aluminium expands further when exposed to heat than does cast iron, the face play of the gearwheels must be compensated. For this purpose, a compensation wheel is positioned in a shackle joint between the camshaft wheel and the drive wheel of the belt drive module.



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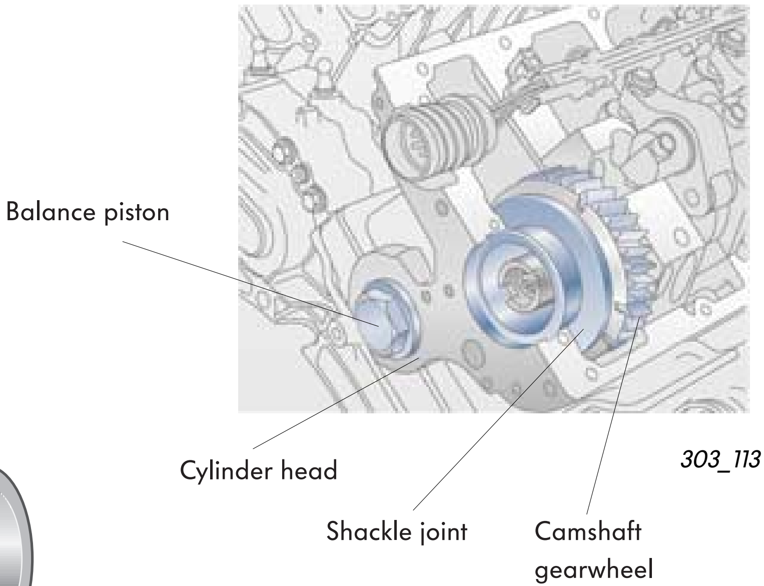

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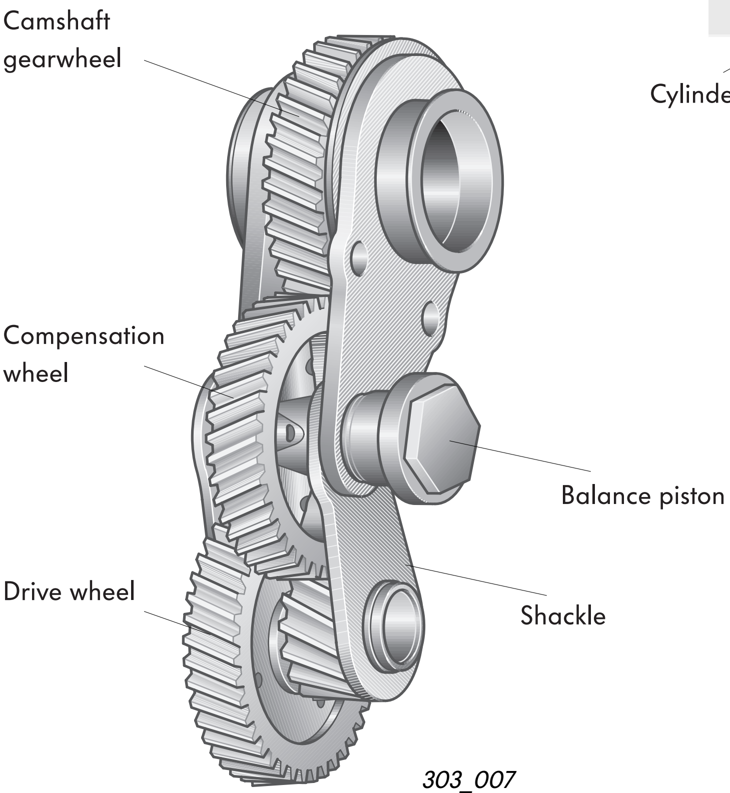

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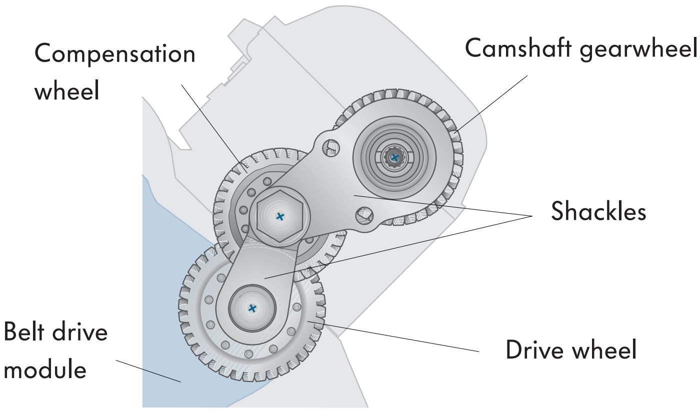
How it works

When subjected to heat, the axle spacing of the camshaft to the belt drive module changes.

The compensation wheel in the shackle joint follows the joint movement; the face play between the wheels within the shackle joint remains equal.

Setting for **"Cold engine"**



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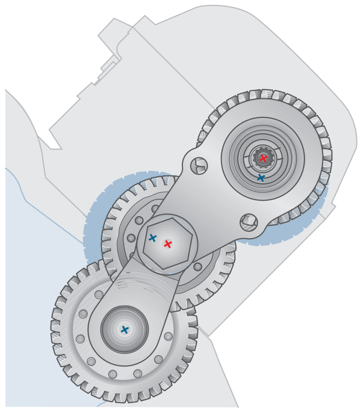
Setting for **"Warm engine"**



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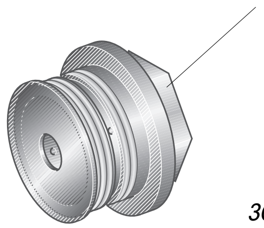
Balance piston

The shackles of the shackle joint are tensioned by a balance piston. The piston consists of a sleeve in which several spring washers are arranged behind one another and are axially tensioned.

The balance piston is screwed into the cylinder head; using a full floating axle, it tensions the two shackle joints. This prevents "dangling movements" of the shackle joint.



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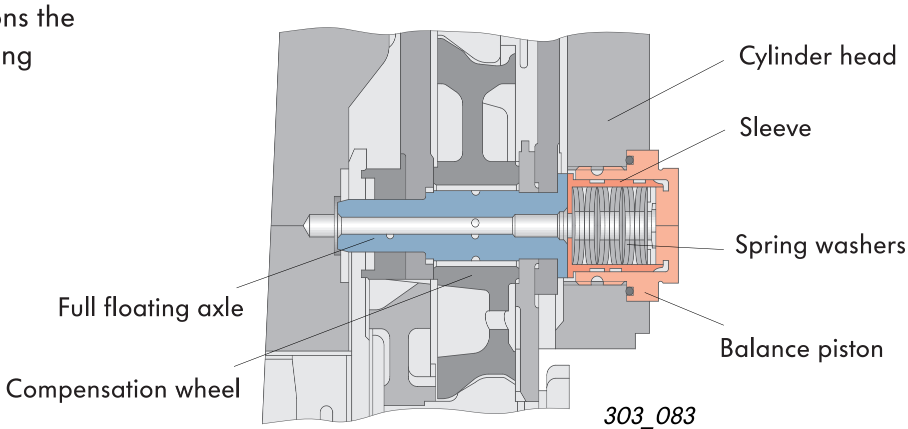

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Engine mechanics

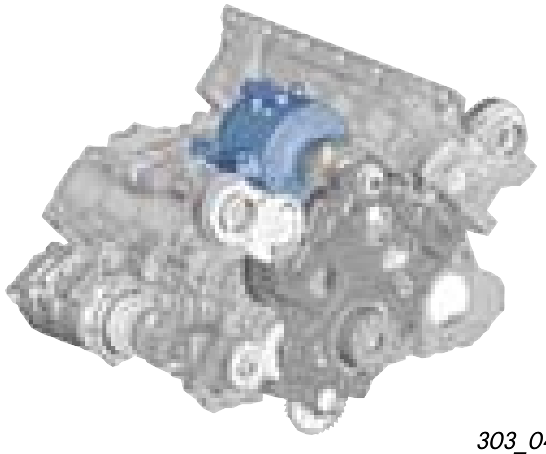
Alternator

The alternator is arranged in a space-saving manner in the V-space of the engine.

It is driven by a geared drive via a transmission shaft and a Hardy disc of the geared drive. Due to the transmission shaft, the alternator speed increases by a factor of 3.6 compared to the engine speed.

This provides an increased alternator performance that can cover high power demands of the vehicle electrical system even when idling.

The alternator is liquid-cooled.



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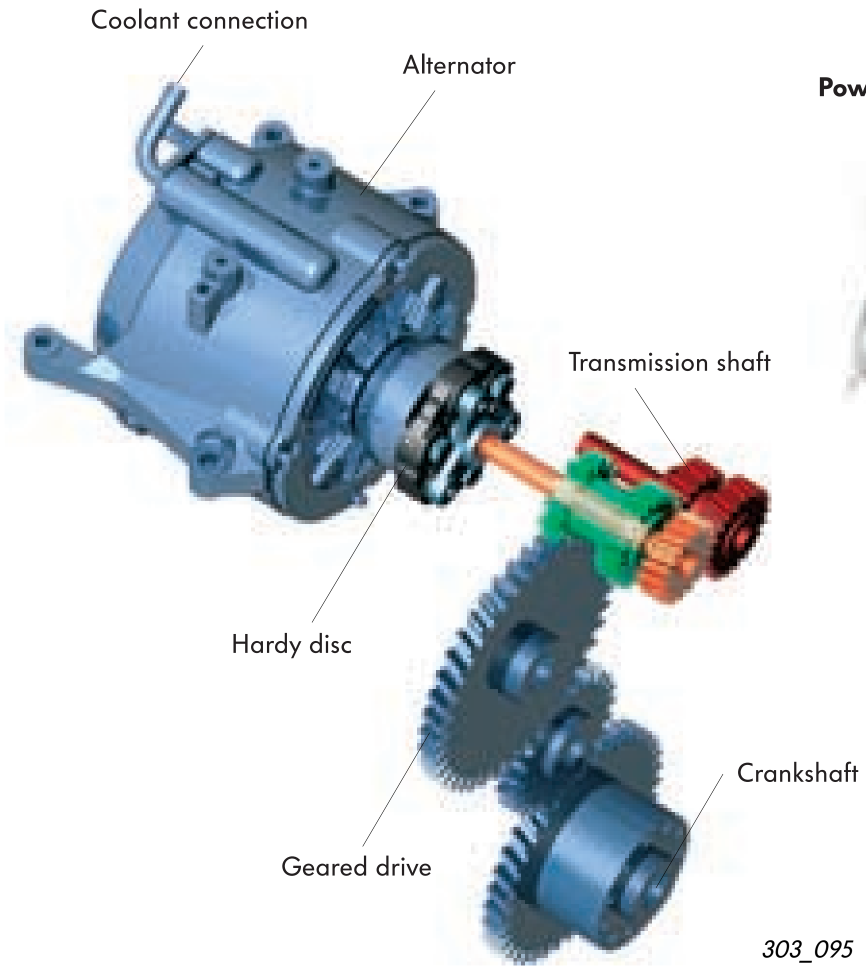

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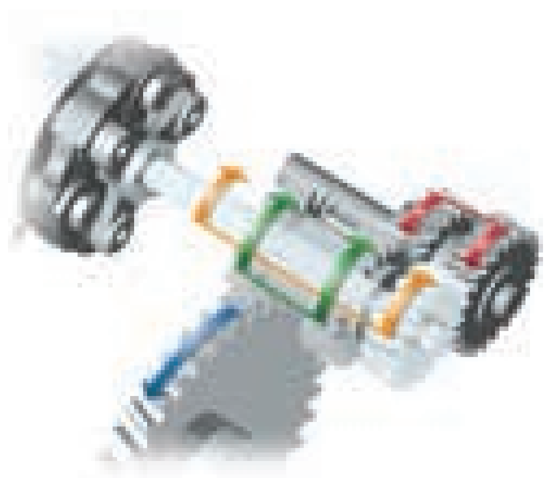
Power flow



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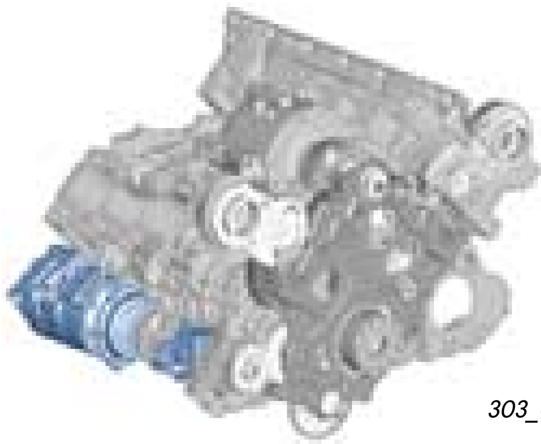
Power steering pump/air-conditioning system compressor

The power steering pump and the air-conditioning system compressor are arranged in a row on the engine block. The power steering pump is driven directly by the geared drive. The air-conditioning system compressor is driven by the shared drive axis and two Hardy discs that are arranged in a row.

The overload protection of the air-conditioning system compressor is implemented by a shaped rubber element.



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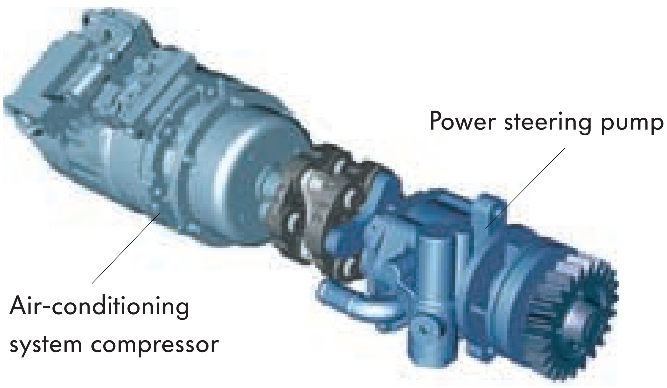
Further information regarding the externally controlled air-conditioning system compressor can be found in Self-Study Programme No. 301 ”The Phaeton – Heating/Air-Conditioning System”



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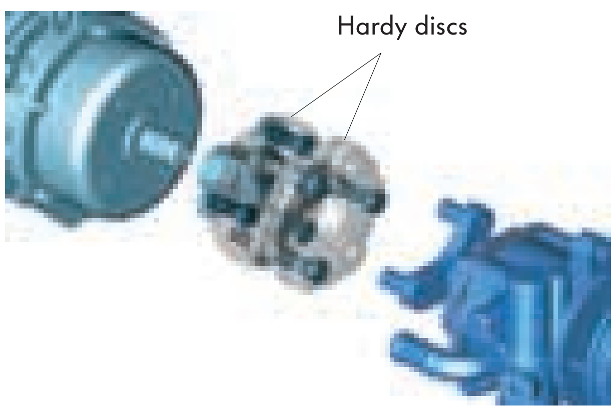
The Hardy disc consists of a rubber body with integrated steel sleeves. It has the advantage that, due to its material elasticity, it permits small bending angles of the rotary axles and compensates for small changes in length between the connecting flanges. In addition, it has a vibration-dampening effect on torque fluctuations.



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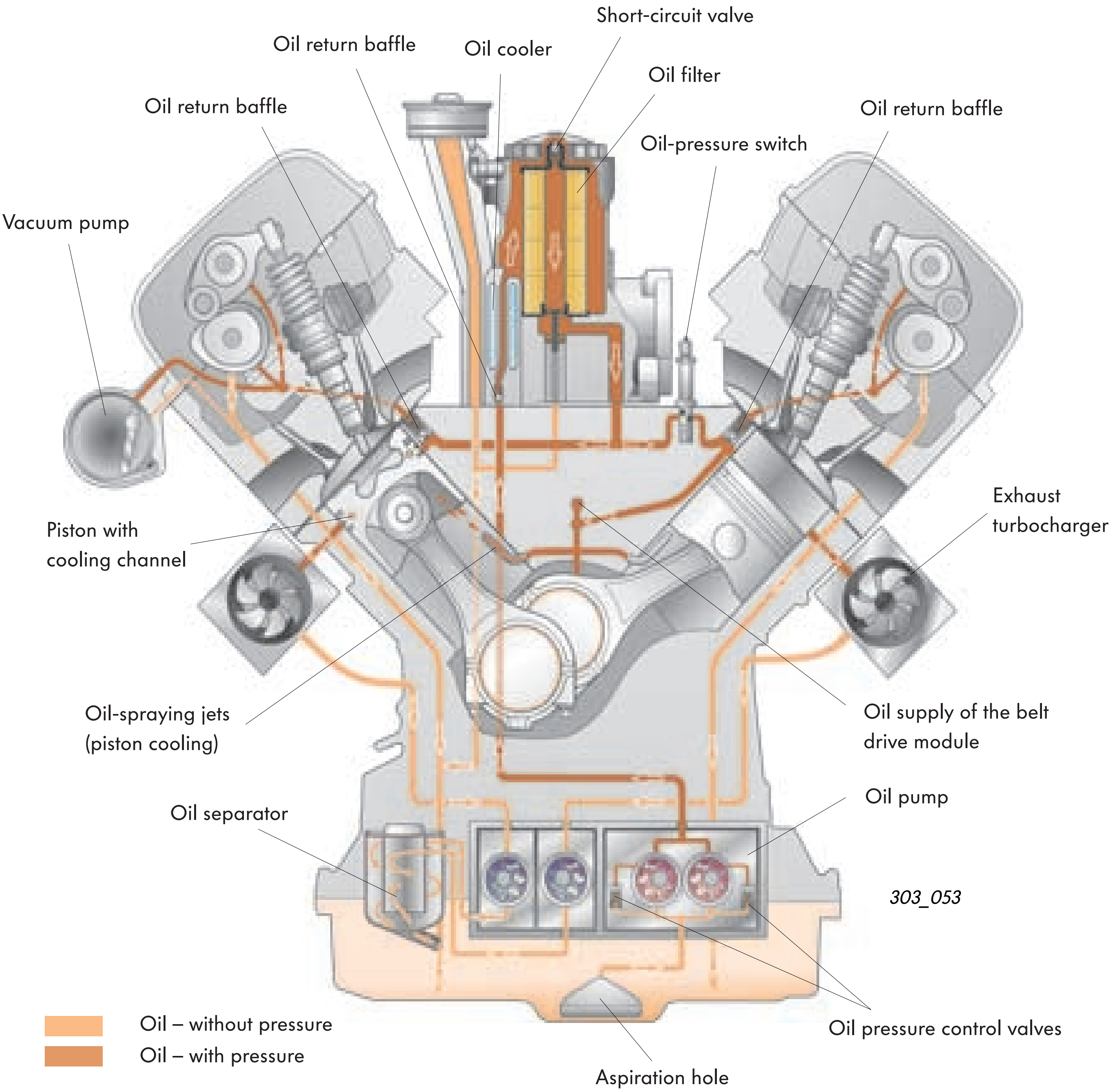
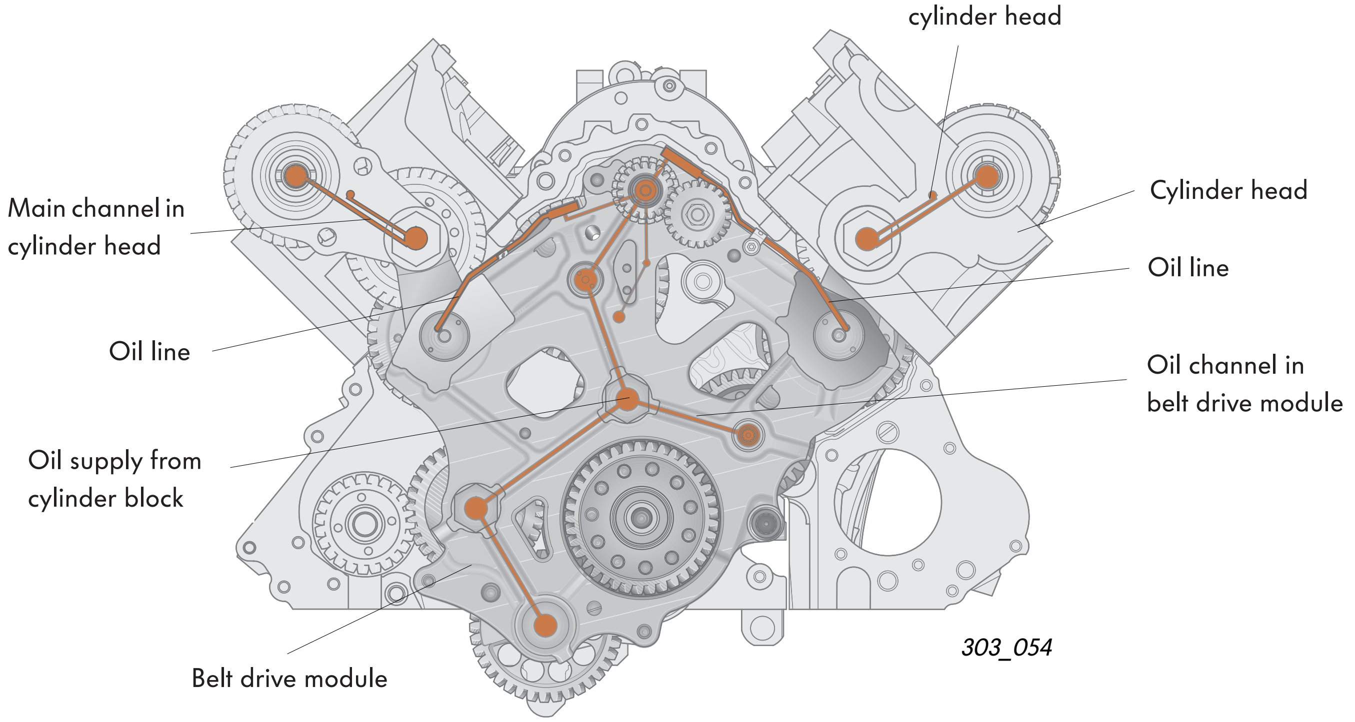
Oil circulation



The **oil pressure control valves** control the oil pressure of the engine. They open as soon as the oil pressure reaches the maximum permitted value.
The **oil return baffles** prevent oil from flowing back out of the cylinder head and the oil filter housing into the oil pan when the engine is at a standstill.

The **short-circuit valve** opens when the oil filter is occluded, thus ensuring the oil supply to the engine.

Oil supply in belt drive module



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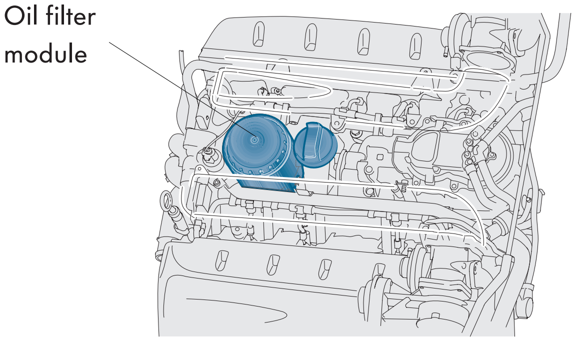
Oil filter module

The oil filter module is located in a space-saving manner in the V-space of the engine. The oil filters, the oil filler neck and the oil cooler are integrated in the oil filter module.



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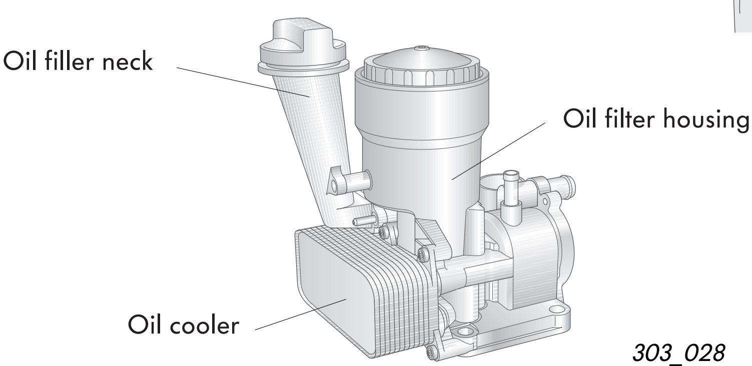

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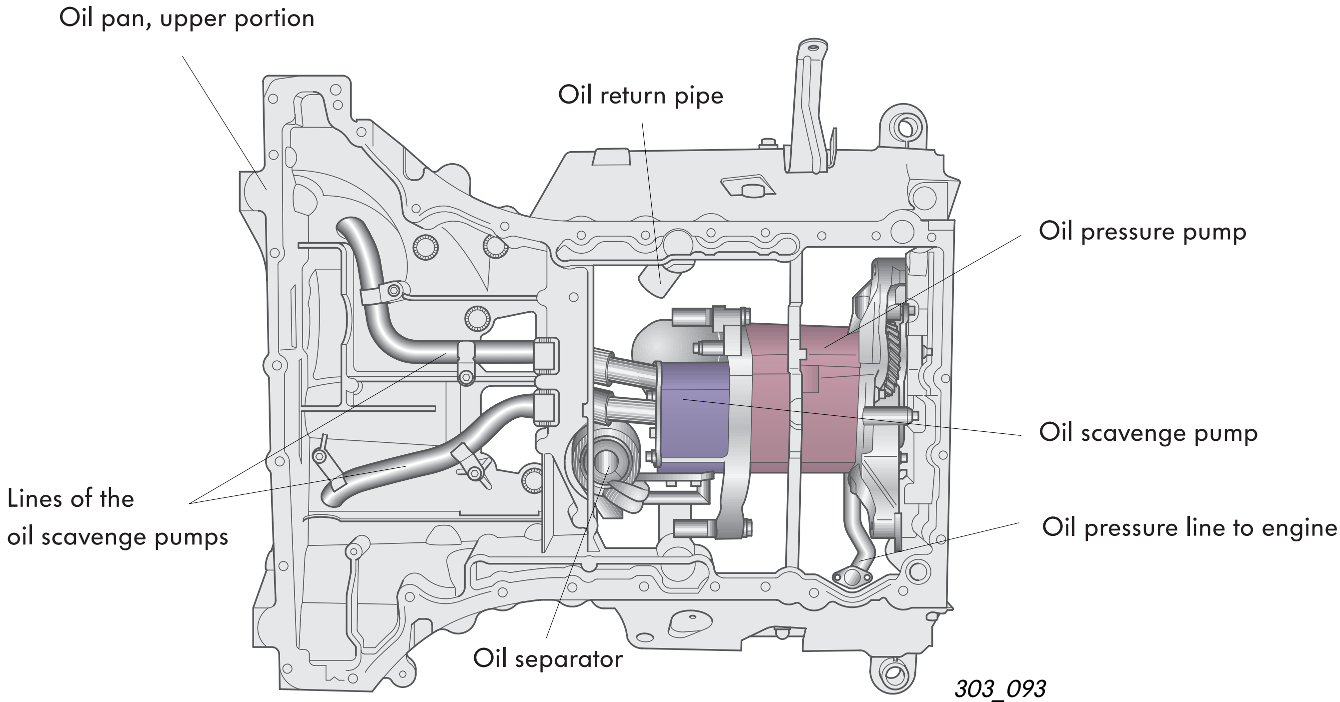
Oil pump

The oil pump is located on the engine face in the oil sump of the oil pan. It has four pairs of toothed wheels, working according to the duocentric principle. Two of these are oil pressure pumps that generate the oil pressure that is required for the oil circulation.

The other two are oil scavenge pumps that suction the oil out of the areas of the exhaust turbocharger oil returns, ensuring that there is a sufficient amount of oil in the oil filler neck in every operating state.

The oil pump is driven by the geared drive via the balancer shaft.



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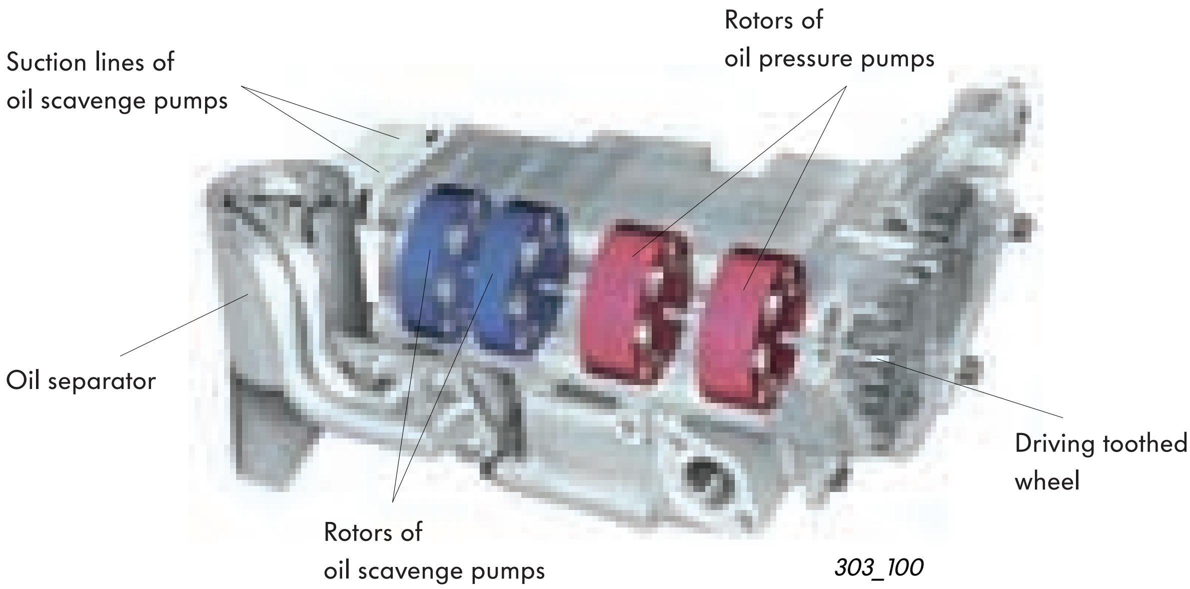

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