No. 860,104. PATENTED JULY 16, 1907.

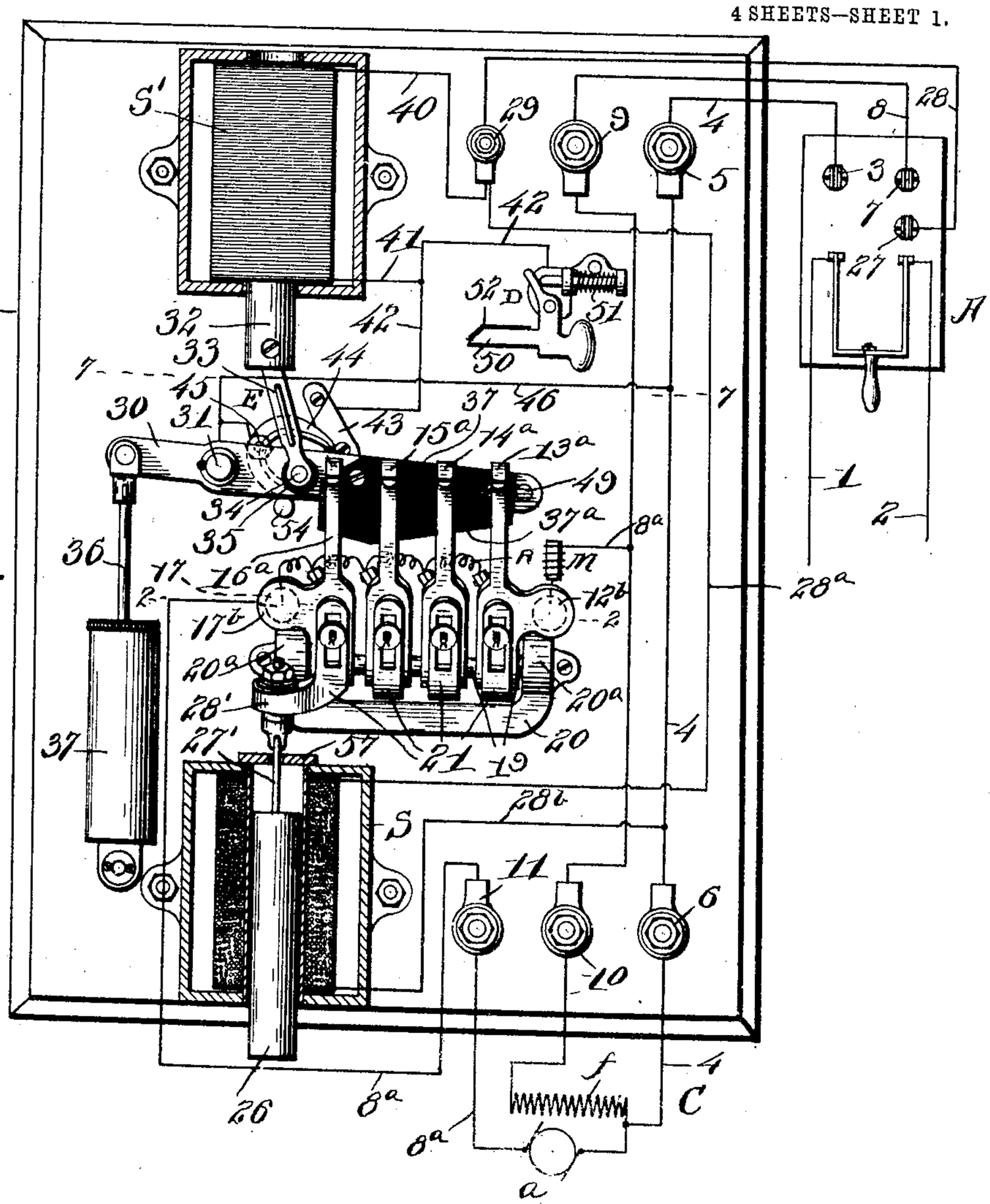
W. C. O'BRIEN.

AUTOMATIC STARTER FOR ELECTRIC MOTORS.

APPLICATION FILED APR. 19, 1905.

4 SHEETS—SHEET 1.

Fig. 1.



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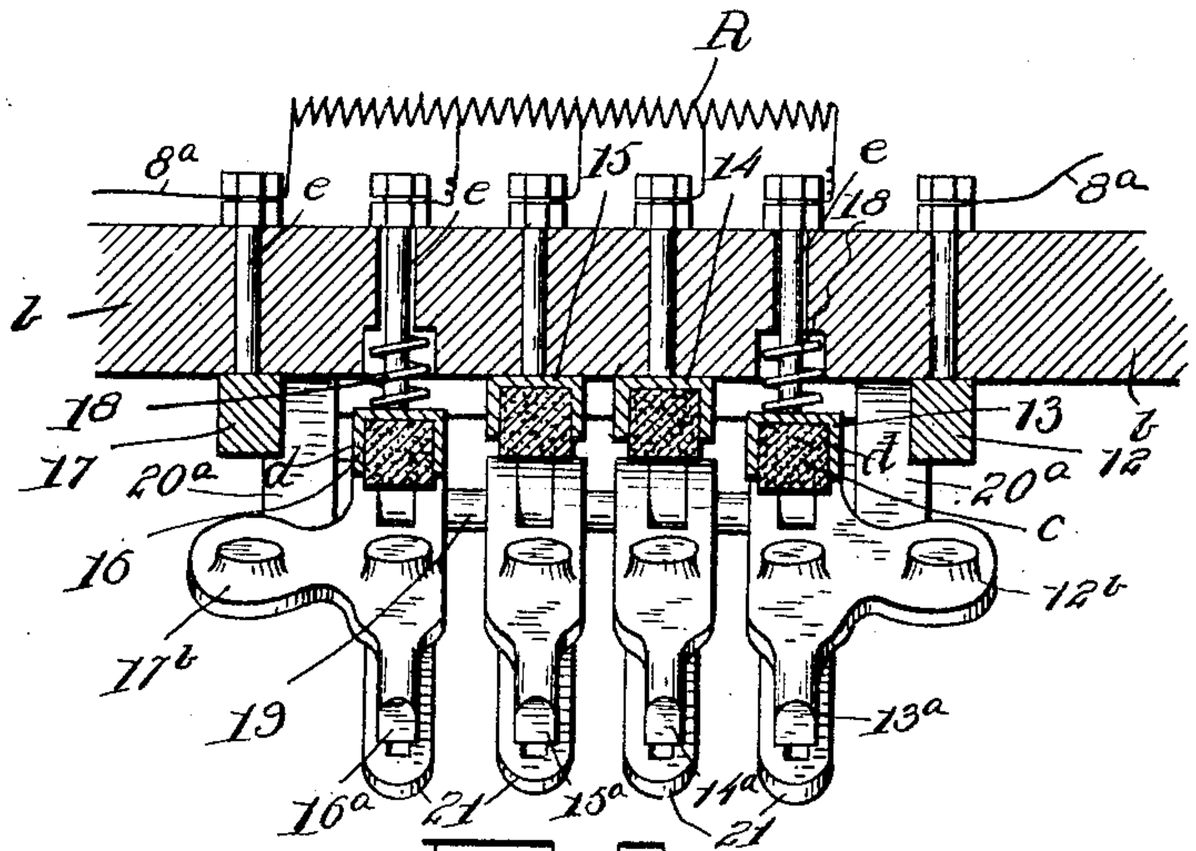

Fig. 2.

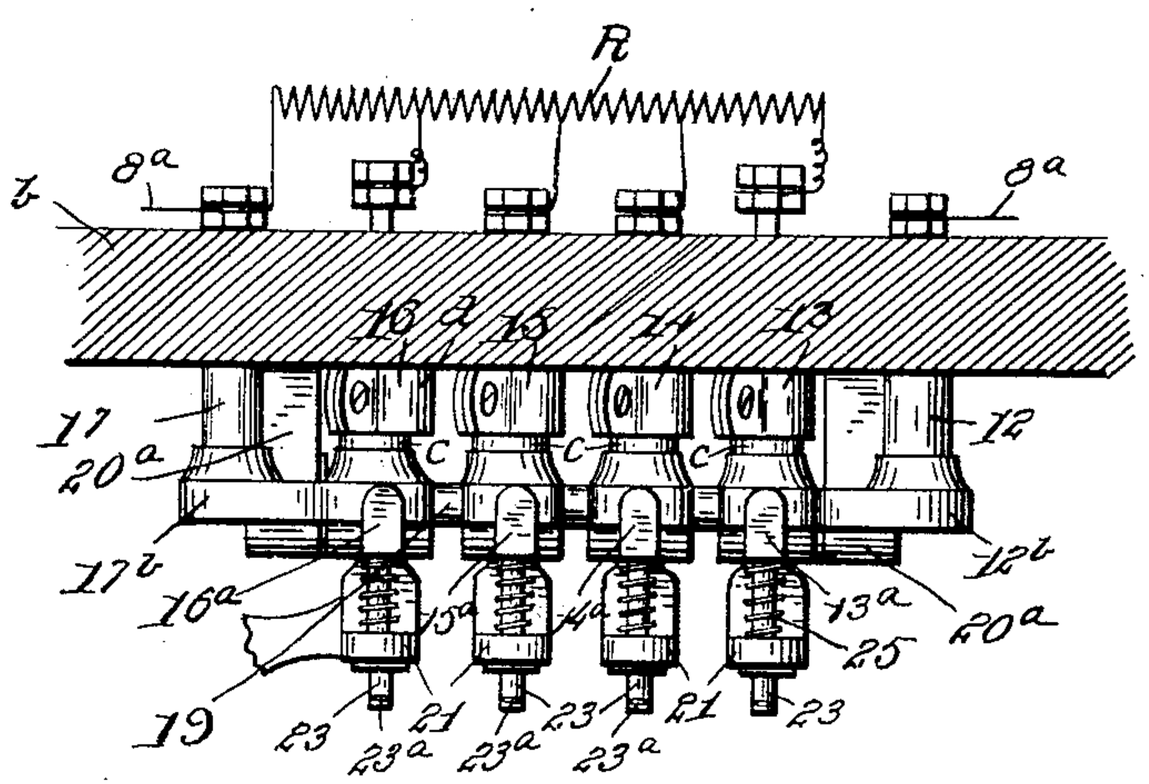

Fig. 4

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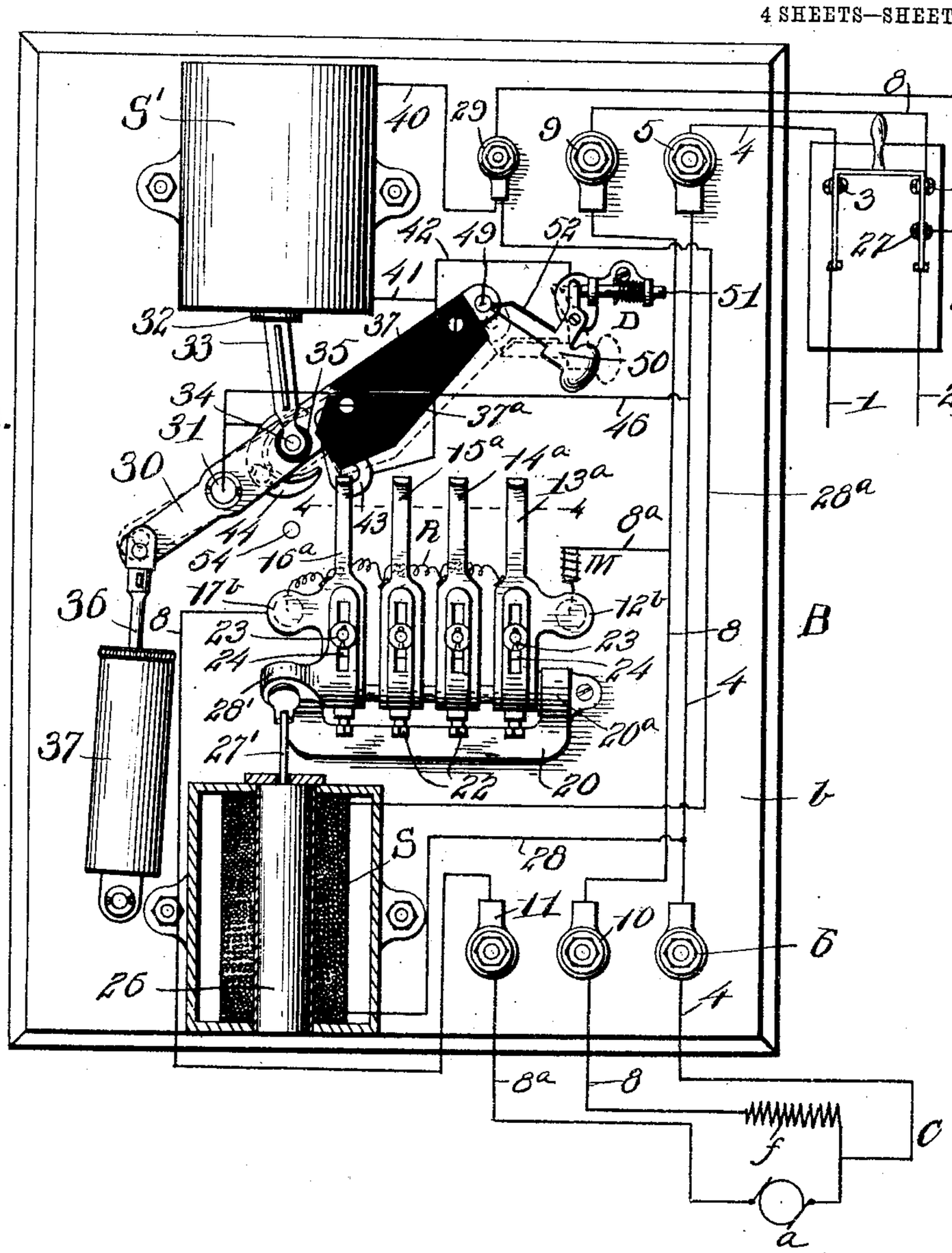
4 SHEETS—SHEET 3.

Fig. 2.



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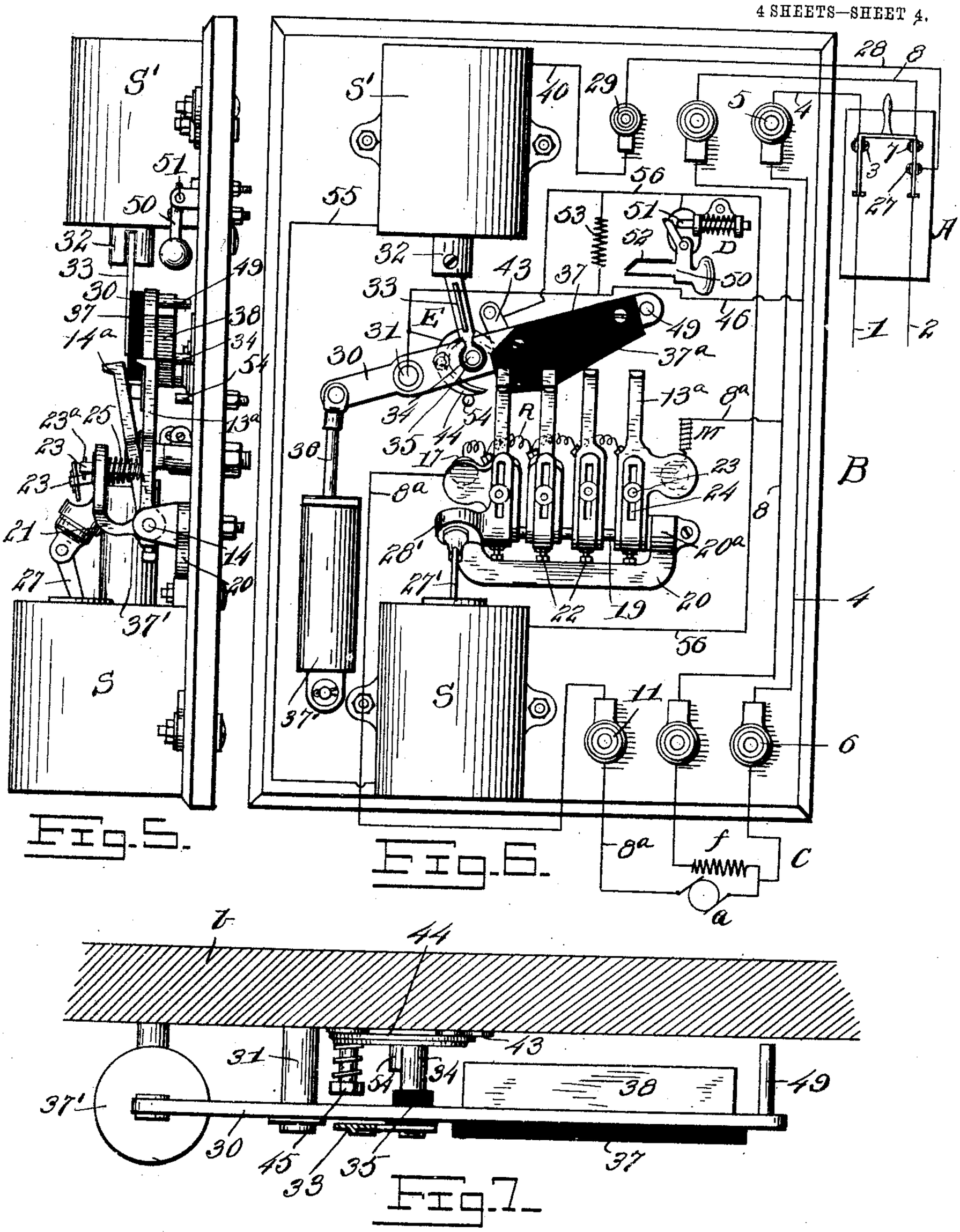

Fig. 5.

Fig. 6.

Fig. 7.

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AUTOMATIC STARTER FOR ELECTRIC MOTORS.

No. 860,104. Specification of Letters Patent. Patented July 16, 1907.

Application filed April 19, 1905. Serial No. 256,428.

To all whom it may concern:

Be it known that I, WILLIAM C. O'BRIEN, a citizen of the United States, residing at Baltimore, in the State of Maryland, have invented certain new and useful Improvements in Automatic Starters for Electric Motors, of which the following is a specification.

This invention comprises improvements in automatic starters for electric motors, the details and advantages of which will be pointed out in the following specification, taken in connection with the accompanying drawing, in which,

Figure 1 is a front elevation of the device, partly in section, the parts being shown in their normal positions, and the circuits being shown diagrammatically. Fig. 2 is a section through the base plate of the starter on the line 2—2 of Fig. 1, the contact fingers being shown in end view and in their raised positions. Fig. 3 is a front elevation of the starter, partly in section, showing the interposing lever in full lines at the point where the solenoid circuit is about to be interrupted, and in dotted lines, in the position which it occupies while the motor is running. Fig. 4 is a section through the base-plate on the line 4—4 of Fig. 3, showing the contact fingers pressed against the contact points or buttons of the starting resistance the fingers being shown in end view. Fig. 5 is a side elevation of the starter with the interposing lever partly raised. Fig. 6 is a front elevation of the same, showing also in diagram, a modified arrangement of the solenoid circuit, and Fig. 7 is a section on the line 7—7 of Fig. 1, showing the interposing lever and the circuit closer operated by said lever.

Referring to the drawing, A indicates a main switch, B the automatic starter; C indicates diagrammatically an electric motor, and 1 and 2 indicate the line wires of an electric circuit which are connected to one side of the switch. One terminal 3 of the switch is connected by a wire 4, through binding posts 5 and 6 to one terminal of the field *f* and armature *a* of the electric motor. Another terminal 7 of the switch is connected by a wire 8 through binding posts 9 and 10 to the opposite terminal of the field *f*, and the armature circuit is completed through a wire 8^a, leading from the armature to a binding post 11, thence to the metal contact piece 17, thence to the starting resistance R, and from said resistance through a blow-out magnet M to the wire 8.

Contact pieces or buttons 13, 14, 15 and 16, are connected to the resistance R, as shown in Fig. 2. These contact buttons preferably consist of cylindrical pieces of carbon *c* arranged within cups *d* which are mounted upon studs *e*, the latter extending through the front plate *b* of the starting device and being connected to the resistance, as shown. The contact points 12 and 17, at the ends of the series of contacts, are made of solid metal and the adjacent contact pieces 13 and 16 are normally pressed upward from the front plate by springs 18, as shown in Fig. 2.

Upon a rock shaft 19, which is journaled in a bracket 20 having bearings 20^a, at its ends, are arranged a series of loosely mounted contact fingers 13^a, 14^a, 15^a, and 16^a adapted to bear upon the contacts 13, 14, 15 and 16, respectively, when these fingers are pressed downward, as shown in Fig. 4. The contact fingers 13^a and 16^a are provided with lateral projections 12^b and 17^b adapted to engage the metal contact pieces 12 and 17, respectively, when the fingers are depressed. The rock shaft 19 carries a series of arms 21, which are rigidly secured to the shaft by set screws 22, and are arranged in front of the contact fingers 13^a to 16^a, inclusive. Each contact finger has a stud 23 rigidly secured to it and these studs project through slots 24 in the arms 21. Springs 25 are arranged upon the studs between the arms 21, which are rigidly secured to the rock shaft and the contact fingers 13^a, 14^a, etc. which are loosely mounted upon the rock shaft. Stop pins 23^a are arranged upon the outer ends of the studs. When the rock shaft is moved in one direction the arms 21, engaging the stops 23^a carry the contact fingers outward away from the contact pieces 12 to 17 inclusive and when the rock shaft is moved in the opposite direction, pressure is applied to the fingers tending to force them against the contact pieces. This rocking of the shaft is accomplished automatically by means of a solenoid S having a core 26 which is connected by a link 27′ to a lug 28′ on one of the arms 21 which is secured to the rock shaft. When the main switch is closed the solenoid core 26 is lifted and the contact fingers are pressed toward the contact points or buttons. When the main switch is opened the core 26 drops downward and causes the rock shaft to turn in a reverse direction, thus drawing the contact fingers away from the contact pieces 12 to 17 inclusive, as shown in Figs. 1 and 2. The circuit for the solenoid S in Figs. 1 and 3 extends from a terminal 27 on one side of the main switch through a wire 28, terminal 29 and wire 28^a to one terminal of the solenoid and thence by a wire 28^b to the wire 4, which is connected to the opposite pole of the switch. The closing of the main switch, therefore, is immediately followed by the lifting of the core 26 and the application of pressure to the fingers 13^a to 16^a inclusive, and the opening of the switch, by interrupting the solenoid circuit allows the core of the solenoid to drop and release the pressure from the contact fingers and draw them outward. When the contact fingers are all pressed downward, as shown in Fig. 4, the armature circuit between the contact posts or buttons 12 and 17 is completed through the contact fingers and the rock shaft 19 and its support 20, and the starting re-

sistance R is then shunted; when the contact fingers are all raised as shown in Fig. 2, the armature circuit is interrupted between the contact pieces or buttons 12 and 13.

I provide means for permitting the contact fingers 13^a to 16^a inclusive to be pressed successively against the contact pieces 12 to 17 inclusive, in order to cut the starting resistance gradually out of the armature circuit. When the contact finger or member 13^a is pressed downward, it first engages the spring pressed contact 13 having a carbon block and forces the latter downward until the lateral projection 12^b engages the metal contact piece 12. The armature circuit is then completed through the contact arm 13^a from the contact piece 12, to the contact piece 13, and thence through the starting resistance R. The contact finger or member 14^a is then caused to engage the contact piece 14 thus cutting out part of the starting resistance and the contact members 15^a and 16^a successively engage the contact pieces 15 and 16, thus further reducing the resistance in the armature circuit. The spring pressed contact piece 16 containing a carbon block is depressed by the member 16^a until the laterally projecting arm 17^b of the latter engages the metal contact piece 17, thus cutting out the resistance between the contact pieces 16 and 17. A complete metal circuit is then formed in shunt to the starting resistance from the metal contact piece 12 through the fingers or members 13^a and 16^a and the rock shaft 19 and its support 20 to the metal contact piece 17.

In order to operate the contact fingers or members successively when the main switch is closed, I provide a lever 30 which is mounted upon a pivot pin 31 and is operated by a solenoid S′. The solenoid S′ has a core 32 connected by a link 33 to a pin 34 which is secured within an insulated bushing 35 extending through the lever 30. One end of the lever 30 is connected to the piston 36 of a dash pot 37′ and the longer arm of the lever has a plate or facing of insulating material 37 secured to its outer or forward side and a weight 38 secured to its rear side. This lever is so arranged that in its normal position when the motor is not in operation, its longer arm will be interposed between the contact fingers or members 13^a to 16^a inclusive and the base *b* of the starter, thus preventing the engagement of the contact fingers with the contact pieces 12 to 17 inclusive. When the main switch is closed the solenoids S and S′ are simultaneously energized, the former instantly forcing the contact fingers, with spring pressure, against the insulating piece 37 on the interposing lever 30, and the latter solenoid causing the lever to move slowly upward, the lever being retarded in its movement by the dash pot. The lower edge 37^a of the insulating piece 37 is so formed that as the interposing lever moves upward the contact fingers or members 13^a to 16^a will be released successively from its lower edge and will engage their respective contact points or pieces connected with the starting resistance. In Fig. 1 the interposing lever is shown in its normal position in the rear of the contact fingers; in Figs. 5 and 6 the lever is shown partly raised with some of the fingers released and the remainder still resting upon the insulating piece 37. In Fig. 3 the interposing lever is shown in full lines at about the limit of its upward travel, with all of the fingers released. In the latter position the starrting resistance is entirely shunted.

When the interposing lever reaches the upward limit of its travel the solenoid S′ is deënergized in the manner hereinafter described, either by the interruption of its circuit or the inclusion in its circuit of a high resistance, while the solenoid S remains energized until the main switch is opened or the line circuit otherwise interrupted. The solenoid S, therefore, continually presses the contact fingers against the contact pieces 12 to 17 inclusive, while the motor is in operation. After the interposing lever has moved upward and the solenoid S′ is deënergized the lever drops back into the position shown in dotted lines in Fig. 3 and rests upon the end of the contact finger 16^a. The lever remains in this position until the switch is opened or the line circuit interrupted, when the core 26 of the solenoid S drops downward and pulls the contact fingers outwardly thus allowing the interposing lever to drop into the position shown in Fig. 1.

In Figs. 1 and 3 the solenoids S and S′ are connected in independent circuits. As shown in these figures one terminal 40 of the solenoid S′ is connected to the binding post 29 and thence through wire 28 to the auxiliary contact piece 27 of the main switch. The other terminal 41 of the solenoid is connected to a wire 42 which extends between a circuit interrupting device D and a contact plate 43 arranged upon the front of the starter. A crescent-shaped circuit-closing device 44 which is mounted upon a pivot pin 45 back of the interposing lever normally rests upon the contact plate 43 and a wire 46 connects said closing device with the wire 4 extending to the contact piece 3 upon the main switch. The circuit for the solenoid S′ is thus complete from opposite terminals of the main switch, when the parts are in their operative positions through wire 28, terminals 40 and 41, wire 42, contact plate 43, circuit closing device 45, wire 46, and wire 4 to the terminal 3. The wire 46 is also connected to the pivot pin 31 of the interposing lever 30 which is made of metal. When the main switch is closed, therefore, the solenoid S′ will cause the interposing lever to move upward. The pin 34, which is insulated from the interposing lever engages the upper arm of the crescent-shaped circuit closing device and turns the latter about its pivotal point, as shown in Fig. 3, until, toward the end of the movement of the lever the device 44 leaves the upper end of the contact piece 43 thus interrupting the circuit of the solenoid S′ between these two points. Before the device 44 leaves the contact piece 43, however, a metal pin 49 upon the outer end of the interposing lever engages the lower edge of a swinging arm 50 of the circuit interrupting device D, and the circuit of the solenoid S′ is thus maintained through the wire 42, interrupting device D, pin 49, lever 30 and wire 46, after the circuit closing device 44 has left the contact plate 43. As this engagement of the pin 49 with the swinging arm 50 occurs before the interrupting device 44 leaves the plate 43, no spark occurs between said device and plate. As the lever continues to move upwardly the swinging arm 50 is rocked, as shown in Fig. 3, forcing back a spring pin 51 upon the circuit interrupting device. As soon as the pin 49 passes the end of the swinging arm the latter is forced quickly downward by the spring pin thus making a wide gap

between the pin and arm and preventing an arc between these parts. The interposing lever then drops downward until it rests upon the top of the arm 16ª as shown in dotted lines in Fig. 3 and the swinging arm 50, after its oscillation rests in a horizontal position, as shown in dotted lines in said figure, beneath the pin 49. An insulating piece 52 is arranged upon the upper side of the swinging arm to prevent the latter from making contact with the pin 49 if the arm should be thrown against it after it has been returned by the spring pin, or if from any cause the main switch or the line circuit should be opened and immediately closed.

It will thus be seen that in Figs. 1 and 3 the circuit of the solenoid S′ is interrupted and the solenoid thus de-energized after the motor has been started, preventing further consumption of current by said solenoid. The lower solenoid S is wound with fine wire of high resistance and consumes a comparatively small amount of current.

When the interposing lever drops downward behind the contact fingers or members when the main switch is opened, the pin 34 upon said lever engages the lower arm of the crescent-shaped circuit closing device 44 and rocks said device until its lower arm engages a stop pin 54 upon the front plate of the starter. This stop pin limits the downward movement of the circuit closing device and also of the lever. In the normal position the pin 34 rests upon the lower arm of said circuit closing device.

In Fig. 6 I have shown a modified arrangement of the solenoid circuits, the two solenoids S and S′ being connected in series, instead of in independent circuits, as in Figs. 1 and 3.

In Figs. 1 and 3 the solenoids are in independent circuits and as the solenoid S′ is the only one which is to be affected by the interposition of a high resistance or the interruption of the circuit, in said figures, after the motor has started one terminal of said solenoid is connected to the circuit interrupting device D and the plate 43, the other terminal being connected to the auxiliary contact 27 on the main switch. In Fig. 6 the arrangement is substantially the same, except that as the two solenoids are connected in series, there being but one solenoid circuit, one terminal of said circuit is connected to the auxiliary contact piece 27 and the other terminal is connected to the circuit interrupting device D and the plate 43. As shown in Fig. 6 the solenoid circuit extends from the contact piece 27 on the main switch through wire 28, binding post 29, and wire 40 to the solenoid S′, thence by wire 55 to the solenoid S, and thence by wire 56 to the circuit interrupting device D and the plate 43 of the circuit closing device E. A high resistance 53 is arranged between the wire 56 and the wire 46. It will be evident that when the interposing lever passes the swinging arm 50 of the device D, the solenoid circuit will not be entirely interrupted, the current then passing from the wire 56 through the high resistance 53 and wire 46 to the wire 4 and thence to the contact 3 on the main switch.

An iron plate or armature 57 is arranged upon the top of the solenoid S and the core 26 adheres to this armature when the solenoid is energized. When the high resistance is interposed in the solenoid circuit, the solenoid S will have sufficient power to hold the core 26 against the armature 57 and thus hold the contact fingers in engagement with the contact pieces connected to the starting resistance, while the solenoid S′, which is wound with fewer turns of coarser wire, will not have sufficient energy to support its core and the interposing lever after the resistance has been interposed in the solenoid circuit.

When the main switch is opened and the contact fingers are drawn backward away from the contact pieces 12 to 17 inclusive, the armature circuit is interrupted between the contact pieces 12 and 13, a double air gap being formed between said contact pieces and the coöperating parts 12ᵇ and 13ª, respectively. The blow out magnet M blows out any arc which may be formed between the metal contact piece 12 and the arm 12ᵇ.

As the solenoid circuits are connected, at one end to an independent or auxiliary contact piece 27 upon the main switch, it will be seen that when the main switch is opened, the solenoid circuit or circuits will be entirely interrupted, and will not be affected by the counter-electro-motive force of the motor. If the solenoid S′ were connected directly to the terminals 3 and 7 of the switch or to the wires leading to the motor, the counter-electro-motive force of the latter would affect the solenoid and prevent its core from dropping immediately after the opening of the switch.

In my improved starting device it will be noted that I have dispensed entirely with sliding contacts in connection with the starting resistance. As automatic starters are usually operated at a distance from the person closing the main switch, it is desirable to dispense with sliding contacts which frequently burn and prevent the movement of the contact arm.

As the motor circuit is normally open between the contact pieces 12 and 13, only a small current passes through the main switch A at the instant when the latter is closed. When the interposing device moves upward allowing the first contact member 13ª to spring downward against the contact pieces 12 & 13, the armature circuit is then closed through the entire resistance. Immediately following the opening of the main switch the contact members are pulled outward, interrupting the circuit between the contact pieces 12 and 13. At the moment when the switch A is opened, the contact members being then in engagement with their respective contact pieces, it will be seen, by following the field and armature circuits in Fig. 1, that the discharge from the field can pass through the armature, so that the discharge from the field will not cause arcing at the main switch when the latter is opened. The circuit through the armature then breaks between the contact pieces 12 and 13, this following quickly after the opening of the line switch, and the blow-out magnet M extinguishes any arc occurring at the point of interruption. In my invention also it will be noted that the contact fingers or members act quickly and positively in both directions of movement.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:—

1. In an automatic starter for electric motors, the combination with the motor circuits, including a starting resistance having contact pieces, of a series of independently movable fingers, an interposing device normally preventing the engagement of said fingers with the contact

pieces, a rock shaft having arms thereon, springs interposed between said arms and the fingers, a solenoid having its core operatively connected to the rock shaft, a second solenoid having its core connected to the interposing device, and means for reducing the current in said second solenoid after the interposing device has been moved to release said fingers.

2. In an automatic starter for electric motors, the combination with the motor circuits, including a starting resistance having contact pieces, of a series of contact members movable toward and from said contact pieces, an interposing device movable in a plane transverse to the planes of movement of said contact members, electromagnetic means for moving said interposing device out of the paths of movement of said members, and means for moving said members into the path of movement of said interposing device when the current is turned on, whereby said interposing device is held out of its normal position by said members while the motor is running.

3. In an automatic starter for electric motors, an armature circuit, including a starting resistance having contact pieces, contact members arranged to open and close the armature circuit of the motor and to introduce and cut out said resistance, an electro-magnetic device for operating said members, a circuit for said device, and a main switch having terminals for the motor circuits and having an independent terminal for the circuit of said device, said switch being adapted to make and break connections between both of said circuits and the line circuit.

4. In an automatic starter for electric motors, a starting resistance having contact pieces, contact members arranged to coöperate with said contact pieces, an interposing device adapted to normally prevent the engagement of said contact members with said contact pieces, and means for moving said interposing device from normal position when the current is turned on, one of said contact members being arranged to hold said interposing device out of normal position after the motor is started.

5. In an automatic starter for electric motors, the combination with the motor circuits comprising a starting resistance having contact pieces, of a series of independently movable metal contact members, means for pressing said members toward said contact pieces when the current is turned on, a metal interposing lever having insulating material thereon arranged to be engaged by said members when the latter are pressed toward the contact pieces, and electro-magnetic means for moving said lever to release said members when the current is turned on.

6. In an automatic starter for electric motors, the combination with independently movable contact members and means for operating the same, of an interposing lever, a solenoid for operating said lever, a circuit for said solenoid, a circuit closing device arranged in said circuit and movable by said lever to open position, and a swinging circuit interrupter adapted to be engaged by said lever before the circuit closing device is moved to open position and to be tripped by said lever after the circuit closing device has opened, said lever and said interrupter being connected to the solenoid circuit at opposite sides of the circuit closing device.

7. In an automatic starter for electric motors, the combination with a solenoid and a lever operated thereby, of means for interrupting the solenoid circuit comprising a swinging circuit interrupter having a metal surface adapted to be engaged by the lever during the movement of the latter in one direction and having a surface of insulating material adapted to be engaged by the lever during its movement in the opposite direction.

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

WILLIAM C. O'BRIEN.

Witnesses:
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THOS. H. DRIVER.