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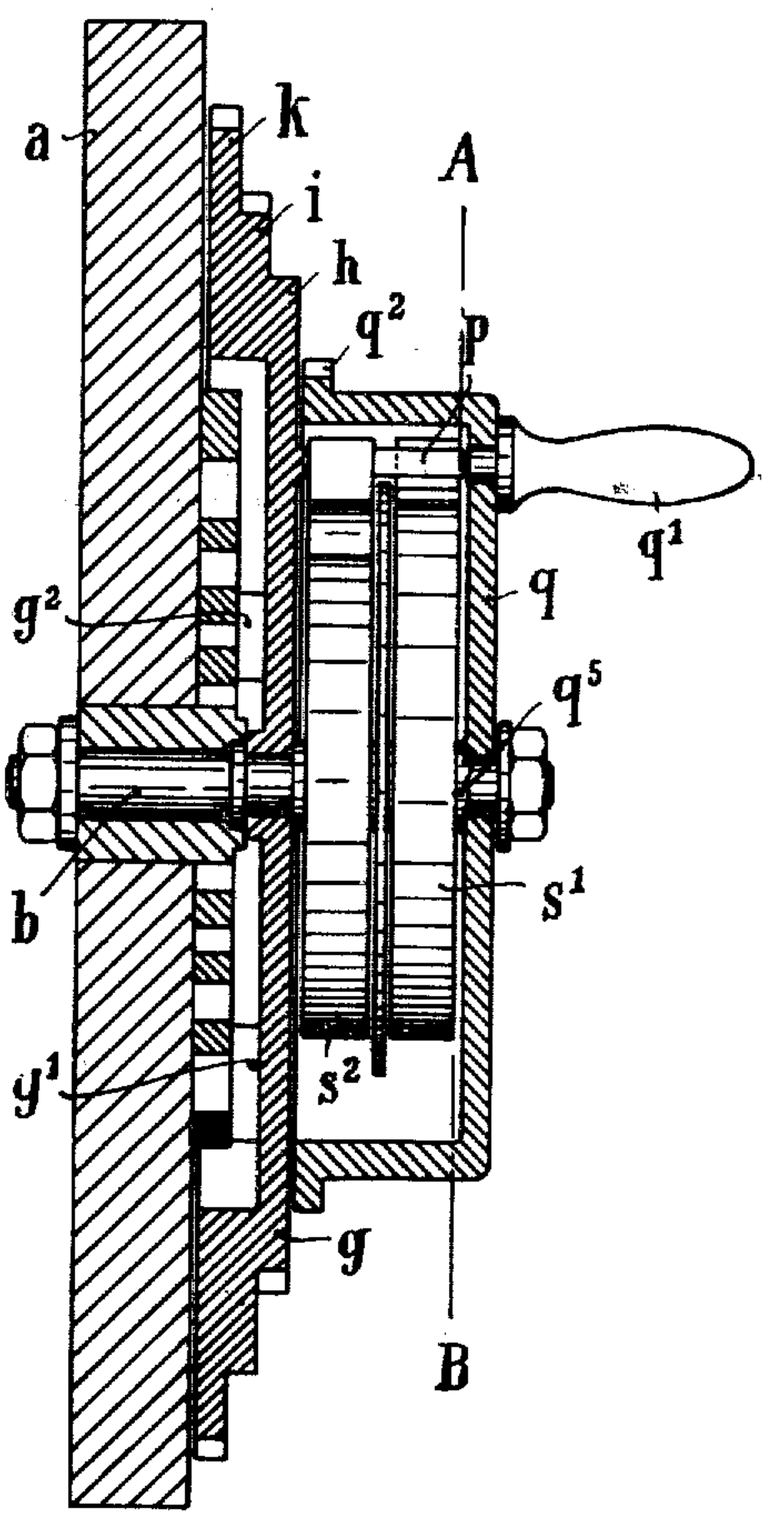
APPARATUS FOR STARTING AND STOPPING ELECTRIC MOTORS.

APPLICATION FILED JUNE 1, 1909.

943,047. **Patented Dec. 14, 1909.**

3 SHEETS—SHEET 1.

Fig. 1.



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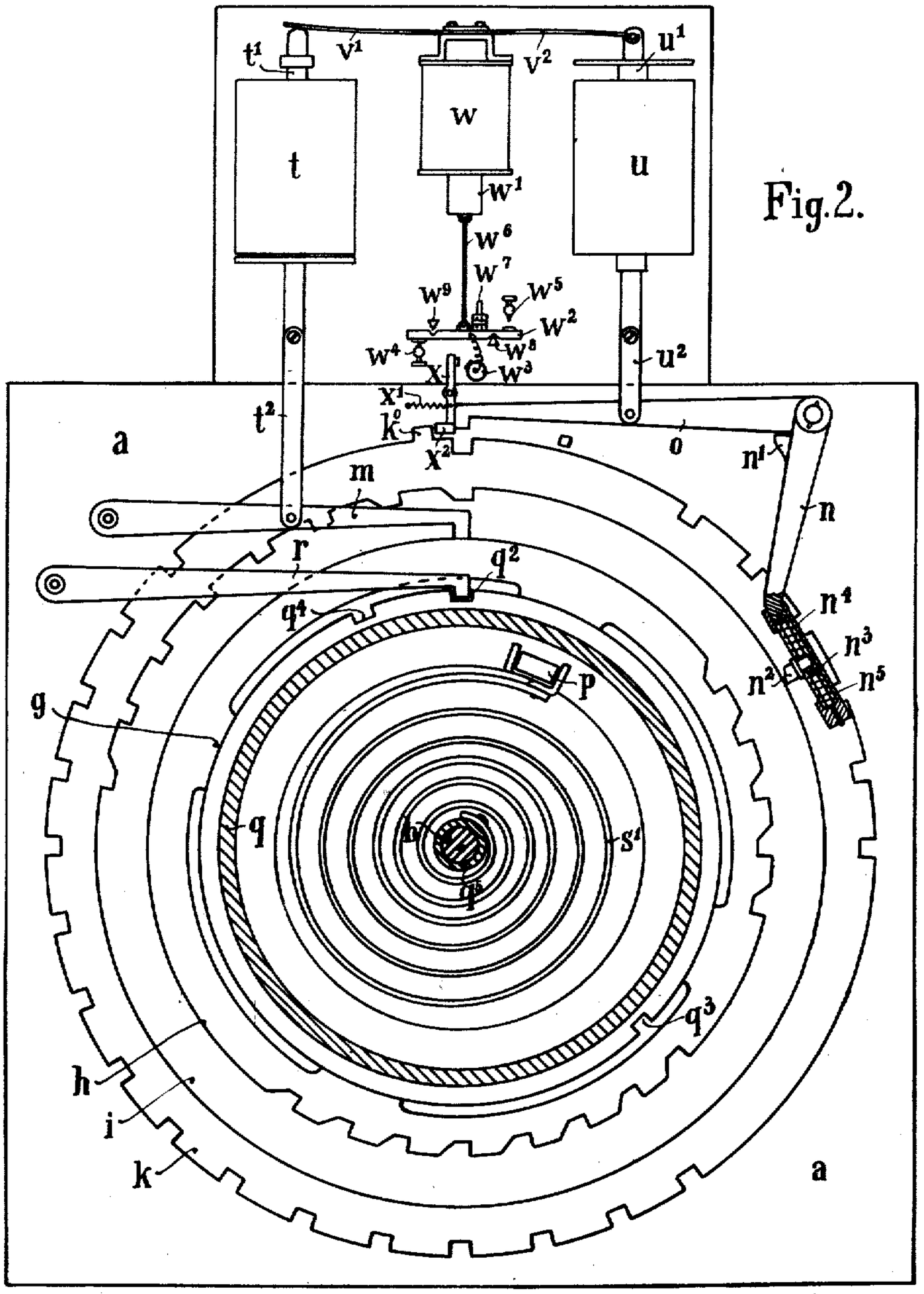

Fig. 2.

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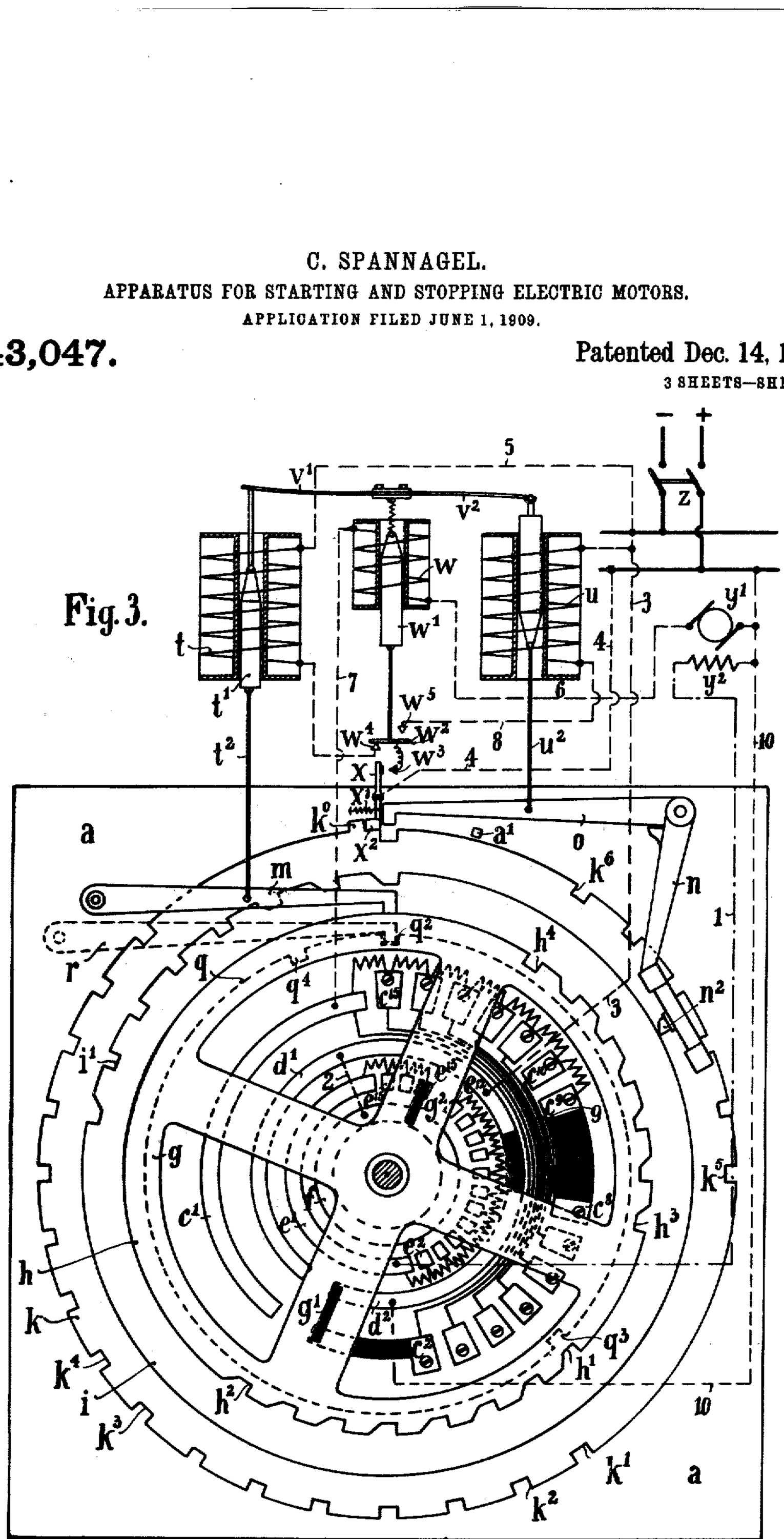
3 SHEETS—SHEET 3.

Fig. 3.



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APPARATUS FOR STARTING AND STOPPING ELECTRIC MOTORS.

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Application filed June 1, 1909. Serial No. 499,268.

To all whom it may concern:

Be it known that I, CARL SPANNAGEL, engineer, a subject of the King of Bavaria, residing at Mannheim, Germany, have invented new and useful Improvements in Apparatus for Starting and Stopping Electric Motors, of which the following is a specification.

In apparatus for starting electric motors it is known to introduce a spring between the driving device and the switching apparatus, and to have operating upon this latter a double pawl controlled by the armature current which only allows a slow step by step movement of the switching apparatus. In these devices, however, account is only taken of the starting and not of the stopping of the motor, for which a slow step by step movement of the switching apparatus is equally of great importance, especially if it is desired to return current to the line or to brake the motor in a purely electrical way.

According to this invention, the disadvantage mentioned is avoided by placing the switching apparatus under the action of one spring specially for starting and one for stopping, and connecting it rigidly with the notched wheel for the double pawl.

In the drawings an apparatus for starting and stopping a D. C. shunt motor is shown as an example of the invention.

Figure 1 is a cross section through the switching apparatus, Fig. 2 shows a switching apparatus in section on the line A—B of Fig. 1 and in connection with the auxiliary device serving to move the pawls. Fig. 3 is a diagram of connections.

The special switching apparatus consists in the first place of an insulating base plate a in which is fastened the pivot b and on the front of which are arranged four sets of contacts in circles. The outermost set of contacts includes the arc c^1 and the contacts c^2—c^{15}. The second set of contacts reckoned from without inward, consists of the arcs d^1 and d^2, the third set of contacts includes the arc e^1 and the contacts e^2—e^{15}, the innermost contact finally is formed by the closed ring f.

On the pivot b is revolubly mounted the contact wheel g upon the back of which are mounted the insulated brushes g^1 and g^2, the brush g^1 rubs upon the sets of contacts c and d, while the brush g^2 rubs on the sets of contacts e and f. The contact wheel g has three rims h i k which are provided with notches and are adapted to co-act with the pawls m n o. On the front of the switch wheel g is provided a pin p. On the pivot b there is also revolubly mounted a cap q on the front of which is the handle q^1. The edge of the cap q at the back is formed as a flange which is provided with three notches q^2—q^4 for engagement with the pawl r. Upon the hub q^5 of the cap q are fastened two spiral springs s^1 s^2, one of which is right-handed and the other left-handed. The outer ends of the spiral springs lie to the right and left of the pin p of the switch wheel g.

The pawls m n o are loosely revoluble around pivots fastened in the base plate a. The pawl n turns upon the same pivot as the pawl o and is fitted with a nose piece n^1 which lies beneath the pawl o. If, therefore, the latter is turned to the left, it moves the pawl n with it. On the other hand so long as the pawl o is in the position shown, the pawl n can engage in the slots of the rim i without moving the pawl o. While the teeth of the remaining pawls are rigid, that n^2 of the pawl n is elastically mounted. It moves upon a pin n^3 and is guided in a slot on the inner side of the pawl n. Upon the pin n^3 are wound two springs n^4 n^5 on the two sides of the tooth n^2, and these press in opposite directions so as to normally hold the tooth n^2 in the position shown. Solenoids t and u serve on the one hand for the movement of the pawls m and o, and on the other hand for the movement of the pawl n, their cores t^1 and u^1 being illustrated in their normal position in Fig. 3. The cores are connected below to the pawls m and o, respectively by rods t^2 and u^2, while springs v^1 and v^2 act on their upper ends, v^1 tending to move the core t^1 downward, and v^2 to move the core u^2 upward.

w is a relay formed as a solenoid, the core w^1 which serves to move up and down the contact piece w^2 (Fig. 3). This is conductively connected with the contact w^3, and in its lowermost position lies against the contact w^4 while in its highest position it touches the contact w^5.

In Fig. 2 is illustrated a form of construction of the contact piece w^2 differing somewhat from that in Fig. 3, and this will

be described in further detail below. With the contact w^3 there co-acts a switch x which is acted upon by a spring x^1 and carries at its lower end a piece x^2 of insulating material. This, in the position of rest illustrated, lies between the tooth k^0 of the rim k and the nose of the pawl o.

y^1 is the armature and y^2 the magnet winding of the motor to be controlled.

The interconnections of the different parts and their relation to the switching devices can be understood, without further explanation, from Fig. 3.

The method of operation of the construction described may be first explained with reference to Figs. 1 and 3, while the form of relay w according to Fig. 2 will, as above remarked, be dealt with in detail later. In order to start the motor, the main switch z is closed and the cap q is turned to the left by means of the handle q^1 when the pawl r has been lifted out of the notch q^2. According as the motor is to run at full speed or a less speed, the revolution is continued until either the notch q^4 or the notch q^3 is beneath the pawl r. For the sake of simplicity, it may be supposed that the motor is to be run at full speed. Then, as already mentioned, the cap q will be turned to the left about 330° and the pawl r will engage in the notch q^4. On the closing of the main switch z the magnet winding y^2 of the motor first receives current along the following path: positive pole z, y^2, l, e^1, three parts of the shunt resistance, e^{13}, g^2, 2, d^1, 3, z, to the negative pole. As the cap q is turned to the left, the spring s^1, the inner end of which is connected to the boss q^5, is stretched. The outer end of the spring engages with the pin p and so turns the switch wheel g to the left with it. This latter can at first rotate upon its shaft without hindrance. The tooth k^0 of the rim k leaves the switch x free, and this latter presses against the contact w^3. By this means the solenoid t is energized through the following circuit: positive pole, z, 4, x, w^3, w^2, w^4, t, 5, negative pole. The core t^1 is then drawn up and the pawl m prevented from engaging in the notches of the rim h. Upon the further revolution of the switch wheel g the three parts of the shunt resistance between e^{13} and e^1 are cut out, and the brush g^1 moves over the contacts c^2 to c^8 without the armature y^1 receiving current thereby. This only happens when the brush g^1 comes into contact with c^9 and the current then takes the following circuit: positive pole, z, y^1, 6, w, 7, all the seven parts of the starting resistance c^9, g^1, 3, z, negative pole of the mains. The armature y^1 therefore turns and takes so much current that the relay w attracts its core w^1. As the result of this, the solenoid t is cut out and the solenoid u energized. The circuit of the latter is as follows: positive pole z, 4, x, w^3, w^2, w^5, 8, u, z, negative pole. The pawl m falls back upon the rim h and so comes into engagement with the notch h^1, which like the following notches does not prevent a further turning of the switch wheel to the left. Through excitation of the solenoid u, the pawl o is moved downward and engages in a notch k so that the switch wheel can turn no farther. Since, however, the current in the armature y^1 now diminishes because the resistance in circuit is not lessened, the relay w after a short time allows its core w^1 to fall again and so cuts out the solenoid u. The switch wheel g then turns farther to the left until the strength of the current through to armature y^1 is again increased sufficiently to effect the closing of the circuit of the solenoid u by means of the relay w. In consequence of this, the pawl o engages in the next notch k^2. This operation is repeated as the starting resistance is cut out step by step until the pawl o engages with the notch k^3. As soon as it emerges from this notch the tooth n^2 of the pawl n comes into operation. This latter engages in the notch i^1 and is moved by this as far as the slot in the under end of the pawl n allows. In its end position, however, the tooth n^2 holds the switch wheel g fast; it is only taken out when the pawl o engages in the next notch k^4. The pawl n thus prevents the switch wheel from turning through more than one step at a time as soon as the motor has reached a certain speed. Were it not present, the switch wheel g could easily turn to the left through more than one step while the pawl o is raised. Obviously notches similar to i^1 can be provided prior to this notch so as to coöperate for example with the notch k^1. In general, however, this is not necessary because at the beginning of the starting of the motor the current passing does not increase so speedily as later. When the whole starting resistance has been cut out, that is when the brush g^1 comes into contact with the arc c^1, the shunt resistance between e^1 and e^{12} is inserted in the circuit of the magnet winding y^2 step by step. Finally, the tooth k^0 of the switch wheel g comes against the projection a^1 of the base plate a and therefore its revolution ceases. During the normal driving of the motor, the contact piece w^2 of the relay w swings between the contacts w^4 and w^5 without resting on either.

In order to stop the motor again, the cap q is turned to the right until the pawl r engages in the notch q^2. By this means the spiral spring s^2 is extended and this in its turn causes the switch wheel g to move around. The current impulse thus sent into the motor circuit first excites the relay w so strongly that it excites the solenoid u. The same operation then proceeds as at starting, that is, the pawl o is alternately raised and lowered so that the switch wheel can only

turn step by step. The switching of the motor which now returns current to the line, is first of all only changed by the gradual cutting out of the shunt resistance and gradual insertion of the starting resistance. The magnitude of the starting resistance is so chosen that the E. M. F. at the brushes of the motor is somewhat greater than the potential of the supply, so that the relay w receives the necessary current. Thus the operation proceeds until the brush g^1 leaves the contact c^9. So soon as the brush g^1 comes against the contact c^8, the current generated by the armature y^1, takes the following path: y^1, 6, w, 7, c^1, six parts of the starting resistance, c^{10}, 9, c^8, g^1, d^2, 10, y^1. The circuit of the armature y^1 is therefore now closed over a resistance and is no longer connected to the supply terminals. Upon the further revolution of the switch wheel to the left, the resistance in the armature circuit is diminished. Finally the brush g^1 leaves the contact c^2 and so opens the armature circuit. In the last part of the movement of the switch wheel to the right, the pawl o comes into engagement with the notches k^5—k^6.

The manner of operation of the pawl m has intentionally been referred to only at the commencement of the exposition of the switching process. As is obvious without further explanation, from what has been said above and from the drawings, this pawl always lies upon the rim h when no current is flowing through the winding of the solenoid t. This is the case, however, so long as the strength of the current through the motor armature does not go below a certain limit. Now the armature current can be below the limit in question on the one hand, on the starting of the motor, if no current at all is flowing through the motor armature, that is if the brush g does not at least rest upon the contact c^9, and on the other hand upon the stopping when the brush g^1 has at least come into contact with the contact c^8. If the brush g^1 rests on the contact c^8 in starting and in stopping, the pawl n begins to coöperate with the notches h^1—h^2 or h^3—h^4 which are beveled upon one side. The notches h^1—h^2 consequently prevent the revolution of the switch wheel to the right, and the notches h^3—h^4, revolution to the left as soon as the pawl m engages in them. The purpose of these notches and of the pawl m is thus to prevent a reversal of the direction of revolution for the time being of the switch wheel so long as current of the determined strength flows through the armature.

A form of construction of the relay w in Fig. 2 differing somewhat from that in Fig. 3, has a contact piece w^2 which, by means of the rod w^6, is suspended as a pendulum on the core w^1. The center of gravity of the contact piece w^2, the position of which can be regulated by small auxiliary weights w^7, lies between the point of engagement with the rod w^6 and the knife edge w^8 on which the contact piece w^2 lies in the position of rest. In this position the left hand end is also resting on the contact w^4. If the core w^1 is drawn in, the left hand end of the contact piece w^2 leaves the contact w^4 and touches against the knife edge w^9. Upon further increase of the current in the winding of the relay w, the contact piece w^2 is lifted about the knife edge w^9 and rests against the contact w^5. The screws of the contacts w^4 and w^5 are so adjusted that in this latter position the contact w^4 is not closed. If the current strength diminishes again, the contact piece w^2 turns about the knife edge w^9. Its right hand end therefore moves away from the contact w^5, but also does its left hand end from the contact w^4. The purpose of this arrangement is to prevent immediate re-closing of the contact w^4 upon variations of the armature current, which may easily occur.

Although in the preceding only one form of construction of the invention has been described, which relates to the starting and stopping of a direct current motor and particularly to one in which on stopping, current is to be returned to the line, it is clear without further explanation that by corresponding alteration of the contact pieces e—f, the construction can be applied in an entirely similar way for other motors, that is to say d. c. motors connected in other ways as well as for alternating current and three phase motors. Finally it is also to be remarked that the new apparatus is suitable for distant control. The handle q^1 is then removed and a cord or the like is wound around the cap q. This cord is moved in one direction or the other by a lever, a second cord pulley, or the like. The notches q^2—q^4 are then mounted upon the device which serves to move the spring.

I claim:

1. In an apparatus for starting and stopping electric motors a control member, a switching member, two springs acting in opposite direction interposed between said two members, a solenoid, a double pawl operated by said solenoid and acting upon two notched rims rigidly connected with said switching member. substantially as and for the purpose set forth.

2. In an apparatus for starting and stopping electric motors a control member, a switching member, two springs acting in opposite direction interposed between said two members, a solenoid, a double pawl operated by said solenoid and acting upon two notched rims rigidly connected with said switching member, the double pawl being formed by two parts having a little free

motion and one of said parts carrying a yielding tooth, substantially as and for the purpose set forth.

3. In an apparatus for starting and stopping electric motors a control member, a switching member, two springs acting in opposite direction interposed between said two members, a solenoid, a double pawl operated by said solenoid and acting upon two notched rims rigidly connected with said switching member, a second solenoid, a third pawl operated by said second solenoid and acting upon a third notched rim rigidly connected with said switching member, substantially as and for the purpose set forth.

4. In an apparatus for starting and stopping electric motors a control member, a switching member, two springs acting in opposite direction interposed between said two members, a solenoid, a double pawl operated by said solenoid and acting upon two notched rims rigidly connected with said switching member, a second solenoid, a third pawl operated by said second solenoid and acting upon a third notched rim rigidly connected with said switching member, a relay controlling said two solenoids and being traversed by the armature current, substantially as and for the purpose set forth.

5. In an apparatus for starting and stopping electric motors a control member, a switching member, two springs acting in opposite direction interposed between said two members, a solenoid, a double pawl operated by said solenoid and acting upon two notched rims rigidly connected with said switching member, a second solenoid, a third pawl operated by said second solenoid and acting upon a third notched rim rigidly connected with said switching member, a relay controlling said two solenoids and being traversed by the armature current, the contact-piece of which in one of its end positions closes the circuit of the one solenoid and in the other end position that of the other solenoid while during normal running of the motor it rests against neither of its contacts, substantially as and for the purpose set forth.

6. In an apparatus for starting and stopping electric motors a control member, a switching member, two springs acting in opposite direction interposed between said two members, a solenoid, a double pawl operated by said solenoid and acting upon two notched rims rigidly connected with said switching member, a second solenoid, a third pawl operated by said second solenoid and acting upon a third notched rim rigidly connected with said switching member, a relay controlling said two solenoids and being traversed by the armature current, the contact piece of said relay on leaving the working contact being at first also moved away from its other contact, substantially as and for the purpose set forth.

7. In an apparatus for starting and stopping electric motors a control member, a switching member, two springs acting in opposite direction interposed between said two members, a solenoid, a double pawl operated by said solenoid and acting upon two notched rims rigidly connected with said switching member, a second solenoid, a third pawl operated by said second solenoid and acting upon a third notched rim rigidly connected with said switching member, a relay controlling said two solenoids and being traversed by the armature current, said relay receiving its current through a switch which is opened by the switching device when the motor is at a standstill, and automatically closes when the switching device leaves the position of rest, substantially as and for the purpose set forth.

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

CARL SPANNAGEL.

Witnesses:
S. H. SHANK,
WILH. C. STUCKLER.