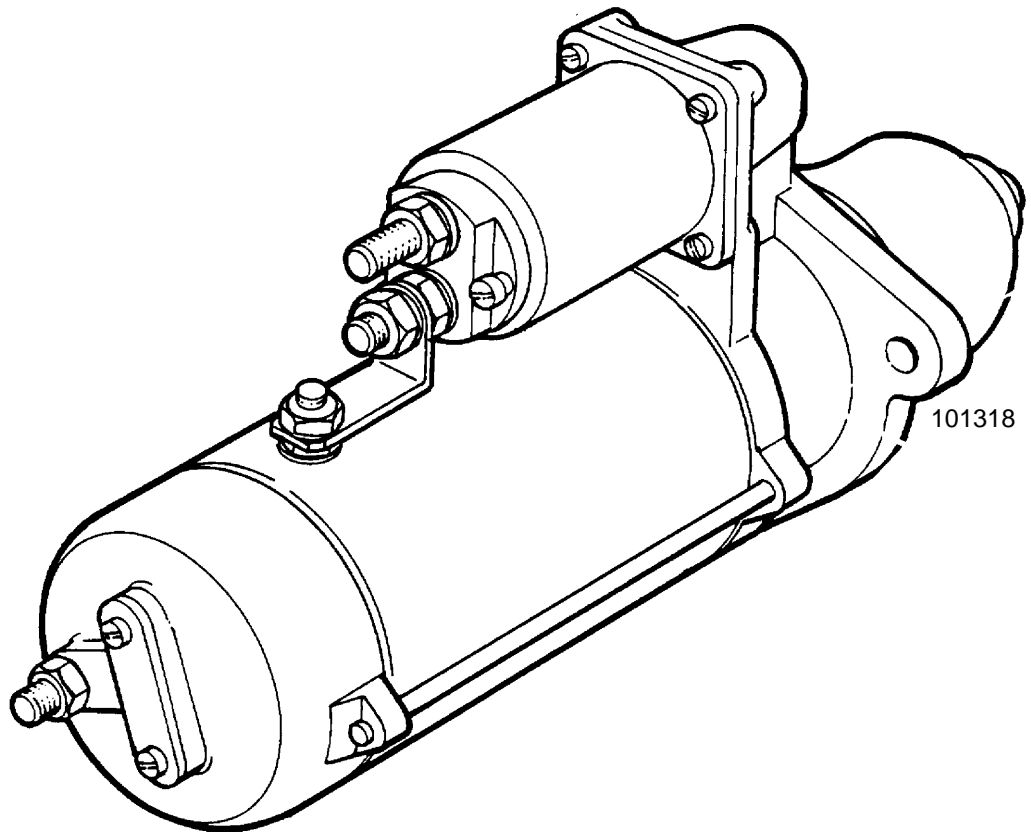


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Issue 1 en

Starter motor



Description of operation
Work description

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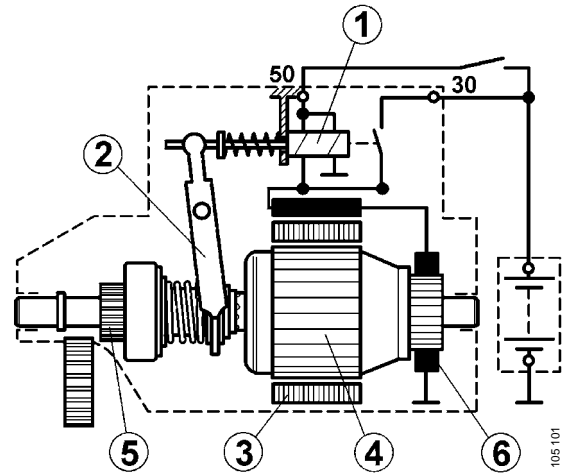
Work description

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System description

Constituent parts

- 1 Solenoid switch
- 2 Actuating arm
- 3 Field windings and pole shoes
- 4 Rotor and commutator
- 5 Starter pinion
- 6 Brush holder and four brushes



Activation

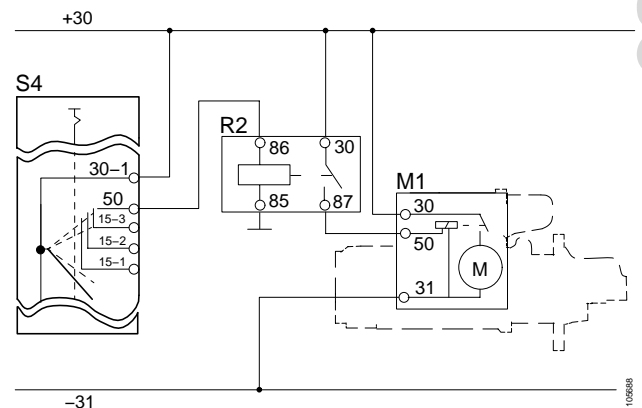
The starter motor is activated partly via the control voltage (50 volts) and partly via the battery supply (30 volts).

The 50 V voltage is activated via a relay. Precisely how the relay is activated differs from one vehicle to another depending on its equipment.

When the 50 V voltage is activated, the solenoid switch in the starter motor is charged. When it is cut, the solenoid switch returns to its currentless state.

The 30 V voltage is fed direct from the battery and alternator.

Circuit diagram



S4 Starter lock

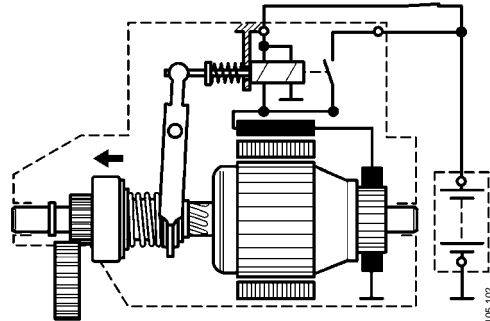
R2 Starter relay

M1 Starter motor

Starting - a brief description

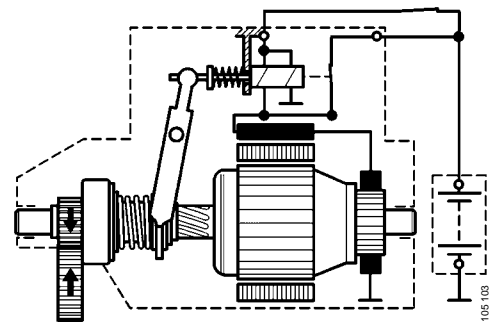
The starter motor and solenoid switch are integrated into a single unit.

- 1 When the solenoid switch is activated, it utilizes a control lever to pull the starter pinion into the ring gear of the diesel engine. The starter pinion can be pushed on to the rotor shaft of the electric motor.

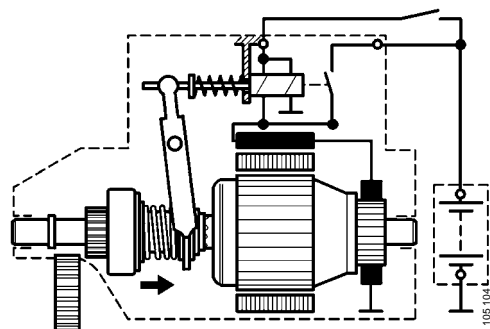


- 2 When the pinion has meshed with the ring gear of the diesel engine, a pair of connectors in the solenoid switch is connected and powers the electric motor.

- Bosch JF: The electric motor receives full power as soon as the pair of connectors is connected. The starter pinion does not need to have meshed with the ring gear for the rotor to start.



- 3 When the diesel engine has started, the starter pinion will, via a freewheel device, prevent it from running the starter motor at too high and damaging a speed. The starter pinion remains meshed with the ring gear until the voltage supply to the solenoid switch is terminated. It is returned into position by a return spring in the solenoid switch which breaks the power supply to the starter motor.

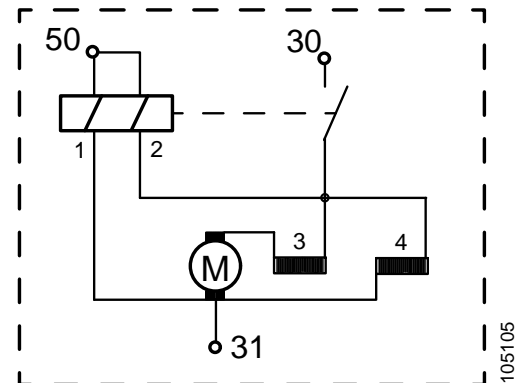


Bosch JE

Meshing with the ring gear

The starter pinion and idling gear are spring-loaded. When the starter pinion touches a tooth of the ring gear, the spring recoils and the starter pinion turns around the helical splines. When the starter pinion reaches a tooth space, the pinion is pushed into mesh and the starter motor begins to run.

Internal connection



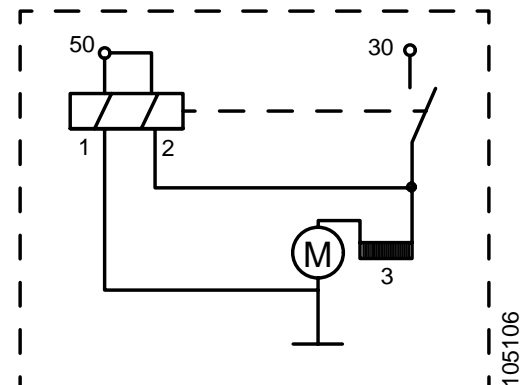
1) Holding winding, 2) Pull-in winding, 3) (Series) field winding, 4) (Shunt) field winding, 30) Battery+, 31) Earth, 50) Control voltage

Bosch JF

Meshing with the ring gear

The starter pinion and idling gear are spring-loaded. When the starter pinion touches a tooth of the ring gear, the spring recoils and the starter motor turns the starter pinion into mesh at full force. When the starter pinion reaches a tooth space, the pinion is pushed into mesh by the spring.

Internal connection



1) Holding winding, 2) Pull-in winding, 3) (Series) field winding, 30) Battery+, 50) Control voltage

Bosch KB

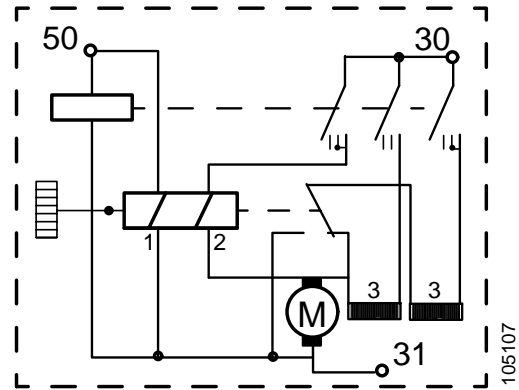
Starting

A starter motor of type Bosch KB does not have an exterior solenoid switch. Instead, the centre shaft is equipped with a stem for the rotor which magnetizes and then moves the starter pinion into mesh.

Meshing with the ring gear

The starter motor turns the starter pinion slowly at low power until a tooth space is reached. At the same time, the built-in solenoid switch pushes the pinion towards the ring gear. When the starter pinion reaches a tooth space, the pinion is pushed into mesh and the starter motor begins to run at full power.

Internal connection



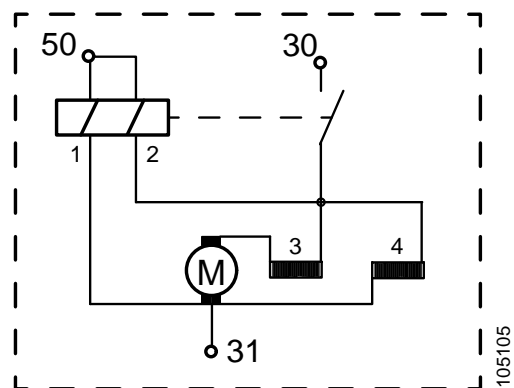
- 1) Holding winding, 2) Pull-in winding,
3) (Series) field winding, 30) Battery+,
31) Earth, 50) Control voltage

Valeo D13 HP

Meshing with the ring gear

The starter pinion and idling gear are spring-loaded. When the starter pinion touches a tooth of the ring gear, the spring recoils and the starter pinion turns around the helical splines. When the starter pinion reaches a tooth space, the pinion is pushed into mesh and the starter motor begins to run.

Internal connection



- 1) Holding winding, 2) Pull-in winding,
3) (Series) field winding, 4) (Shunt) field winding,
30) Battery+, 31) Earth, 50) Control voltage

Fault diagnosis

Starter motor circuit

Testing the insulation of the starter motor requires 80 V of voltage. As a result, an ordinary multimeter cannot be used.

Connecting the starter motor

1. The starter motor does not receive voltage when the starter key is turned.

Fault:

Starter relay R2 has not activated.

Cause:

The relay has not sensed that starter lock S4 has activated connection 86 of the relay.

Remarks:

Relay R2 should change to the starting position when the starter lock is in the 50 position (i.e., 50 volts to relay pin 86) and pin 85 on the relay is earthed (31).

- Trucks with VPS: The relay's earth is controlled via control unit E7.
- Buses: Relay R2 is activated via R505 which is controlled in part by the alternator passing voltage D+.

Remedial measures:

Check the wiring and connectors of the starter motor, and the connecting pins of the starter relay.

2. The solenoid switch activates but the starter pinion doesn't mesh.

Fault 1:

The starter pinion is caught on the shaft.

- Bosch JF: The starter motor "spins".
- Bosch KB: The starter motor "rotates".

Cause:

The 50 V voltage may have been too low. Rust on the shaft of the starter pinion may have caused such a high level of friction that the pinion was unable to move. The solenoid switch may have overheated. The actuating arm may have slipped, snapped or lost its securing bolt.

Remarks:

The fault may lead to damage in the ring gear.

Remedial measures:

Allow 5 minutes for the solenoid switch to cool. Check the 50 V voltage. Remove the starter motor if necessary and check that the starter pinion can move along the shaft without jamming. If the shaft is rusty, lubricate and clean it. Check the starter pinion and the ring gear for signs of damage. Replace the starter motor and/or the ring gear if necessary. Examine the actuating arm.

Fault 2:

The starter pinion can't find a tooth space.

Cause:

The 50 V voltage may be too low, the starter motor fitting may be broken or the solenoid switch may have overheated.

Remarks:

Look up the starter motor in question under "Meshing with the ring gear" in the Work description.

Remedial measures:

Allow 5 minutes for the solenoid switch to cool. Check the 50 V voltage. Make sure that the starter pinion fitting can move.

3. The starter motor meshes but doesn't turn.

Fault:

The starter motor is not receiving 30 V of voltage.

Cause:

A break in the starter motor or the voltage supply.

Remarks:

The fault is either in the starter motor or in the earth or battery+ connections.

Remedial measures:

Check connections 30 and 31 on the starter motor. Examine the connectors in the brush holder, and check the brushes and commutator for wear. Replace the brushes if necessary.

Disconnecting the starter motor

1. The solenoid switch doesn't switch off when the starter key has been released.

Fault 1:

The starter relay has not deactivated.

Cause:

The relay has not sensed that starter lock S2 has deactivated its 86 connection, or, the relay is defective.

Remarks:

The relay should remain at the starting position as long as the starter lock is in the 50 position (i.e., 50 V voltage to relay pin 86).

Remedial measures:

Check the starter relay.

Pin 86 should only receive voltage when the starter key is in the starting position (50 V). Pins 30 and 87 should only be in contact when pin 86 is active.

Fault 2:

The 50 V supply switches the starter motor off but the solenoid switch does not return to its "Off" (without load) position.

Cause:

The return spring in the solenoid switch is fatigued or out of position.

Remarks:

The spring compression required to return the starter pinion to position is insufficient or lacking.

Remedial measures:

Examine the spring and replace if necessary the solenoid switch.

2. The starter motor continues to run even after the starter key has been released.

Fault:

The rotor is still receiving voltage.

Cause:

The 'make' contact to the rotor supply has been overloaded and has short-circuited in the solenoid switch. The pinion is jamming against the rotor shaft.

Remarks:

Damage to other parts of the starter motor will result. Try to find out the cause of overloading to prevent the fault from reoccurring.

Remedial measures:

Check that the pinion is not jamming against the rotor shaft. Replace the solenoid switch and 'make' contact. Take measures to remove the cause of overloading.

3. The starter pinion doesn't disengage when the engine starts even though the solenoid is deactivated.

Fault:

The solenoid no longer controls the starter pinion.

Cause:

The actuating arm may have slipped or snapped, or the bolt on the fork become broken. The pinion may have jammed against the shaft.

Remarks:

The fault will soon lead to serious damage in the starter motor. Excessive motor speed should cease as soon as the starter key has been released.

Remedial measures:

Check that the starter pinion has not jammed against the rotor shaft, and that the actuating arm is functioning correctly.

Noise

1. The sound emitted by the starter motor is not as it should be.

Fault:

Damage has occurred to the bearings of the rotor or starter pinion, or the teeth of the pinion or ring gear.

Cause:

Damage to the surfaces of the bearings has caused excessive friction. The teeth of the pinion or ring gear have sustained damage due to the starter motor being activated when the diesel engine was running.

- Bosch JF: The teeth of the pinion or ring gear have been damaged by the pinion jamming against the shaft.

Remarks:

One or more bearings have been damaged by wear or dirt.

Remedial measures:

Replace the starter motor. Examine the ring gear and replace if necessary.

- Bosch JF: Check that the pinion has not jammed against the shaft. Clean and lubricate if necessary.

Performance

1. The starter motor is "weak".

Fault:

The starter motor does not attain a speed that is sufficient to start the diesel engine.

Cause:

The 30 V voltage is too low or the connection to the starter motor is poor.

Remarks:

The power to the starter motor must be at least 18 V to activate the solenoid switch. Resistance in the 30 V cable should be less than 0.003 ohm.

Remedial measures:

Check the condition of the battery and the level of resistance in the 30 V cable. Make sure that the connectors in the starter motor are not burnt.

Work description

Starter motor

Removal (all types)

- 1 Switch off the power supply to the vehicle using the battery master switch or by detaching the battery terminals.
- 2 Remove any noise insulation covers.
- 3 On certain types of starter motor: Detach the screws to earth braid (31).
- 4 Detach the cable to positive cable (30) and control cable (50).
- 5 Bend the cables to one side.
- 6 Detach the screws that hold the starter motor in the flywheel housing.



**Danger! The starter motor is very heavy.
Be careful!**

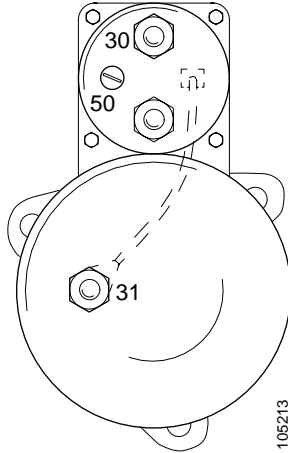
- 7 Remove carefully the starter motor.

IMPORTANT! Examine the starter pinion for damage. If there are signs of damage, the ring gear must also be examined. See Group 1, "Engine".

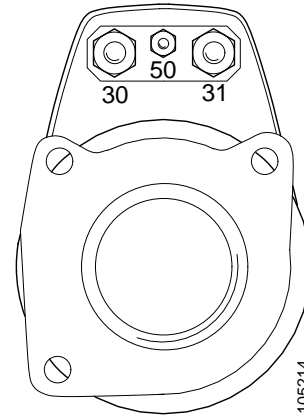
Refitting (all types)

Connections

Pole positions for Bosch JE/JF, Valeo D13 HP



Pole positions for Bosch KB



The conductor marked by broken lines shows the earthing for the solenoid switch in a 2-pole starter motor

Dimensions and torque

	Bosch JE	Bosch JF	Bosch KB	Valeo D13 HP
50 (control cable)	M6: 2.5 +/- 0.5 Nm	M4: 1.2 +/- 0.1 Nm	M6	M6: 3.5 +/- 0.5 Nm
30 (positive cable)	M12: 28 +/- 4 Nm	M10: 28 +/- 4 Nm	M10	M12: 23 +/- 3 Nm
31 (earth cable)	M10: 18 +/- 2 Nm	(M8 ¹)	M10	M10 15 +/- 3 Nm

1. Only on 2-pole starter motors. One-pole motors are ground-connected via the flywheel housing.

Description

- 1 Make sure that the power supply to the vehicle has been switched off.
- 2 Clean the surfaces surrounding the hole in the flywheel housing.
- 3 Place the starter motor in position and secure it to the flywheel housing.
 - Bosch JF in D9 engines: Check that the spacing washer is in place between the starter motor and the flywheel housing.
- 4 Clean the cable connections.
- 5 Connect the cables to the poles in the following order:
 - Control cable, 50
 - Battery +, 30
 - In certain types of starter motor: Earth, 31
- 6 Switch on the power supply to the vehicle and start the engine.
- 7 Remount the noise insulation covers.

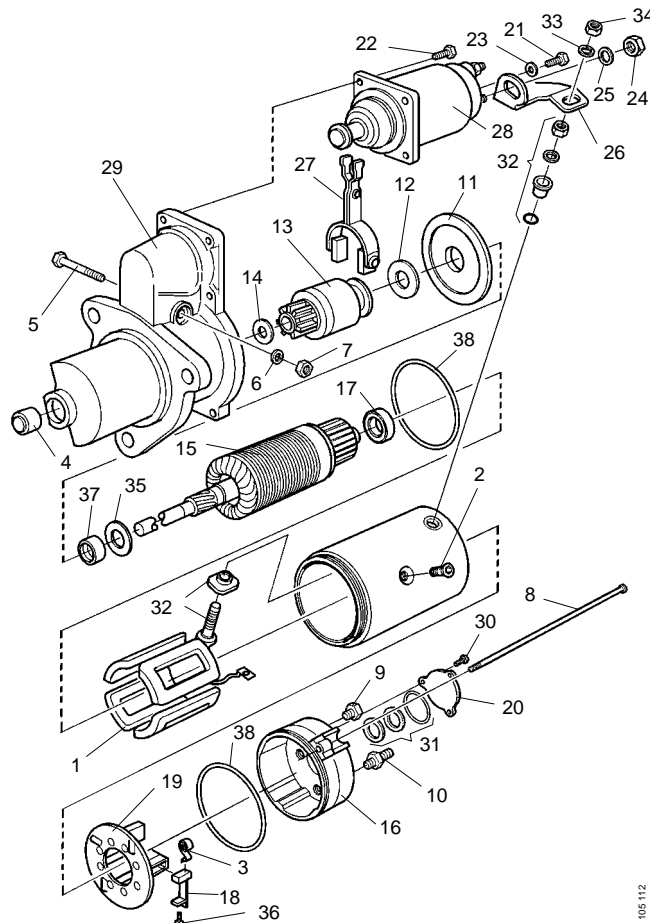
Bosch JE 6.7 kW

Assembly

Specifications

Power	6.7 kW
Rotational direction (as seen against the flywheel housing)	Counter-clockwise
Commutator, min. diameter	42.5 mm
Brushes, min. length	17.5 mm
Brushes, spring compression	47-53 N
Resistance in the pull-in winding	0.5 ohm
Resistance in the holding winding	2.5 ohm
Max. radial run-out in the rotor	0.10 mm
Max. radial run-out in the commutator	0.03 mm

Exploded view drawing



105 112

- 1 *Excitation winding*
- 2 *Screw*
- 3 *Compression spring*
- 4 *Bearing*
- 5 *Screw*
- 6 *Gasket*
- 7 *Nut*
- 8 *Stud*
- 9 *Screw*
- 10 *Screw*
- 11 *Bearing*
- 12 *Bearing washer*
- 13 *Idling gear*
- 14 *Washer*
- 15 *Rotor*
- 16 *Rear bearing shield*
- 17 *Bearing*
- 18 *Brush unit*
- 19 *Brush holder*
- 20 *Cover*
- 21 *Screw*
- 22 *Screw*
- 23 *Washer*
- 24 *Nut*
- 25 *Washer*
- 26 *Conductor*
- 27 *Actuating arm*
- 28 *Solenoid switch (solenoid)*
- 29 *Front bearing shield / nose*
- 30 *Screw*
- 31 *Spacing washers and gasket*
- 32 *Parts for mounting the conductor*
- 33 *Washer*
- 34 *Nut*
- 35 *Washer*
- 36 *Screw*
- 37 *Bearing*
- 38 *O-ring*

Bosch JE Brushes

Replacing

Dimensions

Brushes, min. length	17.5 mm
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Requisite equipment

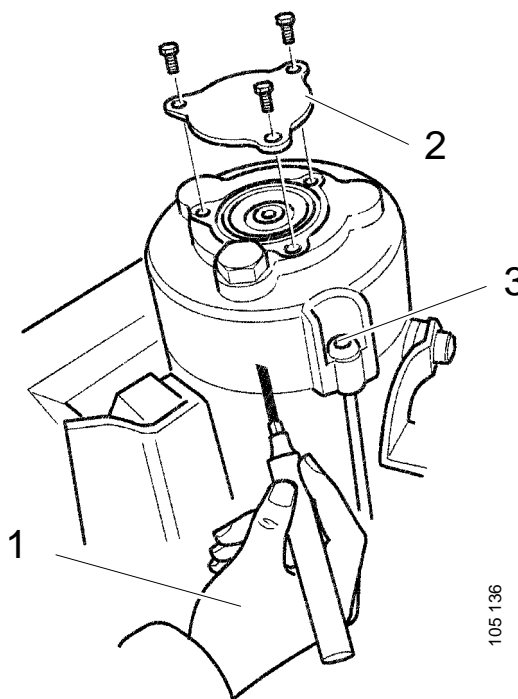
To replace the brushes and springs in a simple and effective way requires four spring locks. These can easily be made from thin plate cut into four pieces of approximately 20 x 40 mm.

Brush unit	Part No. 1 405 977
Brush springs	Part No. 1 405 976

Work description

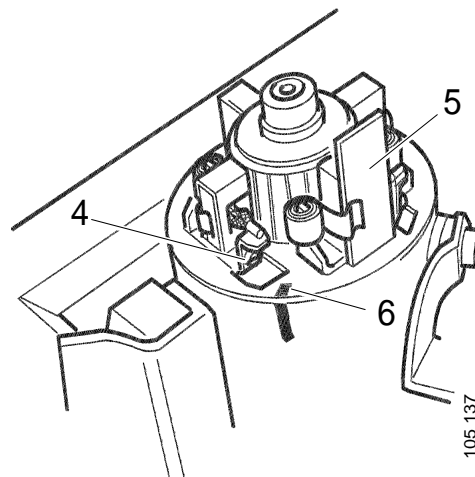
Before replacing the brushes, remove the starter motor (see "Removing the starter motor").

- 1 Mark the position of the rear bearing shield with a marking pen.
- 2 Remove the rear protection cover.
- 3 Detach the through screws and remove the rear bearing shield.

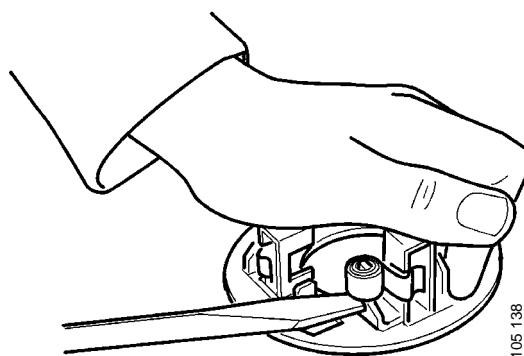


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- 4 Detach the screws of the brush connections.
- 5 Fit the spring locks to relieve the brushes of the spring compression.
- 6 Mark the position of the brush-holder plate against the pole housing and, having done so, remove it.
- 7 Examine the commutator for damage. Clean it and, if necessary, the plates as well.



- 8 Remove the carbon brushes and the old springs with a screwdriver.



- 9 Put new carbon brushes in the brush holder. Do not refit the springs yet.
- 10 Replace the brush-holder plate containing the new carbon brushes into its correct and previously marked position. Connect the cables to the carbon brushes.

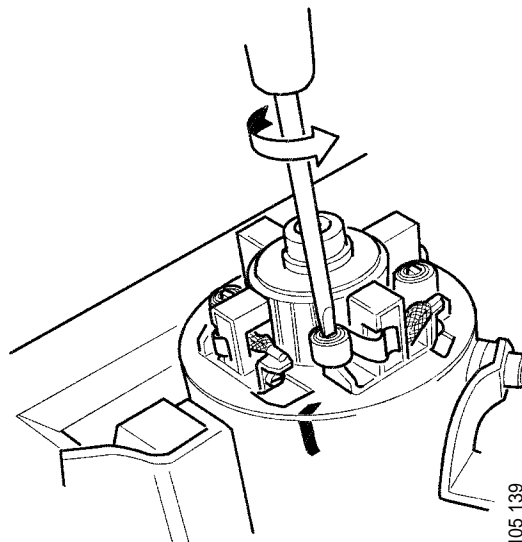
- 11 Fit new springs on to the carbon brushes.
Apply a small screwdriver to the centre of each spring and tighten them with a half turn counter-clockwise.



WARNING!

Use protective goggles! The springs of the carbon brushes are extremely resilient.

- Place the cam that presses down the carbon brush into position.
 - Tighten the spring a half turn.
 - Press the centre of the spring on to the mounting foil.
- 12 Refit the bearing shield as per the markings.
- 13 Refit the protection cover.
- 14 Mount the starter motor (see "Refitting the starter motor").



Bosch JE Solenoid switch (solenoid)

Replacing

Dimensions

Pull-in circuit	0.5 ohm
Holding circuit	2.5 ohm

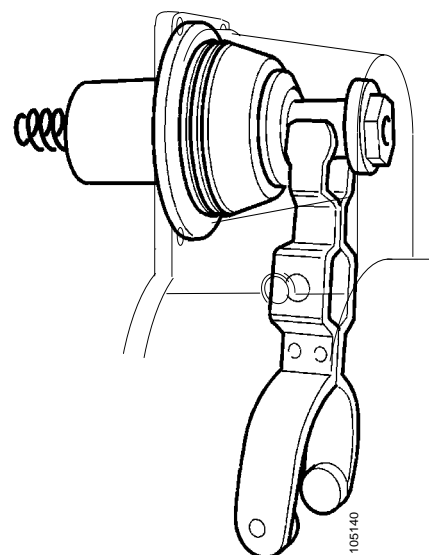
Requisite parts

Solenoid switch (assembly)	Part No. 1 405 979
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Work description

Before replacing the brushes, remove the starter motor (see "Removing the starter motor").

- 1 Detach the screws that hold the solenoid switch to the front bearing shield.
- 2 Detach the conductor of the solenoid switch towards the pole housing.
- 3 Remove the housing and centre piece of the solenoid switch.
- 4 Fit the new centre piece into place. Lubricate the surface by the actuating arm with heat-resistant grease. Make sure that it grips the actuating arm by the front bearing shield.
- 5 Grease the centre piece with heat-resistant grease and refit the solenoid switch housing. Secure it with screws to the front bearing shield. Connect the conductor to the pole housing.
- 6 Mount the starter motor (see "Refitting the starter motor").



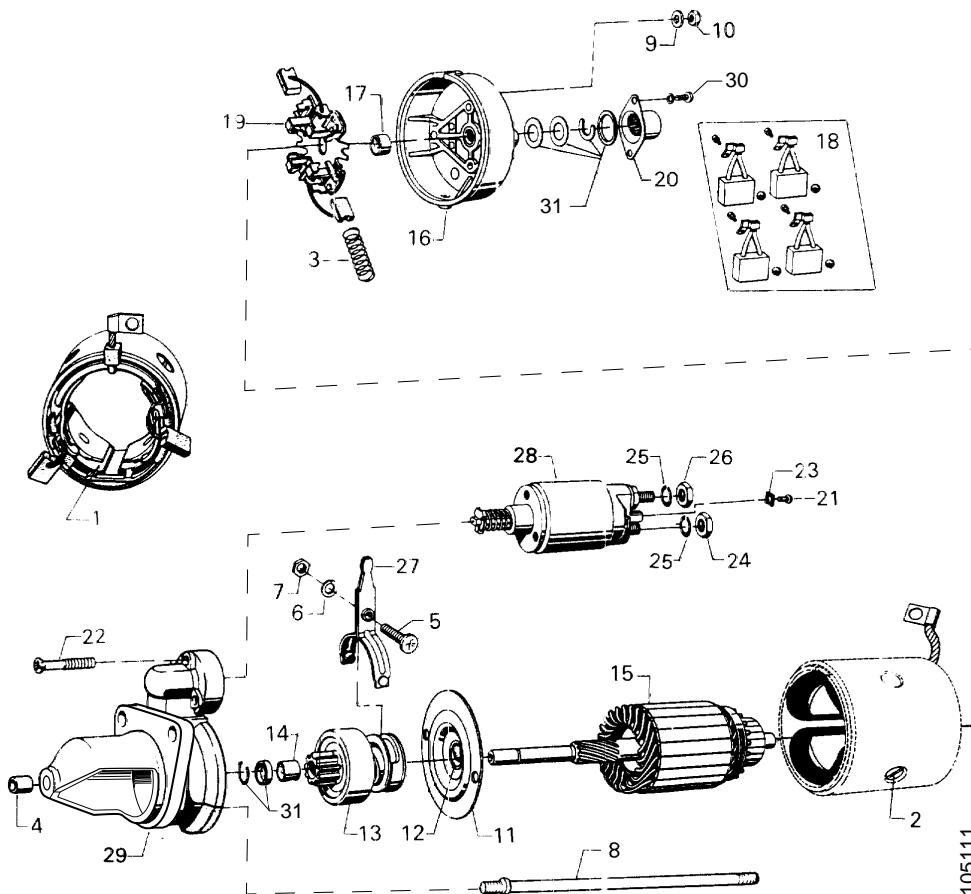
Bosch JF 4 kW

Assembly

Specifications

Power	4 kW
Rotational direction (as seen against the flywheel housing)	Counter-clockwise
Commutator, min. diameter	42.5 mm
Brushes, min. length	8.5 mm
Brushes, spring compression	27-46 N
Resistance in the pull-in winding	1.33 ohm
Resistance in the holding winding	4.34 ohm
Max. radial run-out in the rotor	0.05 mm
Max. radial run-out in the commutator	0.03 mm

Exploded view drawing



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- 1 *Excitation winding*
- 2 *Screw*
- 3 *Compression spring*
- 4 *Sintered bushing*
- 5 *Screw*
- 6 *Spring washer*
- 7 *Nut*
- 8 *Stud*
- 9 *Washer*
- 10 *Nut*
- 11 *Bearing*
- 12 *Sintered bushing*
- 13 *Idling gear*
- 14 *Sintered bushing*
- 15 *Rotor*
- 16 *Rear bearing shield*
- 17 *Sintered bushing*
- 18 *Brush unit*
- 19 *Brush holder*
- 20 *Cover*
- 21 *Screw*
- 22 *Screw*
- 23 *Bracket*
- 24 *Nut for pole screw*
- 25 *Spring*
- 26 *Nut for pole screw*
- 27 *Actuating arm*
- 28 *Solenoid switch (solenoid)*
- 29 *Front bearing shield / nose*
- 30 *Screw*
- 31 *Piece for armature parts*

Bosch JF Brushes

Replacing

Dimensions

Brushes, min. length	8.5 mm
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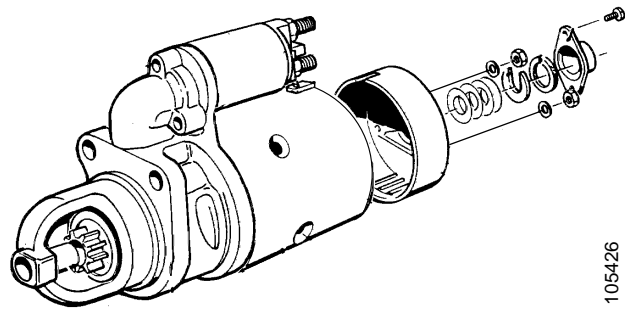
Requisite equipment

Brush unit	Part No. 313 267
Brush springs	Part No. 313 261

Work description

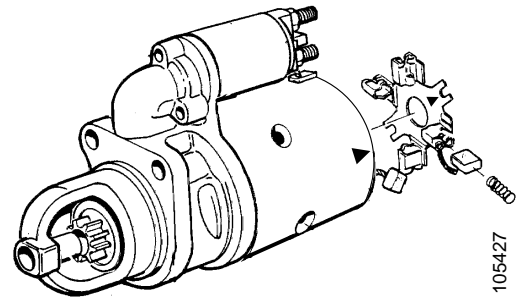
Before replacing the brushes, remove the starter motor (see "Removing the starter motor").

- 1 On 2-pole starter motors only: Detach the 31 connection of the solenoid switch on the rear bearing shield.
- 2 Remove the rear protection cover.
- 3 Remove the U-shaped lock plate, the shims, rubber seal and the two nuts. Remove the rear bearing shield.
- 4 Bend the buckle tongues to one side and remove the two positive brushes from the brush holder. The positive brushes have red protective hoses. The negative brushes can remain in the brush holder once the spring tension against the commutator has been released.

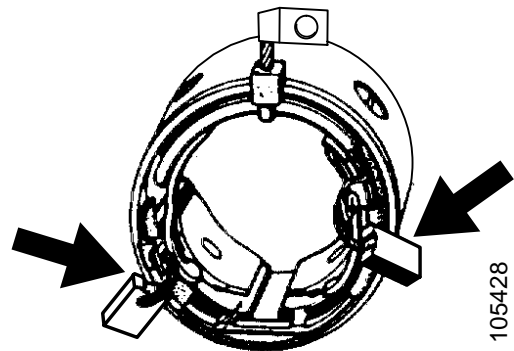


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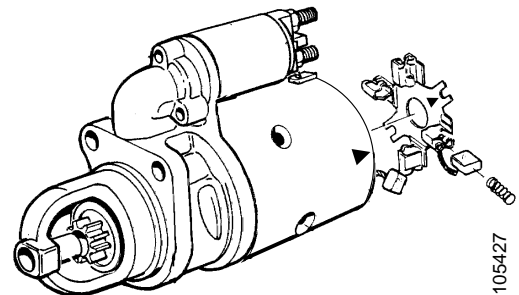
- 5 Remove the brush-holder plate and negative brushes after marking the position of the plate against the pole housing.
- 6 Remove the negative brushes and the old springs with a screwdriver.
- 7 Examine the commutator for damage. Wipe it, and clean it if necessary.



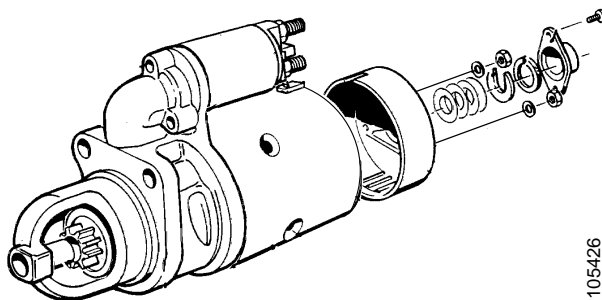
- 8 Remove the screw-on connections of the positive brushes on the field winding.
- 9 Fit new positive brushes on to the field winding in the pole housing.



- 10 Fit new negative brushes on to the brush holder.
- 11 Refit the brush holder as per the markings. Fit new positive brushes and new springs, and bend the buckle tongues to the brushes using flat-nose pliers.



- 12 Refit the rear bearing shield and fit the cable grommet into the shield.
- 13 Fasten the starter motor with the two nuts, and refit the shims and lock plate on to the end of the rotor shaft.
- 14 On 2-pole starter motors only: Connect the 31 connection of the solenoid switch on to the rear bearing shield.
- 15 Check the axial clearance of the rotor shaft. It should be 0.1-0.3 mm. Adjust, if necessary, the number of shims until the correct clearance is obtained. Refit the rubber seal and protection cover.
- 16 Mount the starter motor (see "Refitting the starter motor").



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Bosch JF Solenoid switch (solenoid)

Replacing

Dimensions

Pull-in circuit	1.33 ohm
Holding circuit	4.34 ohm

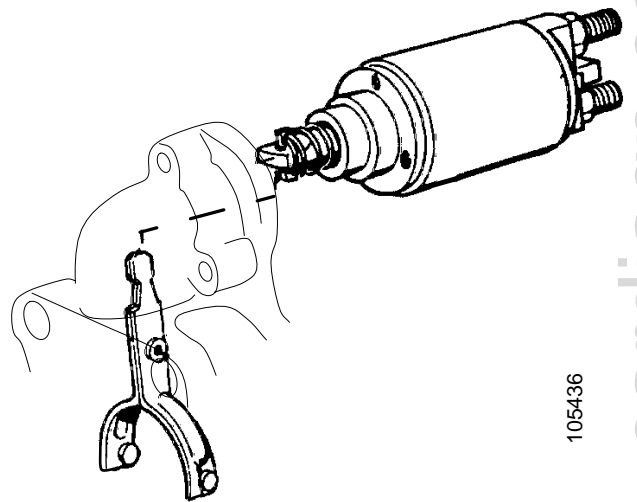
Requisite parts

Solenoid switch (assembly)	Part No. 386 768
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Work description

Before replacing the solenoid switch, remove the starter motor (see "Removing the starter motor").

- 1 On 2-pole starter motors only: Detach the earth cable of the solenoid switch from the 31 connection on the rear bearing shield.
- 2 Remove the field winding connection to the solenoid switch.
- 3 Detach the screws that hold the solenoid switch to the front bearing shield.
- 4 Remove the housing and centre piece of the solenoid switch.
- 5 Fit the new centre piece into place. Lubricate the surface by the actuating arm with heat-resistant grease. Make sure that it grips the actuating arm by the front bearing shield.
- 6 Grease the centre piece with heat-resistant grease. Fit the new solenoid switch housing and secure it with screws to the front bearing shield.
- 7 Refit the field winding connection on to the solenoid switch.
- 8 On 2-pole starter motors only: Connect the earth cable of the solenoid switch to the 31 connection on the rear bearing shield.
- 9 Mount the starter motor (see "Refitting the starter motor").



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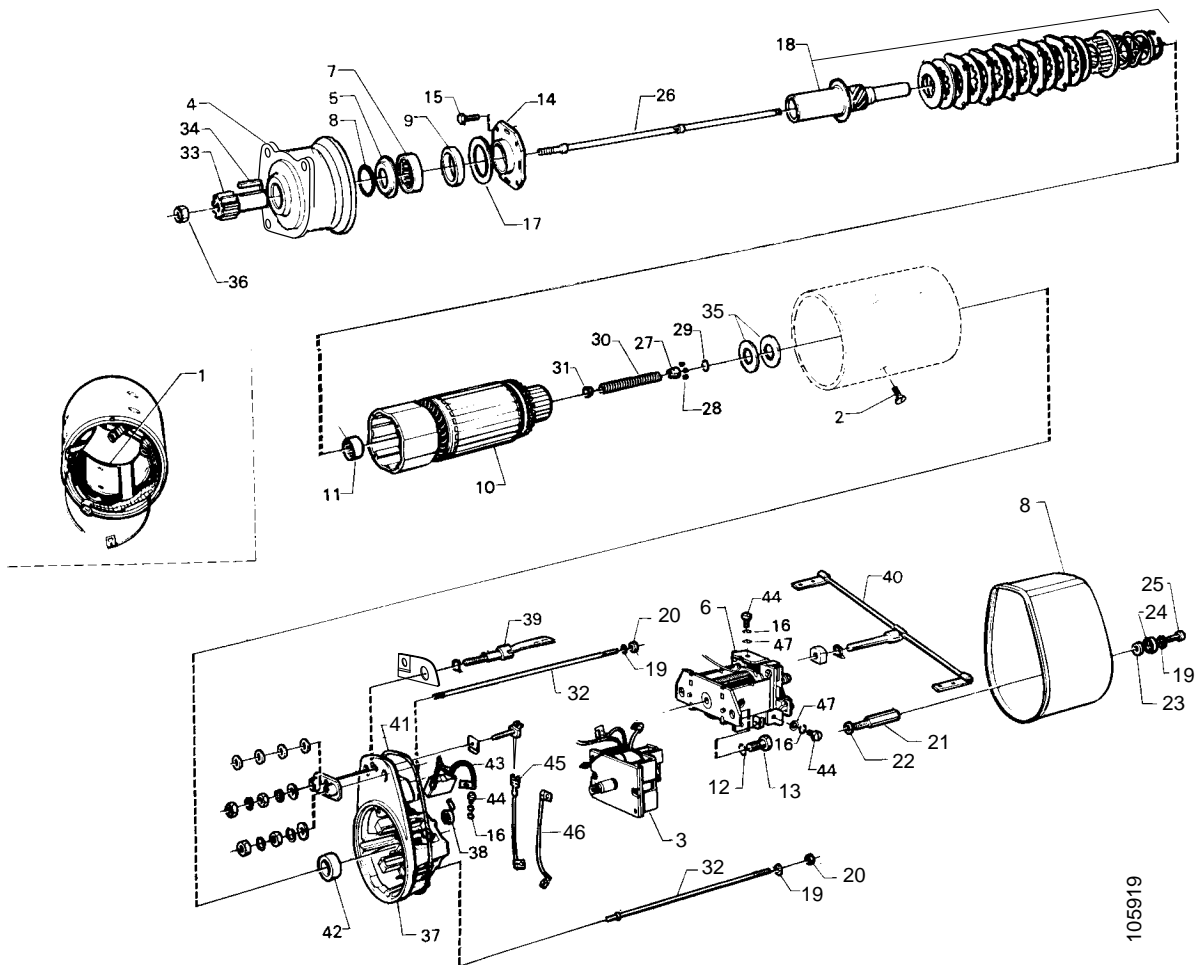
Bosch KB 6.6 kW

Dismantling

Specifications

Power	6.6 kW
Rotational direction (as seen against the flywheel housing)	Counter-clockwise
Commutator, min. diameter	47.5 mm
Brushes, min. length	10 mm
Brushes, spring compression	20-23 N
Resistance in the pull-in winding	0.33 ohm
Resistance in the holding winding	6.3 ohm
Max. radial run-out in the rotor	0.08 mm
Max. radial run-out in the commutator	0.03 mm

Exploded view drawing



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- 1 *Excitation winding and starter motorframe*
- 2 *Screw*
- 3 *Solenoid switch*
- 4 *Starter motor wall*
- 5 *Seal*
- 6 *Starter relay*
- 7 *Roller bearing*
- 8 *Cap*
- 9 *Sintered bushing*
- 10 *Rotor*
- 11 *Needle bearing*
- 12 *Spring*
- 13 *Screw*
- 14 *Cover*
- 15 *Screw*
- 16 *Spring*
- 17 *Washer*
- 18 *Disc coupling and shaft*
- 19 *Washer*
- 20 *Nut*
- 21 *Spacing screw*
- 22 *Washer*
- 23 *Seal*
- 24 *Washer*
- 25 *Screw*
- 26 *Pushrod*
- 27 *Ring*
- 28 *Ball*
- 29 *Spring-ring*
- 30 *Compression spring*
- 31 *Ring*
- 32 *Stud*
- 33 *Starter pinion*
- 34 *Key*
- 35 *Shim*
- 36 *Nut*
- 37 *Starter motor wall*
- 38 *Compression spring*
- 39 *Connection tab*
- 40 *Electric cables*
- 41 *Gasket*
- 42 *Bushing*
- 43 *Brush*
- 44 *Screw*
- 45 *Cable*
- 46 *Cable*
- 47 *Washer*

Valeo D13 HP 6.6 kW

General

At present, there is no work description and exploded view drawing of the Valeo D13 HP 6.6 kW starter motor.