



PART 3

ELECTRICAL
SYSTEM

C3-series

SERVICE MANUAL

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GROUP 30 GENERAL

DATA

BATTERY

Type	Boliden 108 M 57 K op
Number	1
System voltage	12 V
Battery capacity	57 Ah
Electrolyte specific gravity:	
Fully charged battery	1.28
When charging should be done	1.21
Recommended charging current	6 A

ALTERNATOR

Designation	S.E.V. Marchal 14/55 712 713 12
Output	770 W
Max. speed	250 r/s (15 000 r/min)
Direction of rotation	Optional
Ratio, alternator – crankshaft	1.72:1
Resistance in rotor, (across slip rings)	4 Ω \pm 10%
Brushes, minimum length	5 mm (3/8")
Stator resistance between phases	ca 0,13 Ω
Output tests:	
Alternator speed	50.0 r/s (3000 r/min)
Engine speed	29.1 r/s (1750 r/min)
Current, min.	48 A
Voltage	14 V
Ambient temperature	77°F

Tightening torques:	Nm	Kpm	Lbftf
Inhex bolts	4	0.4	3.0
Terminal B+	4	0.4	3.0
Other connections	2.8–3.0	0.28–0.30	20–22
Pulley nut	40	4	29

VOLTAGE REGULATOR

Type	Bosch AD 1 14V
Control voltage measured under following test conditions:	
Alternator speed	66.6 r/s (4000 r/min)
Engine speed	38.8 r/s (2320 r/min)
Load	26–30 A
Temperature	20°C (68°F)
Control voltage	14.1–14.6V, measured within 30 seconds after start.

STARTER MOTOR

Type	Bosch GF 12 V 1 PS
Voltage	12 V
Grounded	Negative terminal
Direction of rotation	Clockwise
Output	Approx. 736 W (1 hp)
Brushes, number	4

Test values**Mechanical**

Rotor and float	0.05–0.3 mm (0.002–0.012")
Brush spring tension	11.5–13 N (2.53–2.86 lbf)
Distance from pinion to ring gear	1.2–4.4 mm (0.047–0.173")
Frictional torque of rotor brake	0.25–0.40 Nm (2.17–3.81 lbinf)
Pinion idling torque	0.13–0.45 Nm (1.13–1.56 lbinf)
Backlash	0.35–0.45 mm (0.14–0.018")
Minimum diameter of commutator	33 mm (1.3")
Minimum length of elec. brushes	14 mm (0.6")

Electrical (on a test bench with a battery capacity of 135 Ah)

Unloaded starter motor	
12V and 40–50 A	115–135 r/s (6900–8100 r/min)
Loaded starter motor	
9 V and 185–200 A	17.6–22.5 r/s (1050–1350 r/min)
Locked starter motor	
6 V and 300–350 A	0 r/s

Control solenoid

Cut-in voltage	Min. 8 V
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IGNITION SYSTEM

Firing sequence	1-5-3-6-2-4
Ignition timing, vacuum governor disconnected	10° 800 r/min
Basic firing position, engine switched off	10°
Spark plugs	W 200 T 35 or corresponding
Electrode gap	0.7–0.8 mm (0.028–0.032")
Tightening torque	35–40 Nm (3.5–4.0 kpm = 25–29 lbftf)
Condenser, ignition coil	0.45 uF
Damper resistance for ignition cables	1000 Ω at 20°C

Distributor

Type	PFU 6
Direction of rotation	Anti-clockwise
Breaker contacts, gap	min. 0.25 mm (0.010")
dwell angle	42°±3°
contact pressure	5.0–6.3 N (0.50–0.63 kp = 1.1–1.4 lbf)
Condenser	0,15–0,20 uF
Rotor, resistance	4500–6000 Ω

Centrifugal governor

Advance, total	11.5–13.5 distr. degrees
Advance begins at	10.2–12.1 distr. r/s (610–725 distr. min)
Values, 5°	14.3–16.7 distr. r/s (860–1000 distr. min)
10°	26.3–32.9 distr. r/s (1575–1975 distr. min)
Advance, maximum	37.5 distr. r/s (2250 distr. min)

Vacuum governor (positive)

Advance, total	4–6 distr. degrees
Advance begins at	10.7–16.0 kPa (80–120 mm Hg = 3.1–4.7" Hg)
Values at 2.5 distr. degrees	15.3–21.3 kPa (115–160 mm Hg = 4.5–6.3" Hg)
Advance, maximum	23.3–25.3 kPa (175–190 mm Hg = 6.9–7.5" Hg)

LIGHTING**Bulbs**

Description	Qty	Output	Socket	Type
Headlamps with insert	2			Sealed Beam
Direction indicators	4	23 W	Ba 15 s	
Position lights	2	4 W	Ba 9 s	
Black-out lights (front)	2	15 W	S 8.5	
Stop lights	2	23 W	Ba 15 s	
Stop lights, black-out	2	3 W	SV 5.5	
Tail lights	2	10 W	Ba 15 s	
Tail lights, black-out	2	3 W	SV 5.5	
Interior lighting	1	10 W	S 8.5	
Indicator/warning lights:				
Fullbeams	1	2 W	Ba 9 s	
Alternator charging	1	2 W	Ba 9 s	
Oil pressure	1	2 W	Ba 9 s	
Direction indicators	2	2 W	Ba 9 s	
Differential carriers	2	2 W	Ba 9 s	
Four-wheel drive	1	2 W	Ba 9 s	
Brakes	1	2 W	Ba 9 s	
Instruments:				
Speedometer	1	2 W	Ba 9 s	
Temperature gauge	1	2 W	Ba 9 s	
Fuel gauge	1	2 W	Ba 9 s	
Oil pressure gauge	1	2 W	Ba 9 s	
Ammeter	1	2 W	Ba 9 s	
Switches:				
Light switch	1	2 W	Ba 7 s	
Windscreen wipers	2	2 W	Ba 7 s	
Washers	1	2 W	Ba 7 s	
Hazard warning flashers	1	2 W	Ba 7 s	

FUSES

Rated current	16 A	8 A
Number	1	17

General Service Procedures

Before carrying out any repairs, look at the electrical wiring diagram to see how the component in question is connected up. If there is current up to the component or near to it, you must always first disconnect the battery before doing any work on that particular component. The simplest way to disconnect the

battery is to remove the negative cable from the battery.

In order to facilitate troubleshooting, replacement of components, etc., a principle wiring diagram has been made for the following components:

FUNCTION	GROUP	PICTURE
1. Lighting, instruments and switches	35	35-10
2. Black-out lighting	35	35-14
3. Direction indicators and hazard warning flashers	36	36-8
4. Windscreen wipers with relay	36	36-10

CONNECTION DESIGNATIONS ON VARIOUS COMPONENTS

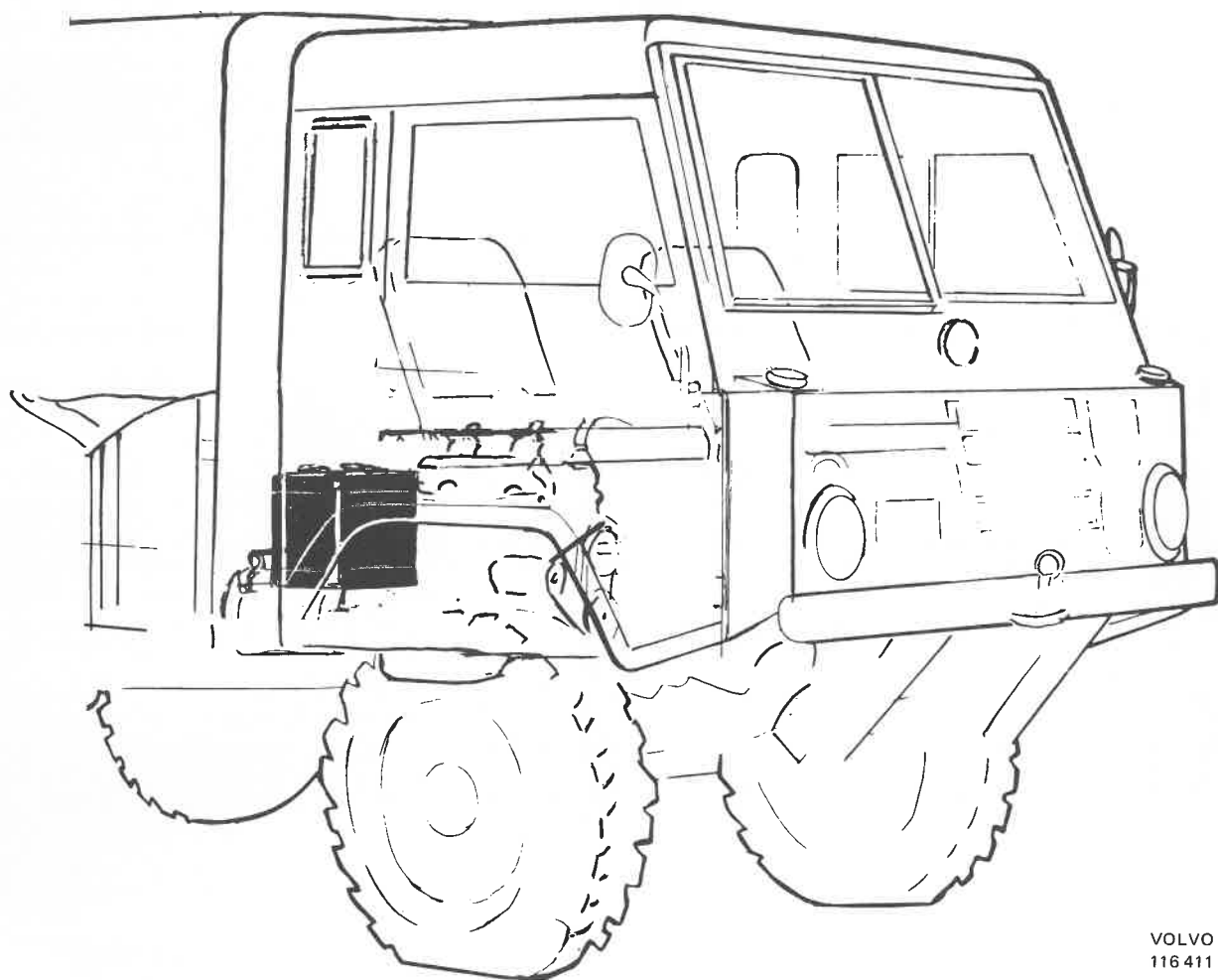
The listing below is to show the association between wire connection and the component terminal designation

FROM	TO
Group 31	
30 Battery	30 Starter motor
30 Starter motor (via ammeter L+)	B+ Alternator
30 Starter motor (via ammeter L+)	30 Ignition
Group 32	
61 Ignition across battery charging warning light	61 Alternator
L+ Ammeter	B+ Alternator
B+ Ammeter	30 Starter motor
Group 33	
50 Starter button	50 Control magnet, starter motor

FROM	TO
Group 34	
15 Ignition	15 Ignition coil
15 Ignition	Fuses A2, A3, A4 and A5
15 Ignition	Starter button
Group 35	
56 Lighting switch	86 Relay, headlight flasher
56a Step relay	Fullbeams
56b Step relay	Dipped beams
58 Lighting switch	Relay, parking lights, 86
87 Relay, parking lights	Fuses, B2, B3, B4 and B5
Group 36	
54 Flasher unit (terminal 49a) via T-junction	Direction indicator lever
L Direction indicator lever	Left direction indicator
L Switch, emergency warning flashers	Left direction indicator
R Direction indicator lever	Right direction indicator
R Switch, emergency warning flashers	Right direction indicator
C Flasher unit	Indicator light, direction indicator
C2 Flasher unit	Indicator light, direction indicator (trailer)
53 Switch, windscreen wipers	Windscreen wiper motor, semi-speed
53a Switch	Wiper motor, wipers parking position
53b Switch	Windscreen wipers, full speed
53e Switch	Windscreen wipers, brake coil
31 Wiper motor	Chassis connection
Relays	
85 Relay coil (possibly via sender)	Chassis connection
86 Battery "+" (direct or across switch)	Relay winding
87 Relay (possibly via terminal 30)	Consumer
87a Relay	Consumer
30 Battery "+" (direct or across switch)	Relay
30 Relay	Consumer
Group 38	
G Instruments	Senders

GROUP 31 BATTERY

Description



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Fig. 31-1. Battery

The battery is situated on the right-hand side behind the cab and consists of a 12-volt lead-type battery.

The battery negative pole (—) is wired to the vehicle chassis.

Service Procedures

When replacing, charging or installing the battery, make sure that the new battery is connected up with the correct polarity (minus to vehicle chassis).

Observe due care when using a rapid charger as an aid in starting. Disconnect it immediately when the engine has started. The battery cables must not be disconnected while the engine is running.

When using an extra battery, it should be connected in parallel with the vehicle standard battery. (That is, positive to positive and negative to negative.)

When about to do any electrical welding on the vehicle, first disconnect both the battery cables and the connector at the charging regulator. The welding unit should always be connected as near the place where the welding is to be carried out as possible and on the same main component. If, for example, the frame is to be welded, then connect the welding unit to the frame, and so on.

Changing the battery

Removing

1. Unlock the battery cover and fold it down.
2. Disconnect the battery cables from the battery.
3. Remove the battery from the vehicle.

Installing

1. Place the new battery in position.
2. Fit the battery cable terminals to the battery (negative to vehicle chassis).
3. Fit the cover over the battery.

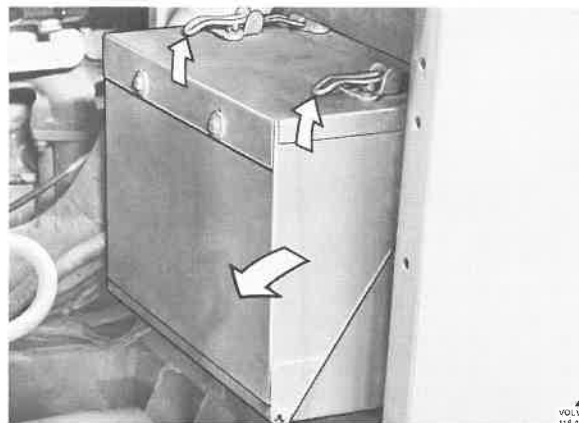


Fig. 31-2. Battery box



Fig. 31-3. Battery

GROUP 32 ALTERNATOR

Description



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Fig. 32-1. Alternator lay-out

The alternator is placed on the right-hand side of the engine and is driven by two belts from the crankshaft pulley.

The charging regulator is placed at the back of the cab.

The battery charging warning light is located on the instrument panel.

ALTERNATOR

The alternator is a three-phase, delta-connected alternator unit which is located on the right-hand side of the engine and is driven by 2 drivebelts from the crankshaft pulley. The alternator has a rectifier built into the slip ring end shield. This rectifier consists of six silicon diodes. The alternator has a rotating field (rotor) and stationary generating windings (stator).

The rotor is of the claw-pole type with the field windings fed over the slip rings. The construction of

the rotor has made it possible for the alternator to have a max. speed of 250 r/s (15000 r/min).

The magnetizing diodes have two functions: They prevent the battery from discharging through the regulator and alternator field, and they provide a simple means of operating the charging warning lamp.

The alternator is self-limiting (max. 55 A) and for this reason a simple voltage regulator can be used with only voltage control.

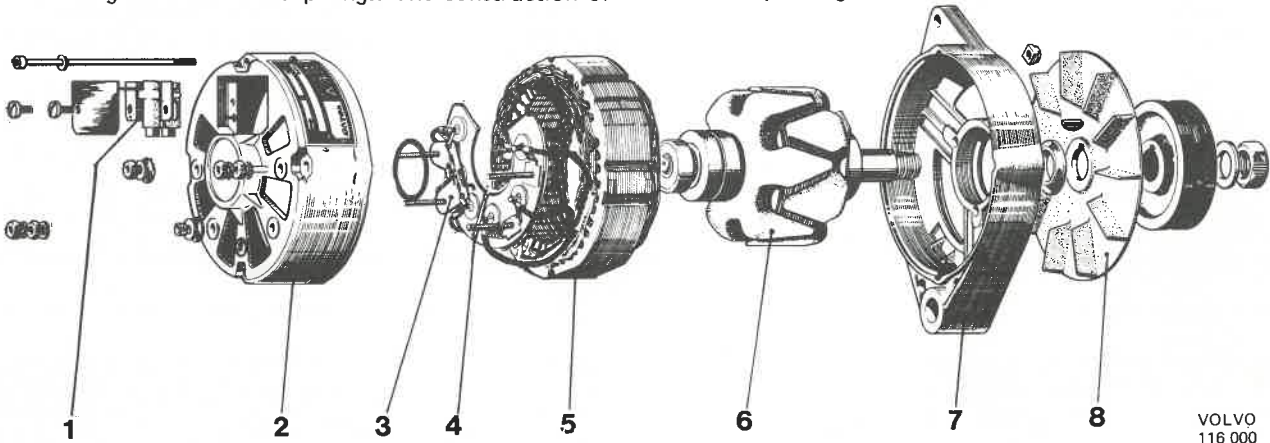


Fig. 32-2. Exploded view of alternator

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- | | | |
|-----------------------------------|-------------------------------|---------------------|
| 1. Brush holder | 4. Rectifier (silicon diodes) | 7. Drive end shield |
| 2. Slip ring end shield | 5. Stator | 8. Fan |
| 3. Magnetizing diodes with holder | 6. Rotor | |

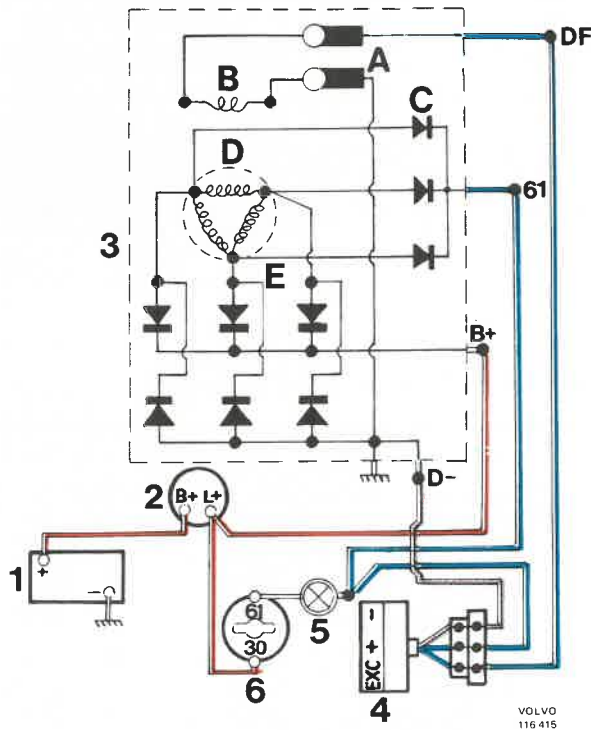


Fig. 32-3. Charging function wiring

VOLVO
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- | | |
|-----------------------------------|-----------------------|
| 1. Battery | A. Slip rings |
| 2. Ammeter | B. Rotor |
| 3. Alternator | C. Magnetizing diodes |
| 4. Regulator | D. Stator |
| 5. Battery charging warning light | E. Rectifier diodes |
| 6. Ignition | |

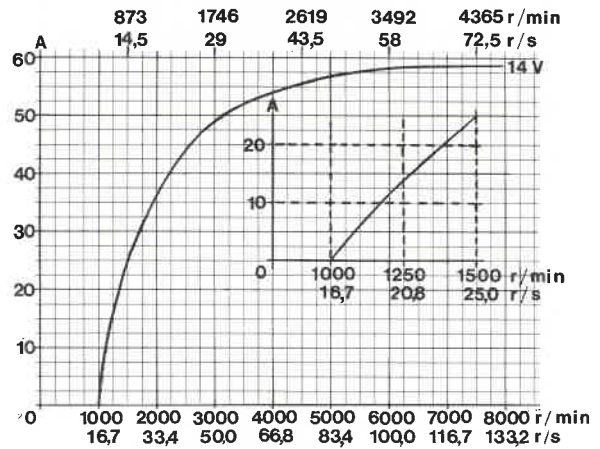


Fig. 32-4. Alternator output curve

The voltage regulator is a mechanical, single-pole voltage regulator with a lower contact, a movable contact and an upper contact, see Fig. 32-5. The regulator resistor is placed under a plate underneath the regulator. Temperature compensation is operated by a bimetal spring which influences the spring tension so that the regulator receives lower regulating voltage at higher temperatures.

Function

When the ignition key is switched on, current flows through the charging warning lamp to D+ (61) on the regulator. It is then conducted via the regulator through the field winding to earth.

When the alternator starts rotating, alternating current is formed in the stator. This alternating current is rectified by the silicon diodes and the direct current produced is re-fed via the regulator to the field winding until the regulating voltage has been reached. When the regulating voltage has been reached the armature is attracted by the coil. This causes the contacts to open and the field current must pass the resistances R1.

If in spite of this, the voltage rises, the armature is drawn further down and the movable contact meets the lower contact so that the field winding is earthed at both ends, this causing the voltage to drop rapidly. The cycle is repeated continuously so that the voltage is maintained constant.

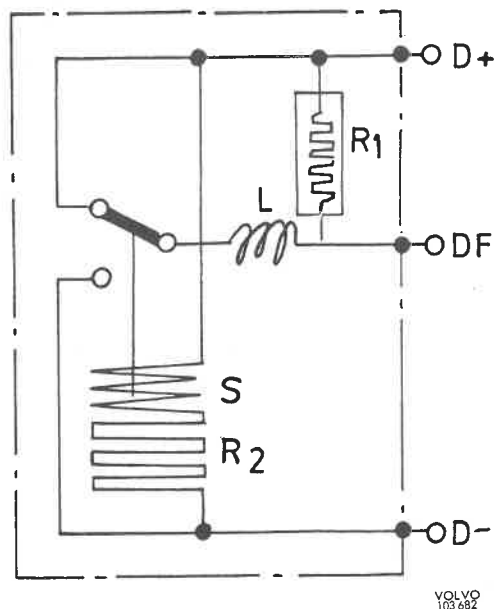
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Fig. 32-5. Regulator internal wiring

- S. Voltage winding
- R1. Regulator resistor
- R2. Compensation resistor
- L. Contact impedance coil

Service Procedures

SPECIAL INSTRUCTIONS FOR WORK ON ALTERNATOR EQUIPMENT

1. When replacing or fitting the battery, make sure that the new battery is connected with the correct polarity.
2. Never run the alternator with the main circuit broken. The battery and/or alternator and regulator leads must never be disconnected while the engine is running.
3. No attempt should be made to polarize the alternator since this is not necessary.
4. When charging the battery while installed in the vehicle, the negative battery lead should be disconnected.
5. A rapid charger should not be used as a help in starting.
6. When using an extra battery as an aid in starting, always connect it in parallel.
7. When carrying out any electric welding on the vehicle disconnect the negative battery lead as well as all the alternator leads. The welding unit should always be connected as near as possible to where the welding is to be carried out.

ALTERNATOR

Removing the alternator

1. Remove the cover over the battery and disconnect the negative cable from the battery.
2. Mark the cables to ensure that they are re-fitted in the same place on the alternator and then disconnect the cables, see Fig. 32-6.

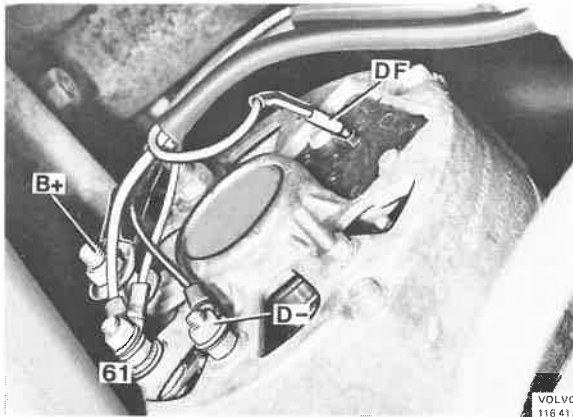


Fig. 32-6. Alternator cable terminals

3. Remove the bolt securing the tensioning bar at the alternator and slacken the bolts securing the attaching iron to the cylinder head a couple of turns.

Remove the alternator retaining bolt with spacer washer and lift off the alternator drive belts, see Fig. 32-7.

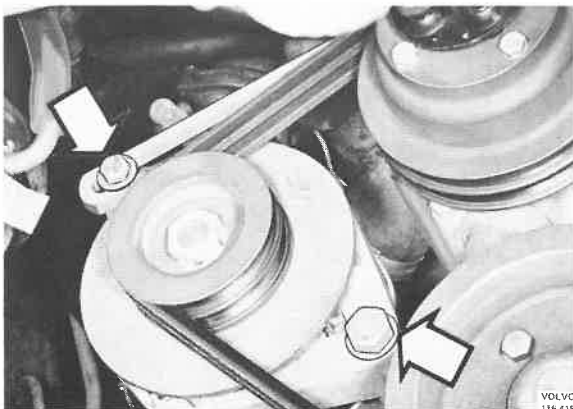


Fig. 32-7. Alternator mounted

Disassembling alternator

1. Fit the alternator pulley and pulley belt according to Fig. 32-8 in a vice with soft jaws. Remove the nut and washer.

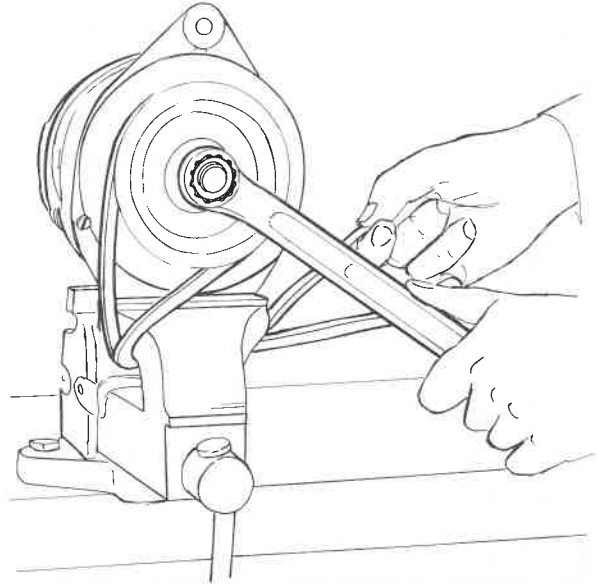


Fig. 32-8. Removing the pulley

2. Release the two screws holding the brush holder. Pull out the brush holder.



Fig. 32-9. Removing the brush holder

3. Remove the nuts and washers on terminal 61.
4. Mark the drive end shield, stator and slip ring end shield to avoid confusion when assembling. Remove the four attaching screws.

5. Remove the stator and slip ring end shield with the help of two screwdrivers which are inserted in two of the sockets between the stator and drive end shield, see Fig. 32-10.

NOTE! The screwdrivers may not be inserted deeper than 2 mm (just over 1/16"), otherwise the stator may be damaged.

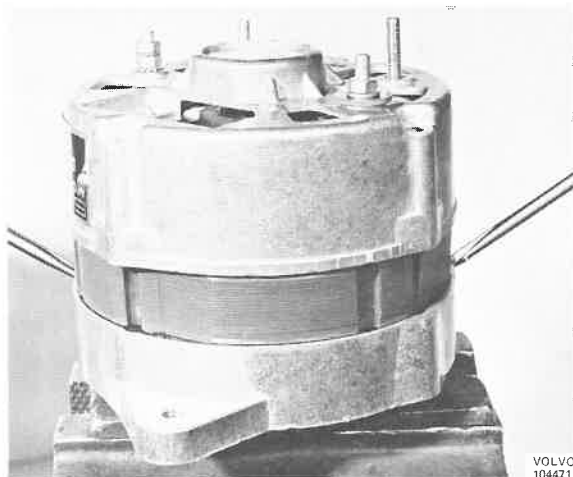


Fig. 32-10. Disassembling alternator

6. Release the three screws holding the support plate of the drive end bearing. Release the bearing by knocking the end of the shaft against a piece of wood, see Fig. 32-11.



Fig. 32-11. Removing drive end shield

7. Remove the nuts and washers for the diode holders.
8. Remove the stator and diode holders for the slip ring end shield.

Checking disassembled alternator

Stator

Check the stator for any short-circuiting. If one or several of the coils are burnt, there must be a short-circuit in the stator. Connect a test lamp (12 V. 2-5 W) between the stator plates and a terminal on the stator, see Fig. 32-12.

If the lamp lights, the insulation between the stator winding and the stator plates must be burnt out, in which case the stator should be replaced.

NOTE! Only a 12 V 2-5 W test lamp may be used; 110 or 220 V.D.C. or A.C. lamps may NOT be used. This applies to all the alternator components.

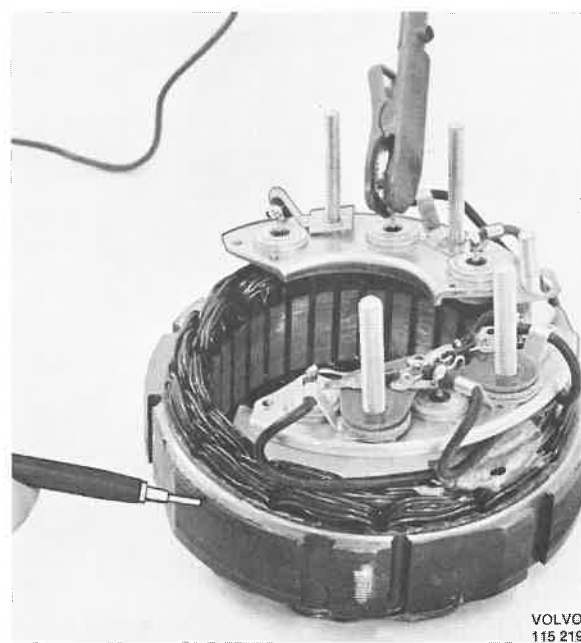


Fig. 32-12. Checking stator

Check the diodes with a diode tester, see Fig. 32-13. If any of the rectifier diodes is faulty, the entire diode holder (with three diodes) must be replaced. If any of the magnetizing diodes is faulty, replace the holder, complete with magnetizing diodes.

If a diode tester is not available, the diodes should be soldered loose (see previous page) and tested with an ohmmeter. The diodes should have high resistance in reverse direction and low resistance in the flow direction.

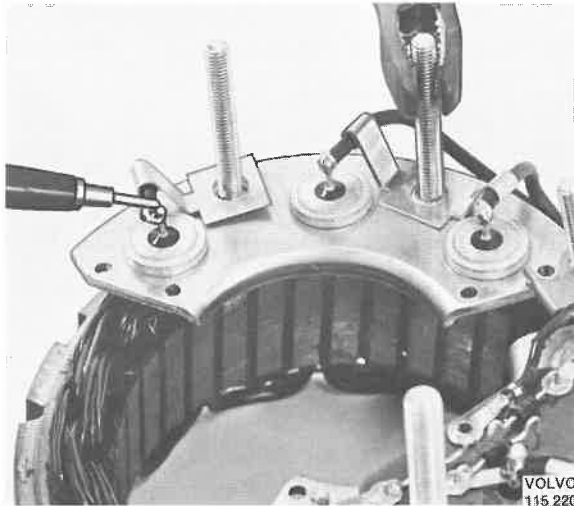


Fig. 32-13. Checking diodes

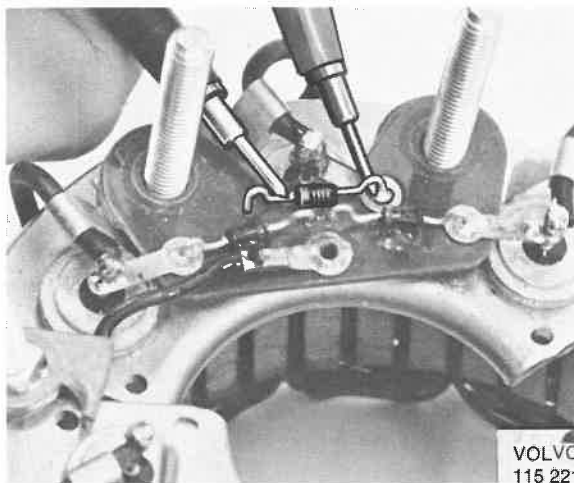


Fig. 32-14. Checking magnetizing diodes

Rotor

Check to make sure that the slip rings are not dirty or burnt.

Check the winding for breakage or damaged insulation. Measure the resistance between the slip rings, see Fig. 32-15. At 77°F the resistance should be 3.7 ohms.

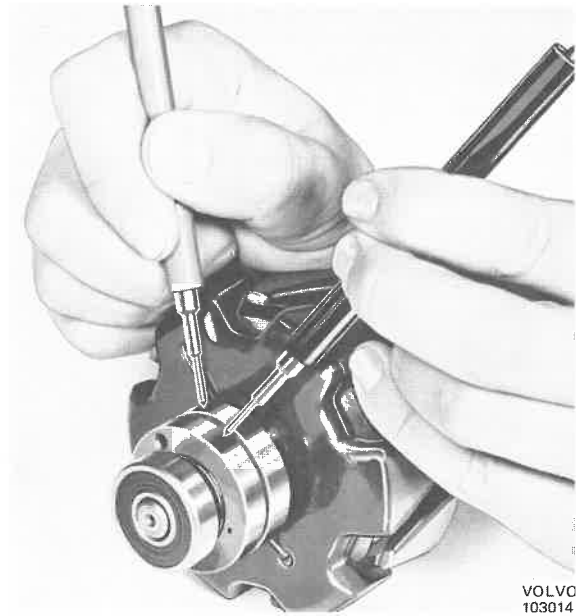


Fig. 32-15. Check-measuring rotor

If the slip rings are dirty, clean them carefully with a cloth moistened in trichloroethylene. The slip rings can also be polished with fine sand paper.

If the winding is faulty, the entire rotor must be replaced. Check the bearings, (The bearings should always be replaced when the alternator has been disassembled.)

Brush holder

Connect a test lamp between the brushes. The lamp must not light.

Connect the test lamp between the DF-terminal and "+" brush. The lamp should give a steady light even if the brush or the terminal cable is moved, see Fig. 32-16. Connect the test lamp between the brush holder frame "-" brush. The lamp should give a steady light even if the brush or the terminal lead is moved.

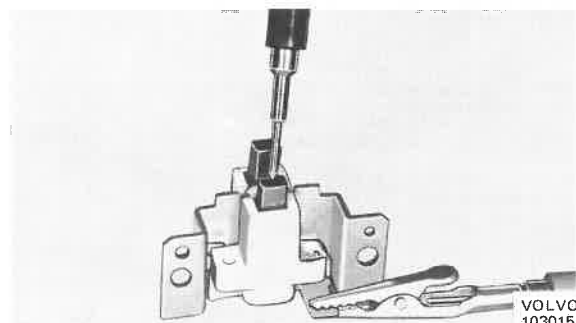


Fig. 32-16. Checking brush holder

If the brush holder does not meet the above requirements or if the brush length is less than 5 mm (approx. 3/16"), then replace the brush holder.

The brush length is measured between the brush contact surface and holder, with the brush resting against the spring, see Fig. 32-17.

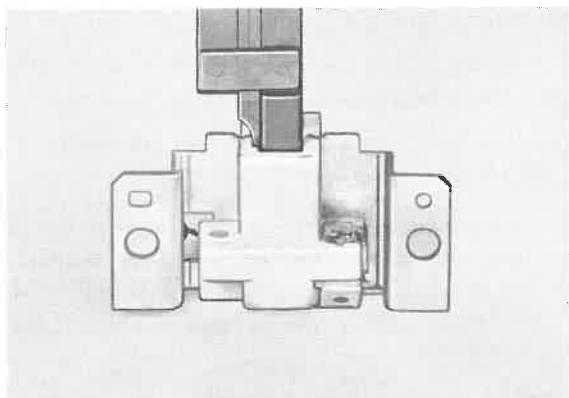
VOLVO
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Fig. 32-17. Measuring brush length

Replacing rectifier diodes

1. Mark the leads connecting the stator to the diodes. Solder loose the leads.
2. Place the new diode holder in exactly the same position occupied by the old one. Hold the outgoing diode lead with a pair of flat pliers. (This is to conduct the heat from the soldering point so as not to damage the new diode.)
3. Solder on the diodes, see Fig. 32-18.

NOTE! The complete "+" or "-" diode holder must be replaced even if only one diode is faulty.

Use a well-heated soldering iron, minimum 100 W for the soldering.

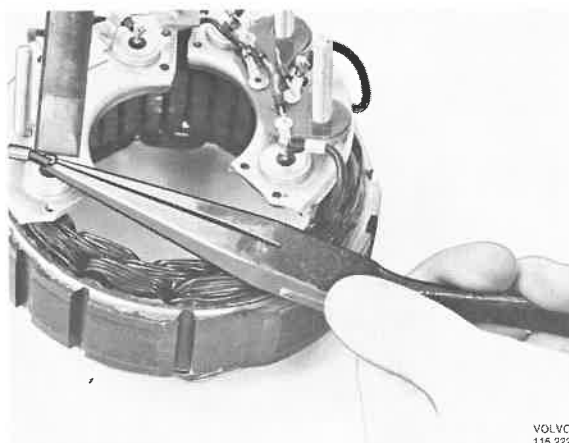
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Fig. 32-18. Soldering on diodes

Never change places for the two diode holders. The **Positive diode holder** is insulated from the frame by means of insulation washers and sleeves and its diodes are marked in **red**.

The **negative diode holder** is not insulated and its diodes are marked in **black**.

Replacing bearings

Drive end shield bearing

Removing

1. Place the rotor in a vice with soft jaws.
2. Pull the bearing off with a claw puller, see Fig. 32-19.

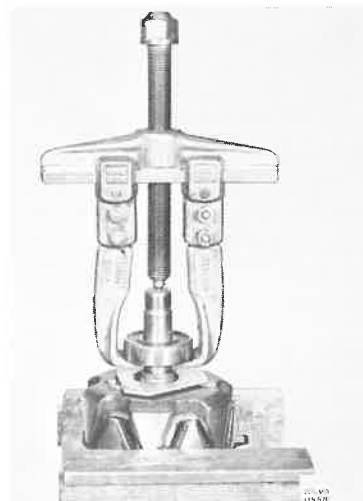


Fig. 32-19. Removing bearing

Installing

1. Place the support plate on the rotor shaft with the three elevations facing the rotor winding.
2. Press the bearing in with the help of a tubular sleeve which presses on the bearing inner ring, see Fig. 32-20.



Fig. 32-20. Installing bearing

Slip ring end bearing

Removing

1. Place the rotor in a vice with soft jaws.
2. Pull the bearing off with a claw puller.

Installing

1. Press the bearing on with a tubular sleeve which presses on the bearing inner ring.

Replacing slip ring end shield O-ring

1. Remove the O-ring with a steel blade with

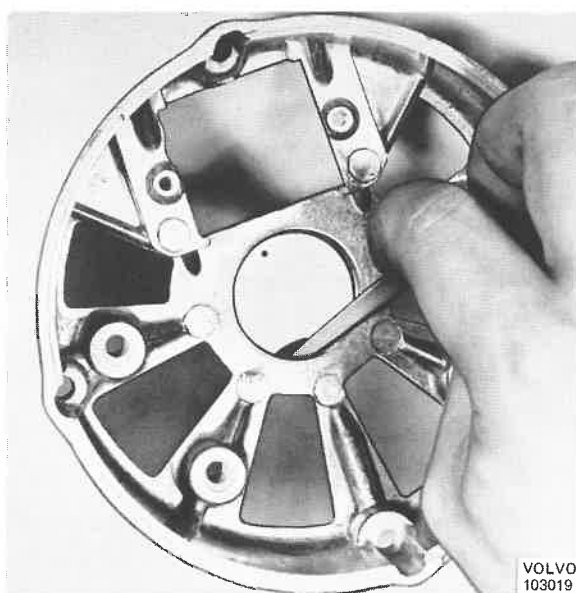


Fig. 32-21. Removing O-ring

rounded edges (for example, a feeler gauge), see Fig. 32-21.

2. Wash the groove clean.
Check that the hole in the bearing shield is not blocked.
3. Fit a new O-ring.
Lubricate the O-ring and the hole with mineral oil or similar.

The O-ring should be replaced each time the alternator has been disassembled.

Assembling alternator

1. Fit the stator and the diode holders in the slip ring end shield. (Do not forget the insulation washers for the positive diode holder.) Fit the nuts and washers on the negative diode holder screws.
2. Press the rotor into the drive end shield. Fit the three screws for the drive bearing support plate.
3. Fit together the rotor and stator sections.
4. Fit the attaching screws. Tightening torque: 2.8-3.0 Nm (0.28-0.30 kpm = 2.0-2.2 lbftf).
5. Fit the brush holder.
6. Fit the spacer washer, key, fan, pulley, washer and nut. Tightening torque: 40 Nm (4 kpm = 29 lbftf).
7. Connect a test lamp between B+ and the alternator frame. Switch the terminals. The lamp should light only in one direction, see Fig. 32-22. After any repairs, the alternator should be test-run in a test bench.



Fig. 32-22. Checking alternator

Installing

1. Place the alternator in position and fit the retaining bolt with spacer washer.
2. Fit the drive belts.
3. Fit the bolt securing the tensioning bar.
4. Tension the drive belts by levering the alternator drive bearing end and then tighten up the bolt securing the tensioning bar.
5. Tighten up the alternator retaining bolt.
6. Tighten up the bolt on the cylinder head and connect the cables to their terminals, see Fig. 32-23.

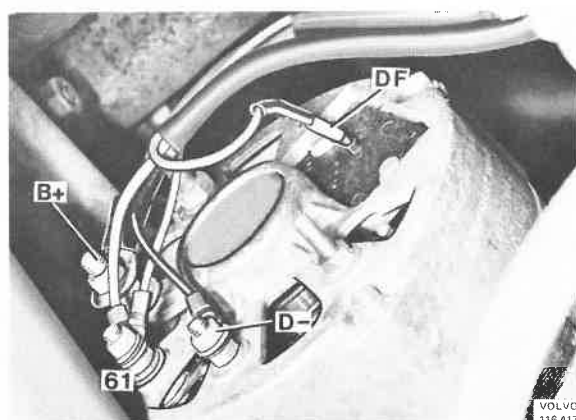


Fig. 32-23. Alternator cable terminals

7. Connect the negative cable to the battery and fit the cover over the battery.

CHARGING REGULATOR

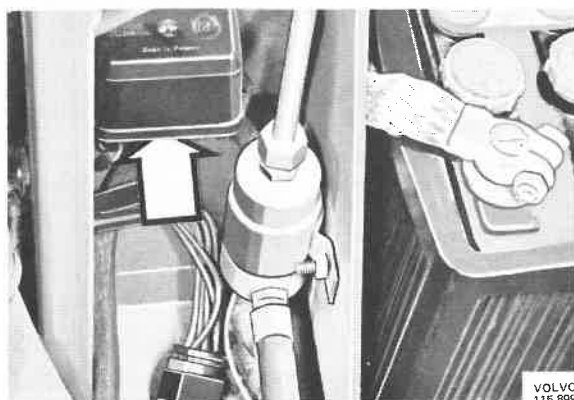


Fig. 32-24. Charging regulator

Removing

1. Remove the cables from the regulator.
2. Remove the two bolts securing the regulator.

Installing

1. Check that the number on the new regulator is the same as the old number.
2. Fit the regulator with the two bolts and connect up the cables.

TESTING THE ALTERNATOR AND VOLTAGE REGULATOR

General

Fixed clamps should be used for all testing of the alternator equipment. So-called crocodile clamps should not be used as they have a certain tendency to loosen. A loose lead can result in the alternator and regulator being damaged. When about to connect up instruments, disconnect the battery first.

TESTING THE ALTERNATOR CIRCUIT

Before carrying out any tests on the alternator or regulator in the vehicle, check the battery and vehicle wiring system for damaged leads or insulation, loose or corroded lead terminals and poor earthing. Any of the above faults must be remedied before the electrical checks can be started.

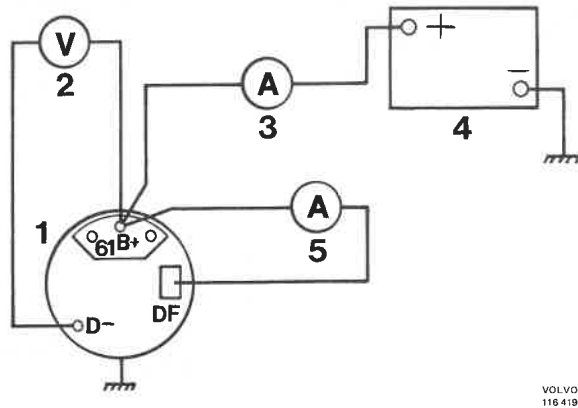
TESTING THE BATTERY

Test the battery with a hydrometer and battery tester. If the battery is not fully charged, remove it from the car and charge it or replace it with a new one if necessary. A fully charged battery which is otherwise in good condition should always be used when testing.

TESTING THE ALTERNATOR

(On a test bench or in the vehicle)

Connect up the alternator as shown in Fig. 32-25.



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Fig. 32-25. Wiring diagram for testing alternator

- | | |
|---------------------|-------------------|
| 1. Alternator | 4. Battery 60 Ah |
| 2. Voltmeter 0-20 V | 5. Ammeter 0-10 A |
| 3. Ammeter 0-50 A | |

Check that the current through the field winding (ammeter C) is 3-3.5 A. (If the current is not the correct one, then check the brush holder and field winding.) Run the alternator to a speed of 50 r/s (300 r/min). Engine speed 29.1 r/s (1750 r/min).

The alternator should then produce at least 48 A at 14 V. (A further load may be connected up in order to maintain the voltage at 14 V.) This applies to a warm alternator and an ambient temperature of 77°F.

Measure the voltage at B+ and 61 when the alternator charges.

TESTING THE VOLTAGE REGULATOR

(On a test bench or in the vehicle)

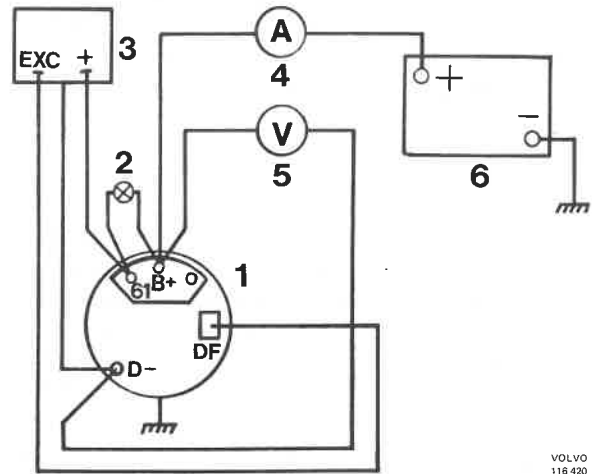
Connect the regulator to an alternator as shown in Fig. 32-26.

Run the alternator at 66.7 r/s (4000 r/min). Load the alternator with 26-30 amps.

Quickly lower the alternator speed to about 16.7 r/s (1000 r/min), and then increase it to 66.7 r/s (4000 r/min) and adjust the load to 26-30 amps. Read off the voltmeter. The voltage should be between 14.1-14.6 volts and the regulator should regulate on the left (lower) contact (1, Fig. 32-27). The voltmeter must be read off within 30 seconds after the test has started.

Lower the alternator load to 3-7 amps and read off the regulator voltage. The regulator voltage should now be 0.1-0.4 volt lower compared with the first reading. Now regulate the regulator on the right (upper) contact (2, Fig. 32-27).

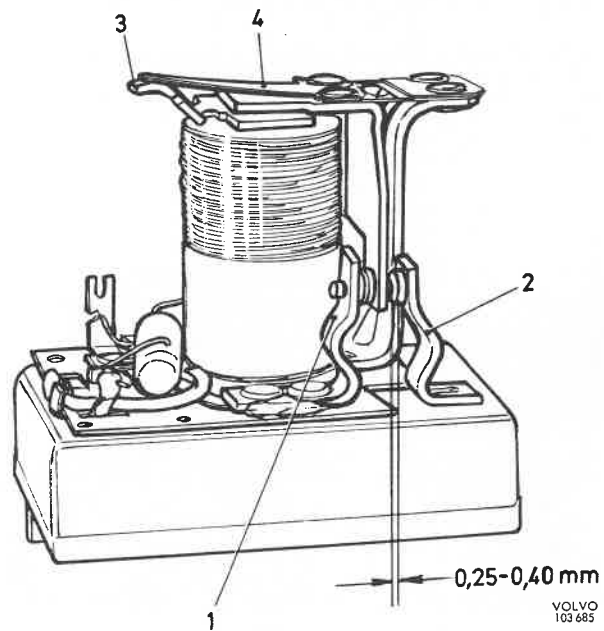
Adjust the control voltage in the lower control range by bending the contact bracket for the bi-metal spring as shown in Fig. 32-28.



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Fig. 32-26. Wiring diagram for testing voltage regulator

- | | |
|---------------------------|---------------------|
| 1. Alternator | 4. Ammeter 0-50 A |
| 2. Warning lamp 12 V, 2 W | 5. Voltmeter 0-20 V |
| 3. Voltage regulator | 6. Battery 60 Ah |



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Fig. 32-27. Charging regulator

1. Regulator contact for lower control range (lower contact)
2. Regulator contact for upper control range (upper contact)
3. Stop bracket
4. Spring upper section: steel spring
Lower section: bi-metal spring

Bending down the stop bracket lowers the control voltage, bending it up increases the control voltage. If the control voltage is too high in the upper control range or too low in relation to the lower control range (0.1-0.4 volt), adjust by bending the holder for

the left (lower) contact while correcting the gap between the higher (upper) contact and the movable contact according to Fig. 32-28.

If the holder is bent towards the right (upper) contact, this lowers the control voltage in the upper control range.

In order to avoid faulty adjustment because of residual magnetism in the regulator iron parts, it is necessary to lower the alternator speed towards 0 after each adjustment, and then increase the speed and carry out a new reading.

(If the adjusting work is going to take some time and the regulator is warm, it can suitably be cooled to room temperature by means of compressed air before carrying out the final reading.)

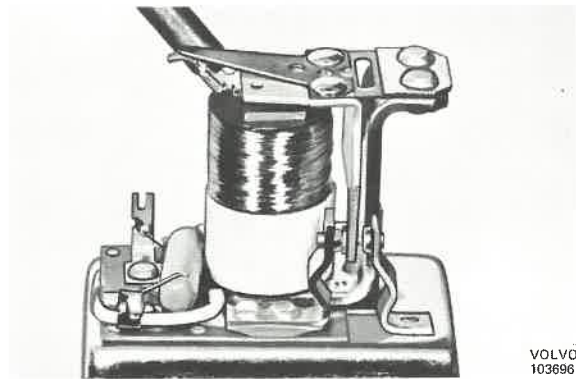


Fig. 32-28. Adjusting the control voltage

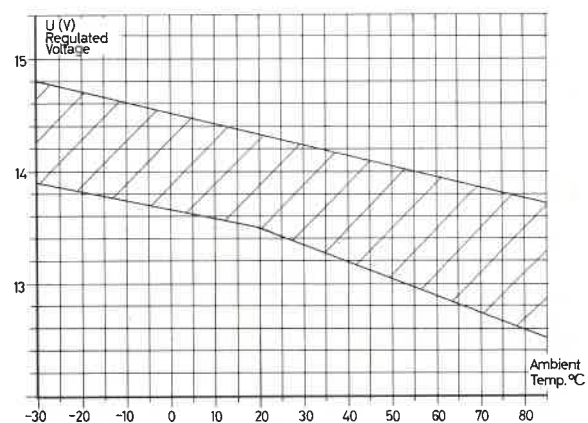


Fig. 32-29 Voltage – temperature diagram (0 – Max load)

SERVICE DIAGNOSIS

Condition	Possible cause
Alternator, does not charge	Worn or insufficiently tensioned fan belt. Breakage in charging circuit. Worn brushes. Breakage in rotor winding. Breakage in magnetizing diodes. Defective regulator.
Charging weak or irregular	Worn or insufficiently tensioned fan belt. Intermittent breakage in charging circuit. Worn brushes. Breakage or short-circuiting in one or several rectifier diodes. (Breakage in a diode reduces the charging current about 5 A. Short-circuiting in a diode limits the alternator charging current to 7–8 A and causes a rumbling sound in the alternator.) Rotor partly shorted. Stator broken or shorted. Defective regulator.

GROUP 33 STARTER MOTOR

Description

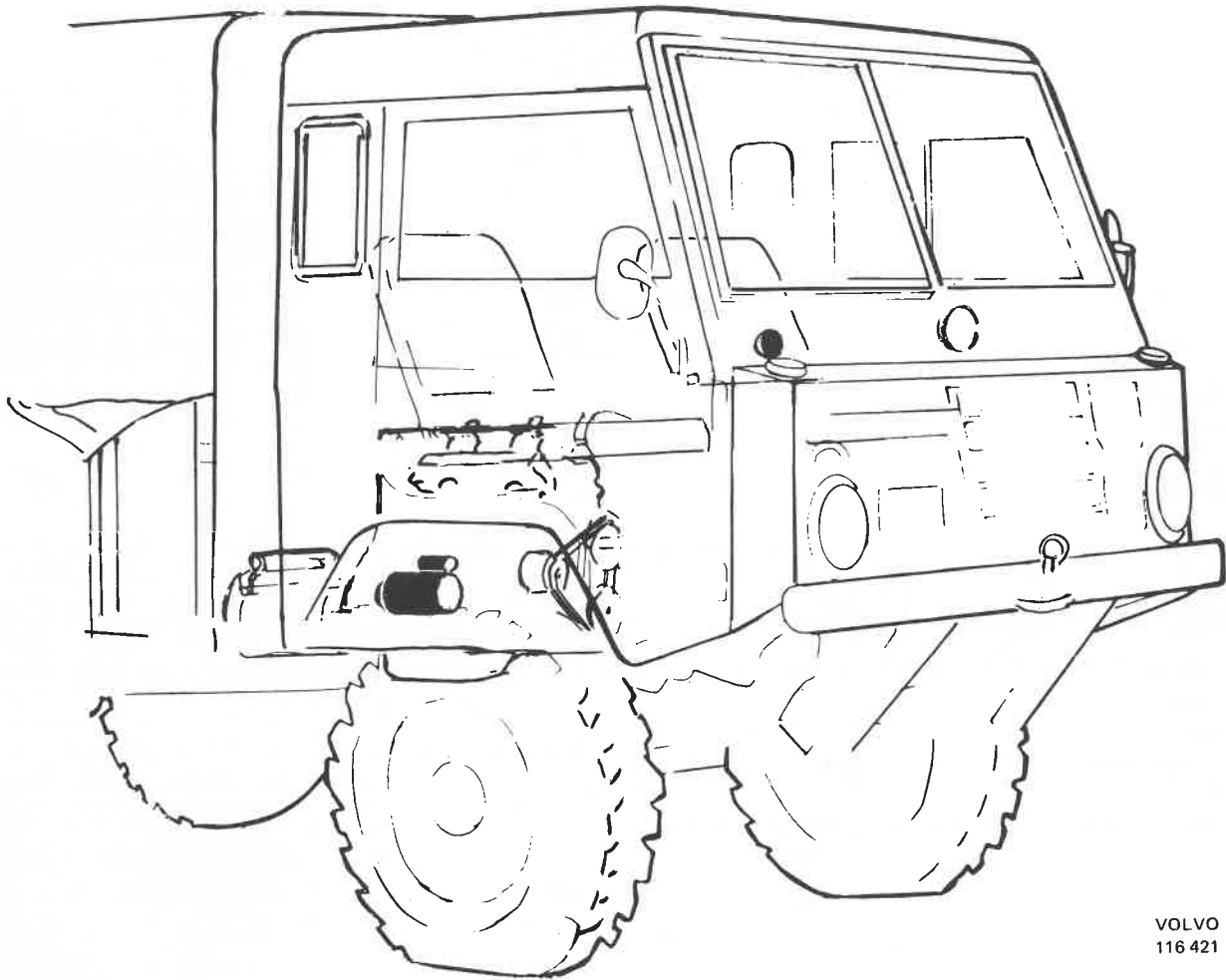
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Fig. 33-1. Starter motor

The starter motor is mounted on the flywheel housing on the left-hand side of the engine. It consists of a four-pole series-wound motor. The starter motor rotor shaft pinion moves axially to engage with the flywheel ring gear. The pinion is controlled by a solenoid.

Turning the ignition key to the starting position cuts

in the solenoid, causing the armature in the solenoid to be drawn in and the starter pinion to engage the ring gear on the engine flywheel.

When the armature has moved a certain distance, the contacts for the main current close and the starter motor starts running.

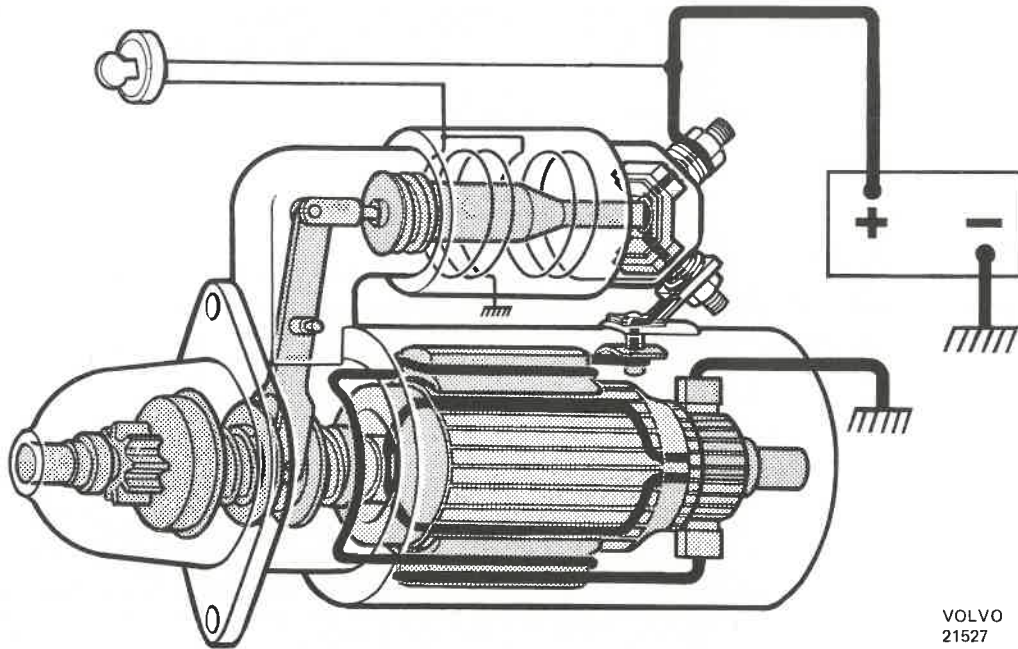


Fig. 33-2. Starter motor interior wiring

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Service Procedures

STARTER MOTOR

Testing in vehicle (locked starter motor)

Before starting to test the electrical system, check the battery positive and negative cables as well as the starter motor cables are functioning properly.

Connect measuring instruments as shown in Fig. 33-3.

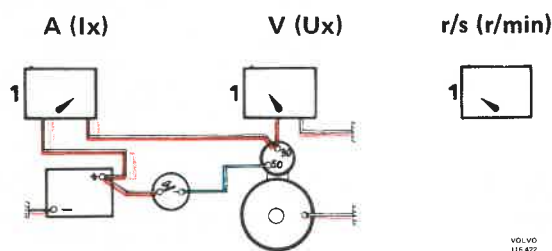


Fig. 33-3. Wiring diagram
Starter motor testing

Engage top gear and brake vehicle with handbrake and footbrake. Push in starter button. Keep it pressed in max. 5 seconds and read off the instrument.

Depending on the capacity of the battery and the state of charge, the read-off current must be connected to the test values of the maker according to the following formula:

$$I = \frac{I_x \cdot U}{U_x}$$

$I = 300-350$ A test value from maker

$U = 6$ V test value from maker

$I_x =$ Current measured in vehicle

$U_x =$ Voltage measured in vehicle

Example: Test values $I = 300-350$ A, $U = 6$ V
Measured value $I_x = 270$ A, $U_x = 5$ V

$$I = \frac{270 \text{ A} \cdot 6 \text{ V}}{5 \text{ V}} \quad I = 324 \text{ A}$$

324 A lies within the test value tolerance, which is 300-350 A. This indicates that the starter motor power consumption is correct.

Removing the starter motor

1. Disconnect the negative cable from the battery.
2. Remove the gear lever control ball joints from the gearbox and lift up the control tube, see Fig. 33-4.

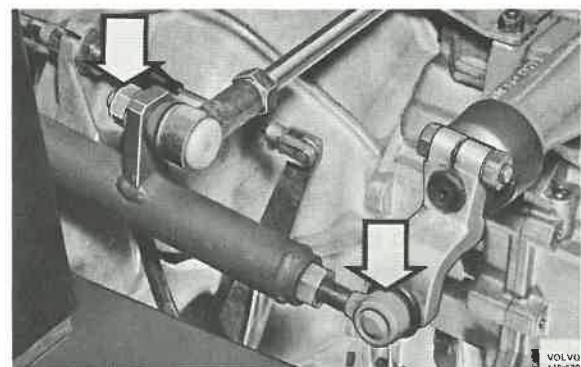


Fig. 33-4. Removing gear lever control ball joints

- Remove the cables from the starter motor, Fig. 33-5.

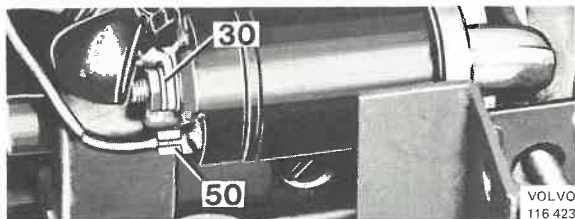


Fig. 33-5. Starter motor electrical connections

- Remove the screws, washers and nuts securing the starter motor to the flywheel casing and lift off the starter motor.

Checking the solenoid

Wire the solenoid according to Fig. 33-6. Test the voltage at terminal 50. It should be minimum 8 V. When the voltage is switched on, the solenoid should push out the pinion to the engaging position and it should keep it there as long as the voltage is on. When the circuit is broken, the solenoid should immediately disengage so that the pinion returns to the rest position.

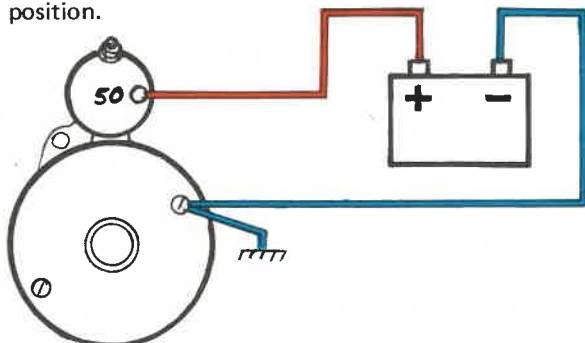


Fig. 33-6. Testing the solenoid

Clean the outside of the starter motor with alcohol. Remove the protective casing for the electric brushes. Place the starter motor on a test bench and connect up the instruments according to Fig. 33-7.

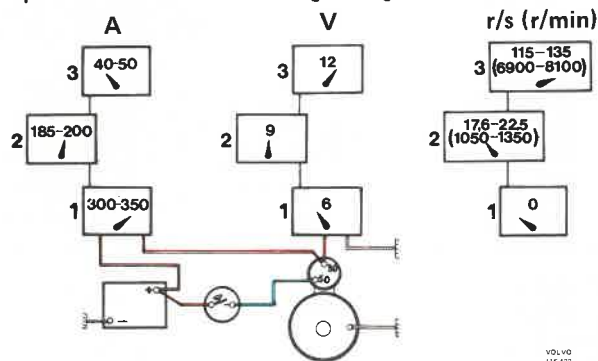


Fig. 33-7. Wiring diagram for testing starter motor

Note! The test bench ammeter should be provided with a shunt for minimum 500 A.

Fault

Reason

- | | |
|--|--|
| <ol style="list-style-type: none"> Low speed and current Low speed and high current. Powerful sparking, low rotation. Pinion engages, but returns to rest position before circuit is broken. Pinion does not return to rest position when circuit is broken. Solenoid switches on, but starter motor does not operate. | <p>Great resistance due to dirty commutator, worn electric brushes or too low brush spring pressure.</p> <p>Short-circuiting in solenoid windings. Rotor goes against pole shoes due to worn bearings or bent rotor shaft.</p> <p>Low spring pressure due to worn electric brushes or fatigued brush springs. Short-circuiting or partial breakage in rotor winding.</p> <p>Poor contact at terminal 50 or faulty solenoid.</p> <p>Pinion sticks on rotor shaft.</p> <p>Faulty solenoid, poor contact with electric brushes. Breakage in magnetic winding. Rotor jams in journaling.</p> |
|--|--|

Disassembling the starter motor

Unscrew both the screws securing the small cover on the front end of the shaft. Remove the cover, Fig. 33-8.

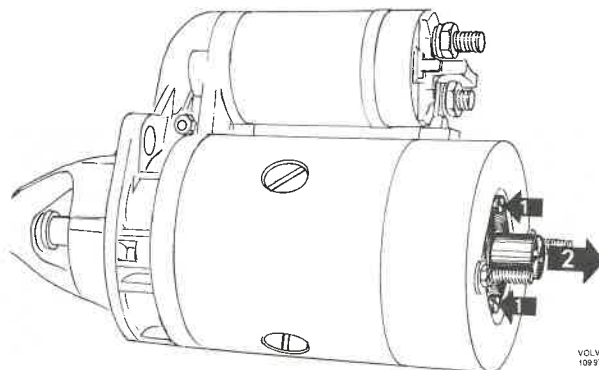


Fig. 33-8. Removing the cover

Lift off the lock washer and adjusting washers.
Remove the two bolts holding the commutator end frame. Remove the frame, Fig. 33-9.

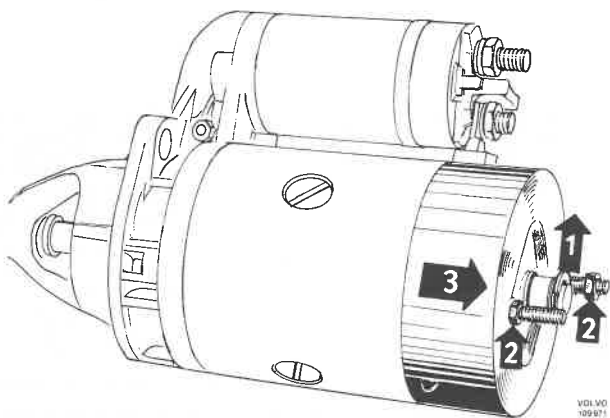


Fig. 33-9. Removing the adjusting washers and nuts

Lift up the brushes and holders.
Remove the brush bridge from the rotor shaft.
When the bridge is removed, the negative brushes also follow, but the positive brushes will remain in the field winding, Fig. 33-10.

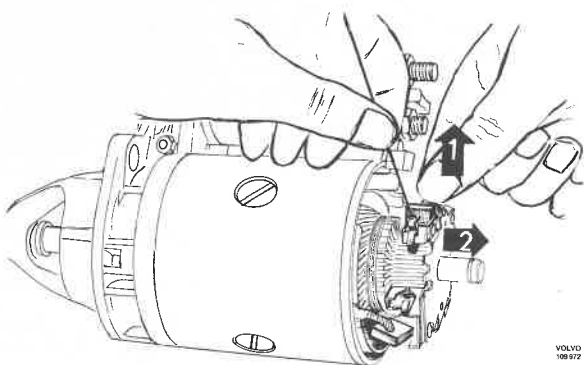


Fig. 33-10. Removing the brush bridge

Remove the nut holding the field terminal connection to the control solenoid.
Remove the screws securing the solenoid to the drive end frame.
Remove the solenoid, Fig. 33-11.

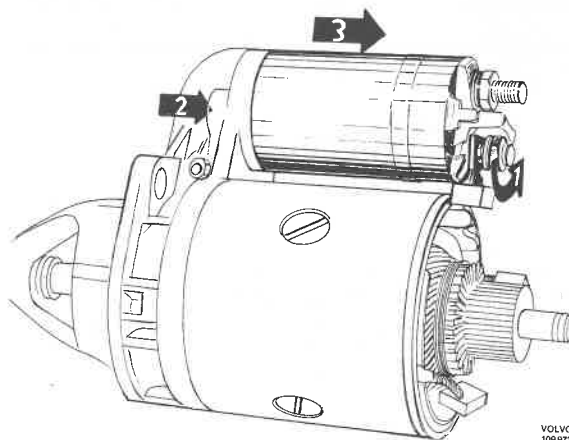


Fig. 33-11. Removing the solenoid

Remove the stator from the drive end frame, Fig. 33-12.

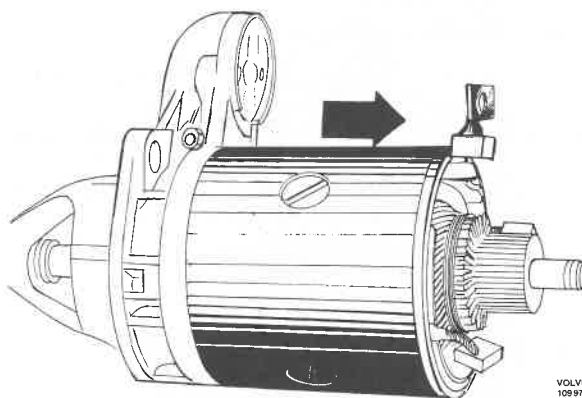


Fig. 33-12. Removing the starter motor housing

Remove the rubber washer and metal washer.
Remove the screw on which the shift lever is carried.
Lift the armature with pinion and lever out the drive end frame, Fig. 33-13.

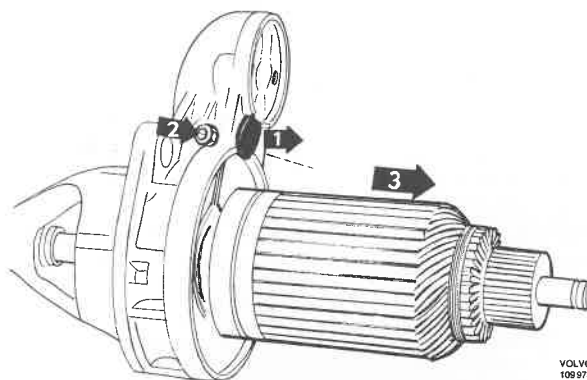


Fig. 33-13. Removing the rotor.

Knock back the stop washer with the help of a suitable sleeve. Remove the snap ring, stop washer and armature shaft, Fig. 33-14.

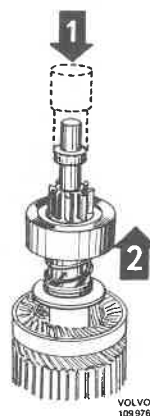


Fig. 33-14. Removing the pinion

Inspection

Examine the armature for mechanical damage. If the armature shaft is bent or worn, the armature should be replaced.

If the commutator is scored or unevenly worn, it should be turned, Fig. 33-15.

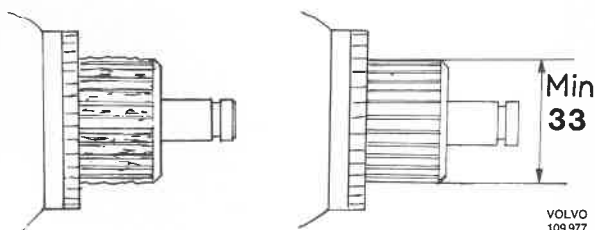


Fig. 33-15. Commutator

The commutator diameter must not be less than 33 mm (1.3"). After turning, the commutator should be checked with a micrometer. A radial throw of up to 0.08 mm (0.003") is permitted.

The insulation between the laminations should be milled down to 0.4 mm (0.016") below the surface of the laminations, Fig. 33-16.

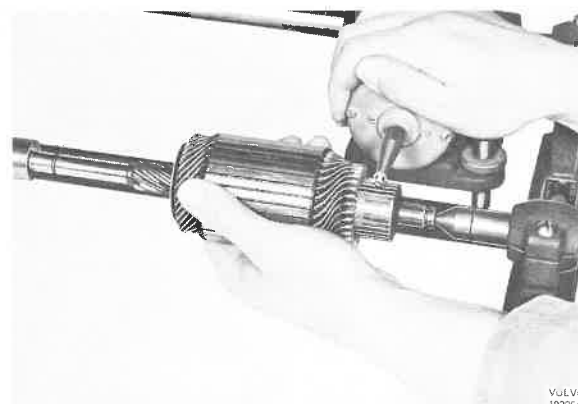


Fig. 33-16. Grooving the commutator

This work is carried out in a special apparatus, or if such is not available, with a ground-off hacksaw blade.

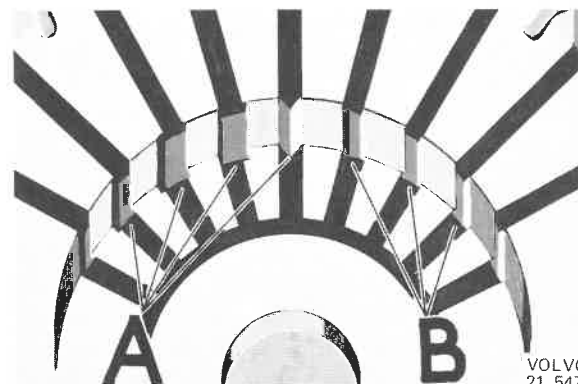


Fig. 33-17. Commutator

- A. Incorrectly milled
- B. Correctly milled

Examine the armature for shorts by placing it in a growler. Switch on and hold a hacksaw blade a few mm from the armature, Fig. 33-18.

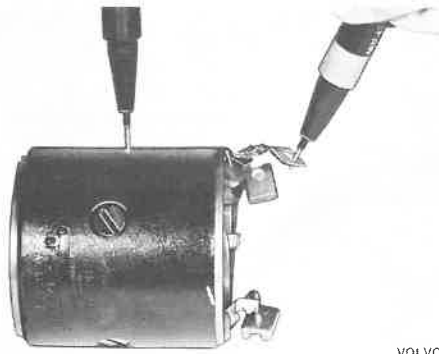


Fig. 33-18. Testing the rotor

If the blade vibrates in any position when the armature is rotated, one of the following faults can be the reason: shorting through the armature frame, shorting in the commutator or between the windings.

A shorted armature should be replaced by a new one.

Check the pole housing with 40 volts A.C., Fig. 33-19.

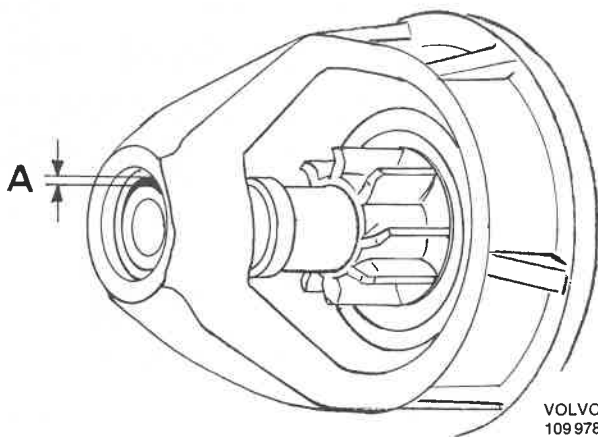


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Fig. 33-19. Starter motor housing

Examine the drive end frame and brush holders.

If damaged or excessively worn, they must be replaced. A bearing clearance "A" between the shaft and bushing of up to 0.12 mm (0.005") may be considered permissible, Fig. 33-20. Examine the other parts and replace any that are damaged or worn. The snap ring should always be replaced with a new one, since it may have been damaged or lost its tension when being removed.



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Fig. 33-20. Clearance, rotor shaft and drive end frame

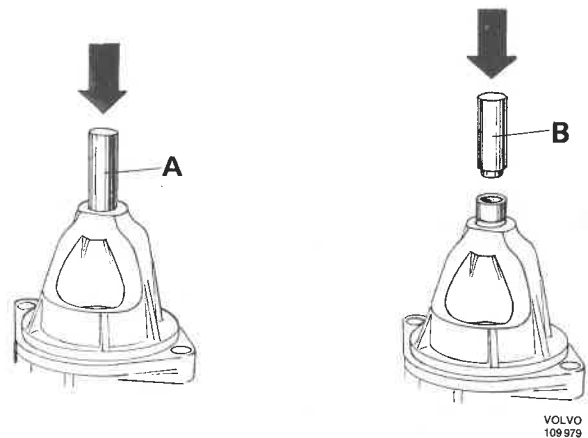
Replacement of self-lubricating bushings

(Starter motor disassembled)

Before the new bushings are installed, they should be immersed in oil (Bosch 01 1 V 13 or corresponding) for at least 1/2 hour. Otherwise they will wear rapidly and at worst seize.

The bushings are supplied with correct fit and should not be machined, otherwise the pores may become blocked and deteriorate the self-lubrication.

Drive out the worn bushings with a suitable tool, A. Clean the hole for the bushings and cut away any burr. Press in the new bushings with a suitable drift, B, Fig. 33-21.



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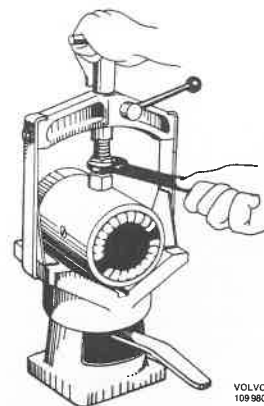
Fig. 33-21. Replacing a bushing

Replacement of field coils

(Starter motor disassembled)

Mark the poles and pole housing in a suitable manner so that they are re-fitted in the same position.

Place the stator in the rotating clamping block (Bosch EFAW 9 or corresponding) and remove the pole screws. Remove the stator from the rotating clamping block and remove the pole shoes and field coils, Fig. 33-22.



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Fig. 33-22. Removing pole shoes

Push in the new field coils and pole shoes into the stator, Fig. 33-23. Before installing the field coils, warm them slightly. Make sure the pole shoes are located according to the marks.

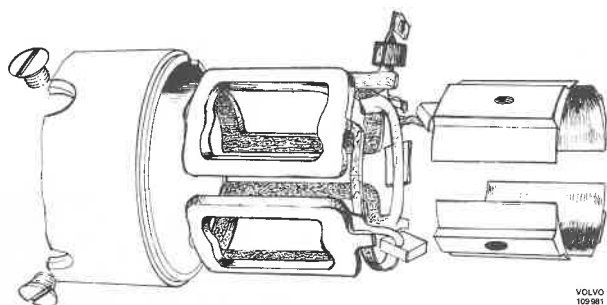


Fig. 33-23. Installing field coils

Press in a suitable drift and place the stator in the rotating clamping block. Tighten up the pole shoes. Force out the press drift with a drift press. Check the installed field coils for breakage and shorts.

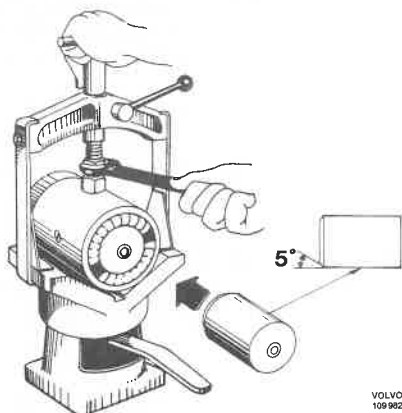


Fig. 33-24. Rotating clamp

Replacement of brushes

(Alternator removed)

Brushes worn down less than 14 mm (approx. 1/2") should be replaced with new ones. Replacement is as follows:

1. Carry out steps 1 to 5 under "Disassembling alternator".
2. Heat the brushes loose from their respective attachments on the brush holder and field coils. This can be done rapidly with the help of a properly heated soldering iron.

3. Solder well the new brushes with a properly heated soldering iron.

The solder must not run down onto the brush wires, since this will impede the movement of the brushes in the brush holders.

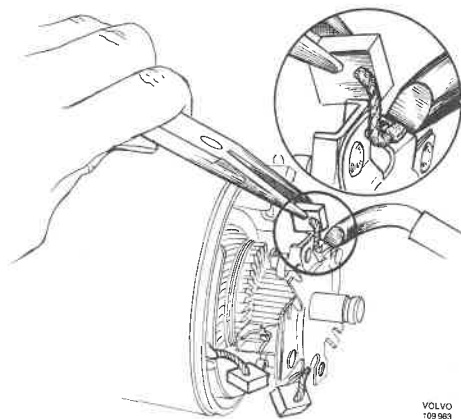


Fig. 33-25. Replacing electric brushes

Starter motor assembly

Lubricate the parts of the starter motor according to the Fig. Use Bosch lubricant (or equivalent) in accordance with the following directions:

1. Ft 2 V 3 Place a thin layer of grease on the insulation washers, the shaft end, the adjusting washers and lock washer.
2. OI 1 V 13 Place the bushing in oil for 1/2 hour before installation.
3. Ft 2 V 3 Apply plenty of grease to the armature thread and the engaging lever groove.
4. Ft 2 V 3 Place a thin layer of grease on the armature shaft.
5. OI 1 V 13 Place the bushings in oil for 1/2 hour before installation.
6. Ft 2 V 3 Lubricate the engaging lever joints and the iron core of the solenoid with a thin layer of grease.

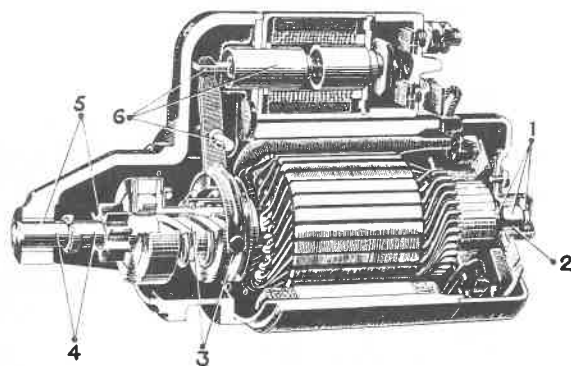


Fig. 33-26. Lubricating scheme

Install the starter pinion, the stop washer and snap ring. Pull the stop washer into position with a suitable puller, Fig. 33-27.

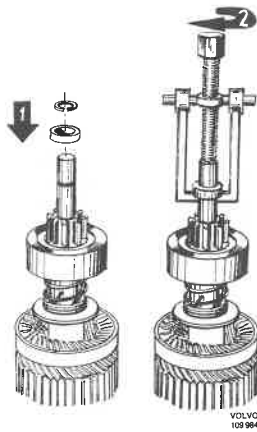


Fig. 33-27. Installing the pinion

Install the engaging arm on the starter pinion. Install the armature in the drive end frame. Install the screw for the engage arm.

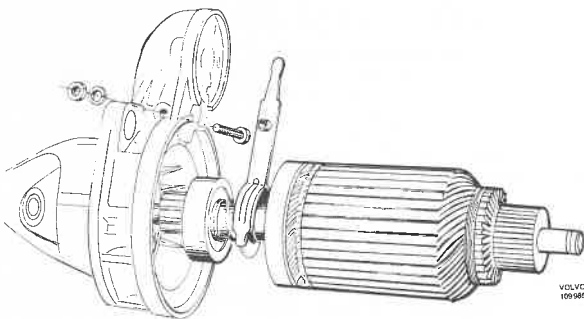


Fig. 33-28. Installing the engaging arm

Install the metal washer and rubber washer on the drive end frame.

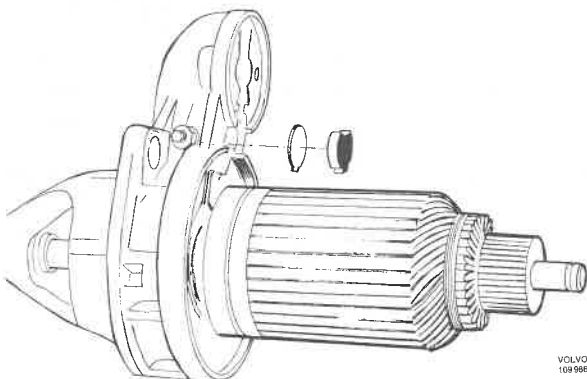


Fig. 33-29. Installing the washers

Install the solenoid, Fig. 33-30.

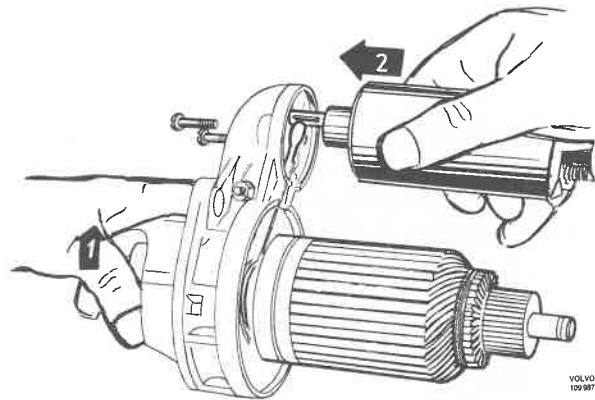


Fig. 33-30. Installing the solenoid

Install the starter motor housing and fit the solenoid nut.

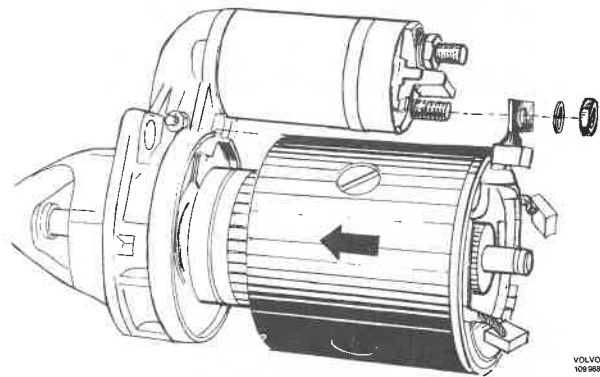


Fig. 33-31. Installing starter motor housing

Place the brush bridge in position. Install the brushes.

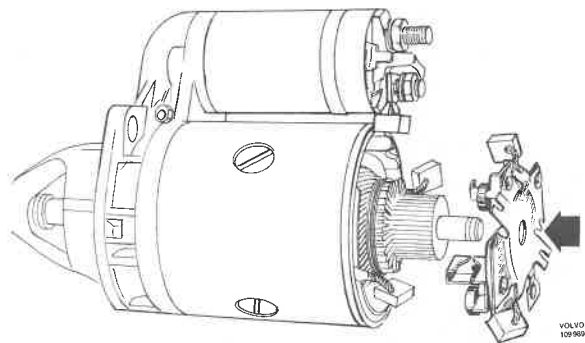


Fig. 33-32. Installing the retainer for the electric brushes

Install the commutator bearing frame.
Screw the starter motor together with the two long bolts.

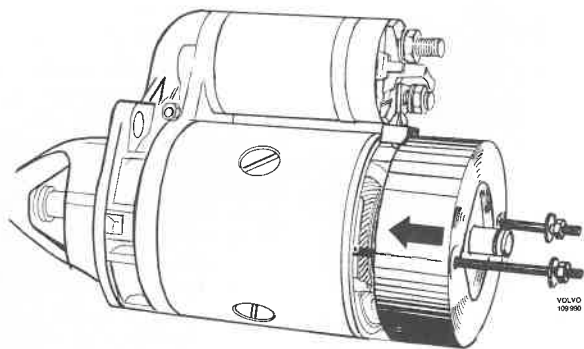


Fig. 33-33. Installing the commutator bearing frame

Install the adjusting washers and the snap ring on the shaft end. Check that the armature axial clearance is 0.05–0.3 mm (0.002–0.012"). If necessary adjust with a suitable number of washers until the clearance is correct.

Screw tight the small casing over the shaft end.

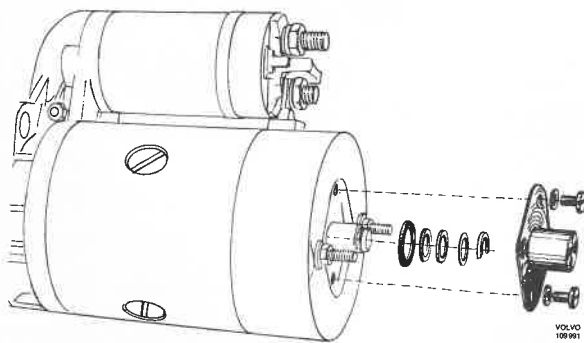


Fig. 33-34. Installing washers and cover.

Before installing the starter motor, it should be run on a test bench. Compare figures from Fig. 33-7.

Installing the starter motor

1. Screw the starter motor into position on the flywheel casing and connect up the cables, see Fig. 33-35.
2. Install the gear lever control ball joints on the gearbox.

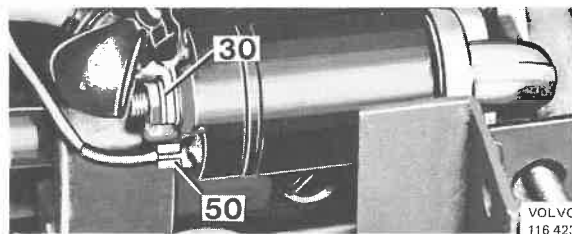
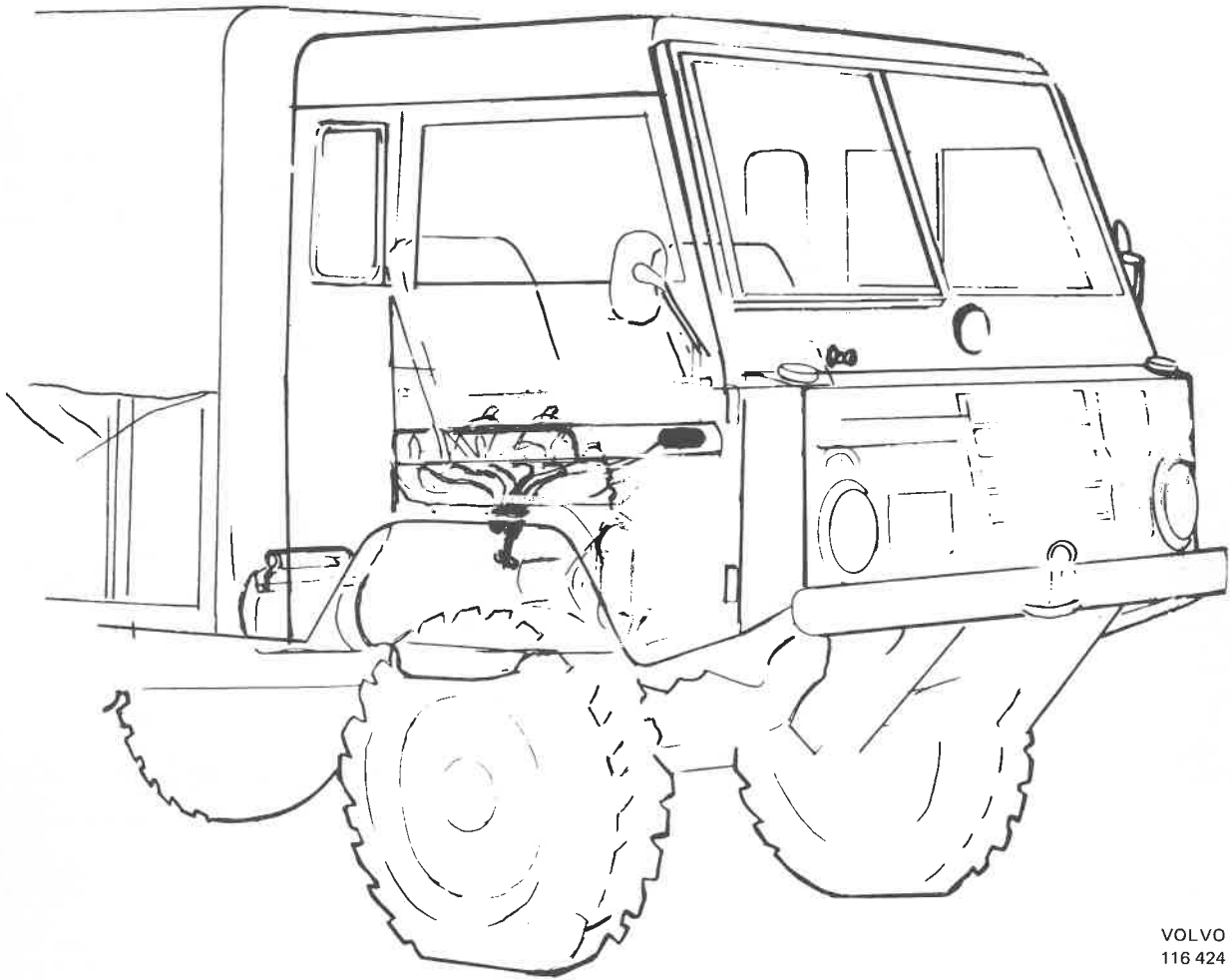


Fig. 33-35. Starter motor electrical connections

3. Connect the negative battery cable to the battery.
4. Test the starting function.

GROUP 34 IGNITION SYSTEM

Description



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Fig. 34-1. Ignition components

The ignition system is of the battery-ignition type. It consists of the following main components: ignition

coil, distributor, ignition, ignition cables and spark plugs.

IGNITION COIL

The ignition coil is situated in the engine compartment, see Fig. 34-2.

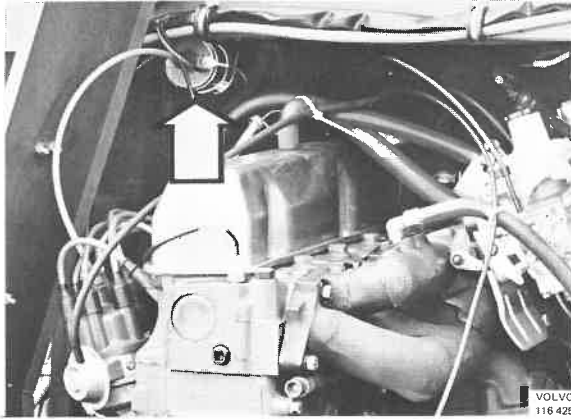


Fig. 34-2. Ignition coil installed

IGNITION

The ignition has two positions:

1. Switched-off position (the ignition key can be removed), with voltage on terminal 30.
2. Ignition position (starting and driving position), with voltage on terminals 30, 15 and 61.

DISTRIBUTOR

The distributor is placed on the left-hand side of the engine, see Fig. 34-3, and is driven from the camshaft. Its setting in relation to engine speed is regulated by the centrifugal governor located under the breaker plate, see Fig. 34-4. Its setting in relation to engine load is regulated by the vacuum governor which is mounted on top of the distributor (see A, Fig. 34-3).

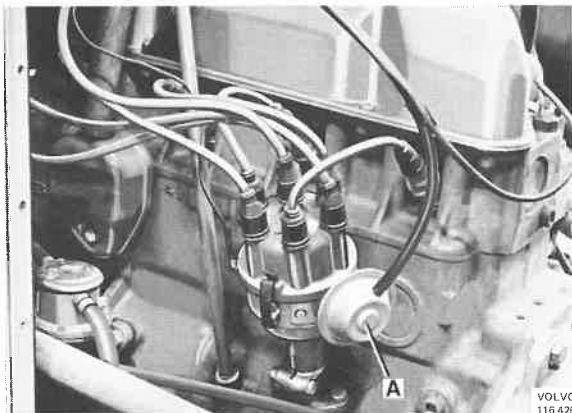


Fig. 34-3. Distributor with ignition cables
Firing order: 1-5-3-6-2-4

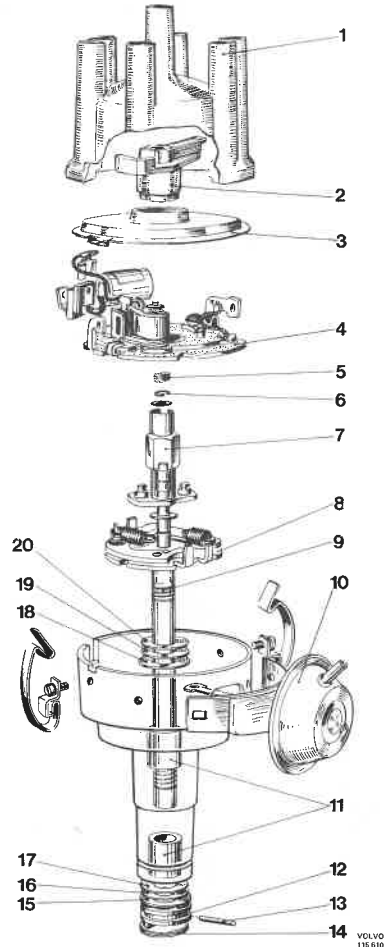


Fig. 34-4. Exploded view of distributor

1. Distributor cap
2. Rotor
3. Condensate trap
4. Breaker plate
5. Lubricating felt
6. Circlip
7. Breaker cam
8. Centrifugal governor
9. Shaft
10. Vacuum governor
11. Bushings
12. Companion flange
13. Pin
14. Resilient ring
15. Large steel washer
16. Fibre washer
17. Small steel washer
18. Large steel washer
19. Fibre washer
20. Small steel washer

Service Procedures

IGNITION COIL

Removing

Disconnect the cable terminals and unscrew the screw, Fig. 34-5, sufficiently to remove the ignition coil.

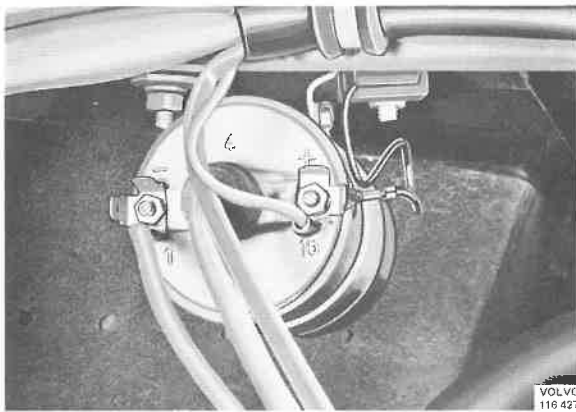


Fig. 34-5. Ignition coil with cable terminals

Installing

Install the coil and tighten up the clamp screw. Connect up the cables. The cable from the distributor must be fixed to the negative output on the coil.

Replacing the ignition

1. Disconnect the negative battery cable.
2. Remove the nut (A, Fig. 34-6).

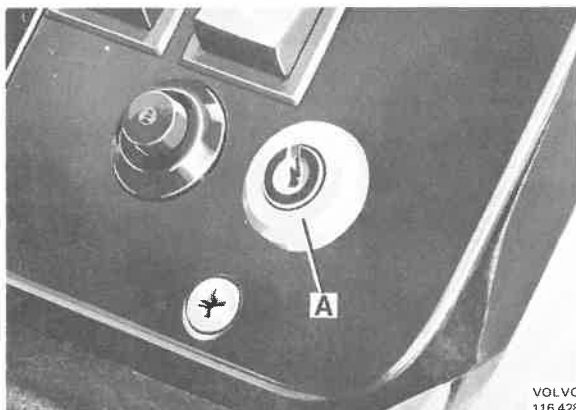


Fig. 34-6. Ignition

3. Lift forward the ignition.
4. Transfer the cables to the new ignition.
5. Install the ignition and screw it tight with the nut.

6. Connect the negative cable to the battery and place the cover over the battery.

SUPPRESSORS

Each spark plug has a suppressor. Its resistance must be 1000Ω at 68°F . The distributor rotor should have a resistance of $4500\text{--}6000 \Omega$. If the suppressors or rotor do not have these resistances, they must be replaced.

DISTRIBUTOR

Removing

1. Unclasp the lock clasps for the distributor cap and lift off the cap, see Fig. 34-7.

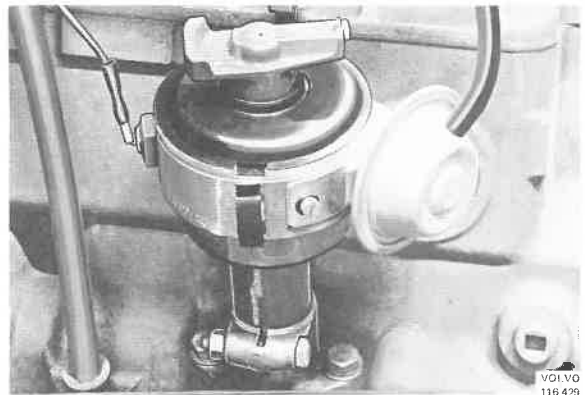


Fig. 34-7. Distributor cap removed

2. Disconnect the low-voltage cable at the distributor. Remove the vacuum hose from the vacuum governor. Lift off the distributor rotor and remove the condensate trap. Release the retaining screw and pull up the distributor, see Fig. 34-8.

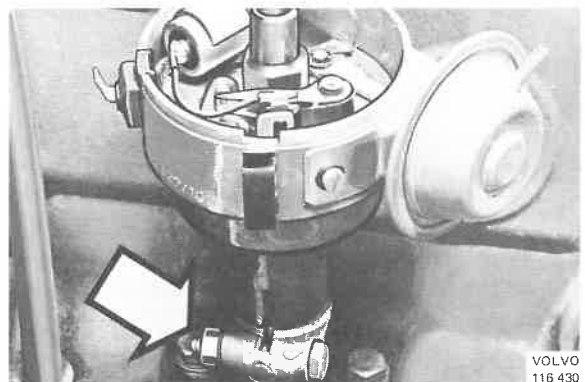


Fig. 34-8. Removing distributor

Disassembling

1. Remove the vacuum governor, see Fig. 34-9.

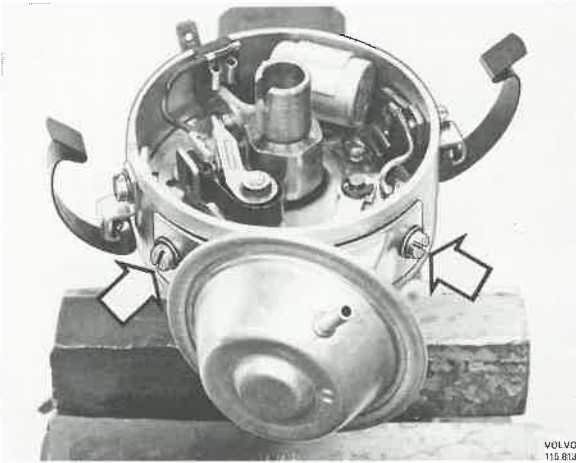


Fig. 34-9. Removing vacuum governor

2. Unclasp the lock clasps from the cap. Disconnect the cable from the breaker contacts and remove the condenser with its low-voltage terminal, see Fig. 34-10.

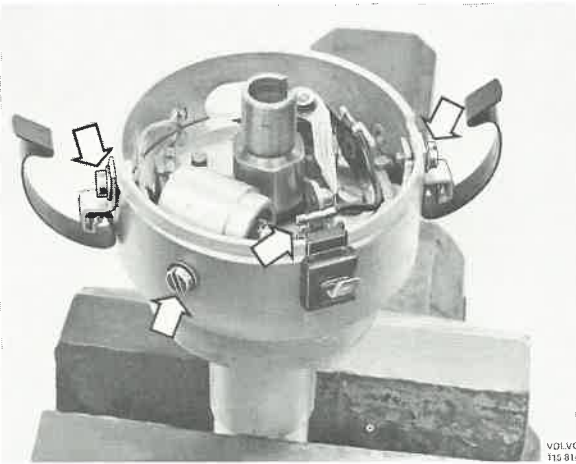


Fig. 34-10. Removing low-voltage terminal

3. Mark the location of the breaker plate in relation to the distributor housing and lift up the plate.
4. Release the springs for the centrifugal governor. Remove the lubricating felt and line-up mark to ensure that the breaker cam is re-fitted in the right place in relation to the distributor shaft, see Fig. 34-11.



Fig. 34-11. Marking breaker cam and distributor shaft

5. Fix the breaker cam in a vice with soft jaws. Carefully tap on the distributor housing with a plastic mallet until the circlip loosens, see Fig. 34-12.

Take care of the circlip and washer

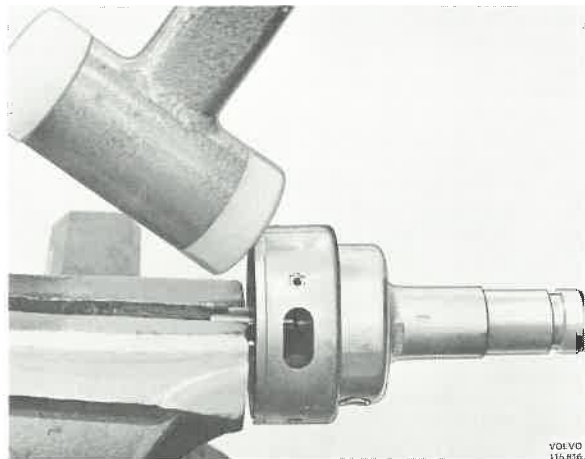


Fig. 34-12. Removing breaker cam

6. Remove the resilient ring and line-up mark the flange to ensure that it is re-fitted in the proper place in relation to the distributor shaft. Tap out the pin, see Fig. 34-13. Lift off the flange and pull up the distributor shaft. Take care of the washers.
7. Remove the lock pins for the centrifugal weights and lift off the weights.

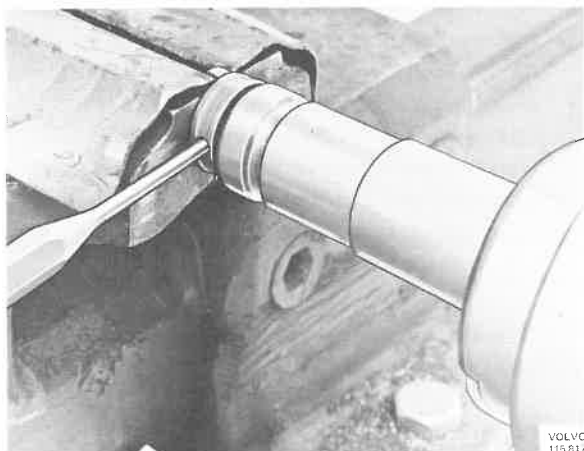


Fig. 34-13. Removing the flange pin

Checking and replacing parts

Breaker plate

The contacts should be smooth and even on the contact surfaces. The colour of the contact should be grey.

Replace oxidized or burnt contacts. The breakers can get worn after being used for some time and the spring can become fatigued, so the contacts should be replaced if the distributor is disassembled for some reason or other.

Distributor shaft

The clearance between the distributor shaft and breaker cam may not exceed 0.1 mm (0.004"). The cams on the breaker cam may not be scored or worn since this would alter the dwell angle.

The holes in the centrifugal weights may not be oval or deformed in any other way. The springs for the weights may not be deformed or damaged.

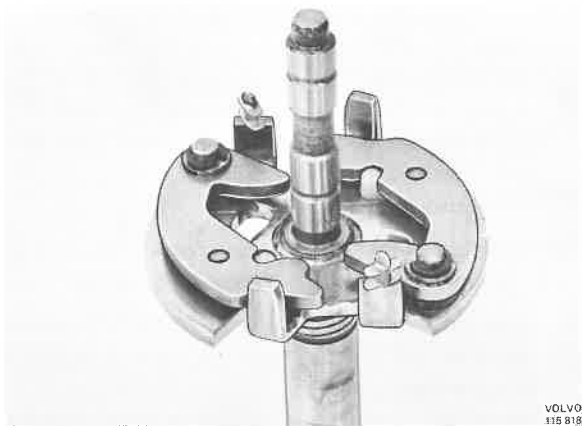


Fig. 34-14. Shaft with weights

Distributor housing

Check to make sure that the clearance between the distributor housing and shaft does not exceed 0.2 mm (0.008"). If the clearance is excessive, replace the bushings and, if this is insufficient, also the shaft.

Assembling

Lubricate the parts of the distributor according to the directions give on Fig. 34-15.

Use Bosch lubricant or corresponding according to the designations given below.

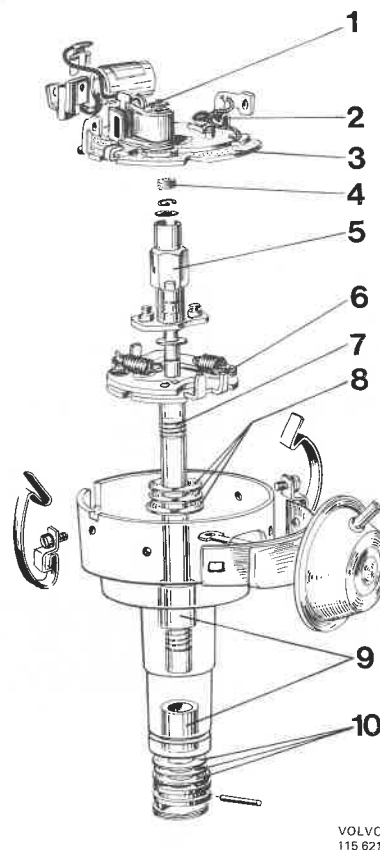


Fig. 34-15. Lubricating chart

Ft = grease Ol = oil

- | | | |
|-----|--|-----------|
| 1. | Coat the fibre tab with a light layer of grease | Ft 1 v 4 |
| 2. | Grease the top and the ball for the vacuum governor | Ft 1 v 26 |
| 3. | Oil the breaker plate | Ol v 2 |
| 4. | Douse the lubricating felt | Ol 1 v 13 |
| 5. | Cover the breaker cam with a light layer of grease | Ft 1 v 4 |
| 6. | Lubricate the weights sparingly | Ft 1 v 4 |
| 7. | Oil the shaft before fitting it | Ol 1 v 13 |
| 8. | Grease the washers | Ft 2 v 3 |
| 9. | The bushings should lie in oil for at least half an hour before fitting them | Ol 1 v 13 |
| 10. | Grease the washers | Ft 2 v 3 |

1. Place the centrifugal weights in position and lock them tight with the lock pins.
2. Place the washers on the distributor and fit the shaft through the housing.
3. Fit the washers and flange. Check the line-up marks to ensure that parts are replaced in the same position as they were when removed. Fit the pin and the resilient ring.
4. Check the line-up marks and fit the breaker cam with washers, circlip and lubricating felt. Secure the springs to the breaker cam.
5. Check the line-up marks and fit the breaker plate with the two lock clasps. Fit the condenser, and also fit the low-voltage output on the housing.
6. Fit the vacuum governor with screws and lock pin. Connect the cable from the breaker contacts.
7. Test-run the distributor, see under the heading "Testing the distributor on a test bench".
8. Place the condensate trap so that it fits in the recess on the distributor housing. Fit the distributor rotor.

Test-running distributor on test bench

1. Run the distributor at approx. 8.3 r/s (500 r/min) in its ordinary direction of rotation (anti-clockwise) and adjust the dwell angle of the breaker contacts to $42^{\circ} \pm 3^{\circ}$ according to below.
2. Slightly slacken the screw for the breaker contacts. Then place a screwdriver in the recess, see Fig. 34-16, and turn the screwdriver until the dwell angle is correct. Tighten up the screw for the breaker contacts.



Fig. 34-16. Recess for dwell angle

3. Run the distributor and adjust the protractor on the test bench so that a marking comes opposite 0° at such a low speed that the centrifugal governor cannot function, below 3.3 distr. r/s (200 distr. r/min). Slowly increase the speed and read off the values at the prescribed degrees. A newly greased distributor should first be driven up to max. speed several times. The permitted times for the centrifugal governor is $\pm 1^{\circ}$.
4. Run the distributor at low speed and adjust the protractor so that the marking is obtained at 0° . Connect the vacuum hose from the test bench to the vacuum governor. Gradually increase the vacuum and read off the values at the prescribed degrees. Compare the firing advance curve, see Fig. 34-17.

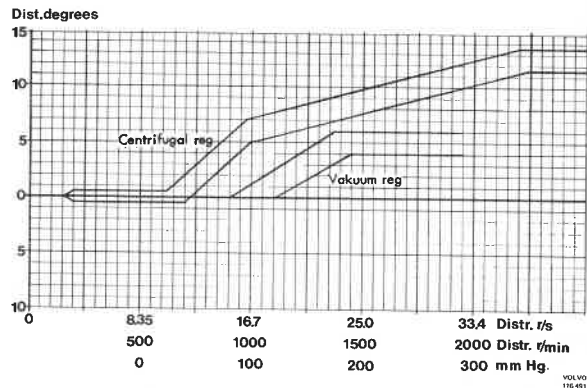


Fig. 34-17. Firing advance curve

Installing

1. Install the distributor.
2. Press the distributor downwards while turning the distributor rotor at the same time. When the distributor has gone down approx. 5 mm (3/16") and the rotor cannot be turned any longer, then the distributor flange is in the groove on the distributor pinion.
3. Rotate the distributor housing so that it takes up the same position as it did before being removed.
4. Connect the low-voltage cable to the low-voltage terminal and also connect the vacuum hose. Fit the distributor cap.
5. Start the engine and adjust the firing. (If the engine does not start, rotate the distributor housing until the engine does start.)

Adjusting the ignition

The ignition should be adjusted while the engine is running and with the help of a Stroboscope. Adjust as follows:

1. Clean the vibration damper so that the timing mark can be seen.
2. Disconnect the hose from the vacuum governor.
3. Connect the Stroboscope to No. 1 cylinder spark plug and the battery.
4. Start the engine and run it at approx. 13.3 r/s (800 r/min). Aim the Stroboscope at the timing mark on the vibration damper. Slacken the distributor retaining screw (1), and turn it until the firing position is 10° . Tighten up the distributor and check that the firing position and speed have not altered.

5. Remove the Stroboscope and connect the hose to the vacuum governor.

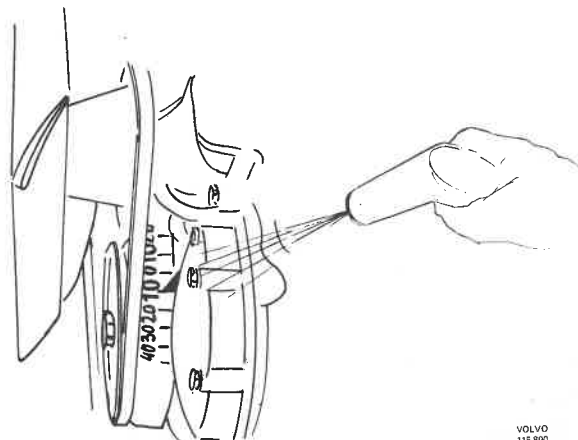


Fig. 34-18. Vibration damper with graduation

The firing setting can be adjusted as follows with the engine switched off:

1. Clean the vibration damper in order to see the firing mark. Remove the cap and condensate trap.
2. Connect a 12 V lamp between the engine body and the low-voltage terminal on the distributor.
3. Turn the ignition key to the firing position.
4. Slowly rotate the crankshaft (by hand) in the rotational direction of the engine until the 10°

timing mark on the vibration damper is opposite the firing mark. The distributor rotor should then point to the line-up mark on the edge of the distributor housing. The test lamp should light.

5. If the lamp does not light, slacken the distributor and turn it slowly in its direction of rotation until the lamp does light. When the lamp lights, tighten up the distributor.
6. If the lamp lights earlier than according to point 4, slacken the distributor and turn it slowly in its direction of rotation until the lamp goes out. Then tighten up the distributor.

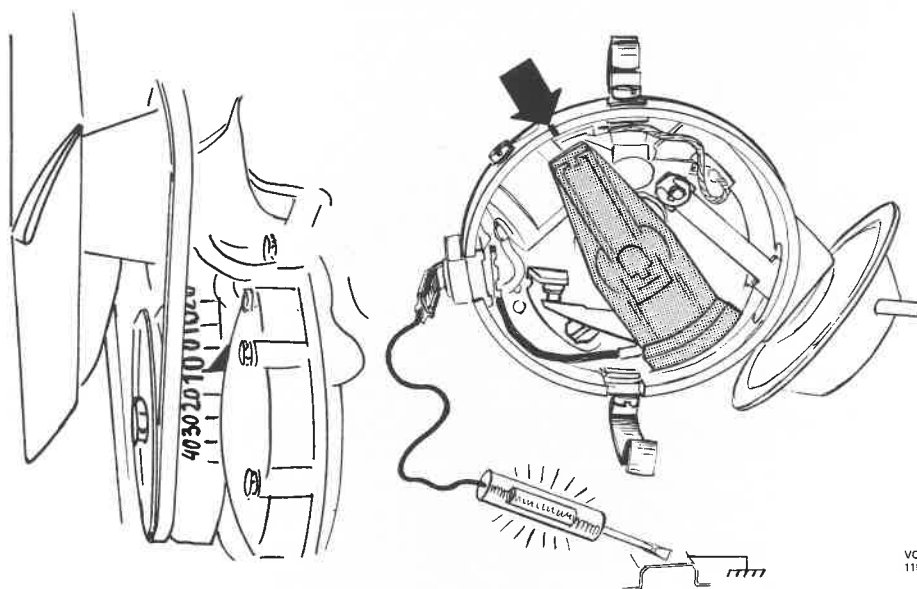


Fig. 34-19. Basic setting

Replacing the breaker contacts

The breaker contacts can be replaced in the vehicle, but the distributor must be disconnected from the block.

1. Lift off the distributor arm and condensate trap.
2. Disconnect the cable from the low-voltage terminal.
3. Remove the old contacts.
4. Fit the new contacts and re-connect the cable to the low-voltage terminal.
5. Check to make sure that vertically the breaker contacts are situated properly and that they are flat. This adjustment can be done with a special tool, e.g., Bosch EFAW 57. But only the fixed contact may be bent.
Cover the breaker cam and fibre tab with a light layer of grease (1, Fig 34-15).
6. Clean the breaker contacts with trichloroethylene or chemically pure petrol.
7. Run the distributor on a test bench and adjust according to the distributor data.
8. Fit the condensate trap and the distributor rotor.

GROUP 35 LIGHTING

Description

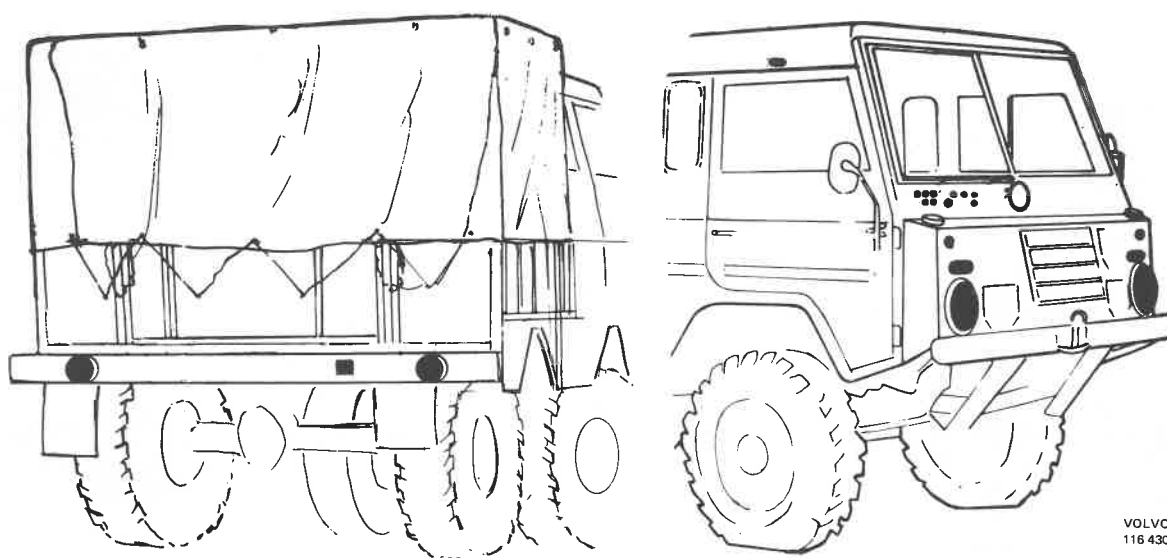
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Fig. 35-1. Vehicle lighting

To switch between fullbeams and dipped beams, move the direction indicator lever towards the steering wheel. This causes the step relay, Fig. 36-28, to switch on the beams.

The tail lights are provided with separate bulbs for the tail light, black-out tail light, stop lights, black-out stop lights and direction indicators.

The vehicle is equipped with a switch for the black-out lighting. With the black-out lighting switch, it is possible either to switch off all the lighting or reduce the lighting points to a minimum.

Service Procedures

HEADLAMPS

Checking and adjusting

Check the headlamp glass. If it has been damaged by gravel, or if it is cracked or defective in any other way, replace the inserts complete with bulbs (Sealed Beam). If a headlamp glass has been damaged by gravel, etc., its lighting will have deteriorated. And it can also give rise to irritating sub-beams.

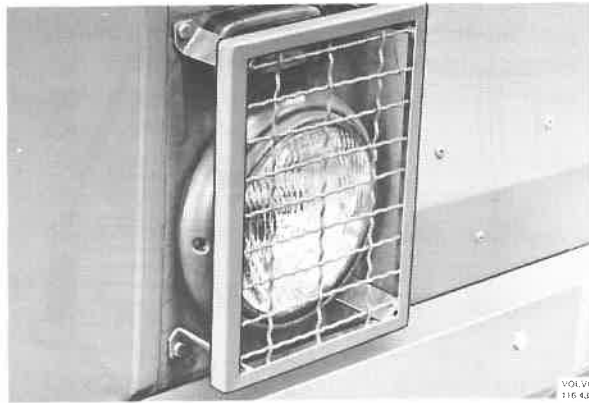


Fig. 35-2. Headlamp with grille

If the reflector is mat, buckled or damaged in any other way, replace it complete. The headlamps can deteriorate so much after 200 hours of operation that the reflector should be replaced. The headlamps can be adjusted according to current regulations. But an approved light-adjusting apparatus should be used for the adjustment.

The lighting is adjusted by manipulating the screws (1 and 3, Fig. 35-3). Screw 1 adjusts the lighting laterally and screw 3 vertically.

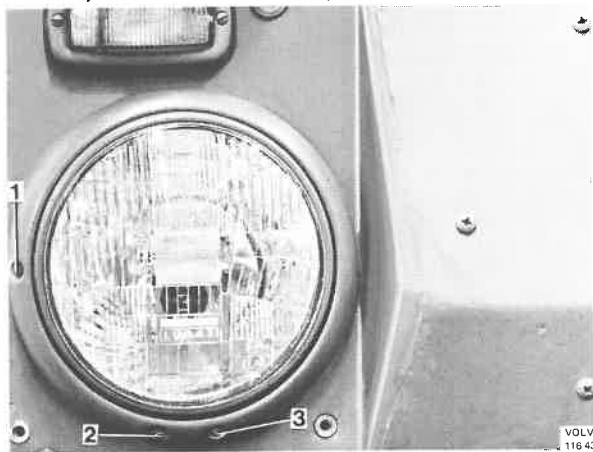


Fig. 35-3. Headlamp without grille

1. Adjusting screw, lateral adjustment
2. Retaining screw
3. Adjusting screw, vertical adjustment

Replacing the headlamp insert (complete with rim, retainer ring and bulb)

1. Remove the protective grille and the headlamp rim screw.
2. Lift forwards the rim with insert and retainer ring. Remove the connector from the insert, Fig. 35-4.

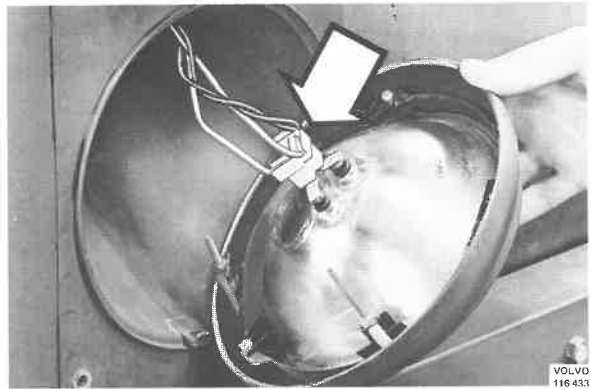


Fig. 35-4. Headlamp insert (Sealed Beam)

3. Fit the connector on the new insert. Place the insert with rim and retainer ring in position.
4. Re-fit and tighten up the screw securing the rim and fit the protective grille.

SIDE AND DIRECTION INDICATOR LIGHTS

Replacing the bulbs

1. Remove the protective grille and the screws securing the glass.
2. Remove the faulty bulb by pressing it in and turning it (bayonet type), see Fig. 35-5.



Fig. 35-5. Side and direction indicator bulbs

3. Fit the new bulb. (Do not touch the bulb globe with your fingers.)
4. Wipe the light glass with a moist cloth and fit it with the two screws.
5. Fit the protective grille.

TAIL LIGHTS

Replacing the bulbs in the tail lights.

1. Remove the grille and the screws retaining the glass, see Figs. 35-6 and 35-7.

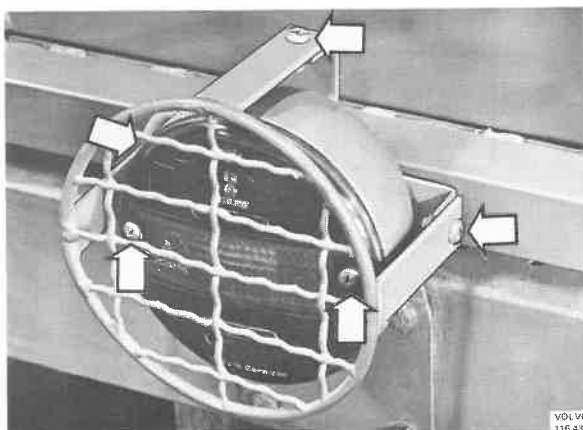


Fig. 35-6. Tail light with grille

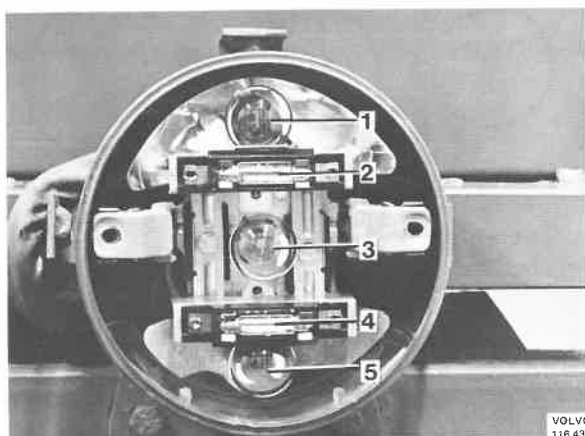


Fig. 35-7. Tail light bulbs

1. Stop light, 23 W
2. Stop light, 3 W
3. Direction indicator, 23 W
4. Tail light, 3 W
5. Tail light, 10 W

2. Remove the faulty bulb by pressing it in and then turning it, or if it is of the coiled type, by pulling it straight out.

3. Fit the new bulb, but do not touch the globe with your fingers. Wipe the light glass with a moist cloth. Fit the glass and the grille.

COURTESY LIGHT

Replacing the bulb

1. Move the glass by pulling it rearwards, see Fig. 35-8.

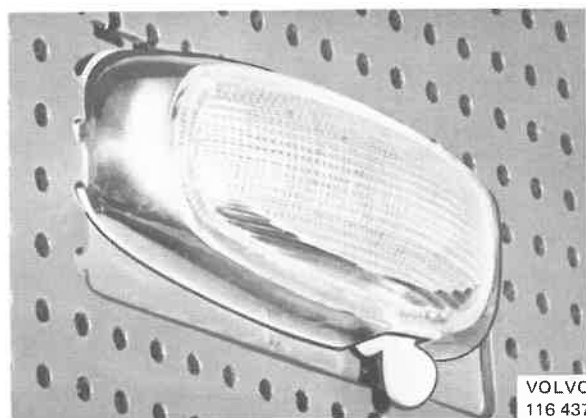


Fig. 35-8. Courtesy lighting

2. Remove the bulb and fit a new one, see Fig. 35-9.
3. Place the glass in position and push it straight in.

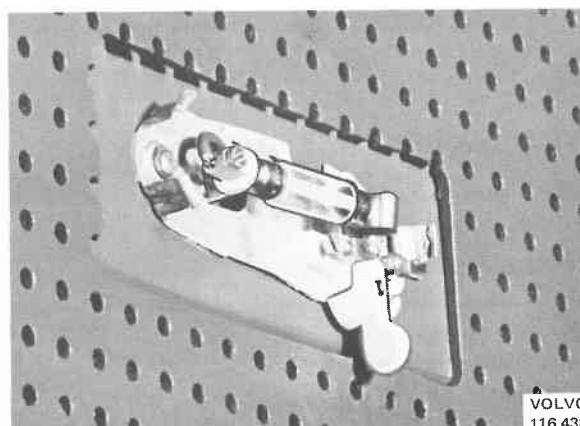


Fig. 35-9. Courtesy light bulb

INSTRUMENT PANEL AND SWITCH LIGHTING

Fig. 35-10 shows how the instruments and switches are lighted. The switches and instruments used for black-out purpose cross the rheostat.

Replace the bulbs in the switches and instruments.

NOTE! The cables running to the bulb retainers for the switches are **earth cables**.

The cables running to the retainers for the instrument bulbs are feed lines direct from the rheostat.

1. Disconnect the negative battery cable from the battery.
2. Separate the bulb retainer from the switch and instrument by pulling it straight out.
3. Remove the faulty bulb by pressing it in and turning it. Fit the new bulb.
4. Fit the bulb retainer in the switch or instrument by pushing it straight in.
5. Re-fit the negative battery cable to the battery.

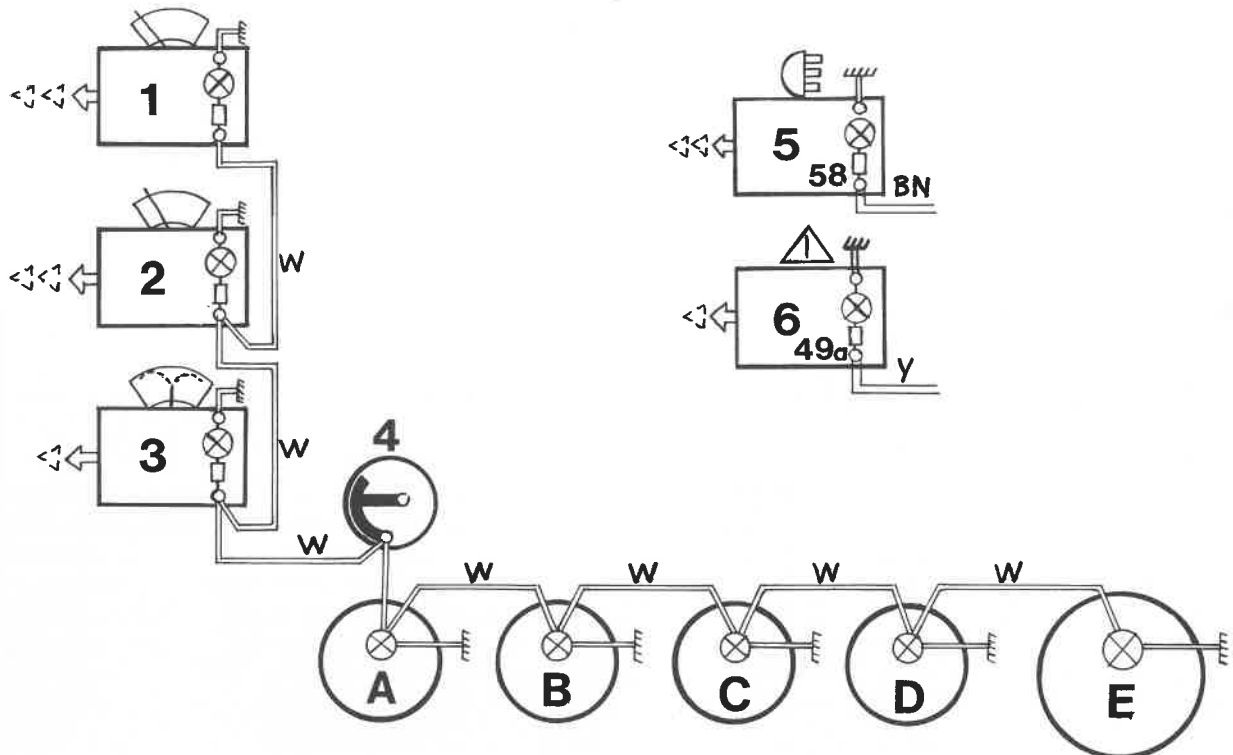


Fig. 35-10. Lighting in switches and instruments

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- | | |
|------------------------------|-----------------------|
| 1. Switch, windscreen wiper | A. Fuel gauge |
| 2. Switch, windscreen wiper | B. Ammeter |
| 3. Switch, windscreen washer | C. Temperature gauge |
| 4. Rheostat | D. Oil pressure gauge |
| 5. Switch, lighting | E. Speedometer |
| 6. Switch, warning light | |

TRAILER CONTACT (5-pole)

The 5-pole socket, see Fig. 35-11, has the following output terminals:

1. Side lights
2. Left direction indicator
3. Stop lights
4. Right direction indicator
5. Earth

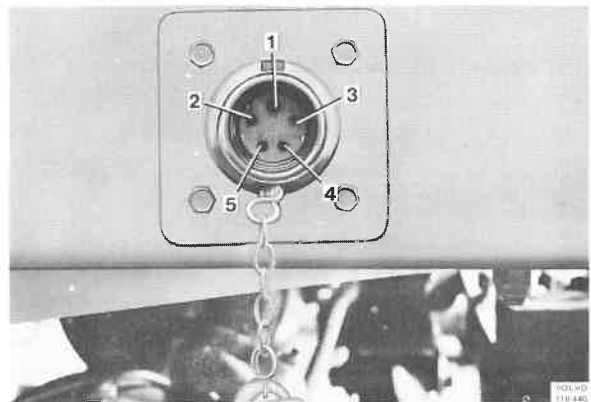


Fig. 35-11. Trailer contact

BLACK-OUT LIGHTING

Replacing the bulbs in the front lights.

1. Remove the glass from the light, see Fig. 35-12.
2. Replace the old bulb with a new one.

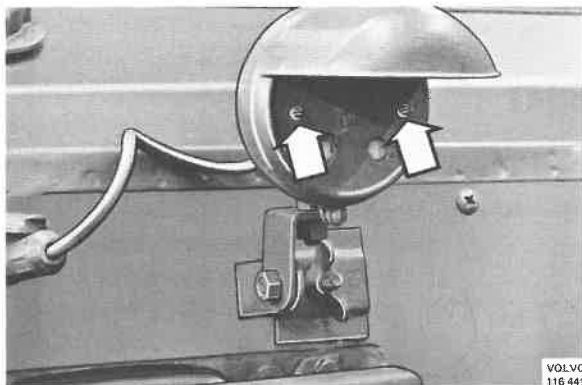


Fig. 35-12. Black-out light

3. Re-fit the glass.

Concerning replacing bulbs for the rear black-out lighting, see under the heading "Replacing the bulbs in the rear lights".

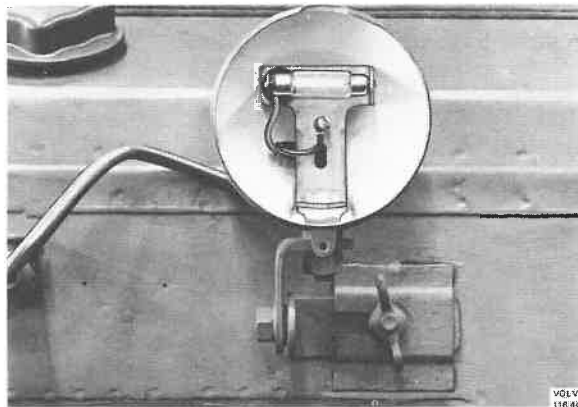


Fig. 35-13. Bulb

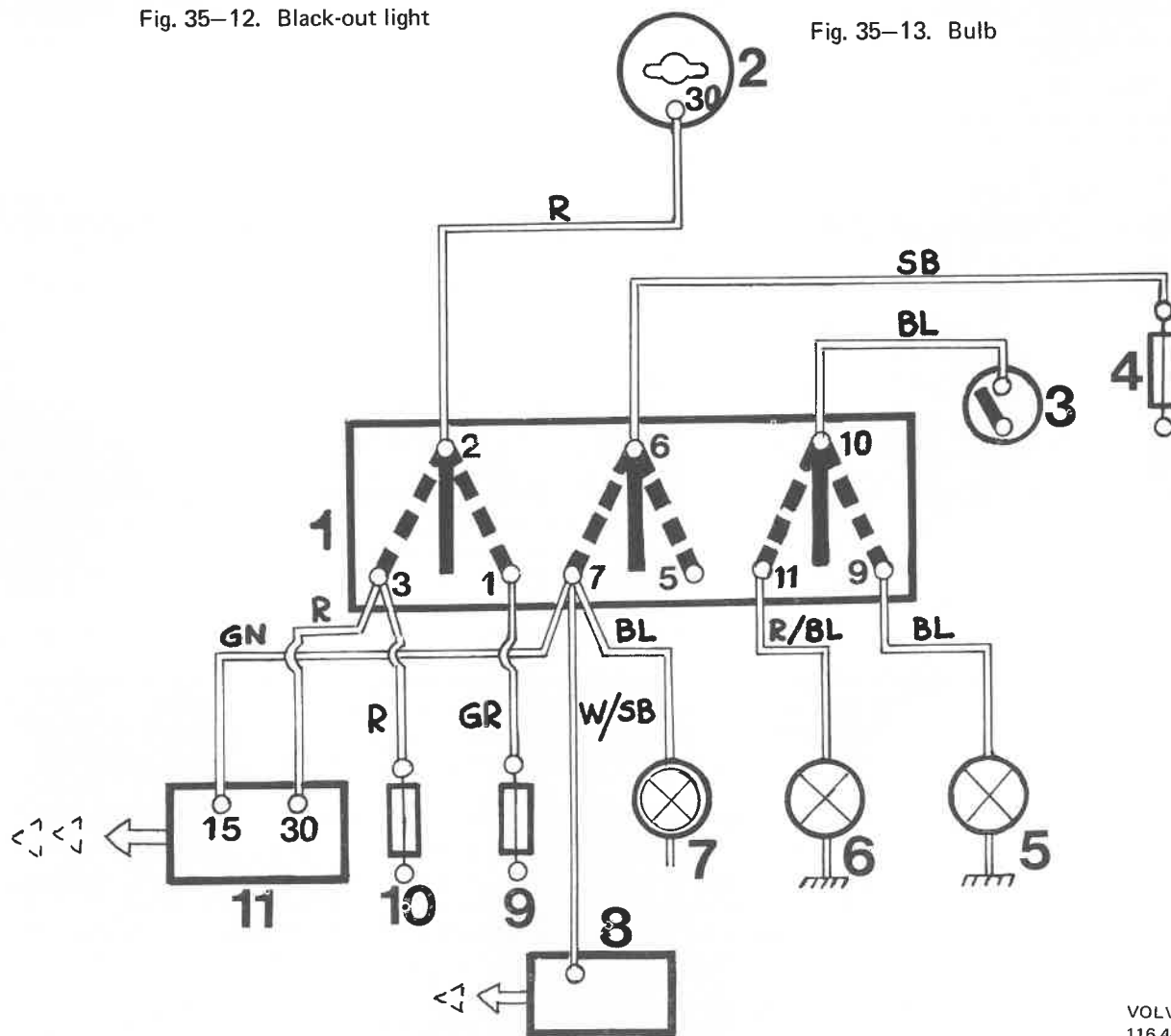


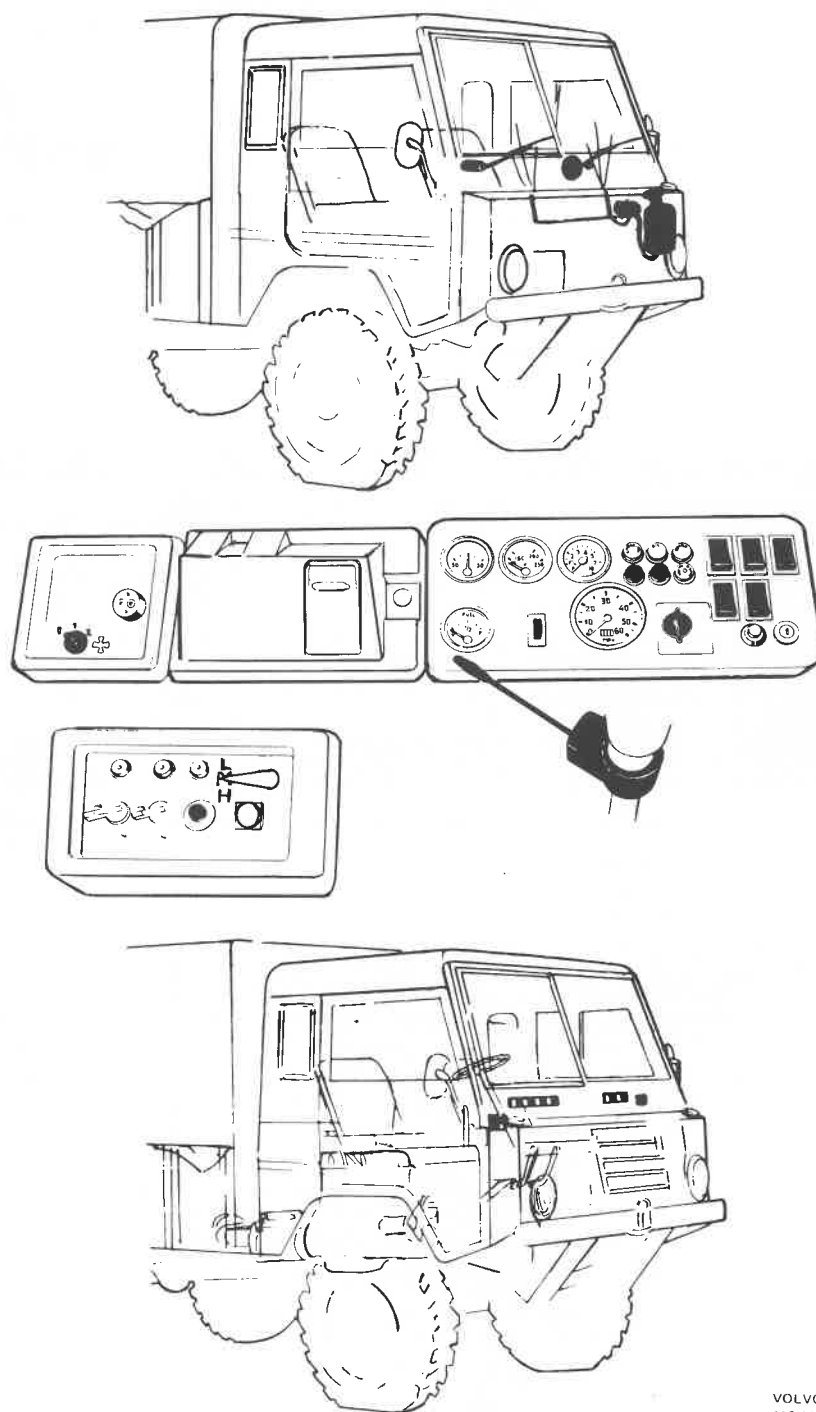
Fig. 35-14. Black-out lighting system

- | | | | |
|-----------------------|--------------------------|------------------------------------|------------------|
| 1. Black-out switch | 4. Fuse A4 | 7. Brake warning light | 10. Fuse B1 |
| 2. Ignition | 5. Bulb, stop light 3 W | 8. Switch, hazard warning flashers | 11. Light switch |
| 3. Stop light contact | 6. Bulb, stop light 23 W | 9. Fuse A8 | |

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GROUP 36 DIRECTION INDICATORS WITH WARNING FLASHERS, HORN, WINDSCREEN WIPERS WITH WASHERS, SWITCHES AND RELAYS

Description



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Fig. 36-1. Layout diagram

DIRECTION INDICATORS AND HAZARD WARNING FLASHERS

The direction indicator system includes an electronically operated flasher device, switches, indicator lights (for vehicle and trailer) as well as indicator lights front and rear.

The hazard warning flasher system includes a switch with built-in blinker, flasher device and lights (front and rear), which also function as direction indicator lights.

The blinking frequency for the direction indicators (emergency warning lights) should be 90 ± 15 blinks per minute with bulbs with a wattage of 23 W.

HORN SYSTEM

The horn system comprises a horn button and horn. The horn operates when the ignition switch is on and when the horn button in the centre of the steering wheel is pushed in.

WINDSCREEN WIPERS AND WASHERS

Each of the windscreen wipers is operated by its electric motor and two switches, one for each motor. The wiper motors are two-speed.

The wiper blades will automatically return to the parking position as long as the ignition switch is on.

The windscreen wiper motors are radio-suppressed.

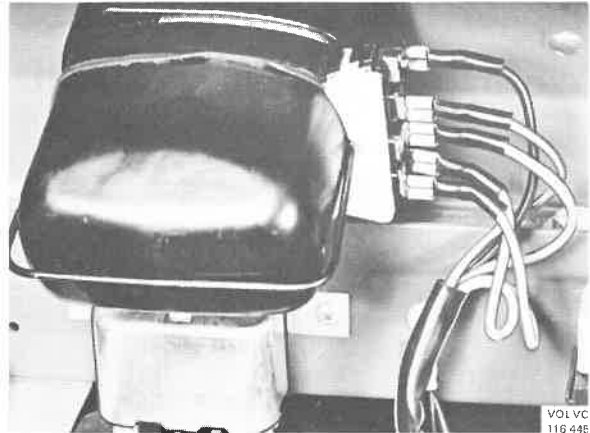


Fig. 36-2. Windscreen wiper motor, l-h side

The windscreen washer system for the vehicle consists of an electric motor, hoses, valves and nozzles.

The washer motor is also radio-suppressed.

The pump and the electric motor are integrally built as a unit. The washer fluid container holds about 3 litres (3 qts.). The windscreen washer motor is operated by means of a switch, which automatically returns to the shut-off position.

SWITCHES

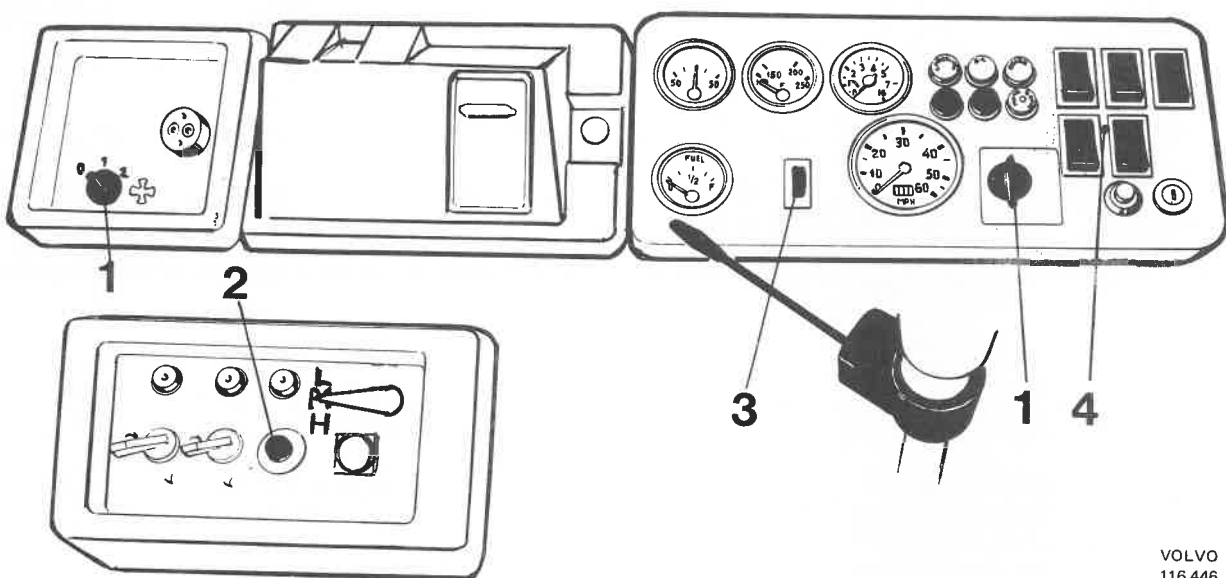


Fig. 36-3. Switches

- 1. Turn switch
- 2. Push-push switch
- 3. Rheostat
- 4. Rocker-type switch

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The vehicle is equipped with three different types of switches: rocker, turn and push-push switches. The rocker type switches (4, Fig. 36-3) is used for the following four functions: lighting, windscreen wipers (2), washers and hazard warning lights.

The turn switches (1, Fig. 36-3) are used for car heating and black-out function. The switch for the car heater motor has three positions: 0 = Off; 1 = Full output; 2 = Half output.

The black-out switch also has three positions: I = Ordinary lighting can be switched on, II = No lighting can be switched on, III = Some lighting can be switched on.

The push-push switch (2, Fig. 36-3) engages and disengages front-wheel drive.

The rheostat (3, Fig. 36-3), is wired up in such a way that when the ignition switch is switched on the lighting power can be regulated for the following components: fuel gauge, ammeter, speedometer, temperature gauge, oil pressure gauge and the switches for the washers and windscreen wipers.

RELAYS

The vehicle is equipped with 9 relays (Fig. 36-4). Seven of these are of the cut-in type.

The other two are step-relays for mainbeam/dipped beams and an electronically operated flasher device.

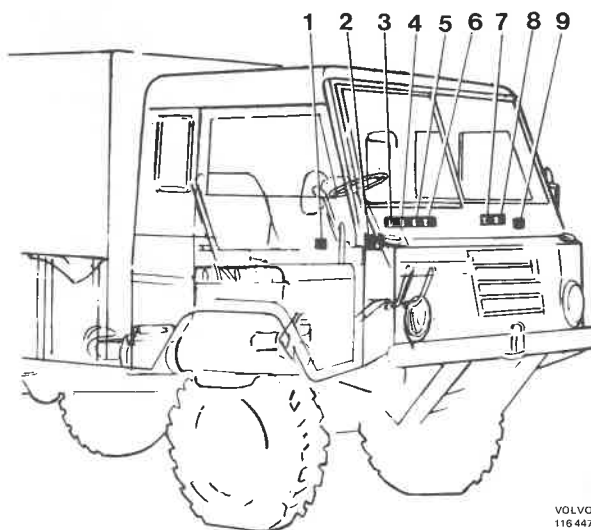
VOLVO
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Fig. 36-4. Relays

- | | |
|----------------------------|----------------------------|
| 1. Relay, air compressor | 6. Relay, windscreen wiper |
| 2. Flasher device | 7. Relay, parking lights |
| 3. Relay, windscreen wiper | 8. Relay, mainbeam flasher |
| 4. Relay, windscreen wiper | 9. Step relay |
| 5. Relay, windscreen wiper | |

Service Procedures

DIRECTION INDICATORS AND HAZARD WARNING FLASHERS

Replacing the direction indicator lever

1. Remove the screws securing the lever to the steering column, see Fig. 36-5.

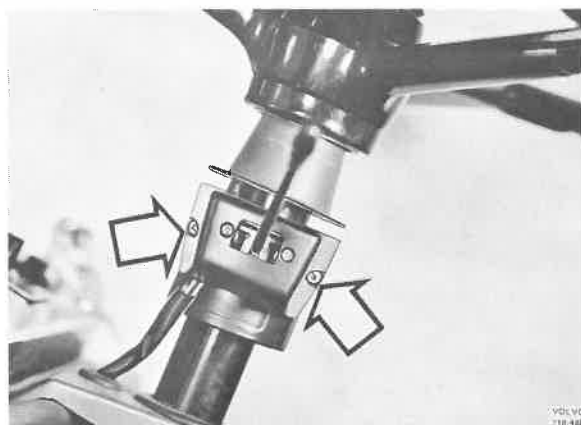
VOLVO
116 448

Fig. 36-5. Direction indicator lever

2. Remove the U-shaped washer and the two screws holding the switch, Fig. 36-6, to the retainer.

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116 449

Fig. 36-6. Direction indicator lever with U-shaped washer

3. Mark up for correct re-installation and disconnect the electric cables under the dashboard that go to the lever.
4. Remove the lever with cables by pulling out the cables through the dashboard, see Fig. 36-7.
5. Insert the electric cables for the new lever through the hole in the dashboard and connect up according to the marking.
6. Secure the lever to the retainer and fit the U-shaped washer.
7. Secure the lever with retainer to the steering column.

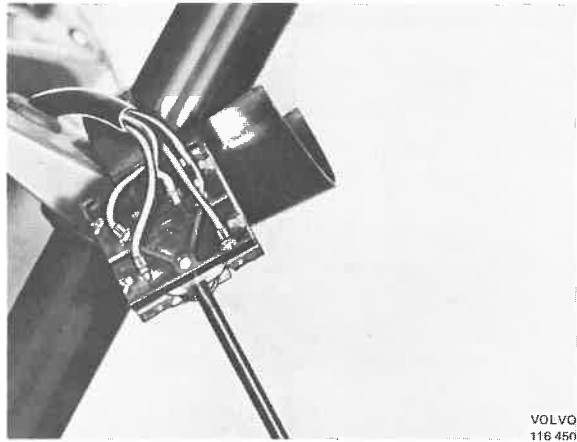


Fig. 36-7. Direction indicator lever with cables

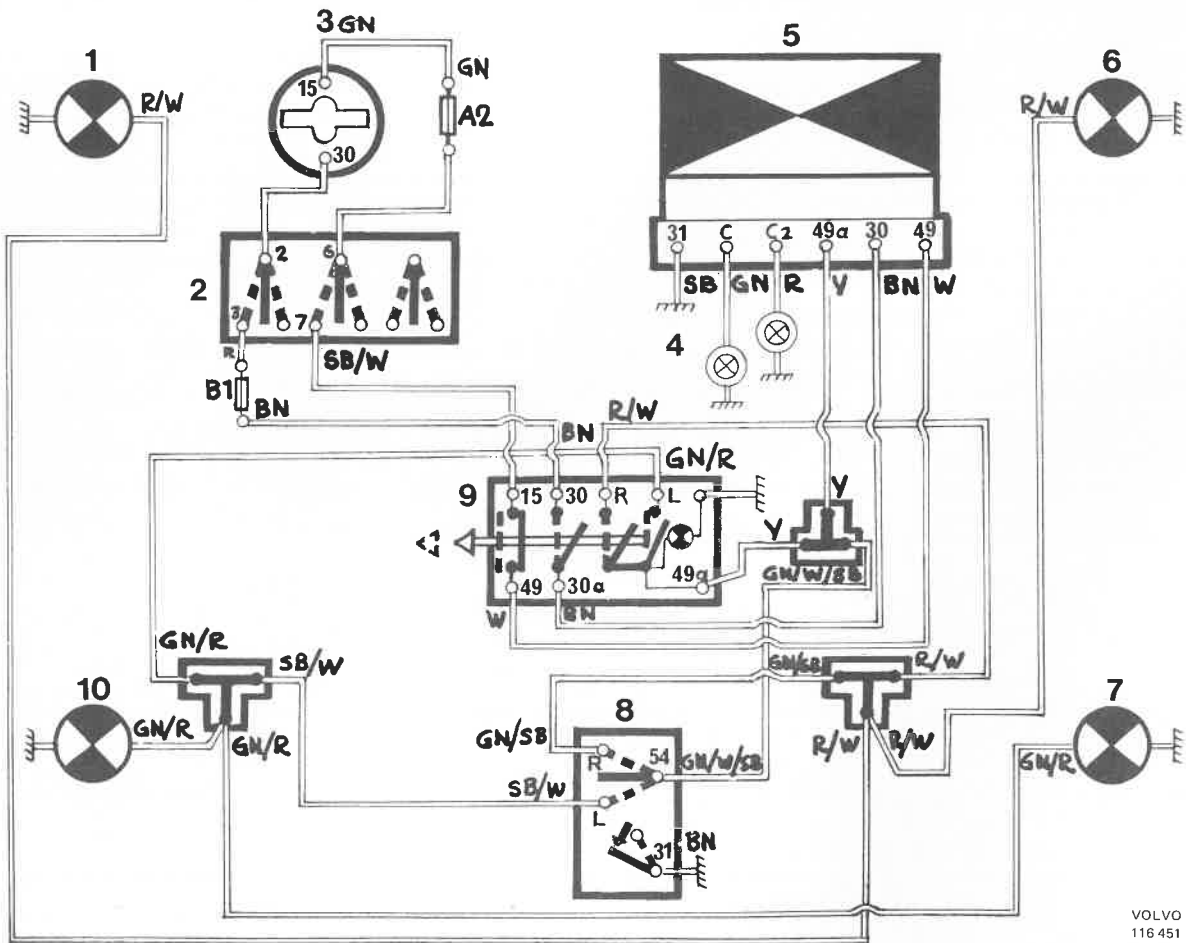


Fig. 36-8. Basic wiring diagram for direction indicators/hazard warning flashers

- | | |
|--|---|
| 1. Right direction indicator light, front | 6. Right direction indicator light, rear |
| 2. Black-out switch | 7. Left direction light, rear |
| 3. Ignition | 8. Direction indicator switch |
| 4. Indicator lights for direction indicators | 9. Switch, warning flashers |
| 5. Flasher device | 10. Left direction indicator light, front |

HORN SYSTEM

Replacing the horn

1. Remove the cable terminals and the nut securing the horn.
2. Fit the new horn and connect up the cables.

Replacing the horn button

1. Remove the horn button by lifting it off the steering wheel with a small screwdriver or similar tool, see Fig. 36-9.
2. Undo the screw securing the cable to the button.

3. Fit the cable with the new button and push the button into the steering wheel.

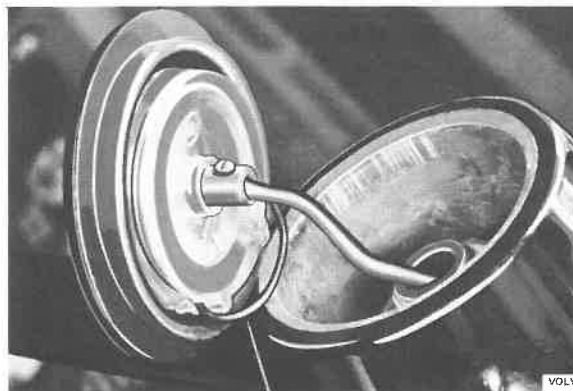


Fig. 36-9. Horn button

WINDSCREEN WIPERS AND WASHERS

Checking the windscreen wipers

If the windscreen wipers do not function (ignition switched on) either at high or low speed, check to make sure fuse **A5** is in good condition. If it is not, probably the reason is a short-circuit to the vehicle

chassis at the wiper motors, switches, relays, rheostat or on the cables to these components. Use the wiring diagram, Fig. 36-10 as an aid when fault-tracing and connecting up replaced parts.

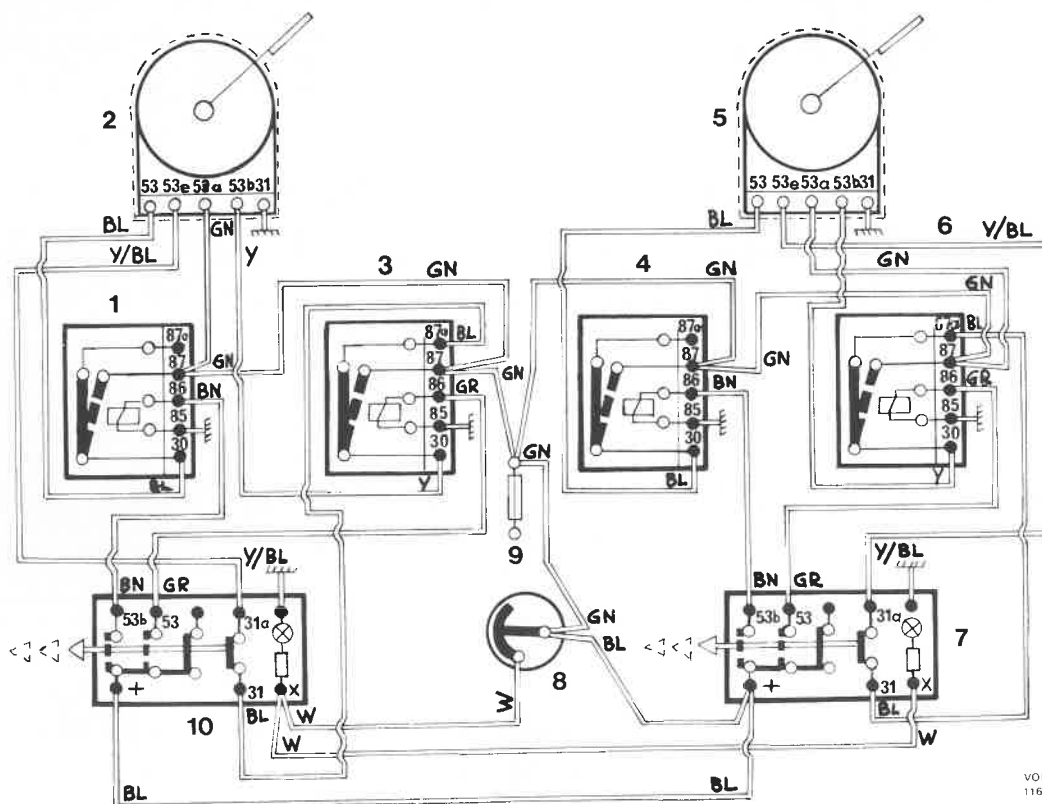


Fig. 36-10. Wiring diagram for windscreen wipers

- | | |
|--|--|
| 1. Relay, windscreen wiper motor, low-speed | 6. Relay, windscreen wiper motor, high-speed |
| 2. Windscreen wiper motor | 7. Switch |
| 3. Relay, windscreen wiper motor, high-speed | 8. Rheostat |
| 4. Relay, windscreen wiper motor, low-speed | 9. Fuse, A5 |
| 5. Windscreen wiper motor | 10. Switch |

Replacing the windscreen wipers

Removing

1. Disconnect the negative cable from the battery.
2. Remove the protective cap and wiper arm.
3. Remove the flange, dust cover, nut, washers and seal.
4. Lift forward the wiper motor, mark up for correct re-installation and remove the cables.

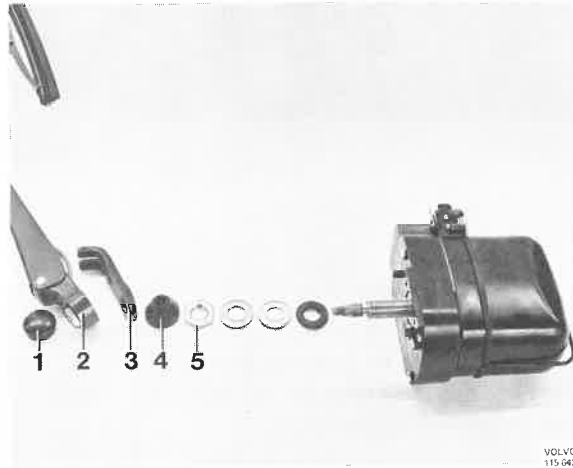


Fig. 36-11. Windscreen wiper complete

1. Arm
2. Protective
3. Flange
4. Dust cover
5. Nut
6. Motor

Installing

1. Connect up the cables according to the marking and fit the wiper motor with seal, washers and nut.
2. Fit the dust cover. Adjust and fit the flange so that the wiper arm is located properly.
3. Secure the wiper arm to the wiper shaft with the protective cap.
4. Connect up the negative cable to the battery.

Overhauling the windscreen wiper motor

Disassembling

1. Remove the casing from the wiper motor and the two screws securing the brush retainer bridge. Pull the rotor straight up and remove the two screws securing the stator, see Fig. 36-12.

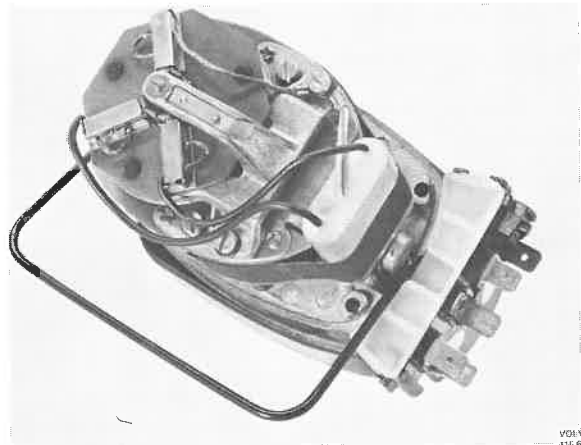


Fig. 36-12. Wiper motor with removed brush retainer bridge

2. Remove the plastic plate over the parking switch. Remove the switch, brush retainer bridge and radio suppressor from the housing, see Fig. 36-13.

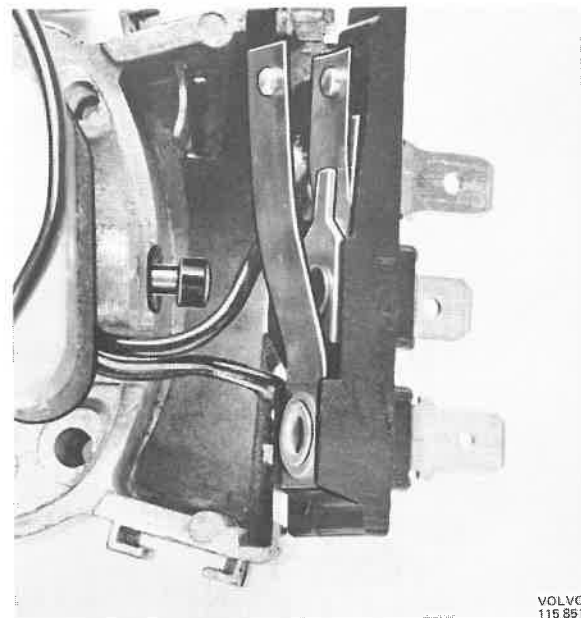


Fig. 36-13. Removing the parking switch

3. Remove the end and gasket from the output shaft. Remove the output shaft and tooth segment. Remove the four screws securing the lower housing half, see Fig. 36-14.

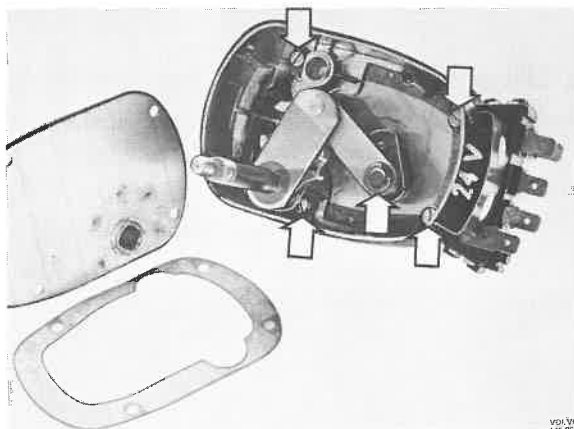


Fig. 36-14. Output shaft with tooth segment

4. Remove the lower housing half with gasket, see Fig. 36-15.

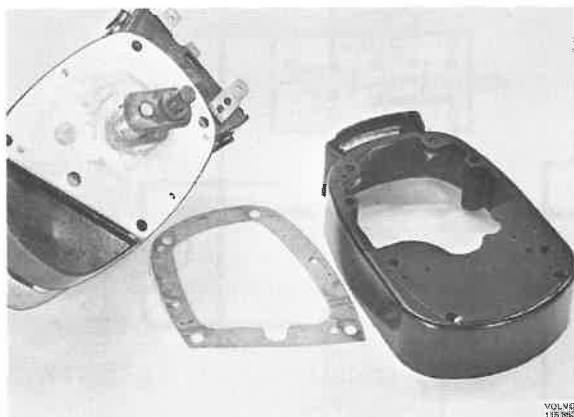


Fig. 36-15. Removing the housing and gasket

5. Remove the plate, gasket, gear wheel and pinion from the pinion housing, see Fig. 36-16.

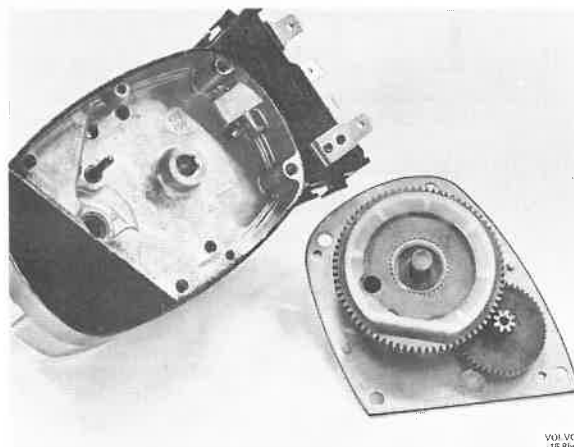


Fig. 36-16. Pinion housing with pinion and gear wheel

Checking and replacing parts

Clean all the parts and check for wear or any other defect. Check also the rotor for flash-over between commutator and rotor body as well as flash-over between, and breakage in, the winding coils.

Test flash-over between commutator and rotor body by connecting a test lamp (40 V A.C.) between them, see Fig. 36-17. The light must not go on.

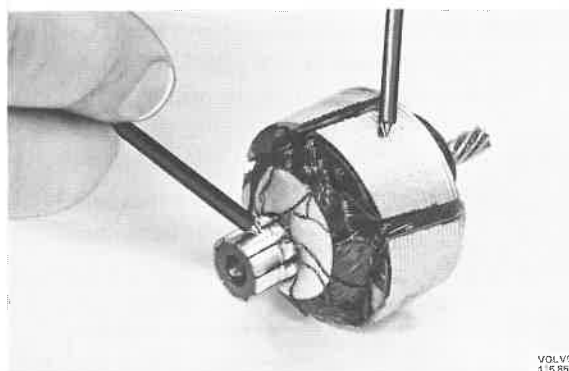


Fig. 36-17. Insulation test, rotor

Test flash-over between the winding coils with a smaller type of growler or with a Bosch coil tester EFAW 90 or 95 with ancillary test prob EFAW 96 or corresponding. Total breakage in any of the commutator discs can be checked with a test lamp (12 V D.C.). One of the measuring points of the test lamp is placed on a commutator disc and the other measuring point is moved round the commutator. The lamp should light, see Fig. 36-18.

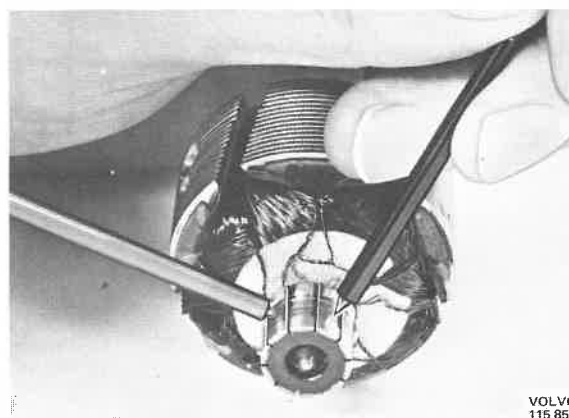
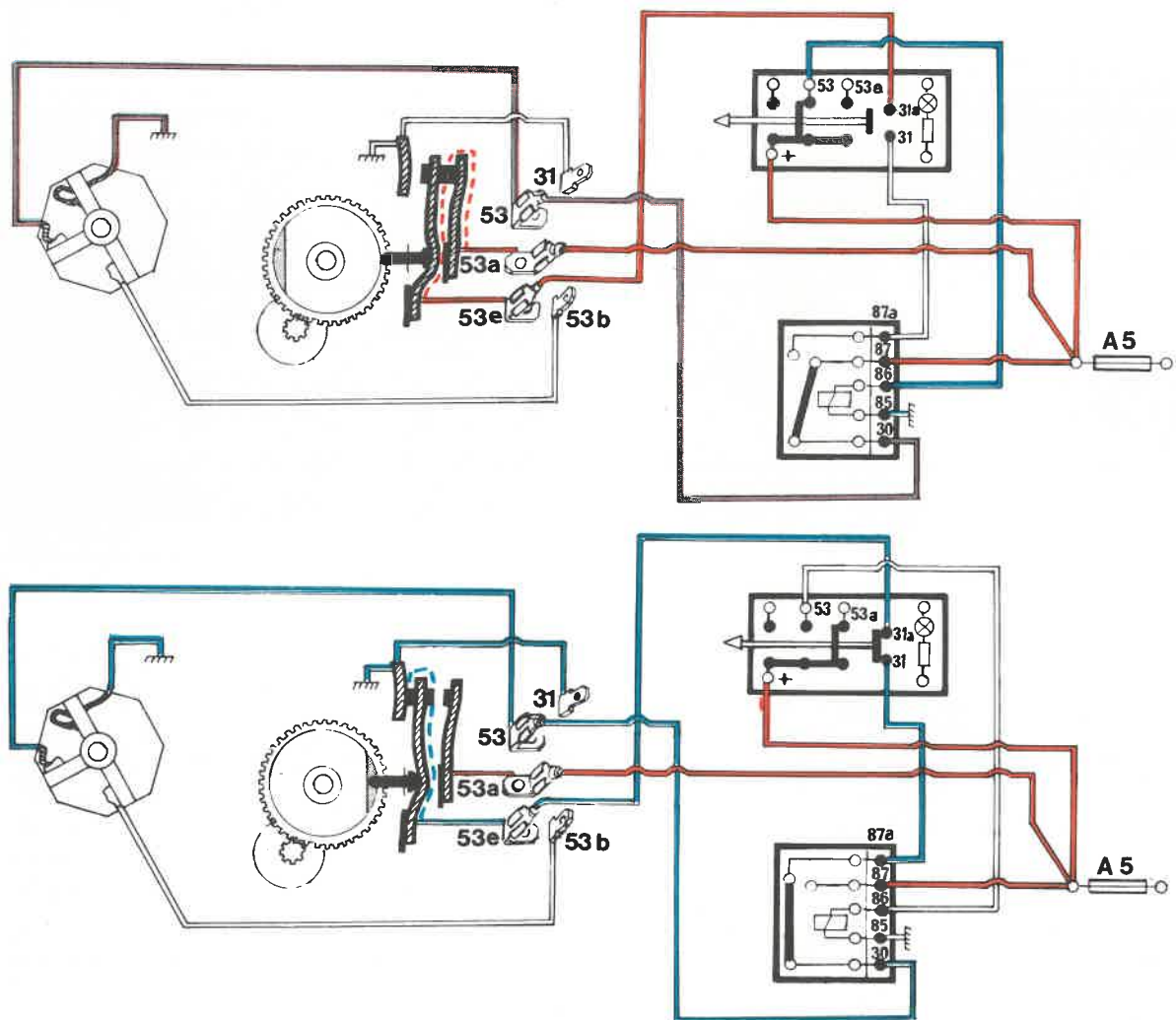


Fig. 36-18. Breakage test, rotor

Considerable burns on one or several of the diametrically located discs indicate that there is a breakage in one of the cables to a commutator disc.

Assembling

1. Place plenty of grease in the pinion housing, use Bosch Ft 1 V 35 or corresponding, and oil the pin for the parking light switch.
2. Grease the gear wheel and pinion.
Fit the gear wheel and pinion and also the gasket and cover.
3. Fit the lower housing half and the gasket.
4. Grease the tooth segment and oil the output shaft. Fit the tooth segment and shaft. Lock the tooth segment with a lock pin.
Fit the gasket and end on the output shaft.
5. Fit the parking switch and the plastic plate.
6. Fit the stator with the two screws. Oil the rotor shaft.
Fit the rotor and secure the suppressor.
7. Fit the brush retainer bridge on the stator.
8. Fit the protective casing and test-run the wind-screen wiper motor.
Check the parking function, see layout diagram Fig. 36-19.



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Fig. 36-19. Layout diagram for parking function

Replacing the washer motor

Removing

1. Remove the screws securing the motor (left-hand side under the instrument panel).
2. Mark-up for correct re-installation and move the hoses and electric cables from the washer motor.

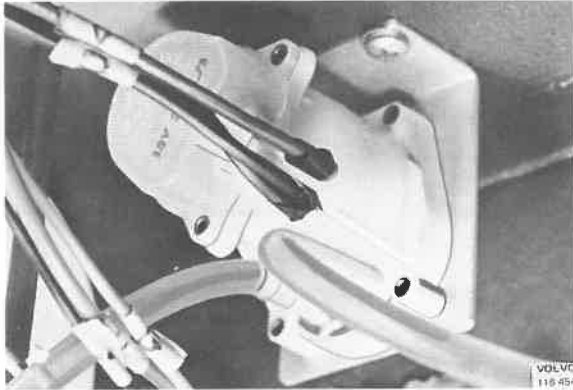


Fig. 36-20. Windscreen washer motor

Installing

1. Install the hoses and electric cables according to the marking.
2. Screw tight the motor to the body.

SWITCHES

Replacing rocker-type switches

Removing

1. Disconnect the negative cable from the battery.
2. Push out from the reverse side of the instrument panel the switch complete with connector and bulb holder, see Fig. 36-21.

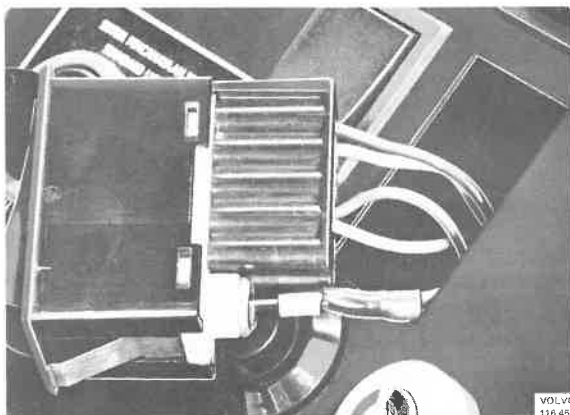


Fig. 26-21. Rocker-type switch

3. Separate the connector and bulb holder from the switch.

Installing

1. Fit the bulb holder and connector to the new switch.
2. Push in and secure the switch on the instrument panel.
3. Connect up the negative cable to the battery.

Replacing the turn switch (car heater)

Removing

1. Disconnect the negative cable from the battery.
2. Remove the panels over the fuse holder or brake fluid containers.
3. Remove the four screws securing the panel on which the switch is mounted, see Fig. 36-22.

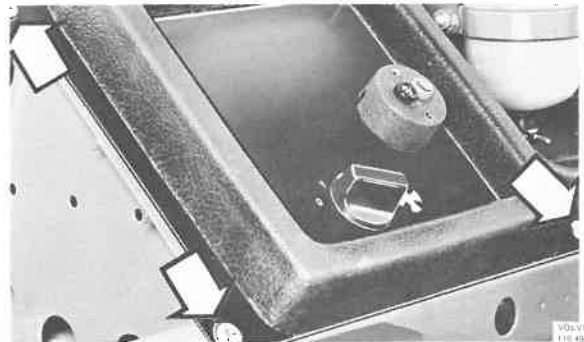


Fig. 36-22. Panel for switch

4. Remove the knob from the switch by pulling it straight out. Remove the nut securing the switch.
5. Mark up for correct re-installation of the cables and remove them.

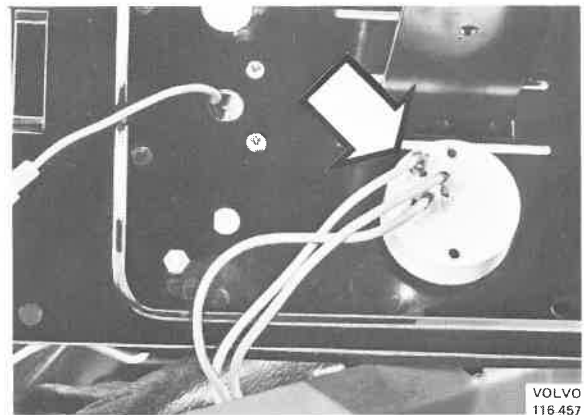


Fig. 36-23. Car heater switch

Installing

1. Fit the cables according to the marking and then screw the switch tight in the panel.
2. Fit the panel with the four screws.
3. Fit the knob on the switch and the panels over the fuse holder or brake fluid container.
4. Connect up the negative cable to the battery.

Replacing the turn switch (black-out)

Removing

1. Disconnect the negative cable from the battery.
2. Remove the switch handle.
3. Remove the two screws securing the switch and lift forward the switch so that the cables can be disconnected.



Fig. 36-24. Switch without lever

4. Mark up for correct re-installation and remove the cables.

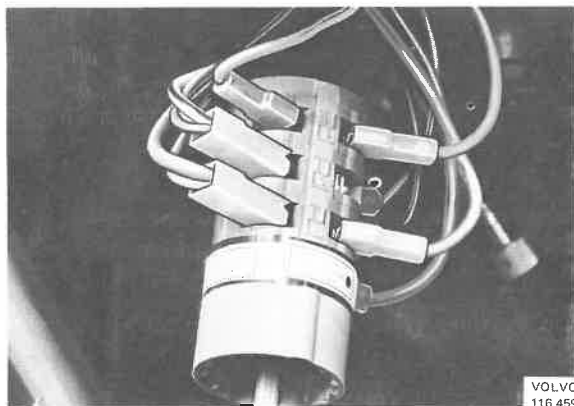


Fig. 36-25. Switch with cables

Installing

1. Connect the cables according to the marking.
2. Place the switch in position and tighten it up with the two screws.
3. Fit the switch handle and check that it is in its proper position in relation to the marking on the indicator plate.
4. Connect up the negative cable to the battery.

Replacing the push-push switch

Removing

1. Lift out the switch from the panel, see Fig. 36-26.

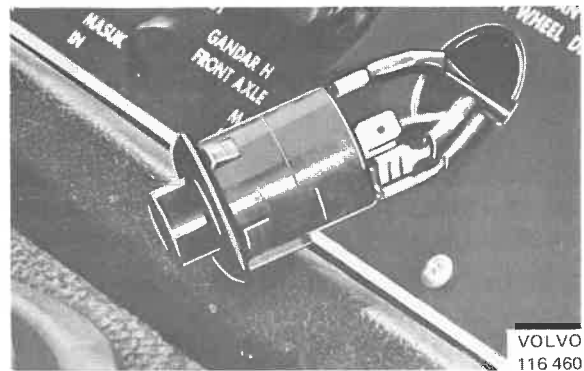


Fig. 36-26. Push-push switch

2. Mark up for correct re-installation and remove the cables from the switch.

Installing

1. Connect the cables according to the marking.
2. Secure the switch in the panel.

Replacing the rheostat

Removing

1. Make sure that the ignition is switched off.
2. Press out the rheostat from the reverse side of the dashboard, see Fig. 36-27. Mark up for correct re-installation and disconnect the cables from the rheostat.

Installing

1. Connect the cables according to the marking.
2. Press the rheostat securely into the dashboard.

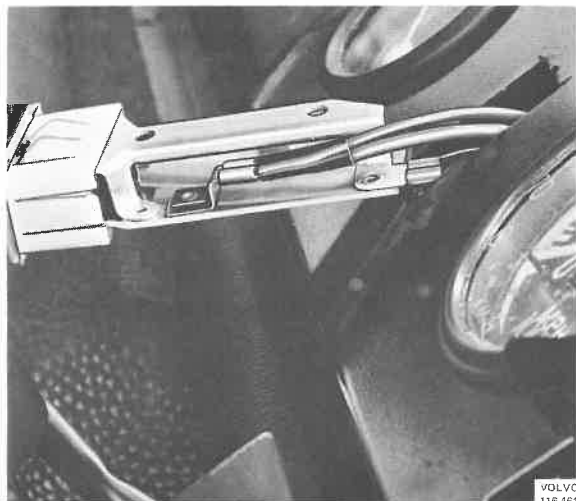


Fig. 36-27. Rheostat

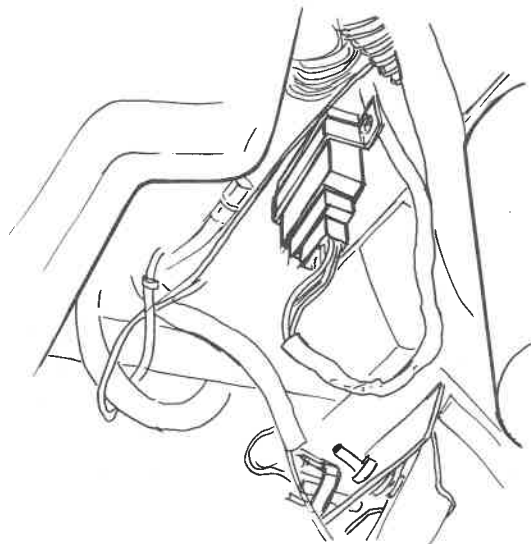


Fig. 36-29. Flasher device

RELAYS

All the relays in the vehicle (nine) cannot be repaired but must be replaced if they do not function satisfactorily.

Replacing cut-in relays

1. Pull the relay straight up from the relay socket, see Figs. 36-28 and 36-31.
2. Push the new relay securely into the socket.

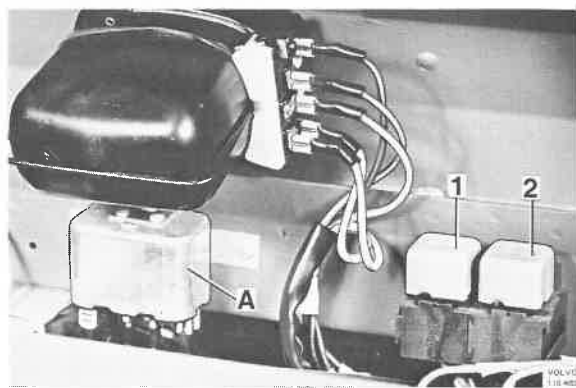


Fig. 36-28. Cut-in relay

1. Main beam flasher
 2. Parking lights
- A. Step relay

Replacing the flasher device

Removing

1. Remove the screws securing the flasher device, see Fig. 36-29.
2. Separate the connector from the flasher device.

Installing

1. Connect the connector to the new flasher device.
2. Place the device in position and secure it with the screws.

Replacing the step relay for mainbeams/dipped beams

Removing

1. Disconnect the negative cable from the battery.
2. Remove the screws securing the relay, see A Fig. 36-28.
3. Mark up correct re-installation and disconnect the cables from the step relay.

Installing

1. Connect up the cables according to the marking, see Fig. 36-30.

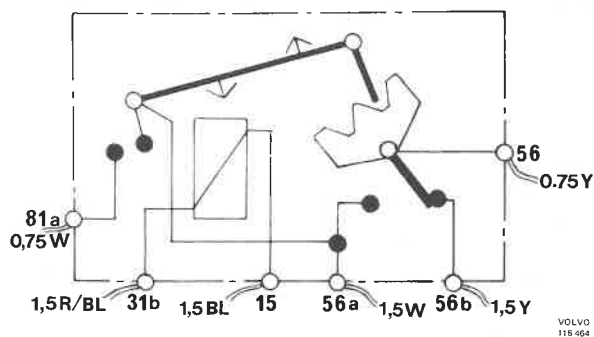


Fig. 36-30. Step relay internal wiring

2. Fit and secure the relay.
3. Connect up the negative cable to the battery.

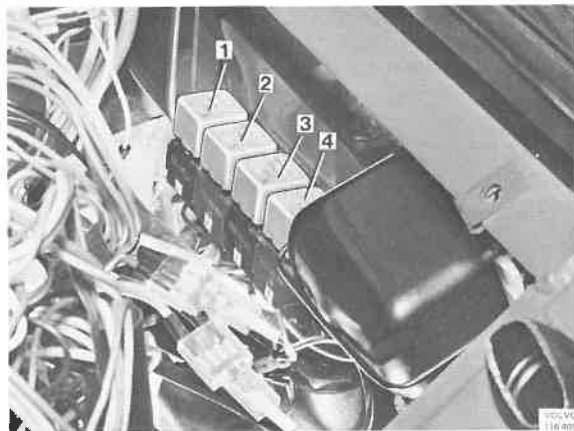
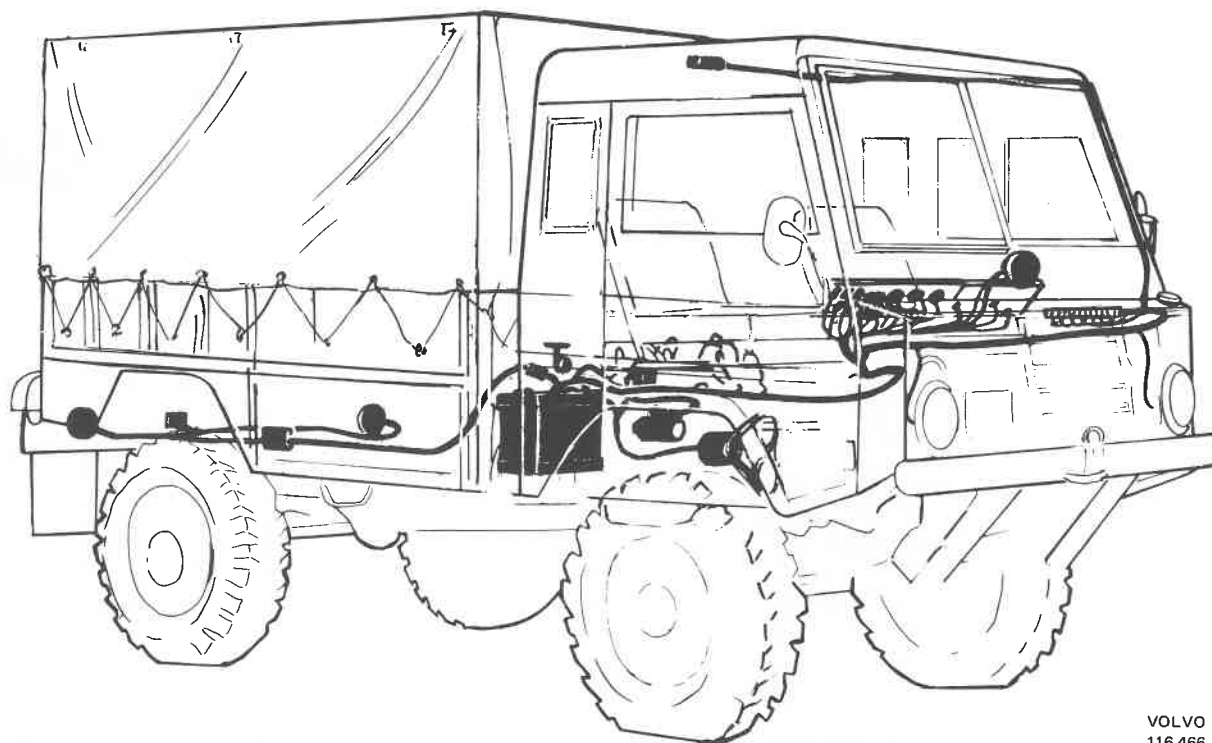


Fig. 36-31. Relays for windscreen wipers

1. Low speed, L-h side
2. High speed, L-h side
3. Low speed, R-h side
4. High speed, R-h side

GROUP 37 CABLES AND FUSES

Description



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Fig. 37-1. Layout for cables and fuses

CABLES

Cables have been made in different lengths, colours and areas in order to make it easier to know which component they are connected to.

FUSES

The vehicle has two fuseboxes. They are marked A and B, see Fig. 37-5 and on the wiring diagram at the very end of this manual.

Together the fuseboxes A and B have 18 fuses.

One fuse is at 16A, but the others are rated for 8A.

If a new fuse burns out immediately after it has been fitted, then there must be a fault in that particular part of the system protected by the fuse in question so the electrical components and cables there must be examined.

CONNECTORS

The vehicle has a connection box, Fig. 37-2, which is placed on the right-hand side on the frame, immediately in front of the final drive.

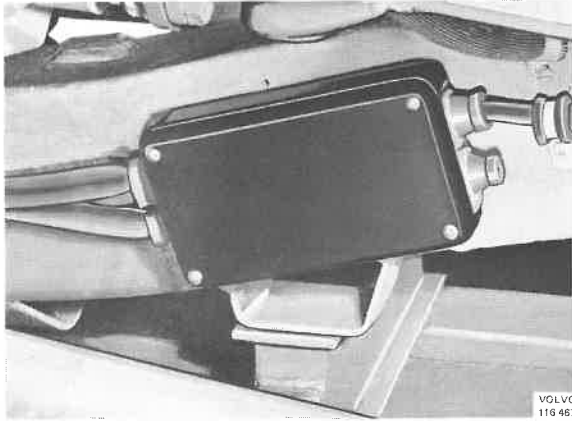


Fig. 37-2. Connection box

This box contains two six-pole connectors, see Fig. 37-3.

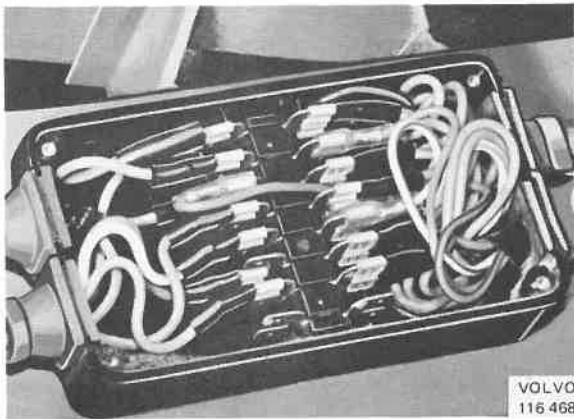


Fig. 37-3. Connection box with cover off

The cables that run to this box come from a connector which is located at the battery box, see Fig. 37-4.

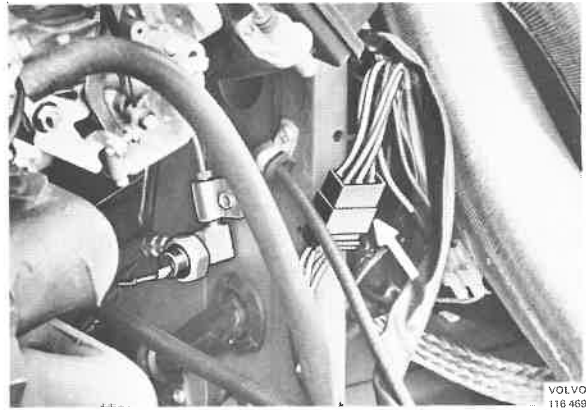


Fig. 37-4. Connector

Service Procedures

ELECTRIC CABLES

If there is a breakage or short-circuiting in a cable, it must be replaced. The new cable must have the same

area, colour and insulation as the old one and also be multi-wire of the RK-type.

FUSES

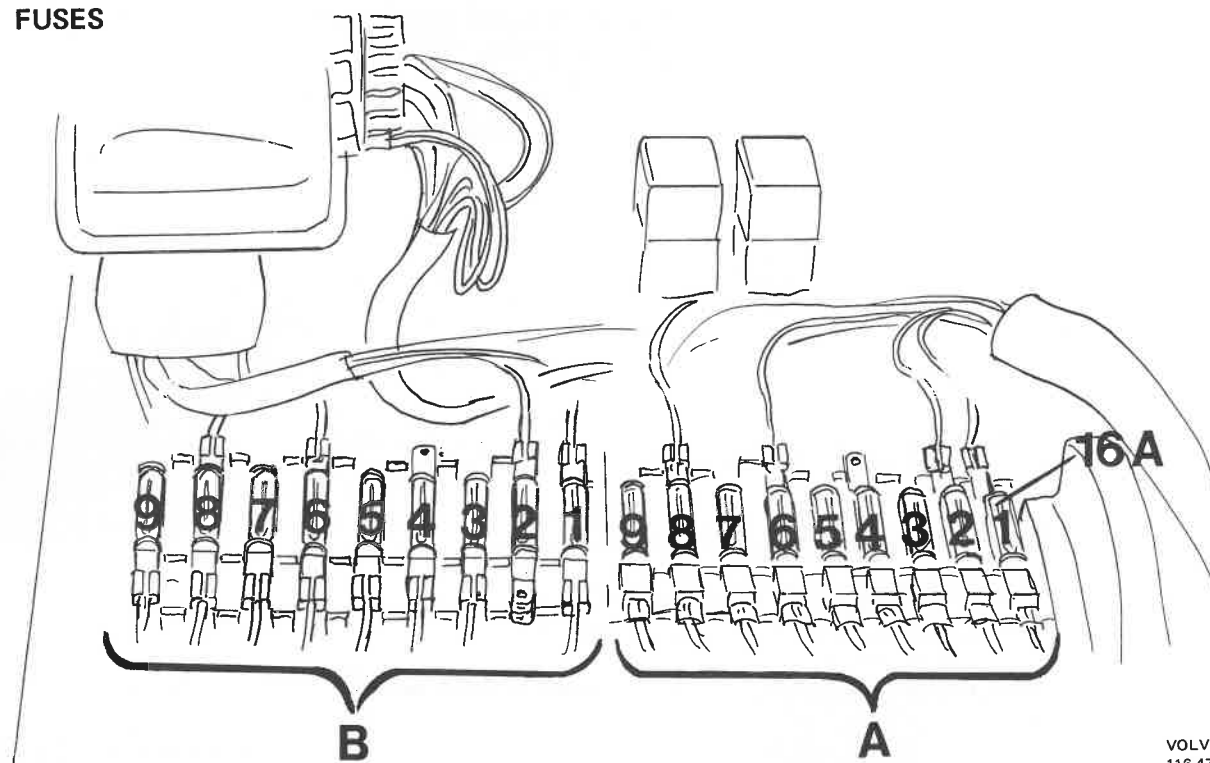
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Fig. 37-5. Fuse panels

- B9 Left-hand fullbeam and indicator lights
- B8 Right-hand fullbeam
- B7 Left-hand dipped beam
- B6 Right-hand dipped beam
- B5 Side light left-hand, front
- B4 Tail light and trailer contact (No. 1)
- B3 Side light, right-hand, front
- B2 Vacant
- B1 Interior lighting and warning light (terminal 30)
- A9 Black-out, rear + left-hand, front
- A8 Black-out, right-hand, front

- A7 Stop light contact
- A6 Step relay (coil)
- A5 Windscreen wipers and rheostat
- A4 Through black-out switch terminals 6 and 7 for flasher device, direction indicators, fullbeams/dipped beams lever and brake warning light
- A3 Fuel and temperature gauges, horn, washers and oil pressure warning light
- A2 Car heater, solenoid and indicator lights for diff. carriers and front-wheel drive
- A1 Two-pole sleeve socket (16A)

CONNECTION BOX

Replacing the connection box

Removing

1. Lift off the cover over the battery and disconnect the negative cable from the battery.
2. Remove the cover from the connection box and the two clamps securing the cable harnesses on each side of the box.
3. Remove the connection box and the earth lines from the frame.
4. Separate the connector from the box.
5. Mark-up for correct re-installation and remove the cables from the connector. Remove the cables from the box.

Installing

1. If necessary remove the old rubber seals and fit new ones.
2. Install the cables in the box and connect them to the connector according to the marking.
3. Mount securely the terminal board to the box.
4. Secure the box in the frame. Secure the earth cables with the retaining screws. Make sure there is good contact with the vehicle chassis.
5. Fit the rubber seals in the box and clamp tight the cable harnesses next to the box.
6. Spray with Tectyl 151 A or corresponding.
7. Fit the cover over the connection box. Connect up the negative cable to the battery and fit the cover over the battery.

GROUP 38 INSTRUMENTS, CONTACTS AND INDICATOR/WARNING LIGHTS

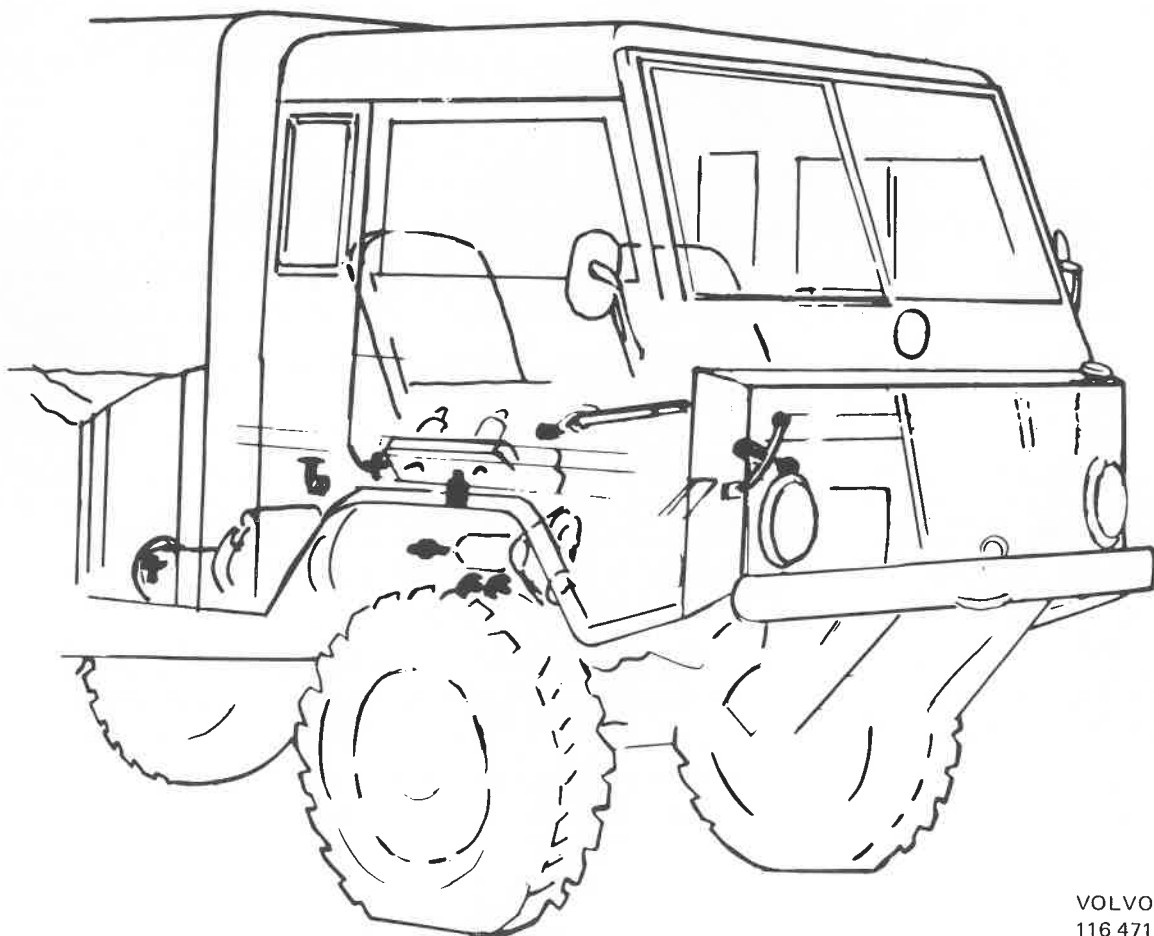
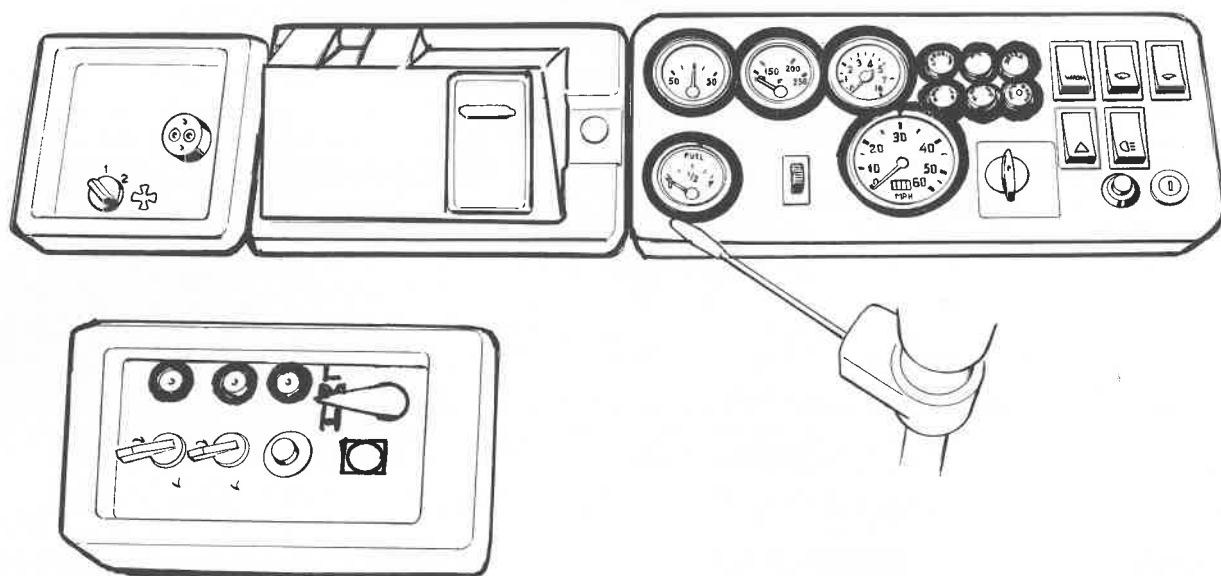


Fig. 38-1. Instruments, contacts and indicator/warning lights

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Description

SPEEDOMETER

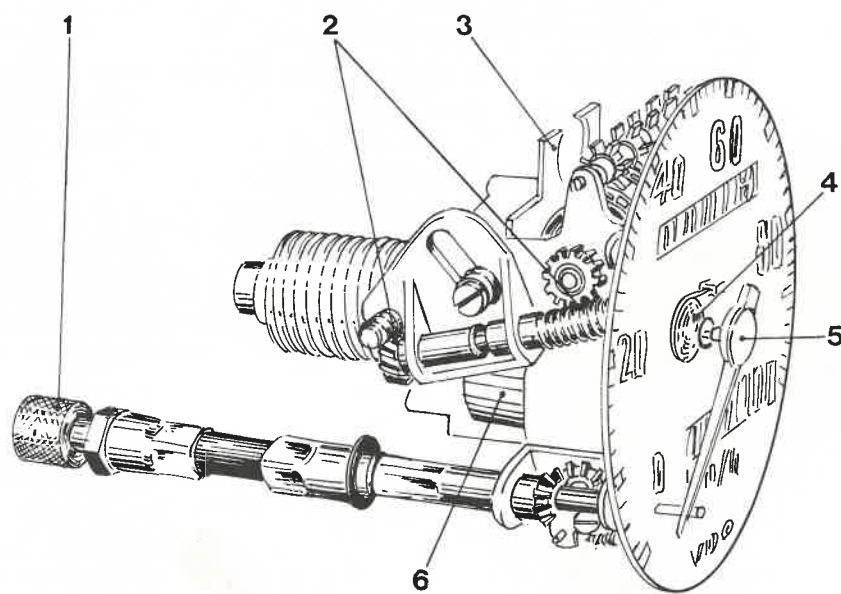
The speedometer is of the eddy-current type. It is driven by a wire (speedometer cable) from a worm on the gearbox output shaft. The speedometer contains a permanent magnet, a mounting disc and an aluminium rotor drum. The rotor drum is situated at one end of the instrument's pointer shaft. The shaft is also linked to a balance spring. This spring brakes the movement of the rotor drum and turns the pointer to zero at the same time when the car stops.

The mileometer is driven directly from the speedometer cable via a number of small gears. The reductions of these gears are so selected that the wire can rotate 617.5 revs in order for the meter to register one km. The speedometer also has a tripmeter which indicates distances driven up to 999 kilometers. The figure extreme right indicates metres in hundredths.

The tripmeter is re-set to zero by turning the small knob.

The part of the speedometer which indicates the speed functions magnetically. When the vehicle starts moving, the drive line rotates and this causes the permanent magnet to rotate. The rotating magnet generates a rotating magnetic field, which causes eddy currents to form in the rotor drum. The magnet's lines of force flow over the instrument's mounting disc. The rotating effect which the magnetic field and the induced eddy currents have on the rotor drum is dependent on speed (increased vehicle speed causes speedometer to register higher speed) and partly by the counteracting force of the balance spring.

The construction of the speedometer is shown in Fig. 38-2.



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Fig. 38-2. Layout of speedometer

- | | |
|------------------------------|-------------------------------------|
| 1. Re-set knob for tripmeter | 4. Balance spring |
| 2. Worm | 5. Speedometer pointer |
| 3. Mounting disc | 6. Rotor drum with permanent magnet |

ENGINE TEMPERATURE GAUGE

The engine temperature gauge system has two main parts: a temperature gauge on the dashboard and a temperature sender in the engine block.

The temperature sender consists of a temperature-sensitive semi-conductor. The resistance through the sender reduces as the temperature of the engine rises.

The temperature gauge has three coils which function as electromagnets. One is connected in series to the sender, the other two are wired to the vehicle chassis via a fixed resistor, see Fig. 38-3.

When the engine coolant is cold (high resistance in the sender), most of the current goes through the two coils connected in series and through the fixed resistor to the vehicle chassis.

The magnetic force which arises at these coils attracts the armature plate and this causes the pointer to indicate the temperature.

When the engine coolant temperature starts rising (the resistance in the sender reduces), more and more current passes through the coil connected in series to the sender. The magnetic force which arises attracts the gauge pointer armature plate in the opposite direction to previously. The gauge pointer moves on the dial, and thus indicates the temperature, in relation to the amount of current flowing through the coils. And the amount of current flowing through the coils is determined by the temperature of the coolant.

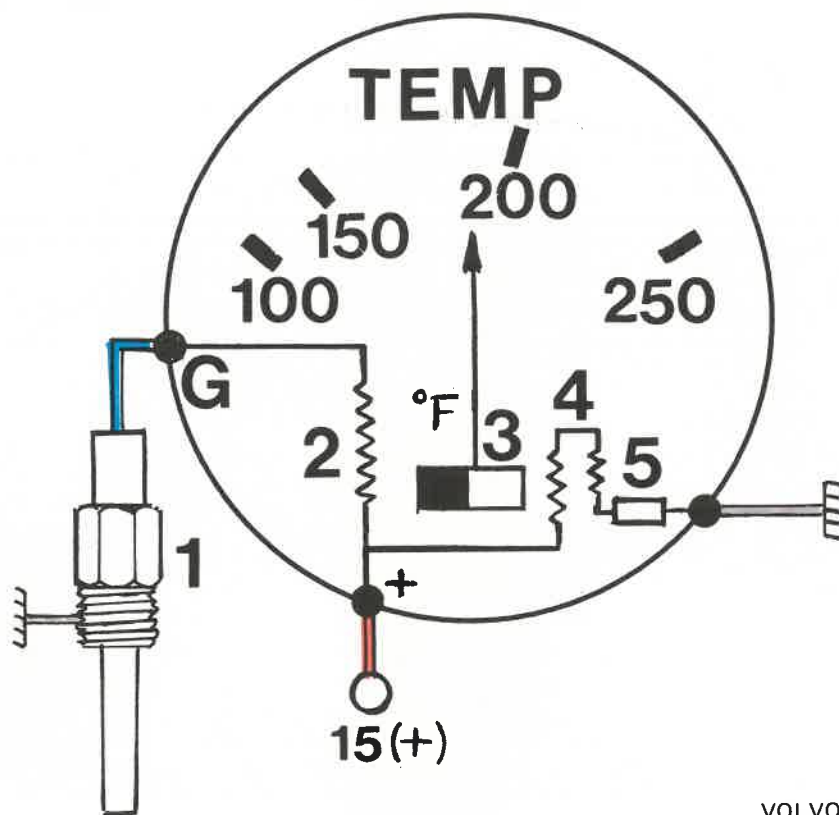


Fig. 38-3. Temperature gauge with sender, layout diagram

- | | |
|-------------------|-------------|
| 1. Sender | 4. Coils |
| 2. Coil | 5. Resistor |
| 3. Armature plate | |

FUEL GAUGE

The fuel gauge system, see Fig. 38-4, has two main parts: a fuel gauge on the dashboard and a fuel level sending unit in the fuel tank.

The fuel level sending unit consists of a float which is in contact with a contact plate via a lever. The contact plate glides over a rheostat. When there is more or less fuel in the tank (the fuel level rises or drops) more or less of the rheostat coils are in circuit.

The fuel gauge has two coils, which function as electro-magnets. The gauge needle armature plate is attracted to whichever of the two coils has the greatest magnetic force, and this in its turn will depend on how much current is flowing through either of these coils, see Fig. 38-4. If, for example, the magnetic force is the same in each coil, then the

gauge pointer indicates that the tank is 1/2 full. The fuel tank indicator unit determines how much current will flow through the coil.

Ex.: When the float is at the bottom position (the tank is empty), then there is little resistance in the rheostat. Most of the current will then flow through the coil which is connected in series to the rheostat, and only a little part of the current flows through the coil which is connected to the vehicle chassis.

When the float is at its top position (the tank is full), then there is great resistance in the rheostat. Most of the current will then flow through the coil which is connected to the vehicle chassis.

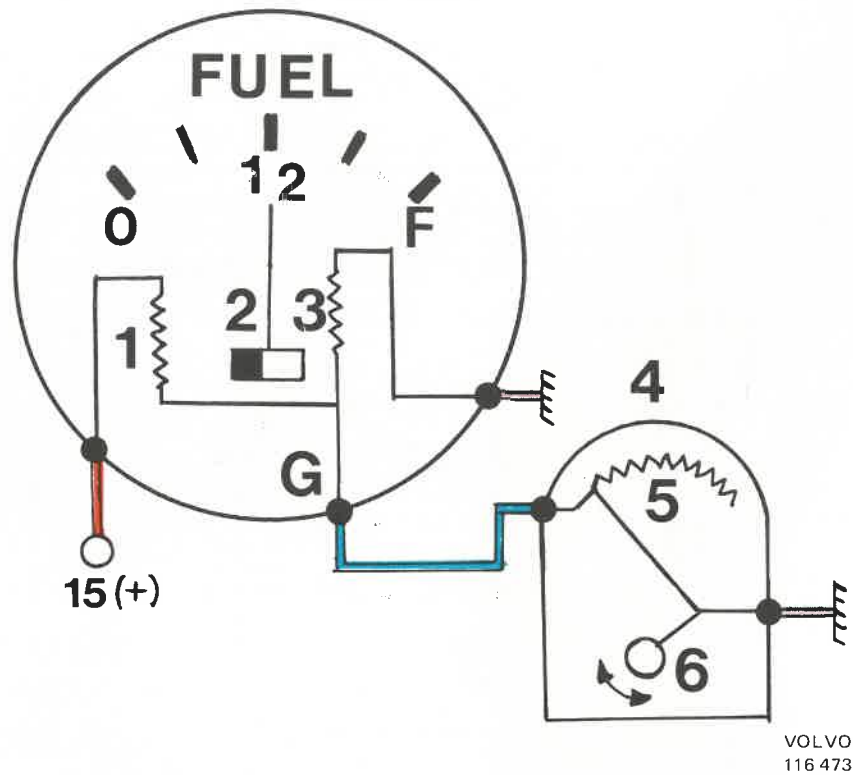


Fig. 38-4. Fuel gauge and fuel tank level sending unit, layout diagram

- | | |
|-------------------|---------------------------------|
| 1. Coil | 4. Fuel tank level sending unit |
| 2. Armature plate | 5. Rheostat |
| 3. Coil | 6. Float |

AMMETER

The ammeter is a soft-iron instrument. It has measuring range 50-0-50. The gauge consists of a brass bridge and a dial. A soft-iron plate is riveted to the underside of the bridge.

The gauge functions in the following way: when no charging takes place, the dial pointer is at 0 due to the magnetic field which has formed round the dial pointer permanent magnet.

When charging takes place, current flows through the bridge and this causes a powerful magnetic field to form round the soft-iron plate. Because of the poles which form on the plate, the permanent magnet is attracted and this causes the pointer to swing to plus. When discharging takes place, the current flows in the opposite direction through the bridge and this causes a change in the poles on the plate so that the pointer swings to minus.

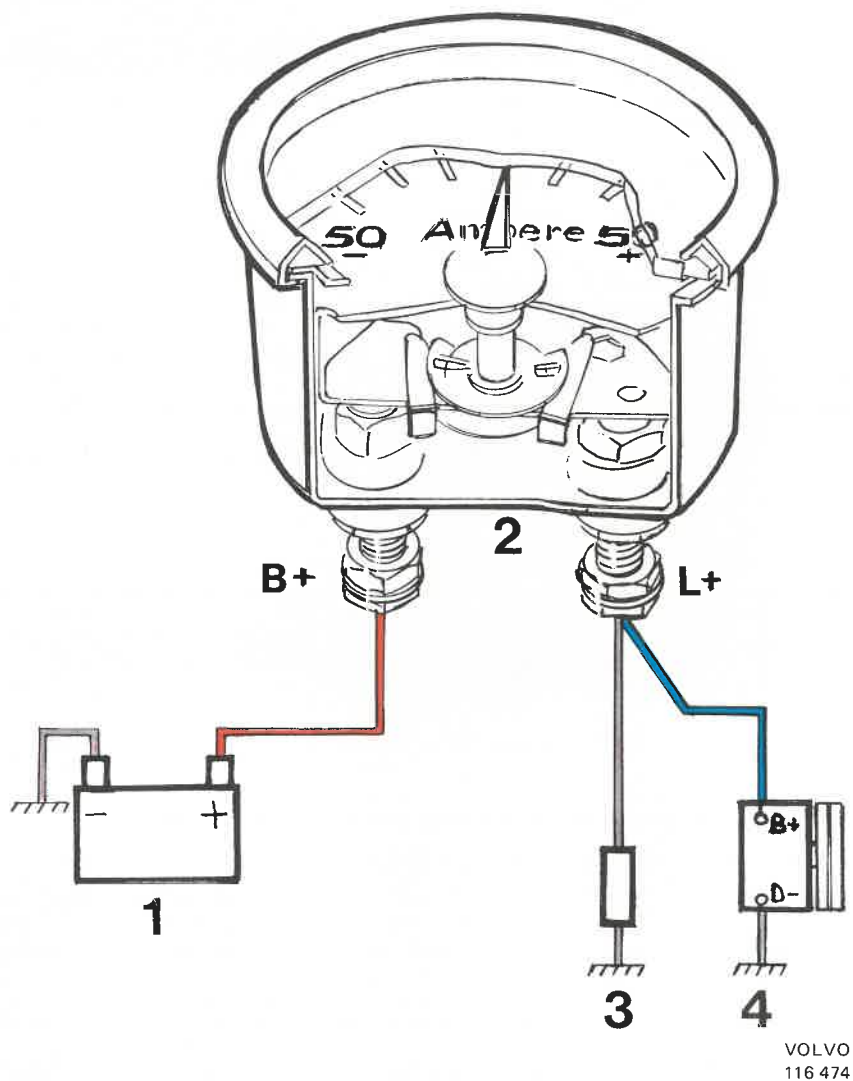


Fig. 38-5. Ammeter function

- | | |
|------------|-------------------|
| 1. Battery | 3. Power consumer |
| 2. Ammeter | 4. Alternator |

OIL PRESSURE GAUGE

The oil pressure gauge is connected to the engine lubricating system by means of a pipe. Pressure changes in the lubricating system are transmitted through the pipe to the oil pressure gauge.

The tubular-spring system is so constructed that the tubular spring tends to straighten itself out under pressure. This affects a gear segment which is connected to the gauge pointer. To prevent the pointer from vibrating due to any looseness in joints and the gear segment, a stabilizing spring is connected to the segment.

The gauge is graduated from 0–16 kp/cm² (0–227 lbf/in²).

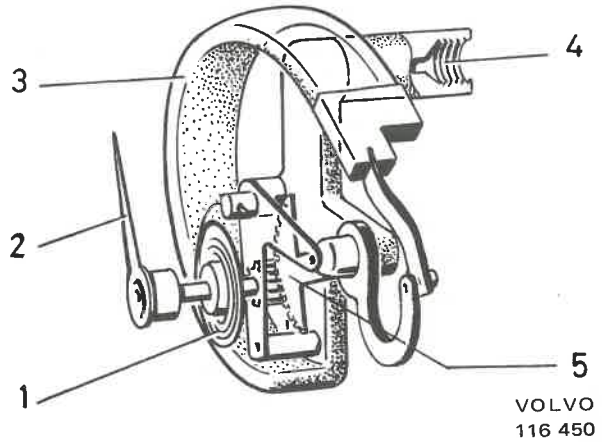


Fig. 38-6. Oil pressure gauge layout

- | | |
|-----------------------|---|
| 1. Stabilizing spring | 4. Connection to lubricating oil system |
| 2. Gauge pointer | 5. Gear segment |
| 3. Spring | |

SOLENOID, FRONT-WHEEL DRIVE

The electrical system which operates the mechanical engagement of the front-wheel drive comprises the following components: solenoid, switch, contact and indicator light, see layout diagram Fig. 38-7.

When the ignition is switched on, current flows through the solenoid winding, the pressure contact in the auxiliary gearbox, the push-push switch on the panel and then to the vehicle chassis. The current circuit is closed and the armature in the solenoid has been pulled to its top position. When the current circuit is opened, the armature in the solenoid goes to its lowest position and this engages the front-wheel drive.

As the above shows, disengaging and engaging the front-wheel drive will depend on whether there is current through the solenoid winding or not. The front-wheel drive can thus be operated with:

- Ignition. With the ignition key in neutral, the current is broken and front-wheel drive is engaged. When the key is turned, the front-wheel drive is disengaged providing that the contacts and switches are in the position shown on Fig. 38-7.
- Gear lever. When a low gear is engaged, the contact breaks the auxiliary gearbox current and the front-wheel drive engages.
- Panel switch. Pushing in the switch breaks the current circuit and engages the front-wheel drive.

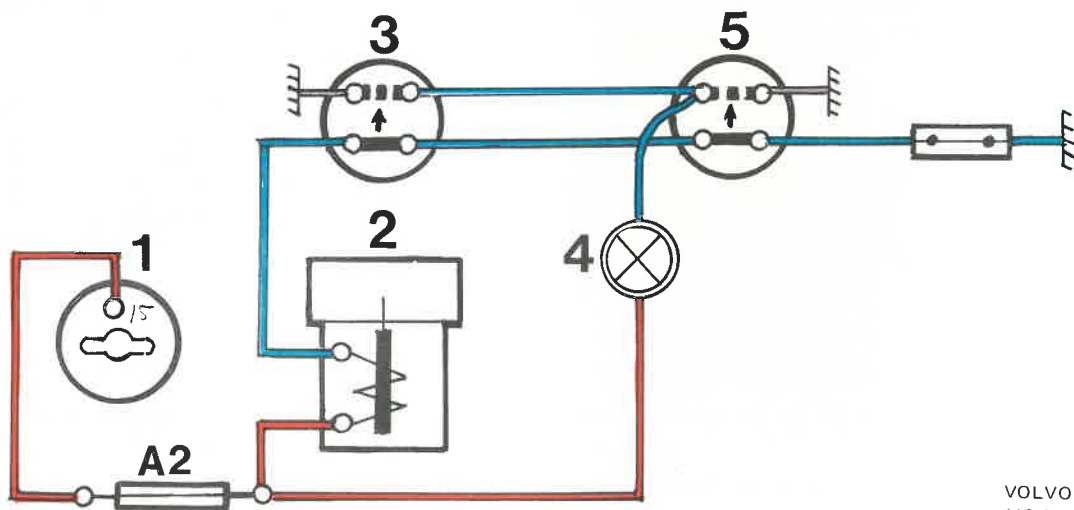


Fig. 38-7. Wiring diagram for front-wheel drive

- | | |
|--------------------------|---------------------------------------|
| 1. Ignition | 4. Indicator light, front-wheel drive |
| 2. Solenoid | 5. Switch, panel |
| 3. Contact, aux. gearbox | |

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CONTACTS

Oil pressure

When the ignition is switched on, current flows through the oil pressure warning light and further through the oil pressure sender to the vehicle chassis. When the engine starts and the oil pressure exceeds 40–70 kPa (0.4–0.7 kp/cm² = 6–10 lbf/in²), a diaphragm is actuated which breaks the electrical connection between the sender and the chassis. The warning light goes out.

Stop lights

The contact for the stop lights is mechanical and is actuated by the brake pedal. When the brake pedal is not depressed, the current circuit is broken. When the pedal is depressed, the current circuit to the stop lights is closed so that the lights go on.

Brake pedal movement

The contact is actuated by the brake pedal. As the brake linings wear down, pedal travel becomes greater. In order for the brakes to be able to function, even if one of the circuits fails, the pedal must not go down too far. When the pedal goes down to 90–100 mm (4") from the bottom position, that is, pedal travel reserve has reduced to this distance, the warning light goes on. This means that the brakes should be adjusted as soon as possible. After the contact has indicated too large brake pedal travel, the contact pin must be re-set by hand.

Parking brake

The warning light marked "Brake" is lighted by the contact when the parking brake is applied. The contact is actuated mechanically by a lever from the parking brake control.

Differential carriers

The contacts for the differential carriers are connected to the vacuum lines which go to the front and rear control cylinder, see Fig. 38–8.

The function of the contacts is to switch on the indicator lights marked "Diff. carrier" when the vacuum exceeds 39.5–40.5 kPa (0.395–0.405 kp/cm² = 5–6 lbf/in²).

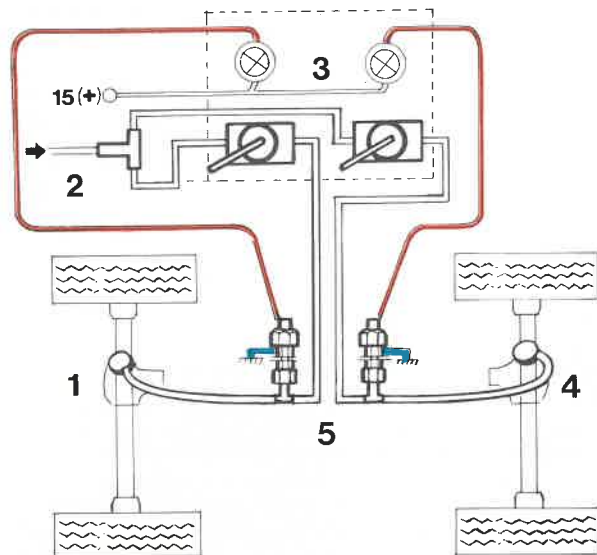


Fig. 38–8. Wiring for the vacuum contacts

- | | |
|---------------------------|--------------------------|
| 1. Front control cylinder | 4. Rear control cylinder |
| 2. From vacuum tank | 5. Vacuum contacts |
| 3. Indicator lights | |

WARNING/INDICATOR LIGHTS

Battery charging

This light is marked "Charging". It is connected between the ignition terminal 61 and the alternator terminal 61. When the alternator voltage is lower than the battery voltage, the light goes on. When the voltage rises and the alternator starts charging the battery, the light goes out. This indicates that the alternator is charging.

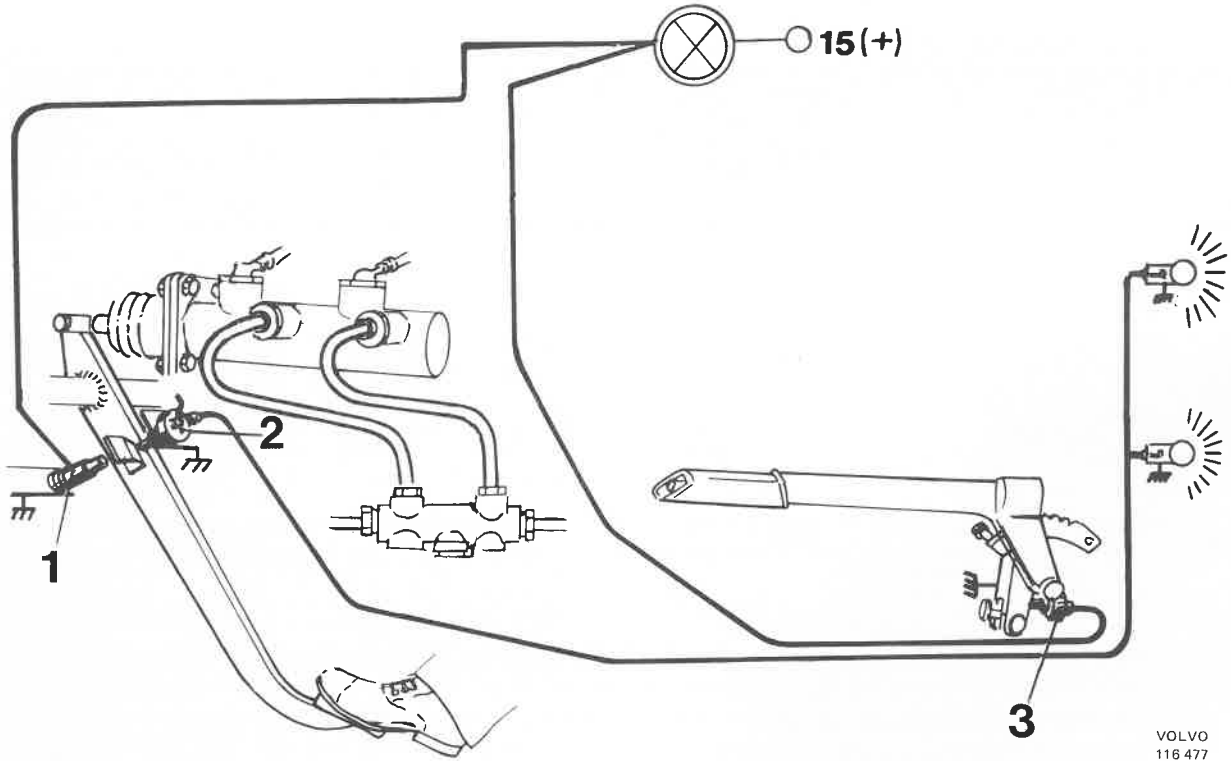
Oil pressure

The light marked "OIL" should go on when the lubricating oil pressure in the engine goes below 40–70 kPa (0.4–0.7 kp/cm² = 6–10 lbf/in²).

Brake

The light marked "BRAKE" should go on: when the parking brake is applied, or when the brake

pedal travel exceeds a certain distance, see Fig. 38-9.



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Fig. 38-9. Warning system for warning light marked "BRAKE"

- 1. Contact, brake pedal travel
- 2. Contact, stop lights
- 3. Parking brake contact

Front-wheel drive

The light marked "FRONT WHEEL DR" should light when the contact in the auxiliary gearbox or the panel switch is engaged, see Fig. 38-7.

Differential locks

The lights marked "DIFF LOCK" go on when the vacuum in the lines to the control cylinders for the front and rear differential locks exceed 39.5-40.5 kPa (0.395-0.405 kp/cm² = 4-6 lbf/in²).

Main beams

The light marked "MAIN BEAM" goes on when the main beams are on.

The light is connected in parallel with the main beam for the left-hand side at the fuse (B9).

Direction indicators

The lights marked "DIRECT IND." blink in unison with the direction indicators.

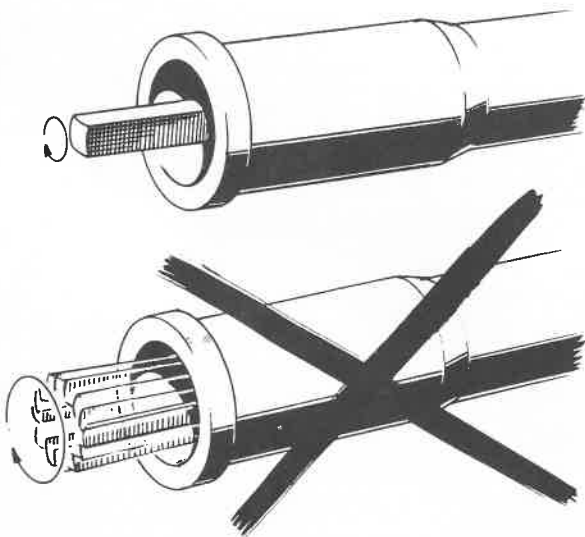
The "DIRECT IND." for a trailer blinks only if a trailer is connected to the vehicle.

The blinking frequency should be 75-105 blinks per minute.

Service Procedures

SPEEDOMETER

If the speedometer, see Fig. 38-11 does not give a reading but the mileometer is functioning or if the speedometer is functioning but not the mileometer, then the fault is in the speedometer. If the instrument is not working at all, or if the speedometer pointer swings, probably the drive line is broken or is jamming in its sleeve. If this is the case, replace the speedometer cable complete.



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Fig. 38-10. Drive line rotation



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Fig. 38-11. Speedometer

Reverse side of speedometer

Removing

1. Remove the cover over the battery and disconnect the negative cable from the battery.
2. Remove the speedometer cable connection from the instrument and the bulb holder for the instrument lighting.
3. Remove the nuts securing the bracket and lift out the instrument.

Installing

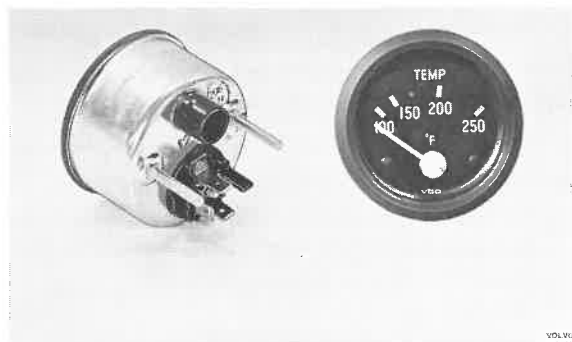
1. Place the instrument in position. Make sure that it is fitted properly in relation to the other instruments.
2. Install the bracket and tighten up the instrument with the two nuts.
3. Install the bulb holder for the instrument lighting and screw the speedometer cable nut on the instrument.
4. Connect up the negative cable to the battery and fit the battery cover.

ENGINE TEMPERATURE GAUGE

Testing

If the engine temperature gauge, see Fig. 38-12, gives incorrect temperature or no temperature at all, then the fault may lie in the instrument, its sender (see Fig. 38-13) or in the cables. The first thing to check is that there is good contact between the various instrument and sender connections and that the instrument is properly wired to the vehicle chassis.

Examine with a voltmeter or test lamp to make sure there is voltage on the instrument feed side. If the cables and contacts are without fault, carry out the following tests:



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Fig. 38-12. Engine temperature gauge

Reverse side of temperature gauge

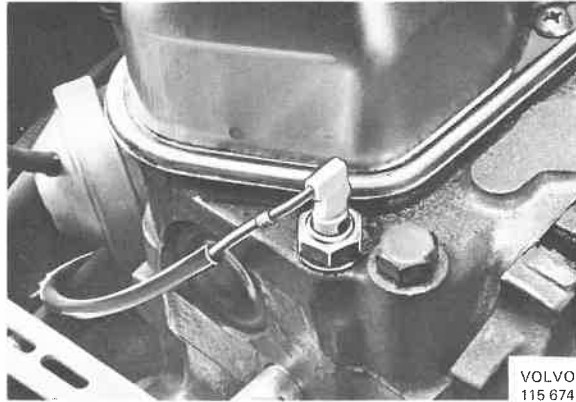


Fig. 38-13. Sender for engine temperature gauge

Temperature gauge indicates 100°F

1. Remove the cable at the sender.
2. Switch on the ignition.
3. Hold the cable against a scraped clean part on the engine in order to get an earth connection. If the gauge pointer goes over to 250°F, then the cable and instrument are in good condition so that the fault must be looked for in the sender. See under "Checking the sender".
4. If the gauge pointer does not swing to 250°F, remove the cable also at the instrument. Connect contact pin "G" to the chassis. If the instrument is functioning properly, the indicator should swing over to 100°F. And if the instrument is without fault, there must be a breakage in the cable to the sender.
If this is the case, repair or replace the cable.

Temperature gauge shows 250°F

1. Disconnect the cable running from the instrument to the sender.
2. Switch on the ignition. If the gauge pointer swings to 100°F, then the gauge is in good condition.
3. Switch off the ignition and connect up the cable between instrument and sender.
4. Disconnect the cable at the sender and insulate it from the vehicle chassis.
5. Switch on the ignition. If the gauge pointer also swings to 100°F now, then the cable is in good condition. The fault must be looked for in the sender.
See under "Checking the sender".

Checking the sender

Check the sender with an ohmmeter, which is connected between the connection terminal and the vehicle chassis. The following values apply (the sender body should be lowered into the coolant until the threads start):

Temperature	Resistance in sender
140°F	134.0±13.5 ohms
194°F	51.2±4.3 ohms
212°F	38.5±3.0 ohms

Replace sender if faulty.

Replacing the temperature sender

1. If necessary drain a little coolant from the cooling system.
2. Remove the sender, see Fig. 38-13, with gasket.
3. Fit a new sender with gasket and connect up the electric cable.
4. Add if necessary coolant to the cooling system.

Checking the temperature gauge

The temperature gauge is checked with a faultless sender connected up. Lower the sender body into the coolant until the threads start. Heat the coolant in a suitable way and check the temperature with the help of a mercury thermometer.

Replace the instrument if faulty.

Removing the temperature gauge

1. Remove the cover over the battery and disconnect the negative cable from the battery.
2. Remove the bulb holder for the instrument lighting and the cable connection for the gauge.
3. Remove the nuts securing the bracket and lift out the temperature gauge.

Installing the temperature gauge

1. Place the temperature gauge in position. Make sure that it is fitted properly in relation to the other instruments.
2. Install the bracket and tighten up the gauge with the two nuts.
3. Fit the bulb holder for the instrument lighting and connect the cable connections to the gauge.
4. Connect up the negative cable to the battery and fit on the battery cover.

FUEL GAUGE

Testing

If the fuel gauge, see Fig. 38-14, gives a wrong reading or no reading at all, then the fault may be in the instrument, the fuel tank level sending unit (see Fig. 38-15) or in the cables to the respective components. Before starting the test, check that the connections at the instrument and sending unit are in good condition. Also check the earth cable to the fuel tank level sending unit. With a voltmeter or test lamp find out if there is voltage on the feed side of the instrument (when the ignition is switched on). If the cables and contacts are in good condition, continue testing as follows:

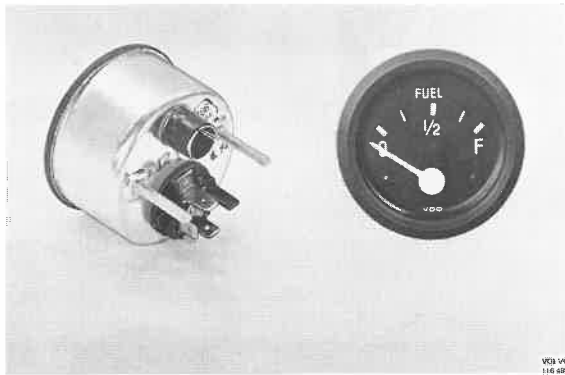


Fig. 38-14. Fuel gauge

Fuel gauge pointer points to O

1. Disconnect the cable which goes to the fuel tank level sending unit at the gauge.
2. Switch on the ignition key; if the gauge pointer swings to F, then the gauge is in good condition.
3. Turn the ignition key to neutral and re-connect the cable at the instrument.
4. Disconnect the cable at the fuel tank gauge sending unit and keep it insulated from the vehicle chassis. Turn the ignition key; if the gauge pointer swings to F, then the cable is also in good condition. The fault is probably in the fuel tank gauge sending unit, which should be removed and tested with an ohmmeter.
5. The resistance with an empty tank (the float is at its lowest position) should be 0-6 ohms. With a full tank (the float is at its top position) the resistance should be 178-192 ohms. Move the sending unit float up and down. The ohmmeter pointer should follow the movements of the float (due to increased or reduced resistance) without jerking or interruption.

6. A faulty gauge or fuel tank gauge level sending unit must be replaced with new ones.

Fuel gauge pointer points to F

1. Disconnect the cable at the fuel gauge level sending unit.
2. Switch on the ignition.
3. Hold the disconnected cable against the chassis. If the pointer swings over to O, then the cable and gauge are without fault, so the fault is probably in the sending unit. See point 5 under the previous test.
4. If, when doing the test described above, the gauge pointer does not swing to O, disconnect the cable at the gauge. Connect the contact washer to the chassis with a piece of cable or corresponding. If the gauge is in good condition, the pointer will swing to O. And if the instrument is without fault, then the fault is probably a poor contact at the connections to the instrument or in the cables to the fuel gauge level sending unit.
Replace a faulty gauge or fuel tank gauge level sending unit with new ones.

Removing the fuel gauge

1. Remove the cover over the battery and disconnect the negative cable from the battery.
2. Remove the bulb holder for the instrument lighting and the cable connections at the instrument.
3. Remove the nuts holding the bracket and lift out the fuel gauge.

Installing the fuel gauge

1. Place the fuel gauge in position. Make sure that it is located properly in relation to the other instruments.
2. Fit the bracket and tighten up the gauge with the two nuts.
3. Fit the bulb holder for the instrument lighting and connect up the cables.
4. Connect the negative cable to the battery.

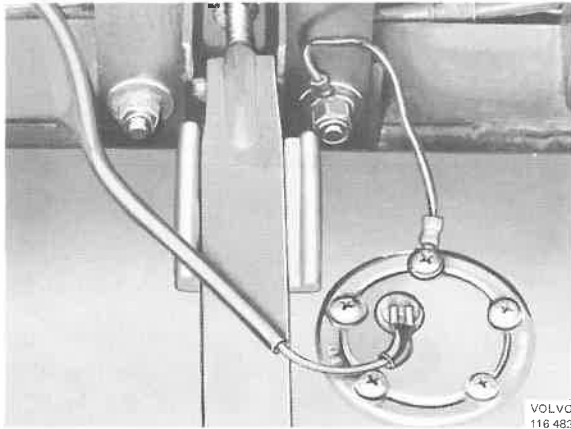


Fig. 38-15. Fuel tank level sending unit

Removing the fuel tank level sending unit

1. Disconnect the cables from the sending unit. Make a line-up mark (with for example a screwdriver) on the sending unit and fuel tank.
2. Remove the screws securing the sending unit and then remove the unit. Remove the gasket from the unit.

Installing the fuel tank level sending unit

1. Fit a new gasket and place the sending unit in position.
2. If necessary replace the rubber seals for the screws. Screw tight the sending unit and connect up the electric cables.

AMMETER

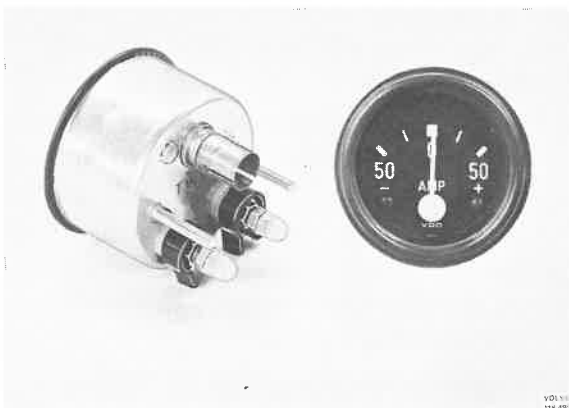


Fig. 38-16. Ammeter

Removing

1. Remove the cover over the battery and disconnect the negative cable from the battery.
2. Remove the two nuts holding the ammeter.
3. Lift out the ammeter. Mark up and remove the cables.

Installing

1. Connect the cables to the ammeter according to the marking.
2. Screw tight the ammeter in the instrument panel.
3. Connect up the negative cable to the battery and fit the battery cover.

OIL PRESSURE GAUGE

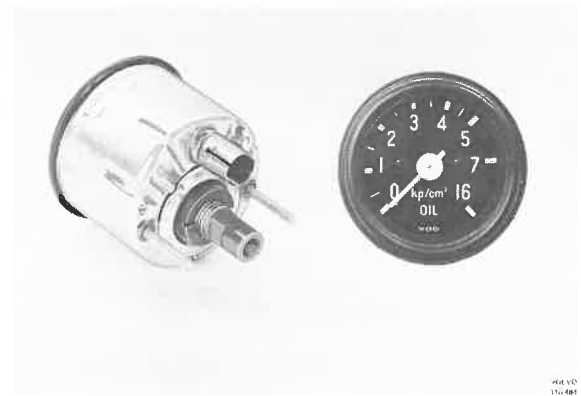


Fig. 38-17. Oil pressure gauge

Removing

1. Remove the cover over the battery and disconnect the negative cable from the battery.
2. Remove the two nuts holding the gauge.
3. Lift out the gauge and disconnect the pipe connection.

Installing

1. Fit the pipe connection.
2. Screw tight the gauge in the instrument panel.
3. Connect up the negative cable to the battery and fit the battery cover.

Replacing oil pressure contact

1. Disconnect the cable from the oil pressure contact, see Fig. 38-18.
2. Hold the new sender ready and fit it as soon as the old one has been removed.

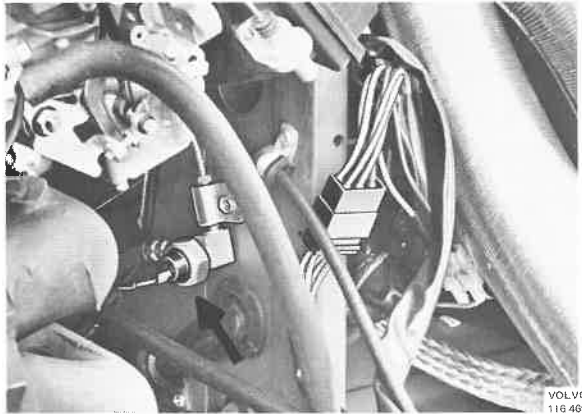


Fig. 38-18. Oil pressure contact

Solenoid for front-wheel drive

Removing

1. Make sure that the ignition is switched off. Disconnect the cables at the terminal panel.
2. Slacken the pipe and hose connections at the solenoid several turns, see Fig. 38-19.
3. Remove the screws securing the solenoid and also the pipe and hose connections.

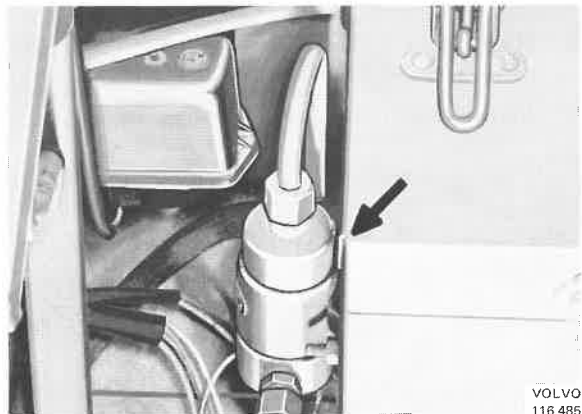


Fig. 38-19. Solenoid

Installing

1. Connect the pipe and hose connections to the solenoid.
2. Install the solenoid.
3. Screw tight the pipe and hose connections and connect the cables to the terminal panel.

Replacing the contact for brake lights

1. Remove the cables and the nut securing the contact to the bracket.
2. Fit the contact in the bracket and connect up the cables.

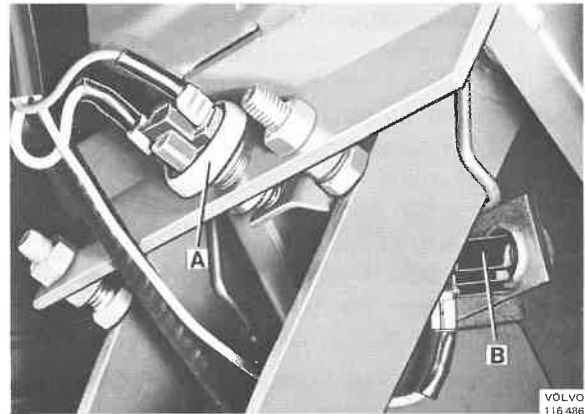


Fig. 38-20. A, Contact for brake lights
B, Contact for pedal travel

Adjusting

In order for the contact to function correctly and to prevent it from being damaged, the contact must have a certain position in relation to the brake pedal. The distance between the pedal in the rest position and the brass sleeve on the contact should be 2-6 mm (3/16"), see Fig. 38-21. With a different distance, slacken the nuts and move the contact in order to obtain the correct distance. Thereafter tighten up the nuts.

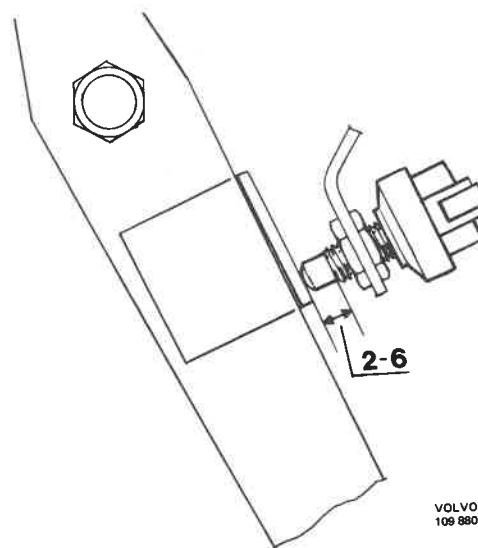


Fig. 38-21. Contact for brake lights, adjustment measurement

Replacing contact for brake pedal travel

1. Disconnect the cable and the nut securing the contact to the bracket.
2. Fit the new contact to the bracket and connect up the cable.

Adjusting

The contact should warn when there remains 90–100 mm (4") of pedal travel, measured at the centre of the footplate. Since this normally can only be checked with bleeding, check the position of the contacts by measuring the distance between the brake pedal bracket and the contact pin (see Fig. 38–22), with the brake pedal in the rest position. This distance should be 15–17 mm (5/8"). If the distance is otherwise, slacken the nut and move the contact in order to obtain the correct distance. Thereafter tighten up the nut.

The contact is re-set from the warning position by pushing back the contact pin to the rest position.

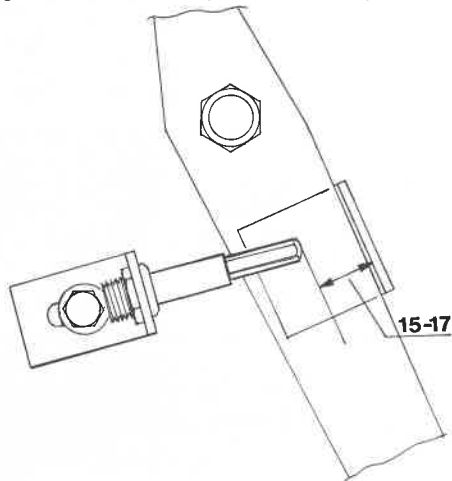


Fig. 38–22. Contact for brake pedal travel, adjustment measurement

Replacing the parking brake contact

1. Remove the inspection cover.
2. Disconnect the cable and the nut securing the contact, see Fig. 38–23, to the bracket.

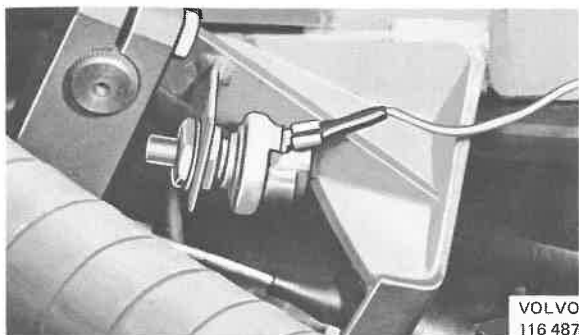


Fig. 38–23. Parking brake contact

3. Fit the new contact and connect up the cable. The contact should cut in the current to the warning light marked "Brake" at the second or third ratchet notch. Put back the inspection cover.

Replacing the vacuum contact for differential locks

1. Disconnect the cable from the contact, see Fig. 38–24.
2. Remove the contact.
3. Fit the new contact and connect up the cable.

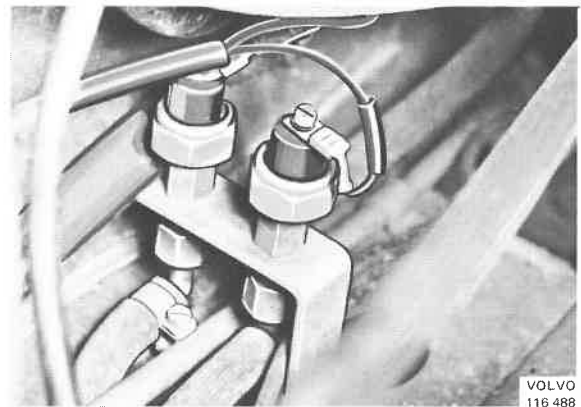


Fig. 38–24. Vacuum contact for diff. locks

Front-wheel drive contact (with auxiliary gearbox)

Removing

1. Remove the plate over the gearbox.
2. Mark up and disconnect the cables from the contact, see Fig. 38–25.
3. Remove the contact and the copper washer.

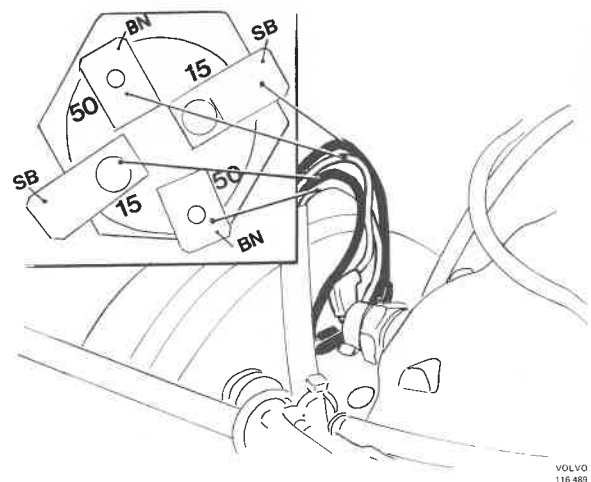


Fig. 38–25. Front-wheel drive contact, with auxiliary gearbox

Installing

1. Screw on the contact together with a new copper washer.
2. Connect up the cables according to the marking.
3. Fit the plate over the gearbox.

Indicator/warning lights**Replacing indicator light bulb**

1. Screw out the indicator light lens and remove the bulb.
2. Fit the new bulb and screw on the lens.

Removing the indicator light

1. Remove the cover over the battery and disconnect the negative cable from the battery.
2. Screw off the indicator light lens.
3. Mark and disconnect the cables from the indicator light.
4. Unscrew the nut securing the indicator light and pull out the indicator light from the panel.

Installing the indicator light

1. Fit the new indicator light and tighten it up in the panel with the nut.
2. Connect up the cables according to the marking.
3. Fit a new bulb if necessary and then screw on the lens.
4. Connect up the negative cable to the battery and fit on the battery cover.

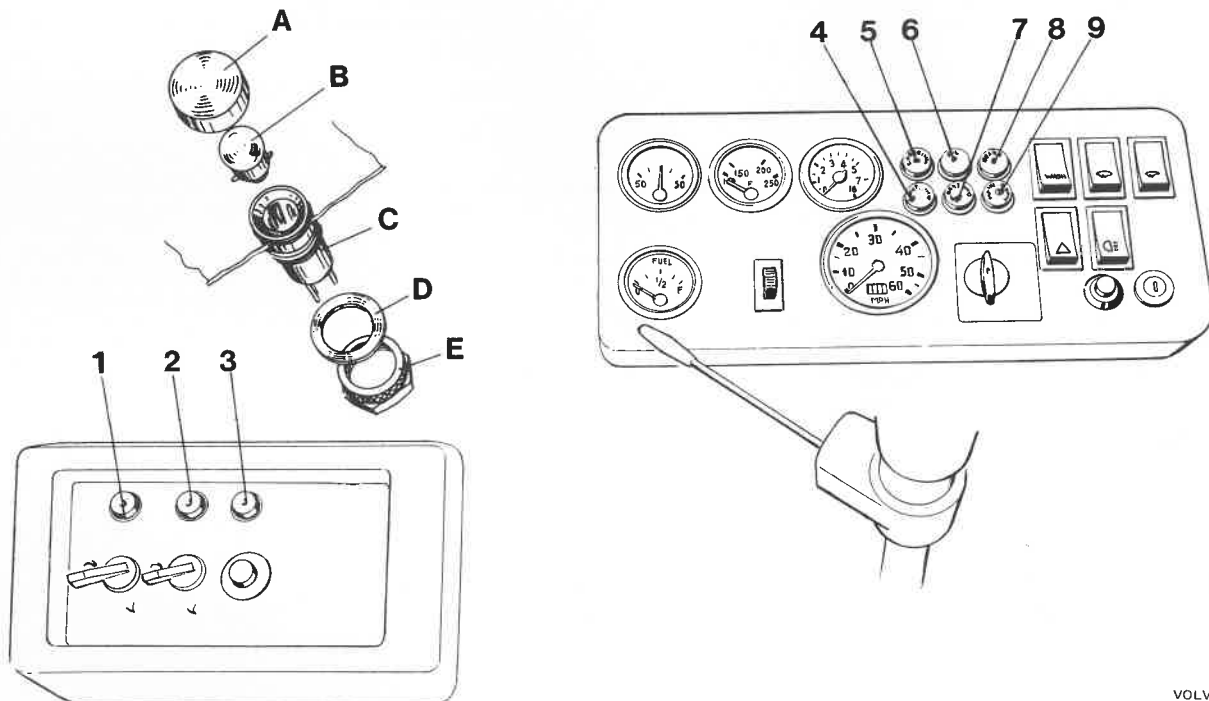
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Fig. 38-26. Warning/indicator lights

- | | | | | |
|----------------|---------------|--------------------|----------------|--------------|
| A. Lens | D. Washer | 2. Diff. lock | 5. Charging | 8. Brake |
| B. Bulb | E. Nut | 3. Front wheel dr. | 6. Oil | 9. Main beam |
| C. Bulb holder | 1. Diff. lock | 4. Direct ind. | 7. Direct ind. | |

LIST OF COMPONENTS

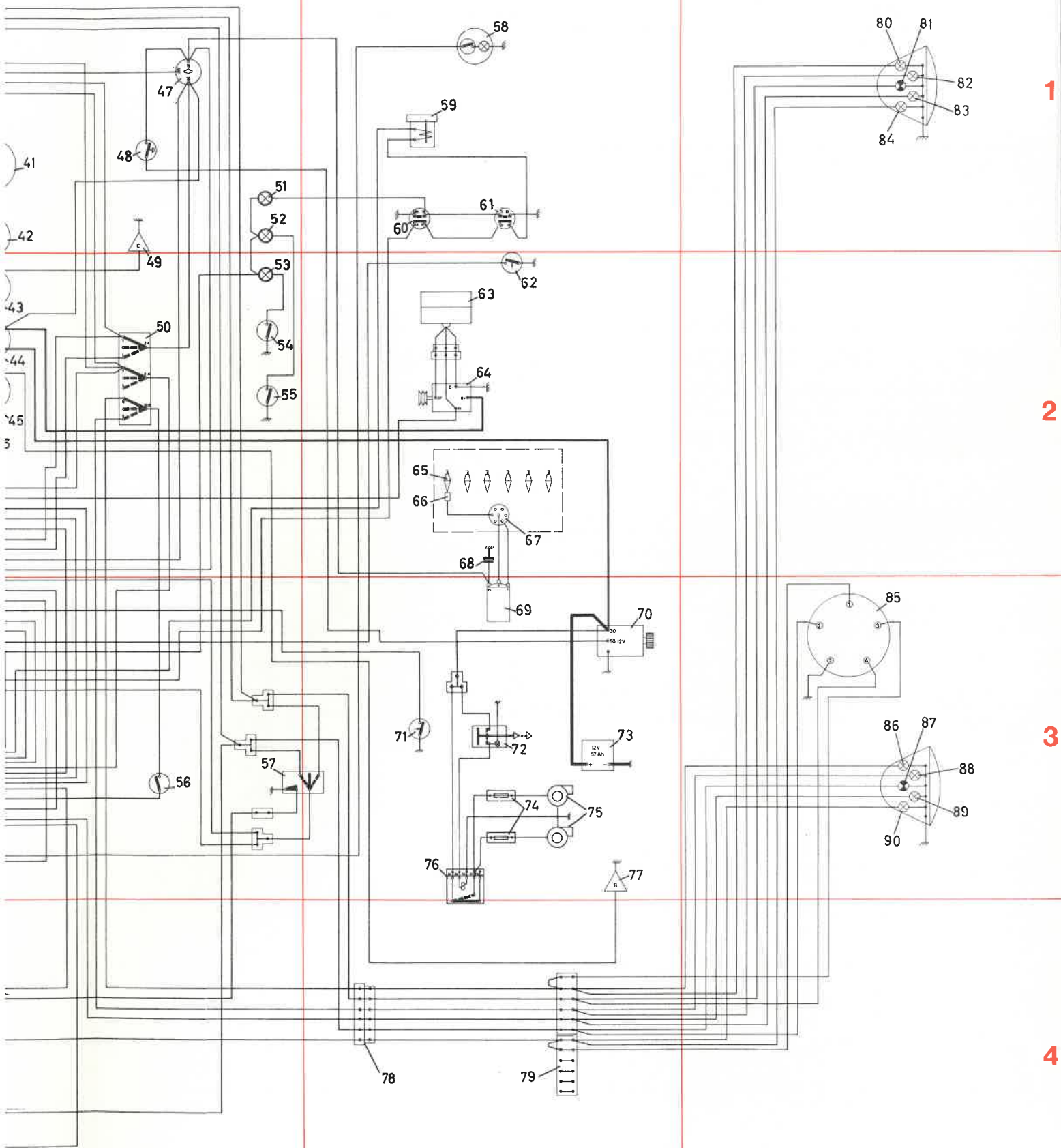
The letter and figure within brackets indicate the square in which the component in question is located.

1. Black out lamp (A 1)
2. Out line (A 1)
3. Lamp 12 V—23 W (A 1)
4. Lamp 12 V—4 W (A 1)
5. Headlight insert (A 2)
6. Wiper motor (A 2)
7. Windscreen washer pump (A 2)
8. Horn (A 3)
9. Horn button (A 3)
10. Step relay (A 3)
11. Wiper motor (A 4)
12. Headlight insert (A 4)
13. Lamp 12 V—4 W (A 4)
14. Lamp 12 V—23 W (A 4)
15. Out line (A 4)
16. Blackout lamp (A 4)
17. Switch for wiper (B 1)
18. Switch for wiper (B 1)
19. Lighting switch (B 1)
20. Switch for windscreen washer (B 1)
21. Switch for hazard (B 1)
22. Relay, wiper motor, high speed (B 2)
23. Relay, wiper motor, low speed (B 2)
24. Relay, wiper motor, high speed (B 2)
25. Relay, wiper motor, low speed (B 2)
26. Flasher unit (B 2)
27. Direction indicators (B 2)
28. Direction indicators (trailer) (B 2)
29. Brake (B 2)
30. Mainbeam (B 2)
31. Oil (B 2)
32. Charging (B 2)
33. Contact for brake pedal travel (B 3)
34. Out line (B 3)
35. Mainbeam flasher (B 3)
36. Side lights (B 3)
37. Fan motor (B 3)
38. Switch for fan motor (B 3)
39. Fuse holder, A (B 3)
40. Fuse holder, B (B 3)
41. Speedometer (C 1)
42. Oil pressure gauge (C 1)
43. Temperature gauge (C 2)
44. Ammeter (C 2)
45. Fuel gauge (C 2)
46. Rheostat for instr. light (C 2)
47. Ignition (C 1)
48. Starter button (C 1)
49. Temperature gauge sender (C 2)
50. Blackout light switch (C 2)
51. Front-wheel drive (C 1)
52. Diff. lock (C 1)
53. Diff. lock (C 2)
54. Vacuum contact for diff. lock (C 2)
55. Vacuum contact for diff. lock (C 2)
56. Brake light contact (C 3)
57. Direction and mainbeam flasher (C 3)
58. Courtesy lighting (D 1)
59. Solenoid valve for front-wheel drive (D 1)
60. Switch for front-wheel drive (D 1)
61. Front-wheel drive contact, with auxiliary gear-box (D 1)
62. Oil pressure contact (D 2)
63. Charging regulator (D 2)
64. Alternator (D 2)
65. Spark plug (D 2)
66. Suppressor (D 2)
67. Distributor (D 2)
68. Condenser (D 2)
69. Ignition coil (D 3)
70. Starter motor (D 3)
71. Handbrake contact (D 3)
72. Switch for compressor (D 3)
73. Battery (D 3)
74. Fuse holder (D 3)
75. Compressor (D 3)
76. Relay for compressor (D 3)
77. Fuel gauge sender (D 3)
78. Connector (D 4)
79. Connection box (D 4)
80. Lamp 12 V—23 W (E 1)
81. Lamp 12 V—23 W (E 1)
82. Lamp 12 V—3 W (E 1)
83. Lamp 12 V—3 W (E 1)
84. Lamp 12 V—10 W (E 1)
85. Trailer contact (E 3)
86. Lamp 12 V—23 W (E 3)
87. Lamp 12 V—23 W (E 3)
88. Lamp 12 V—3 W (E 3)
89. Lamp 12 V—3 W (E 3)
90. Lamp 12 V—10 W (E 3)

C

D

E



1

2

3

4

C

D

E

