CONTENTS

## GROUP E: ELECTRICAL SYSTEM

## GENERATOR

A 12 volt, 300 watt generator is utilized. The alternator charges the battery and supplies current to the electrical units of the car.

## ENGINE STARTER

An 8/10 HP, solenoid-operated starter is utilized. The starter is controlled by the ignition/starter switch on the instrument panel.

## BATTERY

The six-cell, 12 volt, 45 Ah battery is located within the luggage compartment under the front lid. The negative battery terminal is connected to the ground.

## IGNITION SYSTEM

The ignition system is battery operated and includes a high tension coil as well as a distributor which is equipped with a centrifugal spark advance mechanism. The distributor is driven by a worm gear mounted on the crankshaft. The ignition current is switched on through the ignition switch on the instrument panel.

## LIGHTING

The two headlamps are mounted in the front fenders and have high and low beams in each. Parking lights are accomodated in the front directional blinker housings. The parking lights and headlights are switched on through a switch on the instrument panel, next to the ignition switch. Instrument light brightness can be varied with the light switch knob by turning it to the desired position. Tail lights go on with headlights.

The headlights are dimmed with the blinker/dimmer/headlamp flasher switch located on the steering post below the steering wheel. A blue headlamp control light goes on in the tachometer dial when high beams are on.

The two tail lights are combined with stop lights and directional blinkers. Two small lamps illuminate the license plate in the back.

The stoplights are controlled through a switch mounted in the brake master cylinder and go on when the foot brake is depressed. The backup lights go on when reverse gear is engaged; the lamps are located in the tail lamp housing, the switch in the side of the transmission housing.

The interior lamps are located above the doors. The lamps can be turned on by tilting the entire lens. In the same manner, the lamps can be set for courtesy operating together with the opening doors.

The cigar lighter socket in the instrument panel can also be used for plugging in a hand lamp.

## ELECTRICAL ACCESSORIES

The signal horns can be sounded through a horn button in the center of the steering wheel; the contact is made through a contact ring in the blinker/dimmer/flasher switch.

The directional blinkers and headlamp signal flasher can be actuated through switch lever in the steering post extension; the switch also controls the high and low headlamp beams. Operation of the directional blinkers is indicated by a green control light in the tachometer dial as well as through an audible ticking noise in unison with the flasher.

The windshield wipers and washers are actuated through a combination wiper/washer switch on the steering post. The fuses for the various accessories are located in the left part of the luggage compartment and are covered with a plastic top.

## INSTRUMENTS

The speedometer and odometer are driven by a gear in the transmission by means of a cable drive. The tachometer is transistorized; electrical pulses emanating from the ignition system pass through a transistorized conventer and are fed into an electric counter in the tachometer unit.

The fuel level is indicated by means of a fuel gauge which is connected to an electrical sending unit in the fuel tank. In addition, the gauge has a low fuel warning light.

## NOTE

Repairs in the electrical system normally are confined to the replacement of worn or defective parts and the repair of the wiring system. In general, damaged wiring removed from the system should be replaced wire of same cross-section as shown in the wiring diagram. BOSCH components should be repaired by BOSCH service whenever possible.

## CAUTION

To avoid shorting the circuit and minimize fire hazards due to electrical sparks, the battery ground strap should be removed from the battery prior to the initiation of any work in the electrical system.

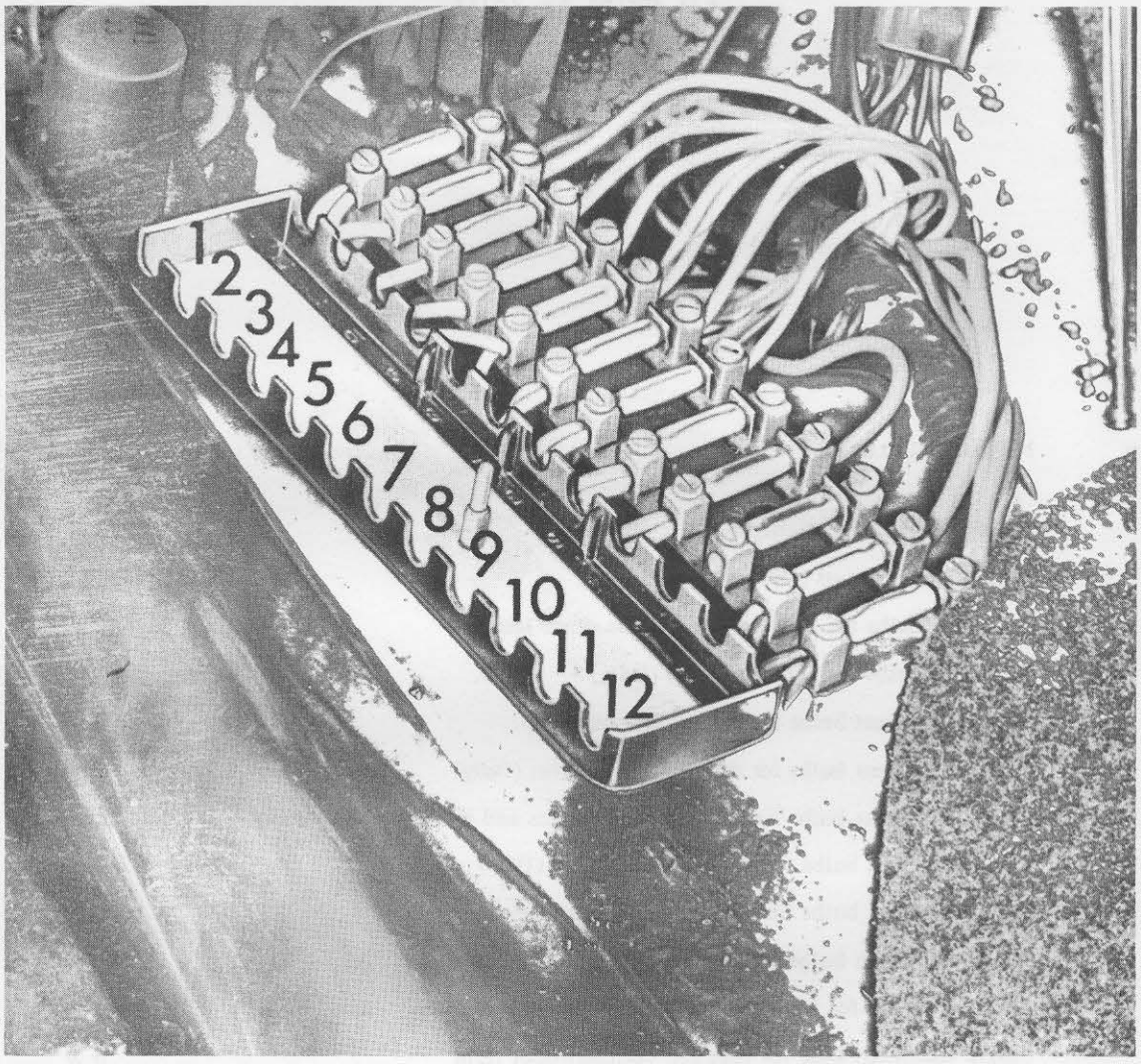



Fig. 1

1 High beam, left
2 High beam, right
High beam indicator
3 Low beam, left
4 Low beam, right
5 Parking lamp, left
6 Parking lamp, right
7 License plate lamp and luggage compartment lamp
8 Fog lamps
9 Windshield wipers and washer
10 Auxiliary combustion heater
11 Interior light, cigar lighter, electric clock
12 Stop lights, blinkers, backup light

## BULB CHART

All bulbs 12 volts

| Qty | Nomenclature | Wattage |
|---|---|---|
| 2 | Twin filiament headlamp bulbs | 45/40 W |
| 2 | Sealed beam inserts (US made) | 50/40 W |
| 4 | Cartridge bulbs for parking and license plate lamps | 4 W |
| 2 | Cartridge bulbs for parking lamps (Italy) | 3 W |
| 4 | Single filiament bulbs for directional blinkers | 18 W |
| 4 | Single filiament bulbs for directional blinkers (Italy) | 15 W |
| (6) | Single filiament bulbs for directional blinkers and backup lights (USA) | 32 cp |
| (2) | Twin filiament bulbs for stop and tail lights (USA) | 32/4 cp |
| 2 | Twin filiament bulbs for stop and tail lights | 18/5 W |
| 2 | Single filiament bulbs for backup lights | 25 W |
| 2 | Cartridge bulbs for interior lights | 10 W |
| 1 | Single filiament bulb for luggage compartment light | 5 W |
| 16 | Bulbs for instrument illumination and control lamps | 2 W |
| (2) | Single filiament bulbs for parking lights (USA) | 2 cp |

## General

The generator has the function of supplying all the current consuming units in the vehicle and to charge the battery satisfactorily. It is driven by the engine by means of a V-belt. To regulate the voltage which varies according to the loading of the generator by the current consumers or by the varying speed of the engine there is a toggle regulator with a sloping characteristic curve.

## Method of operation

The generator is a DC shunt-wound machine. Its voltage is maintained at approximately the same level by means of a electro-magnetic high-speed regulator independently of engine speed and loading. In addition this regulator prevents overloading of the battery. An electro-magnetic switch switches the generator on automatically and at low speeds disconnects it from the battery so that discharge of the battery through the generator is prevented. Regulator and switch are combined to form a regulator switch.

In order to protect the generator from overloads resulting from the very high charging current occuring when current consumers are switched on the battery is flat and the voltage constant, regulators with output limitation are used.

## Variode regulator

The variode regulator fitted in the vehicle has on the voltage regulator unit a second winding (control winding). This is connected on one side to the switch contact and on the other side via the variode (semiconductor unit) to D+. When current flows through the main current lead a potential drop arises between D+ and the switch contact. When the output limit of the generator is reached the variode becomes conductive as a result of the potential drop. In the control winding flows a current which strengthens the magnetic field on the voltage regulator unit and thus reduces the generator potential. The generator is thus protected against overload.

## Construction of generator

The main components of a generator are:

The pole housing with pole shoes and the exciter winding

the armature with armature winding and commutator

the carbon brushes and brush holders

the bearing cap (drive bearing and commutator bearing)

the special regulator switch

The pole housing is a hollow cylinder of special iron which forms a very good conductor for the magnetic flux. The pole shoes are fixed on the inside of the housing by means of countersunk bolts into the housing.

On the pole shoes are located exciter coils connected in series which consist of a large number of windings of insulated copper wire.

Between the pole shoes rotates the armature, an iron core in which are bedded the windings (armature conductors) of the armature coil and on whose shaft is also fitted the commutator (current reversal switch) from which the induced generator potential is collected.

The iron core of the armature is made up of a large number of thin stamped out metal plates which are insulated from each other for suppression of eddy currents. The armature coils which consist of a fairly large number of windings of insulated copper wire are located and insulated in the grooves of the armature. The armature conductors are protected against centrifugal throw-out. The total number of all the coils is called the armature winding which consists of as many coils as the commutator has segments. To ensure that all commutator coils are conductively connected to each other and thus always contribute collectively to the production of the generator potential the end of one coil is soldered into one of the commutator segments with the beginning of the next coil. Thus a closed circuit armature winding is effected.

The commutator consists of copper segments which are insulated from each other and from the armature shaft. The insulators between the individual segments must be recessed back from the commutator surface so that the carbon brushes will only run on the copper even after a considerable period of operation.

The carbon brushes are pressed against the commutator under uniform spring pressure and collect the current produced in the armature coils. The carbon brushes locate in box shaped brush holders.

The armature shaft is mounted in ball bearings on both sides. Both the bearing caps, that of the drive bearing and the commutator bearing seal off the pole housing from outside. The commutator bearing is covered by a cover strip so that the generator will be easily accessible for servicing of the carbon brushes and the commutator.

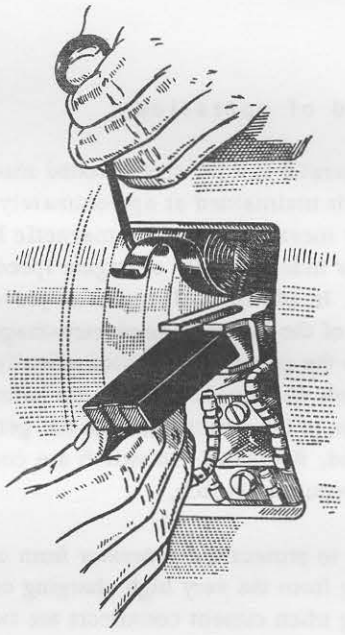


Fig. 2

## Maintenance

The ball bearings in the generator are packed with ball bearing grease (e. g. Bosch FT IV 33) and normally require no attention. Repacking with grease, which under no circumstances should be done with normal lubricating grease, will normally only take place during the course of an engine overhaul. Approximately every 10,000 km (6000 miles) the cover strap should be opened and the carbon brushes checked for wear and free travel. Used brushes should be replaced. The carbon brushes should not be oiled.

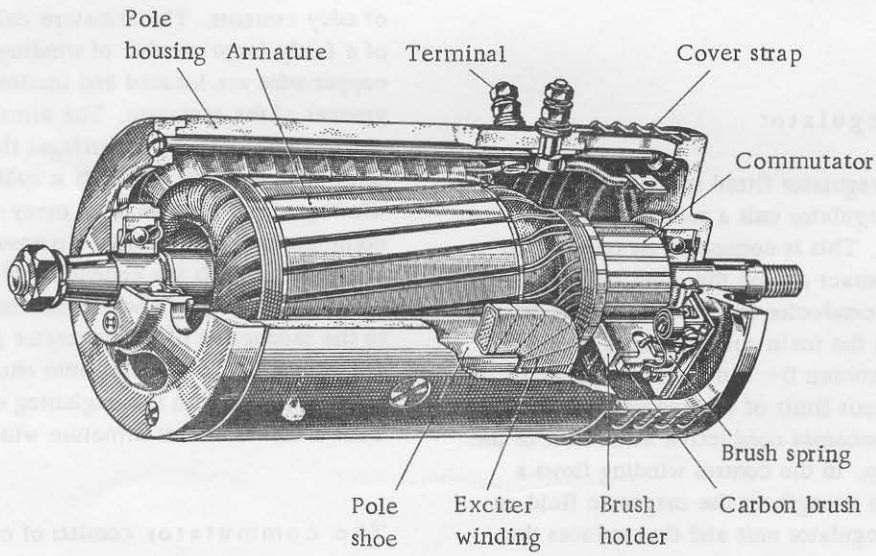



Fig. 3

## General

The ignition warning light (red) is connected between the B+ terminal and 61 of the regulator switch of the generator and lights up in the combination instrument on the instrument panel when the ignition is switched on. After starting the engine the light will go out as soon as the increasing charge voltage of the generator is equal to the battery voltage.

The light serves at the same time as a check on the V-belt and thus also on the cooling fan. If the V-belt breaks the generator and fan will remain stationary and the light will come on.

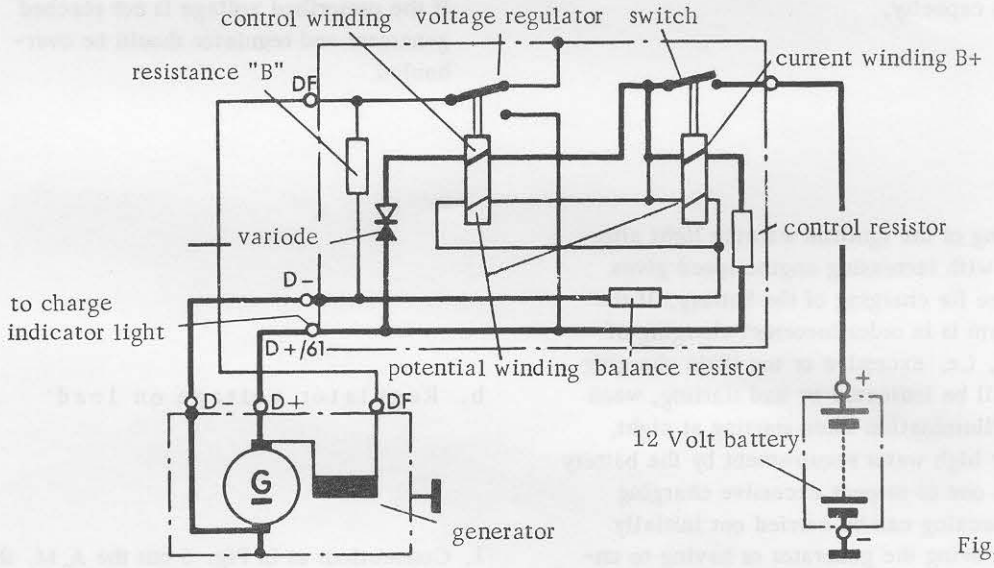



Fig. 4

## Testing

Switch on ignition, the ignition warning light on the instrument panel must light up. Undo generator cable from terminal D+ 61 on regulator, the light must go out. If this is not the case the cable is shorting to earth and this fault must be rectified. Reconnect cable to terminal D+ 61.

## Changing the bulb

1. Pull out bulb with holder.
2. Push bulb slightly into holder rotate slightly and withdraw.
3. Fit new bulb in reverse order.

2 LI

# CHECKING THE GENERATOR

Remark

For checking the electrical system the following test instruments are required:
One Voltmeter range 0 - 20 Volts

1. One voltmeter range 0 - 20 Volts.
2. One ammeter range 10 - 0 - 60 Amps.
3. Load resistance (adjustable) of 500 Watts nominal capacity.

Note

Extinguishing of the ignition warning light after starting and with increasing engine speed gives no guarantee for charging of the battery. If the wiring system is in order incorrect charging of the battery, i.e. excessive or too little charging current, will be indicated by bad starting, weak headlamp illumination when starting at night. Abnormally high water requirement by the battery should lead one to suspect excessive charging current, checking can be carried out initially without removing the generator or having to uncover the regulator. In the first instance the condition and tension of the V-belt should be checked.

a. Regulator voltage no load

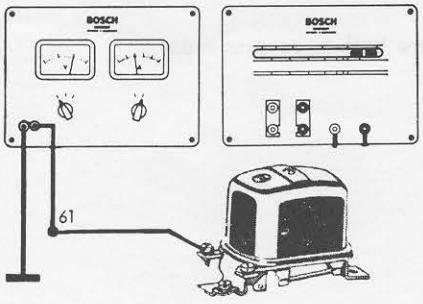



Fig. 5

1. Undo battery lead from terminal B+ on regulator and temporarily insulate cable shoe. The positive lead of the voltmeter should be connected to termianl "D+/61" and the negative lead to earth.
2. Start the engine and run the generator up to double the rated speed, the voltmeter must then show the correct regulator voltage.

   If the prescribed voltage is not reached generator and regulator should be overhauled.

b. Regulator voltage on load

1. Connections as in Fig. 5 but the A.M. should be connected in series with the control resistor between terminal B+ on regulator and earth.
2. Start engine, increase speed up to generator test speed and keep constant. Adjust resistor until the A.M. indicates the corresponding test voltage. At this setting the voltmeter must indicate at least 12 V with a generator in good condition.
3. If during this test the generator gives off no current it must be removed and repaired.

c. Use of the variodes

1. Connections as in Fig. 5, generator to run at double nominal speed.

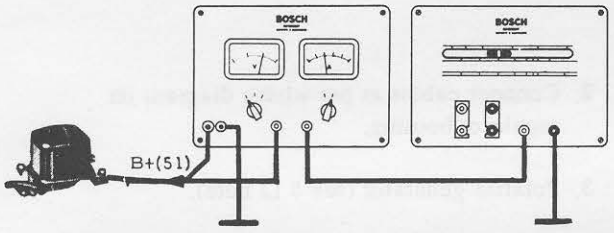



Fig. 6

2. With the sliding resistance increase loading up to maximum capacity of generator. With any further increase of load the voltage must drop.

See page L 51 for permissible current values.

3. If the voltage drops at low loads or loading just above the recommended value, the regulator must be exchanged.

Checking the reverse current switch

Remark:
Before carrying out this test check the battery which must be in good condition and at least at half charge: S.G. of electrolyte min. 1. 230 g/cm$^3$.

a. Normal "switch on voltage"

1. Connections as in Fig. 5 but connect voltmeter positive to B+ 61 on regulator. Set control resistor to nominal capacity, check as detailed in item 2.

2. Start engine and gradually increase speed. The voltage should gradually increase. No current should flow if the switch is open. On closing the switch the indicated voltage will fall and the A. M. will begin to rise. The maximum reading before the pointer starts to fall back again will give the switch on voltage. The value should be 12 Volts. If this is not the case the switch must be adjusted.

b. Checking switch opening.

1. Connect generator lead B+ (up to now insulated) to negative lead of A. M. Connect positive lead of A. M. to terminal B+ on regulator (Fig. 6).

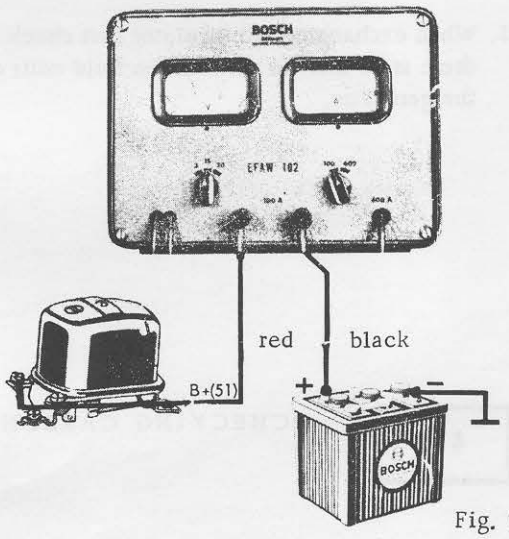



Fig. 7

2. The engine speed should be increased until the A. M. indicates charging current. The engine speed should then be slowly reduced and thus the A. M. needle will pass the 0 mark and will indicate a negative value. The maximum negative reading of the A. M. indicates the reverse current necessary for interruption of the connection between the generator and the battery. (See electrical data.)
If the contacts open whilst the A. M. indicates a charge, there is a short circuit in the relay winding. In this case the regulator should be replaced. Slow running should be set so that the A. M. falls back to 0 during slow running (the engine must be at operating temperature). If this is not the case the regulator must be adjusted or exchanged in a workshop (Bosch Service).

## 3 LI

## REMOVING AND REFITTING REGULATOR SWITCH

Removal

1. Disconnect battery.
2. Remove leads from regulator.
3. Undo fixing bolts and detach regulator.

Refitting

The following should be noted:

1. When exchanging the regulator first check that there is no short to earth in the field coils of the generator.
2. Connect cables as per wiring diagram on regulator housing.
3. Polarise generator (see 5 LI note).
4. If incorrect values are obtained even after fitment of a new regulator either the generator or the wiring system is not in order and a Bosch service station should be contacted.

## 4 LI

## CHECKING CARBON BRUSHES AND COMMUTATOR

1. Undo cover strap of generator.
2. Check carbon brushes for wear and free travel in the brush holder guides. Brushes which completely disappear into the brush holder are worn and must be replaced; the same applied to brushes which have become heavily oiled.
3. If the commutator is oily or greasy it can be cleaned with a clean cloth which has been soaked in petrol and wrapped round a piece of wood.
   When doing this care should be taken to ensure that no dirt gets into the ball bearing.
4. Check the pressure springs for tension (see electrical data) if necessary, replace defective springs.
5. If the commutator surface has become uneven as a result of running in of the brushes or has burn spots, it should be skimmed.

Note

Any petrol on the commutator should be allowed to evaporate completely before start-up (fire risk).

## REMOVING AND REFITTING GENERATOR

5 LI

### Removal

1. Disconnect cable at generator.
2. Detach V-belt.
3. Remove clamp strip of generator.
4. Undo fixing bolts on generator bracket.
5. Undo four bolts on fan cover and extract generator.

### Refitting

When refitting the following should be noted:

1. Ensure satisfactory condition of paper gasket on the generator bracket at the crankcase.
2. Reconnect leads in accordance with wiring diagram.

Note:
Before fitment of the V-belt the generator should always be polarised to prevent any damage to the regulator and to ensure correct charging. For this purpose one should connect the battery lead for a short time to the terminal 61 D+ on the regulator. The generator must now start to run as an electric motor i.e. in the direction of rotation of the engine.

## DISMANTLING AND REASSEMBLING GENERATOR

6 LI

### Dismantling

1. Detach V-belt pulley and cooling fan.
2. Undo field coil connection from brush holder of positive brush.
3. Undo both generator housing bolts.
4. Take generator housing apart and extract armature.
5. Pull out ball bearings. After dismantling individual parts wash carefully in petrol and blow through with compressed air.

### Reassembling

Reassembly should be effected in the reverse order observing the following points:

1. Check armature, field coils, cable connections and brushes.
2. Check ball bearings for wear and damage and replace if necessary. Wash bearings carefully in petrol and pack with Bosch grease Ft 1 V 33.
3. Ensure correct connection of leads to brush holders.

7 LI

# CHECKING ARMATURE

Armature faults are in many cases not externally visible. Checking should include tracing of open circuits as well as winding and earth shorts.

## Testing

1. Open circuits are generally recognisable on the commutator by burn spots between two segments. They can also be measured with a sensitive resistance measuring bridge.

2. Winding short circuits between windings of an armature coil can be traced on an armature test meter. The armature is rotated between two test probes, a magic eye then indicates the winding short circuit. Another instrument consists of an AC magnet with two jaws which take the armature. Here the armature is slowly rotated about its axis a thin piece of steel sheet being placed on top of the armature. If there is a short circuit in the winding the sheet of metal will begin to vibrate violently at 2 or more places around the perifery of the armature. With another instrument the armature is rotated in the same way over the jaws of an AC magnet while the tester probes the commutator core with a probe.

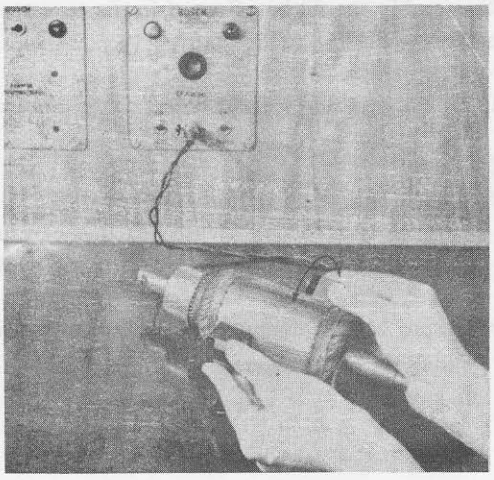


Fig. 8

The alternating current produced in the coil of the probe as a result of induction from a winding short circuit can be heard in the test head phones as a humming noise.

3. A short to earth will occur if the armature core is shorted to the winding or if carbon dust has penetrated into the winding. The test should be carried out with a test lamp of 40 V between armature iron and commutator. The test lamp should not light up.

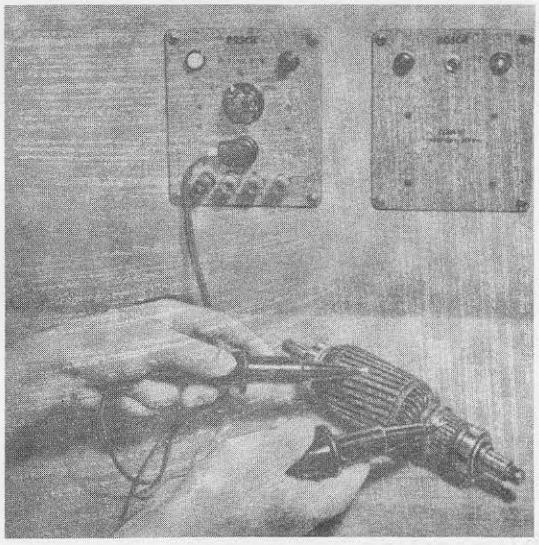


Fig. 9

4. If the commutator is oval or is rough as a result of burn spots or grooves have occurred as a result of running in of the carbon brushes it must be skimmed and polished which is essential to obtain a satisfactory surface.

   The insulators between the segments should be reworked with a commutator saw until they are recessed back about 0.3-0.5 mm from the contact face of the commutator.

## CHECKING FIELD COILS

Both field coils should be checked for open circuit, winding and earth shorts.

1. Check each field coil separately for open circuit connecting its ends with a 12 V test lamp in series with the battery. In the case of open circuit the test lamp will not light up.

2. Winding shorts can be checked by connecting the ohmmeter with the ends of each coil and comparing the test result with the recommended values (see electrical data). If an ohmmeter is not available one should connect a 12 V battery in series with an ammeter to the coil ends and should then compare the current intensity at the coils. If the current consumption difference between the two coils is greater than 0.5 Amps, the coil with the higher reading has a short circuit.

3. One should check the coils for short circuit to earth by connecting a 40 V test lamp to one end of the fild coil and the generator housing. The test lamp should not light up.

4. The field coils should also be checked for satisfactory electrical and mechanical contact with each other.

Fig. 10

## GENERATOR FAULTS AND THEIR ELIMINATION

The red ignition warning light on the combination instrument should light up when the ignition is switched on and should go out after the engine has started and the engine speed has begun to rise.

The possible causes of trouble are summarised below:

| FAULT | CAUSE | REMEDY |
|---|---|---|
| Warning light does not come on when ignition is switched on | a. Battery flat | a. Charge up battery |
| | b. Battery defective | b. Renew battery |
| | c. Bulb burned out | c. Renew bulb |
| | d. Battery terminal corroded or loose | d. Clean connections and if necessary tighten up |
| | e. Cable loose or broken | e. Tighten cable or repair |
| | f. Ignition switch defective | f. Renew ignition switch |
| | g. Generator brushes are not running on commutator | g. Free carbon brushes or renew or replace pressure springs<br>Do not oil carbon brushes! |
| Ignition warning light does not go out when engine speed rises or flickers, glows | a. V-belt loose or defective | a. Tighten or renew belt |
| | b. Regulator switch defective | b. Exchange regulator switch |
| | c. Charging lead loose or broken | c. Check cables and connections |
| | d. Generator defective | d. Check generator |
| | e. Ignition switch lead has bad connection | e. Tighten connections |
| Ignition warning light only goes out at high engine speeds | a. Generator defective | a. Check generator, repair |
| | b. Regulator switch defective | b. Exchange regulator switch |
| Ignition warning light continues to burn after ignition switched off | a. Short to earth in cable or warning light | a. Eliminate earth short |

## General

The purpose of the starter is to start the engine. Type 911 and 912 cars are equipped with a starter of 0.8 HP rating, designed for 12 V systems.
The starter has a helical spline drive with a self-releasing pinion (BOSCH Type EB).

As in most cases, the starter is a DC motor. It provides a considerable amount of torque needed for turning the crankshaft at speeds needed for starting the engine and with enough force to overcome the initial resistance on the compression stroke.

To obtain the necessary torque from a starter and battery of proportionately acceptable size, the starter drives the starter ring on the flywheel with a small pinion. The gear teeth in the starter ring and starter pinion are beveled on one side to make engagement smoother.

Due to the high gear reduction ratio between the starter ring and pinion, the pinion cannot remain engaged with the starter ring longer than necessary since the armature would be forced to spin at excessively high revolutions. Therefore, the connection between the armature and starter ring must be automatically interrupted as soon as the engine has fired up. In the BOSCH helical spline starters the interruption is accomplished by means of an overrunning clutch situated between the pinion and armature. The clutch breaks the connection as soon as the engine speed becomes higher than that of the starter. A coupling, which rides on the helical spline shaft of the armature, is connected with the pinion through the overrunning clutch. Located on the coupling is an actuating sleeve which can slide back and forth. A fork-shaped end of the actuating lever is constantly engaged in the actuating sleeve. The actuating lever moves the locking ring forward. Balls located in the coupling bores are freed and the pinion is free to move towards the engagement phase. When moving forward, the pinion rotates on the helical splines. The application of thrust and rotation prompted the designation as helical spline starter.

## Operation

When the starter/ignition key is switched on for starting, the starter solenoid is energized. The actuating lever pushes the actuating sleeve and the locking ring against the engagement ring; through this action, the engagement spring is tensioned.

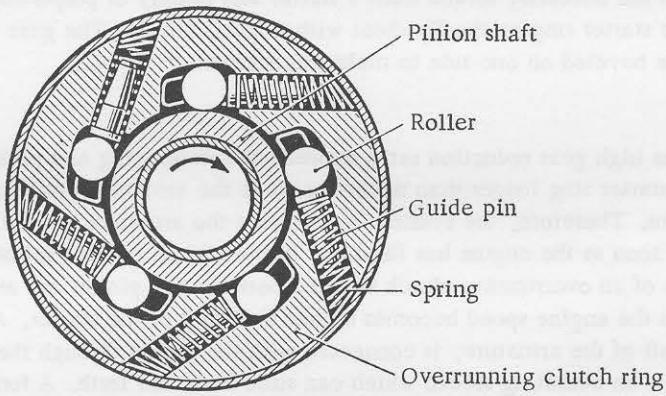
When the locking ring has moved forward by about 1/8" (2-3 mm), the balls located in the bores of the coupling are freed and can slide out of the shaft groove into the enlarged part of the locking ring. Thus the engagement components are freed and the fork begins to move the pinion; being mechanically connected to the helical splines, the pinion "bores" itself with a turning motion into the teeth in the starter ring on the flywheel.
At this time, the switch in the solenoid closes and, simultaneously, energizes the main field windings, causing the armature to turn. As the armature proceeds to turn, the effect of the helical splines further presses the pinion into the starter ring up to the point where the balls come to rest against the flanks of the helical spline portion on the armature shaft.

The actuating lever, also mechanically connected to the engagement components, is dragged along in the forward direction and tensions the disengagement spring located on the drag link of the solenoid switch. If, for instance, the pinion should be stuck due to gear tooth pressure in cases where the engine fails to fire up, the disengagement spring makes the solenoid plunger move back enough to open the switch contacts when the starter switch is released.

As a result, the starter is deenergized, gear tooth pressure ceases, and the pinion is drawn back through spring tension.

Normally, the pinion leaves the starter ring when the starter switch is released due to spring force exerted by the solenoid return spring which travels the distance allowed by the disengagement spring. This occurence is further supported by the fact that the overrun clutch breaks the torque transmitting connection between the pinion and armature shaft when the engine begins to turn faster than the armature. This also protects the armature from overspeeding.

Under the pressure of the engagement spring, the balls return into their groove in the shaft. The engagement spring decompresses further and pushes the locking ring over the balls. The brake disc is pressed against the brake pot of the armature and, at the same time, the balls in the coupling bores are pressed against the edge of the resting groove in the armature shaft. The decelerating armature is thus braked under the pressure of the engagement spring, further supported in this by the solenoid return spring.




Overrunning clutch

Fig. 11

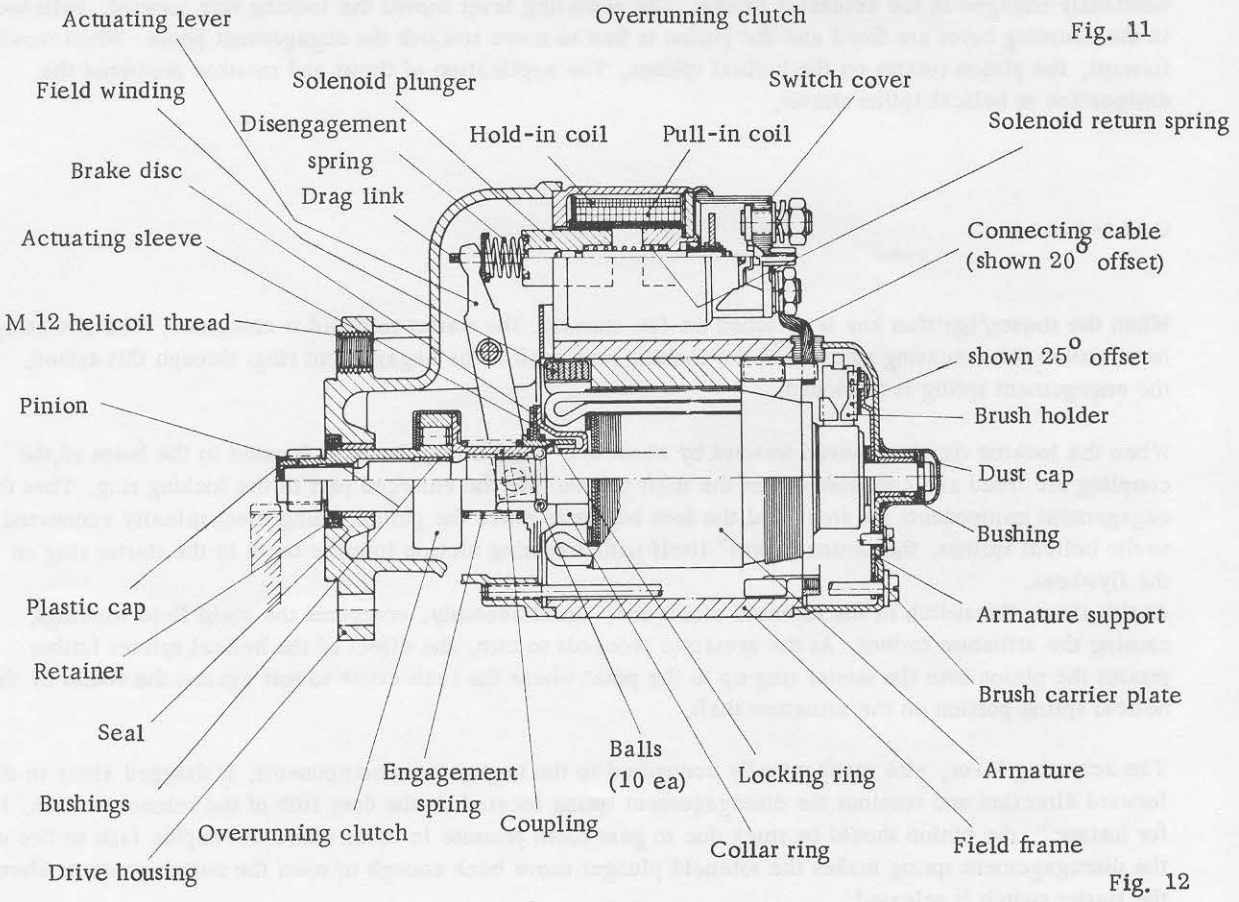



Fig. 12

## REMOVING AND INSTALLING STARTER



Removal

1. Disconnect battery ground strap.
2. Detach battery and generator cables from Terminal 30 at the starter.
3. Detach control wire (to ignition switch) from Terminal 50 at the starter.
4. Remove flanging bolts and take starter out.

When reinstalling, make sure that terminals are clean and properly tightened.

Note:

If the starter gear on the flywheel shows unusual traces of wear, the starter ring will have to be replaced.

Terminals:

1. Battery ground strap.
2. Generator and battery cables at the starter solenoid.
3. Control wire to ignition switch.

## REMOVING AND INSTALLING STARTER SOLENOID



Removal

1. Detach wire strand from solenoid.

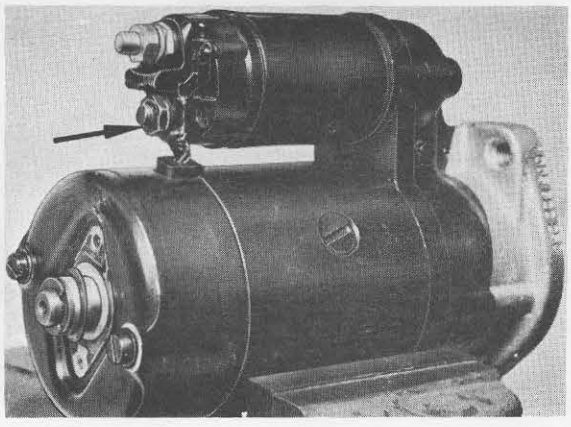


Fig. 13

2. Remove retaining bolts of solenoid from the drive housing.
3. Pull starter pinion out somewhat and withdraw solenoid switch.
   Defective solenoids should be replaced with new units. It is advisable to install a new solenoid when overhauling an engine.
   Do not attempt to readjust the solenoid.

Installation

Note the following at reassembly:

1. Hold the cable terminals when tightening the cable retaining nuts in the solenoid. Tighten the nuts moderately tight since it is possible to twist the solenoid switch contacts.

2. Pull the starter pinion forward so that the connecting end of the actuating lever moves closer to the solenoid mounting flange, and insert connecting end of solenoid plunger into the receptacle in the actuating lever.

3. When installing a new solenoid switch, adjust the connecting end of the solenoid plunger so that the distance from the hole center in the plunger clevis to the switch mounting flange is 1.276" $\pm$ .004" (32.4 $\pm$ 0.1 mm) when the plunger is in position.

Checking Starter Solenoid Switch

When the switch pulls up, travel of the solenoid plunger must be .394 $\pm$ .008" (10 $\pm$ 0.2 mm). Of that, .118" (3 mm) is engagement reserve.

## 11 LI CHECKING BRUSHES AND COMMUTATOR

1. Remove starter dust cover.

2. Brushes which completely disappear in the holders so that the connecting strand touches the holder are worn out and must be replaced with new ones of the same type; also, such brushes which have been soaked in grease or whose connecting strand is loose. When installing the brushes make sure that the connecting strands are free so as to prevent their binding in the holder. If one brush is used up, it is best to install a whole new set.

3. Check brush springs for tension. Slacked or annealed springs must be replaced.

4. If the commutator is oily or dirty, it can be cleaned with a clean cloth which is wrapped around a wooden stick and wetted in gasoline. Make sure that gasoline and dirt is kept out of the bearing.

5. If the commutator is scored or uneven, it should be redressed on a lathe.

## 12 LI DISASSEMBLING AND REASSEMBLING STARTER

Disassembly

1. Remove dust cover, lock ring, and spacers, watching the O-rings.
   Detach connecting strand from the solenoid (see Fig. 51).

2. Remove solenoid retaining screws. Withdraw solenoid from drive housing, in the process unhooking the solenoid plunger from the actuating lever.
   Remove through-bolts.
   Remove commutator support.

3. Withdraw brushes from holders.
   The plus-brushes are soldered to the winding, the minus-brushes to the brush holders. (see Fig. 52).

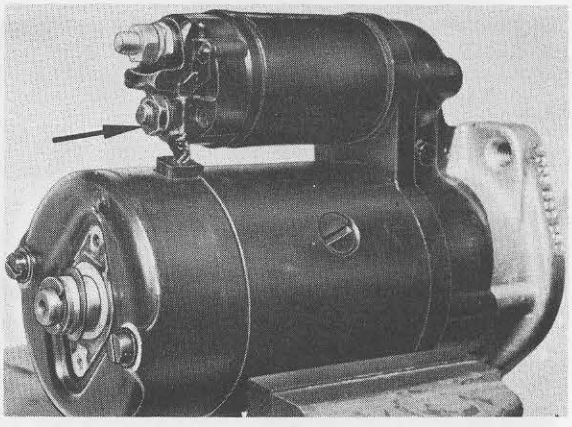


Fig. 14

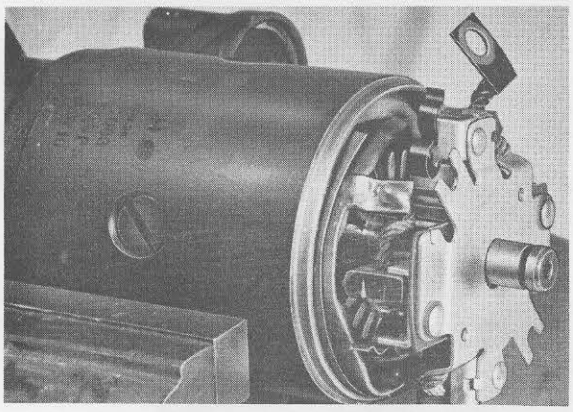


Fig. 15

4. Remove brush carrier plate, watch for the insulating washer and metal disc.

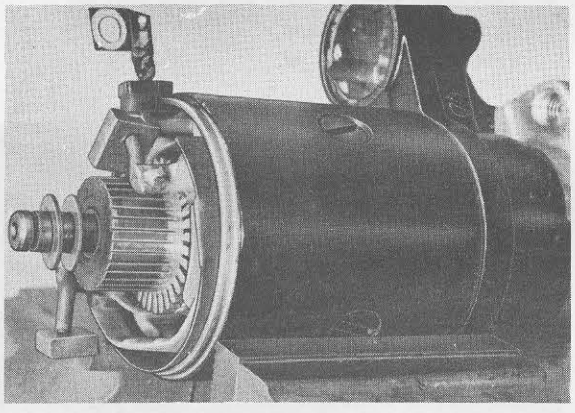


Fig. 16

5. Take field frame off drive housing, watch sealing rubber and metal plate.
Take out stud bolt from drive housing.

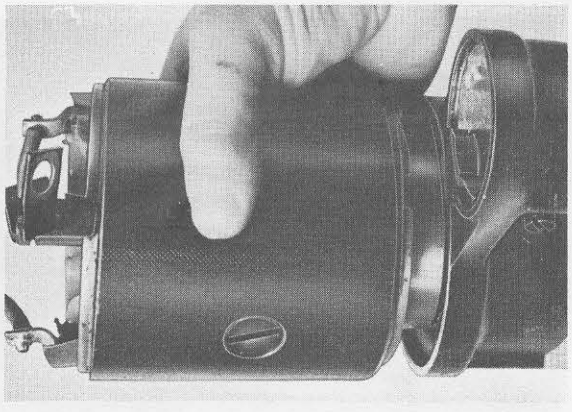


Fig. 17

6. Take armature and actuating lever out of the drive housing.

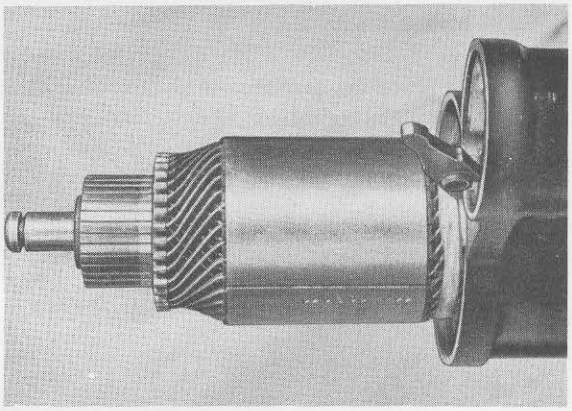


Fig. 18

7. Place armature in a vise.
Press actuating sleeve against the overrunning clutch and take it off the armature shaft, watching the locking balls.

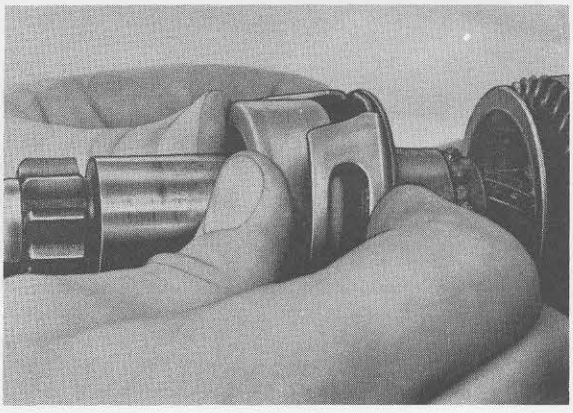


Fig. 19

## Cleaning Components

1. Clean the parts in gasoline or "Tri" solvent and blow out with air.

2. Do not place the armature or overrunning clutch into the cleaning solvent.

3. Bearing bushings must be replaced.

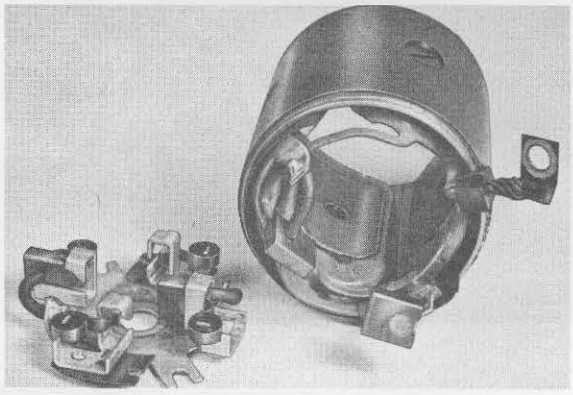


Fig. 21

## Inspecting and Conditioning Parts

1. The mechanical engagement parts must slide freely on the armature shaft. The actuating lever and linkage must not rub or bind anywhere. Bent actuating levers must be replaced.

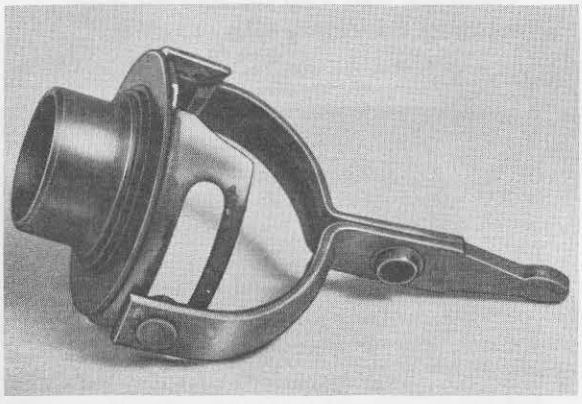


Fig. 20

2. Replace brake disc, if necessary.

3. Field coil:
   The field coil must not be scorched or the solder melted, nor be protruding beyond the pole shoes. Check the coil for continuity. Closely inspect connecting joints.

4. Test brush carrier plate and field coil for shorting to the ground.
   Test voltage: 40 V AC.

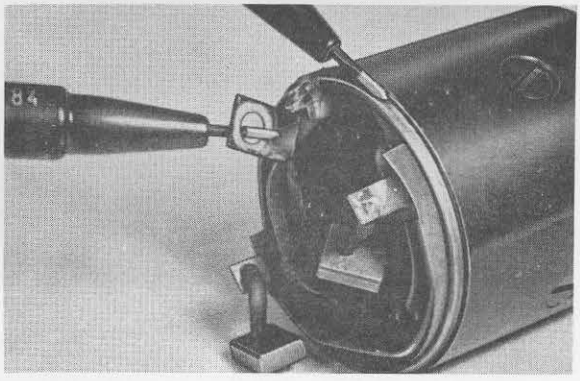


Fig. 22

5. Test armature for shorting to the ground.
   Test voltage: 40 V AC.

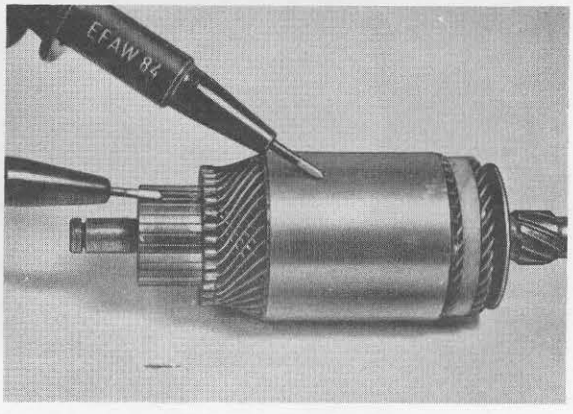



Fig. 23

A ground short will occur when the armature core comes in contact with the winding or when carbon dust has entered the assembly (direct or indirect short to the ground). The best method to test the armature is with a test lamp by connecting one lead to the metal core of the armature and the other to the commutator. The test lamp should not light.

6. Commutator:
   Max. permissible runout is .002" (0.05 mm).
   Min. diameter is 1.319" (33.5 mm).
   If necessary, remove insulating mica to a depth of about .031" (0.8 mm) with a commutator file; work with care around the segments and soldered points.

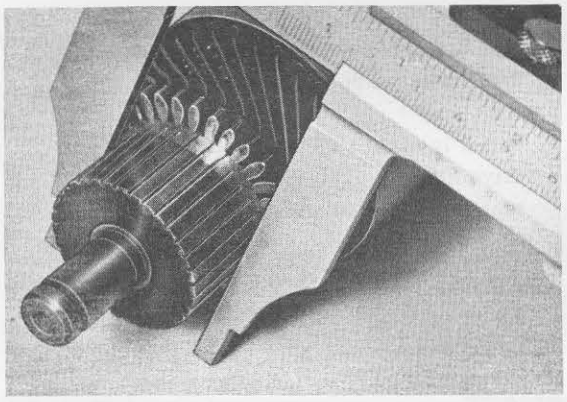


Fig. 24

7. The brushes must move freely in the holders. The brushes should not be dirty, broken, or desoldered.
   Replace brushes only in sets.

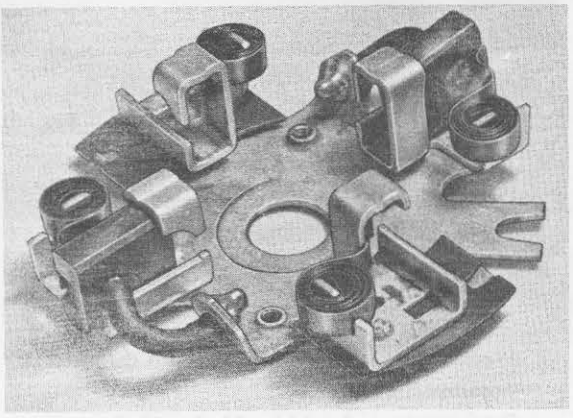


Fig. 25

8. Drive housing:
   Replace worn or unserviceable bearing bushings.
   The bushing must be flush on the inside.
   Use proper drivers for pressing the bushing in or out.
   Peen with care.

9. When replacing the metal bushing (sintered) and the sealing ring, replace the rivets with screws; peen screw ends.
   4 Fillister screws M 4 x 10
   4 Spring washers
   4 Nuts

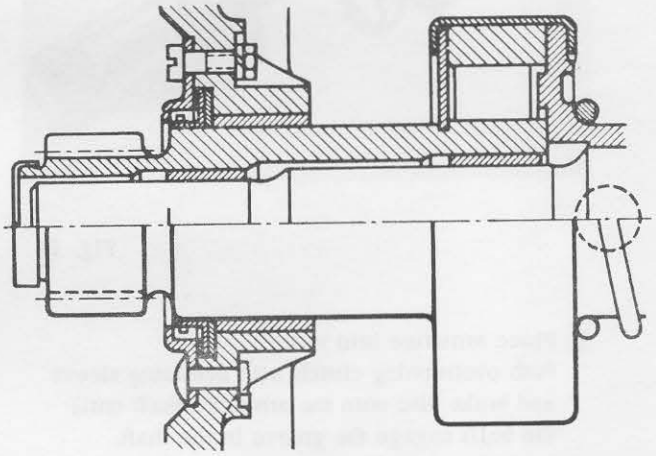


Fig. 26

10. Center the sealing ring with an aligning mandrel.

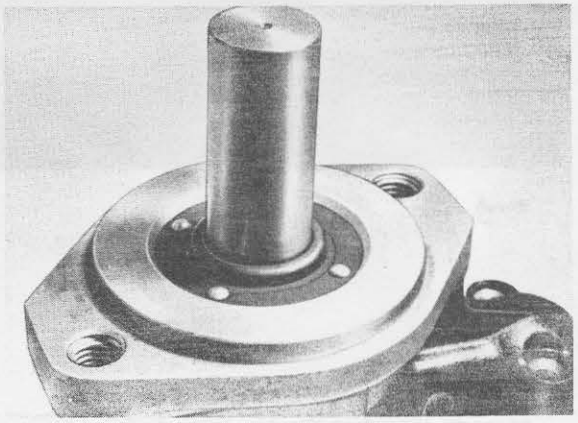


Fig. 27

## Reassembling Starter

1. Place balls into locking ring with grease (such as Ft 2 v 3).

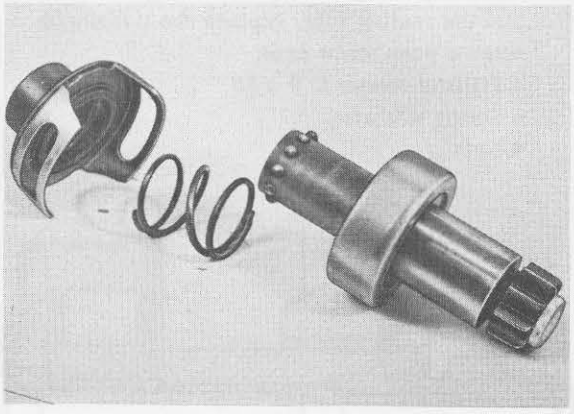


Fig. 28

2. Place armature into vice.
   Push overrunning clutch with actuating sleeve and brake disc onto the armature shaft until the balls engage the groove in the shaft.

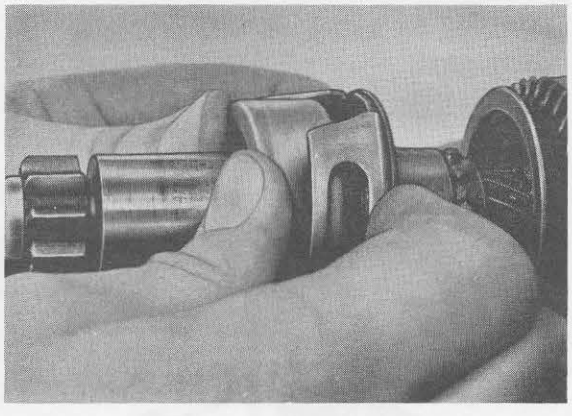


Fig. 29

3. Check if pinion and overrunning clutch are properly seated on the armature shaft.
   The mechanical engagement parts must move freely on the armature when released.

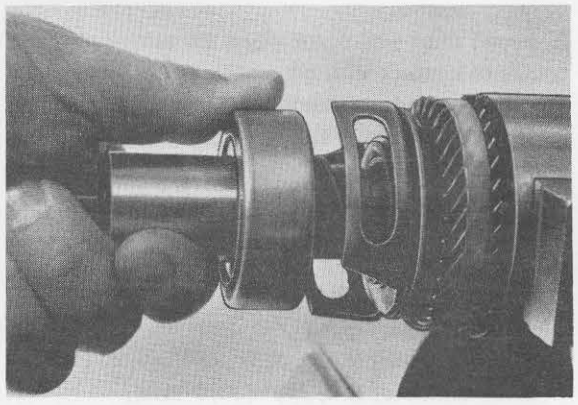


Fig. 30

4. Push armature together with the actuating lever into the drive housing.

5. Screw in pivot stud of actuating lever into drive housing. Tab of profiled rubber must seat in the cutout within the field frame.

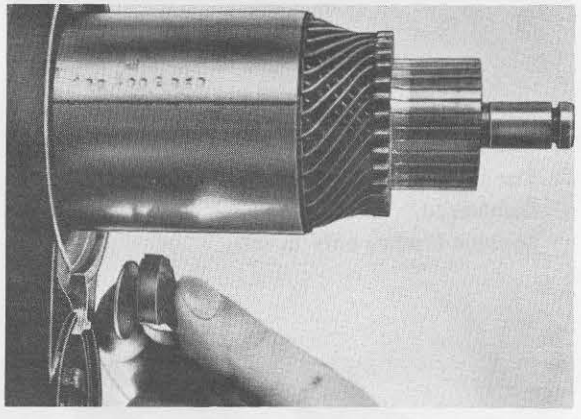


Fig. 31

6. Push the field frame over the armature.
   Do not forget the steel shims and insultating washer on the commutator side.

7. Place the brush carrier plate onto the commutator shaft.
   Brush pressure should be 40. 6 - 47. 6 oz. (1150 - 1350 p).
   Note placement of the twist notch in the plate.

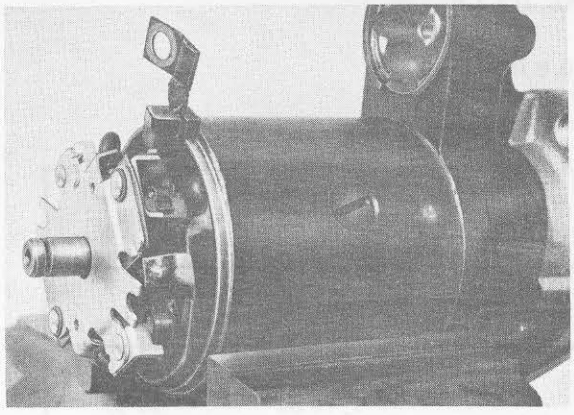


Fig. 32

8. Install dust cover.
   Make sure that rubber grommet for the connecting strand sits well. Ground connections between the brush carrier plate and cover, as well as between cover and housing, must be bare.

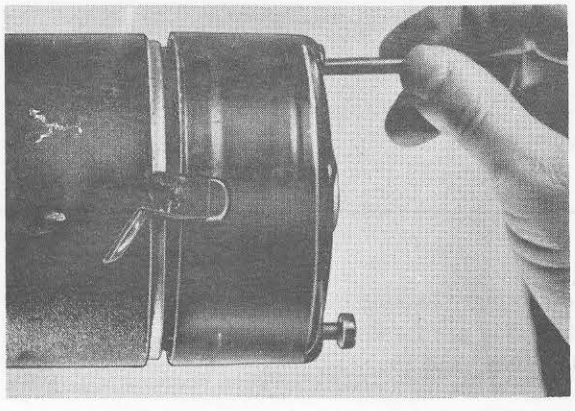


Fig. 33

9. Install spacer discs and lock ring.
   Axial play of armature should be .004 - .006" (0.1 - 0.15 mm).

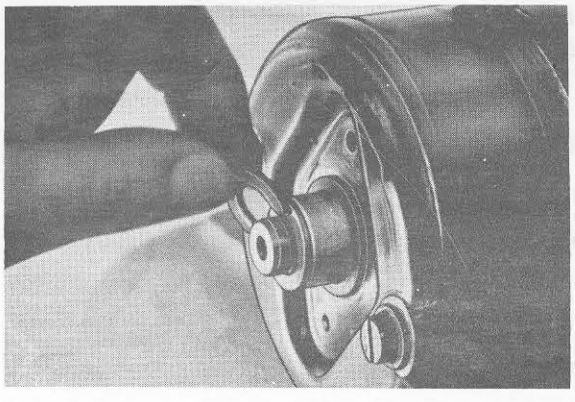


Fig. 34

10. Bolt cap of commutator bearing in place.
    Connect the solenoid plunger and bolt solenoid switch to drive housing.
    Connect terminal of winding to solenoid switch.

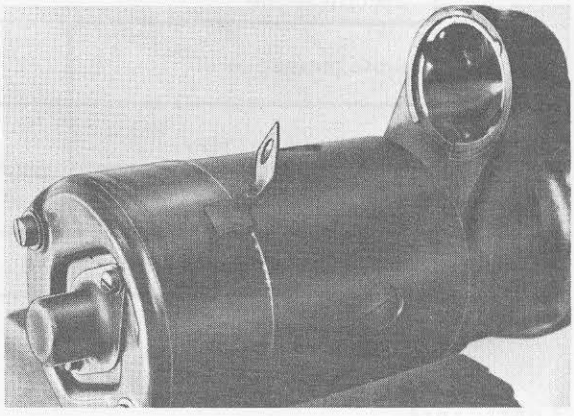


Fig. 35

TECHNICAL DATA

EB 12 V, 0.8 HP

| | |
|---|---|
| Minimum voltage for solenoid actuation | 7 volts |
| Specifications: | |
| Brush pressure | $42.3 \begin{smallmatrix} + 5.29 \text{ oz} \\ - 1.76 \text{ oz} \end{smallmatrix}$ $(1200 \begin{smallmatrix} + 150 \text{ p} \\ - 50 \text{ p} \end{smallmatrix})$ |
| Armature axial play | .004 - .006" (0.10 - 0.15 mm) |
| Overrun torque of clutch | 1.56 - 2.17 in-lb (1.8-2.5 kpcm) |
| Brake torque | 3.04 - 4.34 in-lb (3.5-5.0 kpcm) |

Lubricants

Lubrication prior to or during the reassembly.

| Lubricants (BOSCH) | Lubricating Points | Dosage |
|---|---|---|
| Ft 2 v 3 | Engagement Parts<br>Coupling shaft, coil springs, locking ring, surfaces of the guide pan for the actuating lever pin, discs, and 10 greased balls. | Grease well |
| Ft 2 v 3 | Armature Shaft<br>Pinion running surface, helical spline shaft, commutator bearing | Grease lightly |
| Ol 1 v 13 | Shaft Bushing<br>Bushings in drive housing and commutator support | Oil well |
| Ft 2 v 3 | Actuating Lever<br>Pivot stud, studs in coupling | Grease lightly |
| Ft 2 v 3 | Thrust Washers<br>-on commutator side of armature | Grease lightly |
| Ft 2 v 3 | Solenoid Switch<br>Pivot, spring, spring pan at the actuating lever receptacle | Grease lightly |

| Symptom | Cause | Remedy |
|---|---|---|
| Starter does not turn when starter switch is actuated: | Switch the lights on for testing:<br>a. Lights do not burn: Wire connecting or ground broken; dead battery.<br>b. Lights burn but go dim or off when starter switch is turned on: Excessive resistance due to loose or corroded connections.<br>c. Lights burn but slowly grow dim when starter is engaged: Low battery.<br>d. Lights burn brightly. Jump-wire Terminal 30 with 50 at starter: starter runs. Connection 50 to starter switch broken; connection 30 to light switch broken; ignition/starter switch defective.<br>e. Lights burn brightly, solenoid working Battery cable from Terminal 30 at the starter should be detached and connected to the contact bolt of the connecting strip -- starter runs. Solenoid contacts worn or dirty. | <br>a. Check battery cables and connections. Check battery charge, recharge if necessary.<br>b. Clean battery terminals and clamps. Make sure that electrical connections between battery, starter, and ground are adequate.<br>c. Charge battery.<br>d. Eliminate defect, replace defective parts.<br>e. Replace solenoid. |
| Starter does not turn when battery cable is placed directly onto the contact bolt of the connecting strip;<br>starter turns too slow or can't turn crankshaft: | a. The brushes are sticking.<br>b. Worn brushes.<br>c. Insufficient spring tension; brushes not making contact.<br>d. Dirty commutator.<br>e. Scored or scorched commutator.<br>f. Defective armature or field coils. | a. Clean brushes and holders in the brush carrier.<br>b. Replace brushes.<br>c. Replace springs.<br>d. Clean commutator.<br>e. Overhaul starter.<br>f. Overhaul starter. |
| Starter engages and pulls, but engine does not turn or turns only intermittently;<br>pinion does not disengage: | a. Dead battery.<br>b. Excessive resistance due to loose or corroded connections.<br>c. Brushes are sticking.<br>d. Worn out brushes.<br>e. Dirty commutator.<br>f. Scored or scorched commutator.<br>g. Defective starter or field coils. | a. Charge battery.<br>b. Clean battery terminals and clamps, tighten connections.<br>c. Clean brushes and brush holders.<br>d. Replace brushes.<br>e. Clean the commutator.<br>f. Overhaul starter.<br>g. Overhaul starter. |
| Starter engages and pulls, but engine does not turn or turns only intermittently. | a. Defective pinion.<br>b. Defective starter ring in flywheel. | a. Replace pinion.<br>b. Dress starter ring, replace flywheel if necessary. |
| Pinion does not disengage: | a. Dirty or defective pinion or helical spline shaft.<br>b. Defective solenoid switch. | a. Overhaul starter.<br>b. Replace solenoid. |

13 LI

## BATTERY MAINTENANCE

### General

The battery is a cushion and reservoir for the electrical energy in the vehicle.

### Specific gravity of electrolyte:

The specific gravity of electrolyte can be determined with a hydrometer. The hydrometer float rises higher, the higher the specific gravity is. By reading a scale in the hydrometer, the specific gravity can be obtained in degrees Baume. Specific gravity increases proportionately with decreasing state of charge of the battery:

Dead battery..... $18^{o}$ Be = specific gravity of 1142

Half-charged battery..... $27^{o}$ Be = specific gravity of 1230

Fully charged battery..... $32^{o}$ Be = specific gravity of 1285

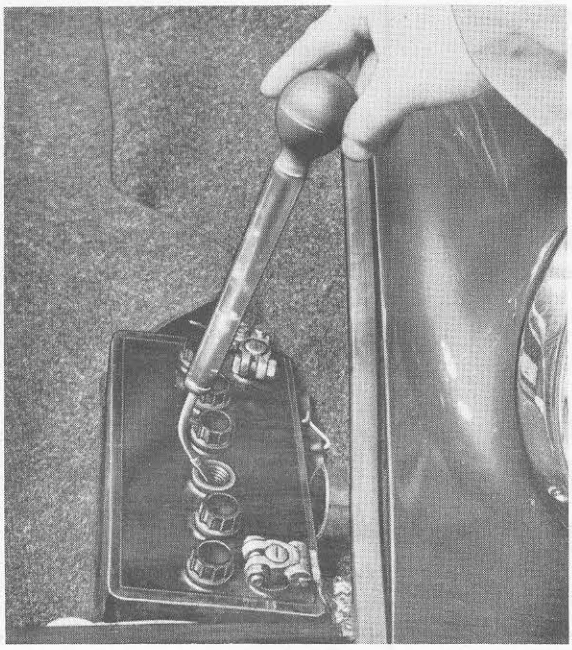


Fig. 36

### Electrolyte Level

In course of operation, the electrolyte level drops due to evaporation and deterioration of water. Replenish only with distilled water since city water contains chemical contaminants, even if the water has been boiled first.
The electrolyte level should be about 1/2 - 3/4 inch (10-15 mm) above the upper edge of the plates.

### Testing Battery Voltage

The battery can be tested with a cell tester, a voltmeter with a parallel wired resistance of 80 to 100 amps.
Each battery cell is tested individually by placing the pointed voltmeter probes onto the respective plus and minus poles of the given cell.

The voltage of a given cell must not drop below 1.6 volts during the test periods of 10-15 seconds each; if the voltage drops to less than 1.6 volts, then the given cell is defective or dead. Normal tension is 2 volts. The voltages of the invidual cells should not vary by more than 0.2 volts.

## Battery Care

The battery must be firmly attached to the car. The battery terminals and wire clamps must be clean to keep the resistance low. The terminals should be greased with vaseline or corrosion preventing grease. Wire clamps which have corroded and cannot be lifted off the battery terminals must be handled with a special puller. Spilled electrolyte must be immediately neutralized with a soda solution to prevent damage to fabrics and painted surfaces.

## Charging

It is a good practice to remove the battery at intervals of 3 to 4 months and discharge it to a cell voltage of 1.8 volts, then recharging it fully.
Normally, all batteries will discharge slowly at the rate of about 1 % per day.

## Important

If the car is taken out of operation for prolonged periods of time, or if the battery is to be stored for such extended periods, it should be charged at four week intervals with a trickle of about 4 amps to prevent deterioration of the plates. In such cases the battery should be discharged prior to each third charging at a rate of 2 to 4 amps until the low limit of 1.75 volts per cell has been reached. After that, the battery should be fully recharged.

## General

A 12 volt battery ignition is utilized. The battery current flows through a contact breaker which sends it on in the form of electrical pulses to the primary winding of the coil, inducing a high tension of about 20 kV in the secondary coil. This high voltage flows to the spark plugs in individual cylinders through an ignition distributor which is equipped with a centrifugal spark advance mechanism. Radio interference suppression is in accordance with VDE 0879, Part 1.

## Coil Design

The primary and secondary coils are wound around an iron core which is built up of laminations to keep eddy currents down. The winding of the secondary coil starts at the iron core which is connected to the high tension ignition lead. The end of the secondary coil joins the beginning of the primary coil windings and both are connected to Terminal 15 of the coil. The coil is filled with oil to facilitate a better dissipation of heat.

## Coil Operation

The operation of the coil is based on the transformer principle. The low voltage (12 V) but relatively high amperage (3 A) current flows from the battery through the primary coil and closed points to the ground. When the breaker points open, a high tension voltage of approx. 20 kV, with low amperage of a few mA, is induced in the secondary coil. This current flows to the spark plug where it crosses the electrode gap in the form of an electrical spark on the way to the ground of the car.

Wired in parallel with the distributor is a condenser whose function it is to greatly reduce breaker point arcing.

## Condenser Operation

When the contact breaker points are closed, the current flows only through the primary winding in the ignition coil since the condenser acts as a strong resistor for the direct current. When the breaker points open, the primary windings induce a high tension voltage in the secondary coil. According to Lenz's law, however, an opposing induction forms simultaneously in the primary coil. Without the condenser, this opposing current would jump across the open breaker points in the form of an arc and quickly destroy these.

## Ignition Coil

Defects in the ignition coil normally are difficult to diagnose without an electronic tester since in many cases the malfunction occurs in warm coils at high pulse frequency.

When such test instrument is not available for use, a superficial coil test can be made by pulling the high tension lead, which connects the coil with distributor, from the distributor cap and holding it about 9/32" (7 mm) away from ground of the car. When the engine is cranked by the starter, a spark must jump from the lead to the ground.

## Ignition Distributor

The distributor controls the current flow to the individual spark plugs. The ignition timing advance at varying engine speeds is performed by a built-in centrifugal spark advance mechanism.

## Distributor Design

The grey cast distributor housing is shaped like a pot. It accomodates the breaker point plate with point carrier and breaker points, the centrifugal spark advance mechanism, and the distributor rotor.

The supporting neck of the distributor housing is mounted in an orifice in the crankcase. The neck is hollow and accomodates the distributor drive shaft which is driven by a gear mounted on the crankshaft. The contact breaker plate supports the breaker arm and fixed breaker support. Each of the breaker components has a wolfram contact point brazed on. Contact breaker gap in open position should be .016" (0.4 mm) and is adjustable by means of an eccentric screw. The actual distributor consists of the rotor atop the cam, and the distributor cover.

## IGNITION PROBLEMS

14 LI

If engine malfunctions should be poining to troubles in the ignition system, the following checkout procedure should contribute to the determination as to whether the ignition is working properly, and if not, where the malfunction may be located. This procedure, however, is not intended to take place of a thorough analysis which can be accomplished only by specialized auto-electric shops, such as BOSCH SERVICE.

Engine does not fire when cranked:

1. Check high tension lead between coil and distributor for proper seating. Pull the lead out of the distributor cap and hold about 1/4" (5-7 mm) from car's ground; when the engine is cranked, electrical sparks should cross from the lead to the ground, which shows that the primary and secondary coil windings are in working order.
   If no sparks occur, do the following:

2. Connect a 12 volt test lamp between Terminal 1 at the distributor and the car's ground. Switch the ignition on and operate starter. If the test lamp goes on and off when the engine is cranked up, the primary coil winding is in working order.

3. If the test lamp should continue to burn while the engine is being cranked, check if the breaker point gap is too wide, or if grease, oil, dirt, or similar obstruction happens to be caught between the breaker points.

4. If the test lamp does not burn when the engine is being cranked, then the primary coil winding is interrupted or the points do not open fully. The test includes checking for loose cable connections, broken terminal ends, grounding distributor wire, and condition of the points. To make sure, a different ignition coil may be hooked up.

5. Remove distributor cap and check inside for condensation, corrosion, and electrical scorching. Check spark plug connectors for water condensation and current conductivity. Take the spark plugs out, check, and readjust electrode gap if necessary.

6. If the malfunction still has not been found, the ignition timing should be checked. If the timing is in order, then the malfunction is not in the ignition system and should be looked for in the fuel system.

## 15 LI ADJUSTING BREAKER POINTS

Adjust breaker points as follows:

1. Remove distributor cap and rotor.

2. Turn crankshaft through the crankshaft pulley until a cam lobe in the distributor fully lifts the breaker point arm.

3. Check breaker point gap with a feeler gauge; the gap should be not less than .010" (0.25 mm).

4. Check dwell angle with engine tester; dwell angle should be $50^{\circ} \pm 3^{\circ}$ (or 55 % ± 3 %)

5. Dwell angle can be corrected by changing the breaker point gap.
   Loosen set screw in fixed contact support.
   Keep resetting the breaker gap until the dwell angle is correct.

6. Tighten set screw in fixed contact support.

Note:

Subsequent to the adjustment of the dwell angle, always check the ignition timing since changes in dwell angle adjustment affect the timing.

## 16 LI REPLACING BREAKER POINTS

The breaker points are subject to erosion and should, therefore, be replaced when pitting is in evidence.

Removal

1. Remove distributor cap and rotor.

2. Loosen nut of screw which secures the leaf spring of the breaker arm.

3. Remove lock ring from breaker arm pivot stud.

4. Pull breaker arm out.

5. Remove retaining screw from fixed contact support (anvil) and take the support out.

Reinstall in reversed order.

Breaker Point Care

Pitted points always should be replaced. Due to their high state of tuning, tuned engines are very sensitive to ignition malfunctions.

The rotor as well as the electrodes in the distributor cap are subject to erosion since the ignition sparks continuously cross between them when the engine is running. Malfunctions may occur when the insulating qualities of the distributor cap or rotor are impaired due to a small cracks through which the high tension voltage may be escaping to the ground.

A spring-loaded carbon contact in the distributor cap conducts the high tension voltage to the rotating rotor. From there, the current jumps across a .026" (0.7 mm) wide gap, in proper sequence from the moving to the stationary electrodes.

The distributor cap must be well ventilated to prevent damage by the ozone created inside. The distributor cap should be kept clean, in and out, to keep creeping currents and arcing down.

## SETTING IGNITION TIMING

17 LI

Note

Before adjusting the ignition timing the closing angle of the contact breaker points must always be checked and if necessary corrected.

Adjustment

With high-performance engines as a matter of principle the ignition timing must be adjusted with a stroboscope with the engine running.

1. Connect engine to engine tester.
2. The V-belt pulley has a notch on its outer edge of TDC on No. 1 cylinder.
3. Run the engine at 650 rpm.
   Set the ignition with the help of the stroboscope to 3° before TDC.
4. The ignition timing should be set by rotating the distributor after previously slackening the clamp bolt at the foot of the distributor.
5. Retighten clamp bolt at foot of distributor without disturbing distributor setting.

## CHECKING AUTOMATIC IGNITION ADVANCE/RETARD

18 LI

The automatic ignition advance works on the centrifugal principle. The centrifugal governor is fitted in the ignition housing below the contact breaker plate.

On a plate connected to the distributor spindle two arms with weights of different sizes are located so that they are free to rotate. They are pulled inwards by two coil springs. As the engine speed rises the centrifugal weights are pushed increasingly further outwards and advance the contact breaker cam.
The shape of the distributor advance curve is governed by the differing weights of the centrifugal weights and by special design of the carrier arms.

Checking ignition advance

It is possible to make superficial check of the centrifugal governor, after removal of the distributor cap, by rotating the distributor in a clockwise direction. When released the distributor arm must spring back to the stop at its starting position.

An exact check of the advance curve is only possible with a distributor test rig or an electronic engine test instrument.

If measurement is carried out with an engine test instrument further marks must be made around the perifery of the V-belt pulley.

The diameter of the V-belt pulley is 145 mm. The linear measurement for 5° will therefore be 6.15 mm and this can be marked out on the pulley with the aid of a caliper working from the TDC mark.

If the ignition advance is functioning satisfactorily the amount of advance should be within the tolerance limit of the ignition advance curve.

IGNITION ADVANCE CURVE FOR BOSCH DISTRIBUTOR

Type 0 231 129 022 J FR 4 (R)

FOR TYPE 912 ENGINES

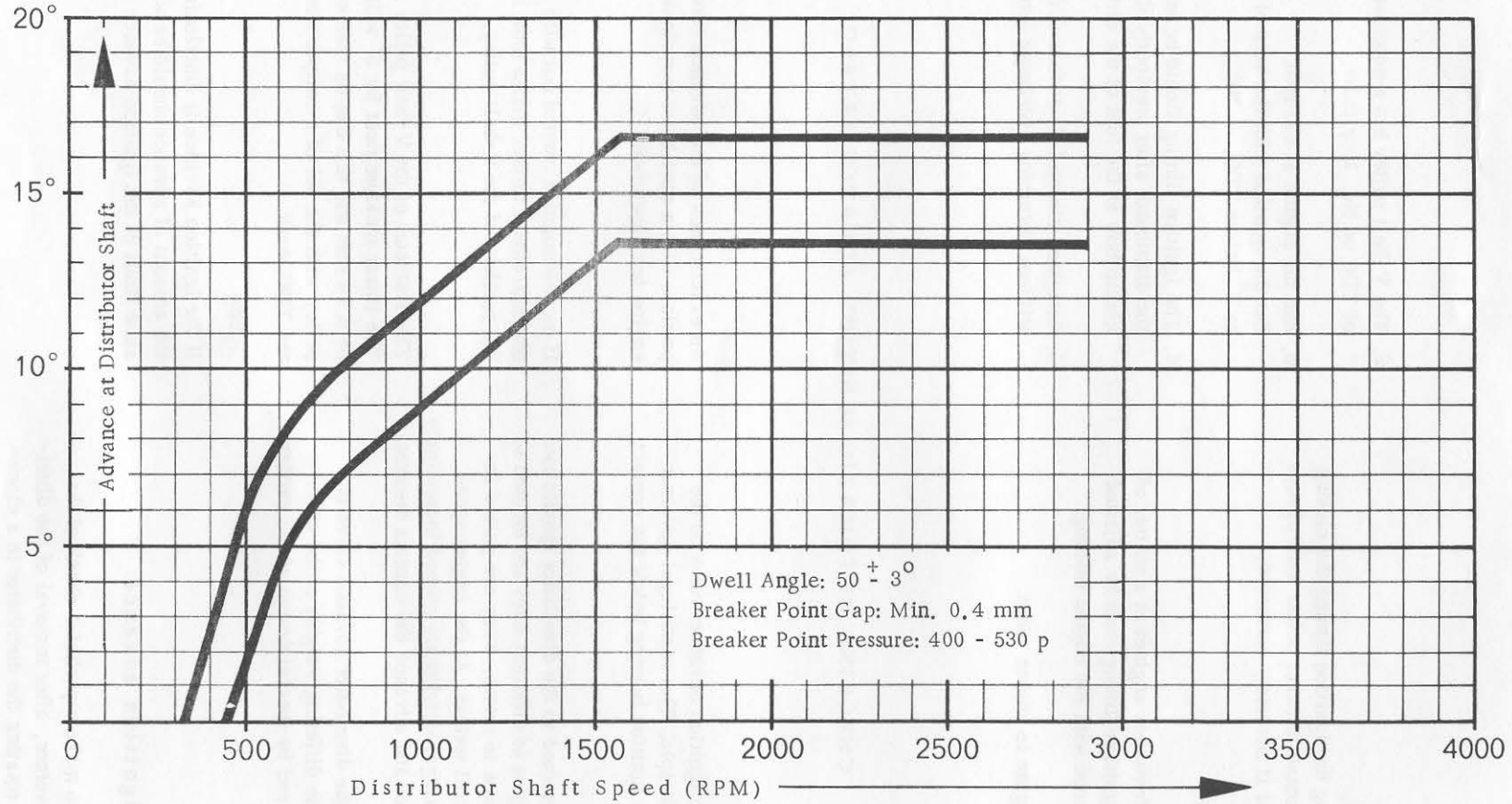



Fig. 37

# REMOVING AND REFITTING DISTRIBUTOR



## Removal

1. Detach distributor cap.

2. Undo leads at distributor.

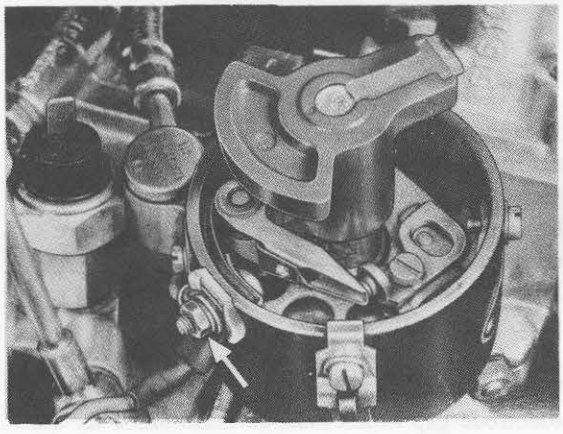


Fig. 38

3. Undo hexagon bolt at distributor bracket.

4. Pull out distributor.

## Refitment

Set cylinder 1 to TDC; here the central slot in the head of the distributor drive shaft should be at right angles to the longitudinal axis of the engine and the smaller segment of the drive shaft head should point towards the V-belt pulley.

20 LI

## CHECKING CONDENSER

A defective condenser will show itself by bad engine performance, difficult starting and excessive burning of the distributor contacts.

The condenser can be checked on an electronic engine test instrument but it is recommended that the condenser should be renewed straight away if it is suspected that it is defective.

## SPARK PLUGS

### General

The spark plug has the function of introducing the high-voltage ignition current in insulated form into the engine combustion chamber and to induce combustion of the compressed fuel/air mixture by means of the sparks bridging its electrodes.

### Care

As a matter of principle only plugs recommended by Messrs. Porsche should be used.

### Maintenance and testing

The plugs should be unscrewed at intervals of about 5,000 km and should be checked for appearance, electrode gap and satisfactory function.

A guide to working condition and carburettor setting can be obtained with a little experience from the "face of the plug". One should ensure however, that the engine is warmed up before unscrewing the plugs and is then shut off immediately, i.e. it should not be allowed to idle.

The construction of the plug determines the electrode gap which must be maintained for the plug in question.
The plug types recommended by Porsche are constantly being added to and dealers are notified of this through circulars.

| Maker | Type | Electrode gap |
|---|---|---|
| Bosch | W 225 T 7 | 0.6 - 0.7 |
| Bosch | W 200 T 35 | 0.6 - 0.7 |
| Beru | P 225/14 | 0.6 - 0.7 |

As at March 1967

## HEADLAMPS

### General

Both headlamps are mounted in the front fenders and are a combination of headlights with the asymmetric low beam, utilizing double filiament bulbs. Four-watt bulbs are used in the parking lamps. The double diliament bulb is located centrally in the headlamp reflector. Contrary to the old bulb system, the asymmetric lamps have bulbs with three-prong snapon connectors (same as sealed-beam connectors) onto which the cable connectors are slipped on. The bulb is held in place by means of a ring with a bayonet lock with three fastening tabs. The parking light bulb is situated below the headlamp bulb. The headlamp reflector can be moved vertically and horizontally to make headlamp beam adjustment possible.

Cars which are equipped for export to the USA are equipped with sealed-beam headlamps instead of the asymmetric-type headlamps with bulbs. However, the sealed-beams are not approved for use on public roads in various European countries; at time of this printing, the following countries prohibited the use of sealed-beam lights:

France

Holland

Italy

Sweden

Germany

In the sealed-beam headlamp, the double-filiament bulb is replaced by a sealed unit which encompasses the reflector, lamp lens, and the filiaments. When a filiament fails, the entire unit must be replaced. The sealed-beam unit cannot be installed into normal headlamp housings; installation is possible only through the use of special housings.

When driving a US-export car in Germany, or any of the above listed countries, the sealed beam unit must be replaced with the so-called "sealed-beam substitute" (SB-substitute). The SB-substitute has the same shape as the regular sealed beam unit but it consists of only the headlamp lens and reflector. In the center of the reflector an opening has been provided for the accomodation of a normal double-filiament bulb of the asymmetric type. When the car is returned to the USA, the substitutes must be replaced with regular sealed-beam units. The cable connector fits both, the sealed beam and the filiament bulb, whichever is used.

### Description

The high beam effect at night conforms to the German traffic code; the high beam filiament is 45 watts, low beam 40 watts. The low beam light dispersion is asymmetrical, extending low-beam vision farther than that provided by the symmetric low beam, namely 130 to 160 feet (40-50 m). Despite this intensified low beam effect, approaching drivers are not flashed more than normally was the case with the symmetric beam. The low beam light intensity of the European system equals that of the sealed beam but does this with less blinding of the oncoming drivers. The dark/bright dispersion line of the light follows a horizontal plane to the left of the beam's center, rising at a $15^{o}$ angle to the right of it. The asymmetric light beam effect has been achieved by clipping one side of the shield below the low beam filiament and, also, providing an appropriate light outlet in the lamp lens with less beam dispersion in that area. Both headlamps are of equal light intensity and have identical means for adjustment.

Servicing

Make sure during all service operations that the reflectors are kept clean; avoid holding the unit by placing fingers onto the reflector, such as through the light bulb opening. Reflectors which have become dirty for any reason may not be wiped clean; dulled reflectors must be replaced.

The asymmetric beam effect can be eleminated when necessary, such as when driving through countries with left-hand traffic, by covering the taper-shaped light outlet in the lens with tape. This will prevent your blinding oncoming drivers.

## 21 LI REPLACING HEADLAMP BULB

General

If the bulb blackens in an area due to tungsten evaporation, it should be replaced since its light intensity is no longer as high as originally intended.

Removal

1. Loosen Phillips screw in the lower center of the lamp rim and withdraw lamp assembly.
2. Withdraw cable connector, depress retaining ring and turn to the left (bayonet lock). Remove retainer and withdraw bulb.
3. Insert new bulb. Make sure that the aligning tab in the base of the bulb fits into the corresponding cutout in the reflector.
4. Position bulb retainer and turn to right while pressing the retainer down.
5. Slip cable connector onto tabs in bulb.
6. Install lamp unit and check lights for proper functioning.

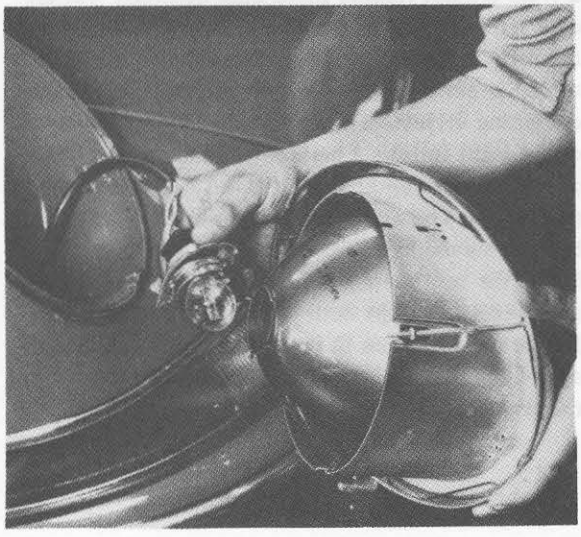


Fig. 39

Note:
Keep the bulb glass clean and free of grease. Hold the bulb only through a clean towel or soft paper since moisture carried on the bulb will evaporate from the bulb when in use and will deposit itself on the lamp reflector surface.

Note:
When changing the bulbs make sure that only the prescribed headlamp bulbs are used (brand-name items), avoiding the use of different makes or uneven wattage.

## REPLACING HEADLAMP LENS

22 LI

1. Remove headlamp unit.
2. Remove bulb with retainer.
3. Unscrew reflector adjusting screws and remove reflector.
4. Using a screwdriver, remove lens retainers from rim.
5. Withdraw reflector support.
6. Take out lens or glass remnants.
7. Place rubber sealing ring onto new headlamp lens and place lens into the lamp rim so that the BOSCH inscription is upright, or the wedge-shaped asymmetric low beam outlet in the lens is on the left side when looking in the direction of travel.
8. Replace retaining ring with reflector, check if the sealing ring between the lens holder and retaining ring is well positioned.
9. Install retaining springs.
10. Adjust headlamps.

## ADJUSTING HEADLAMPS

23 LI

Note:

The easiest way to adjust the headlamps exactly is with the aid of an optical adjuster by proceeding according to the manufacturers intructions.

If an adjuster is not at hand, the headlamps may be adjusted with the aid of a board. Headlamps with asymmetric low beam should be adjusted only on basis of the low beam projection. The reflector position can be reset with the two adjusting screws in the lamp rim.

Adjusting

1. Place the board perpendicular to the vehicle's axis at a distance of about 16. 5 feet (5 m); the reference lines may, however, be painted on a wall as well.
2. Adjust the headlamps with proper tire pressure. Before proceeding, roll the car back and forth a few times to normalize the suspension attitude.
3. The height of the headlamp center should be determined in each car by measuring it from the floor level and then marking the board appropriately (Value "b").
4. Value "c" should be equal to 1 % of the distance between the board and the vehicle, i. g., at 198" (16. 5') value "c" should be about 2" (at 5 m = 50 mm).
5. The horizontal headlamp spacing should be marked on the lower reference line of "c" by means of two crosses.

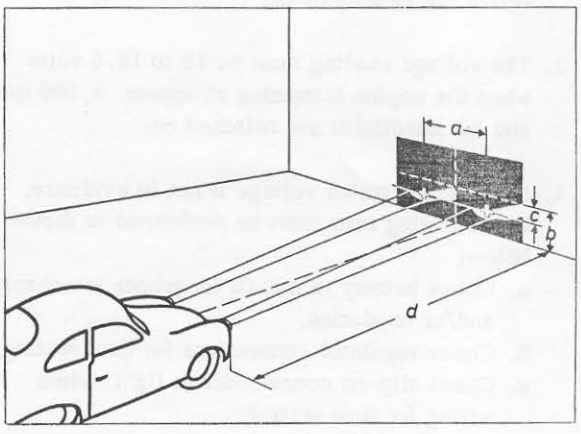



Fig. 40

6. Cover one headlamp while adjusting the other.

7. First adjust horizontally, bringing the kink in the dark/bright projection border onto the cross marked on the board.

8. In the vertical adjustment, the horizontal plane of the dark/bright projection must line up with the adjustment reference line, with the asymmetric sweep rising to the right from the center of the cross.

9. After adjusting the vertical setting, recheck the horizontal adjustment.

BOSCH Headlamp Adjusting Screws:

Vertical Adjustment b Upper screw:
turn right = lower
turn left = higher

Horizontal Adjustment a Lower screw:
turn right = beam to left
turn left = beam to right

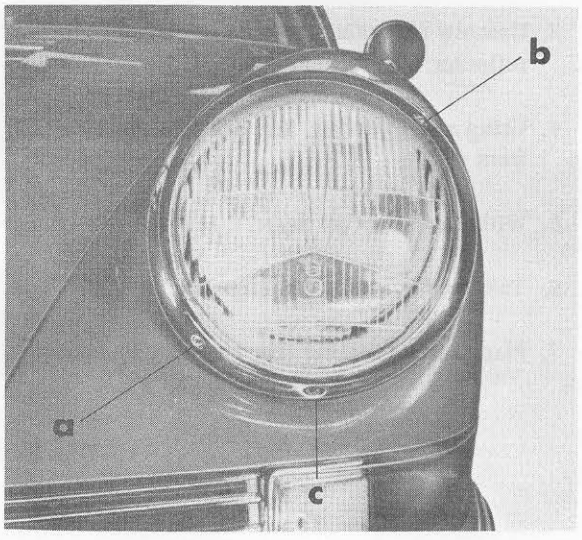



Fig. 41

## 24 LI

## TESTING HEADLIGHT VOLTAGE

Procedure

1. Remove headlamp unit.

2. Connect a voltmeter to the two terminals (yellow and brown, or white and brown), and switch the headlights on.

3. The voltage reading must be 12 to 12.5 volts when the engine is running at approx. 2,000 rpm and the headlights are switched on.

4. If the above stated voltage is not in evidence, the following tests must be performed as shown below:
   a. Check battery terminals for proper attachment and/or oxydation.
   b. Check regulator connections for firm seating.
   c. Check slip-on connections in light switch wiring for firm seating.
   d. Check electrical conductivity at both ends of the fuse box, including the fuse for oxydation and firm seating.
   e. Check wire connections at the double-filiament bulb.

5. If the required voltage is still not obtained after the above procedure, check the voltage after installing a new bulb. Aged bulbs have weakened filiaments which can cause a voltage drop.

Should the required voltage still not be obtained, then the defect probably lies in the battery, generator, or voltage regulator.

# DIRECTIONAL BLINKER SYSTEM AND COMBINED BLINKER, DIMMER, AND HEADLAMP FLASHER SWITCH

## General

As already outlined, the blinker lamps are located below the headlamps at front, and together with the tail and stop lights at rear. The stop and tail lights use a common bulb for each side. The directional signals are actuated through the self-cancelling switch which is mounted on the steering post. The green blinker control lamps are accomodated within the tachometer dial. The blinker pulse switch is located in the luggage compartment under the mat next to the steering post support; the switch is held in place through a three-prong connector and can be easily slipped off when required. A magnetic switch interrupts the ground connection of the blinker control lamp whenever one of the blinker lamps should become inoperative to indicate this condition; this indication works, of course, only as long as the control lamp is in working order.
When replacing bulbs, make sure that proper type is used.

## REMOVING AND INSTALLING COMBINED BLINKER, DIMMER, AND FLASHER SWITCH

25 LI

### Removal

1. Remove steering wheel (see 14 St, 911 Workshop Manual).
2. Detach all wire connections from the combination switch.
3. Remove the two slotted screws from the horn contact ring, detach the wire, remove the ring.
4. Remove upper housing assembly retaining nuts (SW 8) and pull the assembly upward to remove. Lead wires and connectors through the hole which has been provided for that purpose.
5. Remove the three retaining screws which secure the combination switch and remove switch.

Install in reversed order of the above, making certain that the wires are connected properly.

## COMBINED BLINKER, DIMMER, AND HEADLAMP FLASHER SWITCH

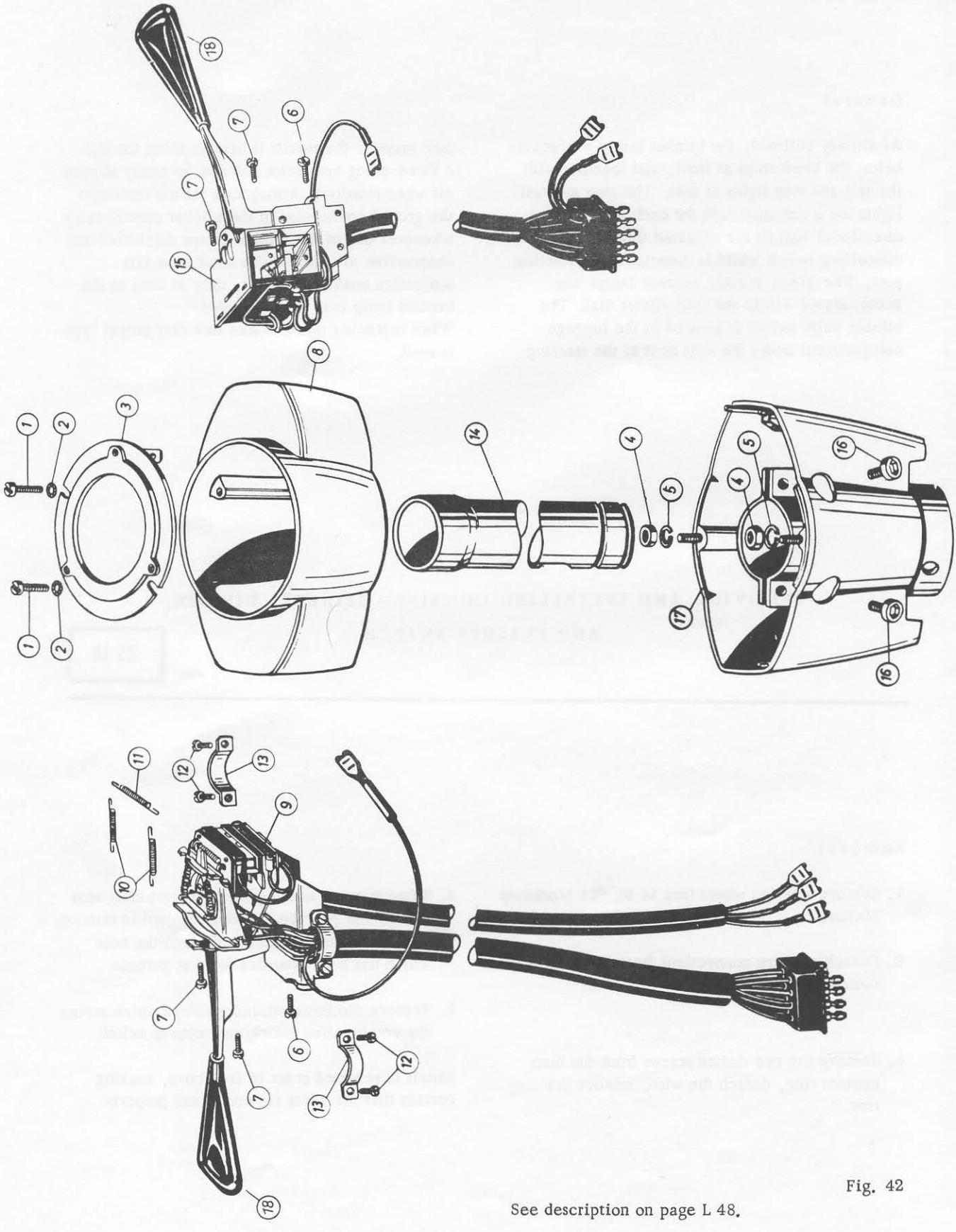



Fig. 42

See description on page L 48.

## COMBINED BLINKER, DIMMER, AND HEADLAMP FLASHER SWITCH

1 ... Fillister screw
2 ... Serrated lock washer
3 ... Contact ring
4 ... Hex nut
5 ... Lock washer
6 ... Fillister screw
7 ... Round head countersunk screw
8 ... Upper housing assembly
9 ... Combination switch
10 ... Spring
11 ... Spring
12 ... Fillister screw
13 ... Clamp
14 ... Steering post extension
15 ... Wiper and washer switch
16 ... Allen bolt
17 ... Lower housing assembly
18 ... Lever knob

## REPLACING BLINKER SWITCH RETURN SPRING

26 LI

1. Remove steering wheel (see 14 St, 911 Workshop Manual).
2. Remove slotted screws from horn contact ring, detach wire, remove ring.
3. Unhook return spring.
4. Install new spring.

## REPLACING BLINKER, PARKING, BACKUP, AND STOP LIGHT BULBS

27 LI

1. Remove lamp unit retaining screws and remove unit.
2. Using a screwdriver, lift the plastic holder at the cut off corner and withdraw holder.
3. Push the bulb into the holder and turn to left (bayonet lock).
4. Remove bulb.
5. Install new bulb.
6. Fasten bulb by pushing into the holder and turning 90° to the right until the socket pins have engaged their seat.
7. Place holder into lamp unit and push lightly in so it snaps into place.
8. Install lamp unit and tighten slotted retaining screws.
9. Check lamp for proper functioning.

## 28 LI

## REPLACING FOG LAMP BULBS

1. Remove slotted screws from retaining ring at lamp lens and withdraw lamp unit.
2. Pull lamp socket out of lamp unit (snap fit).
3. Push the bulb into the socket and turn to the left (bayonet lock).
4. Take old bulb out, insert new bulb.

Note:

Keep glass bulb clean and free of grease, handling it through soft paper or clean towel.

5. Push bulb into socket and turn to the right.
6. Push the socket into the lamp unit to firmly seat it.
7. Put the lamp unit back in place and tighten slotted retaining screws.
8. Check fog lamps for proper functioning.

## 29 LI

## REMOVING AND INSTALLING DOOR CONTACT SWITCH

General

The door contact switch is accomodated within the forward door posts and controls the interior light when the latter is preset for automatic functioning. When the doors are opened, a contact is made through the switch in the door post and the interior light goes automatically on.

Removal

1. Remove rubber cap.
2. Unscrew contact switch with a 12 mm box wrench, detach wire.
3. Connect wire to new switch and reinstall.


Fig. 43

## REPLACING BULB IN INTERIOR LAMP

30 LI

Gently press the lamp base out with a screwdriver, always applying force at the rear part of the base (as seen in direction of travel).

When installing new bulb, make sure that the bulb holding clamps are sufficiently tensioned to firmly hold the 10 W cartridge bulb in place.

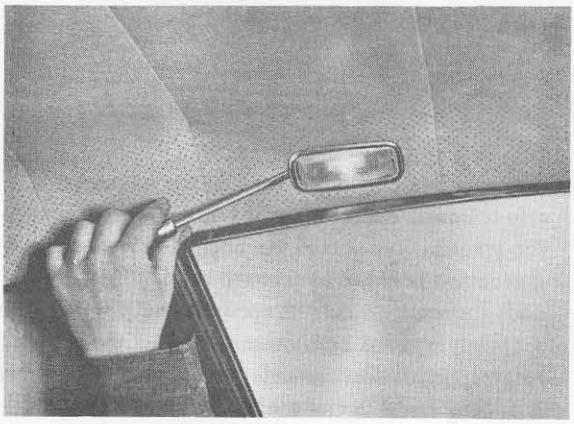


Fig. 44

## REPLACING BULB IN LUGGAGE COMPARTMENT LAMP

31 LI

The luggage compartment lamp is located on the lower part of the lid. The lamp goes off automatically when the lid is closed.

1. Remove the glass lens.
2. Replace the 4 W cartridge bulb which is held in clamp contacts.

## REPLACING LICENSE PLATE LAMP BULB

32 LI

1. Remove both screws which secure the license plate lamp assembly to the engine compartment lid and withdraw lamp assembly.
2. Replace bulb.
3. Reinstall in reversed order.

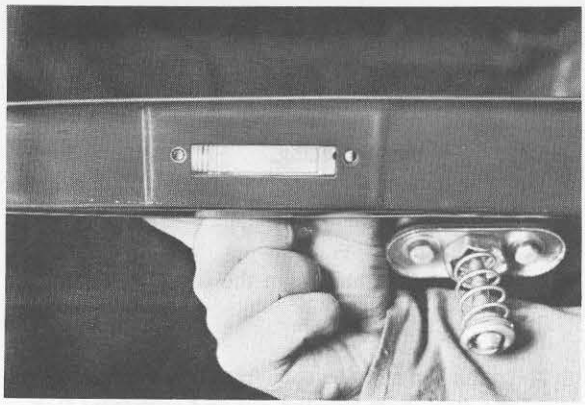


Fig. 45

General

The speedometer unit includes the odometer and trip mileage counter. A flex shaft connected to the transmission drives the unit. The speedometer indication is effected through the application of eddy currents. A disc-shaped magnet rotates within a closely-spaced aluminum shell. As the magnet rotates, induction currents are generated and create a turning force in the shell, the force being proportionate to the speed of the magnet. The shell is connected to the speedometer needle. Located on the axis of the indicator needle is a spiral spring which works against the force created by the induction currents, being matched to the electro-magnetic system. As the car moves and, thus, the driving flex shaft rotates, both forces maintain an equilibrium and the needle of the speedometer shows the given speed at which the vehicle is moving.

The odometer drive consists of a triple reduction gear. The odometer has a five-digit counter, The trip mileage counter can be reset to zero by means of a knob on the instrument panel.

## 33 LI REMOVING AND INSTALLING INSTRUMENTS

Note:

Connecting terminals of all instruments are accessible from the luggage compartment upon removal of the carpeting.

1. Detach all cables from the instrument that is to be removed.
2. In the case of the speedometer, also remove the flex shaft knurled nut and withdraw flex shaft.
3. Remove small knurled nuts which secure the instrument, withdraw the retaining clamp, and take instrument out, with care, from within the passenger compartment.
4. Reinstall the new or repaired instrument in reversed order of the above.

## REPLACING CONTROL LAMPS AND INSTRUMENT ILLUMINATION LAMPS

34 LI

1. Loosen luggage compartment mat retainers and pull mat forward.
2. Pull out the respective lamp socket from a given component.
3. Take bulb out of socket.
4. Install new bulb.

## REMOVING AND INSTALLING FUEL GAUGE SENDER

35 LI

Removal

1. Fold luggage compartment mat back.
2. Withdraw multiple-pin socket.
3. Remove sender retaining bolts and withdraw sender unit.

When reinstalling, check the gasket for condition and proper seating.

## REPLACING BACKUP LIGHT SWITCH

36 LI

General

The backup light switch is located on the transmission housing side. The switch is actuated through the respective positioning of the internal shift rod within the transmission when reverse gear is engaged, moving a contact pin and thus switching the backup light on.

Removal

1. Remove rubber cap.
2. Pull snap-on terminal connectors off.
3. Unscrew switch with an open end wrench (SW 22).

Reinstall in reversed order of the above making sure that the contacts are firmly seated and the rubber cap securely attached.

## HEADLAMP FLASHER SIGNAL

The headlamp flasher signal is released by means of the combination switch on the steering post. The flasher relay switch is situated under the left floorboard.

The purpose of the flasher relay switch is to reduce the current load of the headlamps, i.e., routing the high current flow through heavy contacts in the flasher relay rather than through the switch on the steering post.

37 LI

## REPLACING FUSES

The fuse box is located under the luggage compartment mat. The fuses can be easily removed by applying pressure against the retaining clamps. When a fuse burns out, the matter should be investigated to determine the cause rather than simply replacing the fuse.

We suggest that a small supply of fuses (8/15 amp and 25/40 amp) be always carried in the car.

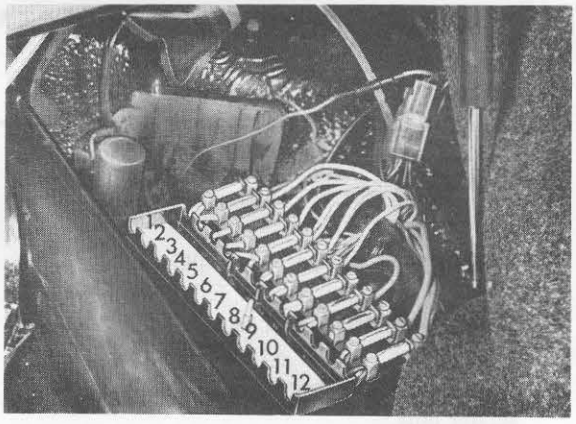



Fig. 46

38 LI

## REMOVING AND INSTALLING SIGNAL HORNS

General

The signal horns are cushion-mounted under both front fenders.

1. Detach snap-on wire connectors.

2. Remove horn retaining nut and take horn out.

When reinstalling the horn, make sure that it does not make contact with the body.

General

The windshield wiper motor and actuating linkage are located just in front of the instrument units. The motor is controlled by a four-position wiper/ washer switch. The windshield wiper linkage joints are service free.

The windshield wiper blades should make an even contact with the windshield and move equally far on both sides.

39 LI

## REMOVING AND INSTALLING WIPER MOTOR WITH LINKAGE

Removal

1. Remove the forward ventilating case after removing the retaining clip and air duct.

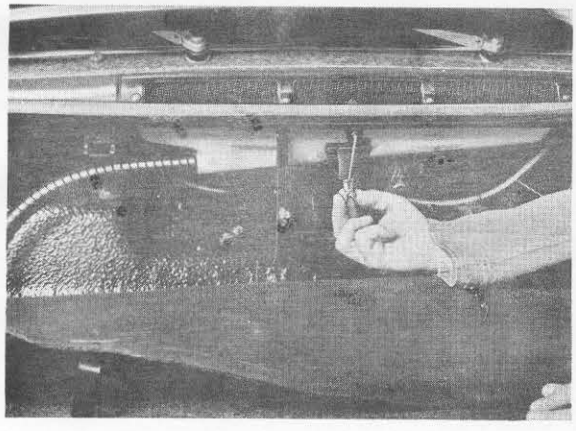


Fig. 47

2. Detach all (5) wire terminals from the wiper motor.

3. Remove wiper arms.

4. Remove rubber discs located beneath the wiper arms and unscrew retaining hex nuts.

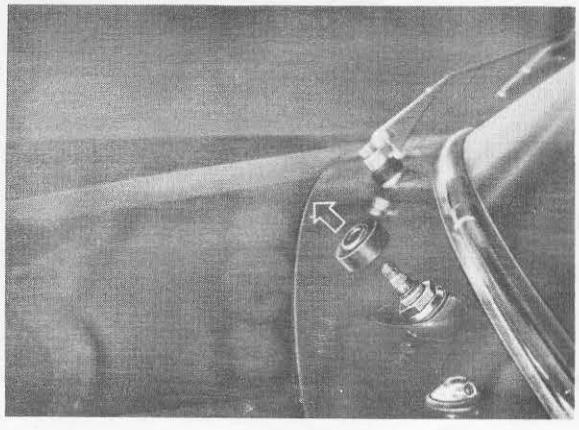


Fig. 48

5. Withdraw wiper motor downward, together with linkage.

Check for proper placement of connecting wires and free movement of the wiper linkage when reassembling the wiper system.

The electrical windshield washer pump is located in the forward luggage compartment next to the windshield washer reservoir.

Removal

1. Remove both slotted screws which secure the reservoir.

2. Withdraw the reservoir.

3. Detach wires from pump.

4. Loosen plastic retaining straps from pump and pull the pump out.

Install in reversed order of the above.

Note:

Up to Chassis Serial Nr. 351 292/451 373, the windshield washer reservoir was installed into a recess along the side of the luggage compartment floor. The windshield washer pump was installed in the right rear part of the luggage compartment (looking in the direction of travel) under the compartment mat.

Removing Reservoir

1. Pump the reservoir completely dry.

2. Remove cap and hose.

3. Remove reservoir by turning it.

Removing Windshield Washer Pump

1. Detach cables from pump.

2. Detach suction and pressure hoses from pump.

3. Loosen plastic retaining straps from pump and pull the pump out.

Install in reversed order of the above.

General

The car radio must perform well under relatively unfavorable conditions. On one side, the antenna input (signal strength) is very low due to the short antenna length; on the other side, the ignition system, generator, and windshield wiper motor are a more or less constant source of static or interference. For this reason it is of great importance that the vehicle is well freed of interference generators, especially in the case of FM reception. Loose ground connections, for one, are a common source of static noise. When installing a radio in the car, much care should be devoted to checking the ground connections. Normally, radio noise suppressors are selected by the set manufacturer and may be found in the radio accessory lists.

If a test drive should reveal that the radio reception still suffers from static or other interference, despite the installation of suppressors, the entire system should be rechecked, including all ground connections. If further corrections should be necessary, it is best to have the problem eliminated by soliciting the services of a radio shop which will have the necessary testing equipment on hand.

Note:

The maximum suppressor condenser capacity between the generator terminal D+ and ground is 3.0 mfd, and at the regulator terminal D+ it is 0.3 mfd, since otherwise the contacts will burn.

# ELECTRICAL DATA

| | |
|---|---|
| Generator BOSCH shunt wound | 0101 206 113 |
| Load setting for output test | 300/2500 rpm (generator armature) |
| Speed at rated voltage | 1850 - 2050 rpm (generator armature) |
| Field coil resistance | 3.5 Ohm |
| Carbon brush spring pressure | 450 - 600 g |
| Regulator (BOSCH) | 0190 350 014 |
| Switch-on voltage | 12.4 - 13.1 V |
| Reverse current | 2 - 7.5 A |
| Switch contact gap (at rest) | Main contact 0.5 - 1.2 mm |
| Regulator voltage at idling speed | no load: 13.5 - 14.5 V on load: 12.8 - 13.8 V |
| Magnet gap voltage regulator | Closed min.: 0.2 mm open: 0.8 - 1.3 mm |
| Contact gap voltage regulator | 0.25 - 0.4 mm |
| Starter (BOSCH) | 0001212002 |
| Free running test | 11.5 V 33 - 50 A at 6400 - 7900 rpm |
| Load test | 9 V 160 - 200 A at 1100 - 1400 rpm |
| Short circuit test | 6 V 250 - 300 A |
| Carbon brush spring pressure | $1200 \begin{smallmatrix} + 130 \\ - 50 \end{smallmatrix}$ p |
| Distributor (BOSCH) | 0231 129022 |
| Contact breaker gap | min. 0.3 mm |
| Centrifugal advance, degrees at engine speed | Commences at 5 - 14 ... 1000 29 - 34 ... 3000<br>30 - 35 ... 3100<br>13 - 19 ... 1250<br>21 - 26 ... 2000 |
| Closing angle | 47 - 53° |
| Contact pressure | 400 - 530 p |
| Condenser | 0.27 - 0.32 Microfarad |
| Ignition coil (BOSCH) | 0221 102 016 |
| Spark on tester with ionised spark gap | 14 mm, 1.4 A Primary current<br>Primary resistance 3.1 - 3.6 Ohm |
| Spark plugs | Electrode gap 0.6 - 0.7 mm |
| Battery | 12 V 45 Ah |