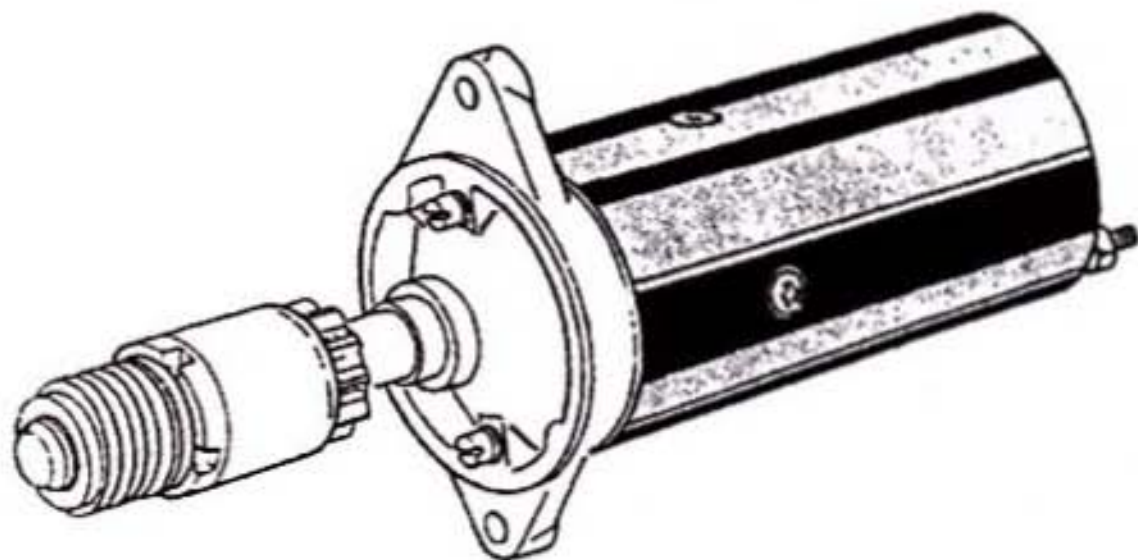
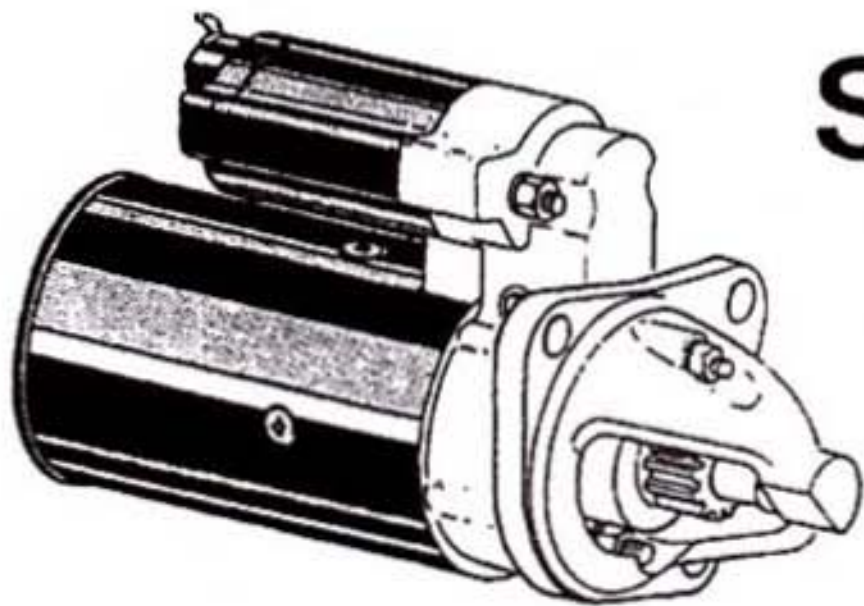


# STARTERS



## INTRODUCTION

The starter is a motor which converts electrical energy, supplied from the battery, into mechanical energy for the purpose of cranking the engine.

There are two basic types of starter, the inertia type and the pre-engaged type, employing different methods of coupling the starter drive pinion to the engine flywheel ring gear.

*The inertia type* - used on the majority of cars and light commercials employing petrol engines. When the starter is energised rapid increase of speed at the armature and screwed sleeve, carrying the pinion, causes the pinion to move along the sleeve (due to its inertia) and engage the ring gear, thus rotary movement is transmitted to the engine, the ratio between the starter pinion and the ring gear, being approximately 10:1. When the engine fires and the flywheel accelerates to drive the pinion faster than the rotation of the armature, the pinion is ejected back along the screwed sleeve and consequently disengaged from the engine.

*The pre-engaged type* - used on heavier petrol engines but particularly suitable on diesel engines, where, due to intermittent firing characteristics and cranking speed surges (high compression) the pinion of the normal inertia type would be ejected prematurely.

By the operation of a solenoid the starter pinion is engaged with the flywheel ring gear before the starter is energised, after which the pinion can be retained in mesh for as long as is necessary to start the engine. When the engine is firing and the pinion being driven at high speed by the flywheel, the armature is protected against overspeeding by the freewheel action of a roller or plate clutch.

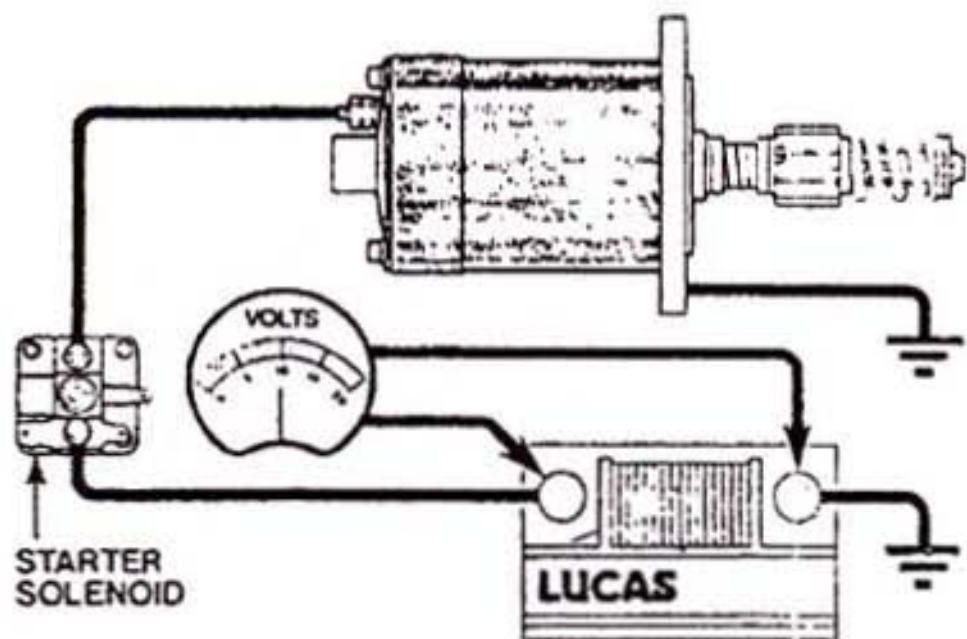


Fig. 10 Battery terminal voltage under load

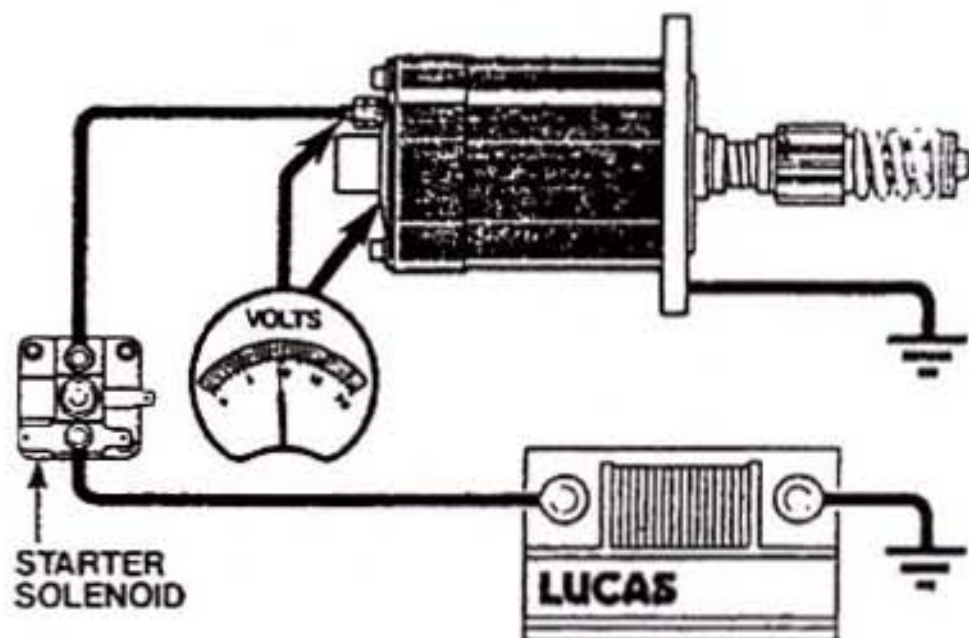


Fig. 11 Starter terminal voltage under load

## TEST 1. Battery Test

Using a hydrometer, check that the battery is at least 70% charged. The full battery test procedure is outlined in Section 1.

Note: A battery in poor condition will cause difficult starting.

## CHECKING THE STARTER SYSTEM (INERTIA DRIVES)

If the previous test has proved that the battery is satisfactory, a moving coil voltmeter (0-40V range) should be used to determine whether there is excessive voltage drop in the circuit.

Note: During the voltmeter checks, the starter should crank the engine, without starting it.

*Petrol engines:* The low-tension circuit of the ignition coil should be disconnected between the coil and distributor.

*Diesel engines:* Operate engine stop so that engine will not start.

## TEST 2. Checking the Battery Terminal Voltage under Load Conditions

This check enables the working voltage at the battery to be verified.

Fig. 10 shows a voltmeter connected between the positive and negative battery terminals.

The reading is noted when the starter switch is operated. The readings for a 12 volt system depends on the engine capacity, battery size (Ah) and type of starter. A typical figure for petrol engines is about 10.0 volts. Proceed to Test 3.

A low voltage reading would indicate excessive current in the circuit. The starter should be removed for bench testing.

### TEST 3. Checking the Starter Terminal Voltage under Load Conditions

Having ascertained the battery voltage, the voltage across the starter is checked. Fig. 11 shows a voltmeter connected between the starter terminal and earth (commutator end bracket). When the starter operating switch is closed, the difference between this reading and that taken at the battery should not exceed 0.5V.

If the voltage drop is excessive proceed with the following tests.

### TEST 4. Checking the Voltage Drop on the Insulated Line

For this test the voltmeter should be connected as shown in Fig. 12. The voltmeter is connected between the starter terminal and the battery supply terminal.

When the operating switch is open, the voltmeter should register battery voltage, but when the operating switch is closed the voltmeter reading should be noted.

### TEST 5. Checking the Voltage Drop across the Solenoid Contacts

The solenoid contacts can be checked for voltage drop by connecting a voltmeter across the two main terminals as shown in Fig. 13. When the operating switch is open, the voltmeter should register battery voltage. When the operating switch is closed, the voltmeter reading should be noted.

### TEST 6. Checking the Voltage Drop on the Earth Line

To check the voltage drop on the earth line, connect the voltmeter between the battery earth terminal and the starter earth (commutator end bracket), as shown in Fig. 14. When starter operating switch is closed the voltage reading should be practically zero.

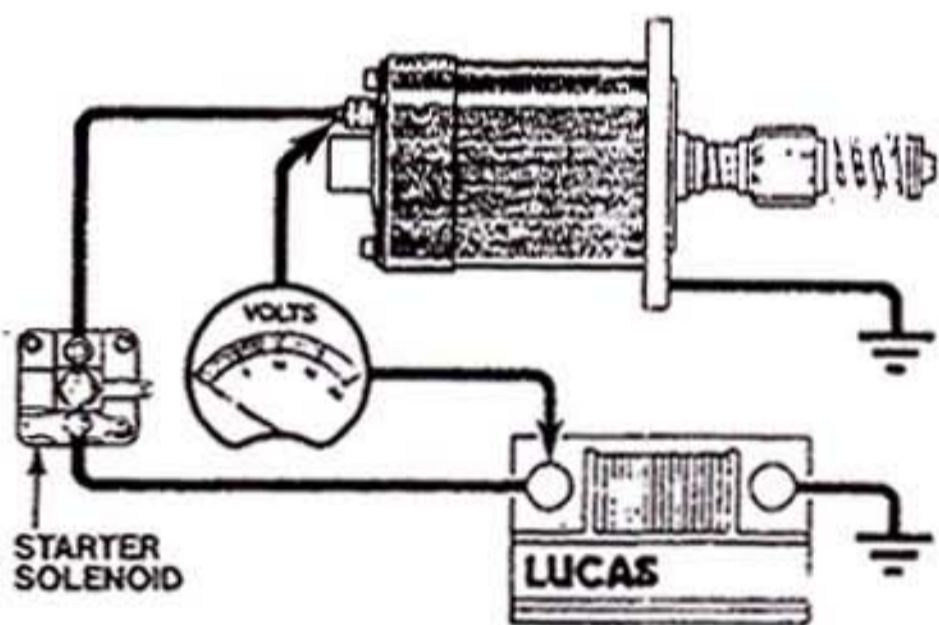


Fig. 12 Voltage drop on the insulated line

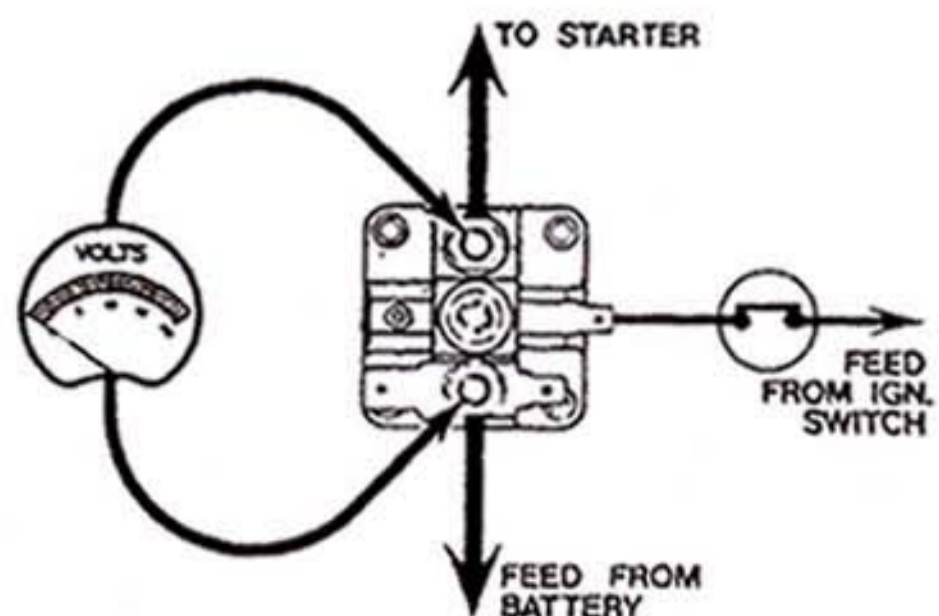


Fig. 13 Voltage drop across the solenoid contacts

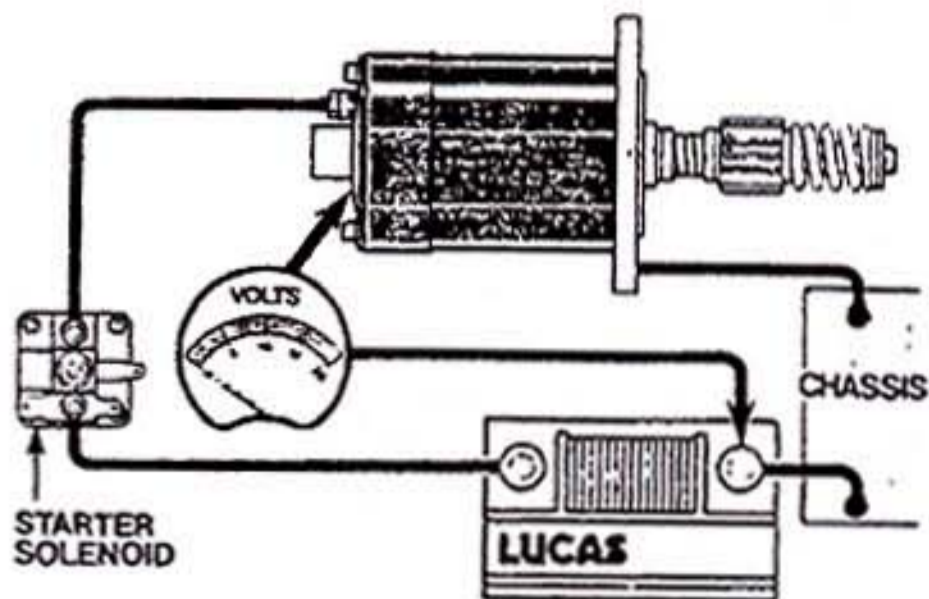


Fig. 14 Voltage drop on the earth line

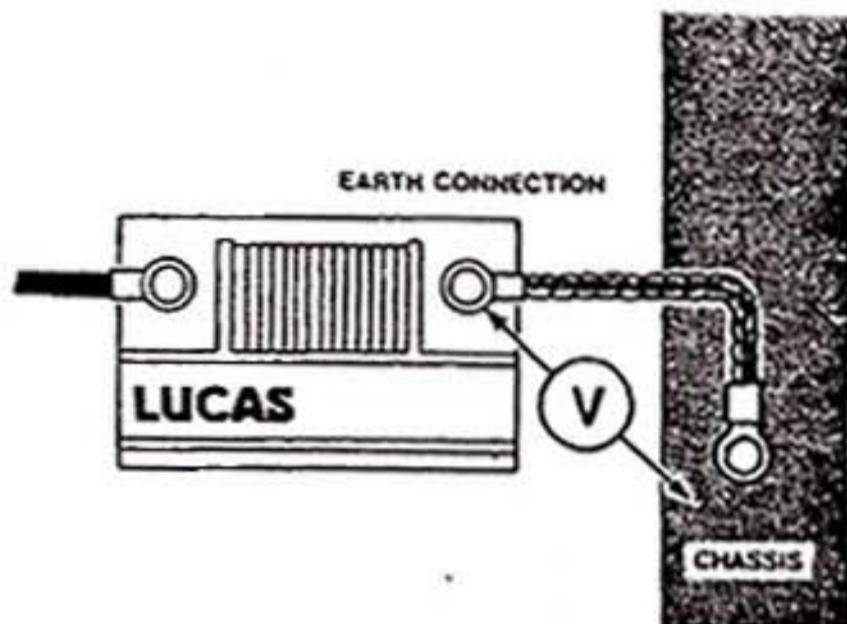


Fig. 15 Checking the earth connections

### TEST 7. Checking Earth Connections

Connect the voltmeter between the chassis of the vehicle and the battery earth terminal (Fig. 15). Operate the starter. Once again note the reading.

### TEST 8. Checking Bonding Strap (Fig. 16)

As most vehicle engines are rubber mounted, the bonding strap must make a good electrical connection between the engine block and the chassis. The units mounted on the engine block (i.e. distributor, dynamo and starter) must have an efficient earth connection in order to function correctly.

If the bonding strap is incorrectly fitted or frayed, it will have a serious effect on the performance of the starter, and may even immobilise the vehicle.

Note: The total voltage drop on the starter installation must not exceed 0.5V.

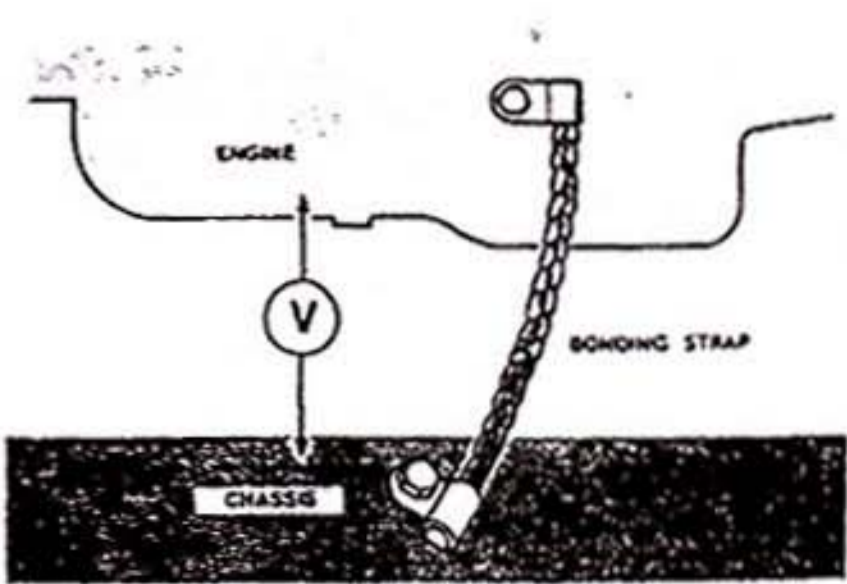


Fig. 16 Checking the bonding strap

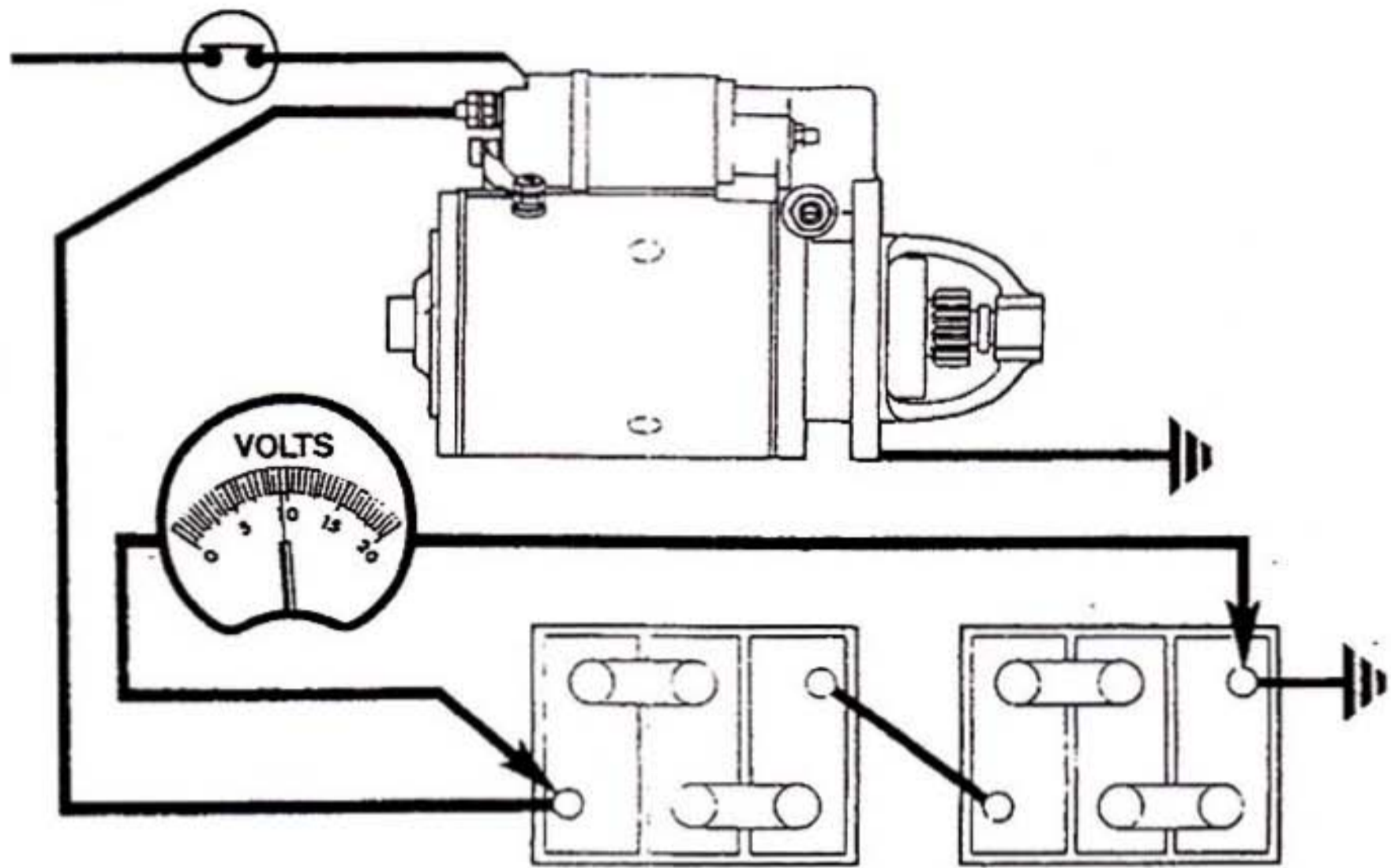


Fig. 17 Battery terminal voltage under load

## CHECKING THE STARTER SYSTEM (PRE-ENGAGED DRIVES)

The procedure for checking for excessive voltage drop in the pre-engaged starter circuit is similar to that used for inertia drive starter systems but in addition, the voltage available at the solenoid feed terminal must be checked. The complete procedure is as follows:

### TEST 1. Checking the Battery Terminal Voltage under Load Conditions

Connect the voltmeter across the terminals, as shown in Fig. 17 and operate the starter switch. The readings for a 12 volt system depend on the engine capacity, battery size (Ah) and type of starter. A typical figure for petrol engines is about 10.0V, and for diesel engine (12V system), 9.0V.

A low voltage reading would indicate excessive current flow in the circuit. The starter should then be removed for bench testing.

**Note:** If the solenoid operates intermittently during the test or the engine is cranked at a low or irregular speed, there may be insufficient voltage at the solenoid operating winding terminal or the solenoid is faulty.

To check the switching circuit for high resistance, connect the voltmeter between the solenoid operating winding terminal and earth (commutator end bracket) as shown in Fig. 18.

When the switch contacts are closed, the reading on the voltmeter should be slightly less than the reading in Test 1. A satisfactory reading indicates a negligible voltage drop in the circuit and consequently the fault may be in the solenoid.

If the reading is appreciably lower than in Test 1, check the switching circuit for high resistance or faulty connections. Check the cable size is as recommended, i.e. 28/0.30 mm (28/012").

In order to reduce voltage drop in the switching circuit on some vehicle applications a 4ST solenoid is incorporated in the circuit as shown in Fig. 18a.

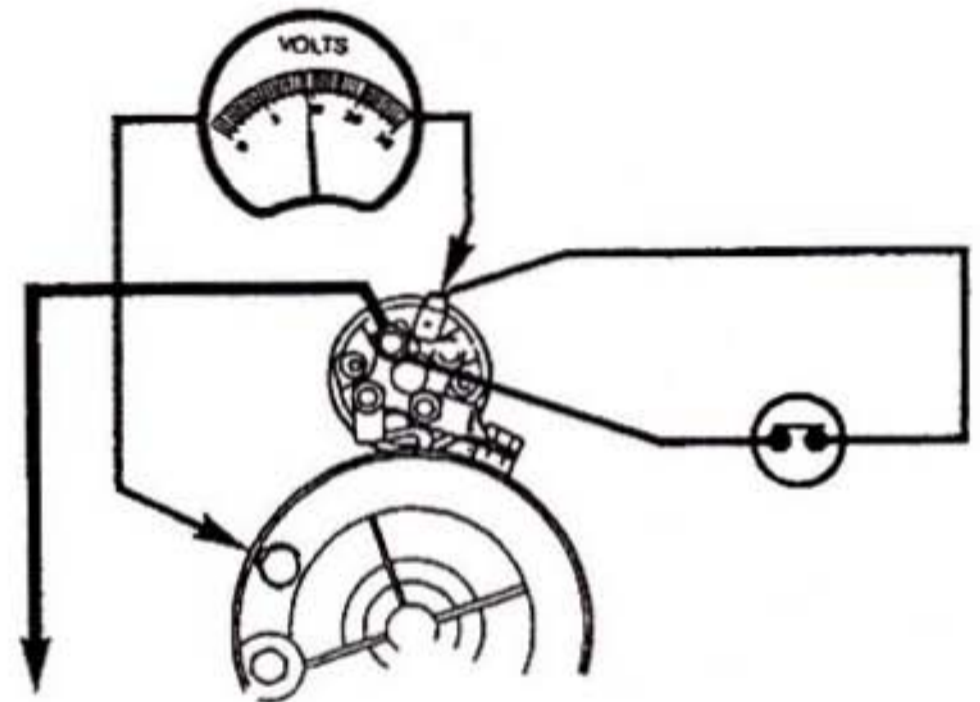


Fig. 18 Checking the solenoid switching circuit

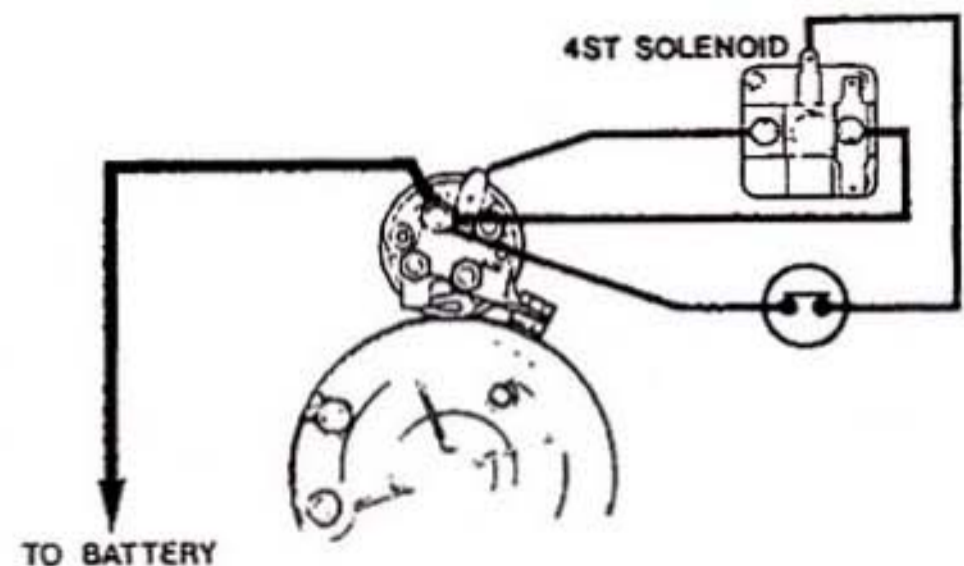


Fig. 18A Solenoid switching circuit incorporating additional solenoid (4ST)

### TEST 2. Checking the Starter Terminal Voltage under Load Conditions

Having ascertained the battery voltage under load, the voltage across the starter is checked. Fig. 19 shows a voltmeter connected between the starter input terminal and earth (commutator end bracket). When the operating switch is closed, the difference between this reading and that taken at the battery should not exceed 0.5V.

If the reading is within this limit, the starter circuit is satisfactory. If there is a low reading across the starter, but the voltage at the battery is satisfactory, it indicates a high resistance in the starter circuit.

### TEST 3. Checking the Voltage Drop on the Insulated Line

The voltage drop on the insulated line is then checked. Fig. 20 shows the voltmeter connected between the starter input terminal and the battery (insulated) terminal.

When the operating switch is open, the voltmeter should register battery voltage. When the operating switch is closed, the voltmeter reading should be practically zero. A high voltage reading indicates a high resistance in the insulated line.

All insulated connections at the battery, solenoid and starter should be checked.

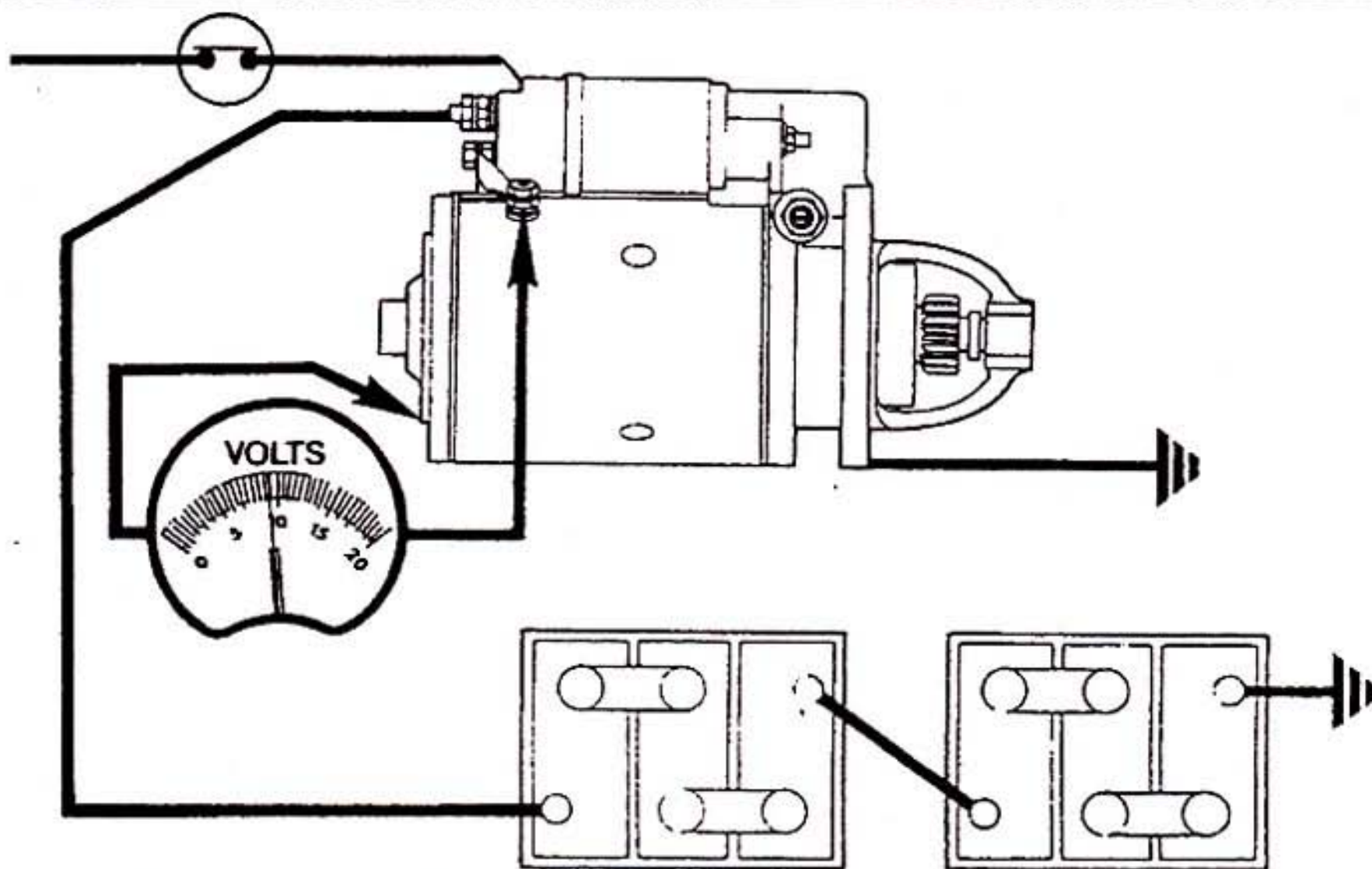


Fig. 19 Starter terminal voltage under load

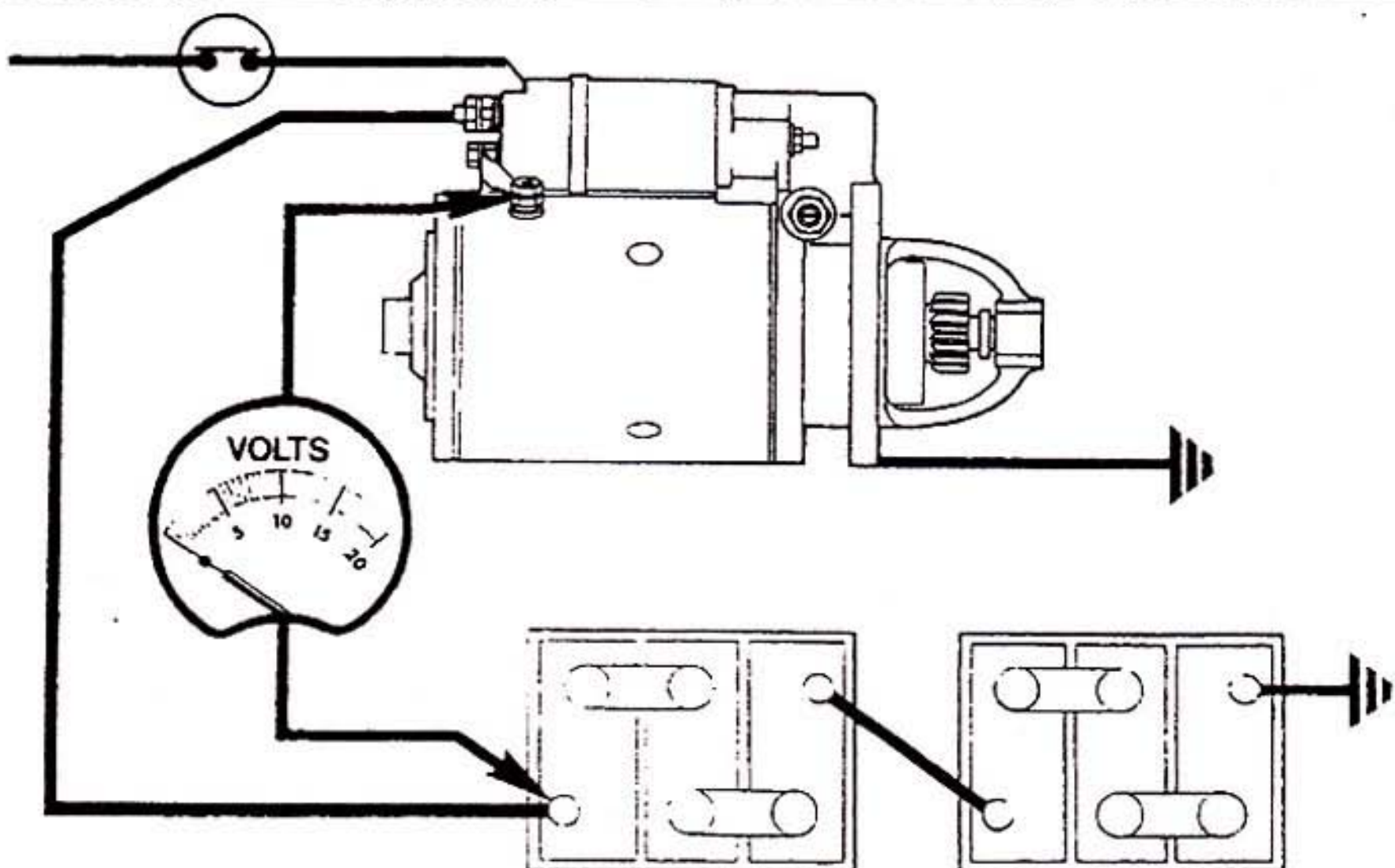


Fig. 20 Voltage drop on the insulated line

If all connections are in order, the starter solenoid contacts must be checked. (Proceed to Test 4).

#### TEST 4. Checking the Voltage Drop across the Solenoid Contacts

To check the voltage drop across the solenoid contacts, connect the voltmeter across the two main solenoid terminals, as shown in Fig. 21. When the operating switch is open, the voltmeter should register battery voltage. When the operating switch is closed, the voltmeter reading should fall to a fractional value.

A zero or fractional reading on the voltmeter indicates that the high resistance deduced in Test 3 must be due either to high resistance starter cables or soldered connections.

A high reading (similar to that in Test 3) indicates faulty solenoid contacts.

#### TEST 5. Checking the Voltage Drop on the Earth Line

Finally, check the voltage drop on the earth line. Connect the voltmeter between the battery earth terminal and the starter earth (commutator end bracket) as shown in Fig. 22. Note readings.

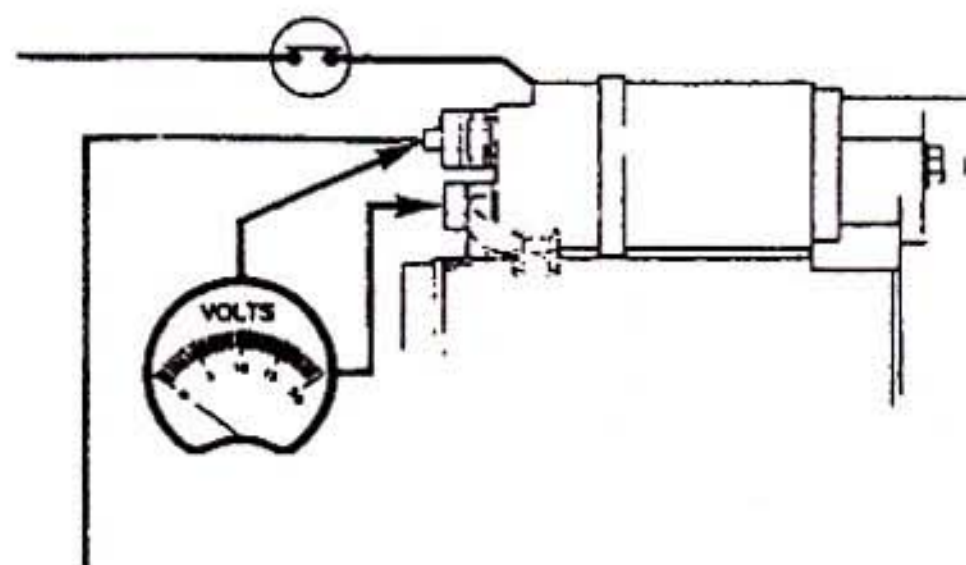


Fig. 21 Voltage drop across the solenoid contacts

- Note: 1. Check earth connections and bonding strap as described in the "Inertia Starter" section (Tests 7 and 8).
2. The total voltage drop in the starting circuit (i.e. insulated line and earth line) must not exceed 0.5V.

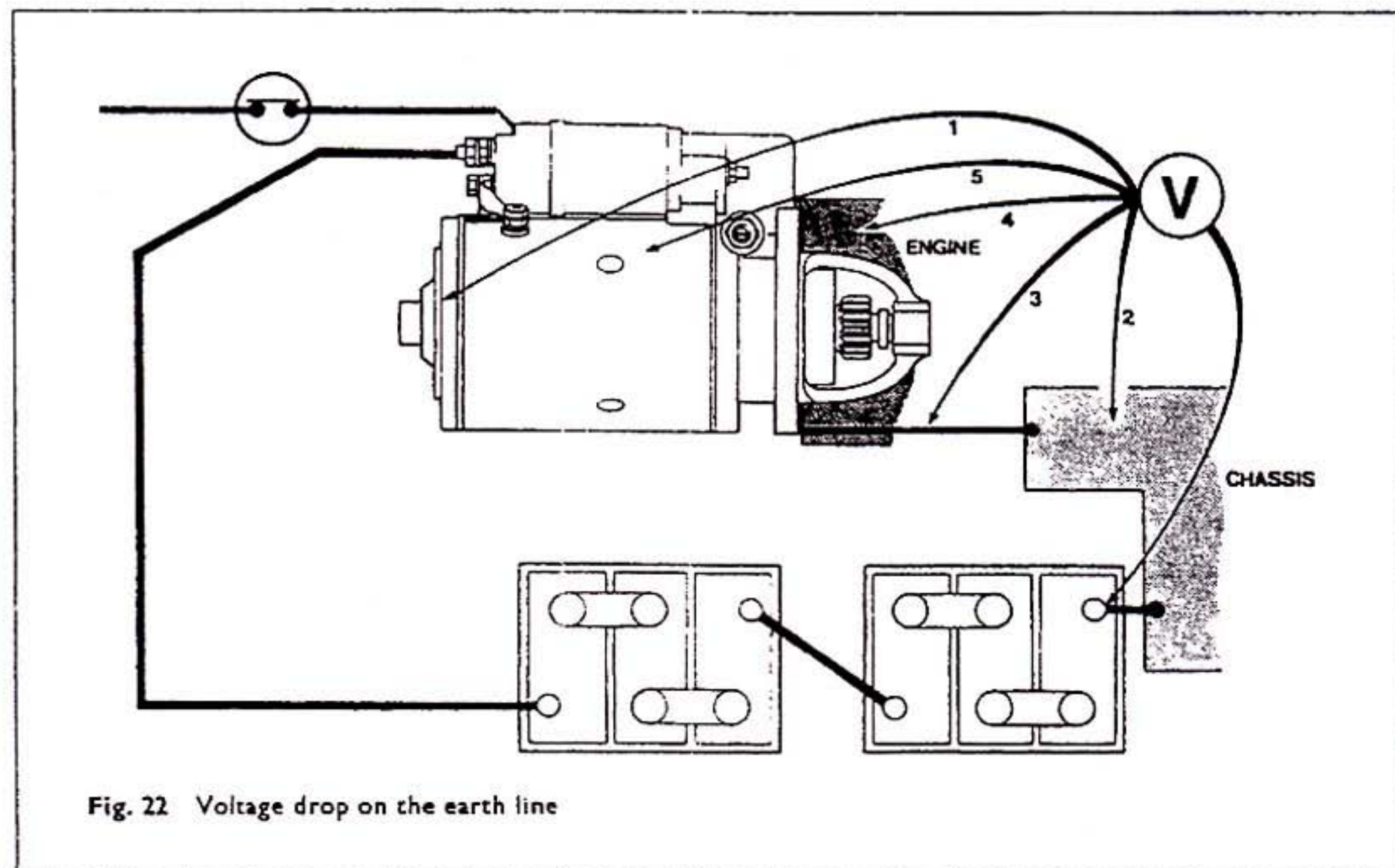


Fig. 22 Voltage drop on the earth line