MOTORIZATION ELEMENTS

OF THE

HOUSEHOLD AND INDUSTRIAL MACHINES

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INTRODUCTION

This booklet has been written to instruct the mechanics who are interested in the maintenance and repair of the household and industrial sewing machines.

In the first part are described the principles of general electrotechnics which are necessary to understand the working of the electrical machines.

In the second part are described the types of systems used in the motorization of the household machines.

In the third part are described the types of systems used in the motorization of the industrial machines.

Particular importance is given to the rules and expedients to observe for maintenance and repairs.

PART 1

NOTES ON GENERAL ELECTROTECHNICS

ELECTRIC CURRENT

The electric current is a passage of electric charges within the conductors. It is measured in Amperes (A) with an instrument called AMPEROMETER. The main effects of the electric current are :

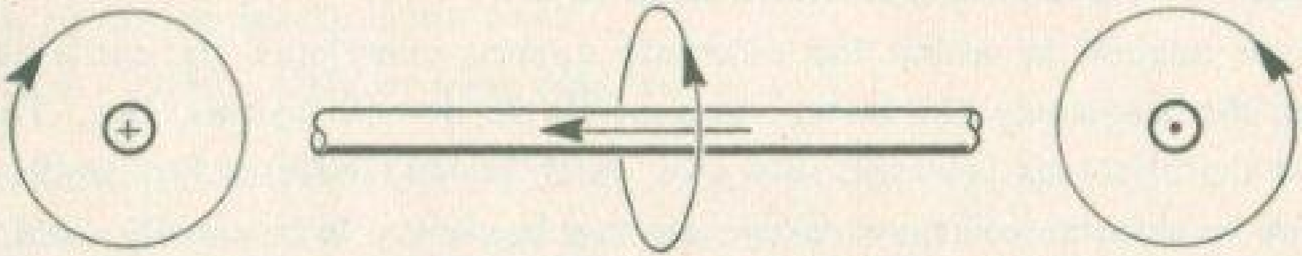


Fig. 1

1) THERMAL effect : when an electric current runs through a conductor, it heats it. Heating depends on intensity of current and on the length, cross section and nature of the conductor itself. Lamps, hot plates, electric heaters utilize this principle. The same principle is utilized also in protection by means of fuses : in these a metallic alloy wire with low melting point is charged by current.

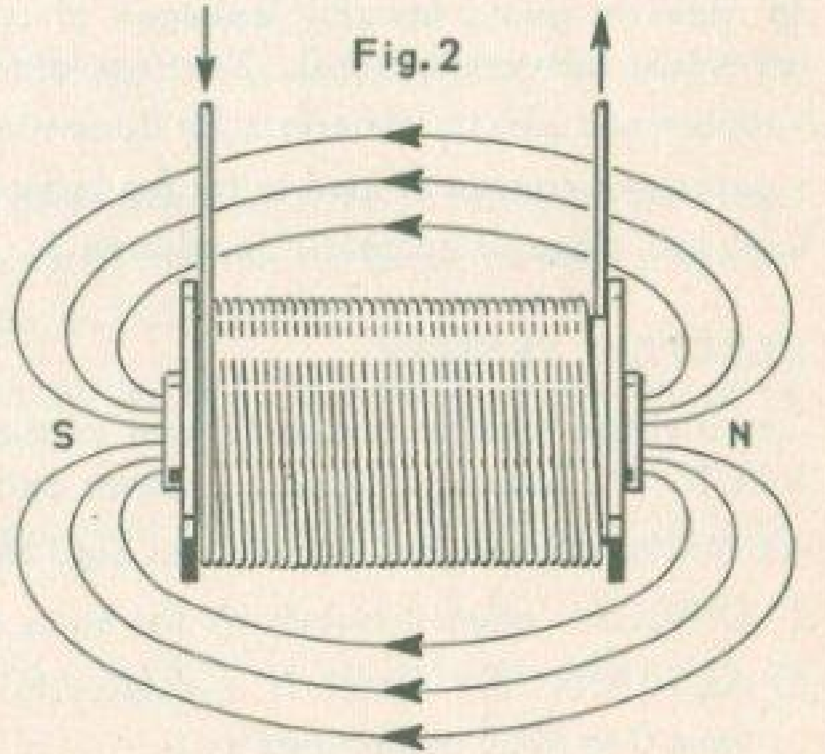
   The wire melts and breaks the circuit if the current exceeds a given value that depends on the nature and cross section of the fuse.

   If a fuse melts, before replacing it, you must detect the cause, which can also be a breakdown, which has provoked the melting. Once the breakdown in repaired, the fuse must be replaced by one of the same material and of the same cross section.

2) MAGNETIC effect: when a current runs through a conductor, fig. 1, it generates a magnetic field round it. By joining a certain number of conductors (i.e. by making a bobbin) fig. 2, the magnetic field so generated is intensified.

   Electromagnets are based on this principle.

Fig. 2



TYPES OF CURRENT

The principal types of electric current are :

1) DIRECT current : when the electric charges run through the conductor always keeping the same direction and intensity. The direct current is used in particular types of installations (electric circuit of motor vehicles, trolley wires and many railway systems).

2) ALTERNATE current : when the electric charges periodically change the motion direction and the intensity, for each direction, ranges from 0 to MAX and comes back to 0.

   The number of times per second in which the alternate current completes its cycle is called frequency (f). The standard value of the frequency, in Italy, corresponds to f = 50 cycles/sec. The alternate current is largely utilized in most installations (electric networks, road, house, industrial networks, etc.).

   In the United States and in ship installations 60 cycles/sec frequency is commonly used.

CONDUCTOR AND INSULATING MATERIALS

All kinds of electric networks are composed of wires or cables of copper or aluminium (exceptionally) since these two metals have shown themselves to be the best and most economical current conductors.

In order to avoid harmful leakages of current, and danger to the users, conductors are covered with insulating materials (non conductors). The insulators most commonly used are :

- rubber and plastic materials for domestic installations;
- paper and canvas dipped in tar for large cables for the underground lines in towns;
- air and glass or porcelain insulators in overhead lines.

ELECTRIC TENSION

The electric tension can be defined as that which propels the current within an electric circuit. It is measured in VOLTS (V) by means of an instrument called VOLTAMETER.

As for the current, the tension can also be :

1) DIRECT : when it maintains the same direction and the same value.

2) ALTERNATE : when it periodically changes its direction and value, and for every direction, it goes from 0 to MAX and reverts to 0.

NOTES

In Italy, besides the standard values of 125V - 220V - 380V, 50 cycles/sec the following values are at present employed :

160V - 280V at 50 cycles/sec

In Great Britain and the Commonwealth the following tensions are most commonly used :

230V - 240V at 50 cycles/sec

In the United States, the following tensions are used :

110V - 115V - 220V at 60 cycles/sec

In France, the following tensions are at present used :

110V - 115V - 120V at 50 cycles/sec, which must be transformed in the standard tension of :

220V - 380V at 50 cycles/sec.

WARNING

1) Before linking a set to the mains, you must know the characteristics of the input tension. This can be made by asking the user or reading the plate on the electric meter.

   The practice of reading the tension on the sets already installed sometimes does not give accurate information, because there can be a difference of max. 5% tolerance between the nominal tension of the mains feed and that of the plate on the set (i.e. : a 220V motor can be fed by a 230 V mains and viceversa).

   Once the mains tension is known, you must adapt the receiving apparatus, if it is necessary, to the mains tension.

2) The tension obtained as above described is the rated feed tension. The actual tension can be different from the rated one and can oscillate in excess or in defect of the rated one.

   Wide oscillations of the tension can damage the sets : generally, all the sets have an oscillating tolerance of $\pm$ 10%.

You must always ask the electrician whether there are tension changes and that must be done above all in all cases of breakdowns of the electrical equipment.

The best thing to do would be to take two measures of tension by a voltmeter, once between 9 and 11 a.m. or 2 and 5 p.m. (hours of the maximum fall), and a second time when the factory is not working (i.e. from 12 to 1 p.m.).

If that cannot be done, you must pay attention to the following characteristics:

tension too low:

- incandescent lamps with a reddish light;
- motor speeds lower than normal (especially for the commutator motors) together with an excessive heating (especially in the asynchronous motors);

tension too high:

- incandescent lamps with too brilliant a light;
- excessive heating of the induction motors without their losing speed (on the other hand, the commutator motors are subject to this increase and they increase their revolutions).

TABLE OF THE TENSION VALUES

AND THEIR PERMISSIBLE LIMITS OF CHANGE

Lower limit	Tension	Upper limit
Value – 10%	Nominal value	Value + 10%
115	127	140
145	160	176
200	220	242
254	280	308
345	380	418

ELECTRIC CIRCUIT

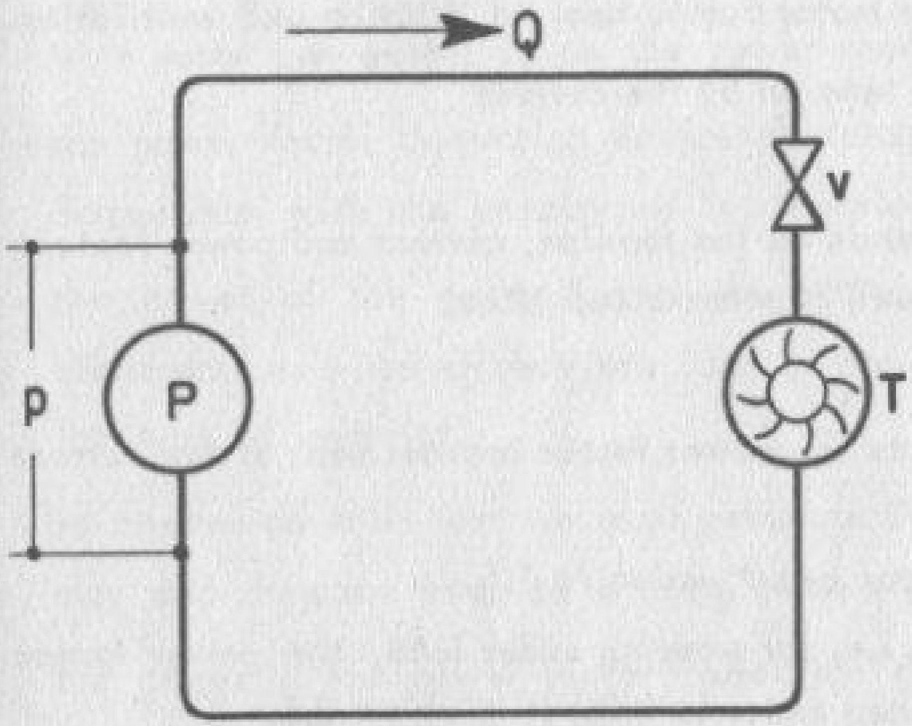
This is a circuit charged by electric current. In its simplest type it is formed by a generator G, a line, an electric equipment M and a switch. There is a strong analogy between electric circuit and hydraulic circuit; comparing them directly, we can draw up the following consequences :

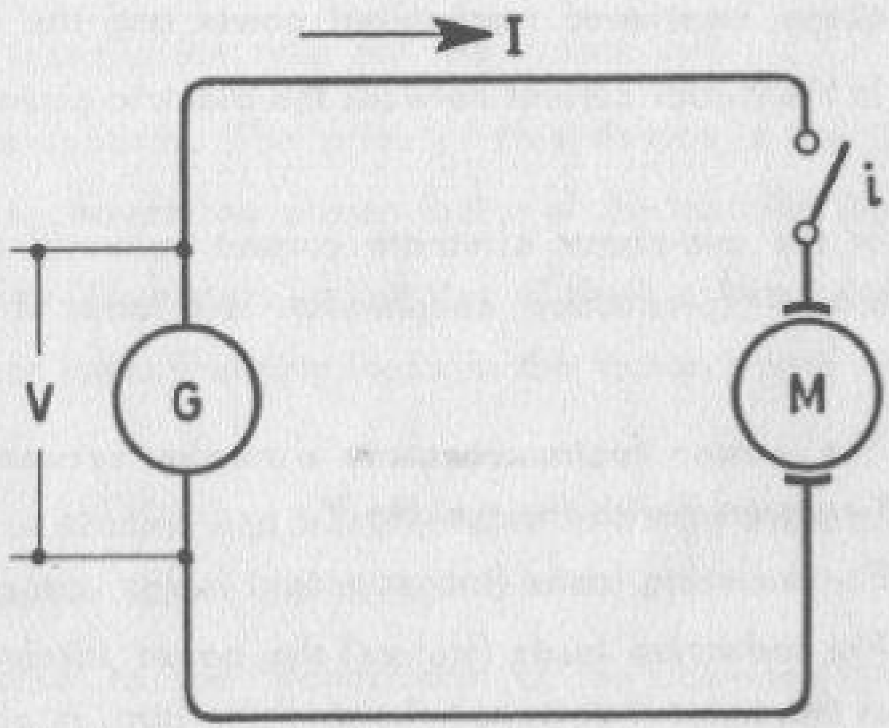
hydraulic circuit

P = pump
p = pressure
T = turbine
Q = capacity
V = valve
– = pipe line

electric circuit

G = generator
V = tension
M = motor
I = current
i = switch
– = conductor





- The pump P generates the pressure p which puts the capacity Q into circulation.
- The turbine T transforms the hydraulic energy into mechanical energy.
- The power of the turbine depends on the pressure p and the capacity Q.

- The generator G generates the tension V which puts the current I into circulation.
- The electric motor M transforms the electric energy into mechanical energy.
- The power of the motor depends on the tension V and the current I.

MECHANICAL POWER — ELECTRIC POWER — POWER FACTOR — POWER FACTOR IMPROVEMENT

The mechanical power of a motor is the power given to the axis and it is always indicated on the motor plate. It is normally measured in Watts (W) or in Kilowatts (K), which has the value of 1000 Watts. It can also be measured in horse-powers (HP). The relations between the above mentioned units are the following:

1 Kw = 1000 Watts 1 Kw = 1,36 HP 1 HP = 0,736 KW

Both in motors for household machines and in those for industrial machines, the power is always indicated in Watts. The most common value for the motors of the household machines is 40 Watts, while for the motors of the industrial machines it ranges from 70 to 370 Watts.

Electric power is the power that the motor absorbs from the network. In the case of the motor, it is equal to the above mentioned mechanical power and the losses that occur in a motor due to heating, friction and ventilation.

In the direct current network the electric power is the product of the tension by the current

$$P = V.I.$$

In the one-phase alternate current network, the electric power depends on the tension, current and power factor : $\cos\varphi$ (pronounce cosphee-φ is a letter of the Greek alphabet which is pronounced phee)

$$P = V.I.\ \cos\varphi .$$

The power factor $\cos\varphi$ is a number between 0 and 1 which reflects the power factor improvement of the current I compared with the tension V.

For resisting loads (incandescent lamps, hot plates), the power factor $\cos\varphi$ value is 1.

For inductive loads (motors) the power factor value is less than 1 : i.e. for working under load, the power factor of the motor that makes the machine turn, is about 0,8. For idling (when motor is idle) it is about 0,5.

Since at equality of absorbed power P, the lower the power factor, the larger will be the current value and the losses due to resistance in the network of the distributor Company, this maintains a contractual clause that the power factor should not be lower than 0,8. Otherwise, fines are imposed.

It is, therefore, necessary and economically convenient for the user to secure the power factor improvement of the network.

POWER FACTOR CORRECTION

For the domestic installations, since the motors for household machines always operate together with resisting loads, the total power factor is always more than 0,8 and, therefore, there are no objections.

On the contrary, for the industrial clothing factories, motor load can be predominant over the resisting loads (electric heating) and the power factor can be lower than 0,8, becoming lower and lower as long as motor is idling.

For the load power factor correction, you should take into account that:

- the power factor correction is the responsibility of the user and not of the motor supplier;
- it is more convenient to do the power factor correction for the installation than for the motors only;
- the power factor correction device is constituted by a set of condensers. The price of this device is low in comparison with the penalty; it is, therefore, more convenient to correct the power factor of the installation;
- the power of the power factor correction depends on the power of motors, principles of their scheme and construction, whether they are idle or not, whether there are other loads (heating loads in the factory) and on the type of contract.

  In connexion with that we must point out that our motors have been studied and manufactured in a very accurate way and they are such as to have, even when idle, the highest power factor possible;
- the power of the power factor correction device can be asked also to the technicians of the Company that distributes electric energy, because the Company has generally a very good information service.

PART 2

MOTORIZATION OF HOUSEHOLD MACHINES

DOMESTIC ELECTRIC NETWORKS

The domestic electric network is made up of the cables (encased or running along the walls), which feed the electric household appliances.

It starts from one or more meters on which are indicated the voltage,the max available current and the frequency and it ends with sockets to which the different consumer appliances are connected.

ELECTRIC MACHINES AND DEVICES USED FOR THE MOTORIZATION OF THE HOUSEHOLD MACHINES

TRANSFORMER AND AUTO-TRANSFORMER

V_1 primary tension

V_2 secondary tension

n_1 number of turns of the primary winding

n_2 number of turns of the secondary winding

The electric transformer is a static apparatus (without moving parts) which makes it possible to transform the value of the primary tension V_1 into the value V_2 (secondary tension).

It is formed by the core A, the primary winding n_1 and the secondary n_2 and it is schematically represented in fig. 3.

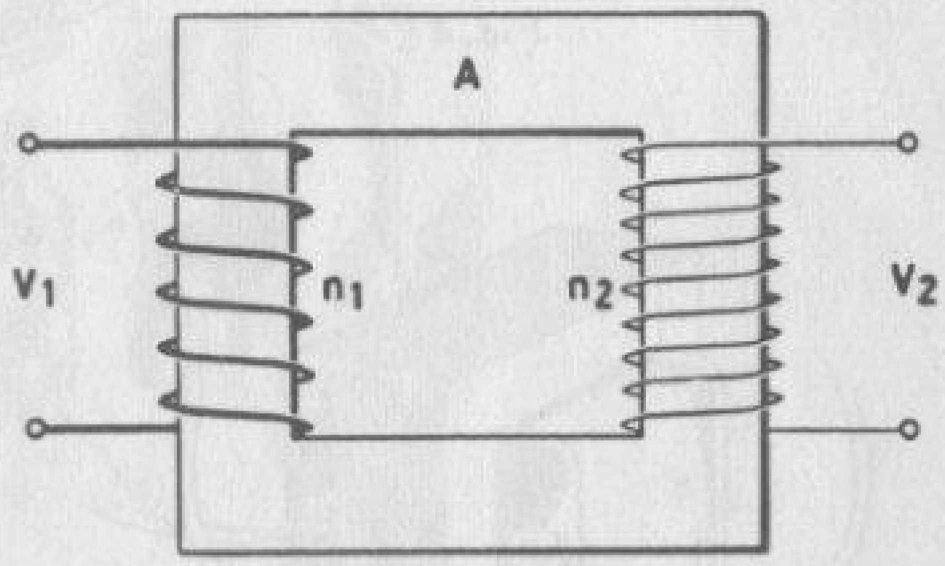


Fig. 3

The core is made of a stack of silicon steel laminations electrically insulated from each other by a layer of varnish which is also used as a glue for the whole stack. Both the primary and secondary windings are made of a skein of enameled copper wire having the turns perfectly insulated from each other and therefore insulated as regards the magnetic core.

The transformer operates as such only if it is charged by alternate current. Therefore, it cannot and must not be linked to mains fed by direct current. The data of the transformer plate are the following:

- the power which can be transformed = W
- the primary tension V_1
- the secondary tension V_2
- n_1 number of turns of the primary
- n_2 number of turns of the secondary.

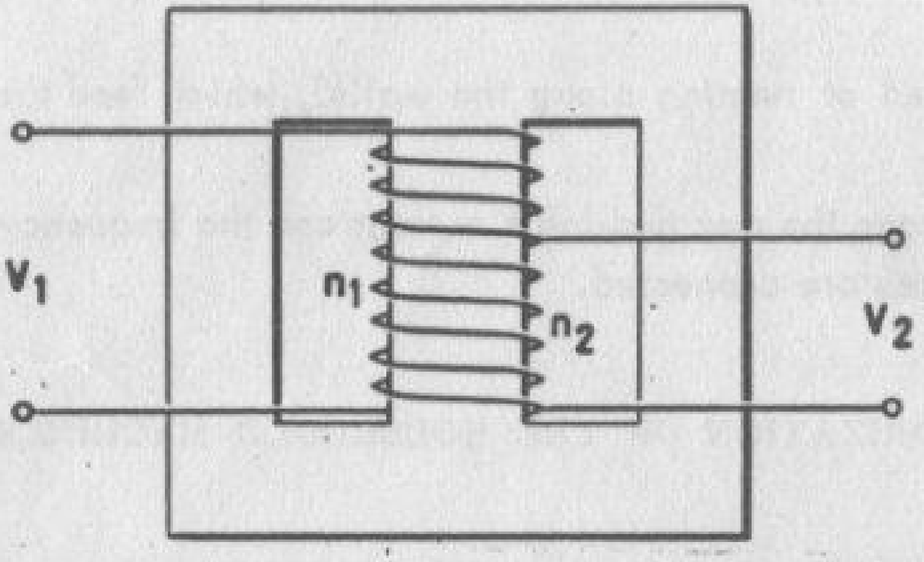


Fig. 4

The auto-transformer, on the contrary, is a transformer with only one winding which is simultaneously used as primary and secondary. The principle of working is of course the same as that of the transformer. The auto-transformer is preferred to the transformer (for low powers) to reduce to the minimum the overall dimensions.

The transformer used in the electric installation system of our household sewing machines, operates as an auto-transformer for the motor and as a transformer for the lamp. It is represented in perspective in fig. 5.

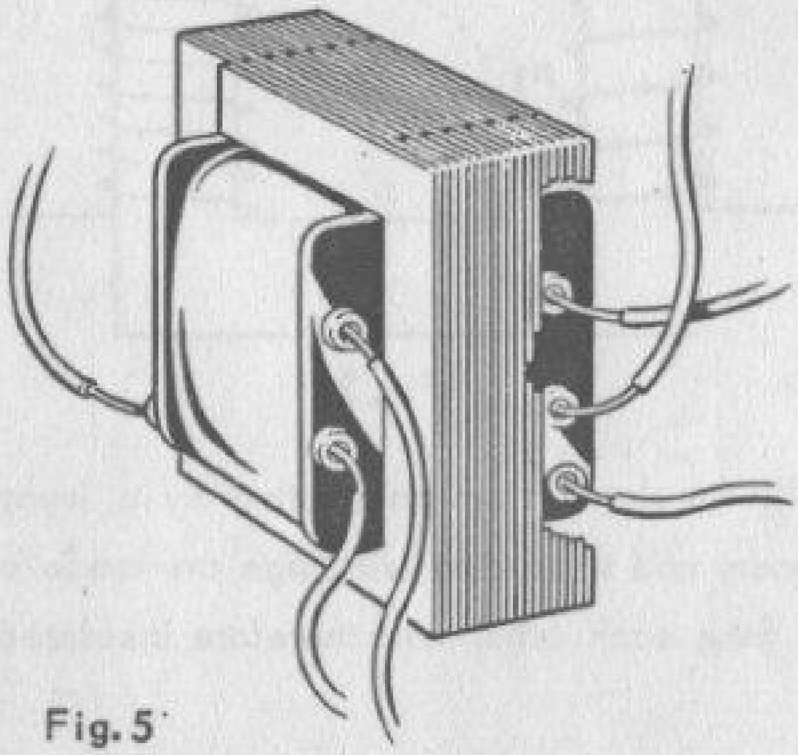


Fig. 5

The working of the transformer is as follows:

when the primary winding is linked to the mains, it is charged by an alternate current which generates an alternate flux that goes through the core.

This flux generates in each turn a tension V which is identical for every turn and the value of which is given by the primary tension V_1 divided by the number of turns n_1 of the primary winding $V = \frac{V_1}{n_1}$.

The ratio between the primary and secondary tensions is the same as between their respective number of turns $\frac{V_1}{V_2} = \frac{n_1}{n_2}$.

ELECTRIC COMMUTATOR MOTOR

The electric commutator motor used for the motorization of household machines is represented in perspective in fig. 6.

1 - Brush pressure spring
2 - Carbon brush
3 - Rear box
4 - Stack of stator laminations
5 - Stator skeins
6 - Small shaft
7 - Commutator
8 - Winding of rotor
9 - Stack of rotor laminations
10 - Cooling fan
11 - Front box
12 - Fixed pulley
13 - Toothed pulley
14 - Box protection
15 - Protection plate
16 - Terminal board

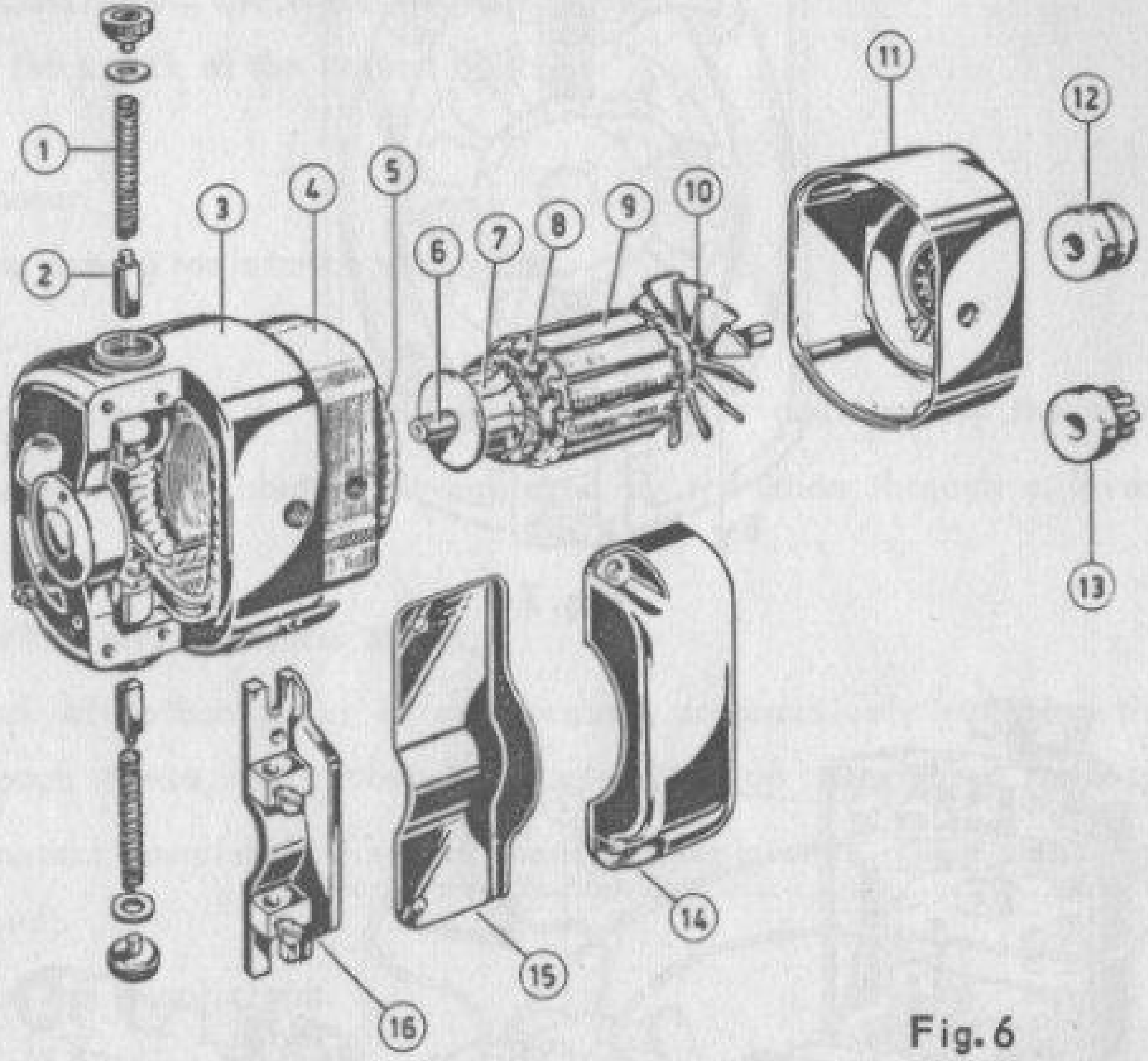


Fig. 6

It is made of a fixed part called stator and of a rotating part called rotor.

The stator is made of a stack of laminations having two pole pieces on which are placed the two skeins of the excitation winding or stator bobbins. The stack of laminations is contained in and supported by the front and rear boxes, which also bear the auto-lubricating bushes, for the small shaft of the rotor.

The rotor is made of the small shaft, on which are shrunk the steel laminations of the magnetic core. In the slots of the core is placed the rotor winding, the small bobbins of which converge at the commutator. On the shaft is also shrunk the cooling fan.

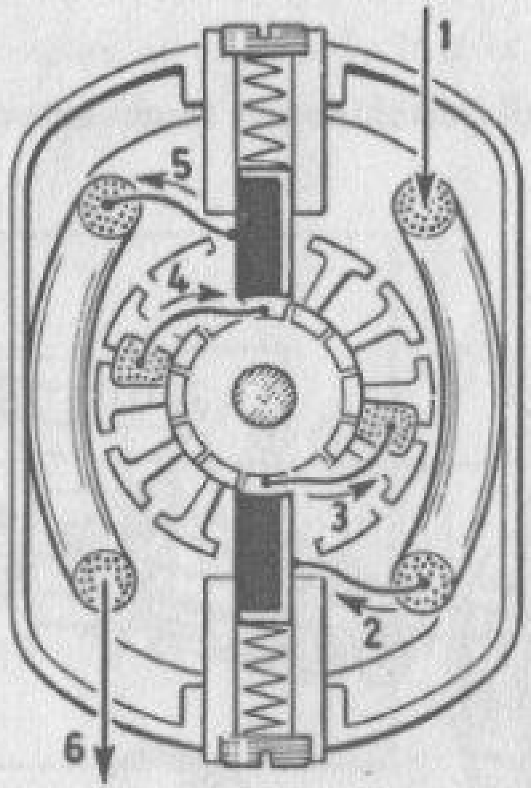


Fig. 7

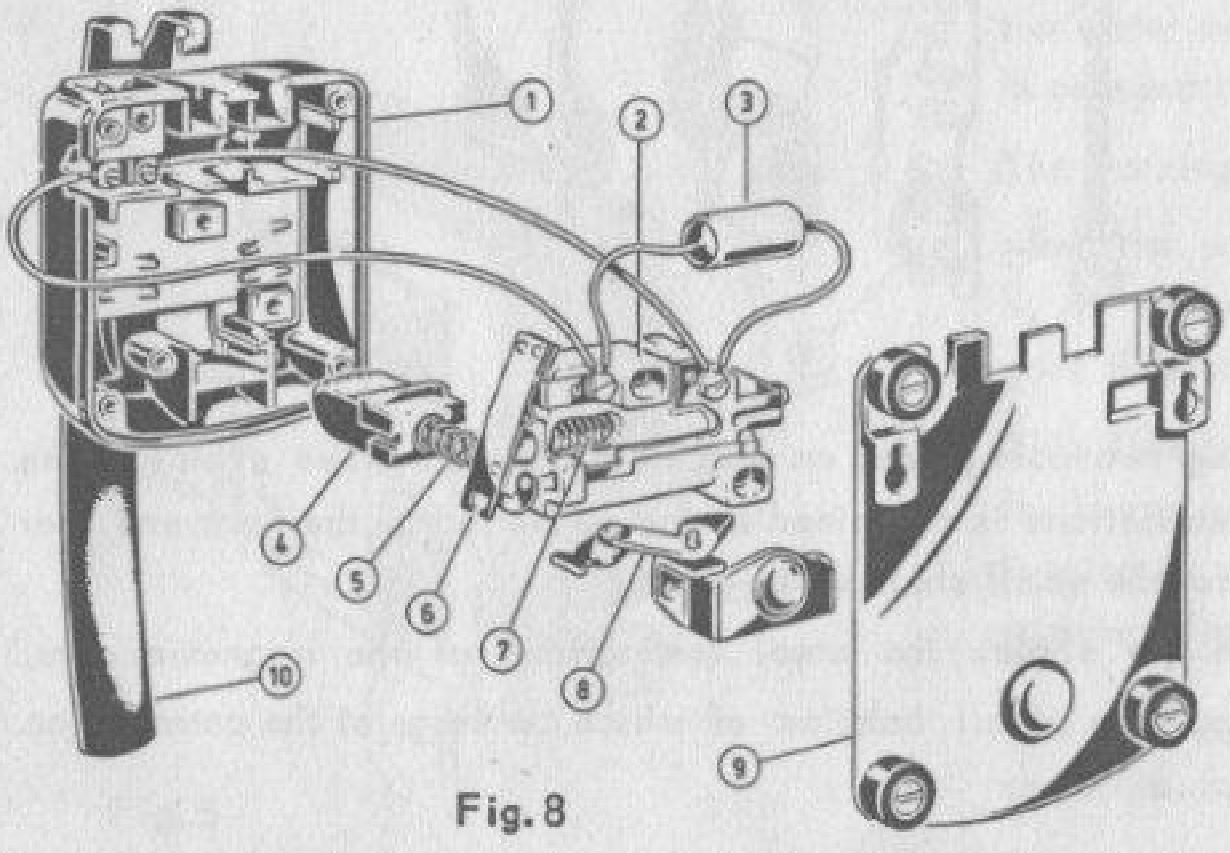


Fig. 8

The working of the motor is the following (fig. 7):

- the current runs through a bobbin of the stator 1-2, crosses a brush, passes through the rotor winding 3-4, leaves the other brush, runs through the other stator bobbin 5-6. The current, running through the two stator bobbins, creates a magnetic field which operates on the rotor wires crossed by current and makes the rotor to turn.

The commutator motor plate data are :

- feeding voltage V in Volts
- mechanical power in Watts
- number of turns per min.

The commutator motor most used in our household machines has the following data :

- tension V = 160 Volt
- power 40 Watt
- speed 4500 turns/1'.

RHEOSTAT

The rheostat, fig. 8, is the apparatus used to regulate the speed of the commutator motor.

1 - Box	6 - Switch
2 - Ceramic block	7 - Stack of carbon disks
3 - Condenser	8 - Levers
4 - Pushbutton	9 - Closing plate
5 - Return spring	10 - Toggle lever

It is arranged in the following way:

- box and its closing plate;
- the ceramic block with the stack of carbon disks consituting the variable resistance;
- the pushbutton to compress, through a lever play, the stack of the carbon disks;
- the return spring of the pushbutton;
- the switch for closing the electric circuit of the motor;
- the condenser to eliminate the radio and TV noises due to resistance variations.

The rheostat can be both treadle or toggle operated.

In the treadle rheostat, placed on the floor or footboard, the pushbutton is directly operated by the foot.

In the toggle rheostat, placed beside the support, the pushbutton is operated by the knee through a lever.

The working is the following:

- by pressing the pushbutton, you first close the switch and the motor starts;
- by pressing the pushbutton still further the stack of carbon disks is compressed, progressively reducing the resistance to the passage of the current through these, and, therefore, speeding up the motor running;
- when the pushbutton is completely lowered, a contact completely cuts out the disks resistance, short circuiting it, which corresponds to the motor's maximum speed;
- releasing the pushbutton, the switch is opened and the motor stops.

RADIO TV INTERFERENCE SUPPRESSOR

The commutator motor and the rheostat generate, during their normal working, electric impulses (i.e. those due to the sparking of the commutator) which are very small and have very different values of frequency.

In order that these impulses do not spread towards the domestic electric line so generating radio and TV interferences, blocks systems are set between the motor-rheostat group and the mains, fig. 9.

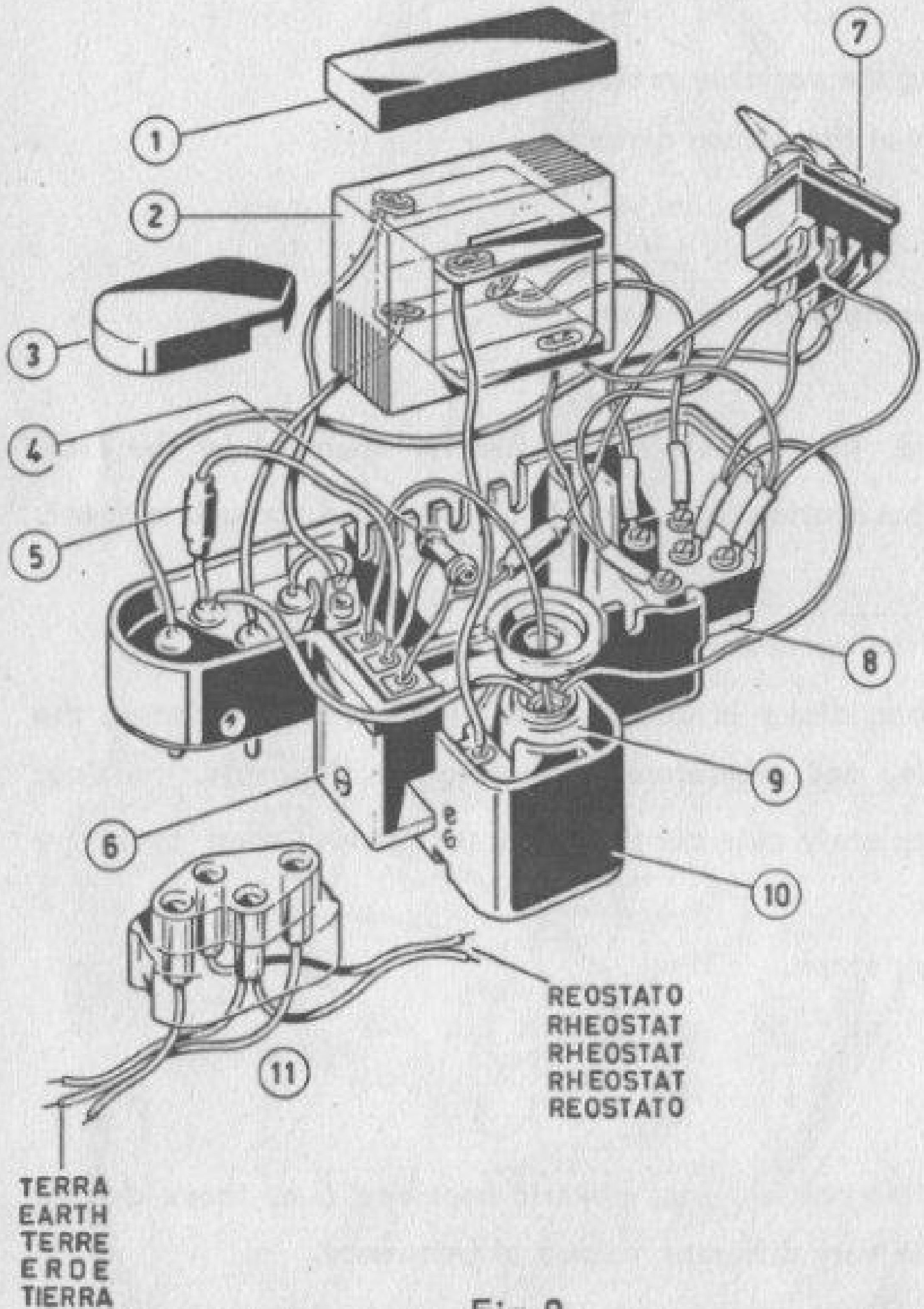


Fig. 9

These are essentially made up of condensers in parallel and inductances in series with said group and are generally placed in the transformer container.

1 - Box
2 - Condenser
3 - Box
4 - Condenser
5 - Inductance
6 - Box
7 - Switch
8 - Voltage change plate
9 - Condenser
10 - Transformer container
11 - Quadripole plug

One of said condensers is contained in the box of the rheostat, as shown before.

Should said condenser short-circuit, because of construction fault or any other reason, it would exclude the whole rheostat and the machine would start on at full running and could be no longer regulated.

While waiting for its replacement, one must take out the burnt condenser by insulating the two wires to which it was welded.