No. 829,340.

PATENTED AUG. 21, 1906.

M. KALLMANN.

STARTING DEVICE FOR ELECTRIC MOTORS.

APPLICATION FILED AUG. 22, 1905.

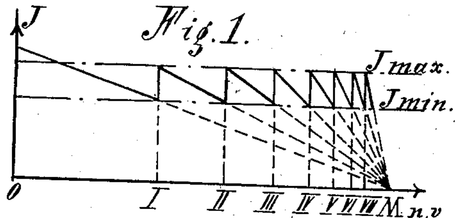

Fig. 1.

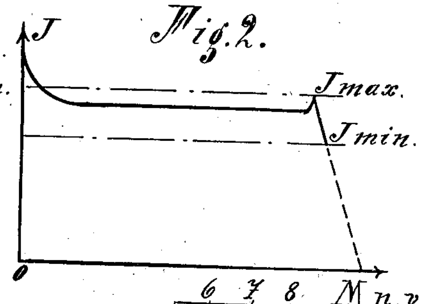

Fig. 2.

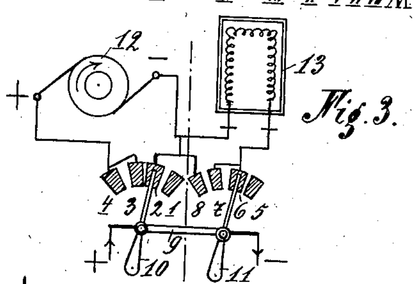

Fig. 3.

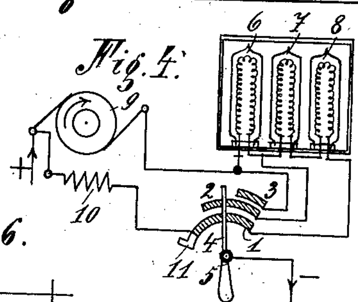

Fig. 4.

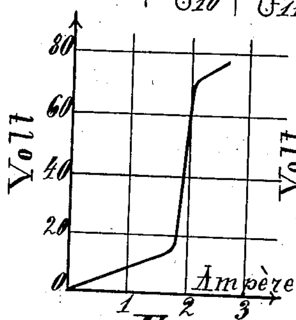

Fig. 5.

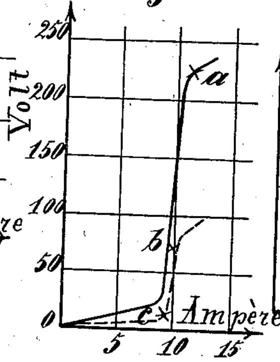

Fig. 6.

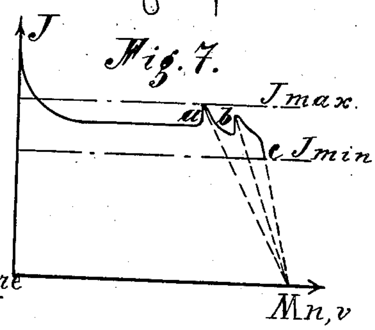

Fig. 7.

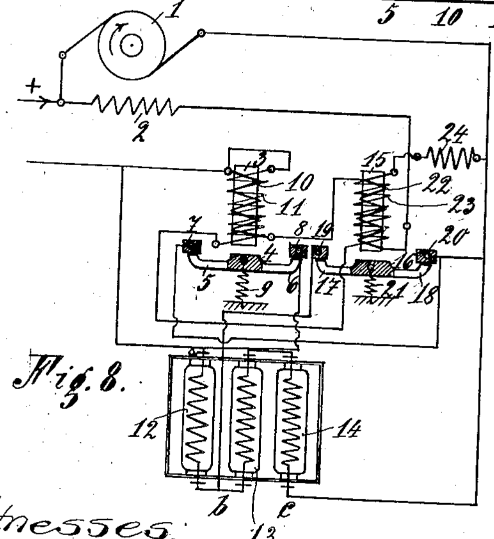

Fig. 8.

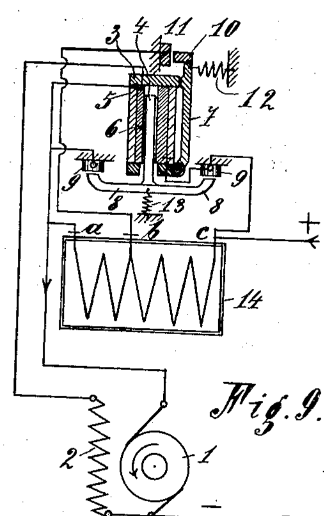

Fig. 9.

Witnesses.
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Severance.

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UNITED STATES PATENT OFFICE.

MARTIN KALLMANN, OF BERLIN, GERMANY.

STARTING DEVICE FOR ELECTRIC MOTORS.

No. 829,340. Specification of Letters Patent. Patented Aug. 21, 1906.

Application filed August 22, 1905. Serial No. 275,266.

To all whom it may concern:

Be it known that I, MARTIN KALLMANN, engineer, of Berlin, Passauerstrasse 1, a subject of the German Emperor, have invented new and useful Improvements in or Relating to Starting Devices for Electric Motors, of which the following is a specification.

This invention relates to starters for electric motors, and has for an object to provide a device of the class embodying new and improved features and parts of convenience, accuracy, and reliability.

A further object of the invention is to provide means to reduce the period of starting as much as possible and to avoid sudden rushes of current and to cut out the resistance in a gradual and effective manner.

With these and other objects in view the invention comprises certain novel constructions, combinations, and arrangements of parts, as will be hereinafter fully described and claimed.

In the drawings, Figure 1 shows a well-known starting diagram for resistance with seven sections. Fig. 2 is a starting diagram in which, as in Fig. 1, the abscissæ indicate the number of revolutions and the ordinates the intensity of the starting-current, which after the first shock of current sink to a medium intensity, the said starting-current being maintained nearly constant. Fig. 3 is a diagrammatic view of the invention forming the subject-matter of this application shown in its elementary form. Fig. 4 is a diagrammatic view of the invention forming the subject-matter of this application, showing the resistance in three sections connected in series. Fig. 5 is a diagram of the section of an iron resistance, the abscissæ indicating the intensity of the current and the ordinates the pressure at the terminals. Fig. 6 is a diagram similar to the diagram shown in Fig. 5, wherein the variation resistance are coupled in series. Fig. 7 is a diagram of the pressure in starting with the device shown in Fig. 4. Fig. 8 is a diagram of an automatic starting resistance with two electromagnetic relays. Fig. 9 is a similar starter, showing one relay and the connections therefor.

As a rule resistances are made of wire of high specific resistance with the smallest possible temperature coefficient—such, for instance, as nickel, German silver, and the like and, more seldom and only for reasons of economy, iron wire. The different sections into which the total resistance can be divided is usually switched out gradually. In this invention is used the property of certain metals, more particularly iron, when strongly incandescent to increase their resistance many times, as they have very high temperature coefficients. For instance, at 850° the resistance of iron rises to ten times the ordinary value and, according to some authorities, even to eighteen times the ordinary value in cold state. To this modification of the resistance corresponds at a given intensity of current a certain fall of pressure, considerably increasing with the temperature, and this property is utilized as means for automatic gradual starting of electric motors. Resistances consisting of thin iron wires, the number of which switched in parallel is sufficient for the given intensity of current, are preferably inclosed in glass boxes containing hydrogen gas in considerable pressure in the same way as is done with resistances for incandescent lamps in order to prevent by means of the hydrogen oxidation of the iron and, owing to the good heat-conducting properties of the said gas, to bring about a quick cooling and heating of the resistance. If the gas-pressure and the shape of the wire are suitably chosen, the "load" capacity required for obtaining a given degree of incandescence alters to such a considerable extent that the current can be maintained almost constant. The variations of resistance shown in Fig. 5 maintains, for instance, nearly constant a current of two amperes intensity between twenty and sixty volts, the resistance rising from the lower limit of the regulating-field from ten up to thirty ohms—that is to say, to treble the amount. With the calculation based on the cold state this resistance can be utilized in working between about four and forty ohms, the current passing through it scarcely exceeding two and one-half amperes, even in the case of an overload. At twenty volts pressure the resistance in question will be dark red and at sixty volts bright red. Between naught and fifteen volts the resistance, as it is not yet incandescent, will correspond on the whole to ordinary fairly constant resistance, as shown by the curve. If, as shown in the elementary form in Fig. 3, such a variation resistance 13 is switched in with a current of suitable intensity in series with the armature of the electric motor 12 the magnetic field of which is not further shown in the drawings, then when the switch-lever is on the contacts 2 and 6 the resistance 13, connected in series therewith, will become heated and incandescent. Then the switch-levers 10 and 11 will move to the contact-blocks 3 and 7, the resistance is switched into series with the armature, and the latter starts then in accordance with the pressure which is left to it, and thus produces in accordance with its increased speed a gradually-increasing electromotive counter-force. In this way the pressure difference at the variation resistance 13 will be gradually reduced, and the incandescence of the latter becomes smaller, and after its temperature and resistance is sufficiently reduced it can be under certain circumstances short-circuited at once by bringing the switch-levers 10 and 11 to the contact-blocks 4 and 8, by which the motor-armature receives the full voltage.

After the first shock of current, depending on the size of the resistance, the resistance quickly sinks to a medium intensity, the said starting-current being maintained nearly constant and only at the end gives a corresponding higher shock of current when the variation resistance, the temperature of which has in the meantime fallen to a sufficient extent, is short-circuited. In this way such a starting resistance requires only very simple switches, and, as a rule, it is not necessary to heat the resistance before switching it in series with the armature, for inside a fraction of a second the ordinary cold resistance, more particularly when it consists of numerous small iron wires connected in parallel to suit the intensity of the current, becomes incandescent, so that the initial rush of current on the motor is merely instantaneous and practically presents no danger and often is even advantageous for assisting in starting. On the contrary, it is generally inadvisable to short-circuit the whole resistance at once after starting, as shown and described in connection with Fig. 3; but it is, as a rule, advisable to have two or more sections of the variation resistance, as shown in Fig. 4. In the said Fig. 4 when the lever 14 is in the first position on the contact 1 the whole resistance 6, 7, and 8 is switched in in series with the armature, the magnetic field 10 being fully excited, and the originally cold resistance 6, 7, and 8 instantaneously becomes heated to a bright red heat, and the shock of current on the armature at the first moment of starting is quite admissible, as shown in Fig. 7. At the next position—that is, on contact 2—two-thirds of the resistance—viz., 7 and 8—are short-circuited after the whole resistance has in the meantime sufficiently cooled down with the increased speed of the armature (see point *a* of diagram 7) and the intensity of the starting-current has fallen down to normal value. When 7 and 8 are short-circuited, there is a rush of current, which is shown at *a* in diagram 7, and the motor increases its speed, as only the section 6 of the resistance remains switched in series until the point *b*, Diagram 7, is reached. By the time the point *b* is reached the last section 6 of the resistance has cooled down to a sufficient extent, and the small pressure carried by the resistance can be safely short-circuited by bringing the lever 4 on contact-block 3, whereby the whole resistance will be cut out and the armature will receive the full current, as shown in the last portion of the diagram 7, point *b* to point *c*. When the greater portion of the resistance 7 and 8 is short-circuited, the remainder 6 again assumes for a moment the still remaining higher pressure and at once becomes heated, although it had cooled before. The difference in pressure which is absorbed by the whole resistance and which in the meantime has cooled is therefore transferred to the section 6, which becomes incandescent. The curve in Fig. 6 shows the behavior of such variation resistances connected in series or of a single resistance operated in several sections and made of a suitable size, as indicated in diagram at 14 in Fig. 9. The dotted curve is that of one single section of the variation resistance, as shown in Fig. 4. It corresponds exactly to the single curve in Fig. 5, for one resistance with a regulating-field and between twenty and sixty volts, but can be still used beyond seventy volts, when the intensity of the current increases very little, and also below the bend down to about ten volts, where it begins to show the quick increase when heated. The full-line curve in Fig. 6 shows three resistances connected in series, which together have to absorb the full voltage (point *a*) and all become then bright red. The resistances must be made of very thin iron wires in order that they should very quickly heat and cool, and for that reason they are preferably made in groups of separate elements.

In order to carry currents of high potential, a plurality of resistances are grouped in parallel and the several groups connected in series, the resistances, as at 6, 7, and 8 in Fig. 4, being but diagrammatic and illustrating either single resistances connected in series or a plurality of groups of resistances so connected with the elements of the several groups connected in parallel. The attendance required is considerably reduced by the use of automatic starters with variation resistances, the phenomena described enabling a very simple construction to be used, as shown in Fig. 8. The connection is therefore the same as shown in Fig. 4, the three resistances 12, 13, and 14, or several groups connected into parallel, as may be required, being switched in series with the armature 1 of the electric motor. Into the field 2 are also switched other windings 10 and 22 of the electromagnetic relays 3 and 15, said windings being the heavier lines shown. The exciting-current of the magnets thus produces a constant attraction of the armatures 4 and 16 of the two relays. This attraction acts in opposition to the springs 9 and 21.

The two fine-wire windings 10 and 23 of the relays (shown in fine lines in Fig. 8) are shunted from the starting resistances 12, 13, and 14 with the independent resistance 24 and their sizes calculated in such manner that in coöperation with the counter-force of the springs 9 and 21 the armatures 4 and 16 are not attracted as long as pressure differences at the variation resistances has not fallen to a predetermined extent, for the winding 10 is connected in opposition to the winding 11 and the winding 22 in opposition to the winding 23.

As long as the pressure at the starting resistances is very great the windings 10 and 22 are unable to attract the armature 4 and 16 in opposition to the windings 11 and 23 and the springs 9 and 21. As soon as the armature of the motor has reached a sufficient speed the weaker relay 15, with the spring 21, will first attract the armature 16, and the windings 11 and 23, excited by this remaining pressure, will have a very strong effect, so that the winding 22, thus switched to the magnetic field, can exercise sufficient attraction to overcome the tension of spring 21. The contacts 19 and 20 will therefore be short-circuited by 17 and 18, and in this way the sections 13 and 14 of the starting resistance bridged over at the point *b* is connected to the contact 19 and the points *c* to the contact 20. Only the section 12 then remains in series with the armature, and as the speed continues to increase the electromotive counter-force reaches nearly the full voltage and there will be only a small pressure acting in the section 12 of the starting resistance, so that through the magnet-exciting current in the winding 10 of the relay 3 the counter action of the winding 11 and the counter-force of the spring 9 will be overcome and the armature 4 attracted and contacts 7 and 8 short-circuited through 5 and 6. As the contact 7 is connected with 20 and the contact 8 with *a*, the whole starting resistance will be short-circuited at 7 and 8 and the armature 1 will receive its full voltage. It will thus be seen that the work of the starting resistance is perfectly automatic, its switching-out being effected by the short-circuiting in two stages without any considerable rush of current.

In the use of the device shown diametrically at Fig. 8 and by the differential windings utilized the result has been attained that when the pressure ceases, owing, say, to a disturbance in the circuit, the armatures 4 and 16 are again released. In this way in the event of such a disturbance the whole starting resistance is automatically switched in series with the armature, so that the renewed starting takes place automatically, as above described. Moreover, by means of the differential winding of this kind any unnecessary consumption of current during the working is avoided by the windings 11 and 23 as they are shunted from the starting resistance. In Fig. 9 the relay 3 acts in a similar manner to the two relays shown in Fig. 8, as in this case. The winding 6, switched into circuit with the magnet-field 2, is in opposition to the winding 5, shunted from the starting resistance. By way of example, the relay is herewith provided with an upper and lower closing iron plate and contains a movable iron core 4 and also a lateral iron armature 7. The armature 7 is attracted by the relay-magnet 3 in opposition to the tension of the spring 12 as soon as the greater portion of the voltage of the starting pressure is reduced in the resistance 14 and the action of the winding 5 overcomes to a sufficient extent that of the winding 6. In that way the contacts 10 and 11 are closed and the section *b c* of the starting resistance 14 is short-circuited. As the speed of the motor continues to increase the power of the winding 5, connected to the starting resistance, becomes so small that the spring 13 is also overcome by the winding 6, switched into the magnet-circuit, and the iron core 4 is drawn into the coil and the two contacts 9 are connected by the contact-lever 8, the whole resistance 14 being short-circuited from *c* to *a*, and thus switched out.

When the switch is operated by hand—as, for instance, in Fig. 4—the degree of incandescence of the resistance indicates whether the switch may be moved farther without fear of an undue rush of current. As soon as it is seen that the resistance is no longer even at a dark-red heat a portion of it can be short-circuited, and so on. There is no need, therefore, to have any current-measuring device. The incandescent wire serves as an indicator, and the switch can be permanently left on an intermediate section—for instance, on the contact 2—if desired. As a rule the variation resistances can permanently carry the corresponding current, and in this way one has a regulating means for slackening the speed by these resistances switched in series with the armature.

Starting-switches of the kind described can be made in any sizes, chiefly for continuous-current motors, but also for polyphase alternating-current motors. They are very durable and automatically prevent overload in starting. Their size is comparatively small, and they can be made to comply with all requirements in combination with automatic relays and regulator construction.

The switches and automatic devices diagrammatically illustrated in the figures and diagrams are merely intended as examples and can be varied as desired without departing from the spirit of this invention.

What I claim is—

1. In a starting device for electric motors, a conductor composed of thin iron wires surrounded by non-oxidizing gases, and arranged in separate sections connected in series and in series with the motor, and means for cutting out the iron conductor by sections.

2. In a starting device for electric motors, a conductor composed of thin iron wires inclosed within a sealed casing and surrounded by non-oxidizing gases, and connected with the motor in series, and means to cut out the iron conductor.

3. In a device for starting electric motors, a conductor composed of thin iron wires, arranged in sections, the said sections being independently inclosed in sealed casings and surrounded by non-oxidizing gases, the said sections being connected in series and in series with the motor, and means to cut out the iron conductor by sections.

4. In a device for starting electric motors, a relay, a conductor formed of thin iron wires and connected in series with the motor, and means whereby when the current supplied to the motor rises in electromotive force, the relay is energized to cut out the iron conductor.

5. In a starting device for electric motors, a relay, a conductor composed of thin iron wires, arranged in sections, means whereby when the current supplied to the motor increases in electromotive force the relay is energized to cut out the iron conductor by sections.

6. In a device for starting electric motors, a relay provided with a plurality of contact-armatures, a conductor composed of thin iron wires arranged in sections, the said sections being connected in series and in series with the motor and controlled by the contact-armatures of the relay, and means whereby when the current supplied to the motor rises in electromotive force the contact-armatures of the relay are independently operated to cut out the iron conductor by sections.

7. In a device for starting electric motors, a relay provided with opposite windings capable of carrying currents of different voltage, and embodying an armature provided with a plurality of contact-points, a conductor composed of thin iron wires arranged in independent sections connected in series and in series with the motor, means for initially energizing the reverse windings of the relay to prevent action, and means whereby as the current supplied to the motor increases in electromotive force the winding carrying the greater current overcomes the winding carrying the lesser current to attract the armature, and cut out the iron conductor by sections.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

MARTIN KALLMANN.

Witnesses:
S. P. REINEMUND,
AUGUST LUDWIG.