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ELECTRIC STARTING SYSTEM FOR INTERNAL COMBUSTION ENGINES.

APPLICATION FILED DEC. 2, 1915.

1,335,507. Patented Mar. 30, 1920.

Fig. 1.

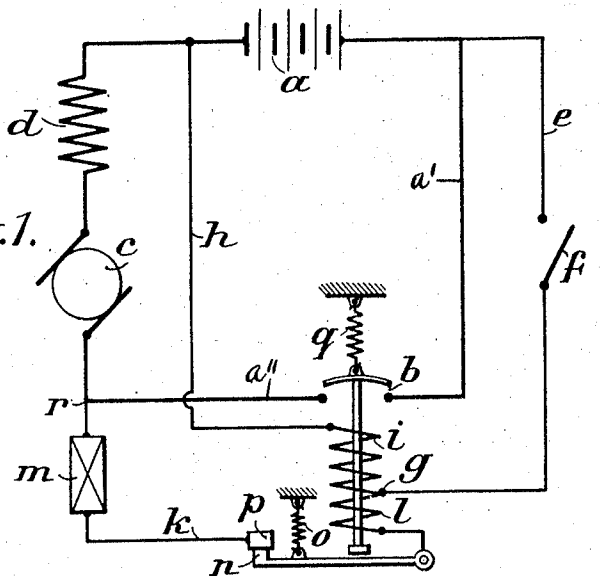


Fig. 2.

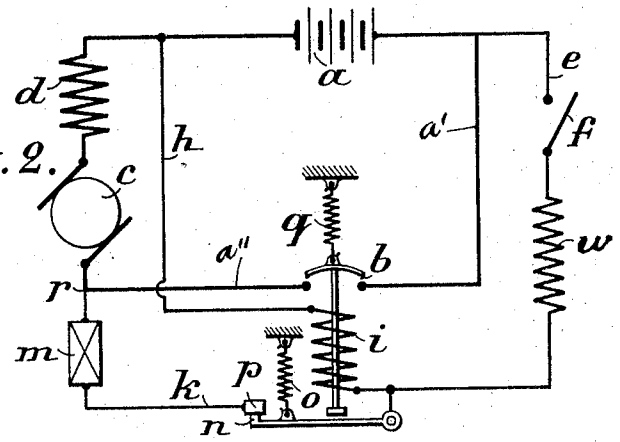
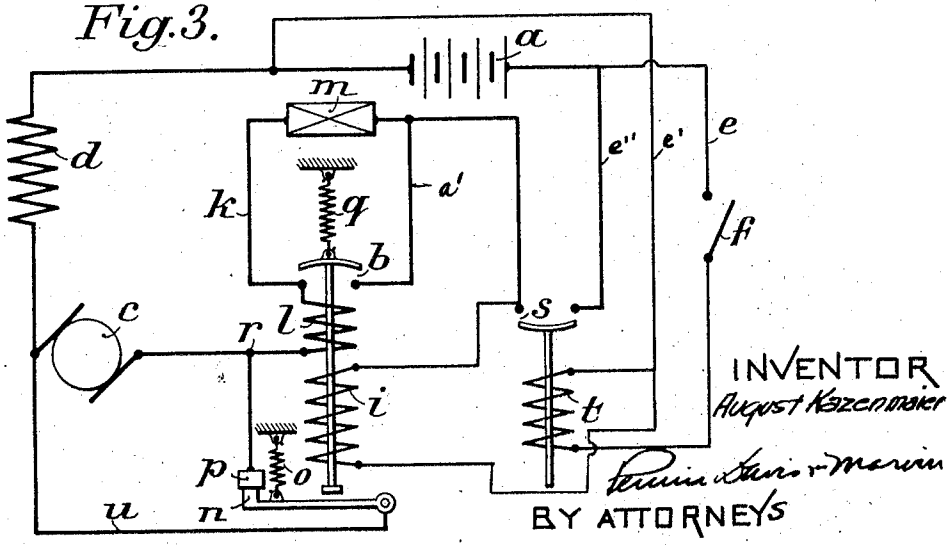


Fig. 3.



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ELECTRIC STARTING SYSTEM FOR INTERNAL-COMBUSTION ENGINES.

1,335,507. Specification of Letters Patent. **Patented Mar. 30, 1920.**

Application filed December 2, 1915. Serial No. 64,670.

To all whom it may concern:

Be it known that I, AUGUST KAZENMAIER, a subject of the German Emperor, residing at Stuttgart, 4 Eduard-Pfeifferstrasse, Germany, have invented certain new and useful Improvements in Electric Starting Systems for Internal-Combustion Engines; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

The present invention relates to electric starting systems for internal combustion engines wherein the starting motor has two distinct phases of operation, one for initial operation for meshing the normally disengaged motor and engine gears, or for primarily taking up the back lash in the gearing between the motor and engine, and the other for driving the engine up to its critical speed at which it starts to operate under its own power; and the principal object of the invention is to provide in such a system automatic means for establishing the main supply connections for the normal operation of the motor after a period of time during which the supplemental connections supply current for the initial operation of the motor. In this way, the system provides automatically an appropriate period of time for meshing the gears or taking up the back lash therein before the normal operation of the motor begins, irrespective of whether the motor is in rotation or at standstill at the time, and it also acts to protect the motor from excessive current in case the motor stops or starts at an abnormally low speed during the initial period.

In the specific embodiments of the invention hereinafter described, the initial phase of operation is obtained by providing a resistance in the supplemental supply connections or by short circuiting the armature of the motor, which in that case is of the series type; and the change from the initial to the normal phase of operation is accomplished by an electromagnet having contacts included in the main supply connections and having an energizing winding affected by an automatically varying resistance such as one varying with its temperature. In the preferred embodiment of the invention, the automatically varying resistance has a high positive temperature coefficient and is traversed by the current flowing to the motor during the initial phase of operation, so that not only is the operating current reduced by the resistance to a value suitable for the slow rotation desired in that period, but a large change in the value of the resistance is rendered available for automatically operating the electromagnet switch to change from the initial to the normal phase of operation of the motor.

In the accompanying drawings illustrating several embodiments of my invention, wherein the starting motor is of the series type,

Figures 1 and 2 show arrangements in which the motor armature and field are permanently connected in series; and Fig. 3 shows an arrangement in which the armature is short circuited in the initial phase of operation.

In Fig. 1, the battery a, forming the source of current supply, is electrically connected by the wires a', a'' and through the contacts b of the electromagnet switch to the terminal r of the series starting motor having the armature c and the field winding d. The wire e containing the manually operated switch f is connected to an intermediate point g of the sectionalized energizing winding i, l of the electromagnet switch, one terminal of that winding being connected to the opposite side of the battery through wire h, and the other terminal being connected to the motor terminal r through the contacts n and p, wire k, and the iron resistance m which, as is well known, has a high positive temperature coefficient. The tension spring o tends to hold the contacts n and p in engagement, and the tension spring q tends to hold the circuit open at contacts b.

The switch f serves to initiate and thereafter discontinue the operation of the starting system. Upon closing that switch, current from the battery flows to the point g where it divides, a part passing through the section i and the other part passing through the motor by way of section l, contacts n, p, wire k, and the resistance m. This resistance is of sufficient value to initially reduce the current to the motor and thereafter keep it at sufficiently low value to permit the slow rotation of the motor for meshing the motor and engine gears, or for taking up the back

lash in the gearing between the motor and engine. In fact, the torque developed by the motor in its initial phase of operation may be insufficient to start the engine from rest, and the motor will then come to a standstill as soon as the gears are meshed and their back lash taken up. At the beginning of the initial phase of operation, the current flowing in opposite directions through the sections *i* and *l* produces opposed ampere turns with a net value ineffective to operate the electromagnet switch. However, the current flowing through the resistance *m*, whether the motor is in slow rotation or at a standstill, heats it until it increases to a predetermined value when the ampere turns of section *i* predominate over the reduced ampere turns of section *l* sufficiently to overcome the springs *o* and *q*, whereupon the contacts *b* are closed and the contacts *n*, *p* are simultaneously opened. The motor then receives normal operating current through wires *a'*, *a''*, whereas the circuit containing wires *e*, *k* is interrupted.

It will be observed that the wires *e* and *k*, the contacts *n*, *p* and the iron resistance *m* form supplemental supply connections for the initial operation of the motor, and that after a period of time independent of the counter electromotive force of the motor, the main supply connections formed by the wires *a'*, *a''* are closed at the contacts *b* for normal operation of the motor. Also, the switch having the energizing winding *i*, *l* forms in effect an electromagnet switch adapted to close the contacts *b* in the main supply connections and simultaneously, that is in the same operation, open the contacts *n*, *p* in the supplemental supply connections. The parts including the iron resistance *m* are so calibrated as to provide automatically and appropropriate period of time, such, for instance, as about two seconds, for meshing the gears or taking up the back lash therein before the normal operation of the motor begins, whether the motor is in rotation or at standstill at the moment of closing contacts *b* and simultaneously opening contacts *n*, *p*. The motor current supplied by the main supply connections for the normal operation of the motor is sufficient to bring the engine to its critical speed, and as soon as the engine reaches that speed and starts to operate under its own power, the operation of the starting system is discontinued by opening the switch *f*.

It is obvious that substantially the same result may be obtained by inserting in the wire *h* a resistance having a high negative temperature coefficient, the resistance *m* being eliminated.

In the embodiment shown in Fig. 2 the energizing winding of the electromagnet has a single section *i* and the contacts *n* and *p*, together with the iron resistance *m*, are connected by wire *k* between one terminal of the winding *i* and the terminal *r* of the motor, said contacts *n*, *p*, resistance *m* and wire *k* forming supplemental supply connections for the initial operation of the motor. A resistance *w* connected in wire *e* does not vary materially with its temperature, although it may have a slight negative temperature coefficient. The current passing through the energizing winding *i* increases as the iron resistance *m* gets hotter, and finally becomes of a sufficiently high value to overcome the springs *o* and *q*, thereby closing the main supply connections formed by the wires *a'*, *a''*, and the contacts *b*, and simultaneously opening the supplemental supply connections to the motor.

In the embodiment shown in Fig. 3, the electromagnet switch, controlling the contacts *b* and the contacts *n*, *p*, has an energizing winding comprising the two parts *i* and *l* and the arrangement is such that, as in Fig. 1, the ampere turns of the two parts oppose one another. The part *i* is included in a circuit containing the wires *e'*, *e* the contacts *s* of a second electromagnet switch, the energizing winding *t* of that switch being supplied from the battery through the manually operated switch *f* and the wires *e*, *e'*. The other part *l* of the energizing winding is connected on one side to the motor terminal *r* and on the other side to one of the contacts *b*, whereas the iron resistance *m* is connected around those contacts so as to be short circuited when they are closed. The contacts *n*, *p* are included in a wire *u* short circuiting the armature of the motor.

Thus, upon closing the switch *f*, the contacts *s* are immediately closed, and current for the initial operation of the motor flows therethrough to the iron resistance *m* and the winding *l* to the motor terminal *r*. At that point, a large part of that current flows around the armature through the wire *u* and thence through the field winding *d*, whereas the remaining small part of that current flows through the armature winding *c*, the result being to slowly rotate the armature as it is being sucked by its field from a magnetically decentered position to a centered position for engaging the normally disengaged motor and engine gears. In its initial phase of operation, the iron resistance *m* conducting the total current heats up and finally reduces the ampere turns of the section *l* to a value sufficient for the ampere turns of the section *i* to overcome the springs *o*, *q*, thereby closing the contacts *b* and simultaneously opening contacts *n*, *p*. Current for normal operation of the motor then flows through contacts *s*, contacts *b*, winding *l* and thence through armature winding *c* and field winding *d* in series back to the other terminal of the battery. The winding *l* is so calibrated that it does not

operate the electromagnet switch after that switch has once been closed.

It will be observed that in Fig. 3, as well as in Figs. 1 and 2, the iron resistance *m* is traversed by the current flowing in the supplemental supply connections for the initial operation of the motor, and acts as a resistance to reduce the current flowing to the motor in that period, as well as an automatically varying resistance effective to close the main supply connections to the motor for normal operation thereof after an appropriate period of time during which the supplemental supply connections supply current for the initial operation of the motor.

Having thus described my invention, what I claim is:

1. In an electric starting system for internal combustion engines; an electric motor; a source of current supply therefor; main connections, including contacts, for supplying current from the source to the motor for the normal operation thereof; supplemental connections, including contacts, for supplying current from the source to the motor for the initial operation thereof; and means, including an automatically varying resistance, for ultimately closing the contacts included in the main connections and in the same operation opening the contacts included in the supplemental connections.

2. In an electric starting system for internal combustion engines; an electric motor; a source of current supply therefor; main connections, including contacts, for supplying current from the source to the motor for the normal operation thereof; supplemental connections, including contacts, for supplying current from the source to the motor for the initial operation thereof; an electromagnet controlling said contacts and having opposed energizing windings; and an automatically varying resistance connected in the circuit of one of said windings to ultimately cause the electromagnet to close the contacts included in the main connections and in the same operation to open the contacts in the supplemental connections.

3. In an electric starting system for internal combustion engines; an electric motor; a source of current supply therefor; main connections for supplying current from the source to the motor for the normal operation thereof; supplemental connections for supplying current from the source to the motor for the initial operation thereof; an electromagnet having contacts in the main connections, and also having a two-part energizing winding; and an automatically varying resistance in circuit with one part of said winding and ultimately effective thereon to close said contacts.

4. In an electric starting system for internal combustion engines; an electric motor; a source of current supply therefor; main connections for supplying current from the source to the motor for the normal operation thereof; supplemental connections for supplying current from the source to the motor for the initial operation thereof; an electromagnet having contacts in the main connections and having a differential energizing winding; and an automatically varying resistance in circuit with the energizing winding and ultimately effective thereon to close said contacts and interrupt the supplemental connections.

5. In an electric starting system for internal combustion engines; an electric motor; a source of current supply therefor; main connections for supplying current from the source to the motor for the normal operation thereof; supplemental connections for short circuiting the armature for the initial operation of the motor; an electromagnet having contacts included in the main connections and having a two part energizing winding; and an automatically varying resistance in circuit with one part of said winding and ultimately effective thereon to close said contacts.

6. In an electric starting system for internal combustion engines; an electric motor; a source of current supply therefor; main connections for supplying current from the source to the motor for the normal operation thereof; supplemental connections for short circuiting the armature for initial operation of the motor; an electromagnet having contacts included in the main connections and having a differential energizing winding; and an automatically varying resistance in circuit with the energizing winding and ultimately effective thereon to close said contacts and open the supplemental connections.

7. In an electric starting system for internal combustion engines; a series electric motor; a source of current supply therefor; main connections connecting the armature and the field in series with each other and the source for normal operation of the motor; supplemental connections short circuiting the armature for initial operation of the motor; and means, including an automatically varying resistance, for interrupting the supplemental connections.

8. In an electric starting system for internal combustion engines; a series electric motor; a source of current supply therefor; main connections, including contacts, for connecting the armature and field in series with each other and the source for normal operation of the motor; supplemental connections, including contacts, for short circuiting the armature for initial operation of the motor; an automatically increasing resistance connected around the contacts included in the main connections; and means for closing the contacts included in the main connections and simultaneously open-

ing the contacts included in the supplemental connections.

9. In an electric starting system for internal combustion engines; an electric motor; a source of current supply therefor; main connections for supplying current from the source to the motor for the normal operation thereof; supplemental connections for supplying current from the source to the motor for initial operation thereof; an electromagnet having opposed energizing windings and having contacts included in the main and supplemental connections; an automatically varying resistance connected in the circuit of one of said energizing windings to close the contacts included in the main connections and to open the contacts included in the supplemental connections; a second electromagnet having contacts in the circuit of the other energizing winding; and a manually operated switch in the circuit of the energizing winding of said second electromagnet.

In testimony whereof I have affixed my signature, in presence of two witnesses.

AUGUST KAZENMAIER.

Witnesses:
PAUL WOLFART,
ADOLPH LEBLURZ.