PU 140

THE NATIONAL ENTERPRISE METRA BLANSKO EXTENDS THE GROUP OF THE PU SMALL UNIVERSAL INSTRUMENTS WITH A NEW TYPE PU 140 MOTORCAR SERVICE INSTRUMENT. IT IS DESIGNATED FOR THE DETERMINATION AND REMOVAL OF FAULTS OR FOR ELECTRICAL EQUIPMENT ADJUSTMENT IN MOTOR-CARS. THE PU 140 INSTRUMENT SHALL BE WIDELY USED LIKE BY AMATEUR DRIVERS, LIKE BY PROFESSIONAL DRIVERS AND LIKE FURTHER PERSONEL AT GARAGES, MOTOR-CAR REPAIR SHOPS ETC.

THIS MANUAL SHALL MAKE YOU ACQUAINTED WITH PROPERTIES AND WIDE POSSIBILITIES OF EXPLOITATION OF THIS INSTRUMENT FOR IT TO SERVE YOU WITHOUT DEFECTS FOR A VERY LONG TIME ENABLING YOU TO EXPLOIT ALL ITS ADVANTAGES.

WE ARE SURE, THAT THE PU 140 INSTRUMENT WILL BE A GOOD HELPER NOT ONLY OF ALL AUTOMOBILE INDUSTRY WORKERS, BUT OF ALL MOTOR-CAR USERS AND HOLDERS.

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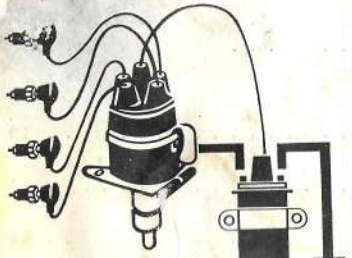
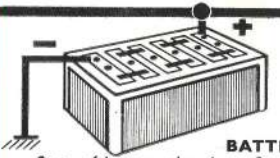


IGNITION COIL WITH DISTRIBUTOR

Check of operation
Measurement of engine r.p.m.
Measurement of switching andle of contact breaker

STARTER

Check of operation
Contakt resistance



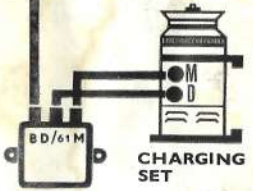
BATTERY

State of battery charging - State of individual cells - State of plates - Contact resistances - Measurement of charging current (from external source)

OTHER ELECTRICAL APPLIANCES

Check of operation
Current measurement

Check of operation
Current measurement (external shunt resistor)



CHARGING SET

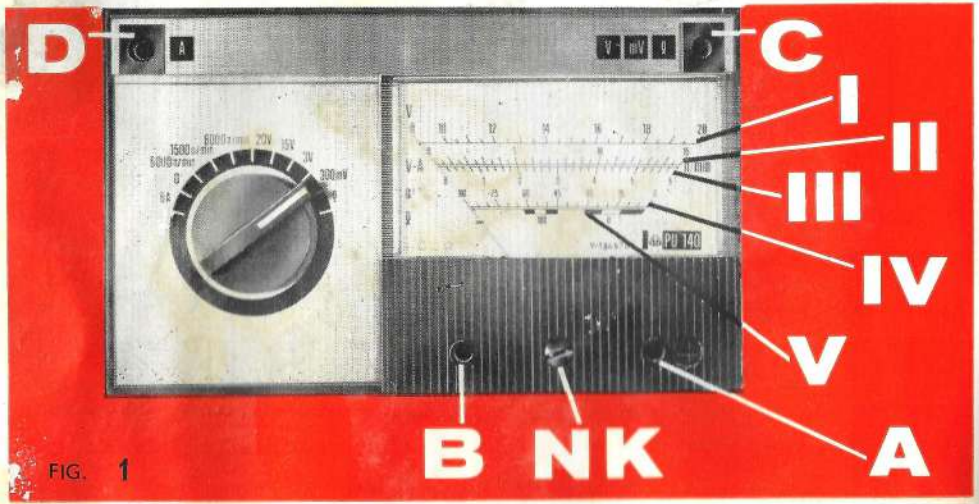


FIG. 1

DESCRIPTION OF THE INSTRUMENT

The type PU 140 instrument can be used for the measurement of certain parameters which are important for correct operation and running of an internal-combustion engine and for faultless operation of a motor car. It can above all detect defects in the automobile which originate in the electrical outfit. Some measurements also make it possible to determine mechanical defects. The instrument is intended above all for measurement on four-cylinder fourstroke engines, but it can also be used for other types of internal-combustion engines (two-stroke, four-stroke, single- to eight-cylinder) with 12-volt (in limited range 6 V, too) electrical outfit. In such instances the actually read value of r.p.m. and switching angle must be converted to the true value according to the instructions on page 66.

The measuring moving-coil system of the instrument is accommodated, in common with measuring printed circuits, in a bipartite thermoplastic cover. On the right side of the instrument lid there is a dial with scales. A thin glass pointer substantially facilitates gooc

reading of the indicated values on all instrument scales. Accommodated under the dial is the zero setting device and two jacks serving for the measurement on the motor-car ignition contact breakers. The measuring range can be selected by means of a range selector

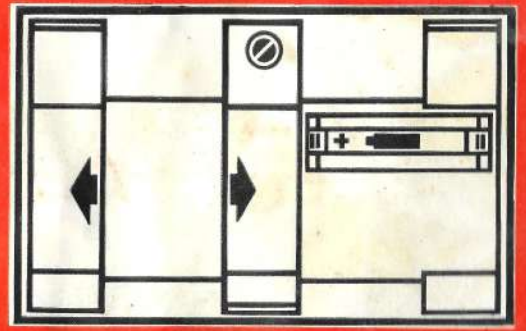


FIG. 2

switch, located on the left side of the dial. Above the selector switch is a jack for 6-amp. current measurement. Another jack in the upper right corner serves for the measurement of all the voltages and of ohmic resistances. During measurement of ohmic resistances, the instrument is energized from a 1.5-volt pencil-shaped dry cell accommodated in a compartment in the bottom instrument section under an extractable lid (Fig. 2).

TYPES OF MEASUREMENTS AND THEIR APPLICATIONS

IN THE FOLLOWING TABLE ARE GIVEN THE INSTRUMENT MEASURING RANGES:

Type of measurement	Measuring range	Selector switch position	Accuracy (%)	Connection to terminals	Scale
Voltage	10—20 V	20 V	1.5 (of max. value)	A—C	I
Voltage	0—15 V	15 V	2.5	A—C	II
Voltage	0—3 V	3 V	2.5	A—C	III : 2
Voltage	0—300 mV	300 mV	2.5	A—C	II × 20
Angular speed	0—1500 r.p.m.	1500 n/min	5	A—B	II × 100
Angular speed	0—6000 r.p.m.	6000 n/min	5	A—B (C)	II × 1000
Switching angle of contacts (α)	0—90 °	α°	2.5	A—B	IV
Current	0—6 A	6 A	2.5	A—D	III
Resistance	0—100 Ω—∞	Ω	—	A—C	V

1. VOLTAGE — 20 V

This range is intended for the measurement of charging set voltage, i.e.:

- **controller operation**
- **generator operation**

To improve the reading accuracy, this measuring range has suppressed zero, whereby a high resolution is attained, this resolution being essential for the determination of correct operation, e.g. of the generator and the controller.

2. VOLTAGE — 15 V

This measuring range can be used for:

- **checking the storage battery voltage under load**
- **measuring the voltage on various appliances**
- **checking the 6-volt charging set**

3. VOLTAGE — 3 V

By means of this measuring range, the following quantities or states can be checked:
- voltage of individual battery cells
- contact resistances in electrical circuits
- state of storage battery by means of a cadmium probe

Voltage can be read on scale III (Fig. 1), dividing the indicated value by 2.
Example: The pointer indicates "5" on scale III, the actual voltage value is 5 : 2 = 2.5 volts.

4. VOLTAGE — 300 mV

This measuring range can be utilized for determination of:
- contact resistances in electrical circuits
- state of storage battery by means of a cadmium probe
- charging current of up to 30 amps by means of an external shunt resistor.

The voltage is read on scale II (Fig. 1) and the indicated value is multiplied by 20.
Example: The pointer indicates "4.5" on scale II, the actual measured voltage is 4.5 × 20 = 90 mV.

5. ANGULAR SPEED — 1500, 6000 r.p.m.

This measuring range can be used for:
- checking the interrupter contacts
- adjusting the idling speed
- testing the engine output (operation of sparking plugs)
- checking the voltage, contacts switching-angle and the output of generator
- r.p.m. measurement in the course of drive

Speed of up to 1500 r.p.m. is read on scale II and the instrument indication is multiplied by 100.
Speed of up to 6000 r.p.m. is read on scale III and the instrument indication is multiplied by 1000. The range "6000" corresponds to two positions of the selector switch, in order that the selector switch need not pass through the position "1500 r.p.m." when generator voltage and switching angle in dependence on r.p.m. are measured.

6. SWITCHING-ANGLE OF INTERRUPTER CONTACTS

This range serves for the following operations:
- check of operation
- adjustment of contacts

7. CURRENT — 6 A

By means of this measuring range the following checks or measurements can be carried out:

- **check of storage battery charging**
- **measurement of generator reverse current**
- **measurement of current drain of electrical appliances**

8. OHMIC RESISTANCE (OHMMETER) 0 - 100 - ∞ OHMS

This measuring range serves for general checks of connection of electrical circuits, such as:

- **check of resistance transducer of the thermometer and check of resistance transducer of fuel gauge**
- **check of pressure switches**
- **check of various circuits of electrical installation, interruption of coil, filaments of incandescent lamps, conductors**

BASIC INSTRUCTIONS FOR USE

The instrument can be used in spaces with ambient temperature of from —20 to +40 °C with no aggressive gases or vapours. Before the measurement, the instrument should not be exposed to such temperature changes which would cause its dewing. Occasionally check whether the dry cell energizing the ohmmeter does not corrode. Protect the connecting jacks against penetration of impurities and dirt. Do not use banana plugs which would have to be inserted and pulled out with violence. Protect the instrument against soiling, e.g. with oil and above oil with acids, as well as against mechanical scratching. If required, clean the instrument cover with a soft cloth.

If possible, do not remove the instrument from the case in the course of measurement. When measuring with the instrument, same should be in horizontal position deflection of the instrument results in an additional error). Prior to measurement, check whether

the pointer shows zero deflection. If this is not the case, slowly and finely turn the zero-correction screw NK (see Fig. 1) and set the instrument pointer to zero.

When measuring the engine r.p.m. when driving, place the instrument on the seat or on the instrument board in horizontal position. The method of positional fixation depends on the sort of vehicle with regard to the possibility of reading.

The instrument can be connected to measuring spots by means of the enclosed three conductors provided with banana plugs on both ends. To enable permanent connection, the banana plugs can be provided with crocodiles, which are also supplied together with the instrument as accessories. If required, the instrument owner can procure longer or otherwise modified conductors. The conductors can have small cross section with the exception of those used for current measurement, where a cross section of at least 1 sq.mm is necessary.

Prior to measurement, carefully check the preset measuring range and make sure that the measuring conductors are connected to the appropriate jacks!

Incorrect manipulation with the instrument could result in its overload or cause a defect in same.

If the instrument is not used for measurement when driving and is stored in the luggage space, it must always be put in the protective cover as otherwise it could suffer from mechanical damage resulting from vehicle vibrations. The instrument must never be exposed to excessive shocks or vibrations. It is recommended to fill the space in which the instrument is accommodated with a soft material (textile) preventing same from spontaneous displacement. Alternatively, the instrument in its cover can be wrapped in a shock-absorbing substance (foam rubber, polyurethane, etc.). Specific instructions for individual types of measurement will be quoted in the following text.

IV DETERMINATIONS OF THE STATE OF MOTOR-CAR ELECTRICAL OUTFIT

1. GENERAL INTRODUCTION

Fig. 3 shows the basic circuit diagram of ignition-, generator-, storage-battery- and starter circuit of a common four-cylinder (four-stroke) internal combustion engine with 12-volt electrical outfit. In case, that the electrical installation has its minus (—) pole connected to the motorstructure, the instrument should be connected in accordance with the kind of measurement, either A, B, or C. By means of the C connection we can measure the charging set voltage, or the angle α in sequence with the engine r.p.m. (by switching over the instrument range selecting switch). In case, that the installation has its plus (+) pole connected to the motorstructure, only the connections A, or B can be used together with the reverse instrument polarity.

The following paragraphs describe the measuring method in three-wire connection. Switch the instrument over to the range "20 V" and connect same to ignition-coil terminals and to engine block (three-wire connection) according to Fig. 3c. Switch-on the ignition by means of the key (switch S1). The voltmeter must indicate a voltage of approx. 12 to 15 volts. If the voltage is substantially lower or if it even equals zero, there is a fault either in the ignition circuit or in the battery. The fault can be localized by switching-on the engine starter for a short while. If the starter can be put into operation, the defect is in the ignition circuit. If, on the contrary, the starter cannot be put into operation, the defect is in the battery circuit. When the actual voltage value is within the limits specified above start the engine.

Switch the instrument over to position "6000 r.p.m." and gradually increase the engine speed. The instrument deflection must continuously increase. If, in the course of engine

A

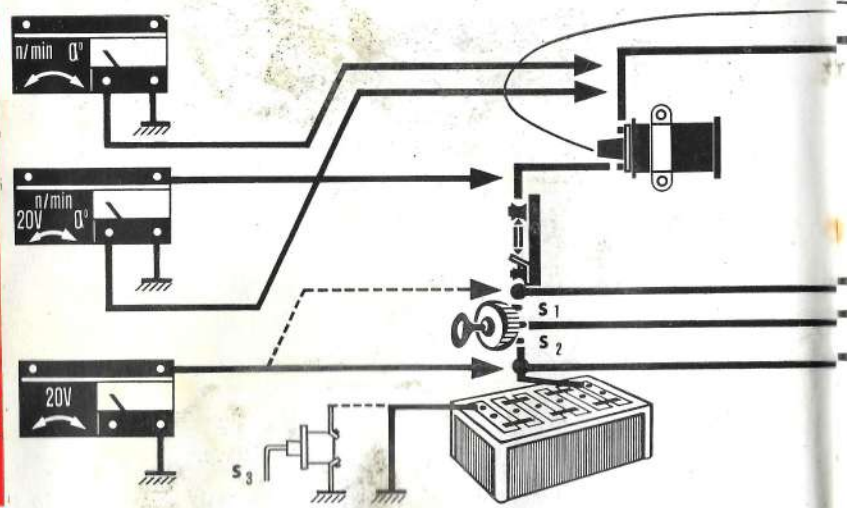
Two-wire connection
Measurement of speed and of contact switching angle

C

Three-wire connection
Measurement of speed, switching angle of contacts, and voltage

B

Two-wire connection — voltage measurement



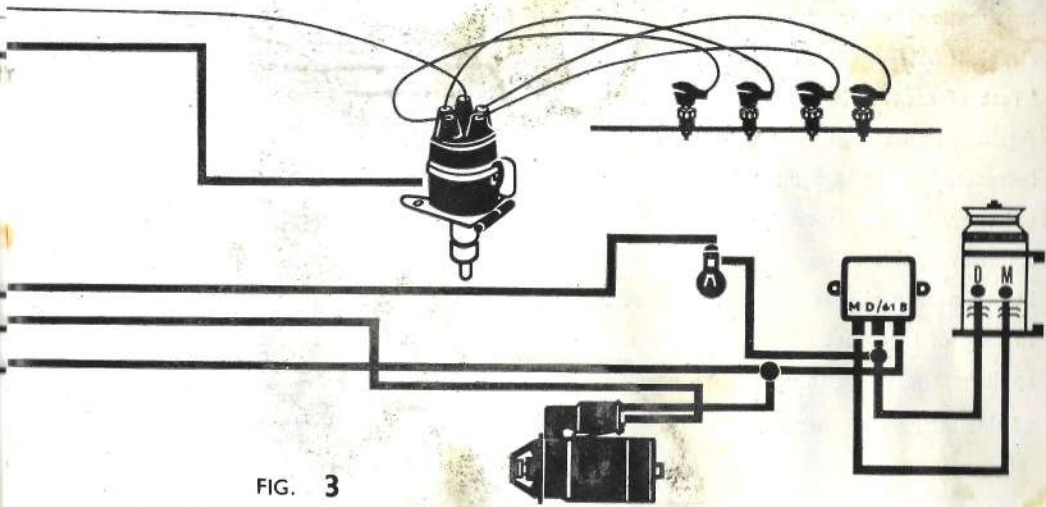


FIG. 3

acceleration, the instrument pointer moves in jumps, the contact breaker in the ignition circuit is not in order. The contact breaker can be checked in conformity with the paragraph "Test of contact breaker".

Again switch the instrument over to the range "20 V" and observe the voltage at speed increase. The voltage must increase by approx. 0.5 to 2 volts when compared with the voltage value corresponding to engine at rest. This means that the charging set is in order. If however, this voltage increase does not take place, the fault is to be determined according to paragraph "Test of charging set".

In case of incorrect operation or in case of checking the properties of other electrical appliances, proceed in conformity with the instructions specified in the subsequent section of this instruction manual.

2. MEASUREMENT OF THE STATE OF THE STORAGE BATTERY

If one of the tests specified in section IV/1 shows that the storage battery is probably faulty, the following measurement must be carried out:

a) Set the selector switch to the range "15 V" and connect the test prods directly to the lead studs (not to the terminals to which the intake wires are secured) acting as storage-battery outlets (Fig. 4). If the voltmeter indicates a voltage lower than 11 volts, the storage battery is discharged and it must be charged prior to making any other measurements.

   If the measured voltage exceeds 12 volts, the storage battery is charged. At full charging, the voltage can reach 15 volts.

b) Switch the instrument over to the range "15 V" and switch-on the starter for a short while The voltage by starting must not sink below 9 volts, as thestarter speed and the voltage

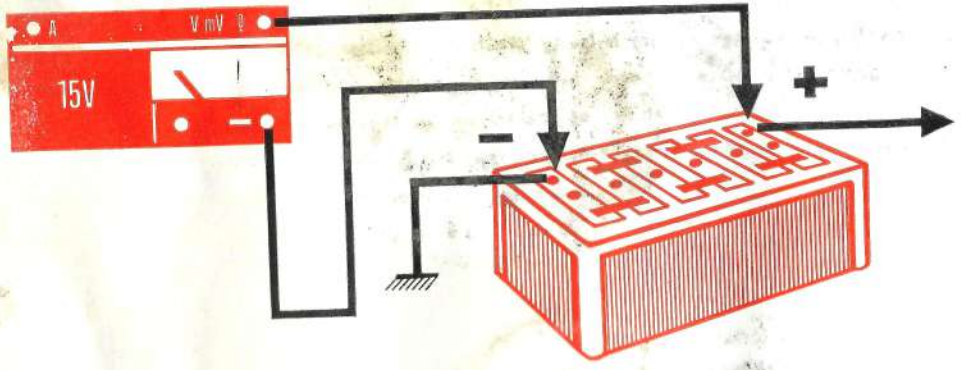


FIG. 4

on the ignition coil would not suffice for starting the engine. If the voltage drops below 9 volts, the storage battery is faulty (its internal resistance is excessively high due to the sulphatation of plates) or else there is a short-circuit in the starter. This is usually manifested by the total inability of the starter to revolve, even slowly.

c) The state of individual storage-battery cells can be checked by switching the instrument over to the range "3 V" and by successive measurement of all the battery cells (see Fig. 5). The battery cells are all connected in series so that the polarity must always be changed when proceeding from one cell to the next. In batteries of newer design the links between individual cells are cast in an insulating substance and, consequently, a test prod must be used for the measurement in order to pierce the insulating substance to obtain contact with the battery electrode. In a good battery the voltage of unloaded battery cells (i.e. without the connection of either an electric appliance or ignition) will be within the limits of from 1.9 to 2.1 volts.

If the foregoing test has shown that the battery voltage drops below 9 volts when th

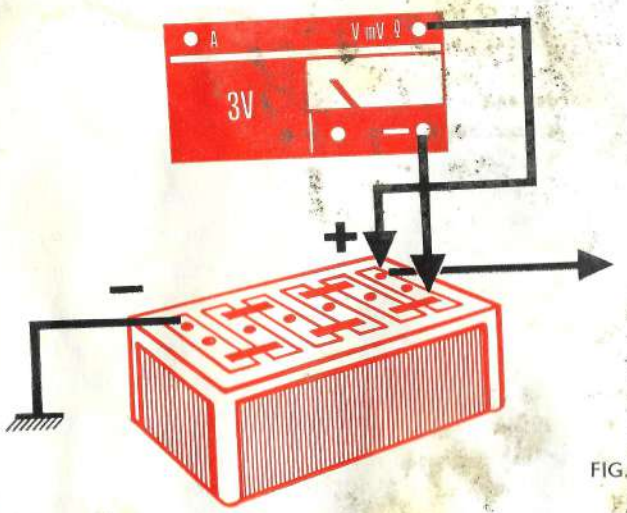


FIG. 5

starter is switched-on, the voltage of individual cells must also be checked with the battery loaded with the starter. Most frequently, the battery defect is due to one faulty cell.

If all the battery cells are in order and if the battery voltage does not drop below 9 volts when same is loaded with the starter, but if, in spite of that, the starter revolves slowly, the fault is in excessively high contact resistances between the storage battery and the starter (see section IV/3).

d) The state of storage-battery plates (capacity) at some conditiois can be determined by measuring the potential of cell electrodes. This can be done by means of a cadmium electrode immersed in the cell electrolyte. The electrode must be immersed into the electrolyte 30 minutes before the beginning of the measurement. Before measurement, the storage battery must not be loaded (starting). The potential is first measured on the range "3 V" and then, if it is small, on the range "300 mV".

The instrument is connected to the measured cell (Fig. 5). The potential of each individual electrode should be measured twice or three times (the cadmium electrode is not supplied as accessory to the instrument — Fig. 5, 6 and the measurement is then evaluated as shown in the table on page 6.

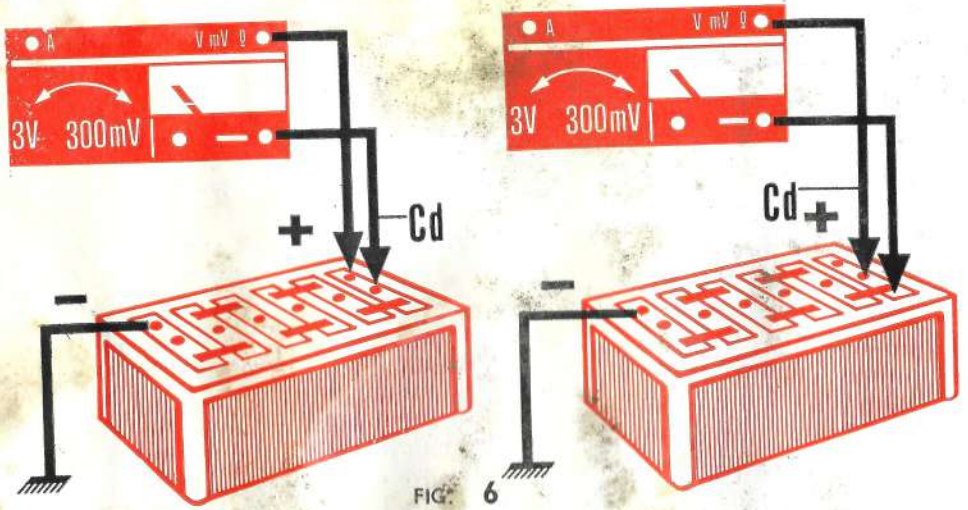


FIG. 6

The measured potential of electrodes practically only depends on the state of the cell electrodes. From the actual potential value one can estimate whether the plates are in normal state, which of the plates is faulty or whether the cell has inverse polarity. Inverse polarity of a cell usually results from a non-uniform discharging of cells when one of the cells is fully discharged so that the continuing discharging of the battery as a whole causes the discharged cell to be again charged by discharging current, but in inverse polarity.

The state or faults of individual battery cells can be determined from the values of potentials between individual electrodes, the respective values being specified in the following table. (More details - Lit. 4).

State of battery	Potential (voltage)			State of battery plates
	Cd — (V)	Cd + (V)	— (V)	
Final stage of discharging	0.20	2.00	1.80	Good plates
Final stage of charging	—0.25	2.45	2.7	Good plates
Final stage of charging	0.22	0.15	—0.07	Faulty negative plates
Final stage of charging	2.15	2.00	—0.15	Faulty positive plates
Inverse polarity of one cell	0.30	2.1	1.8	Smaller charge of negative plates
Inverse polarity of one cell	0.15	1.95	1.8	Smaller charge of positive plates

3. DETERMINATION OF THE SPOT OF INCREASED OHMIC RESISTANCE (MEASUREMENT OF VOLTAGE DROP)

Increased ohmic resistance may appear in a circuit consisting of separable junctions or in a circuit incorporating a conductor with considerably narrowed cross section. An excessively increased resistance is most frequently due to spoiled contacts or junctions, insufficiently tightened contacts, or partly broken conductors. Spots of increased ohmic resistance manifest themselves, above all, in circuits with a heavy loading current (starter, distance lights, horn). On such spots, the current passage causes a voltage drop, by which the voltage across the appliance is reduced. In the case of heavy currents an excessive voltage drop may appear even on a resistance which seems to be low, and this undue voltage drop unfavourably affects the output and, in many cases, even the very operation of a given electrical appliance. To determine and remedy a fault of this sort, proceed as follows:

Prior to measuring the voltage drop across the spot of increased ohmic resistance, determine the voltage on both the battery and the appliance (after having put the appliance into operation — Fig. 7).

a) If the voltage on the loaded battery is adequate (9 to 12 volts with switched-on starter, approx. 12 volts when lower-output appliances are switched-on) and if it is identical with the voltage on the appliance, the fault is in the appliance. The most frequently occurring faults in starter circuits are listed in the last section of this instruction manual.

b) If the difference between the battery voltage and the voltage across the appliance is great (several volts), try to find the connection or the spot with increased ohmic resistance. Proceed from the battery poles to the appliance in succession, according to numbers (letters) quoted in the Figure, with the appliance switched-on (when measuring in the starter circuit, same should only be connected to the battery for a short time — Fig. 8).

Measurement should always proceed between two adjacent numbers of letters. When connecting the voltmeter, pay due attention to correct polarity of the measured voltage drop. Voltage drops on individual connections should be measured with the instrument switched-over to the range "3 V". When the deflection is smaller than 0.3 volt, switch the instrument over to the range "300 mV". If the voltage drop exceeds 100 to 200 millivolts, disassemble the connection, clean same, apply a thin layer of vaseline on contact surfaces and again firmly tighten. If an excessive voltage drop is measured on some of the switches (battery isolating switch, starter switch), same must be disassembled and its contacts cleaned or exchanged. In the course of measurement take care that the instrument is not connected to both the structure and the circuit to be measured, since in this case the instrument would be connected to the voltage of 12 volts. At the instrument range of 300 millivolts, whereby the measuring system of the instrument could be seriously damaged.

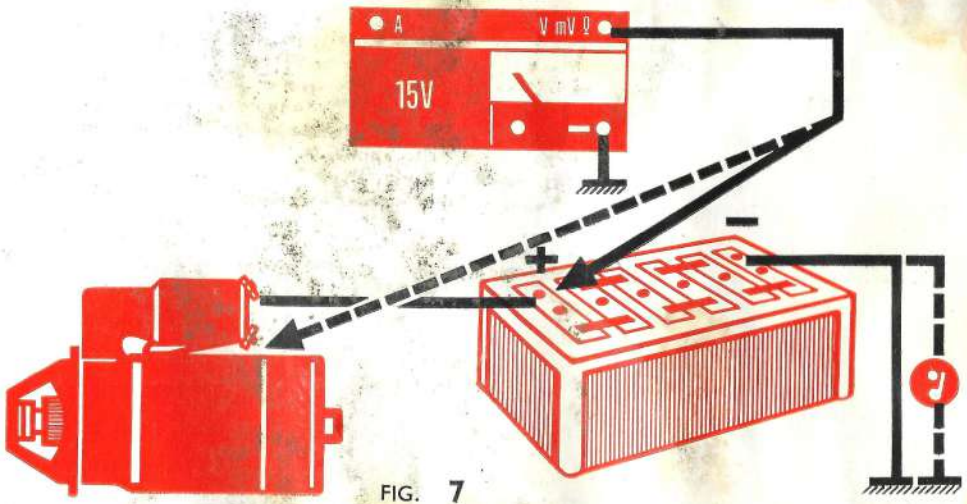


FIG. 7

4. TEST OF CONTACT BREAKER IN IGNITION CIRCUIT

Sufficiently high voltage on the ignition coil can be produced and a discharge on the sparking plug can take place if the contact-breaker contacts close and open at certain well defined instants. Measurement of the distance between contacts by means of a slip gauge is inaccurate, especially in the case of partly worn contacts. With the use of the PU 140 instrument the switching angle can be preset and its dependence on engine r.p.m. can be followed.

The instrument is to be connected to the electrical installation circuit as shown in Fig. 3. The jack C need not be connected, since the instrument will not be used for the measurement of voltage. During the test, first switch the instrument over to the range 1500 r.p.m. — circuit diagram in Fig. 3a. Start the engine and adjust same so that it runs smoothly at a speed only slightly higher than idling speed. This adjustment can be carried out by means of the idling screw or by putting an insertion piece under the stop of the carburettor throttle valve. The instrument must show deflections of approx. 1000 to 1500 r.p.m. If

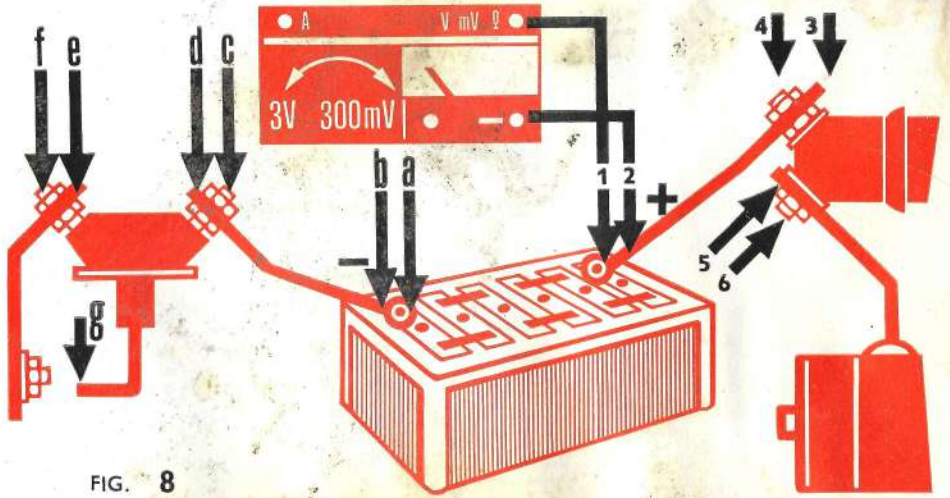


FIG. 8

the instrument pointer deflects beyond the scale, either the contacts bounce at the switching action or their surface is uneven and a repeated sparking takes place at the instant of contact breaking.
In both cases the contact breaker requires mechanical adjustment and careful cleaning of contacts. If the instrument deflection is within the limits mentioned above, switch the instrument over to position "α" (switching angle) and measure the switching angle which is usually specified by the manufacturer within the limits of from 40 to 60°
If the actually measured value considerebly differs from the prescribed one, the stroke of interrupting contacts is incorrectly adjusted. If the actual switching angle is smaller than the correct one, the gap is greater than required and vice versa. If some defects are detected by the measurement, the gap between contacts must be adjusted to correct value prior to making further tests. Then switch the instrument over to the range 6000 r.p.m. and continuously increase the engine speed up to the admissible maximum (6000 r.p.m.). The instrument deflection must steeply increase within the whole range of engine speed. If, at a certain speed, the instrument deflection suddenly rises, the contacts bounce in the course of closing, This effect, which unfavourably affects the engine performance, is due (provided that the active contact surfaces are in order, which has been confirmed by the previous test) to reduced elasticity (fatigue) of the steel spring which returns the contact to initial position, or due to dirt on the pin about which the contact arm revolves. Dirt must be removed by means of petrol. If, however, the spring shows lack of elasticity, the whole contact must be exchanged.

The instrument, connected in such a way, can be used for the basic advanced ignition of the engine.
By engines, whose blocks are marked by an appropriate mark, giving the basic advance ignition setting, we first settle the first cylinder to this mark, after that we turn slowly the distributor to the position, in which contacts begin to disconnect. This position should be indicated by the instrument, whose pointer by connected contacts indicates the zero position, and by disconnected contacts shows maximal value.
If the engine is not marked in such a way, we shall place the first cylinder piston into its top dead center position. After that we shall turn slowly the distributor into such position, at which the contacts begin to disconnect. This position represents the zero advanced ignition. After that we shall turn the distibutor in the rotation opposite sense up to the angle, prescribed by the car producer.

Motor-car type	Contacts closing angle°
Fiat 600	**50,4**
Fiat 850	**58,5**
Fiat 1300, 1500	**54**
Ford Cortina	**51,3—56,7**

Motor-car type	Contacts closing angle °
Ford Taunus 12 M	**49,5**
17 M	**46,8**
20 M	**54**
Moskvič 403, 407, 408, 426	**45**
Renault R 8 (1962)	**58,5**
R 8 (1964—1965)	**54**
R 16 (1965)	**56,7**
R 16 (1967—1968)	**58,5**
Simca 1300	**54**
1301	**55,8**
1501	**45—52,2**
Škoda Felicia, Octavia, Octavia Combi, 1203	**49,5**
Škoda 1202	**45**
Škoda 1000 MB, Š 100, Š 100 L, Š 110, Š 110 L	**54 ± 5**
Volha, GAZ 22 C, GAZ 21 G	**40,5**

5. ENGINE RUN

The revolution counter can also show whether all the engine cylinders are operative. For the purpose of this test, first let the engine warm to working temperature and adjust its speed to 1100 to 1300 r.p.m. Protect your hand with a rubber glove and remove one intake to the sparking plug. Connect this intake to the engige block and measure the engine speed which should decrease by 50 to 200 r.p.m. Repeat this operation with all the engine cylinders in succession. In case of equal state of all cylinders, the speed reduction will also be equal. If, however, the speed decrease is unequal, the cylinder which shows a small or even a negligible speed decrease after the disconnection of cable to the respective sparking plug, is in disorder and in this case the reason of this state must be determined.

6. TEST OF BATTERY CHARGING SET

a) General instructions

The charging set ensures adequate capacity of the storage battery required for motor-car operation. The charging set consists of the generator and the voltage controller.

The charging set operates as follows:

When the motor car is at rest, the battery is disconnected from the generator by means of the make contact in the controller. As soon as the ignition key is inserted into the ignition switch, the charging pilot lamp lights up.

After the engine has been started and after its speed has been increased, the voltage of the generator begins to rise and the charging pilot lamp extinguishes. After the generator voltage has reached a certain level, the controller switch closes the genera-

tor-battery circuit and the generator begins to charge the battery. The voltage controller, interposed in the field circuit of the generator, prevents the voltage from changing with engine speed. Usually, the voltage controller operates in several control stages. At low generator speed, the generator field circuit is directly connected to the generator armature voltage via the controller contacts. In the second stage (at medium speed), a resistor, accommodated in the lower controller section, is interposed in the field circuit. At high speed, the excitation winding is short-circuited. In the course of engine run, these cycles are repeated in short intervals, whereby a nearly constant voltage across generator terminals is attained.

In addition to voltage coils, the controller also has current coils, the purpose of which is to increase the magnetic field and — in three-coil controllers — to limit the maximum current to a value corresponding to rated output of the generator. If the generator voltage drops below the value of battery voltage, the switch must disconnect the battery-generator circuit in order to prevent the battery from being discharged through generator winding, and, at low speed, the charging pilot lamp must again light up. There are great many versions of controllers and they can basically be divided into two main groups, i.e. the two-coil- and the three-coil controllers. For common motor-cars the voltage levels for various types of generators and controllers are specified in the follow- ing tables.

ADJUSTING DATA OF MOST COMMON VOLTAGE CONTROLLERS WITH TWO-STAGE CONTROL

Motor car	Controller (type)	Controlled voltage (V)		Switching voltage (V)	Controlled current (A)		Reverse current (A)
		1st stage	2nd stage		1st stage	2nd stage	
Škoda 1000 MB	029407.02	min. 13.8	max. 14.2	12.3—12.7	21.4	22.6	2—5
Škoda 1200	029407.03				19.4	20.6	
Tatra 603	029407.05				25.4	26.6	3—6
Traktor Major Super	029407.07				11.5	12.5	

ADJUSTING DATA OF COMMON CONTROL RELAYS WITH TWO-STAGE CONTROL

Motor car	Type of controller	No-load voltage (V)		Switching voltage (V)	Working voltage (V)		Loading current (A)	Reverse current (A)
		1st stage	2nd stage		1st stage	2nd stage		
Zetor 15	02-9401.50	min. 7	max. 8.2	6.1—6.5	6.5—6.7	—	11 A/6.5 V	2.5—7
Aero Minor Škoda 1101 Tatra 576	02-9401.53	min. 7	max. 8.2	6.1—6.5	6.5—6.7	—	20 A/6.5 V	2.5—7
Tatra 600, 87 Zetor 25, 35, 50	02-9403.51	min. 14	max. 16	12.5—13	12.4—12.8	—	12 A/12.4 V	2.5—7
Škoda 1200, 1201, 440, 445 Octavia Octavia Super	02-9403.52	min. 14.5	max. 16	12.4—12.9	min. 13.5	max. 14.6	15 A/13.5 V	2.5—7
Felicia, T 603, Škoda 706 R, Škoda 706 RO	02-9403.54	min. 14	max. 15.5	12.5—13	13—13.4	—	25.5 A/13 V	2.5—7
Velorex	02-9403.56	min. 14.5	max. 16	12.4—12.9	min. 13.5	max. 14.6	11.3 V/13.5 V	2.5—7

b) **Measurement in charging-set circuits**

To check correct operation of the charging set, connect the measuring instrument to the circuit as illustrated in Fig. 9a. Gradually increase the engine speed and observe the deflection of the instrument pointer. At increasing speed, the voltage must increase up to the value of switching voltage. At the attainment of this voltage the charging-set circuit is closed and this is manifested by a certain decrease of voltage.

After the switching voltage has been determined, connect the instrument to the circuit as shown in Fig. 9b and again gradually increase the engine speed above that corresponding to the switching voltage. In the whole range of r.p.m. shold not exceed the voltage difference the difference of working voltage of the 2nd stage and the switching voltage, which are tabulated above. If the actually measured voltage has a different value, there is a fault in the controller circuit, which has to be determined. Most probably, the fault is due to incorrect adjustment of the controller. With a thorough knowledge of charging-set circuits it is possible to determine the voltage magnitudes at the individual stages of the working voltage or no-load voltage.

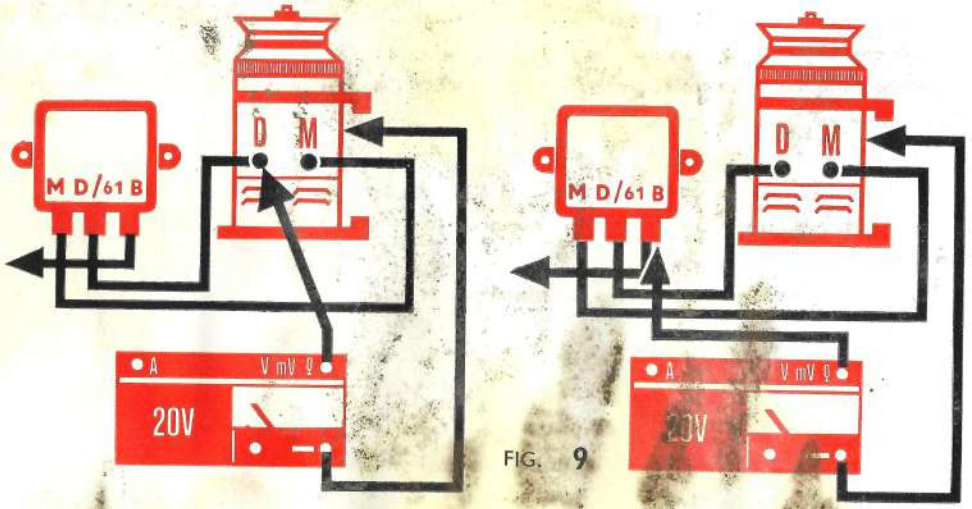


FIG. 9

Manipulation with voltage controllers is inadmissible without a thorough knowledge of their operation. When dismounting the controller cover, take care that live terminals are not short-circuited to the vehicle structure, as otherwise the controller contacts may be welded together. When repairing the controller, first mechanically adjust the controller elements and only then carry out electrical adjustment. This is described in detail for various types of controllers in literature. The list of most common faults in the charging set circuit, their detection and remedy can be found in section VIII/3 of this instruction manual.

Charging and reverse current can be measured according to instructions in section V of this instruction manual.

7. OTHER APPLIANCES

a) The appliance is fully inoperative

First make sure that the appliance itself is in order. For instance, check the state of winding, check whether the filament of the incandescent lamp is not burnt (section VI/3), etc. Then

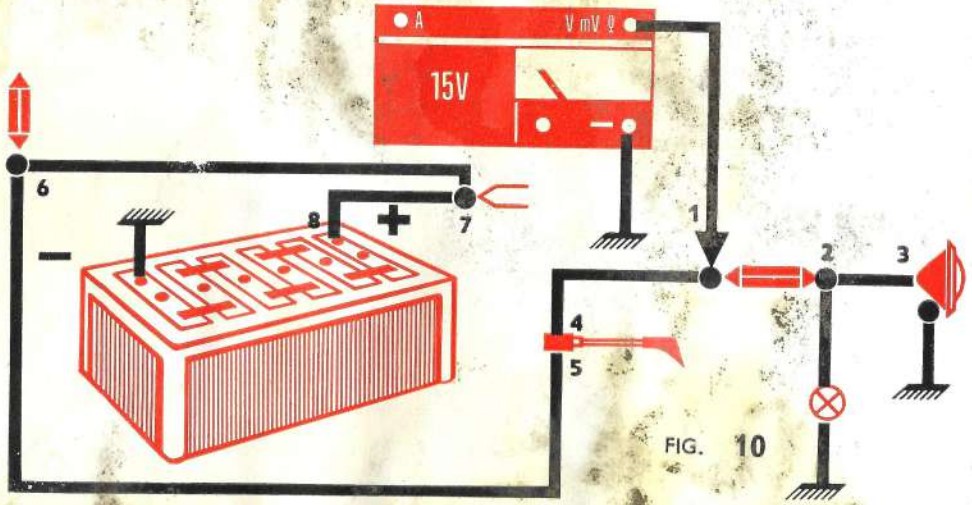


FIG. 10

connect the appliance directly to the storage battery. If, in this case, the appliance operates correctly, the fault is in the electrical installation. Switch the instrument over to the range "15 V" and measure the voltage at individual points, beginning with the fuse of the respective appliance. If a distance light is faulty, proceed as illustrated in Fig. 10. Voltage should be measured in the sequence of points marked 1 to 8.

If there is voltage at point 1, while no voltage can be measured at point 2 behind the fuse, the fuse is defective. In case of voltage at point 2 and lack of voltage at point 3, the line between points 2 and 3 is faulty. If there is voltage even at point 3, the appliance is faulty.

b) **The appliance does not operate with full output**

The source of this defect is usually an excessively high contact resistance in some junction or in some separable contact interposed in the circuit. When measuring (with switched-on appliance) proceed as described in foregoing point and follow the connection on which a lower voltag has been measured than on the preceeding junction. Such a connection must be thoroughly cleaned and tightened.

V CURRENT MEASUREMENTS

When current is to be measured, the instrument must be connected **in series** with the respective appliance. If a current range is connected to a voltage source, the instrument can be seriously damaged.

1. CHECK OF CURRENT IN APPLIANCES

The current I (amperes), corresponding to normal function of a given appliance, can be computed from the formula:

$$I = \frac{P}{U},$$

where P — power consumption of the appliance in watts (specified on each appliance),
U — voltage across the appliance in volts (storage-battery voltage).

Thus, for instance, the current flowing through the incandescent lamp of the main 45-watt headlight at a battery voltage of 12 volts equals I = P/U = 45/12 = 3.8 amps. The current

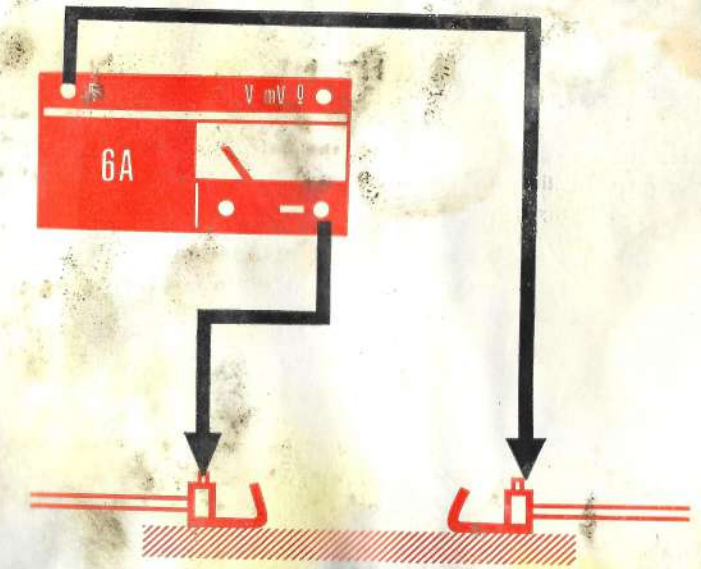


FIG. 11

of a given appliance can be measured without disconnecting the appliance circuit by simply removing the respective fuse and by connecting the PU 140 instrument to the fuse terminals (see Fig. 11).
Current flowing through an appliance which has been taken out of the motor car can be measured by connecting the appliance in question in series with the storage battery, as illustrated in Fig. 12.

2. **CHARGIN OF STORAGE BATTERY** (FROM MAINS)
Many battery chargers are not equipped with the ammeter of charging current. For this purpose the 1-amp. range of the PU 140 instrument can be used, the respective circuit diagram being shown in Fig. 13. The recommended charging current equals

$$I_d = \frac{Ah}{10},$$

where Ah is the storage-battery capacity in amperehours.
Thus, for instance, the maximum charging current of a 35-amperehour storage battery is $I_d = 3.5$ amps, etc. If the actual charging current is lower than the maximum admissible value, the charging time must be correspondingly prolonged.

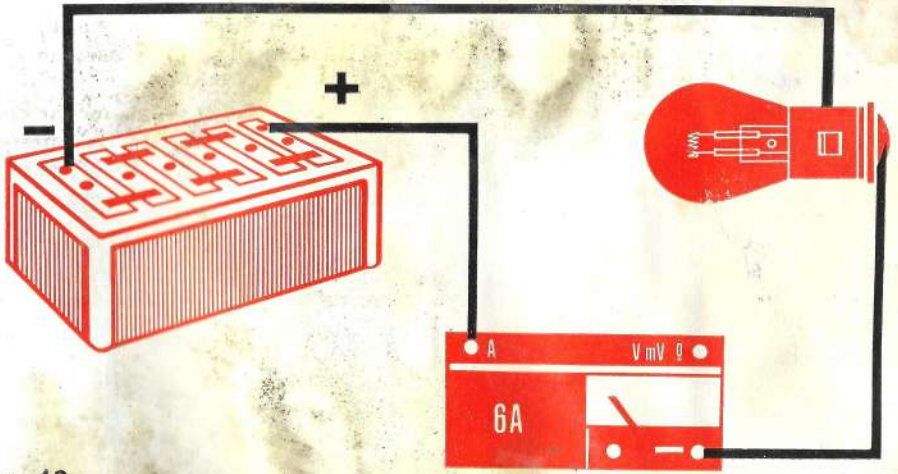


FIG. 12

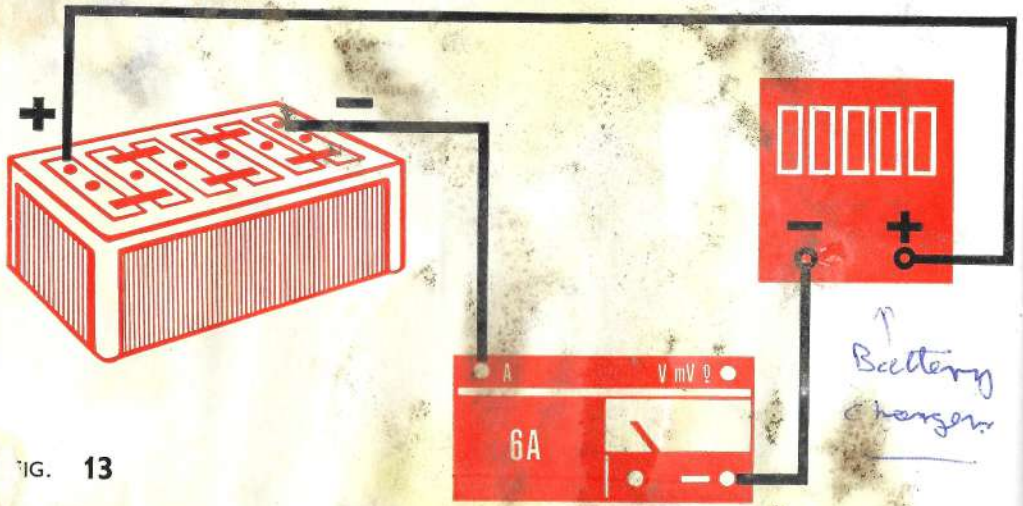


FIG. 13

3. MEASUREMENT OF CHARGING AND REVERSE CURRENT OF GENERATOR

The generator current charging the storage battery depends on engine speed. At a higher speed the charging current will increase and vice versa. To measure this current, the PU 140 instrument must be supplemented with an external 30-amp. shunt resistor, which can be ordered as an additional accessory to the instrument, The instrument should be connected to the circuit as illustrated in Fig. 14 a. When measuring the charging current, be aware that same very much depends on the state of the storage battery. When the battery is fully charged, the current will be smaller and vice versa. If the charging set is equipped with a three-coil controller, also the operation of the current limiter can be checked. If it is intended to measure the true value of the charging current, the battery must be disconnected, after the motor car has been started, and an adequately dimensioned variable resistor must be used as load. The ohmic value of this resistor is to be adjusted

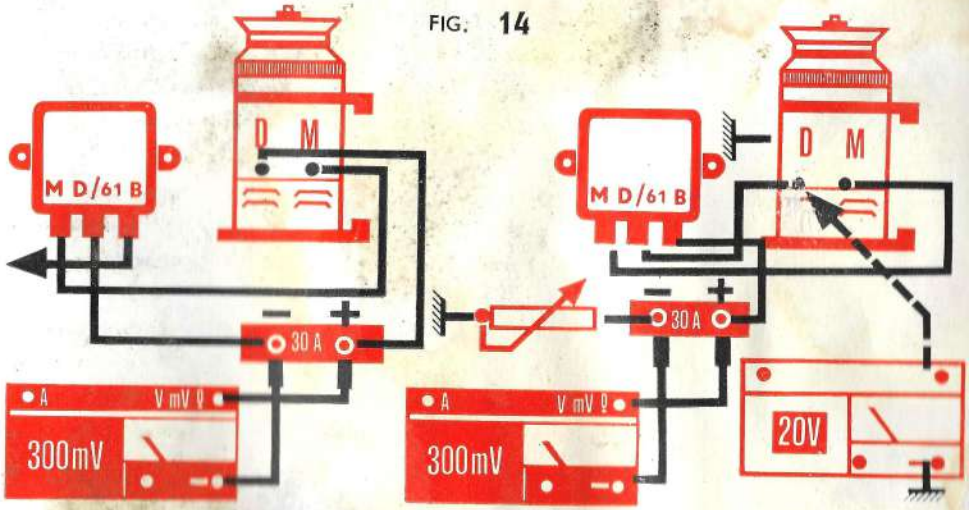
so as to correspond to the current value specified in the table in section IV/6a; after this adjustment measure the voltage on generator. To measure this voltage, disconnect the PU 140 instrument from the shunt resistor (without disconnecting the shunt resistor from the measured circuit) and connect same in parallel to the generator (as shown in dashed lines), while switching-over its measuring range to 20 volts (Fig. 146).

When determining the reverse current, connect the instrument in the same way as shown in Fig. 14, but change its polarity so that the charging current is indicated as a negative value. Gradually descrease the engine speed. At a certain speed, current begins to flow from the battery into the generator, which is indicated as positive deflection of the instrument pointer. With further decrease of speed the current will increase up to a certain value, at which the generator-battery circuit will be disconnected and the current will suddenly decrease to zero. The maximum current value determines the magnitude of reverse current and it must agree with the value specified in section IV/6a. In case of a different value the circuit must be readjusted.

Shunt R = $\frac{V}{I} = \frac{3}{30} = \frac{1}{100}$ ohm

Power 0·3 × 30 = 9 watts

FIG. 14



V USE OF OHMMETER

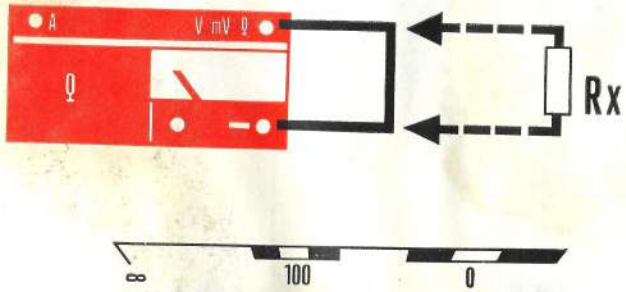
If it is intended to use the PU 140 instrument as an ohmmeter, a 1.5-volt pencil-shaped cell must be inserted into same. Since the cell voltage gradually decreases and the instrument is not equipped with a device for eliminating this voltage change, the measurement is merely informative and only serves for determining whether a circuit is closed or disconnected. To use the instrument as ohmmeter, switch same over to the range "Ω" and short-circuit the jacks A—C (Fig. 1) by means of a link.

If the supply cell has a sufficient voltage, the instrument shows the value of zero ohm in some of the scale fields. The resistance to be measured should be connected to the jacks A—C and the informative resistance value is read on the scale (see Fig. 15), while, for instance, the value of 100 ohms must be read in the field corresponding to the field at the measurement of zero ohm (short-circuit). If the pointer shows ∞, the resistor or the circuit is interrupted. If the actual ohmic value of the measured resistor should be determined by means of the instrument, it is necessary to use the graph shown in Fig. 16.

When measuring, proceed in the following way:

Graph for the determination of ohmic resistance from the value read on scale III (0 to 6) (Fig. 16).

FIG. 15



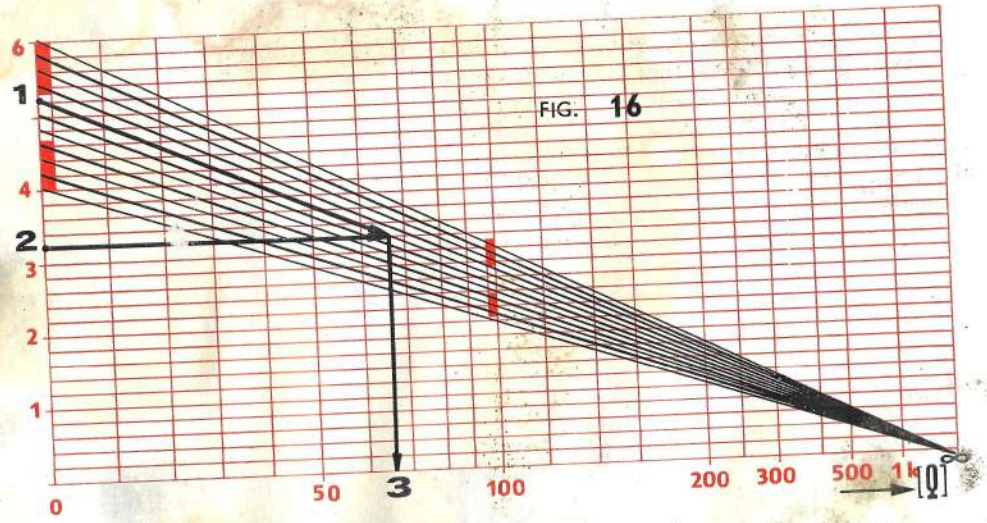


FIG. 16

The measurement is carried out in such a way:
Short-circuit the instrument terminals according to Fig. 15 and read the pointer deflection on scale III — Fig. 1 (range zero to 6). Determine this value on the vertical axis of the graph. Disconnect the short-circuited terminals, connect the resistor to be measured to the instrument and again read the pointer deflection. Then determine the measured ohmic value in the graph shown in Fig. 16.

Example: Deflection, corresponding to short-circuited terminals, equals 5.2, that which is read, when the unknown resistance is connected to the instrument, is 3.2. The ohmic value of the measured resistor, determined from the graph, is 67 ohms.

1. **CHECK OF THERMOMETER RESISTANCE SENSING DEVICE (resistance sensing device of fuel gauge)**

Connect the resistance sensing device to terminals A—C, see Fig. 17. When the instrument shows zero ohm, the sensing device is short-circuited, when it shows ∞, it is interrupted. By immersing the sensing device into water, warmed by the engine, check whether the resistance changes with temperature, as expected.

In like manner, check the resistance sensing device of the fuel gauge. Take out the sensing device and check whether the instrument indicates the resistance change when the float is being displaced.

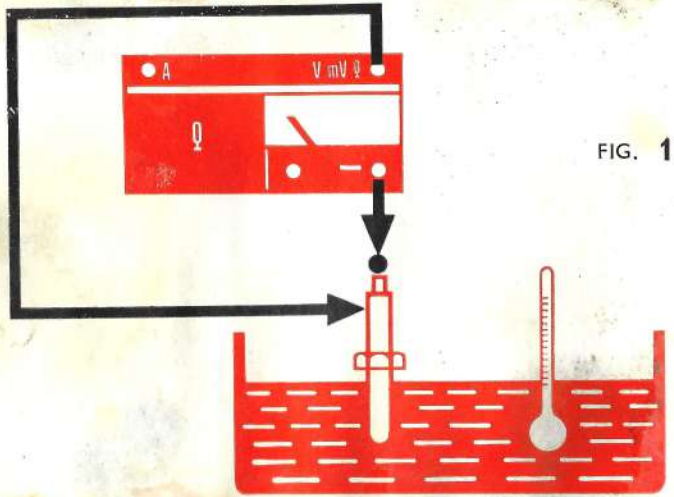


FIG. 17

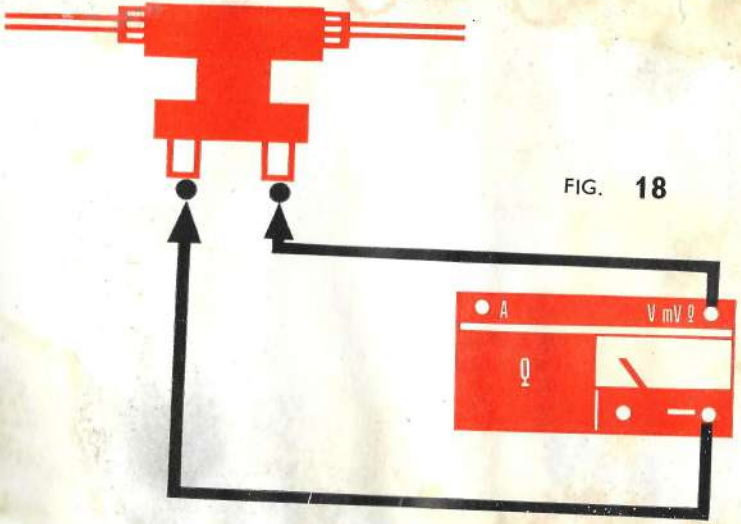


FIG. 18

2. CHECK OF PRESSURE SWITCHES (brakes, oil)

Disconnect the intake wires from the switch and connect both outlets to terminals A—C of the instrument, as illustrated in Fig. 18. If the instrument shows zero ohm, the switch is closed, if it indicates ∞, the switch is disconnected. If the instrument does not show zero ohm when the switch contacts are closed (as in the case of short-circuited terminals) or if the deflection considerably differs from that value, the switch contacts are in a bad state.

3. CHECK OF CIRCUITS, FINDING THE OUTLETS

In the case of motor-car electrical installation the corresponding ends of individual conductors can be found, when these are not properly marked (see Fig. 19). Connect one end of the conductor whose opposite end is to be found to the instrument. Then connect the outlets of the bundle of conductors in succession to the other instrument terminal. The corresponding outlet is that for which the instrument shows zero ohm.

The continuity of a given circuit can be checked by connecting both outlets of the circuit to the instrument terminals. If the instrument indicates ∞, the circuit is interrupted, if it shows zero ohm, the circuit is in order. In this way the interruption of incandescent-lamp filaments or that of coil windings can be determined.

When tracing the paths of a given electrical circuit, take care that the ohmmeter is not connected to the full battery voltage (12 volts). It is recommended to disconnect the battery from the circuit.

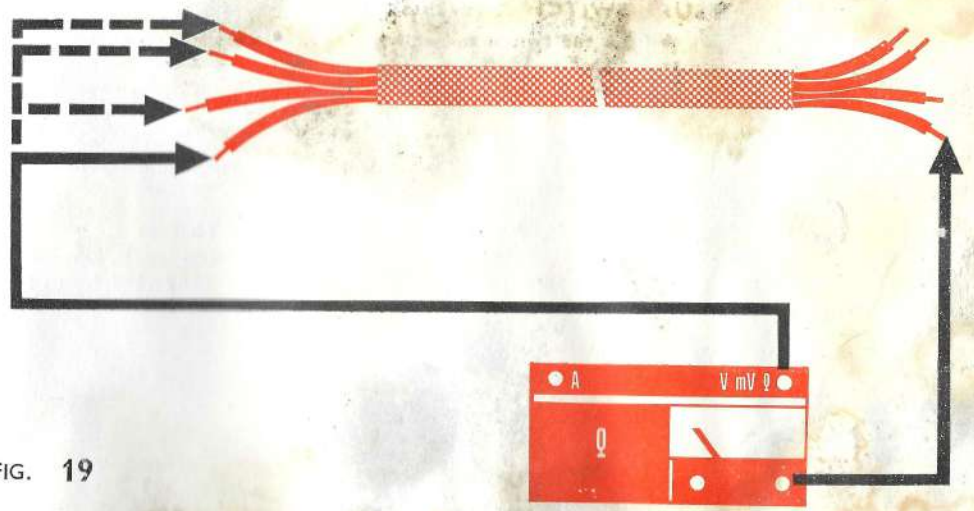


FIG. 19

VI USE OF THE INSTRUMENT FOR OTHER SORTS OF ENGINES

As already mentioned in the preceding text, the chief use of the instrument is for four-stroke engines with 12-volt electrical outfit, with four cylinders and with minus pole connected to structure. Its use for other types of engines is limited.

1. SWITCHING ANGLE OF CONTACT-BREAKER CONTACTS (α)

This measurement can only be carried out on engines with 12-volt electrical outfit. Depending on the number of cylinders, the actually measured angle must be converted into the true value according to the formula: $\alpha' = \alpha \,.\, k$,

where α — angle read on the scale 0 to 90°,
k — constant, specified in the following table.

Number of engine cylinders	1	2	(3 coils)	6	8
Range of α (°)	0—360	0—180	0—360	0—60	0—45
k	4	2	4	2/3	0.5

2. MEASUREMENT OF R.P.M.

Revolutions can be measured with both a 6-volt and 12-volt car battery. For other than four-cylinder, four-stroke engine, the true revolutions must be determined from the formula:

$$n = k \,.\, a,$$

where k — constant tabulated below, depending on the sort of engine,
a — instrument scale reading.

Type of engine	Number of cylinders	Selector switch in position 1500 r.p.m.			Selector switch in position 6000 r.p.m.		
		Range r.p.m.	Scale	k	Range r.p.m.	Scale	k
Two-stroke	1	3000	0—15	200	12 000	0—6	2000
	2	1500	0—15	100	6 000	0—6	1000
	3	1000	0—15	$\frac{2}{3}$ 100	4 000	0—6	$\frac{2}{3}$ 1000
	4	750	0—15	50	3 000	0—6	500

Type of engine	Number of cylinders	Selector switch in position 1500 r.p.m.			Selector switch in position 6000 r.p.m.		
		Range r.p.m.	Scale	k	Range r.p.m.	Scale	k
Four-stroke	1	6000	0—6	1000	24 000	0—6	4000
	2	3000	0—15	200	12 000	0—6	2000
	6	1000	0—15	$\frac{2}{3}$ 100	4 000	0—6	$\frac{2}{3}$ 100
	8	750	0—15	50	3 000	0—6	500

VII DEFECTS OF ELECTRICAL OUTFIT AND THEIR REMEDY

This chapter lists the most common defects occurring in the electrical outfit of motor cars and deals with their detection and remedy. Only defects in circuits important for engine operation will be mentioned. These defects are divided into the following groups:

1. DEFECTS IN STARTER CIRCUIT
2. DEFECTS IN IGNITION CIRCUIT
3. DEFECTS IN CHARGING-SET CIRCUIT

The following tables give the indication of the fault, its supposed source, and remedy. Prompt determination of a fault and its remedy depends on the experience of the worker and on his ability to select a suitable measuring range of the instrument with regard to the instructions given in preceding chapters.

1. DEFECTS IN STARTER CIRCUIT

Indication of the fault	Reason	Remedy
The starter, after it has been switched-on, does not run and the closing of switch contacts is not heard	Faulty intake lead to starter switch - Faulty starter switch - Faulty lead from switch to breaker - Interrupted breaker winding - Short-circuit in breaker winding - Breaker winding connected to structure - Dirty current contacts of the breaker	Measure the voltage on the marked spots in succession and replace (or repair) the faulty component
After the starter has been switched-on, same does not run, but the closing of switch contacts is perceived	Interrupted winding of starter stator - Interrupted winding of starter rotor - Worn brushes - Dirty commutator - Short-circuit to stator structure - Short-circuit to rotor structure - Short circuit to structure of brush holders	Measure the voltage on individual spots, inspect the switch and, if required, also the starter
Inadequate output of the starter	Insufficient capacity of storage battery - Excessive contact resistance in leads - Partial short-circuit in stator winding - Partial short-circuit in rotor winding - Worn brushes - Burnt commutator - Worn bearings	Recharge the battery, clean and tighten the junctions, find the faulty component and replace (or repair) same

2. DEFECTS IN IGNITION CIRCUIT

Indication of the fault	Reason	Remedy
The engine cannot be started	Blown fuse in ignition circuit - Disconnected conductor in ignition circuit - Faulty coil - Faulty lead from coil to contact breaker - Burnt contacts of contact breaker - Faulty capacitor - Disconnected lead from coil to distributor - Incorrect stroke of contacts - Conductor from coil to contact breaker connected to structure - Defective insulation of moving contact - Dirty lid of distributor - Faulty rotor of distributor	Exchange the fuse Determine the faulty component and replace (or rapair) same
After the start, the engine runs irregularly	Dirty contacts of contact breaker - Dirt on the surface of distributor rotor - Dirty lid of distributor - Incorrect gap between contacts - Disconnected cable between distributor and sparking plug - Faulty ignition coil	Determine the faulty component and replace (or repair) same

3. DEFECTS IN CHARGING-SET CIRCUIT

Indication of the fault	Reason	Remedy
After the insertion of ignition key the charging pilot lamp does not glow (while the other appliances operate in normal way)	Burnt pilot-lamp filament - Interrupted conductor from pilot lamp to controller - Poor contact of some of the brushes - Dirty commutator - Loosened lead to melting fuse - Faulty fuse - Interrupted conductor to switching box - Faulty switching box	Exchange the pilot lamp. Measure the voltage at individual points in succession and exchange (or repair) the faulty component
After the engine has been started and after its speed has been increased, the charging pilot lamp glows	Conductor from generator to pilot lamp connected to structure - Brush holder connected to structure - Commutator connected to structure - Generator winding connected to structure - Controller winding connected to structure - Interrupted generator winding - Defect in voltage controller	Disconnect one part of the circuit after the other in succession and determine the faulty spot
Charging pilot lamp indicates correct operation, but the battery is not charged	Incorrectly adjusted voltage controller - Incorrectly adjusted current limiter	To remedy the controller defect, same should be first mechanically and then electrically adjusted (according to literature)
Charging pilot lamp indicates correct operation, the battery is, however, permanently overcharged (intensive development of gases, distilled water must be frequently poured into the battery)	Incorrectly adjusted voltage controller - Incorrectly adjusted current limiter - Welded contacts of the 1st controller stage - Excitation outlet connected to structure outside the controller contacts	The fault is to be remedied equally as in the previous paragraph, the spot, connected to structure should be determined
After the engine has been stopped, the charging pilot lamp does not glow even if the key is switched on	Incorrect mechanical adjustment of the switch - Welded switch contacts	Disconnect the battery and determine the faulty spot or component

IX. Recommended literature

1. Kubín-Fechtera: Dílenská elektrotechnika motorových vozidel (Workshop electrical engineering of motor cars)
2. Pavlák-Vrchovský: Opravy elektrické výzbroje motorových vozidel (Repairs of electrical outfit of motor cars)
3. Enclosure to the review "Elektrotechnik" No. 12, 1967 and No. 1, 2, 3, 1968: Dílenská příručka regulačních relé (Workshop manual of control relays)