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G. H. HILL.

# AUTOMATIC REGULATOR FOR ALTERNATING CURRENT MOTORS.

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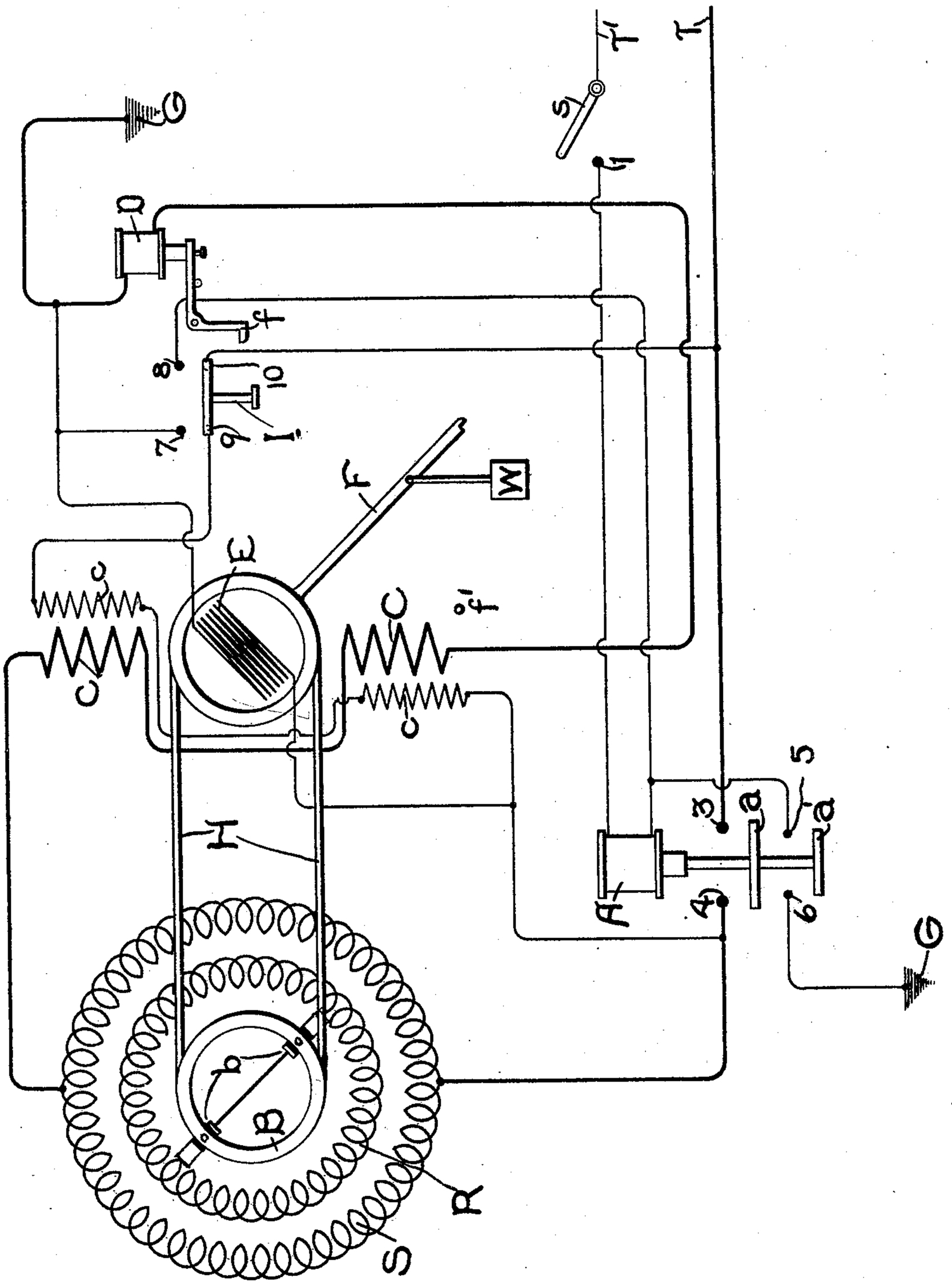


WITNESSES:

George P. Thornton.

Helen Alford.

INVENTOR.

George H. Hill.

BY Albert G. Davis

ATTORNEY.

# UNITED STATES PATENT OFFICE.

GEORGE H. HILL, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

## AUTOMATIC REGULATOR FOR ALTERNATING-CURRENT MOTORS.

No. 795,392. Specification of Letters Patent. Patented July 25, 1905.

Application filed January 15, 1904. Serial No. 189,136.

*To all whom it may concern:*

Be it known that I, GEORGE H. HILL, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Automatic Regulators for Alternating-Current Motors, of which the following is a specification.

My invention relates to controlling alternating-current motors of the type known as "repulsion-motors" in which single-phase alternating current is supplied to the stator or primary winding, while the rotor or secondary winding is provided with a commutator and short-circuiting brushes. In this type of motor the primary and secondary currents, the speed, and the torque may be varied by shifting the position of the brushes. When the brushes are displaced ninety electrical degrees from the line of magnetization produced by the primary winding, the current induced in the rotor-winding is zero and the torque is zero, and the current in the primary winding is simply the magnetizing-current. As the brushes are shifted from this position toward the line of magnetization of the primary winding the current in both stator and rotor increases until the most favorable point of operation is reached, when the brushes are displaced about eighteen electrical degrees from the line of magnetization of the stator-winding.

The object of my invention is to provide means for automatically shifting the brushes of such motors at starting at a proper rate to produce a gradual acceleration from rest to full speed.

One feature of my invention consists in so arranging the circuits of the motor and automatic regulator that the motor may be started from a distance and may thus meet the requirements of train control in which a number of motors on a train must be simultaneously started and controlled from a single point.

In the accompanying drawing, S represents diagrammatically the stator-winding of a repulsion-motor. R represents the rotor-winding of the same, and *b b* represent the short-circuiting brushes carried on the rotatable brush-holder ring B.

C C represent the main stationary or field coils of my automatic regulator, while E represents the rotatable or armature coil of the same.

The motor-circuit, which is shown in heavy lines, passes from the source of current or trolley T through the switch controlled by solenoid A to the stator or primary winding of the motor, thence through the coils C C of the regulator, thence through solenoid-winding D to ground G. The remaining connections, which are shown in light lines, represent the control-circuit energized from the source of current for the control-circuit T'.

The movable coil or armature E of the regulator carries a ring which is connected to the brush-holder ring B of the motor by the sprocket-chain or other band H, or the connection may be by gearing, if preferred. Armature E of the regulator also carries an arm F, which supports the weight W, which tends to turn armature E and brush-holder ring B in a clockwise direction. Stationary coils C C and movable coil E of the regulator are so wound and connected that the torque exerted by one upon the other tends to turn coil E in a counter-clockwise direction. The torque of the regulator-coils is thus opposed by the weight W. It is evident that the effective torque of weight W depends upon the position of arm F and is maximum when arm F is in a horizontal position and zero when arm F is in a vertical position—that is, it varies with the cosine of the angle by which arm F is displaced from the horizontal position. Coil E is so disposed relatively to coils C C that the torque between the two sets of coils also varies by the cosine of the angle by which arm F is displaced from the horizontal position. Thus if the current through armature E is constant the torque produced by weight W will be balanced by the same value of current in coils C C for all positions of arm F. A stop *f'* is employed to prevent arm F from reaching a vertical position, in which the torque of the coils would be zero.

*f* is a catch, controlled by solenoid D, which engages arm F when it is moved to its horizontal position and holds it in that position as long as solenoid D is not energized.

I is a movable bridging member arranged to be operated by arm F, so that when arm F is in its horizontal position and in engagement with catch *f* bridging member I connects contacts 7 and 8, while when arm F is allowed to fall bridging member I also drops and bridges contacts 9 and 10.

The operation is as follows: Assume that

switch *s* in the control-circuit is open, as shown in the drawing, and the bridging members *a a'*, controlled by solenoid A, are also open, as shown in the drawing, and that arm F is at its horizontal position in engagement with catch *f*, raising bridging member I into engagement with contacts 7 and 8. This is the arrangement of circuits for the starting positions of the motor. With arm F in this position brushes *b b* will be displaced ninety electrical degrees from the line of magnetism of the stator-winding S. Now if switch *s* is moved into engagement with contact 1 a circuit is closed from the source of current T' through switch *s*, through solenoid A to contact 8, through bridging member I to contact 7, to ground G. Solenoid A is thus energized, drawing up its core and placing bridging members *a a'* across contacts 3 4 and 5 6, respectively. A circuit is now closed, as follows: from the source of current T through bridging member *a*, through stator-winding S, through coils C C, through solenoid D to ground. No current will flow through the rotor-winding R of the motor, since the brushes *b b* are displaced ninety degrees from the line of magnetization of the stator-winding, and there will be no starting torque. A magnetizing-current, however, will flow through stator-winding S, energizing solenoid D, which rotates catch *f* on its pivot and releases arm F. The circuit through movable coil E of the regulator is also closed from the source of current T through bridging member *a*, through movable coil E to ground G. Arm F will fall, pulled by weight W, until the brushes *b b* are sufficiently displaced to allow a current to flow through stator-winding S and coils C C, which balances the pull of weight W. When arm F falls, contacts 7 and 8 are opened and circuit through solenoid A is maintained through contacts 5 6. As the motor speeds up and the counter electromotive force increases the current through stator-winding S will tend to decrease. Arm F will thus be moved to a lower position until the current through stator-winding S is again increased to balance the pull of weight W. This will continue until the motor is running at full speed and the opposing forces in the regulator are in equilibrium. Thus it is evident that a gradual acceleration and a constant current through the stator-winding will be obtained, since the current necessary to balance the pull of weight W is the same for all positions of arm F. I have thus shown and described an automatic regulator so connected to the brush-holder of the motor as to produce a constant current-flow through the motor and an acceleration corresponding to constant current-flow. It will be understood, however, that the application of my regulator is not limited to constant current, since if an acceleration corresponding to some other function of current-flow is desired it may be obtained without other change than the simple modification of the mechanical connection between the regulator and the brush-holder. Thus by making the ring carried by the regulator eccentric or by using elliptical gears the ratio between the movements of the regulator and of the motor-brushes may be varied at will to produce a gradual acceleration of the motor corresponding to any desired function of the primary current. The method of stopping the motor is as follows: Switch *s* is moved away from contact 1, thereby opening the circuit of solenoid A, bridging member *a* falls, opening the circuit of stator-winding S and of the regulator-coils C C, and the motor accordingly comes to rest. The opening of bridging member *a* removes a short circuit from around the auxiliary regulator-coils *c c*, which were shunted across bridging member *a* through contacts 9 10 and bridging member I. A circuit is accordingly established from source of current T through bridging member I, through coils *c c*, through armature E to ground G. Coils *c c* are wound with sufficient ampere-turns to rotate armature E against the pull of weight W, so as to return arm F to its horizontal position and into engagement with catch *f*. Arm F raises bridging member I out of engagement with contacts 9 10, thus opening the circuit of the auxiliary coils *c c*, and places member I across contacts 7 8. Thus by simply opening switch *s* the regulator and its circuits are automatically restored to proper condition for again starting the motor whenever switch *s* is again closed.

I have shown the main stationary coils C of the regulator connected in series with the stator-winding while the movable coil E is in shunt to the motor-circuit. On the other hand, I have shown the auxiliary regulator-coils *c* connected in series with coil E. It will be understood that the relative connections of these several coils may be varied without departing from the spirit of my invention. It will be seen that the auxiliary coils *c* are merely a reduplication of the main coils C with an increased number of turns. Consequently the main coils themselves may be used by properly energizing them, if preferred, for restoring the regulator to its starting position.

It will be understood that any number of motors with their regulators may be controlled by means of a single switch *s* and that this switch may be at any desired distance from the motors. Thus my system of control is well adapted for controlling a number of motors on a train from a single point.

I do not desire to limit myself to the particular construction and arrangement of parts here shown, since changes therein which do not depart from the spirit of my invention and which are within the scope of the appended claims will be obvious to those skilled in the art.

What I claim as new, and desire to secure by Letters Patent of the United States, is—

1. In combination, a repulsion-motor, a rotatable brush-holder therefor, a device responsive to variations of current-flow through said motor and adapted to shift said brush-holder, and means for controlling from a distance the circuits of said device.

2. In combination, a repulsion-motor, a rotatable brush-holder therefor, a device responsive to variations of current-flow through said motor and adapted to shift said brush-holder as said motor speeds up, and means controlled from a distance for restoring said device to its starting position.

3. In combination, a repulsion-motor, a rotatable brush-holder therefor, a device adapted to shift automatically said brush-holder to decrease the displacement of the brushes from the line of field magnetization of said motor as said motor speeds up, and means controlled from a distance for restoring said device to its starting position.

4. In combination, a repulsion-motor, an automatic brush-shifting device therefor responsive to variations in current-flow through said motor, a latch for restraining said device, and means controllable from a distance for releasing said latch and for restoring said device into engagement with said latch.

5. In combination, a repulsion-motor, a brush-shifting device therefor, coils in series with said motor and arranged to produce a torque in said device, and means for impressing on said device in all positions thereof an opposing torque equal to the torque due to a predetermined current in said coils.

6. In combination, a repulsion-motor, a brush-shifting device therefor responsive to variations in current-flow through said motor, a latch for retaining said device in its starting position, a tripping-magnet for said latch responsive to current-flow through said motor, and means for returning said device into engagement with said latch.

7. In combination, a repulsion-motor, a brush-shifting device therefor comprising a movable and a stationary member, a weighted arm carried by said movable member, and coils arranged to produce in said device a torque varying with the current-flow through said motor.

8. In combination, a repulsion-motor, a brush-shifting device therefor comprising coils in series therewith, means for opposing the torque produced by said coils in said device, and auxiliary coils arranged when energized to restore said device to its starting position.

9. In combination, a repulsion-motor, a device adapted to shift the brushes of said motor to produce a predetermined current-flow through said motor, and means controllable from a distance for restoring said device to its starting position.

10. In combination, a repulsion-motor, a device adapted to shift the brushes of said motor to produce a predetermined current-flow through said motor, a latch for restraining said device in starting position, and means controllable from a distance for releasing said device from said latch, and for restoring said device into engagement with said latch.

11. In combination, a repulsion-motor, a rotatable brush-holder therefor, and a device responsive to variations of current-flow through said motor and adapted to shift said brush-holder.

12. In combination, a repulsion-motor, a rotatable brush-holder therefor, and an electroresponsive device adapted to decrease automatically the displacement of the brushes from the line of field magnetization of the motor as the motor speeds up.

In witness whereof I have hereunto set my hand this 14th day of January, 1904.

GEORGE H. HILL.

Witnesses:

BENJAMIN B. HULL,

HELEN ORFORD.